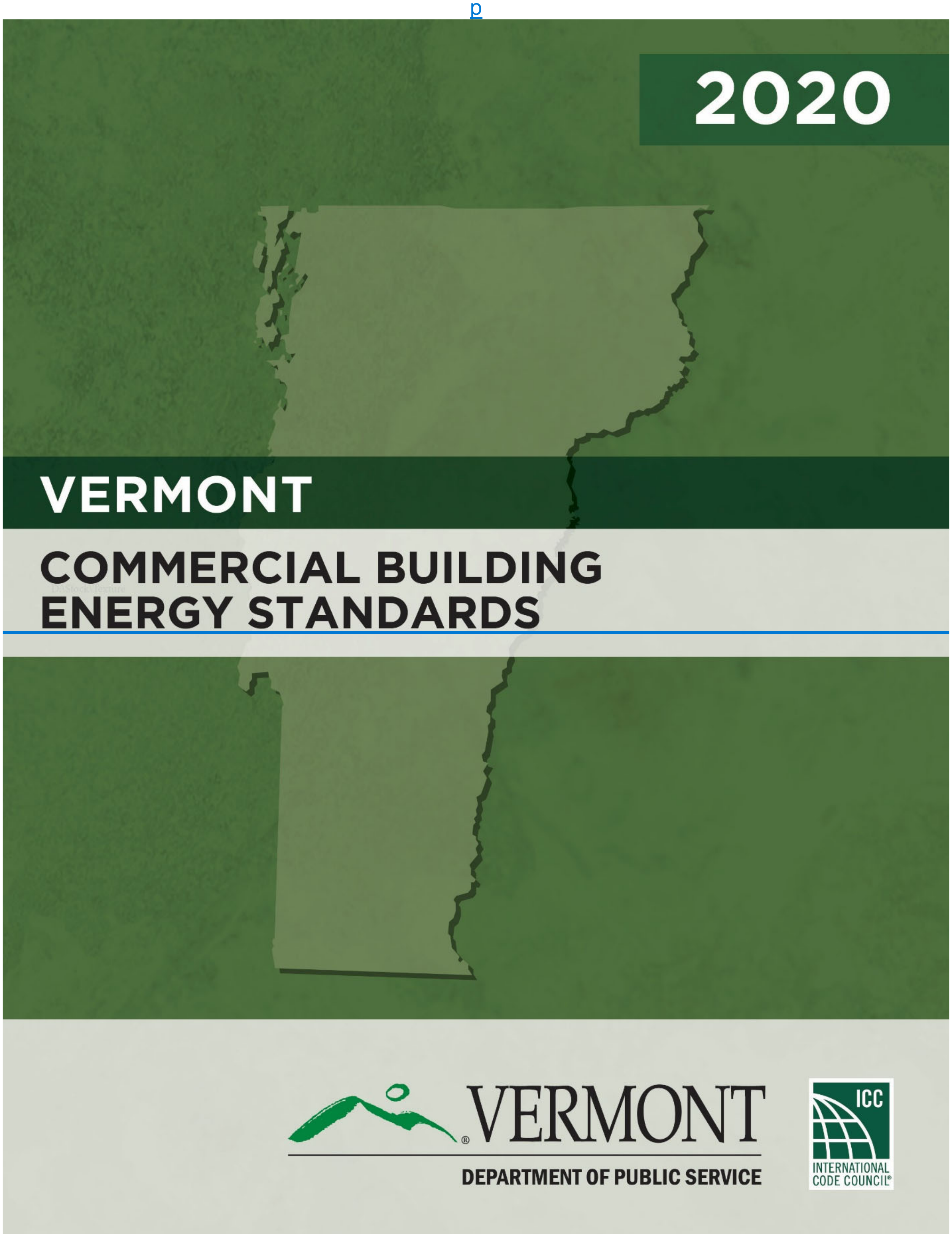
p



~~2020~~ 2023 Vermont Commercial Building Energy Standards

~~2020~~ 2023 Vermont Commercial Building Energy Standards

First Printing: ~~July~~ XXXX ~~2020~~2023

ISBN: 978-1-952468-33-9

To receive free hard copies of the ~~2020~~2023 *Vermont Commercial Building Energy Standards*, please contact the Vermont Department of Public Service at 1-802-828-2811 or the Energy Code Assistance Center at 1-855-887-0673.

PRINTED IN THE USA

PREFACE

Introduction

The ~~2020~~2023 *Vermont Commercial Building Energy Standards* (CBES) is based on the *International Energy Conservation Code*® (IECC®) ~~2018~~2021 edition and incorporates elements of ANSI/ASHRAE/IES Standard 90.1- ~~2016~~2019 *Energy Standard for Buildings Except Low-Rise Residential Buildings.*

This comprehensive energy conservation code establishes minimum regulations for energy efficient buildings using prescriptive and performance-related provisions. It is founded on broad-based principles that make possible the use of new materials and new energy efficient designs.

The *International Energy Conservation Code* provisions provide many benefits, among which is the model code development process that offers an international forum for energy professionals to discuss performance and prescriptive code requirements. This model code also encourages international consistency in the application of provisions.

Development

This 2023 CBES is founded on principles intended to establish provisions consistent with the scope of an energy conservation code that adequately conserves energy; provisions that do not unnecessarily increase construction costs; provisions that do not restrict the use of new materials, products or methods of construction; and provisions that do not give preferential treatment to particular types or classes of materials, products or methods of construction.

~~Development~~

~~This 2020 CBES is founded on principles intended to establish provisions consistent with the scope of an energy conservation code that adequately conserves energy; provisions that do not unnecessarily increase construction costs; provisions that do not restrict the use of new materials, products or methods of construction; and provisions that do not give preferential treatment to particular types or classes of materials, products or methods of construction.~~

Background

The Vermont Commercial Building Energy Standards (CBES) was adopted by statute (30 V.S.A. § 53) in 2006. This code applies to all commercial buildings and residential buildings four stories or greater above grade in Vermont and took effect January 1, 2007.

Update Process

The Commercial Building Energy Standards statute requires that revisions to the CBES are made promptly after the issuance of updated standards under the *International Energy Conservation*

Code (IECC). The Department of Public Service (PSD) is required to convene stakeholders that include mortgage lenders, builders, building designers, utility representatives, and other persons with experience and expertise prior to the adoption of a revised CBES to provide recommendations.

The ~~2020~~ 2023 CBES is based on the language in the *International Energy Conservation Code* (IECC) ~~2018~~2021 edition and incorporates elements of ANSI/ASHRAE/IES Standard 90.1-~~2016~~2019 *Energy Standard for Buildings Except Low-Rise Residential Buildings*. The ~~2020~~2023 CBES includes a new "Additional Efficiency, Renewable, and Load Management Requirements ~~Package options~~" section based on a points approach to code compliance ~~based on building usage~~. The addition of "points" provides builders and designers greater flexibility in complying with the CBES. The Vermont PSD held a series of code collaborative meetings in 2020 and a series of stakeholder and advisory committee meetings in ~~2018 and 2019~~2021 to gather feedback on proposed changes to the CBES. The revisions presented in this document were modified based on input received from these meetings.

EFFECTIVE USE OF THE ~~2020~~2023 VERMONT COMMERCIAL BUILDING ENERGY STANDARDS

The ~~2020~~2023 *Vermont Commercial Building Energy Standards* (CBES) is a code that regulates minimum energy conservation requirements for new buildings as well as additions, alterations, renovations, and repairs to existing buildings. The ~~2020~~2023 CBES addresses energy conservation requirements for all aspects of energy uses in commercial construction, including heating and ventilating, lighting, water heating, and power usage for appliances and building systems.

The ~~2020~~2023 CBES is a design document. For example, before constructing a building, the designer must determine the minimum insulation *R*-values and fenestration *U*-factors for the building exterior envelope. The CBES sets forth minimum requirements for exterior envelope insulation, window and door *U*-factors and SHGC ratings, duct insulation, lighting and power efficiency, mechanical ventilation, and water distribution insulation.

Arrangement and Format of the ~~2020~~2023 CBES

The ~~2020~~2023 CBES, like other codes published by ICC, is arranged and organized to follow sequential steps that generally occur during a plan review or inspection. The ~~2020~~2023 CBES is divided into six different parts:

Chapters	Subjects
1–2	Scope, Administration and Definitions
3	General Requirements
4	Commercial Energy Efficiency
5	Existing Buildings
6	Referenced standards

Italicized Terms

Selected terms set forth in Chapter 2: Definitions, are italicized where they appear in code text. Such terms are not italicized where the definition set forth in Chapter 2 does not impart the intended meaning in the use of the term. The terms selected have definitions that the user should read carefully to facilitate better understanding of the code.

The following is a chapter-by-chapter synopsis of the scope and intent of the provisions of the ~~2020~~2023 *Vermont Commercial Building Energy Standards*:

Chapter 1 Scope and Administration. This chapter contains provisions for the application, enforcement and administration of subsequent requirements of the code. In addition to establishing the scope of the code, Chapter 1 identifies which buildings and structures come under its purview. Chapter 1 is largely concerned with maintaining "due process of law" in enforcing the energy conservation criteria contained in the body of this code. Only through careful observation of the administrative provisions can the code official or other authority having jurisdiction, where one exists, reasonably expect to demonstrate that "equal protection under the law" has been provided.

Chapter 2 Definitions. Chapter 2 is the repository of the definitions of terms used in the body of the code. Codes are technical documents and every word, term and punctuation mark can impact the meaning of the code text and the intended results. The code often uses terms that have a unique meaning in the code and the code meaning can differ substantially from the ordinarily understood meaning of the term as used outside of the code.

The terms defined in Chapter 2 are deemed to be of prime importance in establishing the meaning and intent of the code text. The user of the code should be familiar with and consult this chapter because the definitions are essential to the correct interpretation of the code and the user may not be aware that a term is defined.

Where understanding of a term's definition is especially key to or necessary for understanding of a particular code provision, the term is shown in *italics* wherever it appears in the code. This is true only for those terms that have a meaning that is unique to the code. In other words, the generally understood meaning of a term or phrase might not be sufficient or consistent with the meaning prescribed by the code; therefore, it is essential that the code-defined meaning be known.

Guidance regarding tense, gender and plurality of defined terms as well as guidance regarding terms not defined in this code is provided.

Chapter 3 General Requirements. Chapter 3 provides interior design conditions that are used as a basis for assumptions in heating and cooling load calculations and provides basic material requirements for insulation materials and fenestration materials and provides standards for commercial mechanical ventilation and combustion safety.

Chapter 4 Commercial Energy Efficiency. Chapter 4 contains the energy-efficiency-related requirements for the design and construction of most types of commercial buildings, and residential buildings greater than three stories in height above grade. This chapter defines requirements for the portions of the building and building systems that impact energy use in new commercial construction and new residential construction greater than three stories in height and promotes the effective use of energy. The provisions within the chapter promote energy efficiency in the building envelope, the heating and cooling ~~system~~system, and the service water heating system of the building.

Chapter 5 Existing Buildings. Chapter 5 of each set of provisions contains the technical energy efficiency requirements for existing buildings. Chapter 5 provisions address the maintenance of buildings in compliance with the code as well as how additions, alterations, repairs and changes of occupancy need to be addressed from the standpoint of energy efficiency. Specific provisions are provided for historic buildings.

Chapter 6 Referenced Standards. The code contains numerous references to standards that are used to regulate materials and methods of construction. Chapter 6 contains a comprehensive list of all standards that are referenced in the code. The standards are part of the code to the extent of the reference to the standard. Compliance with the referenced standard is necessary for compliance with this code. By providing specifically adopted standards, the construction and installation requirements necessary for compliance with the code can be readily determined. The basis for code compliance is, therefore, established and available on an equal basis to the code official, or other authority having jurisdiction, where one exists, contractor, designer and owner.

Chapter 6 is organized in a manner that makes it easy to locate specific standards. It lists all of the referenced standards, alphabetically, by acronym of the promulgating agency of the standard. Each agency's standards are then listed in either alphabetical or numeric order based on the standard identification. The list also contains the title of the standard; the edition (date) of the standard referenced; any addenda included as part of the ICC adoption; and the section or sections of this code that reference the standard.

Marginal Markings

Solid vertical lines in the margins within the body of the code indicate Vermont specific additions and changes from the requirements of the IECC ~~2018~~2021 edition. Deletion indicators in the form of an arrow (➡) are provided in the margin where an entire section, paragraph, exception or table has been deleted or an item in a list of items or a table has been deleted.

Abbreviations and Notations

The following is a list of common abbreviations and units of measurement used in this code. Some of the abbreviations are for terms defined in Chapter 2. Others are terms used in various tables and text of the code.

AFUE	Annual fuel utilization efficiency
bhp	Brake horsepower (fans)
Btu	British thermal unit
Btu/h-ft^2	Btu per hour per square foot
C-factor	See Chapter 2—Definitions
CDD	Cooling degree days
cfm	Cubic feet per minute
cfm/ft^2	Cubic feet per minute per square foot
ci	Continuous insulation
COP	Coefficient of performance
DCV	Demand control ventilation
°C	Degrees Celsius
°F	Degrees Fahrenheit
DWHR	Drain water heat recovery
DX	Direct expansion
E_c	Combustion efficiency
E_v	Ventilation efficiency
E_t	Thermal efficiency
EER	Energy efficiency ratio
EF	Energy factor
ERI	Energy rating index
F-factor	See Chapter 2—Definitions
FDD	Fault detection and diagnostics
FEG	Fan efficiency grade
FL	Full load

ft^2	Square foot
gpm	Gallons per minute
HDD	Heating degree days
HERS	Home Energy Rating System
hp	Horsepower
HSPF	Heating seasonal performance factor
HVAC	Heating, ventilating and air conditioning
IEER	Integrated energy efficiency ratio
IPLV	Integrated Part Load Value
Kg/m^2	Kilograms per square meter
kW	Kilowatt
LPD	Light power density (lighting power allowance)
L/s	Liters per second
Ls	Liner system
m^2	Square meters
MERV	Minimum efficiency reporting value
NAECA	National Appliance Energy Conservation Act
NPLV	Nonstandard Part Load Value
Pa	Pascal
PF	Projection factor
pcf	Pounds per cubic foot
PSD	Department of Public Service (Vermont)
psf	Pounds per square foot
PTAC	Packaged terminal air conditioner
PTHP	Packaged terminal heat pump
R-value	See Chapter 2—Definitions
SCOP	Sensible coefficient of performance
SEER	Seasonal energy efficiency ratio
SHGC	Solar Heat Gain Coefficient
SPVAC	Single packaged vertical air conditioner
SPVHP	Single packaged vertical heat pump
SRI	Solar reflectance index
SWHF	Service water heat recovery factor
U-factor	See Chapter 2—Definitions
VAV	Variable air volume
VRF	Variable refrigerant flow
VT	Visible transmittance
W	Watts
w.c.	Water column
w.g.	Water gauge

IECC—COMMERCIAL PROVISIONS

TABLE OF CONTENTS

To be updated at end of process

CHAPTER 1 [CE]
SCOPE AND ADMINISTRATION

PART 1—SCOPE AND APPLICATION

SECTION C101
SCOPE AND GENERAL REQUIREMENTS

C101.1 Title.
This code shall be known as the ~~2020~~2023 *Commercial Building Energy Standards* (CBES) of Vermont and shall be cited as such. It is referred to herein as "this code."

C101.2 Scope.
This code applies to *commercial buildings* and the buildings' sites and provides the minimum energy-efficient, renewable energy, and energy storage requirements for the design and construction, and a plan for operation and maintenance of the following:

1. New buildings and their systems.

2. New portions of buildings and their systems.

3. New systems and equipment in existing buildings.

4. New stand-alone equipment or building systems specifically identified in the standard that are part of industrial or manufacturing processes.

   Exceptions:

   1. **Farm Structures.** This code shall not apply to farm structures as defined in 24 Vermont Statutes Annotated (V.S.A.) § 4413.
   2. **Process applications.** This code shall not apply to manufacturing or industrial processes equipment that are not identified in this standard or are integral to equipment that is not identified in the standard.

C101.3 Intent.
This code shall regulate the design and construction of buildings for the effective use and conservation of energy over the useful life of each building. This code is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve this objective. This code is not intended to abridge safety, health or environmental requirements contained in other applicable codes or ordinances.

This code has been designed to minimize any conflict or difference between other adopted codes and standards. Where there is conflict between the codes or codes and standards, the Life Safety Code (NFPA 101), Fire Code (NFPA 1), and the *International Building Code*® (IBC®) shall apply. Where one code or standard has a requirement and another code or standard does not have a requirement, the code or standard with a requirement shall apply.

C101.4 Applicability.
Where, in any specific case, different sections of this code specify different materials, methods of construction or other requirements, the most restrictive shall govern. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall govern.

C101.4.1 Mixed occupancy.
Where a building includes both *residential* and *commercial* occupancies, the following shall apply:

1. With respect to a structure that is three stories or less in height,

    1.1. The term "residential building" shall include the living spaces in the structure and the nonliving spaces in the structure that serve only the residential users such as common hallways, laundry facilities, residential management offices, community rooms, storage rooms, and foyers.

    1.2 The term "commercial building" shall include all commercial uses within the structure and all common areas and facilities that serve both residential and commercial uses.

2. With respect to a structure that is four stories or more in height, the term "commercial building" shall include all uses and areas within the structure.

C101.4.2 Application to existing buildings.
Existing buildings shall follow the provisions of Chapter 5 of this code.

C101.5 Compliance.
Residential buildings shall meet the provisions of the ~~2020~~2023 *Vermont Residential Building Energy Standards* (RBES), and *Commercial buildings* shall meet the provisions of the ~~2020~~2023 *Vermont Commercial Building Energy Standards* (CBES).

C101.5.1 Compliance materials.
The *code official or authority having jurisdiction* shall be permitted to approve specific computer software, worksheets, compliance manuals and other similar materials that meet the intent of this code.

At the time of application for a construction permit, where required, the designer shall include a statement on the submitted stamped drawings noting that the design complies with the requirements of the CBES.

C101.5.2 Exempt buildings.
The following buildings, or portions thereof, separated from the remainder of the building by building thermal envelope assemblies complying with Section C402 shall be exempt from the building thermal envelope provisions of Section C402.

1. **Low energy buildings.** Those with a peak design rate of energy usage less than 3.4 Btu/h · ft^2 (10.7 W/m^2) or 1.0 watt per square foot (10.7 W/m^2) of floor area for space conditioning purposes.

2. **Unconditioned buildings.** Those that do not contain *conditioned space*.

3. **Greenhouses.**

4. **Inflatable buildings.** Temporary air-supported structures shall be exempt only from the thermal envelope provisions of this code.

5. **Yurt buildings.** A yurt or tent that is not mechanically cooled and is only heated through biomass or other on-site renewable energy.

6. **Equipment buildings.** Buildings that comply with all the following shall be exempt from the building thermal envelope provisions of this code:

   6.1. Buildings that are separate buildings with floor area not more than 500 square feet (50 m^2).

   6.2. Buildings that are intended to house electronic equipment with installed equipment power totaling not less than 7 watts per square foot (75 W/m^2) and not intended for human occupancy.

   6.3. Buildings that have a heating system capacity not greater than 17,000 Btu/hr (5 kW) and a heating thermostat set point that is restricted to not more than 50°F (10°C).

   6.4. Buildings that have an average wall and roof *U*-factor less than 0.120.

SECTION C102
ALTERNATIVE MATERIALS, DESIGN AND METHODS OF CONSTRUCTION AND EQUIPMENT

C102.1 General.
The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. ~~An~~ ~~The code official~~The Public Service Department shall have the authority to approve an alternative material, design or method of construction ~~shall be *approved* where the *code official or authority having jurisdiction* finds~~ upon the written application of the owner or the owner's authorized agent. The code *official* shall first find that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code in quality, strength, effectiveness, *fire resistance*, durability and safety. ~~Where the alternative material, design or method of construction is not *approved*, the~~The *code official or authority having jurisdiction* shall respond to the applicant, in writing, stating the reasons why the alternative was approved or was not *approved*.

C102.1.1 Above code programs.
The *code official or authority having jurisdiction* shall be permitted to deem a national, state or local energy efficiency program ~~to exceed~~an exceeding the energy efficiency required by this code. Buildings *approved* in writing by such an energy efficiency program shall be considered

to be in compliance with this code. The requirements identified as “mandatory” in Chapter 4 shall be met.

PART 2—ADMINISTRATION AND ENFORCEMENT

SECTION C103
CONSTRUCTION DOCUMENTS

C103.1 General.
Where required construction documents and other supporting data shall be submitted in one or more sets, or in a digital format where allowed by the reviewing official, with each application for a permit. The construction documents shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the *code official or authority having jurisdiction* is authorized to require necessary construction documents to be prepared by a registered design professional.

> **Exception:** The *code official or authority having jurisdiction* is authorized to waive the requirements for construction documents or other supporting data if the *code official or authority having jurisdiction* determines they are not necessary to confirm compliance with this code.

C103.2 Information on construction documents.
Where required construction documents shall be drawn to scale on suitable material. Electronic media documents are permitted to be submitted where approved by the *code official or authority having jurisdiction*. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and show in sufficient detail pertinent data and features of the building, systems and equipment as herein governed. Details shall include, but are not limited to, the following as applicable:

1. Energy compliance path.

~~1.~~2. Insulation materials and their *R*-values.

~~2.~~3. Fenestration *U*-factors and solar heat gain coefficients (SHGCs).

~~3.~~4. Area-weighted *U*-factor and solar heat gain coefficient (SHGC) calculations.

~~4.~~5. Design ambient temperatures.

~~5.~~6. Interior temperatures for heating and cooling modes.

~~6.~~7. Relative humidity setpoints.

~~7.~~8. Ventilation rates.

~~8.~~9. Mechanical system design criteria.

~~9.~~10. Mechanical and service water heating systems and equipment types, sizes and efficiencies.

~~10.~~11. Economizer description.

~~11.~~12. Equipment and system controls.

~~12.~~13. Fan motor horsepower (hp) and controls.

~~13.~~14. Duct sealing, duct and pipe insulation and location.

~~14.~~15. Lighting fixture schedule with wattage and control narrative.

~~15.~~16. Location of *daylight* zones on floor plans.

~~16.~~17. Air ~~sealing details~~barrier and air sealing details, including the location of the air barrier, a diagram showing the building's pressure boundary in plan(s) and section(s), and a calculation of the area of the pressure boundary as specified in Section C402.4.1.3.

Mechanical equipment schedules shall be included in the submitted construction documents and shall include, but are not limited to, the following information:

1. Equipment efficiencies.
2. Fan and pump nameplate motor and brake horsepower.
3. Fan efficiency grade (FEG), where applicable.
4. Hydronic system (if applicable) supply and return water design temperatures for boilers and all terminal devices (e.g., baseboards, unit ventilators, etc.).
5. Steam system (if applicable) design pressure for boilers and all terminal devices.

C103.2.1 Building thermal envelope depiction.
The *building thermal envelope* shall be represented on the construction drawings.

C103.2.2 Electrification system. The construction documents shall provide details for additional electric infrastructure, including branch circuits, conduit, or pre-wiring, panel capacity, and electrical service capacity in compliance with the provisions of this code.

C103.3 Examination of documents.
The *code official or authority having jurisdiction* shall examine or cause to be examined the accompanying construction documents and shall ascertain whether the construction indicated and described is in accordance with the requirements of this code and other pertinent laws or ordinances. The *code official or authority having jurisdiction* is authorized to utilize a registered design professional, or other *approved* entity not affiliated with the building design or construction, in conducting the review of the plans and specifications for compliance with the code.

C103.3.1 Approval of construction documents.
When the *code official or authority having jurisdiction* issues a permit where construction

documents are required, the construction documents shall be endorsed in writing and stamped "Reviewed for Code Compliance." Such approved construction documents shall not be changed, modified or altered without authorization from the *code official or authority having jurisdiction*. Work shall be done in accordance with the *approved* construction documents.

One set of construction documents so reviewed shall be retained by the *code official.* The other set shall be returned to the applicant, kept at the site of work and shall be open to inspection by the *code official or authority having jurisdiction* or a duly authorized representative.

C103.3.2 Previous approvals.
This code shall not require changes in the construction documents, construction or designated occupancy of a structure for which a lawful permit has been heretofore issued or otherwise lawfully authorized, and the construction of which has been pursued in good faith within 180 days after the effective date of this code and has not been abandoned.

C103.3.3 Phased approval.
The *code official or authority having jurisdiction* shall have the authority to issue a permit for the construction of part of an energy conservation system before the construction documents for the entire system have been submitted or *approved*, provided that adequate information and detailed statements have been filed complying with all pertinent requirements of this code. The holders of such permit shall proceed at their own risk without assurance that the permit for the entire energy conservation system will be granted.

C103.4 Amended construction documents.
Changes made during construction that are not in compliance with the *approved* construction documents shall be resubmitted for approval as an amended set of construction documents.

C103.5 Retention of construction documents.
One set of *approved* construction documents shall be retained by the *code official* where one exists *or authority having jurisdiction* where one exists for a period of not less than 180 days from date of completion of the permitted work, or as required by state or local laws.

C103.6 Building documentation.
The construction documents shall specify that the documents described in this section be provided to the building owner or owner's authorized agent within 90 days of the date of receipt of the certificate of occupancy.

C103.6.1 Record documents.
Construction documents shall be updated to convey a record of the completed work. Such updates shall include mechanical, electrical and control drawings that indicate all changes to size, type and location of components, equipment and assemblies.

C103.6.2 Compliance documentation.
Energy code compliance documentation and supporting calculations shall be delivered in one document to the building owner as part of the project record documents or manuals, or as a standalone document. This document shall include the specific energy code edition utilized for compliance determination for each system, documentation demonstrating compliance with Section C303.1.3 for each fenestration product installed, and the interior lighting power compliance path, building area or space-by-space, used to calculate the lighting power allowance.

For projects complying with Item 1 of Section C401.2, the documentation shall include:

1. The envelope insulation compliance path.
2. All compliance calculations including those required by Sections C402.1.3, C403.8.1, C405.3 and C405.5~~4~~.

C103.6.3 Systems operation control.
Training shall be provided to those responsible for maintaining and operating equipment included in the manuals required by Section C103.6.2.

The training shall include:

1. Review of manuals and permanent certificate.

2. Hands-on demonstration of all normal maintenance procedures, normal operating modes, and all emergency shutdown and startup procedures.

3. Training completion report.

SECTION C104
RESERVED

SECTION C105
INSPECTIONS

C105.1 General.
Where required, construction or work for which a permit is required shall be subject to inspection by the *code official or authority having jurisdiction*, his or her designated agent or an approved agency, and such construction or work shall remain visible and able to be accessed for inspection purposes until *approved*. Approval as a result of an inspection shall not be construed to be an approval of a violation of the provisions of this code or of other ordinances of the jurisdiction. Inspections presuming to give authority to violate or cancel the provisions of this code or of other ordinances of the jurisdiction shall not be valid. It shall be the duty of the permit applicant to cause the work to remain visible and able to be accessed for inspection purposes. Neither the *code official or authority having jurisdiction*, nor the jurisdiction shall be liable for expense entailed in the removal or replacement of any material, product, system or building component required to allow inspection to validate compliance with this code.

C105.2 Required approvals.
Work shall not be done beyond the point indicated in each successive inspection without first obtaining the approval of the *code official or authority having jurisdiction*. The *code official or authority having jurisdiction*, upon notification, shall make the requested inspections and shall either indicate the portion of the construction that is satisfactory as completed, or notify the permit holder or his or her agent wherein the same fails to comply with this code. Any portions that do not comply shall be corrected and such portion shall not be covered or concealed until authorized by the *code official or authority having jurisdiction*.

C105.2.1 Final approvals.
Where applicable, the building shall have a final inspection and shall not be occupied until *approved*. The final inspection shall include verification of the installation and proper operation of all required building controls, and documentation verifying activities associated with required *building commissioning* have been conducted and findings of noncompliance corrected.

C105.3 Reinspection.
A building shall be reinspected where determined necessary by the *code official or authority having jurisdiction*.

C105.4 Approved inspection agencies.
The *code official or authority having jurisdiction* is authorized to accept reports of third-party inspection agencies not affiliated with the building design or construction, provided that such agencies are *approved* as to qualifications and reliability relevant to the building components and systems that they are inspecting.

C105.5 Inspection requests.
It shall be the duty of the holder of the permit or their duly authorized agent to notify the *code official or authority having jurisdiction* when work is ready for inspection. It shall be the duty of the permit holder to provide access to and means for inspections of such work that are required by this code.

C105.6 Reinspection and testing.
Where any work or installation does not pass an initial test or inspection, the necessary corrections shall be made to achieve compliance with this code. The work or installation shall then be resubmitted to the *code official or authority having jurisdiction* for inspection and testing.

SECTION C106
NOTICE OF APPROVAL

~~C105.7~~C106.1 Approval.
After the prescribed tests and inspections indicate that the work complies in all respects with this code, a notice of approval shall be issued by the *code official* ~~*or authority having jurisdiction*~~.

~~C105.7.1~~C106.2 Revocation.
The *code official* ~~*or authority having jurisdiction*~~ is authorized to suspend or revoke, in writing, a notice of approval issued under the provisions of this code wherever the certificate is issued in error, or on the basis of incorrect information supplied, or where it is determined that the *building* or structure, premise, or portion thereof is in violation of any ordinance or regulation or any of the provisions of this code.

SECTION C10~~6~~7
VALIDITY

C10~~6~~7.1 General.
If a portion of this code is held to be illegal or void, such a decision shall not affect the validity of the remainder of this code.

SECTION C10~~7~~8
REFERENCED STANDARDS

C10~~7~~8.1 Referenced codes and standards.
The codes and standards referenced in this code shall be those listed in Chapter 6, and such codes and standards shall be considered as part of the requirements of this code to the prescribed extent of each such reference and as further regulated in Sections C107.1.1 and C107.1.2.

C10~~7~~8.1.1 Conflicts.
Where conflicts occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.

C10~~7~~8.1.2 Provisions in referenced codes and standards.
Where the extent of the reference to a referenced code or standard includes subject matter that is within the scope of this code, the provisions of this code, as applicable, shall take precedence over the provisions in the referenced code or standard.

C10~~7~~8.2 Application of references.
References to chapter or section numbers, or to provisions not specifically identified by number, shall be construed to refer to such chapter, section or provision of this code.

C10~~7~~8.3 Other laws.
The provisions of this code shall not be deemed to nullify any provisions of local, state or federal law.

SECTION C109~~8~~
RESERVED

SECTION C110~~09~~
RESERVED

CHAPTER 2 [CE]
DEFINITIONS

SECTION C201
GENERAL

C201.1 Scope.
Unless stated otherwise, the following words and terms in this code shall have the meanings indicated in this chapter.

C201.2 Interchangeability.
Words used in the present tense include the future; words in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural includes the singular.

C201.3 Terms defined in other codes and standards.
Terms that are not defined in this code but are defined in the *International Building Code*, *International Fire Code*, *International Fuel Gas Code*, *International Mechanical Code*, *International Plumbing Code*, or ASHRAE Standard 62.1 or by ANSI/SMACNA shall have the meanings ascribed to them in those codes and standards.

C201.4 Terms not defined.
Terms not defined by this chapter shall have ordinarily accepted meanings such as the context implies.

Development

This 2023 CBES is founded on principles intended to establish provisions consistent with the scope of an energy conservation code that adequately conserves energy; provisions that do not unnecessarily increase construction costs; provisions that do not restrict the use of new materials, products or methods of construction; and provisions that do not give preferential treatment to particular types or classes of materials, products or methods of construction.

SECTION C202
GENERAL DEFINITIONS

ABOVE-GRADE WALL. See "Wall, above-grade."

ACCESS (TO). That which enables a device, appliance or equipment to be reached by ready access or by a means that first requires the removal or movement of a panel, or similar obstruction.

ADDITION. An extension or increase in the *conditioned space* floor area, number of stories or height of a building or structure.

AIR BARRIER. One or more materials joined together in a continuous manner to restrict or prevent the passage of air through the building thermal envelope and its assemblies.

AIR CURTAIN. A device, installed at the building entrance, that generates and discharges a laminar air stream intended to prevent or reduce the infiltration of external, unconditioned air into the conditioned spaces, or the loss of interior, conditioned air to the outside.

ALL-ELECTRIC BUILDING. A building that contains no combustion equipment, or plumbing for combustion equipment, installed within the building or building site.

ALTERATION. Any construction, retrofit or renovation to an existing structure other than repair or addition. Also, a change in a building, electrical, gas, mechanical or plumbing system that involves an extension, addition or change to the arrangement, type or purpose of the original installation.

ANNUAL FUEL UTILIZATION EFFICIENCY (AFUE). Boiler and furnace efficiency measurement as the percentage of heating fuel that is effectively turned into usable energy (heat).

APPLIANCE. A device or apparatus that is manufactured and designed to utilize energy and for which this code provides specific requirements.

APPROVED. Approval by the *code official or authority having jurisdiction* as a result of investigation and tests conducted by him or her, or by reason of accepted principles or tests by nationally recognized organizations.

APPROVED AGENCY. An established and recognized agency that is regularly engaged in conducting tests or furnishing inspection services, or furnishing product certification where such agency has been approved by the *code official or authority having jurisdiction*.

AUTHORITY HAVING JURISDICTION. The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative. ~~For purposes of this code, the Vermont Public Service Department is not the authority having jurisdiction~~The state of Vermont has not designated an authority. The Division of Fire Safety has authority over all matters regarding commercial building construction, including the incorporation of energy code provisions into new and existing buildings..

AUTOMATIC. Self-acting, operating by its own mechanism when actuated by some impersonal influence, as, for example, a change in current strength, pressure, temperature or mechanical configuration (see "Manual").

AUTOMOBILE PARKING SPACE. A space within a building or private or public parking lot, exclusive of driveways, ramps, columns, office and work areas, for the parking of an automobile.

BELOW-GRADE WALL. See "Wall, below-grade."

BIOGAS. A mixture of hydrocarbons that is a gas at 60°F (15.5°C) and 1 atmosphere of pressure that is produced through the anaerobic digestion of organic matter.

BIODIESEL. Mono alkyl esters derived from plant or animal matter that meet the registration requirements for fuels and fuel additives established by the Environmental Protection Agency under section 211 of the Clean Air Act (42 U.S.C. § 7545), and the requirements of ASTM D6751.

BIOMASS. The vegetation removed from the forest, usually logging slash, small-diameter trees, tops, limbs, or trees. This includes wood logs, wood pellets and wood chips.

BOILER, MODULATING. A boiler that is capable of more than a single firing rate in response to a varying temperature or heating load.

BOILER SYSTEM. One or more boilers, their piping and controls that work together to supply steam or hot water to heat output devices remote from the boiler.

BUBBLE POINT. The refrigerant liquid saturation temperature at a specified pressure.

BUILDING. Any structure used or intended for supporting or sheltering any use or occupancy, including any mechanical systems, service water heating systems and electric power and lighting systems located on the building site and supporting the building.

BUILDING COMMISSIONING. A process that verifies and documents that the selected building systems have been designed, installed, and function according to the owner's project requirements and construction documents, and to minimum code requirements.

BUILDING ENTRANCE. Any door, set of doors, doorway, or other form of portal that is used to gain access to the building from the outside by the public.

BUILDING SITE. A contiguous area of land that is under the ownership or control of one entity.

BUILDING THERMAL ENVELOPE. The basement walls, exterior walls, floors, ceilings, roofs and any other building element assemblies that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space.

***C*-FACTOR (THERMAL CONDUCTANCE).** The coefficient of heat transmission (surface to surface) through a building component or assembly, equal to the time rate of heat flow per unit area and the unit temperature difference between the warm side and cold side surfaces (Btu/h • ft^2 • °F) [W/(m^2 • K)].

CANOPY. Canopy area is the total rectangular area of the entire plant canopy in the room, and represents the usable production space in your grow rooms. Canopy area may be noncontiguous, but each unique area included in the total canopy calculations shall be separated by an identifiable boundary which includes, but is not limited to: interior walls, shelves and workbenches. Canopy area does not include walkways. If plants are being cultivated using a shelving system, the surface area of each level shall be included in the total canopy calculation.

CAPTIVE KEY OVERRIDE. A lighting control that will not release the key that activates the override when the lighting is on.

CARBON DIOXIDE EQUIVALENT (CO2e). A measure used to compare the impact of various greenhouse gases based on their global warming potential (GWP). CO2e approximates the warming effect of a unit mass of a given greenhouse gas relative to that of carbon dioxide (CO2).

CAVITY INSULATION. Insulating material located between framing members.

Combined Energy Efficiency Ratio (CEER). Window or room air conditioner efficiency measurement which combines the efficiency of the unit both in standby mode and in cooling mode.

CHANGE OF OCCUPANCY. A change in the use of a building or a portion of a building that results in any of the following:

1. A *change of occupancy* classification.
2. A change from one group to another group within an occupancy classification.
3. Any change in use within a group for which there is a change in the application of the requirements of this code.

CIRCADIAN RHYTHM SYSTEMS. Lighting systems meant to mimic natural daylight by having different color correlated temperature (CCT) settings at different times of day. This may be accomplished by a single light source that can change CCT electronically or by using multiple light sources, each with a different CCT.

CIRCULATING HOT WATER SYSTEM. A specifically designed water distribution system where one or more pumps are operated in the service hot water piping to circulate heated water from the water-heating equipment to the fixture supply and back to the water-heating equipment.

CLERESTORY. An outside wall of a room or building that rises above an adjoining roof and contains fenestration.

CLIMATE ZONE. A geographical region based on climatic criteria as specified in this code.

CODE OFFICIAL OR AUTHORITY HAVING JURISDICTION. The officer or designated authority charged with the administration and enforcement of this code, or a duly authorized representative. ~~For purposes of this code, the Vermont Public Service Department is not the *code official* and shall not be required to conduct inspections of construction or construction documents.~~ The state of Vermont has not designated an authority. The Division of Fire Safety has authority over all matters regarding commercial building construction, including the incorporation of energy code provisions into new and existing buildings.

COEFFICENT 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) – 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.

COLD-CLIMATE HEAT PUMP. An air source heat pump with an inverter-driven, variable capacity compressor that is designed to provide full heating heat pump capacity and having a minimum COP of 1.75 or greater at maximum operating capacity at an outside air temperature of 5°F (-15°C). The indoor and outdoor units must be part of an AHRI matched system.

COMBUSTION EQUIPMENT. Any *equipment* or *appliance* used for space heating, *service water heating*, cooking, clothes drying and/or lighting that uses *fuel gas* or *fuel oil*.

COMMERCIAL BUILDING. For this code, all buildings that are not included in the definition of “Residential building.”

COMMERCIAL BUILDING ENERGY STANDARDS (CBES). The Vermont nonresidential Energy Code, based on the ~~2018~~2021 *International Energy Conservation Code* (IECC), but modified substantially.

COMMERCIAL COOKING APPLIANCES. Appliances used in a commercial food service establishment for heating or cooking food, and which produce grease vapors, steam, fumes, smoke, or odors that are required to be removed through a local exhaust ventilation system. Such appliances include deep fat fryers, upright broilers, griddles, broilers, steam-jacketed kettles, hot-top ranges, under-fired broilers (charbroilers), ovens, barbecues, rotisseries, and similar appliances. For the purpose of this definition, a food service establishment shall include any building or a portion thereof used for the preparation and serving of food.

COMPUTER ROOM. A room whose primary function is to house equipment for the processing and storage of electronic data ~~and that~~which has a design ~~electronic data~~total information technology equipment (ITE) equipment power density ~~of~~ less than or equal to 20 watts per square foot (20 watts per 0.092 m^2) of conditioned ~~floor~~ area or a ~~connected~~ design ~~electronic data~~total ITE equipment load ~~of~~ less than or equal to 10 kW.

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

CONDITIONED FLOOR AREA. The horizontal projection of the floors associated with the *conditioned space*.

CONDITIONED SPACE. An area, room or space that is enclosed within the building thermal envelope and is directly or indirectly heated by a heating system whose output capacity is greater than 14 Btu/h·ft^2 of floor area or directly or indirectly cooled by a cooling system whose sensible output capacity is greater than or equal to 3.4 Btu/h·ft^2 of floor area. Spaces are indirectly heated or cooled where they communicate through openings with conditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or cooling.

CONTINUOUS INSULATION (ci). Insulating material that is 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.

CRAWL SPACE WALL. The opaque portion of a wall that encloses a crawl space and is partially or totally below grade.

CURTAIN WALL. Fenestration products used to create an external nonload-bearing wall that is designed to separate the exterior and interior environments.

DATA CENTER. A room or series of rooms that share data center systems, whose primary function is to house equipment for the processing and storage of electronic data and that has a design total ITE equipment power density exceeding 20 watts per square foot (20 watts per 0.092 m^2) of conditioned area and a total design ITE equipment load greater than 10 kW.

DATA CENTER SYSTEMS. HVAC systems and equipment, or portions thereof, used to provide cooling or ventilation in a data center.

DAYLIGHT RESPONSIVE CONTROL. A device or system that provides automatic control of electric light levels based on the amount of daylight in a space.

DAYLIGHT ZONE. That portion of a building's interior floor area that is illuminated by natural light.

DC FAST CHARGE. DC Fast Charge uses a 480V, direct-current (DC) plug, sometimes knows as Level 3.

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.

DEMAND RECIRCULATION WATER SYSTEM. A water distribution system ~~having~~ where one or more ~~recirculation pumps that pump water from a heated water supply pipe back to the heated water source through a cold water supply pipe.~~pumps prime the service hot water piping with heated water upon a demand for hot water.

DIRECT DIGITAL CONTROL (DDC). A type of control where controlled and monitored analog or binary data, such as temperature and contact closures, are converted to digital format for manipulation and calculations by a digital computer or microprocessor, then converted back to analog or binary form to control physical devices.

DESIGN PROFESSIONAL/AGENCY. An individual or group of individuals who are registered, licensed or experienced to practice their respective design profession as defined by the laws of the state or jurisdiction in which the project is to be constructed.

DUCT. A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts.

DUCT FURNACE. A furnace normally installed in a distribution duct~~s~~ of an air-conditioning system~~s~~ to supply warm air for heating and which depends on a blower not furnished as part of the duct furnace for air circulation.

DUCT SYSTEM. A continuous passageway for the transmission of air that, in addition to ducts, includes duct fittings, dampers, plenums, fans and accessory air-handling equipment and appliances.

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.

DYNAMIC GLAZING. Any fenestration product that has the fully reversible ability to change its performance properties, including *U*-factor, solar heat gain coefficient (SHGC), or visible transmittance (VT).

ECONOMIZER, AIR. A duct and damper arrangement and automatic control system that allows a cooling system to supply outside air to reduce or eliminate the need for mechanical cooling during mild or cold weather.

ECONOMIZER, WATER. A system where the supply air of a cooling system is cooled indirectly with water that is itself cooled by heat or mass transfer to the environment without the use of mechanical cooling.

ELECTRIC VEHICLE (EV). An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, neighborhood electric vehicles, and electric motorcycles, primarily powered by an electric motor that draws current from a building electrical service, EVSE, a rechargeable storage battery, a fuel cell, a photovoltaic array, or another source of electric current.

ELECTRIC VEHICLE CAPABLE SPACE (EV CAPABLE SPACE). A designated *automobile parking space* that is provided with electrical infrastructure, such as, but not limited to, raceways, cables, electrical capacity, and panelboard or other electrical distribution equipment space, necessary for the future installation of an *EVSE*.

ELECTRIC VEHICLE FAST CHARGER (EV FAST CHARGER). Also referred to as a Level 3 charger. An *EV fast charger* is an *EVSE* equipped with a~~DC fast charging, also referred to as Level 3, electric vehicle charging parking requires one,~~ direct-current (DC) plug for electric vehicle charging ~~through dedicated electric vehicle supply equipment (EVSE)~~ with either a CHAdeMO or SAE combined charging system (CCS) format connector~~, within 5 feet of the centerline for each EV charging parking space~~. Other DC fast charging plug standards may be accepted as they are developed.

ELECTRIC VEHICLE READY SPACE (EV READY SPACE). An *automobile parking space* that is provided with a branch circuit and either an outlet, junction box or receptacle, that will support an installed *EVSE*.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE). Equipment for plug-in power transfer including the ungrounded, grounded and equipment grounding conductors, and the *electric vehicle* connectors, attachment plugs, personal protection system and all other fittings, devices, power outlets or apparatus installed specifically for the purpose of transferring energy between the premises wiring and the *electric vehicle*.

ELECTRIC VEHICLE SUPPLY EQUIPMENT INSTALLED SPACE (EVSE space). An *automobile parking space* that is provided with a dedicated *EVSE* connection.

ENCLOSED SPACE. A volume surrounded by solid surfaces such as walls, floors, roofs, and openable devices such as doors and operable windows.

ENERGY ANALYSIS. A method for estimating the annual energy use of the *proposed design* and *standard reference design* based on estimates of energy use.

ENERGY COST. The total estimated annual cost for purchased energy for the building functions regulated by this code, including applicable demand charges.

ENERGY EFFICIENCY RATIO~~.~~ (EER). Air handling unit measure of efficiency defined as the system output in Btu/h per watt of electrical energy input.

ENERGY RECOVERY VENTILATION SYSTEM. Systems that employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of preheating, precooling, humidifying or dehumidifying outdoor ventilation air prior to supplying the air to a space, either directly or as part of an HVAC system.

ENERGY SIMULATION TOOL. An *approved* software program or calculation-based methodology that projects the annual energy use of a building.

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. A vertical fenestration product used for occupant ingress, egress and access in nonresidential buildings, including, but not limited to, exterior entrances utilizing latching hardware and automatic closers and containing over 50 percent glazing specifically designed to withstand heavy-duty usage.

ENVIRONMENTAL PRODUCT DECLARATION (EPD), TYPE III PRODUCT-SPECIFIC. An EPD is a document that describes the results of a life cycle assessment (LCA) for a material or product. While there are industry-specific EPDs, which average results across multiple product manufacturers, product-specific EPDs are the most thorough type of EPD. Type III, product-specific EPDs cover a single product from a manufacturer and are reviewed by a third-party entity. They conform to ISO 14025 and either EN 15804 or ISO 21930. Like all product specific EPDs, the scope must cover the product's life-cycle from cradle to gate.

EQUIPMENT. Piping, ducts, vents, control devices and other components of systems other than appliances that are permanently installed and integrated to provide control of environmental conditions for buildings. This definition shall also include other systems specifically regulated in this code.

EQUIPMENT ROOM. A space that contains either electrical equipment, mechanical equipment, machinery, water pumps or hydraulic pumps that are a function of the building's services.

EXTERIOR WALL. Walls including both above-grade walls and basement walls.

FAN, EMBEDDED. A fan that is part of a manufactured assembly where the assembly includes functions other than air movement.

FAN ARRAY. Multiple fans in parallel between two plenum sections in an air distribution system.

FAN BRAKE HORSEPOWER (BHP). The horsepower delivered to the fan's shaft. Brake horsepower does not include the mechanical drive losses such as that from belts and gears.

~~**FAN EFFICIENCY GRADE (FEG).** A numerical rating identifying the fan's aerodynamic ability to convert shaft power, or impeller power in the case of a direct-driven fan, to air power.~~

FAN ENERGY INDEX (FEI). The ratio of the electric input power of a reference fan to the electric input power of the actual fan as calculated in accordance with AMCA 208.

FAN NAMEPLATE ELECTRICAL INPUT POWER. The nominal electrical input power rating stamped on a fan assembly nameplate.

FAN SYSTEM 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 fan airflow rate to conditioned spaces served by the system, other than during air economizer operation.

FAN SYSTEM ELECTRICAL INPUT POWER. The sum of the fan electrical power 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/or return it to the source or exhaust it to the outdoors.

FAN SYSTEM MOTOR NAMEPLATE 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.

FAULT DETECTION AND DIAGNOSTICS (FDD) SYSTEM. A software platform that utilizes building analytic algorithms to convert data provided by sensors and devices to automatically identify faults in building systems and provide a prioritized list of actionable resolutions to those faults based on cost or energy avoidance, comfort and maintenance impact.

FENESTRATION. Products classified as either skylights or vertical fenestration.

Skylights. Glass or other transparent or translucent glazing material installed at a slope of less than 60 degrees (1.05 rad) from horizontal, including unit skylights, tubular daylighting devices and glazing materials in solariums, sunrooms, roofs, greenhouses and sloped walls.

Vertical fenestration. Windows that are fixed or operable, opaque doors, glazed doors, glazed block and combination opaque and glazed doors composed of glass or other transparent or translucent glazing materials and installed at a slope of not less than 60 degrees (1.05 rad) from horizontal.

FENESTRATION PRODUCT, FIELD-FABRICATED. A fenestration product whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door. Field fabricated does not include site-built fenestration.

FENESTRATION PRODUCT, SITE-BUILT. A fenestration designed to be made up of field-glazed or field-assembled units using specific factory cut or otherwise factory-formed framing and glazing units. Examples of site-built fenestration include storefront systems, curtain walls, and atrium roof systems.

***F*-FACTOR.** The perimeter heat loss factor for slab-on-grade floors (Btu/h • ft • °F) [W/(m • K)].

FLOOR AREA, NET. The actual occupied area not including unoccupied accessory areas such as corridors, stairways, toilet rooms, mechanical rooms and closets.

FUEL GAS. A natural gas, manufactured gas, liquified petroleum gas or a mixture of these.

FUEL OIL. Kerosene or any hydrocarbon oil having a flash point not less than 100°F (38°C).

FULLY SHIELDED FIXTURE. A fixture constructed and installed in such a manner that all light emitted by it, either directly from the lamp (bulb) or a diffusing element, or indirectly by reflection or refraction from any part of the fixture, is projected below the horizontal.

FURNACE, WARM AIR. A self-contained, indirect-fired or electrically heated furnace that supplies heated air through ducts to spaces that require it.

GARAGE DOOR. A large door that allows a vehicle to access the building or allows a shipping truck to load or unload.

GENERAL LIGHTING. ~~Lighting~~ Interior 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.~~ a space.

GLOBAL WARMING POTENTIAL (GWP). GWP is an index for estimating the relative global warming contribution of atmospheric emissions of 1 kg of a particular greenhouse gas compared to emissions of 1 kg of CO2. The following GWP values are used based on a 100-year time horizon: 1 for CO_2, < 10 for pentane (e.g., C_5H_{12}), and 1430 for R-134a (CH_2FCF_3).

GLOBAL WARMING POTENTIAL (GWP) INTENSITY. For the purposes of this document, GWP intensity refers to the GWP impact from materials (kg CO2e) divided by the project's total conditioned floor area in square feet (ft2).

GREENHOUSE. A structure or a thermally isolated area of a building that maintains a specialized sunlit environment exclusively used for, and essential to, the cultivation, protection or maintenance of plants. *Greenhouses* are those that are erected for a period of 180 days or more.

GROSS AREA OF EXTERIOR WALLS. The normal projection of all exterior walls, including the edge area of above grade floors, the edge area of roof insulation, and the area of all windows and doors installed therein (see "Exterior wall").

GROUP R. Buildings or portions of buildings that contain any of the following occupancies as established in the *International Building Code*:

1. *Group R*-1.
2. *Group R*-2 where located more than three stories in height above grade plane.
3. *Group R*-4 where located more than three stories in height above grade plane.

HEAT TRAP. An arrangement of piping and fittings, such as elbows, or a commercially available heat trap that prevents thermosyphoning of hot water during standby periods.

HEATED SLAB. Slab-on-grade construction in which the heating elements, hydronic tubing, or hot air distribution system is in contact with, or placed within or under, the slab.

HEATING SEASONAL PERFORMANCE FACTOR (HSPF). Heat pump heating efficiency rating measured as the ratio of heat output over the heating season (in Btu) to electricity used (in watt-hours).

HIGH-EFFICACY ~~LAMPS/LIGHTING~~LIGHT SOURCES. ~~Compact fluorescent lamps, light-emitting diode (LED) lamps, T-8 or smaller diameter linear fluorescent lamps, or other lamps~~Non-linear medium screw- and pin-base lamps with an efficacy of not less than 65 lumens per watt; or light fixtures of not less than ~~55~~ 65 lumens per watt. In determining the number or percent of lamps, each replaceable lamp (or light string) connected to a permanently installed lighting fixture shall count as one lamp.

HIGH SPEED DOOR. A door used primarily to facilitate vehicular access or material transportation, with a minimum opening rate of 32 inches (813 mm) per second, a minimum closing rate of 24 inches (610 mm) per second and that includes an automatic-closing device.

HISTORIC BUILDING. Any building or structure that is one or more of the following:

1. Listed, or certified as eligible for listing by the State Historic Preservation Officer or the Keeper of the National Register of Historic Places, in the National Register of Historic Places.

2. Designated as historic under an applicable state or local law.

3. Certified as a contributing resource within a National Register-listed, state-designated or locally designated historic district.

~~**HUMIDISTAT.** A regulatory device, actuated by changes in humidity, used for automatic control of relative humidity.~~

IEC DESIGN H MOTOR. An electric motor that meets all of the following:

1. It is an induction motor designed for use with three-phase power.

2. It contains a cage rotor.

3. It is capable of direct-on-line starting.

4. It has four, six or eight poles.

5. It is rated from 0.4 kW to 1600 kW at a frequency of 60 hertz.

IEC DESIGN N MOTOR. An electric motor that meets all of the following:

1. It is an induction motor designed for use with three-phase power.

2. It contains a cage rotor.

3. It is capable of direct-on-line starting.

4. It has two, four, six or eight poles.

5. It is rated from 0.4 kW to 1600 kW at a frequency of 60 hertz.

INFILTRATION. The uncontrolled inward air leakage into a building caused by the pressure effects of wind or the effect of differences in the indoor and outdoor air density or both.

INFORMATION TECHNOLOGY EQUIPMENT (ITE). Items including computers, data storage devices, servers and network and communication equipment.

INTEGRATED ENERGY EFFICIENCY RATIO (IEER). Integrated efficiency value of a mechanical system operating at 100%, 75%, 50%, and 25% of full load capacity designed to reflect the efficiency at different load levels.

INTEGRATED PART LOAD VALUE (IPLV). A single-number figure of merit based on part-load EER, COP or kW/ton expressing part-load efficiency for air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for equipment.

INTERNAL CURTAIN SYSTEM. A system consisting of movable panels of fabric or plastic film used to cover and uncover the space enclosed in a greenhouse on a daily basis.

ISOLATION DEVICES. Devices that isolate HVAC zones so that they can be operated independently of one another. *Isolation devices* include separate systems, isolation dampers, and controls providing shutoff at terminal boxes.

LABELED. Equipment, materials or products to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, approved agency or other organization concerned with product evaluation that maintains periodic inspection of the production of the labeled items and whose labeling indicates either that the equipment, material or product meets identified standards or has been tested and found suitable for a specified purpose.

LEVEL 1 ELECTRIC VEHICLE CHARGING. Level 1 charging uses a standard alternating current 120V outlet.

LEVEL 2 ELECTRIC VEHICLE CHARGING. Level 2 uses a 240V alternating current outlet.

LEVEL 3 ELECTRIC VEHICLE CHARGING. Level 3 uses a 480V, direct-current (DC) plug, also known as “DC Fast Charge.”

LARGE-DIAMETER CEILING FAN. A ceiling fan that is greater than 7 feet (2134 mm) in diameter. These fans are sometimes referred to as High-Volume, Low-Speed (HVLS) fans.

LINER SYSTEM (Ls). A system that includes the following:

1. A continuous vapor barrier liner membrane that is installed below the purlins and that is uninterrupted by framing members.

2. An uncompressed, unfaced insulation resting on top of the liner membrane and located between the purlins.

For multilayer installations, the last rated R-value of insulation is for unfaced insulation draped over purlins and then compressed when the metal roof panels are attached.

LISTED. Equipment, materials, products or services included in a list published by an organization acceptable to the *code official or authority having jurisdiction* and concerned with evaluation of products or services that maintains periodic inspection of production of *listed* equipment or materials or periodic evaluation of services and whose listing states either that the equipment, material, product or service meets identified standards or has been tested and found suitable for a specified purpose.

LOW-SLOPED ROOF. A roof having a slope less than 2 units vertical in 12 units horizontal.

LOW-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMER. A transformer that is air-cooled, does not use oil as a coolant, has an input voltage less than or equal to 600 volts and is rated for operation at a frequency of 60 hertz.

LUMINAIRE-LEVEL LIGHTING CONTROLS. A lighting system consisting of one or more luminaires with embedded lighting control logic, occupancy and ambient light sensors, wireless networking capabilities and local override switching capability, where required.

MANUAL. Capable of being operated by personal intervention (see "Automatic").

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~~exterior cladding.

METAL BUILDING ROOF. A roof that meets all of the following criteria:

1. Is constructed with a metal, structural, weathering surface.
2. Has no ventilated cavity.
3. Has the insulation entirely below deck (i.e., does not include composite concrete and metal deck construction nor a roof framing system that is separated from the superstructure by a wood substrate) and whose structure consists of one or more of the following configurations.
   - 3.1. Metal roofing in direct contact with the steel framing members.
   - 3.2. Metal roofing separated from the steel framing members by insulation.
   - 3.3. Insulated metal roofing panels installed as described in sub items (a) or (b).

METAL BUILDING WALL. A wall whose structure consists of metal spanning members supported by steel structural members (i.e., does not include spandrel glass or metal panels in curtain wall systems).

MIXED-FUEL BUILDING. A *building* that contains *combustion equipment* or includes piping for such *equipment.*

MULTIFAMILY DWELLING. A building containing three or more dwelling units where the occupants are primarily permanent in nature and which are adjacent vertically or horizontally. If built side-by-side, at least one of the following is true: (1) they do not have a wall that extends from ground to roof, (2) they share a heating system, or (3) they have interstructural public utilities such as water supply/sewage disposal.

NAMEPLATE HORSEPOWER. The nominal motor output power rating stamped on the motor nameplate.

NEMA DESIGN A MOTOR. A squirrel-cage motor that meets all of the following:

1. It is designed to withstand full-voltage starting and develop locked-rotor torque as shown in paragraph 12.38.1 of NEMA MG 1.
2. It has pull-up torque not less than the values shown in paragraph 12.40.1 of NEMA MG 1.
3. It has breakdown torque not less than the values shown in paragraph 12.39.1 of NEMA MG 1.
4. It has a locked-rotor current higher than the values shown in paragraph 12.35.1 of NEMA MG 1 for 60 hertz and paragraph 12.35.2 of NEMA MG 1 for 50 hertz.
5. It has a slip at rated load of less than 5 percent for motors with fewer than 10 poles.

NEMA DESIGN B MOTOR. A squirrel-cage motor that meets all of the following:

1. It is designed to withstand full-voltage starting.
2. It develops locked-rotor, breakdown, and pull-up torques adequate for general application as specified in Sections 12.38, 12.39 and 12.40 of NEMA MG1.
3. It draws locked-rotor current not to exceed the values shown in Section 12.35.1 for 60 hertz and Section 12.35.2 for 50 hertz of NEMA MG1.
4. It has a slip at rated load of less than 5 percent for motors with fewer than 10 poles.

NEMA DESIGN C MOTOR. A squirrel-cage motor that meets all of the following:

1. Designed to withstand full-voltage starting and develop locked-rotor torque for high-torque applications up to the values shown in paragraph 12.38.2 of NEMA MG1 (incorporated by reference, see A§431.15).
2. It has pull-up torque not less than the values shown in paragraph 12.40.2 of NEMA MG1.
3. It has breakdown torque not less than the values shown in paragraph 12.39.2 of NEMA MG1.
4. It has a locked-rotor current not to exceed the values shown in paragraph 12.35.1 of NEMA MG1 for 60 hertz and paragraph 12.35.2 for 50 hertz.
5. It has a slip at rated load of less than 5 percent.

NETWORKED GUESTROOM CONTROL SYSTEM. A control system, with access ~~accessible~~ from the front desk or other central location associated with a *Group R*-1 building, that is capable of identifying the ~~occupancy~~ rented and unrented status of each guestroom according to a timed schedule, and is capable of controlling HVAC in each hotel and motel guestroom separately.

NONSTANDARD PART LOAD VALUE (NPLV). A single-number part-load efficiency figure of merit calculated and referenced to conditions other than IPLV conditions, for units that are not designed to operate at AHRI standard rating conditions.

OCCUPANCY CLASSIFICATIONS. Building occupancies shall be defined by the ~~2018~~2021 *International Building Code*, which is summarized here. Discrepancies in the summary or further clarifications shall defer to the ~~2018~~ *International Building Code*.

Assembly Group A is the occupancy group used for buildings that are for the gathering of persons for purposes such as civic, social or religious functions; recreation, food or drink consumption or awaiting transportation.

The first occupancy group is A-1. The group is for the production and viewing of the performing arts, motion pictures, or television and radio studios admitting an audience.

The next occupancy group is A-2. The group includes assembly uses intended for food and/or drink consumption, such as: banquet halls, casino gambling areas, night-clubs, restaurants, cafeterias, taverns, and bars.

Group A-3 includes assembly uses intended for worship, recreation or amusement and other assembly uses not classified elsewhere in Group A such as: community halls, courtrooms, gymnasiums, and waiting areas in transportation terminals.

Group A-4 includes assembly uses intended for viewing of indoor sporting events and activities with spectator seating.

Group A-5 includes assembly uses intended for participation in or viewing outdoor activities.

Business Group B is the occupancy group used for office, professional or service-type transactions, including storage or records and accounts.

Educational Group E is the occupancy group used by six or more persons at any one time for educational purposes through the 12th grade.

Factory Industrial Group F is the occupancy group used for disassembling, fabricating, finishing, manufacturing, packaging, repair or processing operation that are not classified as Group H or Group S.

High-hazard Group H is the occupancy group used for manufacturing, processing, generation or storage of materials that constitute a physical or health hazard.

Institutional Group I is the occupancy group where care or supervision is provided to persons who need medical care or are incapable of self-preservation without physical assistance or where persons are detained for penal or correctional purposes or in which the liberty of the occupants is restricted. ~~used for more than 16 persons, excluding staff, who reside on a 24-hour basis in a supervised environment and receive custodial care.~~

Mercantile Group M is the occupancy group used for the display and sale of merchandise, and involves stocks of goods, wares or merchandise.

Residential Group R is the occupancy group used for buildings that include sleeping rooms and are not institutional. There are four different occupancy groups within R.

The first occupancy group is R-1. This group is for transient uses like hotels, motels and boarding houses.

Group R-2 is occupancies containing sleeping units or more than two dwelling units where the occupants are primarily permanent. This includes apartments, dormitories, fraternities and sororities. It also includes vacation timeshares (with more than two units) and convents and monasteries. Boarding houses or congregate living facilities with 16 or fewer occupants go into Group R-3.

Group R-3 is for permanent occupancies that are not R-1, R-2, or R-4.

Group R-4 is for occupancies for more than five but not more than 16 persons, excluding staff, who reside on a 24-hour basis in a supervised residential environment and receive custodial care.

Storage Group S is the occupancy group used for storage that is not classified as a hazardous occupancy.

OCCUPANT SENSOR CONTROL. An automatic control device or system that detects the presence or absence of people within an area and causes lighting, equipment or appliances to be regulated accordingly.

ON-SITE RENEWABLE ENERGY. Energy from renewable energy resources harvested at the building project site. ~~Energy derived from solar radiation, wind, waves, tides, landfill gas, biogas, biomass or the internal heat of the earth. The energy system providing on-site renewable energy shall be located on the project site (see "Renewable energy").~~

OPAQUE DOOR. A door that is not less than 50-percent opaque in surface area.

POWERED ROOF/WALL VENTILATORS. A fan consisting of a centrifugal or axial impeller with an integral driver in a weather-resistant housing and with a base designed to fit, usually by means of a curb, over a wall or roof opening.

PROPOSED DESIGN. A description of the proposed building used to estimate annual energy use for determining compliance based on total building performance.

RADIANT HEATING SYSTEM. A heating system that transfers heat to objects and surfaces within a conditioned space, primarily by infrared radiation.

READY ACCESS (TO). That which enables a device, appliance or equipment to be directly reached, without requiring the removal or movement of any panel or similar obstruction.

REFRIGERANT DEW POINT. The refrigerant vapor saturation temperature at a specified pressure.

REFRIGERATED WAREHOUSE COOLER. An enclosed storage space capable of being refrigerated to temperatures above 32°F (0°C), that can be walked into and has a total chilled storage area of not less than 3,000 square feet (279 m^2).

REFRIGERATED WAREHOUSE FREEZER. An enclosed storage space capable of being refrigerated to temperatures at or below 32°F (0°C), that can be walked into and has a total chilled storage area of not less than 3,000 square feet (279 m^2).

REFRIGERATION SYSTEM, LOW TEMPERATURE. Systems for maintaining food product in a frozen state in refrigeration applications.

REFRIGERATION SYSTEM, MEDIUM TEMPERATURE. Systems for maintaining food product above freezing in refrigeration applications.

REGISTERED DESIGN PROFESSIONAL. An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

RENEWABLE ENERGY RESOURCES. Energy produced using a technology that relies on a resource that is being consumed at a harvest rate at or below its natural regeneration rate including, but not limited to, solar hot water, solar hot air, solar photovoltaics, wind, and hydro.

1. Methane gas and other flammable gases produced by the decay of sewage treatment plant wastes or landfill wastes and anaerobic digestion of agricultural products, byproducts, or wastes shall be considered renewable energy resources, but no form of solid waste, other than agricultural or silvicultural waste, shall be considered renewable.

2. The only portion of electricity produced by a system of generating resources that shall be considered renewable is that portion generated by a technology that qualifies as renewable.

3. The following fuels shall not be considered renewable energy supplies: coal, oil, propane, and natural gas.

4. Biomass is considered renewable.

REPAIR. The reconstruction or renewal of any part of an existing building for the purpose of its maintenance or to correct damage.

REROOFING. The process of recovering or replacing an existing roof covering. See “Roof recover” and “Roof replacement.”

RESIDENTIAL BUILDING. For this code, includes detached one- and two-family dwellings and multiple single-family dwellings (townhouses) and *Group R*-2, R-3 and R-4 (see “Occupancy classifications”) buildings three stories or less in height above grade plane.

RESIDENTIAL BUILDING ENERGY STANDARDS (RBES). The *Vermont Residential Energy Code* based on the 2015 *International Energy Conservation Code with 2018, 2020, and 2023 additions*.

ROOF ASSEMBLY. A system designed to provide weather protection and resistance to design loads. The system consists of a roof covering and roof deck or a single component serving as both the roof covering and the roof deck. A roof assembly includes the roof covering, underlayment, roof deck, insulation, vapor retarder and interior finish.

ROOF RECOVER. The process of installing an additional roof covering over an existing roof covering without removing the existing roof covering.

ROOF REPAIR. Reconstruction or renewal of any part of an existing roof for the purpose of its maintenance.

ROOF REPLACMENT. The process of removing the existing roof covering, repairing any damaged substrate and installing a new roof covering.

ROOFTOP MONITOR. A raised section of a roof containing vertical fenestration along one or more sides.

***R*-VALUE (THERMAL RESISTANCE).** The inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady state conditions, per unit area ($h \cdot ft^2 \cdot °F/Btu$) [($m^2 \cdot K)/W$].

SATURATED CONDENSING TEMPERATURE. The saturation temperature corresponding to the measured refrigerant pressure at the condenser inlet for single component and azeotropic refrigerants, and the arithmetic average of the dew point and *bubble point* temperatures corresponding to the refrigerant pressure at the condenser entrance for zeotropic refrigerants.

SEASONAL ENERGY EFFICIENCY RATIO (SEER). Air conditioner efficiency rating, measured as the ratio of cooling output over a typical cooling season (in Btuh), divided by the provided electrical energy (in watt-hours).

SEMI-CONDITIONED SPACE. An enclosed space within a building that is not a conditioned space, but is directly or indirectly mechanically heated ~~by a heating system whose output capacity is less than or equal to 14 Btu/h·ft^2 of floor area;~~ or ~~if the space is directly or indirectly~~ cooled ~~and the cooling system's sensible output capacity is less than 3.4 Btu/h·ft^2 of floor area~~.

SERVICE WATER HEATING. Supply of hot water for purposes other than comfort heating.

SLEEPING UNIT. A room or space in which people sleep, that can include permanent provisions for living, eating, and either sanitation or kitchen facilities but not both. Such rooms and spaces that are part of a dwelling unit are not *sleeping units*.

SMALL ELECTRIC MOTOR. A general purpose, alternating current, single speed induction motor.

SOLAR HEAT GAIN COEFFICIENT (SHGC). The ratio of the solar heat gain entering the space through the fenestration assembly to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, that is then reradiated, conducted or convected into the space.

SOLAR-READY ZONE. A section of sections of the roof or building overhang designated and reserved for the future installation of a solar photovoltaic or solar thermal system.

STANDARD REFERENCE DESIGN. A version of the *proposed design* that meets the minimum requirements of this code and is used to determine the maximum annual energy use requirement for compliance based on total building performance.

STOREFRONT. A system of doors and windows mulled as a composite fenestration structure that has been designed to resist heavy use. *Storefront* systems include, but are not limited to, exterior fenestration systems that span from the floor level or above to the ceiling of the same story on commercial buildings, with or without mulled windows and doors.

TESTING UNIT ENCLOSURE AREA. The area sum of all the boundary surfaces that define the dwelling unit, sleeping unit or occupiable conditioned space including top/ceiling, bottom/floor and all side walls. This does not include interior partition walls within the dwelling unit, sleeping unit, or occupiable conditioned space. Wall height shall be measured from the finished floor of the conditioned space to the finished floor or roof/ceiling air barrier above.

THERMAL DISTRIBUTION EFFICIENCY (TDE). The resistance to changes in air heat as air is conveyed through a distance of air duct. TDE is a heat loss calculation evaluating the difference in the heat of the air between the air duct inlet and outlet caused by differences in temperatures between the air in the duct and the duct material. TDE is expressed as a percent difference between the inlet and outlet heat in the duct.

THERMOSTAT. An automatic control device used to maintain temperature at a fixed or adjustable setpoint.

TIME SWITCH CONTROL. An automatic control device or system that controls lighting or other loads, including switching off, based on time schedules.

TYPE III PRODUCT-SPECIFIC ENVIRONMENTAL PRODUCT DECLARATION (EPD). See ENVIRONMENTAL PRODUCT DECLARATION, TYPE III PRODUCT-SPECIFIC.

***U*-FACTOR (THERMAL TRANSMITTANCE).** The coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (Btu/h • ft^2 • °F) [W/(m^2 • K)].

VARIABLE REFRIGERANT FLOW SYSTEM. An engineered direct-expansion (DX) refrigerant system that incorporates a common condensing unit, at least one variable-capacity compressor, a distributed refrigerant piping network to multiple indoor fan heating and cooling units each capable of individual zone temperature control, through integral zone temperature control devices and a common communications network. Variable refrigerant flow utilizes three or more steps of control on common interconnecting piping.

VEGETATIVE ROOF. An assembly of interacting components designed to waterproof a building's top surface that includes, by design, vegetation and related landscape elements.

VENTILATION. The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, any space.

VENTILATION AIR. That portion of supply air that comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

VISIBLE TRANSMITTANCE [VT]. The ratio of visible light entering the space through the fenestration product assembly to the incident visible light. Visible transmittance includes the effects of glazing material and frame and is expressed as a number between 0 and 1.

VISIBLE TRANSMITTANCE, ANNUAL [VT_{annual}]. The ratio of visible light entering the space through the fenestration product assembly to the incident visible light during the course of a year, which includes the effects of glazing material, frame, and light well or tubular conduit, and is expressed as a number between 0 and 1.

VOLTAGE DROP. A decrease in voltage caused by losses in the wiring systems that connect the power source to the load.

WALK-IN COOLER. An enclosed storage space capable of being refrigerated to temperatures above 32°F (0°C) and less than 55°F (12.8°C) that can be walked into, has a ceiling height of not less than 7 feet (2134 mm) and has a total chilled storage area of less than 3,000 square feet (279 m^2).

WALK-IN FREEZER. An enclosed storage space capable of being refrigerated to temperatures at or below 32°F (0°C) that can be walked into, has a ceiling height of not less than 7 feet (2134 mm) and has a total chilled storage area of less than 3,000 square feet (279 m^2).

WALL, ABOVE-GRADE. A wall associated with the *building thermal envelope* that is more than 15 percent above grade and is on the exterior of the building or any wall that is associated with the *building thermal envelope* that is not on the exterior of the building. This includes, but is not limited to, between-floor spandrels, peripheral edges of floors, roof knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and skylight shafts.

WALL, BELOW-GRADE. A wall associated with the basement or first story of the building that is part of the *building thermal envelope*, is not less than 85 percent below grade and is on the exterior of the building.

WATER HEATER. Any heating appliance or equipment that heats potable water and supplies such water to the potable hot water distribution system.

ZONE. A space or group of spaces within a building with heating or cooling requirements that are sufficiently similar so that desired conditions can be maintained throughout using a single controlling device.

CHAPTER 3 [CE]
GENERAL REQUIREMENTS

SECTION C301
CLIMATE ZONES

C301.1 General.
The State of Vermont, in its entirety, is classified as *Climate Zone* 6A.

SECTION C302
DESIGN CONDITIONS

C302.1 Interior design conditions.
The interior design temperatures used for heating and cooling load calculations shall be a maximum of 72°F (22°C) for heating and minimum of 75°F (24°C) for cooling.

C302.2 Climatic data.

- Heating Design Temperature, 99.6%: -9°F (ASHRAE Standard 169)
- Cooling Design Temperature Dry-Bulb, 1.0%: 84°F (ASHRAE Standard 169)
- Cooling Design Temperature Wet-Bulb, 1.0%: 69°F (ASHRAE Standard 169)
- Heating Degree Days, 65° Base: 7,626 (ASHRAE Standard 169)
- Cooling Degree Days, 50° Base: 2,183 (ASHRAE Standard 169)

Adjustments may be made only in the following cases:

1. Winter heating design temperatures for projects either:
   - 1.1 Located at an elevation of 1,500 feet or higher, or
   - 1.2. Located in Caledonia, Essex or Orleans counties.
   - 1.3. Adjustments shall be made as listed in the National Climate Data Center for the specific weather station: http://www.ncdc.noaa.gov/cdoweb/.
2. As approved by the *code official or authority having jurisdiction*.

SECTION C303
MATERIALS, SYSTEMS AND EQUIPMENT

C303.1 Identification.

Materials, systems and equipment shall be identified in a manner that will allow a determination of compliance with the applicable provisions of this code.

C303.1.1 Building thermal envelope insulation.
An R-value identification mark shall be applied by the manufacturer to each piece of *building thermal envelope* insulation 12 inches (305 mm) or greater in width. Alternatively, the insulation installers shall provide a certification listing the type, manufacturer and *R*-value of insulation installed in each element of the *building thermal envelope*. For blown-in or sprayed fiberglass and cellulose insulation, the initial installed thickness, settled thickness, settled *R*-value, installed density, coverage area and number of bags installed shall be *listed* on the certification. For sprayed polyurethane foam (SPF) insulation, the installed thickness of the areas covered and *R*-value of installed thickness shall be *listed* on the certification. For insulated siding, the *R*-value shall be labeled on the product's package and shall be *listed* on the certification. The insulation installer shall sign, date and post the certification in a conspicuous location on the job site.

Exception: For roof insulation installed above the deck, the *R*-value shall be labeled as required by the material standards specified in Table 1508.2 of the *International Building Code*.

C303.1.1.1 Blown-in or sprayed roof/ceiling insulation.
The thickness of blown-in or sprayed fiberglass and cellulose roof/ceiling insulation shall be written in inches (mm) on markers and one or more of such markers shall be installed for every 300 square feet (28 m^2) of attic area throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers not less than 1 inch (25 mm) in height. Each marker shall face the attic *access* opening. Spray polyurethane foam thickness and installed *R*-value shall be *listed* on certification provided by the insulation installer.

C303.1.2 Insulation mark installation.
Insulating materials shall be installed such that the manufacturer's *R*-value mark is readily observable upon inspection. For insulation materials that are installed without an observable manufacturer's R-value mark, such as blown or draped products, an insulation certificate complying with Section C303.1.1 shall be left immediately after installation by the installer, in a conspicuous location within the building, to certify the installed R-value of the insulation material.

C303.1.3 Fenestration product rating.
U-factors of fenestration products shall be determined as follows:

1. For windows, doors and skylights, *U*-factor ratings shall be determined in accordance with NFRC 100.

2. Where required for garage doors and rolling doors, *U*-factor ratings shall be determined in accordance with either NFRC 100 or ANSI/DASMA 105.

U-factors shall be determined by an accredited, independent laboratory, and *labeled* and certified by the manufacturer.

Products lacking such a *labeled U*-factor shall be assigned a default *U*-factor from Table C303.1.3(1) or C303.1.3(2). The solar heat gain coefficient (SHGC) and *visible transmittance* (VT) of glazed fenestration products (windows, glazed doors and skylights) shall be determined in accordance with NFRC 200 by an accredited, independent laboratory, and *labeled* and certified by the manufacturer. Products lacking such a *labeled* SHGC or VT shall be assigned a default SHGC or VT from Table C303.1.3(3).

TABLE C303.1.3(1)
DEFAULT GLAZED WINDOW,
GLASS DOOR AND SKYLIGHT *U*-FACTORS

FRAME TYPE	WINDOW AND GLASS DOOR		SKYLIGHT	
	Single	Double	Single	Double
Metal	1.20	0.80	2.00	1.30
Metal with Thermal Break	1.10	0.65	1.90	1.10
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05
Glazed Block	0.60			

Metal Thermal Break = A metal thermal break framed window shall incorporate the following minimum design characteristics:

1. The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/h/ft^2/°F.
2. The thermal break material must produce a gap in the frame material of not less than 0.210 inches.
3. All metal framing members of the products exposed to interior and exterior air shall incorporate a thermal break meeting the criteria in Items 1 and 2, above.

TABLE C303.1.3(2)
DEFAULT OPAQUE DOOR *U*-FACTORS

DOOR TYPE	OPAQUE *U*-FACTOR
Uninsulated Metal[1]	1.20
Insulated Metal (Rolling)	0.90
Insulated Metal (Other)	0.60
Wood	0.50
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	0.35

1. Uninsulated opaque doors are prohibited when part of the thermal envelope.

TABLE C303.1.3(3)
DEFAULT GLAZED FENESTRATION SHGC AND VT

	SINGLE GLAZED		DOUBLE GLAZED		GLAZED BLOCK
	Clear	Tinted	Clear	Tinted	
SHGC	0.8	0.7	0.7	0.6	0.6
VT	0.6	0.3	0.6	0.3	0.6

C303.1.4 Insulation product rating.

The thermal resistance (*R*-value) of insulation shall be determined in accordance with the U.S. Federal Trade Commission *R*-value rule (CFR Title 16, Part 460) in units of $h \cdot ft^2 \cdot °F/Btu$ at a mean temperature of 75°F (24°C).

C303.1.4.1 Insulated siding.

The thermal resistance (*R*-value) of insulated siding shall be determined in accordance with ASTM C1363. Installation for testing shall be in accordance with the manufacturer's instructions.

C303.2 Installation.

Materials, systems and equipment shall be installed in accordance with the manufacturer's instructions and the *International Building Code*.

C303.2.1 Protection of exposed foundation insulation.

Insulation applied to the exterior of basement walls, crawl space walls and the perimeter of slab-on-grade floors shall have a rigid, opaque and weather-resistant protective covering to prevent the degradation of the insulation's thermal performance. The protective covering shall cover the exposed exterior insulation and extend not less than 6 inches (153 mm) below grade.

C303.2.2 Multiple layers of continuous insulation board.

Where two or more layers of continuous insulation board are used in a construction assembly, the continuous insulation boards shall be installed in accordance with Section C303.2. Where the continuous insulation board manufacturer's instructions do not address installation of two or more layers, the edge joints between each layer of continuous insulation boards shall be staggered.

CHAPTER 4 [CE]
COMMERCIAL ENERGY EFFICIENCY

SECTION C401
GENERAL

C401.1 Scope.
The provisions in this chapter are applicable to commercial *buildings* and their *building sites*.

C401.2 Application.
Commercial buildings shall comply with ~~one of the following:~~Section C401.2.1 or C401.2.2.

~~The requirements of Sections C402 through C405 and C407. In addition, commercial buildings shall comply with Section C406 and tenant spaces shall comply with Section C406.1.1.~~

1. ~~The requirements of ANSI/ASHRAE/IESNA 90.1-2016. New buildings using ANSI/ASHRAE/IESNA 90.1-2016 compliance paths (a) or (b) (see ANSI/ASHRAE/IESNA 90.1-2016 section 4.2.1.1 *New Buildings*) shall comply with Section C406 in the 2020 CBES and tenant spaces shall comply with Section C406.1.1 in the 2020 CBES. Commercial building projects utilizing the alternative compliance path of ANSI/ASHRAE/IESNA 90.1-2016 must follow all applicable provisions listed in Section 401.2.1.~~

C401.2.1 CBES Prescriptive Compliance. The Prescriptive Compliance option requires compliance with Sections C402 through C407. Dwelling units and sleeping units in Group R-2 buildings without systems serving multiple units shall be deemed to be in compliance ~~with this chapter~~, provided that they comply with Section R406 of *RBES*.

C401.2.2 ASHRAE 90.1. Commercial buildings shall comply with the requirements of ANSI/ASHRAE/IESNA 90.1-2019. New buildings using ANSI/ASHRAE/IESNA 90.1-2019 compliance paths (a) or (b) (see ANSI/ASHRAE/IESNA 90.1-2019 section 4.2.1.1 *New Buildings*) shall comply with Section C406 in the 2023 CBES. Commercial building projects utilizing the alternative compliance path of ANSI/ASHRAE/IESNA 90.1-2019 must follow all applicable provisions listed in Section C401.2.2.1.

C401.2.2.1 Applicable provisions to Standard 90.1-~~2016~~2019.

1. All instances of the term building official in ASHRAE/IESNA 90.1-~~2016~~2019 shall be replaced with the terms *code official or authority having jurisdiction*.

2. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 4.2.1.1 New Buildings*. Delete the equation for Performance Cost Index Target (PCI_t) and replace with:

   PCI_t = [BPF × (BBUEC + BBREC)]/BBP.

   Delete Table 4.2.1.1 *Building* Performance Factor (BPF) and replace with:

TABLE 4.2.1~~.1~~
BUILDING PERFORMANCE FACTOR (BPF)

BUILDING AREA TYPE[a]	VERMONT BPF
Multifamily	0.~~62~~60
Healthcare/hospital	0.~~46~~52
Hotel/motel	0.~~48~~44
Office	0.~~43~~48
Restaurant	0.~~50~~57
Retail	0.~~44~~42
School	0.~~39~~33
Warehouse	0.~~53~~50
All Others	0.~~45~~46

a. In cases where both a general *building* area type and a specific *building* area type are listed, the specific *building* area type shall apply.

3. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 5.1.4.1 United States Locations*. Delete the exception clause and replace with the following:

   a. Adjustments may be made only in the following cases:

      a. Winter heating design temperatures for projects either:

         i. Located at an elevation of 1,500 feet or higher.

         ii. Located in Caledonia, Essex or Orleans counties.

         iii. Adjustments shall be made as listed in the National Climate Data Center for the specific weather station: http://www.ncdc.noaa.gov/cdo-web/.

      b. As approved by the *code official or authority having jurisdiction*.

4. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 5 Building Envelope*. All envelope requirements shall comply with the following tables in the ~~2020~~2023 *Vermont Commercial Building Energy Standards*(CBES):

   i. *Table C~~402.1(1)~~402.1(2), Conditioned Space Building Envelope Requirements—Opaque Assemblies and Elements*. ~~Any spaces that qualify as Semiheated in ASHRAE/IESNA 90.1-2016 need only comply with the *Semiconditioned* requirement in Table C402.1(1).~~

   ii. *Table C402.1(3), Semi-conditioned Building Envelope Requirements—Opaque Assemblies and Elements.*

iii. *Table C~~402.1(2)~~402.1(4), Building Envelope Requirements—Metal Building Assembly Descriptions*.

iv~~ii~~. *Table C402.3, Building Envelope Fenestration Maximum U-Factor and SHGC Requirements*.

5. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 5.4.3 Air Leakage*. Delete section in its entirety and replace *with Section C402.4 Air leakage—thermal envelope* of the *~~2020~~2023 Vermont CBES*.

6. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 5.5.3.1 Roof Insulation*. Delete section in its entirety and replace with *Section C402.2.1 Roof assembly* of the *~~2020~~2023 Vermont CBES*.

7. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 5.5.3.3 Below-Grade Wall Insulation*. Delete section in its entirety and replace with *Section C402.2.~~3~~ 5 Below-grade walls* of the *~~2020~~2023 Vermont CBES*.

8. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 5.5.3.5 Slab-on-Grade Floor Insulation*. Add to the end of this section the requirements of section *C402.2.~~6~~ 4 Slabs-on-grade ~~perimeter insulation~~* of the *~~2020~~2023 Vermont CBES*.

9. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 6.2 Compliance Path(s)*. Add new section as follows:

   a. *Section 6.2.3 Electric Resistance Space Heating*. Building heating with electrical resistance units, including baseboard radiation, heat pump reheat coils, duct coils, boilers, domestic hot water heaters, and coils in terminal units and air systems is prohibited.

      Exceptions to 6.2.3:

      a. Areas, such as stairways, that are not permitted to be penetrated with piping or duct and no other method of heating is possible.

      b. ~~Replacement of existing electrical resistance unit.~~

      c. Special conditions of occupancy or use that require electrical resistance heat to maintain health, safety or environmental conditions.

      d. Limited areas where a practical application of resistance electrical heat is demonstrated (e.g., small interior space, such as a rest room, which is distant from the distribution system, hazardous material storerooms, stairwell or other means of emergency egress).

      e. ~~Domestic hot water heaters less than or equal to 7.5 kW in total unit input capacity.~~

      f. Multifamily buildings with heating loads less than or equal to 6.0 Btu/hour/square foot at design temperature.*

g. *Cold-Climate Heat Pump* where:∗

a. the full heating demand can be met with the heat pump at an outside air temperature of 5°F (-15°C).

b. the building *thermal envelope* shall be tested in accordance with ASTM E779 at a pressure differential of 0.3 inch water gauge (75 Pa) and deemed to comply with the provisions of Section C402.4.1 when the tested air leakage rate of the building thermal envelope is not greater than 0.~~20~~15 cfm/ft^2 (including the areas of the slab and below grade walls).

∗Buildings served by the City of Burlington Electric (BED) must also receive approval from BED before installing electric resistance heating equipment.

10. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 6.3.2(e) Criteria*. Delete "an electric resistance heater."

11. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 6.4.3.5 Heat Pump Auxiliary Heat Control*. Delete section in its entirety and replace with *Section C403.4.1.1 Heat pump supplementary heat of the ~~2020~~2023 Vermont CBES*.

12. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 6.4.3.8 Ventilation Controls for High-Occupancy Areas*. Add *exception (6)*: Ventilation needs for process loads.

13. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 6.4.3.9 Heated or Cooled Vestibules*. Delete section in its entirety and replace with *Section C403.4.5 Vestibules ~~1.4 Duct and plenum insulation and sealing~~ of the ~~2020~~2023 Vermont CBES*.

14. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 6.4.4.1.2 Duct and Plenum Insulation*. Delete section in its entirety and replace with *Section C403.12~~1~~.1 Duct and plenum insulation and sealing of the ~~2020~~2023 Vermont* CBES.

15. ~~Add new Section 6.4.7 to~~ ASHRAE/IESNA 90.1-~~2016~~2019 Section 6.4.3.12~~, titled~~ *Economizer Fault Detection and Diagnostics (FDD)*. Delete section in its entirety and replace with ~~Insert~~ *Section C403.5.5 Economizer fault detection and diagnostics (FDD) of the ~~2020~~2023 Vermont CBES*.

16. ASHRAE/IESNA 90.1-~~2016~~2019 Section 6.5.1 *Economizers*. Delete section in its entirety and replace with *Section C403.5 Economizers of the ~~2020~~2023 Vermont CBES*.

17. ASHRAE/IESNA 90.1-~~2016~~2019 Tables 6.5.6.1.2-1 and 6.5.6.1.2-2 *Exhaust Air Energy Recovery Requirements for Ventilation Systems*. Delete both tables and replace them with Table C403.7.4 of the 2023 Vermont CBES.~~Both tables shall be greater than or equal to 3,000 hours per year rather than 8,000 hours.~~

~~18. ASHRAE/IESNA 90.1-2016~~2019 ~~Tables 6.5.6.1-1 and Table 6.5.6.1-2 *Exhaust Air Energy Recovery Requirements*, delete requirement for systems with ≥ 10% and < 20% outdoor air (second column of tables).~~

1~~9~~8. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 6.5.6.2 Heat Recovery for Service Water Heating*. Add exception (3): If compliance with Section 6.5.6.2 will be detrimental to chiller operating efficiency due to conflicts with optimized chiller head pressure control.

~~20~~19. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 6.7.2.4 System Commissioning*. Delete section in its entirety and replace with *Section C407 System Commissioning of the ~~2020~~2023 Vermont CBES*.

2~~1~~0. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 7.1 General*. Add new section as follows:

a. *Section 7.1.1.4 Electrical Water Heating Limitation*. Individual electric service water heating units shall be limited to a maximum of 7.5 kW total power input.

Exception: Instantaneous electric water heaters used to serve emergency showers and emergency eye wash stations.

21. ASHRAE/IESNA 90.1-2019 *Table 6.8.1-2 Electrically Operated Air-Cooled Unitary Heat Pumps*. Delete Electric Resistance heating section type equipment.

22. ASHRAE/IESNA 90-1 2019 *Table 6.8.1-8 and 6.8.1-9 Electrically Operated Variable-Refrigerant-Flow Air Conditioners and Applied Heat Pumps*. Delete electric resistance heating type equipment.

22. ASHRAE/IESNA 90.1-~~2016~~2019 *Table 7.8 Performance Requirements for Water Heating Equipment*.

a. Change first row (Electric tabletop water heaters) size category to < 7.5 kW.

b. Change second row (Electric water heaters) size category to < 7.5 kW.

c. Delete entire third row for electric water heaters > 12 kW.

23. In addition to the lighting requirements of ASHRAE/IESNA 90.1-2019 *Section 9 Lighting*, not less than 95 percent of the permanently installed luminaires used for plant growth and maintenance shall have a photon efficiency of not less than 1.7 μmol/J for greenhouses or 1.9 μmol/J for indoor facilities as defined in accordance with ANSI/ASABE S640.

24. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 9 Lighting*. All lighting power density (LPD) requirements shall comply with the following tables in the ~~2020~~2023 *Vermont Commercial Building Energy Standards* (CBES):

i. *Table C405.3.2(1), Interior Lighting Power Allowances: Building Area Method*.

ii. *Table C405.3.2(2), Interior Lighting Power Allowances: Space-by-Space Method*.

iii. *Tables C405.~~4~~5.2(2), ~~Individual~~ Lighting Power Allowances for Building Exteriors and Table C405.5.2(3), Individual Lighting Power Allowances for*

Building Exteriors. Note that Vermont does not have any exterior lighting zone 4 areas.

Exception: *Exterior lighting zone 0 shall follow LPD requirements given by* ASHRAE/IESNA 90.1-~~2016~~2019 Table 9.4.4-2.

~~24~~25.ASHRAE/IESNA 90.1-~~2016~~2019 *Section 9.4.1.3 Special Applications*. At the end of the section add the following wording:

d. Luminaires providing means of egress illumination where the means of egress shall be illuminated at all times the room or space is occupied shall be controlled by occupancy sensors, or a signal from another building control system, that automatically reduces the lighting power by at least 50% when unoccupied for a period longer than 15 minutes.

Exceptions:

1. Means of egress illumination that does not exceed 0.02 watts per square foot of building area is exempt from this requirement.

2. Emergency lighting designated to meet Section 1008.3 of the *International Building Code*.

~~25~~26.ASHRAE/IESNA 90.1-~~2016~~2019 *Section 9.4.1.4 Exterior Lighting Control*. Add the following requirement:

e. Exterior lighting shall be *full cut off* fixtures, limiting the light output to less than 10% at and below 10 degrees below the horizontal. Fixtures shall be independently certified by manufacturer as full cut off or meet the definition of a *fully shielded* light fixture.

~~26~~27.ASHRAE/IESNA 90.1-~~2016~~2019 *Section 9.4.4 Dwelling Units*. Delete section in its entirety and replace with *Section C405.1.1 Lighting for dwelling and sleeping units*~~: Not less than 90% of the *permanently installed* lighting fixtures shall use lamps with an *efficacy* of at least 65 lm/W or have a total *luminaire efficacy* of at least 55 lm/W~~.

~~27~~28. ASHRAE/IESNA 90.1-~~2016~~2019 *Section 9.6.2 Additional Interior Lighting Power.* Delete section in its entirety and replace with *Section C405.3.2.2.1 Additional Interior Lighting Power.*~~Amend the exception in part (a) to read that the power shall not exceed 0.6 W/ft^2 of such *spaces* instead of 0.75 W/ft^2. In part (b), delete the equation for Additional Interior Lighting Power Allowance and replace with:~~

~~Additional interior lighting power allowance = 250 W + (Retail Area 1 × 0.20 W/ft^2) + (Retail Area 2 × 0.20 W/ft^2) + (Retail Area 3 × 0.50 W/ft^2) + (Retail Area 4 × 0.90 W/ft^2)~~

~~28~~29.ASHRAE/IESNA 90.1-~~2016~~2019 *Section 10.4 Mandatory Provisions*. Add the following sections:

i. *10.4.8, Solar-Ready Zone*, which will meet the requirements of *Section C402.5, Solar-ready zone* in the 2023 Vermont CBES.

ii. *10.4.~~6~~9, ~~Renewable energy systems~~Automatic Receptacle Control*, which will meet the requirements of *Section C405.~~10~~ 11 ~~Renewable energy systems~~Automatic receptacle control* in the ~~2020~~2023 Vermont CBES.

iii. *10.4.~~7~~ 10, Electric Vehicle Charging Stations*, which will meet the requirements of *Section C405.~~11~~ 13 Electric Vehicle ~~Charging Stations~~power transfer infrastructure* in the ~~2020~~2023 Vermont CBES.

iv. *10.4.11, Additional Electric Infrastructure*, which will meet the requirements of *Section C405.14 Additional electric infrastructure* in the 2023 CBES.

~~**C401.2.2 Application to replacement fenestration products.**~~
~~Where some or all of an existing *fenestration* unit is replaced with a new *fenestration* product, including sash and glazing, the replacement *fenestration* unit shall meet the applicable requirements for *U*-factor and *SHGC* in Table C402.3.~~

~~**Exception:** An area-weighted average of the *U*-factor of replacement fenestration products being installed in the building for each fenestration product category listed in Table C402.3 shall be permitted to satisfy the *U*-factor requirements for each fenestration product category listed in Table C402.3. Individual fenestration products from different product categories listed in Table C402.3 shall not be combined in calculating the area-weighted average *U*-factor.~~

C401.3 CBES Certificate and Affidavits~~of compliance~~.
30 V.S.A. §53 requires certification that both the design and the construction of a commercial building is in compliance with the CBES. Copies of the CBES Certificate and Affidavits are available on the Department of Public Service website at https://publicservice.vermont.gov/energy_efficiency/cbes.

Certification shall be issued by an approved party completing and signing a certificate ~~permanently~~ and affixing it permanently on a wall in the space where the space conditioning equipment is located, ~~to the outside of the heating or cooling equipment, to~~in the interior space where the electrical service panel is located~~and located inside the building~~, or in a visible location in the immediate vicinity of one of these ~~three~~ areas. If located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. Copies of the signed certification documents shall be included in the construction files for the project, shall be sent to the local town clerk for recording in the land records, and shall be sent to the Vermont Public Service Department. The certificate shall include the following:

1. Compliance method
2. Thermal envelope details including:
   a. R-values of insulation installed in or on ceilings, roofs, walls, foundations and slabs, 101229848 basement walls, crawl space walls and floors and ducts outside conditioned spaces.
   b. U-factors and solar heat gain coefficients (SHGC) of fenestrations.
3. Results from any building envelope air leakage testing performed on the building.
4. An indication of the solar-ready zone and other requirements of Section C402.5.

Where there is more than one value for any component of the building envelope, the certificate shall indicate the area-weighted average value where available. If the area-weighted average is not available, the certificate shall list each value that applies to 10 percent or more of the total component area.

SECTION C402
BUILDING ENVELOPE REQUIREMENTS

C402.1 General ~~(Prescriptive)~~.
In addition to the envelope requirements of Section C402, projects must achieve the required number of credits based on building occupancy group as outlined in Table C406.1.1 and Table C406.1.2. To achieve the required credits, envelope enhancements may be needed. ~~to meet the requirements of Section C406, Additional Efficiency Package Options~~. ~~See Section C406~~

The requirements of C402 that may be affected and the corresponding C406 references are summarized in Table C402.1(1). For a full list of potential measures See Table C406.2.1 and Table C406.3.1.

Table C402.1(1): C406 MEASURES AFFECTING BUILDING ENVELOPE

ID	C406 Energy Credit Title	C402 Reference	C406 Section
E01	Envelope Performance	n/a	C406.2.1.1

E02	UA Reduction	C402.1.3	C406.2.1.2
E03	Envelope Leak Reduction	C403.3.2	C406.2.1.3
E04	Add Roof Insulation	C402.1.1	C406.2.1.4
E05	Add Wall Insulation	C402.1.1	C406.2.1.5
E06	Improve Fenestration	Table C402.3	C406.2.1.6
G03	Automated Shading	n/a	C406.3.4
G07	Building Thermal Mass	n/a	C406.3.8
C01	Insulation Embodied Carbon	n/a	C406.3.9

Building thermal envelope assemblies for buildings that are intended to comply with the code on a prescriptive basis in accordance with the compliance path described in Item 1 of Section C401.2, shall comply with the following:

1. The opaque portions of the building thermal envelope shall comply with the specific insulation requirements of Section C402.2 and the thermal requirements of either the *R*-value-based method of Section C402.1.1; the *U*-, *C*- and *F*-factor-based method of Section C402.1.2; the component performance alternative of Section C402.1.3; or the building above-grade performance alternative of Section C402.1.4. Building assemblies between conditioned and semi-conditioned spaces shall comply with the semi-conditioned requirements.

2. Fenestration in building envelope assemblies shall comply with Section C402.3.

   Exception: Semi-conditioned spaces do not have fenestration requirements.

3. Air leakage of building envelope assemblies shall comply with Section C402.4. Buildings with both conditioned and semi-conditioned spaces shall independently comply with the requirements of Section C402.4.

4. Solar readiness of building envelope assemblies shall comply with Section C402.5.

Alternatively, where buildings have a vertical fenestration area or skylight area exceeding that allowed in Section C402.3, the building and building thermal envelope shall comply with Section C401.2, Item 2.

Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.10.1.

TABLE C402.1(~~1~~2)
CONDITIONED SPACE BUILDING ENVELOPE REQUIREMENTS—OPAQUE ASSEMBLIES AND ELEMENTS[a,b]

COMPONENT	MAXIMUM OVERALL *U*-FACTOR[a]		~~MINIMUM *R*-VALUES[a]~~ EXAMPLE ASSEMBLIES MEETING U-FACTOR REQUIREMENT[~~,b~~]	
	~~Conditioned Space~~All Other *Occupancy Classifications*	~~Semi-Conditioned Space~~R-2 *Occupancy Classifications*	All Other *Occupancy Classifications* ~~Conditioned Space~~	R-2 *Occupancy Classifications*~~Semi-Conditioned Space~~
Roofs				
Insulation entirely above deck–	U-0.~~025~~ 022	~~U-0.039~~Same as All Other ←	R-~~40ci~~ 45ci	Same as All Other ←~~R-25ci~~
Metal buildings[~~a~~]	U-0.~~026~~ 023	~~U-0.037~~Same as All Other ←	R-~~25~~ 10 + R-~~11~~ 10 + R-~~11 LS~~32ci	Same as All Other ←~~R-19 + R-11 LS or R-25 + R-8 LS~~
Attic and Other[i]	U-0.~~021~~ 017	U-0.~~034~~ 020	R-~~49~~ 60	R-~~30~~49
Walls, Above grade				
Mass[f]–	U-0.~~048~~ 037	Same as All Other ←~~U-0.104~~	R-~~19ci~~ 25ci	Same as All Other ←~~R-9.5ci~~
Metal Building[~~a~~]	U-0.~~044~~ 039	Same as All Other ←~~U-0.060~~	R-13 + R-~~17ci~~ 19.5ci or R-~~22.1~~25ci	Same as All Other ←~~R-15.8ci~~
Metal-framed	U-0.~~044~~ 037	Same as All Other ←~~U-0.064~~	R-13 + R-~~15ci~~ 18.8ci or R-~~20ci~~ 25ci	Same as All Other ←~~R-13 + R-7.5ci~~
Wood-framed and other	U-0.~~042~~ 036	U-0.~~064~~ 033	R-13 + R-~~12ci~~ 16ci or R-19 + R-~~8ci~~ 12ci or R-~~20ci~~ 25ci	R-13 + R-~~3.8~~18ci or R-19 + R-14ci or R-27ci
Walls, Below Grade[c]				
Below-grade wall	C-0.~~063~~ 048	Same as All Other ←~~C-0.119~~	R-~~15ci~~ 20ci	Same as All Other ←~~R-7.5ci~~
Floors				
Mass[d]	U-0.~~051~~ 038	Same as All Other ←~~U-0.087~~	R-~~16.7~~23ci	Same as All Other ←~~R-8.3ci~~
Joist/Framing—Metal	U-0.~~032~~ 027	Same as All Other ←~~U-0.052~~	R-38 + R-6ci	Same as All Other ←~~R-19~~
Joist/Framing—Wood and Other	U-0.027~~U-0.033~~	Same as All Other ←~~U-0.051~~	R-~~30~~ 38	Same as All Other ←~~R-19~~
Slab-on-Grade Floors				

Unheated slabs~~[c]~~	F-0.~~036~~ 434	Same as All Other ~~←F-0.54~~	R-20 for 48" below ~~R-10 for entire slab and around perimeter~~	Same as All Other ~~←R-10 for 24 in.~~
Heated slabs[e]	F-0.~~373~~ 433	Same as All Other ~~←F-0.55~~	R-20 for 48" below + R-~~20~~ 15 full~~for entire~~ slab ~~and around perimeter~~	Same as All Other ~~←R-10 for entire slab and around perimeter~~
Opaque Doors				
Swinging[g]	U-0.37		N/A	
Non-Swinging	N/A		R-4.75	
Garage door <14% glazing[h] ~~Upward-acting, Sectional~~	N/A		R-10	

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.
ci = Continuous insulation, NR = No Requirement, LS = Liner System.

a. ~~For all envelope categories the use of opaque~~Where assembly *U*-factors, *C*-factors, and *F*-factors ~~from~~ are established in ANSI/ASHRAE/IESNA 90.1-~~2016~~ 2019 Appendix A, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table, and ~~shall be permitted,~~ provided that the construction, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ASHRAE/IESNA 90.1-~~2016~~ 2019 Appendix A. Alternatively, Table C~~402.1(2)~~402.1(4) for metal building assembly descriptions, Table C~~402.1(3)~~402.1(5) for metal building roof assembly *U*-factors, Table C~~402.1(4)~~402.1(6) for attic roofs with wood joists *U*-factors, Table C~~402.1(5)~~402.1(7) for metal building wall assembly *U*-factors, Table C~~402.1(6)~~402.1(8) for metal-framed wall assembly U-factors, and Table C402.1(9~~7~~) for wood-framed wall assembly U-factors may be used in lieu of ANSI/ASHRAE/IESNA 90.1-~~2016~~ 2019 Appendix A.

b. ~~Opaque assembly~~Where *U*-factors ~~based on designs tested in accordance~~have been established by testing in accordance with ASTM C1363, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table~~permitted~~. The R-value of continuous insulation shall be permitted to be added to or subtracted from the original tested design.

c. Where heated slabs are below grade, below-grade walls shall comply with the ~~*F*~~*U*-factor requirements for ~~heated slabs~~above-grade mass walls.

d. "Mass floors" shall be in accordance with **Section C402.2.3** ~~floors"~~and shall include floors weighing not less than:
1. 35 pounds per square foot of floor surface area; or
2. 25 pounds per square foot of floor surface area where the material weight is not more than 120 pounds per cubic foot.

e. Evidence of compliance with the *F*-factors indicated in the table for heated slabs shall be demonstrated by the application of the unheated slab *F*-factors and *R*-values derived from ASHRAE 90.1-~~2016~~ 2019 Appendix A.

f. "Mass walls" shall be in accordance with **Section C402.2.2**

g. Swinging door U-factors shall be determined in accordance with NFRC-100.

h. Garage doors having a single row of fenestration shall have an assembly U-factor less than or equal to 0.31, provided that fenestration area is not less than 14 percent and not more than 25 percent of the total door area.

i. For Group R buildings, R-49 (U-0.023) for insulation in the ceiling slope

TABLE C402.1(3)
SEMI-CONDITIONED SPACE BUILDING ENVELOPE REQUIREMENTS—OPAQUE ASSEMBLIES AND ELEMENTS[a,b]

COMPONENT	MAXIMUM OVERALL *U*-FACTOR	EXAMPLE ASSEMBLIES MEETING U-FACTOR REQUIREMENT
	All *Occupancy Classifications*	All *Occupancy Classifications*
Roofs		
Insulation entirely above deck	U-0.039	R-25ci
Metal buildings	U-0.037	R-19 + R-11 LS or R-25 + R-8 LS
Attic and Other[i]	U-0.027	R-38
Walls, Above grade		
Mass[f]	U-0.104	R-9.5ci
Metal Building	U-0.060	R-15.8ci
Metal-framed	U-0.064	R-13 + R-7.5ci
Wood-framed and other	U-0.051	R-13 + R-7.5ci
Walls, Below Grade[c]		
Below-grade wall	C-0.119	R-7.5ci
Floors		
Mass[d]	U-0.064	R-12.5ci
Joist/Framing—Metal	U-0.052	R-19
Joist/Framing—Wood and Other	U-0.033	R-30
Slab-on-Grade Floors		
Unheated slabs	F-0.540	R-10 for 24 in. below
Heated slabs[e]	F-0.860	R-15 for 24 in below
Opaque Doors		
Swinging[g]	U-0.37	N/A
Non-Swinging	N/A	R-4.75
Garage door <14% glazing[h]	N/A	R-10

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.
ci = Continuous insulation, NR = No Requirement, LS = Liner System.

a. Where assembly *U*-factors, *C*-factors, and *F*-factors are established in ANSI/ASHRAE/IESNA 90.1-2019 Appendix A, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table, and provided that the construction, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ASHRAE/IESNA 90.1-2019 Appendix A. Alternatively, Table C402.1(4) for metal building assembly descriptions, Table C402.1(5) for metal building roof assembly *U*-factors, Table C402.1(6) for attic roofs with wood joists *U*-factors, Table C402.1(7) for metal building wall assembly *U*-factors, Table C402.1(8) for metal-framed wall assembly U-factors, and Table C402.1(9) for wood-framed wall assembly U-factors may be used in lieu of ANSI/ASHRAE/IESNA 90.1-2019 Appendix A.

b. Where *U*-factors have been established by testing in accordance with ASTM C1363, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table. The R-value of continuous insulation shall be permitted to be added to or subtracted from the original tested design.

c. Where heated slabs are below grade, below-grade walls shall comply with the *U*-factor requirements for above-grade mass walls.

d. “Mass floors” shall be in accordance with **Section C402.2.3** and shall include floors weighing not less than:
   1. 35 pounds per square foot of floor surface area; or
   2. 25 pounds per square foot of floor surface area where the material weight is not more than 120 pounds per cubic foot.
e. Evidence of compliance with the *F*-factors indicated in the table for heated slabs shall be demonstrated by the application of the unheated slab *F*-factors and *R*-values derived from ASHRAE 90.1-2019 Appendix A.
f. “Mass walls” shall be in accordance with **Section C402.2.2**
g. Swinging door U-factors shall be determined in accordance with NFRC-100.
h. Garage doors having a single row of fenestration shall have an assembly U-factor less than or equal to 0.36, provided that fenestration area is not less than 14 percent and not more than 25 percent of the total door area.

TABLE C402.1(~~2~~4)
BUILDING ENVELOPE REQUIREMENTS—METAL BUILDING ASSEMBLY DESCRIPTIONS

BUILDING ENVELOPE REQUIREMENTS—METAL BUILDING ASSEMBLY DESCRIPTIONS	DESCRIPTION	REFERENCE
ROOFS		
Since Layer	The rated R-value of insulation is for insulation installed perpendicular to and draped over purlins and then compressed when the metal roof panels are attached. A minimum R-3 thermal spacer block between the purlins and the metal roof panels is required unless compliance is shown by the overall assembly U-factor.	ANSI/ASHRAE/IESNA 90.1-2019
Double Layer	The first rated R-value of insulation is for insulation installed perpendicular to and draped over purlins. The second rated R-value of insulation is for unfaced insulation installed above the first layer and parallel to the purlins and then compressed when the metal roof panels are attached. A minimum R-3 thermal spacer block between the purlins and the metal roof panels is required unless compliance is shown by the overall assembly U-factor.	ANSI/ASHRAE/IESNA 90.1-2019
Continuous Insulation	For assemblies with continuous insulation the continuous insulation is installed above or below the purlins, uncompressed and uninterrupted by framing members.	ANSI/ASHRAE/IESNA 90.1-2019
Liner system	A continuous membrane installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins. For multilayer installations, the last rated *R*-value of insulation is for unfaced insulation draped over purlins and then compressed when the metal roof panels are attached. A minimum R-5 thermal spacer block between the purlins and the metal roof panels is required unless compliance is shown by the overall assembly *U*-factor.	ANSI/ASHRAE/IESNA 90.1-~~2016~~2019
Filled Cavity (Fc)	The first *rated R-value of insulation* represents faced or unfaced insulation installed between the purlins. The second *rated R-value of insulation* represents unfaced insulation installed above the first layer, perpendicular to the purlins and compressed when the metal *roof* panels are attached. A supporting structure retains the bottom of the first layer at the prescribed depth required for the full thickness of insulation. A minimum R-5 thermal spacer block between the purlins and the metal *roof* panels is required unless compliance is shown by the overall assembly *U-factor*.	ANSI/ASHRAE/IESNA 90.1-~~2016~~2019
WALLS		
~~R-13 + R-17ci~~Single-Layer Compressed	The first rated *R*-value of insulation is for insulation compressed between metal building wall panels and the steel structure. ~~The second rated *R*-value is for continuous insulation (e.g., insulation boards). It is assumed that the insulation boards are installed on the inside of the girts and uninterrupted by the framing members. Insulation exposed to the conditioned space or semi-heated space~~	ANSI/ASHRAE/IESNA 90.1-~~2016~~2019

	~~shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.~~	
~~R-22.1ci~~Continuous Insulation	For assemblies with continuous insulation, the continuous insulation is installed on the outside or inside of the girts, uncompressed and uninterrupted by the framing members.~~The rated R-value is for continuous insulation (e.g., insulation boards). It is assumed that the insulation boards are installed on the inside of the girts and uninterrupted by the framing members. Insulation exposed to the conditioned space or semi-heated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.~~	ANSI/ASHRAE/IESNA 90.1-~~2016~~2019
Single-Layer in Cavity	The insulation is installed in the cavity between the girts, not compressed by the framing. A membrane or facing, installed separately or adhered to the insulation, is installed inside of the girts to form a continuous layer. A thermal spacer block or thermal break strip between the girts and metal wall panels is required when specified in Table A3.2.3.	ANSI/ASHRAE/IESNA 90.1-2019
Double-Layer	The first rated R-value of insulation is for insulation installed in the cavity between the girts, not compressed by the framing. The second rated R-value of insulation is for insulation compressed between metal wall panels and the steel structure. A membrane or facing, installed separately or adhered to the insulation, is installed inside of the girts to form a continuous layer. A thermal spacer block or thermal break strip between the girts and metal wall panels is required when specified in Table A3.2.3.	ANSI/ASHRAE/IESNA 90.1-2019

TABLE C402.1(~~3~~5)
ASSEMBLY *U*-FACTORS FOR METAL BUILDING ROOFS

INSULATION SYSTEM	RATED *R*-VALUE OF INSULATION	OVERALL *U*-FACTOR FOR ENTIRE BASE ROOF ASSEMBLY	OVERALL U-FACTOR FOR ASSEMBLY OF BASE ROOF PLUS CONTINUOUS INSULATION (UNINTERRUPTED BY FRAMING)					
			Rated *R*-Value of Continuous Insulation					
Standing Seam Roofs with Thermal Spacer Blocks[a]			**R-15.8**	**R-19**	**R-22.1**	**R-25**	**R-32**	**R-38**
Single layer[b]	None	1.280					00.031	0.026
	R-10	0.115		0.036	0.032	0.030	0.025	0.021
	R-11	0.107		0.035	0.032	0.029	0.024	0.021
	R-13	0.101		0.035	0.031	0.029	0.024	0.021
	R-16	0.096		0.034	0.031	0.028	0.024	0.021
	R-19	0.082	0.036	0.032	0.029	0.027	0.023	0.020
Double layer[b]	R-10 + R-10	0.088	0.037	0.033	0.030	0.028	0.023	0.020
	R-10 + R-11	0.086	0.036	0.033	0.030	0.027	0.023	0.020
	R-11 + R-11	0.085	0.036	0.033	0.030	0.027	0.023	0.020
	R-10 + R-13	0.084	0.036	0.032	0.029	0.027	0.023	0.020
	R-11 + R-13	0.082	0.036	0.032	0.029	0.027	0.023	0.020
	R-13 + R-13	0.075	0.034	0.031	0.028	0.026	0.022	0.019
	R-10 + R-19	0.074	0.034	0.031	0.028	0.026	0.022	0.019
	R-11 + R-19	0.072	0.034	0.030	0.028	0.026	0.022	0.019
	R-13 + R-19	0.068	0.033	0.030	0.027	0.025	0.021	0.019
	R-16 + R-19	0.065	0.032	0.029	0.027	0.025	0.021	0.019
	R-19 + R-19	0.060	0.031	0.028	0.026	0.024	0.021	0.018
Liner system[c]	R-19 + R-11~~R-25 + R-11 + R-11 LS~~	0.037~~0.026~~						
	R-25 + R-8	0.037						
	R-25 + R-11	0.031						
	R-30 + R11	0.029						
	R-25 + R-11 + R-11 LS	0.026						
Filled cavity[c]	R-10 + R-19 Fc	0.041	0.025	0.023	0.022	0.020	0.018	0.016
Thru-fastened Roofs without Thermal Spacer Blocks								
	R-10	0.184			0.036	0.033	0.027	0.023
	R-11	0.182			0.036	0.033	0.027	0.023
	R-13	0.174			0.036	0.033	0.026	0.023
	R-16	0.157			0.035	0.032	0.026	0.023
	R-19	0.151			0.035	0.032	0.026	0.022

Note: (Multiple *R*-values are listed in order from inside to outside)
Shaded areas comply with minimum requirements for semi-conditioned spaces but not conditioned spaces.

a. A standing seam roof clip that provides a minimum 1.5 inch distance between the top of the purlins and the underside of the metal building roof panels is required.
b. A minimum R-3 thermal spacer block is required.
c. A minimum R-5 thermal spacer block is required.

TABLE C402.1(~~4~~6)
ASSEMBLY *U*-FACTORS FOR ATTIC ROOFS WITH WOOD JOISTS

RATED *R*-VALUE OF INSULATION ALONE	OVERALL *U*-FACTOR FOR ENTIRE ROOF ASSEMBLY[a]
Wood-framed Attic, Standard Framing	
R-38	U-0.027
R-49	U-0.021
R-60	U-0.017
R-71	U-0.015
R-82	U-0.013
R-93	U-0.011
R-104	U-0.010
R-115	U-0.009
R-126	U-0.008
Wood-framed Attic, Advanced Framing	
R-38	U-0.026
R-49	U-0.020
R-60	U-0.016
R-71	U-0.014
R-82	U-0.012
R-93	U-0.011
R-104	U-0.010
R-115	U-0.009
R-126	U-0.008
Wood Joists, Single-Rafter Roof[b]	
R-38 + R-15ci	U-0.020

a. Lightly shaded areas comply with conditioned R-2 spaces, but not other conditioned building occupancies. ~~S~~Darkly shaded areas comply with minimum requirements for semi-conditioned spaces but not conditioned spaces.
b. The first *R*-value is the cavity insulation, while the second value is the continuous insulation uninterrupted by framing.

TABLE C402.1(~~5~~7)
ASSEMBLY *U*-FACTORS FOR METAL BUILDING WALLS

RATED *R*-VALUE OF INSULATION	OVERALL U-FACTOR FOR BASE WALL ASSEMBLY	OVERALL *U*-FACTOR FOR ASSEMBLY OF BASE WALL PLUS CONTINUOUS INSULATION (UNINTERRUPTED BY FRAMING)								
		R-6.5	R-9.8	R-13	R-15.8	R-19	R-22.1	R-25	R-32	R-38
Continuous Insulation Only										
R-0	1.180				0.060	0.050	0.044	0.039	0.030	0.026
Single Compressed Layer										
R-10	0.186			0.054	0.047	0.041	0.036	0.033	0.027	0.023
R-11	0.185			0.054	0.047	0.041	0.036	0.033	0.027	0.023
R-13	0.162			0.052	0.046	0.040	0.035	0.032	0.026	0.023
R-16	0.155			0.051	0.045	0.039	0.035	0.032	0.026	0.022
R-19	0.147		0.060	0.050	0.044	0.039	0.035	0.031	0.026	0.022
Single Layer in Cavity										
R-25[a]	0.059	0.044	0.039	0.035	0.032	0.029	0.027	0.025	0.021	0.019
R-30[b]	0.052	0.042	0.037	0.033	0.031	0.028	0.026	0.024	0.021	0.019
Double Layer										
R-25 + R-10	0.047									
R-25 + R-16	0.042									
R-25 + R-10[c]	0.039									
R-30 + R-16	0.039									
Shaded areas comply with minimum requirements for semi-conditioned spaces but not conditioned spaces.										

Note: Shaded areas comply with minimum requirements for semi-conditioned spaces but not conditioned spaces.

a. A minimum R-0.375 thermal spacer block or thermal break strip is required when installed without continuous insulation.
b. A minimum R-0.75 thermal spacer block or thermal break strip is required when installed without continuous insulation.
c. A minimum R-3 thermal spacer block is required.

TABLE C402.1(~~6~~8)
ASSEMBLY U-FACTORS FOR METAL-FRAMED WALLS

RATED *R*-VALUE OF INSULATION (EFFECTIVE INSTALLED)	OVERALL *U*-FACTOR FOR ASSEMBLY	OVERALL *U*-FACTOR FOR ASSEMBLY OF BASE WALL PLUS CONTINUOUS INSULATION (UNINTERRUPTED BY FRAMING)								
		R-12	R-13	R-14	R-15	R-20	R-25	R-30	R-35	R-40
Steel Framing at 16 in. on Center and 3.5 in. Depth										
R-0 (0.0)	0.352		0.063	0.059	0.056	0.044	0.036	0.030	0.026	0.023
R-11 (5.5)	0.132	0.051	0.049	0.046	0.044	0.036	0.031	0.027	0.024	0.021
R-13 (6.0)	0.124	0.050	0.048	0.045	0.043	0.036	0.030	0.026	0.023	0.021
R-15 (6.4)	0.118	0.049	0.047	0.045	0.043	0.035	0.030	0.026	0.023	0.021
Steel Framing at 16 in. on Center and 6.0 in. Depth										
R-19 (7.1)	0.109	0.047	0.045	0.043	0.041	0.034	0.029	0.026	0.023	0.020
R-21 (7.4)	0.106	0.047	0.045	0.043	0.041	0.034	0.029	0.025	0.022	0.020
Steel Framing at 24 in. on Center and 3.5 in. Depth										
R-0 (0.0)	0.338		0.063	0.059	0.056	0.044	0.036	0.030	0.026	0.023
R-11 (6.6)	0.116	0.048	0.046	0.044	0.042	0.035	0.030	0.026	0.023	0.021
R-13 (7.2)	0.108	0.047	0.045	0.043	0.041	0.034	0.029	0.025	0.023	0.020
R-15 (7.8)	0.102	0.046	0.044	0.042	0.040	0.034	0.029	0.025	0.022	0.020
Steel Framing at 24 in. on Center and 6.0 in. Depth										
R-19 (8.6)	0.094	0.044	0.042	0.041	0.039	0.033	0.028	0.025	0.022	0.020
R-21 (9.0)	0.090	0.043	0.042	0.040	0.038	0.032	0.028	0.024	0.022	0.020

Note: Shaded areas comply with minimum requirements for semi-conditioned spaces but not conditioned spaces.

TABLE C402.1(~~7~~9)
ASSEMBLY *U*-FACTORS FOR WOOD-FRAMED WALLS

RATED *R*-VALUE OF CAVITY INSULATION (EFFECTIVE INSTALLED)	OVERALL *U*-FACTOR FOR ASSEMBLY	OVERALL *U*-FACTOR FOR ASSEMBLY OF BASE WALL PLUS CONTINUOUS INSULATION (UNINTERRUPTED BY FRAMING)								
		R-6	R-9	R-12	R-15	R-20	R-25	R-30	R-35	R-40
Wood Studs at 16 in. on Center and 3.5 in. Depth										
R-0 (0.0)	0.292			~~0.064~~	~~0.053~~	0.042	0.035	0.030	0.026	0.023
R-11 (11.0)	0.096	~~0.059~~	0.050	0.044	0.038	0.032	0.028	0.024	0.022	0.020
R-13 (13.0)	0.089	~~0.056~~	0.047	0.041	0.037	0.031	0.027	0.024	0.021	0.019
R-15 (15.0)	0.083	~~0.053~~	0.045	0.039	0.035	0.030	0.026	0.023	0.020	0.019
Wood Studs at 16 in. on Center and 5.5 in. Depth										
R-19 (18.0)	0.067	0.046	0.040	0.036	0.032	0.027	0.024	0.021	0.019	0.018
R-21 (21.0)	0.063	0.043	0.038	0.034	0.030	0.026	0.023	0.021	0.019	0.017
Wood Studs at 16 in. on Center and R-10 Headers										
R-19 (18.0)	0.063	0.045	0.039	0.035	0.031	0.027	0.024	0.021	0.019	0.017
R-21 (21.0)	0.059	0.042	0.037	0.033	0.030	0.026	0.023	0.020	0.018	0.017
Wood Studs at 24 in. on Center and 3.5 in. Depth										
R-0 (0.0)	0.298			~~0.064~~	~~0.054~~	0.042	0.035	0.030	0.026	0.023
R-11 (11.0)	0.094	~~0.059~~	0.050	0.043	0.038	0.032	0.027	0.024	0.022	0.019
R-13 (13.0)	0.086	~~0.055~~	0.047	0.041	0.036	0.031	0.026	0.023	0.021	0.019
R-15 (15.0)	0.080	~~0.052~~	0.044	0.039	0.035	0.029	0.026	0.023	0.020	0.018
Wood Studs at 24 in. on Center and 5.5 in. Depth										
R-19 (18.0)	0.065	0.045	0.039	0.035	0.032	0.027	0.024	0.021	0.019	0.018
R-21 (21.0)	0.060	0.042	0.037	0.033	0.030	0.026	0.023	0.020	0.018	0.017
Wood Studs at 24 in. on Center and R-10 Headers										
R-19 (18.0)	0.062	0.044	0.039	0.034	0.031	0.027	0.024	0.021	0.019	0.017
R-21 (21.0)	0.057	0.041	0.036	0.032	0.029	0.025	0.023	0.020	0.018	0.017

Note: Lightly shaded areas comply with building occupancies other than conditioned R-2 spaces. Darkly shaded areas comply with minimum requirements for semi-conditioned spaces but not conditioned spaces ~~Shaded areas comply with minimum requirements for semi-conditioned spaces but not conditioned spaces~~.

C402.1.1 Insulation component *R*-value-based method.
Building thermal envelope opaque assemblies shall comply with the requirements of Sections C402.2 and C402.3. For opaque portions of the *building thermal envelope* intended to comply on an insulation component *R-value* basis, the *R*-values for cavity insulation and continuous insulation shall be not less than that specified in the "Minimum R-values" columns of Table C~~402.1(1)~~402.1(2) and Table C402.1(3). Where cavity insulation is installed in multiple layers, the cavity insulation R-values shall be summed to determine compliance with the cavity insulation R-value requirements. Where continuous insulation is installed in multiple layers, the

continuous insulation R-values shall be summed to determine compliance with the continuous insulation R-value requirements. Cavity insulation R-values shall not be used to determine compliance with the continuous insulation R-value requirements in Table C~~402.1~~402.1(2) and Table C402.1(3). Commercial buildings or portions of commercial buildings enclosing *conditioned spaces* shall use the *R*-values from the “Conditioned Space” ~~column of~~ Table C~~402.1(1)~~402.1(2). Commercial buildings or portions of commercial buildings enclosing semi-conditioned spaces shall use the *R*-values from the “Semi-conditioned Space” ~~column of~~ Table C~~402.1(1)~~402.1(3). Walls between conditioned and semi-conditioned spaces shall use the *R*-values from the “Semi-conditioned Space” ~~column of~~ Table C~~402.1(1)~~402.1(3).

C402.1.2 Assembly *U*-factor, *C*-factor or *F*-factor-based method.
Building thermal envelope opaque assemblies shall meet the requirements of Sections C402.2 and C402.3. Building thermal envelope opaque assemblies intended to comply on an assembly *U*-, *C*- or *F*-factor basis shall have a *U*-, *C*- or *F*-factor not greater than that specified in the “Maximum Overall *U*-factor” columns of Table C~~402.1(1)~~402.1(2) and Table C402.1(3). Commercial buildings or portions of commercial buildings enclosing *conditioned spaces* shall use the *U*-, *C*- or *F*-factor from the “*Conditioned Space*” ~~column of~~ Table C~~402.1(1)~~402.1(2). Commercial buildings or portions of commercial buildings enclosing semi-conditioned spaces shall use the *U*-, *C*- or *F*-factor from the “Semi-conditioned Space” ~~column of~~ Table C~~402.1(1)~~402.1(3). Walls between conditioned and semi-conditioned spaces shall use the *R*-values from the “Semi-conditioned Space” ~~column of~~ Table C~~402.1(1)~~402.1(3).

C402.1.2.1 Roof/ceiling assembly.
The maximum, roof/ceiling assembly U-factor shall not exceed that specified in Table C~~402.1~~402.1(2) and Table C402.1(3) based on construction materials used in the roof/ceiling assembly.

C402.1.2.1.1 Tapered, above-deck insulation based on thickness.
Where used as a component of a maximum roof/ceiling assembly U-factor calculation, the sloped roof insulation R-value contribution to that calculation shall use the average thickness in inches (mm) along with the material R-value-per-inch (per-mm) solely for U-factor compliance as prescribed in Section C402.1.1.

C402.1.2.1.2 Suspended ceilings.
Insulation installed on suspended ceilings having removable ceiling tiles shall not be considered part of the assembly U-factor of the roof/ceiling construction.

C402.1.2.1.3 Joints staggered.
Continuous insulation board shall be installed in not less than two layers, and the edge joints between each layer of insulation shall be staggered, except where insulation tapers to the roof deck at a gutter edge, roof drain or scupper.

C402.1.3 Component performance alternative.
Building envelope values and fenestration areas determined in accordance with Equation 4-1 shall be an alternative to compliance with the *U-, F-* and *C*-factors in Tables C~~402.1(1)~~402.1(2) and Table C402.1(3) and C402.3 and the maximum allowable fenestration areas in Section C402.3.1. *Fenestration* shall meet the applicable SHGC requirements of Section C402.3.3.

$$A + B + C + D + E \leq \text{Zero} \qquad \textbf{(Equation 4-1)}$$

where:

A	=	Sum of the (UA Dif) values for each distinct assembly type of the building thermal envelope, other than slabs on grade and below-grade walls.
UA Dif	=	UA Proposed - UA Table.
UA Proposed	=	Proposed *U*-value × Area.
UA Table	=	(*U*-factor from Table C~~402.1(1)~~402.1(2) and Table C402.1(3) or C402.3) × Area.
B	=	Sum of the (FL Dif) values for each distinct slab on-grade perimeter condition of the building thermal envelope.
FL Dif	=	FL Proposed - FL Table.
FL Proposed	=	Proposed *F*-value × Perimeter length.
FL Table	=	[*F*-factor specified in Table C~~402.1(1)~~402.1(2) and Table C402.1(3)] × Perimeter length.
C	=	Sum of the (CA Dif) values for each distinct below-grade wall assembly type of the building thermal envelope.
CA Dif	=	CA Proposed - CA Table.
CA Proposed	=	Proposed *C*-value × Area.
CA Table	=	[Maximum allowable *C*-factor specified in Table C~~402.1(1)~~402.1(2) and Table C402.1(3)] × Area.

Where the proposed vertical glazing area is less than or equal to the maximum vertical glazing area allowed by Section C402.3.1, the value of D (Excess Vertical Glazing Value) shall be zero. Otherwise:

D	=	(DA × UV) - (DA × U Wall), but not less than zero.
DA	=	(Proposed Vertical Glazing Area) - (Vertical Glazing Area allowed by Section C402.3.1).
UA Wall	=	Sum of the (UA Proposed) values for each opaque assembly of the exterior wall.
U Wall	=	Area-weighted average *U*-value of all above-grade wall assemblies.
UAV	=	Sum of the (UA Proposed) values for each vertical glazing assembly.
UV	=	UAV/total vertical glazing area.

Where the proposed skylight area is less than or equal to the skylight area allowed by Section C402.3.1, the value of E (Excess Skylight Value) shall be zero. Otherwise:

E	=	(EA × US) - (EA × U Roof), but not less than zero.
EA	=	(Proposed Skylight Area) - (Allowable Skylight Area as specified in Section C402.3.1).
U Roof	=	Area-weighted average *U*-value of all roof assemblies.
UAS	=	Sum of the (UA Proposed) values for each skylight assembly.
US	=	UAS/total skylight area.

C402.1.4 Building above-grade performance alternative.
Above-grade building envelope values determined in accordance with Equation 4-2 shall be

an alternative to compliance with the *U*-factors in Tables C~~402.1(1)~~402.1(2) and Table C402.1(3) and C402.3 and the maximum allowable fenestration areas in Section C402.3.1. Below-grade walls, floors, and slabs shall meet the applicable requirements of Section C402.1.1 or C402.1.2. *Fenestration* shall meet the applicable SHGC requirements of Section C402.3.3.

UA-Total/Area ≤ 0.032~~5~~ **(Equation 4-2)**

where:

UA-Total	=	Sum of the (UA) values for each distinct above-grade assembly type of the building thermal envelope including above-grade walls, roofs, doors, vertical fenestration, and skylights.
UA	=	Proposed *U*-value × Area.
Area	=	Surface area in square feet of the above-grade thermal barrier (above-grade wall area plus roof area).

C402.2 Specific building thermal envelope insulation requirements ~~(Prescriptive)~~.
Insulation in building thermal envelope opaque assemblies shall comply with Sections C402.2.1 through C402.2.8 and Table C~~402.1(1)~~402.1(2) and Table C402.1(3).

C402.2.1 Roof assembly.
The minimum thermal resistance (*R*-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table C~~402.1(1)~~402.1(2) and Table C402.1(3), based on construction materials used in the roof assembly. ~~Insulation installed on a suspended ceiling having removable ceiling tiles shall not be considered as part of the minimum thermal resistance of the roof insulation. Continuous insulation board shall be installed in not less than 2 layers and the edge joints between each layer of insulation shall be staggered. Mechanical curbs shall be insulated to R-12.~~

~~**Exceptions:**~~

~~1. Continuously insulated roof assemblies where the *R*-value is at least R-12 over the entire roof assembly and where the average, area-weighted *U*-value is equivalent to the *R*-value specified in Table C402.1(1).~~

~~2. A minimum of 60 percent of the required *R*-value from Table C402.1(1) must be maintained in area where the roof insulation tapers, such as at roof drains.~~

C402.2.1.1 Tapered, above-deck insulation based on thickness. Where used as a component of a roof/ceiling assembly R-value calculation, the sloped roof insulation R-value contribution to that calculation shall use the average thickness in inches (mm) along with the material R-value-per-inch (per-mm) solely for R-value compliance as prescribed in Section 402.1.3.

C402.2.1.2 Minimum insulation, lowest point. The minimum insulation of abovedeck roof insulation at its lowest point, gutter edge, roof drain or scupper, shall be not less than ~~1 inch (25 mm).~~R-12.

C402.2.1.3 Suspended ceilings. Insulation installed on suspended ceilings having removable ceiling tiles shall not be considered part of the minimum thermal resistance (R-value) of roof insulation in roof/ceiling construction.

C402.2.1.4 Joints staggered. Continuous insulation board shall be installed in not less than two layers and the edge joints between each layer of insulation shall be staggered, except where insulation tapers to the roof deck at a gutter edge, roof drain or scupper.

C402.2.1~~2~~.5 Mechanical curbs. The minimum insulation of abovedeck roof insulation at the location of a mechanical curb, shall be not less than R-12.

C402.2.1.56~~1~~ Skylight curbs.
Skylight curbs shall be insulated to the level of roofs with insulation entirely above the deck or R-10, whichever is less.

> **Exception:** Unit skylight curbs included as a component of a skylight listed and labeled in accordance with NFRC 100 shall not be required to be insulated.

C402.2.2 Above-grade walls.
The minimum thermal resistance (*R*-value) of materials installed in the wall cavity between framing members and continuously on the walls shall be as specified in Table C~~402.1(1)~~402.1(2) and Table C402.1(3), based on framing type and construction materials used in the wall assembly. The *R*-value of integral insulation installed in concrete masonry units shall not be used in determining compliance with Table C~~402.1(1)~~402.1(2) and Table C402.1(3) except as otherwise noted in the table. In determining compliance with Table C~~402.1(1)~~402.1(2) and Table C402.1(3), the use of the U-factor of concrete masonry units with integral insulation shall be permitted. “Mass walls” where used as a component in the thermal envelope of a building shall comply with one of the following:

1. Weigh not less than 35 pounds per square foot (171 kg/m^2) of wall surface area.
2. Weigh not less than 25 pounds per square foot (122 kg/m^2) of wall surface area where the material weight is not more than 120 pcf (1900 kg/m^3).
3. Have a heat capacity exceeding 7 Btu/ft^2 • °F (144 kJ/m^2 • K).
4. Have a heat capacity exceeding 5 Btu/ft^2 • °F (103 kJ/m^2 • K), where the material weight is not more than 120 pcf (1900 kg/m^3).

C402.2.3 Floors~~ over outdoor air or unconditioned space~~.
The thermal properties (component *R*-values or assembly *U*-, *C*- or *F*-factors) of floor assemblies over outdoor air or unconditioned space~~The minimum thermal resistance (*R*-value) of the insulating material installed either between the floor framing, continuously above the floor assembly, or continuously below the floor assembly~~ shall be as specified in Table

C~~402.1(1)~~402.1(2) and Table C402.1(3), based on construction materials used in the floor assembly. Floor framing *cavity insulation* or structural slab insulation shall be installed to maintain permanent contact with the underside of the subfloor decking or structural slabs.

"Mass floors" where used as a component of the thermal envelope of a building shall provide one of the following weights:

1. 35 pounds per square foot (171 kg/m^2) of floor surface area.

2. 25 pounds per square foot (122 kg/m^2) of floor surface area where the material weight is not more than 120 pounds per cubic foot. (1923 kg/m^3)

Exceptions:

1. The floor framing *cavity insulation* or structural slab insulation shall be permitted to be in contact with the top side of sheathing or continuous insulation installed on the bottom side of floor assemblies where combined with insulation that meets or exceeds the minimum *U*-value in Table C402.1(2) and Table C402.1(3) for "Metal framed" or "Wood framed and other" values for "Walls, Above Grade" and extends from the bottom to the top of all perimeter floor framing or floor assembly members.

2. Insulation applied to the underside of concrete floor slabs shall be permitted an airspace of not more than 1 inch (25 mm) where it turns up and is in contact with the underside of the floor under walls associated with the *building thermal envelope.*

C402.2.4 Slabs-on-grade ~~perimeter insulation~~. ~~Where the slab on grade is in contact with the ground and insulation is not required for the entire slab, t~~The minimum thermal resistance (*R*-value) of the insulation ~~around the perimeter of~~ for unheated or heated slab-on-grade floors designed in accordance with the *R*-value method of Section C402.1.1 shall be as specified in Table C~~402.1(1)~~402.1(2) and Table C402.1(3). ~~The perimeter insulation shall be placed on the outside of the foundation or on the inside of the foundation wall. The perimeter insulation shall extend downward from the top of the slab for the minimum distance shown in the table. Insulation extending away from the building shall be protected by pavement or by not less than of 10 inches (254 mm) of soil.~~

~~**Exception:** Where the slab-on-grade floor is greater than 48 inches (1220 mm) below the finished exterior grade, perimeter insulation is not required.~~

C402.2.4.1 Insulation installation. Where installed, the perimeter insulation shall be placed on the outside of the foundation or on the inside of the foundation wall. The perimeter insulation shall extend downward from the top of the slab for the minimum distance shown in the table or to the top of the footing, whichever is less, or downward to not less than the bottom of the slab and then horizontally to the interior or exterior for the total distance shown in the table. Insulation extending away from the building shall be protected by pavement or by not less than of 10 inches (254 mm) of soil. Where installed, full slab insulation shall be continuous under the entire area of the slab-on-grade floor, except at structural column locations and service penetrations. Insulation required at the heated slab perimeter shall not be required to extend below the bottom of the heated slab and shall be continuous with the full slab insulation.

> **Exception:** Where the slab-on-grade floor is greater than 24 inches (61 mm) below the finished exterior grade, perimeter insulation is not required.

C402.2.5 Below-grade walls.
The *C*-factor for the below-grade exterior walls shall be in accordance with Table C~~402.1(1)~~402.1(2) and Table C402.1(3). The *R*-value of the insulating material installed continuously within or on the below-grade exterior walls of the building envelope shall be in accordance with Table C~~402.1(1)~~402.1(2) and Table C402.1(3). The *C*-factor or *R*-value required shall extend to a depth of not less than 10 feet (3048 mm) below the outside finished ground level, or to the level of the lowest floor of the conditioned space enclosed by the below-grade wall, whichever is less.

C402.2.6 Insulation of radiant heating systems.
Radiant heating system panels, and their associated components that are installed in interior or exterior assemblies shall be insulated to an *R*-value of not less than R-3.5 on all surfaces not facing the space being heated. *Radiant heating system* panels that are installed in the *building thermal envelope* shall be separated from the exterior of the building or unconditioned or exempt spaces by not less than the *R*-value of insulation installed in the opaque assembly in which they are installed or the assembly shall comply with Section C402.1.2.

> **Exception:** Heated slabs on grade insulated in accordance with the “Heated slabs” row of Table C~~402.1(1)~~402.1(2) and Table C402.1(3).

C402.2.7 Airspaces.
Where the ~~*thermal properties of airspaces are used to comply with this code*~~*R*-value of an airspace is used for compliance in accordance with ~~Section C401.2, such airspaces~~Section C402.1, the airspace shall be enclosed in an unventilated cavity constructed to minimize airflow into and out of the enclosed airspace. Airflow shall be deemed minimized where the enclosed airspace is located on the interior side of the continuous air barrier and is bounded on all sides by building components.

> **Exception:** The thermal resistance of airspaces located on the exterior side of the continuous air barrier and adjacent to and behind the exterior wall-covering material shall be determined in accordance with ASTM C1363 modified with an airflow entering the bottom and exiting the top of the airspace at an air movement rate of not less than 70 mm/second.

C402.3 Fenestration ~~(Prescriptive)~~.
Fenestration shall comply with Sections C402.3.1 through C402.3.5 and Table C402.3. Daylight responsive controls shall comply with this section and Section C405.2.3.1.

TABLE C402.3
BUILDING ENVELOPE FENESTRATION MAXIMUM U-FACTOR AND SHGC REQUIREMENTS

VERTICAL FENESTRATION		
***U*-factor**		
Fixed f~~F~~enestration other than *storefront*	0.~~33~~29	
Storefront fenestration	0.33	
Operable fenestration, R-2 *occupancy classifications*	0.27	
Operable fenestration, *occupancy classifications* other than R-2	0.~~37~~36	
Entrance doors	0.~~68~~63	
SHGC		
~~Orientation[a]~~ PF	Fixed~~SEW~~	Operable~~N~~
PF < 0.2	0.38~~40~~	0.34~~7~~
0.2 ≤ PF < 0.5	0.46~~48~~	0.41~~58~~
PF ≥ 0.5	0.61~~4~~	0.54~~64~~
SKYLIGHTS		
U-factor	0.~~48~~41	
SHGC	0.38	

NR = No requirement, PF = Projection factor.

~~a. "N" indicates vertical fenestration oriented within 45 degrees of true north. "SEW" indicates orientations other than "N."~~

C402.3.1 Maximum area.
The vertical fenestration area, not including opaque doors and opaque spandrel panels, shall be not greater than 30 percent of the gross above-grade wall area. The skylight area shall be not greater than 3 percent of the gross roof area.

C402.3.1.1 Increased vertical fenestration area with daylight responsive controls (see Section C405.2.3).
Not more than 40 percent of the gross above-grade wall area shall be vertical fenestration, provided that all of the following requirements are met:

1. In buildings not greater than two stories above grade, not less than 50 percent of the net floor area is within a *daylight zone*.

2. In buildings three or more stories above grade, not less than 25 percent of the net floor area is within a *daylight zone*.

3. *Daylight responsive controls* ~~complying with Section C405.2.3.1~~ are installed in *daylight zones*.

4. Visible transmittance (VT) of vertical fenestration is not less than 1.1 times solar heat gain coefficient (SHGC).

   Exception: Fenestration that is outside the scope of NFRC 200 is not required to comply with Item 4.

C402.3.1.2 Increased skylight area with daylight responsive controls.
The skylight area shall be not more than 6 percent of the roof area provided that *daylight responsive controls* ~~complying with Section C405.2.3.1~~ are installed in *toplit* daylight *zones*.

C402.3.2 Minimum skylight fenestration area.
~~In an enclosed space~~Skylights shall be provided in enclosed spaces greater than 2,500 square feet (232 m^2) in floor area, directly under a roof with not less than 75 percent of the ceiling area with a ceiling height greater than 15 feet (4572 mm), and used as an office, lobby, atrium, concourse, corridor, storage space, gymnasium/exercise center, convention center, automotive service area, space where manufacturing occurs, nonrefrigerated warehouse, retail store, distribution/sorting area, transportation depot or workshop.~~,~~ ~~the~~ The total *toplit daylight zone* shall be not less than half the floor area and shall ~~provide~~ comply with one of the following:

1. A minimum skylight area to *toplit daylight zone* of not less than 3 percent where all skylights have a VT of not less than 0.40, or VT_{annual} of not less than 0.26, as determined in accordance with Section C303.1.3.

2. A minimum skylight effective aperture of not less than 1 percent, determined in accordance with Equation 4-3, of:
   2.1~~.~~ Not less than 1 percent, using a skylight's VT rating; or
   2.2 Not less than 0.66 percent using a Tubular Daylighting Device's VT_{annual} rating.

$$\text{Skylight Effective Aperture} = \frac{0.85 \times \text{Skylight Area} \times \text{Skylight VT} \times \text{WF}}{\text{Toplit Zone}}$$

(Equation 4-3)

where:

Skylight area	=	Total fenestration area of skylights.
Skylight VT	=	Area weighted average visible transmittance of skylights.
WF	=	Area weighted average well factor, where well factor is 0.9 if light well depth is less than 2 feet (610 mm), or 0.7 if light well depth is 2 feet (610 mm) or greater, or 1.0 for Tubular Daylighting Devices with VT_{annual} ratings.~~.~~

Light well depth = Measure vertically from the underside of the lowest point of the skylight glazing to the ceiling plane under the skylight.

Exception: Skylights above *daylight zones* of enclosed spaces are not required in:

1. Spaces where the designed *general lighting* power densities are less than 0.5 W/ft^2 (5.4 W/m^2).

2. Areas where it is documented that existing structures or natural objects block direct beam sunlight on not less than half of the roof over the enclosed area for more than 1,500 daytime hours per year between 8 a.m. and 4 p.m.

3. Spaces where the *daylight zone* under rooftop monitors is greater than 50 percent of the enclosed space floor area.

- ~~4.~~ Spaces where the total area minus the area of ~~sidelight~~ sidelit *daylight zones* is less than 2,500 square feet (232 m^2), and where the lighting is controlled in accordance with Section C405.2.3.

- Spaces designed as storm shelters complying with ICC 500.

C402.3.2.1 Lighting controls in toplit daylight zones.
Daylight responsive controls ~~complying with Section C405.2.3.1~~ shall be provided ~~to control all electric lights within~~ in toplit daylight *zones*.

C402.3.2.2 Haze factor.
Skylights in office, storage, automotive service, manufacturing, nonrefrigerated warehouse, retail store and distribution/sorting area spaces shall have a glazing material or diffuser with a haze factor greater than 90 percent when tested in accordance with ASTM D1003.

Exception: Skylights and tubular daylighting devices designed and installed to exclude direct sunlight entering the occupied space by the use of fixed or automated baffles or the geometry of skylight and light well~~.~~ or the use of optical diffuser components.

C402.3.3 Maximum *U*-factor and SHGC.
The maximum *U*-factor and solar heat gain coefficient (SHGC) for fenestration shall be as specified in Table C402.3.

The window projection factor shall be determined in accordance with Equation 4-4.

$PF = A/B$ **(Equation 4-4)**

where:

PF = Projection factor (decimal).

A	=	Distance measured horizontally from the farthest continuous extremity of any overhang, eave or permanently attached shading device to the vertical surface of the glazing.
B	=	Distance measured vertically from the bottom of the glazing to the underside of the overhang, eave or permanently attached shading device.

Where different windows or glass doors have different *PF* values, they shall each be evaluated separately.

C402.3.3.1 Increased skylight SHGC.
Skylights shall be permitted a maximum SHGC of 0.57 where located above *daylight zones* provided with *daylight responsive controls*.

C402.3.3.2 Increased skylight *U*-factor.
Where skylights are installed above *daylight zones* provided with *daylight responsive controls*, a maximum *U*-factor of 0.72 shall be permitted.

C402.3.3.3 Dynamic glazing.
Where dynamic glazing is intended to satisfy the SHGC and VT requirements of Table C402.3, the ratio of the higher to lower labeled SHGC shall be greater than or equal to 2.4, and the *dynamic glazing* shall be automatically controlled to modulate the amount of solar gain into the space in multiple steps. Dynamic glazing shall be considered separately from other fenestration, and area-weighted averaging with other fenestration that is not dynamic glazing shall not be permitted.

Exception: Dynamic glazing is not required to comply with this section where both the lower and higher labeled SHGC already comply with the requirements of Table C402.3.

C402.3.3.4 Area-weighted *U*-factor.
An area-weighted average shall be permitted to satisfy the *U*-factor requirements for each fenestration product category listed in Table C402.3. Individual fenestration products from different fenestration product categories listed in Table C402.3 shall not be combined in calculating area-weighted average *U*-factor.

C402.3.4 Daylight zones.
Daylight zones referenced in Sections C402.3.1.1 through C402.3.3.2 shall comply with Sections C405.2.3.2 and C405.2.3.3, as applicable. Daylight zones shall include *toplit zones* and sidelit zones.

C402.3.5 Doors.
Opaque swinging doors shall comply with Table C~~402.1(1)~~402.1(2) and Table C402.1(3). Opaque nonswinging doors shall comply with Table C~~402.1(1)~~402.1(2) and Table C402.1(3). Opaque doors shall be considered as part of the gross area of above-grade walls that are part of the building *thermal envelope*. Opaque doors shall comply with Section C402.3.5.1 or C402.3.5.2. Other doors shall comply with the provisions of Section C402.3.3 for vertical fenestration.

C402.3.5.1 Opaque swinging doors. Opaque swinging doors shall comply with Table C402.1(2) and Table C402.1(3).

C402.3.5.2 Nonswinging doors. Opaque nonswinging doors that are horizontally hinged sectional doors with a single row of fenestration shall have an assembly U-factor less than or equal to 0.360, provided that the fenestration area is not less than 14 percent and not more than 25 percent of the total door area.

> **Exception:** Other doors shall comply with the provisions of Section C402.4.3 for vertical fenestration.

C402.4 Air leakage—thermal envelope ~~(Mandatory)~~.

The *building thermal envelope* ~~of buildings~~ shall comply with Sections C402.4.1 through C402.4.~~5~~6.

C402.4.1 Air barriers.

A continuous air barrier shall be provided throughout the building thermal envelope. The continuous air barriers shall be ~~permitted to be~~ located on the inside or outside of the building thermal envelope, located within the assemblies composing the building thermal envelope, or any combination thereof. The air barrier shall ~~either~~ comply with Section C402.4.1.1 ~~or Sections C402.4.1.2 through C402.4.1.8~~.

Exceptions:

1. For buildings larger than 250,000 ft^2 (25,000 m^2), that do not include Group R or Group I occupancies, the air barrier shall either comply with section C402.4.1.1 or Sections C402.4.1.2 through C402.4.1.8.
2. Where air barrier performance testing is determined unfeasible by the Vermont Department of Public Service, the air barrier shall comply with sections C402.4.1.2 through C402.4.1.8.

C402.4.1.1 Air barrier performance testing.

The building *thermal envelope* shall be tested in accordance with ASTM E779, ANSI/RESNET/ICC 380, ASTME3158 OR ASTM E1827 or an equivalent method approved by the Vermont Department of Public Service. The measured air leakage shall not exceed 0.25 cfm/ft^2 of the *building thermal envelope* area at a pressure differential of 0.3 inch water gauge (75 Pa). ~~or an equivalent method approved by the code official or authority having jurisdiction and deemed to comply with the provisions of this section when the tested air leakage rate of the building thermal envelope is not greater than 0.30 cfm/ft² (including the areas of the slab and below grade walls).~~ Alternatively, portions of the building shall be tested and the measured air leakages shall be area weighted by the surface areas of the building envelope in each portion. The weighted average test results shall not exceed the whole building leakage limit. In the alternative approach, the following portions of the building shall be tested:

1. The entire envelope area of all stories that have any spaces directly under a roof.

2. The entire envelope area of all stories that have a building entrance, exposed floor, or loading dock, or are below grade.

~~1.~~3. Representative above-grade sections of the building totaling at least 25 percent of the wall area enclosing the remaining conditioned space.

Exception~~s~~: R-2 *building occupancies* six stories or less shall be tested at a pressure differential of 0.2 inch water gauge (50 Pa), and the measured air leakage shall not exceed 0.15 cfm/ft^2 of the *building thermal envelope* area.

~~1. For buildings having over 50,000 ft^2 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 percent of the wall area enclosing the remaining conditioned space; floor area tested in accordance with Exceptions 1(a) and 1(b) shall not be included in the 25 percent.~~

~~2. Where the measured air leakage rate exceeds 0.30 cfm/ft^2 but does not exceed 0.40 cfm/ft^2, 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.~~

C402.4.1.2 Continuous air barrier commissioning.
Prior to the final inspection, a design professional/Agency shall provide evidence of commissioning of the continuous air barrier by an approved agency. A final commissioning report shall be delivered to the building owner or the owner's representative, and shall include at a minimum:

1. A field inspection checklist showing the requirements necessary for proper installation of the continuous air barrier.

2. Reports from field inspections during project construction showing compliance with continuous air barrier requirements including but not limited to proper material handling and storage, use of approved materials and approved substitutes, proper material and surface preparation, air barrier continuity at building thermal envelope penetrations.

C402.4.1.2.1 Building envelope commissioning guideline.
In addition to complying with C402.4.1.2, projects shall follow all applicable items in Table C402.4.1.2.1.

TABLE C402.4.1.2.1
BUILDING ENVELOPE COMMISIONING CHECKLIST

RELATED SYSTEMS, EQUIPMENT, ASSEMBLIES AND COMPONENTS	TASKS/COMMENTS
Foundations subsoil drainage system	Verify compliance with approved plans, specifications and construction documents.
Foundation damp-proofing and waterproofing	
Flashing at: exterior doors, skylights, wall flashing and drainage systems	
Exterior wall coverings	
Moisture envelopes	Where applicable meet owner's project requirements (OPR), Basis of Design (BOD), Cx Specifications.
Exterior below-grade walls	Check for proper drainage system at exterior wall perimeter to keep water from entering building.
External floor and soffits, slab-on grade	Check for thermal resistance or insulation when required. Slabs: Check drainage for moisture penetration.
Exterior walls	Check drawings for wall assembly requirements.
Exterior glazed window fenestration: windows, glazed doors and sky lights	Drawing reviews and contractor submittal reviews: Check that fenestration products are labeled with a *U*-factor (see NFRC 100) and a solar heat gain coefficient (SHGC) (see NFRC 200), and certification for the air infiltration requirement. Check for proper flashing and caulking at walls and roof Assemblies. Glazed doors: Check for proper flashing, and seals and gaskets; and proper pull force, if provided with a closer. Check for proper door swing.
Site-built fenestration: curtain walls and store-front systems, and atrium roof systems	Check for a label certificate issued by the National Fenestration Rating Council (NFRC) or a label certificate issued by the glazing fabricator that meets the default U-factor and SHGC; or an NFRC component modeling approach (CMA) label certificate or another approved standard. Check for proper door swing.
Field-fabricated fenestrations: fenestration made at the	Check for compliance with the default U-factor and the

site, not pre formed or cut	default SHGC.
Exterior doors	Check for proper flashing installation at header, walls and floor. Check for U-factor requirements for swinging and nonswinging doors. Check for appropriate manufacturer's referenced standard [American Architectural Manufacturer's Association (AAMA); Canadian Standards Association (CSA); and Window and Door Manufacturer's Association (WDMA) or other approved standard] product data sheets.
Sealants, control joints and flashing (stationary and moveable)	Check for proper installation in accordance with the manufacturer's written instructions
Shading devices	Check for proper anchoring to building with proper flashing at wall connections.
Structural systems	Check for proper anchoring in accordance with construction documents, including metal connectors and beam supports.

C402.4.1.3 Air barrier construction.
The *continuous air barrier* shall be constructed to comply with the following:

1. The air barrier shall be continuous for all assemblies that are the thermal envelope of the building and across the joints and assemblies.

2. Air barrier joints and seams shall be sealed, including sealing transitions in places and changes in materials. The joints and seals shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair its ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation.

3. Penetrations of the air barrier shall be caulked, gasketed or otherwise sealed in a manner compatible with the construction materials and location. Sealing shall allow for expansion, contraction and mechanical vibration. Joints and seams associated with penetrations shall be sealed in the same manner or taped. Sealing materials shall be securely installed around the penetration so as not to dislodge, loosen or otherwise impair the penetrations' ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation. Sealing of concealed fire sprinklers, where required, shall be in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.

4. Recessed lighting fixtures shall comply with Section C402.4.1.8. Where similar objects are installed that penetrate the air barrier, provisions shall be made to maintain the integrity of the air barrier.

5. Construction documents shall contain a diagram showing the building's pressure boundary in plan(s) and section(s) and a calculation of the area of the pressure boundary to be considered in the test.

C402.4.1.4 Air barrier compliance options.

A continuous air barrier for the opaque building envelope shall comply with Section C402.4.1.4.1 or C402.4.1.4.2

C402.4.1.4.1 Materials.

Materials with an air permeability not greater than 0.004 cfm/ft^2 (0.02 L/s • m^2) under a pressure differential of 0.3 inch water gauge (75 Pa) when tested in accordance with ASTM E2178 shall comply with this section. Materials in Items 1 through 16 shall be deemed to comply with this section, provided that joints are sealed and materials are installed as air barriers in accordance with the manufacturer's instructions.

1. Plywood with a thickness of not less than $^3/_8$ inch (10 mm).
2. Oriented strand board having a thickness of not less than $^3/_8$ inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than $^1/_2$ inch (12.7 mm).
4. Foil-back polyisocyanurate insulation board having a thickness of not less than $^1/_2$ inch (12.7 mm).
5. Closed-cell spray foam having a minimum density of 1.5 pcf (2.4 kg/m^3) and having a thickness of not less than 1$^1/_2$ inches (38 mm).
6. Open-cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m^3) and having a thickness of not less than 4.5 inches (113 mm).
7. Exterior or interior gypsum board having a thickness of not less than $^1/_2$ inch (12.7 mm).
8. Cement board having a thickness of not less than $^1/_2$ inch (12.7 mm).
9. Built-up roofing membrane.
10. Modified bituminous roof membrane.
11. ~~Fully adhered s~~Single-ply roof membrane.
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than $^5/_8$ inch (15.9 mm).
13. Cast-in-place and precast concrete.
14. Fully grouted concrete block masonry.

15. Sheet steel or aluminum.

16. Solid or hollow masonry constructed of clay or shale masonry units.

C402.4.1.4.2 Assemblies.
Assemblies of materials and components with an average air leakage not greater than 0.04 cfm/ft^2 (0.2 L/s • m^2) under a pressure differential of 0.3 inch of water gauge (w.g.)(75 Pa) when tested in accordance with ASTM E2357, ASTM E1677, ASTM D8052 or ASTM E283 shall comply with this section. Assemblies listed in Items 1 through 3 shall be deemed to comply, provided that joints are sealed and the requirements of Section C402.4.1.3 are met.

1. Concrete masonry walls coated with either one application of block filler or two applications of a paint or sealer coating.

2. Masonry walls constructed of clay or shale masonry units with a nominal width of 4 inches (102 mm) or more.

3. A Portland cement/sand parge, stucco or plaster not less than $^1/_2$ inch (12.7 mm) in thickness.

C402.4.1.5 Air leakage of fenestration.
The air leakage of fenestration assemblies shall meet the provisions of Table C402.4.1.5. Testing shall be in accordance with the applicable reference test standard in Table C402.4.1.5 by an accredited, independent testing laboratory and *labeled* by the manufacturer.

Exception: Field-fabricated fenestration assemblies that are sealed in accordance with Section C402.4.1.

TABLE C402.4.1.5
MAXIMUM AIR LEAKAGE RATE
FOR FENESTRATION ASSEMBLIES

FENESTRATION ASSEMBLY	MAXIMUM RATE (CFM/FT^2)	TEST PROCEDURE
Windows	0.20 [a]	AAMA/WDMA/ CSA101/I.S.2/A440 or NFRC 400
Sliding doors	0.20 [a]	
Swinging doors	0.20 [a]	
Skylights – with condensation weepage openings	0.30	
Skylights – all other	0.20 [a]	
Curtain walls	0.06	NFRC 400 or
Storefront glazing	0.06	

Commercial glazed swinging entrance doors	1.00	ASTM E283 at 1.57 psf (75 Pa)
Power-operated sliding doors and power-operated folding doors	1.00	
Revolving doors	1.00	
Garage doors	0.40	ANSI/DASMA 105, NFRC 400, or ASTM E283 at 1.57 psf (75 Pa)
Rolling doors	1.00	
High-speed doors	1.30	

For SI: 1 cubic foot per minute = 0.47 L/s, 1 square foot = 0.093 m^2.

a. The maximum rate for windows, sliding and swinging doors, and skylights is permitted to be 0.3 cfm per square foot of fenestration or door area when tested in accordance with AAMA/WDMA/CSA101/I.S.2/A440 at 6.24 psf (300 Pa).

C402.4.1.6 Rooms containing fuel-burning appliances that are not direct vented. Where combustion air is supplied through openings in an exterior wall to a room or space containing a space-conditioning fuel-burning appliance, one of the following shall apply:

1. The room or space containing the appliance shall be located outside of the *building thermal envelope*.

2. The room or space containing the appliance shall be enclosed and isolated from conditioned spaces inside the building thermal envelope. Such rooms shall comply with all of the following:

   2.1. The walls, floors and ceilings that separate the enclosed room or space from conditioned spaces shall be insulated to be not less than equivalent to the insulation requirement of below-grade walls as specified in Table C~~402.1(1)~~402.1(2) and Table C402.1(3).

   2.2. The walls, floors and ceilings that separate the enclosed room or space from conditioned spaces shall be sealed in accordance with Section C402.4.1.3.

   2.3. The doors into the enclosed room or space shall be fully gasketed.

   2.4. Water lines and ducts in the enclosed room or space shall be insulated in accordance with Section C403.

   2.5. Where an air duct supplying combustion air to the enclosed room or space passes through conditioned space, the duct shall be insulated to an *R*-value of not less than R-10.

Exception: Fireplaces and stoves complying with Section 2111.14 of the *International Building Code*.

C402.4.1.7 Doors and access openings to shafts, chutes, stairways and elevator lobbies.
Doors and *access* openings from conditioned space to shafts, chutes stairways and

elevator lobbies not within the scope of the fenestration assemblies covered by Section C402.4.1.5 shall be gasketed, weather-stripped or sealed.

Exceptions:

1. Door openings required to comply with Section 716 of the *International Building Code*.

2. Doors and door openings required to comply with UL 1784 by the *International Building Code*.

C402.4.1.8 Recessed lighting.
Recessed luminaires and any other building component installed in the *building thermal envelope* shall be all of the following:

1. IC-rated.

2. Labeled as having an air leakage rate of not more 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E283 at a 1.57 psf (75 Pa) pressure differential.

3. Sealed with a gasket or caulk between the housing and interior wall or ceiling covering.

C402.4.2 Dwelling and sleeping unit ~~air infiltration~~enclosure testing.

The *building thermal envelope* shall be tested in accordance with ASTM E779, ANSI/RESNET/ICC 380, ASTM E1827 or an equivalent method approved by the code official. The measured air leakage shall not exceed 0.15 cfm/ft^2 (1.5 L/s m^2) of the testing unit enclosure area at a pressure differential of 0.2 inch water gauge (50 Pa). Where multiple dwelling units or sleeping units or other occupiable conditioned spaces are contained within one building thermal envelope, each unit shall be considered an individual testing unit, and the building air leakage shall be the weighted average of all testing unit results, weighted by each testing unit's enclosure area. Units shall be tested separately with an unguarded blower door test as follows:

1. Where buildings have fewer than eight testing units, each testing unit shall be tested.
2. For buildings with eight or more testing units, the greater of seven units or 20 percent of the testing units in the building shall be tested, including a top floor unit, a ground floor unit and a unit with the largest testing unit enclosure area. For each tested unit that exceeds the maximum air leakage rate, an additional two units shall be tested, including a mixture of testing unit types and locations.

~~A sampling of dwelling units shall be tested in accordance with ASTM E779 at a pressure differential of 0.3 inch water gauge (75 Pa) or an equivalent method approved by the code official or authority having jurisdiction and deemed to comply when the tested air leakage rate of each dwelling unit is not greater than 0.35 cfm/ft^2. For purposes of this section, enclosure surface area of a unit means the total surface area of all walls, floors, and ceiling, even if below~~

~~grade. Testing and inspection shall be conducted by a third-party design professional/agency. A written report of the test results shall be signed by the party conducting the test and provided to the building owner or owner's representative. Testing shall be performed at any time after completion of all penetrations of the dwelling unit's thermal envelope. The sampling of dwelling units tested shall include at least 10 percent of the dwelling units in each building, at least one unit per floor, at least one corner unit, and approximately an equal number of units on each floor level. Each of these units must be tested and pass without a failure. If a failure occurs, items causing the failure must be diagnosed, and corrected, and the unit retested until it passes. A minimum of at least two additional units in the same building must also be tested and pass. During testing:~~

~~1. The tested units will be randomly selected, and the construction contractor will not have prior knowledge as to which units will be tested.~~

~~2. Exterior windows and doors, fireplace doors and stove doors shall be closed, but not sealed beyond the intended weather stripping or other infiltration control measures.~~

~~3. Dampers, including exhaust, intake, makeup air, backdraft and flue dampers, shall be closed, but not sealed beyond intended infiltration control measures.~~

~~4. Interior doors, if installed at the time of the test, shall be open.~~

~~5. Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed.~~

~~6. Heating and cooling systems, if installed at the time of the test, shall be turned off.~~

~~7. Supply and return registers, if installed at the time of the test, shall be fully open.~~

C402.4.3 Air intakes, exhaust openings, stairways and shafts.
Stairway enclosures, elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be provided with dampers in accordance with Section C403.7.7.

C402.4.4 Loading dock weather seals.
Cargo door openings and loading door openings shall be equipped with weather seals that restrict infiltration and provide direct contact along the top and sides of vehicles that are parked in the ~~opening~~doorway. If equipped with an interior dock leveler, the deck of the leveler, ~~and~~ rear pit wall, and the deck plate shall be insulated with a minimum of 1.5 inches of sprayed closed cell foam. The side pit walls and pit slab shall be insulated in accordance with the ASTM E283 slab on grade standard found in Table C~~402.1(1)~~402.1(2) and Table C402.1(3). The spaces between the pit wall and the deck skirts for the leveler shall be weather-stripped. Provide each dock board with an exterior face closure curtain to reduce air infiltration under the dock board.

C402.4.5 Vestibules.
Building entrances shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time. The installation of one or more revolving doors in the building entrance shall not eliminate the requirement that a vestibule be provided on any doors adjacent to revolving doors. Interior and exterior doors shall have a minimum distance between them of not less than 7 feet (2134 mm). The exterior envelope of conditioned vestibules shall comply with the requirements for a conditioned space. Either the interior or exterior envelope of unconditioned vestibules shall comply with the requirements for a conditioned space.

Exception: Vestibules are not required for the following:

1. Doors not intended to be used by the public or common occupants of the building, such as doors to mechanical or electrical equipment rooms.
2. Doors opening directly from a *sleeping unit* or dwelling unit.
3. Doors that open directly from a space less than 3,000 square feet (279 m^2) in area.
4. Revolving doors, where a required adjacent accessible entry has a complying vestibule enclosure.
5. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.
6. Doors that have an air curtain with a velocity of not less than 6.56 feet per second (2 m/s) at the floor that have been tested in accordance with ANSI/AMCA 220 and installed in accordance with the manufacturer's instructions. Manual or automatic controls shall be provided that will operate the air curtain with the opening and closing of the door. Air curtains and their controls shall comply with Section C407.2.3.
7. Elevator doors in parking garages provided that the elevators have an enclosed lobby at each level of the garage.
8. Doors opening directly from a semi-conditioned space.

C402.4.5.1 Vestibule tempering.
Where vestibule space tempering is included, a maximum temperature setting of 55°F

(13°C) for heating mode shall be utilized. Mechanical cooling of vestibules is prohibited.

C402.4.5.2 Vestibule thermostatic controls.
Vestibules meeting the requirements of Section C402.4.5.1 shall be zoned separately from the conditioned building. Thermostats located inside vestibules shall be programmable, and one of the following:

1. Tamper-proof.

2. Placed in a location inaccessible to the general public.

Exception: Vestibule spaces served by radiant floor heating may utilize a nonprogrammable thermostat.

C402.4.6 Operable openings interlocking. Where occupancies utilize operable openings to the outdoors that are larger than 40 square feet (3.7 m^2) in area, such openings shall be interlocked with the heating and cooling system so as to raise the cooling setpoint to 90°F (32°C) and lower the heating setpoint to 55°F (13°C) whenever the operable opening is open. The change in heating and cooling setpoints shall occur within 10 minutes of opening the operable opening.

Exceptions:

1. Separately zoned areas associated with the preparation of food that contain appliances that contribute to the HVAC loads of a restaurant or similar type of occupancy.
2. Warehouses that utilize overhead doors for the function of the occupancy.
3. The first entrance doors where located in the exterior wall and are part of a vestibule system.

C402.4.6.1 Operable controls. Controls shall comply with Section C403.14.

C402.5 Solar-ready zone

C402.5.1 General.
A solar-ready zone shall be located on the roof of buildings and are oriented between 110 degrees and 270 degrees of true north or have low-slope roofs. Solar-ready zones shall comply with Sections C402.5.2 through C402.5.8.

Exceptions:

1. A building with a permanently installed, on-site renewable energy system.

2. A building with a solar-ready zone that is shaded for more than 70 percent of daylight hours annually.

3. A building where the licensed design professional certifies that the incident solar radiation available to the building is not suitable for a solar-ready zone.

4. A building where the licensed design professional certifies that the solar zone area required by Section C402.5.3 cannot be met because of extensive rooftop equipment, skylights, vegetative roof areas or other obstructions.

C402.5.2 Construction document requirements for a solar-ready zone.
Construction documents shall indicate the solar-ready zone.

C402.5.3 Solar-ready zone area.
The total solar-ready zone area shall be not less than 40 percent of the roof area calculated as the horizontally projected gross roof area less the area covered by skylights, occupied roof decks, vegetative roof areas and mandatory access or set back areas as required by the *International Fire Code*. The solar-ready zone shall be a single area or smaller, separated sub-zone areas. Each sub-zone shall be not less than 5 feet (1524 mm) in width in the narrowest dimension.

C402.5.4 Obstructions.
Solar ready zones shall be free from obstructions, including pipes, vents, ducts, HVAC equipment, skylights and roof-mounted equipment.

C402.5.5 Roof loads and documentation.
A collateral dead load of not less than 5 pounds per square foot (5 psf) (24.41 kg/m^2) shall be included in the gravity and lateral design calculations for the solar-ready zone. The structural design loads for roof dead load and roof live load shall be indicated on the construction documents.

C402.5.6 Interconnection pathway.
Construction documents shall indicate pathways for routing of conduit or piping from the solar-ready zone to the electrical service panel and electrical energy storage system area or service hot water system.

C402.5.7 Electrical energy storage system-ready area.
The floor area of the electrical energy storage system-ready area shall be not less than 2 feet (610 mm) in one dimension and 4 feet (1219 mm) in another dimension and located in accordance with rules adopted by Vermont fire safety code. The location and layout diagram of the electrical energy storage system-ready area shall be indicated on the construction documents.

C402.5.8 Electrical service reserved space.
The main electrical service panel shall have a reserved space to allow installation of a dual-pole circuit breaker for future solar electric and a dual-pole circuit breaker for future electrical energy storage system installation. These spaces shall be labeled “For Future Solar Electric and Storage.” The reserved spaces shall be positioned at the end of the panel that is opposite from the panel supply conductor connection.

SECTION C403
BUILDING MECHANICAL SYSTEMS

C403.1 General.
In addition to the mechanical requirements of Section C403, projects must achieve the required number of credits based on building occupancy group as outlined in Table C406.1.1 and Table

C406.1.2. To achieve the required credits, mechanical enhancements may be needed ~~to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406~~.

The requirements of C403 that may be affected and the corresponding C406 references are summarized in Table C403.1(1). For a full list of potential measures see Table C406.2.1 and Table C406.3.1.

TABLE C403.1(1): C406 MEASURES AFFECTING MECHANICAL SYSTEMS

ID	**C406 Measure Title**	**C403 Reference**	**C406 Section**
H01	HVAC Performance	n/a	C406.2.2.1
H02	Heating efficiency	C403.3.2	C406.2.2.2
H03	Cooling efficiency	C403.3.2	C406.2.2.3
H04	Residential HVAC control	C403.7.6	C406.2.2.4
H05	Energy Recovery	C403.7.3	C406.2.2.5
Q04	Fault Detection	C403.2.3	C406.2.4
G02	HVAC Load Management	n/a	C406.3.3
G05	Cooling Energy Storage	n/a	C406.3.6
G07	Building Thermal Mass	n/a	C406.3.8

Mechanical systems and equipment serving the building heating, cooling, ventilating or refrigerating needs shall comply with ~~this section.~~one of the following:

1. Sections C403.1.1 and C403.2 through C403.14
2. Data Centers shall comply with C403.1.1, C403.1.2 and C403.6 through C403.14
3. Section C403.1.3 and Sections within Section C403 that are listed in Table C407.2

Exception: Data center systems are exempt from the requirements of Sections C403.4 and C403.5.

C403.1.1 Calculation of heating and cooling loads.
Design loads associated with heating, ventilating and air conditioning of the building shall be determined in accordance with ANSI/ASHRAE/ACCA Standard 183 or by an *approved* equivalent computational procedure using the design parameters specified in Chapter 3. Heating and cooling loads shall be adjusted to account for load reductions that are achieved where energy recovery systems are utilized in the HVAC system in accordance with the ASHRAE *HVAC Systems and Equipment Handbook* by an approved equivalent computational procedure.

C403.1.2 Data centers. Data center systems shall comply with Sections 6 and 8 of **ASHRAE 90.4** with the following changes:

1. Replace maximum design mechanical load component (MLC) values specified in Table 6.2.1.1 of the ASHRAE 90.4 with the values in Table C403.1.2(1) ~~as applicable in each climate zone~~.
2. Replace maximum annualized MLC values specified in Table 6.2.1.2 of the ASHRAE 90.4 with the values in Table C403.1.2(2) ~~as applicable in each climate zone~~.

TABLE C403.1.2(1)

MAXIMUM DESIGN MECHANICAL LOAD COMPONENT (DESIGN MLC)

CLIMATE ZONE	DESIGN MLC AT 100% AND AT 50% ITE LOAD
6A	0.22

TABLE C403.1.2(2)
MAXIMUM ANNUALIZED MECHANICAL LOAD COMPONENT (ANNUALIZED MLC)

CLIMATE ZONE	HVAC MAXIMUM ANNUALIZED MLC AT 100% AND AT 50% ITE LOAD
6A	0.17

C403.1.3 HVAC total system performance ratio (HVAC TSPR).

HVAC systems serving buildings or portions of buildings listed in C403.1.3.1 that are not served by systems listed in C403.1.3.2 shall have an HVAC total system performance ratio (HVAC TSPR) of the proposed design HVAC systems that is greater than or equal to the HVACTSPR of the standard reference design divided by the applicable mechanical performance factor (MPF) from Table C408.3.1. HVAC TSPR shall be calculated in accordance with Section C408, Calculation of HVAC Total System Performance Ratio. Systems using the HVAC TSPR method shall also meet requirements in C403.1.3.3.
C403.1.3.1 Included Building Types. HVAC systems that serve the following building use types are allowed to use the TSPR Method:

1. occupancy group B,
2. occupancy group M,
3. occupancy group A-3,
4. occupancy group E,
5. occupancy group R-1,
6. the dwelling units and common areas within occupancy group R-2 multifamily buildings.

C403.1.3.2 Excluded Systems. The following HVAC systems are excluded from using the TSPR Method:

1. HVAC Systems using
   - 1.1 district heating water, chilled water or steam
   - 2.1 small duct high velocity air cooled, space constrained air cooled, single package vertical air conditioner, single package vertical heat pump, or
   - 3.1 double-duct air conditioner or double-duct heat pump as defined in subpart F to 10CFR part 431
   - 4.1 packaged terminal air conditioners and packaged terminal heat pumps that have cooling capacity greater than 12,000 Btu/hr 5.(3500 kW)
   - 5.1 a common heating source serving both HVAC and service water heating equipment, or
2. HVAC systems that provide recovered heat for service water heating
3. HVAC systems not included in Table C408.5.2.10.1
4. HVAC systems included in table C408.5.2.10.1 with parameters in Table C408.5.2.10.2, not identified as applicable to that HVAC system type.

5. HVAC systems with chilled water supplied by absorption chillers, heat recovery chillers, water to water heat pumps, air to water heat pumps, or a combination of air and water cooled chillers on the same chilled water loop.
6. HVAC systems served by heating water plants that include air to water or water to water heat pumps.
7. Underfloor air distribution and displacement ventilation HVAC systems.
8. Space conditioning systems that do not include mechanical cooling.
9. HVAC systems serving laundry rooms, elevator rooms, mechanical rooms, electrical rooms, data centers, and computer rooms.
10. Buildings or areas of medical office buildings that comply fully with ASHRAE Standard 170, including but not limited to surgical centers, or that are required by other applicable codes or standards to provide 24/7 air handling unit operation
11. HVAC systems serving laboratories with fume hoods
12. Locker rooms with more than 2 showers
13. Natatoriums and rooms with saunas
14. Restaurants and commercial kitchens with total cooking capacity greater than 100,000 Btu/h
15. Areas of buildings with commercial refrigeration equipment exceeding 100 kW of power input.
16. Cafeterias and dining rooms

C403.1.3.3 TSPR Method Partial Prescriptive Requirements. HVAC systems using the HVAC Performance Rating Method shall meet relevant prescriptive requirements in Section C403 as follows:

1. Air economizers shall meet the requirements of Section C403.5.3.4 “relief of excess outdoor air” and Section C403.5.5 “Economizer fault detection and diagnostics.”
2. Variable-air-volume system systems shall meet requirements of Sections C403.6.5, C403.6.6, and C403.6.9.
3. Hydronic systems shall meet the requirements of C403.4.4.
4. Plants with multiple chillers or boilers shall meet the requirements of Section C403.4.5.
5. Hydronic (Water Loop) Heat Pumps and Water-Cooled Unitary Air Conditioners shall meet the requirements of Section C403.4.3.3.
6. Cooling tower turndown shall meet requirements of Section C403.10.4.
7. Heating of unenclosed spaces shall meet the requirements of Section C403.13.1.
8. Hot-gas bypass shall meet the requirements of Section C403.3.3.
~~1.~~ 9. Systems shall meet the operable openings interlock requirements of Section C402.5.11.10.
10. Refrigeration systems shall meet the requirements of Section C403.11.

C403.2 System design ~~(Mandatory).~~
Mechanical systems shall be designed to comply with Sections C403.2.1 through C403.2.3~~4.~~ Where elements of a building’s mechanical systems are addressed in Sections C403.3 through C403.14~~2~~, such elements shall comply with the applicable provisions of those sections.

C403.2.1 Zone isolation required ~~(Mandatory).~~

HVAC systems serving *zones* that are over 25,000 square feet (2323 m^2) in floor area or that span more than one floor and are designed to operate or be occupied nonsimultaneously shall be divided into isolation areas. Each isolation area shall be equipped with *isolation devices* and controls configured to automatically shut off the supply of conditioned air and outdoor air to and exhaust air from the isolation area. Each isolation area shall be controlled independently by a device meeting the requirements of Section C403.4.2.2. Central systems and plants shall be provided with controls and devices that will allow system and equipment operation for any length of time while serving only the smallest isolation area served by the system or plant.

Exceptions:

1. Exhaust air and outdoor air connections to isolation areas where the fan system to which they connect is not greater than 5,000 cfm (2360 L/s).

2. Exhaust airflow from a single isolation area of less than 10 percent of the design airflow of the exhaust system to which it connects.

3. Isolation areas intended to operate continuously or intended to be inoperative only when all other isolation areas in a *zone* are inoperative.

C403.2.2 Ventilation ~~(Mandatory).~~
Ventilation, either natural or mechanical, shall be provided in accordance with ~~Chapter 4 of the International Mechanical Code~~. ASHRAE Standard 62.1. Where mechanical ventilation is provided, the system shall provide the capability to reduce the outdoor air supply to the minimum required by ~~Chapter 4 of the International Mechanical Code~~ ASHRAE Standard 62.1. The design professional shall utilize ventilation rates based on the expected occupancy level of the space. Life safety maximum allowable occupancy density shall not be used as a ventilation basis of design.

Exception: All Residential occupancies. See the ventilation requirements of Section 304 of the *Vermont Residential Building Energy Standards*.

C403.2.3 Electric resistance space heating.
Building heating with electrical resistance units, including baseboard radiation, heat pump reheat coils, duct coils, boilers, outdoor air intake grids, and coils in terminal units and air systems, is prohibited.

Exceptions:

1. Areas, such as stairways, that are not permitted to be penetrated with piping or duct and no other method of heating is possible.

2. Special conditions of occupancy or use that require electrical resistance heat to maintain health, safety or environmental conditions.

3. Limited areas where a practical application of resistance electrical heat is demonstrated (e.g., small interior space such as a restroom which is distant from the distribution system, hazardous material storerooms, stairwell or other means of emergency egress).

4. Multifamily buildings with heating loads less than or equal to 6.0 Btu/hour/square foot at design temperature.*

5. *Cold-Climate Heat Pump* where:*

5.1 The full heating demand can be met with the heat pump at an outside air temperature of 5°F (-15°C).

5.2 The supplemental electric resistance heat is controlled to prevent it from operating at an outside air temperature of 5°F (-15°C) or higher.

5.3 The building thermal envelope shall be tested in accordance with ASTM E779 at a pressure differential of 0.3 inch water gauge (75 Pa) and deemed to comply with the provisions of Section C402.4.1 when the tested air leakage rate of the building thermal envelope is not greater than 0.~~20~~ 15 cfm/ft^2 (including the areas of the slab and below grade walls).

*Buildings served by the City of Burlington Electric (BED) must also receive approval from BED before installing electric resistance heating equipment.

C403.2.4~~3~~ Fault detection and diagnostics. New buildings with an HVAC system serving a gross conditioned floor area of 100,000 square feet (9290 m2) or larger shall include a fault detection and diagnostics (FDD) system to monitor the HVAC system's performance and automatically identify faults. The FDD system shall:

1. Include permanently installed sensors and devices to monitor the HVAC system's performance.
2. Sample the HVAC system's performance at least once every 15 minutes.
3. Automatically identify and report HVAC system faults.
4. Automatically notify authorized personnel of identified HVAC system faults.
5. Automatically provide prioritized recommendations for repair of identified faults based on analysis of data collected from the sampling of HVAC system performance.
6. Be capable of transmitting the prioritized fault repair recommendations to remotely located authorized personnel.

Exception: R-1 and R-2 occupancies.

C403.2.5~~4~~ Mechanical systems commissioning and completion requirements. Mechanical systems shall be commissioned and completed in accordance with Section C407.

C403.3 Heating and cooling equipment efficiencies ~~**(Mandatory).**~~
Heating and cooling equipment installed in mechanical systems shall be sized in accordance with Section C403.3.1 and shall be not less efficient in the use of energy than as specified in Section C403.3.2.

C403.3.1 Equipment sizing ~~**(Mandatory).**~~
The output capacity of heating and cooling equipment shall be not greater than that of the smallest available equipment size that exceeds the loads calculated in accordance with Section C403.1.1. A single piece of equipment providing both heating and cooling shall satisfy this provision for one function with the capacity for the other function as small as possible, within available equipment options. Heating and cooling equipment sizing is permitted to be up to 10 percent greater (to the next nearest available size) than the calculated peak heating and cooling loads to allow for building pickup and cool down after temperature setback conditions or for proper airflow volumes. Heat pump equipment shall not be sized greater than the calculated peak heating and cooling loads, as they are exempt from temperature setbacks and are

significantly less efficient when oversized. Outdoor condensing units serving multiple indoor heat pump units shall be sized equal or less than the total capacity of the indoor units

Exceptions:

1. Required standby equipment and systems provided with controls and devices that allow such systems or equipment to operate automatically only when the primary equipment is not operating.

2. Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that are configured to sequence the operation of each unit based on load.

C403.3.2 HVAC equipment performance requirements ~~**(Mandatory).**~~
Equipment shall meet the minimum efficiency requirements of Tables C403.3.2(1) through C403.3.2(16~~11~~) when tested and rated in accordance with the applicable test procedure. Plate-type liquid-to-liquid heat exchangers shall meet the minimum requirements of AHRI 400 ~~Table C403.3.2(12)~~. The efficiency shall be verified through certification under an approved certification program or, where a certification program does not exist, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements. Where components, such as indoor or outdoor coils, from different manufacturers are used, calculations and supporting data shall be furnished by the designer that demonstrates that the combined efficiency of the specified components meets the requirements herein.

TABLE C403.3.2(1)
~~**MINIMUM EFFICIENCY REQUIREMENTS:**~~
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS – MINIMUM EFFICIENCY REQUIREMENTS[c, d]

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air conditioners, air cooled	< 65,000 Btu/h[b]	All	Split system, three phase ~~and applications outside US single phase[b]~~	13.0 SEER before 1/1/2023 13.4 SEER2 after 1/1/2023	AHRI 210/240-2017 before 1/1/23 AHRI 210/240 – 2023 after 1/1/2023
			Single package, three phase ~~and applications outside US single phase[b]~~	14.0 SEER before 1/1/2023 13.4 SEER2 after 1/1/23	
Space constrained, aircooled	≤30,000 Btu/h[b]	All	Split System, three phase ~~and applications~~	12.0 SEER before 1/1/2023	AHRI 210/240 – 2017 before 1/1/2023

			~~outside US single phase~~[b]	11.7 SEER2 after 1/1/2023	AHRI 210/240 – 2023 after 1/1/2023
			Single package, three phase ~~and applications outside US single phase~~[b]	12.0 SEER before 1/1/2023 11.7 SEER2 after 1/1/2023	
~~Through-the-wall (air cooled)~~	~~≤ 30,000 Btu/h~~[b]	~~All~~	~~Split system~~	~~12.0 SEER~~	
			~~Single Package~~	~~12.0 SEER~~	
Small-duct, high-velocity, (air cooled)	< 65,000 Btu/h[b]	All	Split System, three phase ~~and applications outside US single phase~~[b]	12~~1~~.0 SEER before 1/1/2023 12.1 SEER2 after 1/1/2023	AHRI 210/240 – 2017 before 1/1/2023 AHRI 210/240 – 2023 after 1/1/2023
Air conditioners, air cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)~~None~~	~~Split System and Single Package~~ ~~Split System and Single Package~~	11.2 EER 12.9~~8~~ IEER before 1/1/2023 14.8 IEER after 1/1/2023	AHRI 340/360
		All other~~Non-Electric~~[c]	~~Split System and Single Package~~ ~~Split System and Single Package~~	11.0 EER 12.7~~6~~ IEER before 1/1/2023 14.6 IEER after 1/1/2023	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)~~None~~	~~Split System and Single Package~~ ~~Split System and Single Package~~	11.0 EER 12.4 IEER before 1/1/2023 14.2 IEER after 1/1/2023	
		~~Non-Electric~~[c] All other	~~Split System and Single Package~~ ~~Split System and Single Package~~	10.8 EER 12.2 IEER before 1/1/2023 14.0 IEER after 1/1/2023	
	≥ 240,000 Btu/h and < 760,000 Btu/h	~~None~~Electric resistance (or none)	Split system and single package	10.0 EER 11.6 IEER before 1/1/2023	

				13.2 IEER after 1/1/2023	
		~~Non-Electric~~[c] All other		9.8 EER 11.4 IEER before 1/1/2023 13.0 IEER after 1/1/2023	
	~~□~~≥ 760,000 Btu/h	~~None~~ Electric resistance (or none)		9.7 EER 11.2 IEER before 1/1/2023 12.5 IEER after 1/1/2023	
		~~Non-Electric~~[c] All other		9.5 EER 11.0 IEER before 1/1/2023 12.3 IEER after 1/1/2023	
Air conditioners, water cooled	< 65,000 Btu/h ~~[b]~~	All	~~Split System and Single Package~~	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	~~None~~Electric resistance (or none)	~~Split System and Single Package~~	12.1 EER 13.9 IEER	AHRI 340/360
		All other~~Non-Electric~~[c]	~~Split System and Single Package~~	11.9 EER 13.7 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	~~None~~Electric resistance (or none)	~~Split System and Single Package~~	12.5 EER 13.9 IEER	
		All other~~Non-Electric~~[c]	~~Split System and Single Package~~	12.3 EER 13.7 IEER	
	~~□~~≥ 240,000 Btu/h and < 760,000 Btu/h	~~None~~Electric resistance (or none)	~~Split System and Single Package~~	12.4 EER 13.6 IEER	
		~~Non-Electric~~[c] All other	~~Split System and Single Package~~	12.2 EER 13.4 IEER	
	~~□~~≥ 760,000 Btu/h	~~None~~Electric resistance (or none)	~~Split System and Single Package~~	12.2 EER 13.5 IEER	
		~~Non-Electric~~[c] All other	~~Split System and Single Package~~	12.0 EER 13.3 IEER	

			~~Split System and Single Package~~Split system and single package		

~~(continued)~~

TABLE C403.3.2(1)—continued
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air conditioners, evaporatively cooled	< 65,000 Btu/h[b]	All	~~Split System and Single Package~~ ~~Split System and Single Package~~ ~~Split System and Single Package~~ ~~Split System and Single Package~~ ~~Split System and Single Package~~ ~~Split System and Single Package~~ ~~Split System and Single Package~~ ~~Split System and Single Package~~ Split system and single package	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)~~None~~		12.1 EER 12.3 IEER	AHRI 340/360
		All other~~Non-Electric[c]~~		11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)~~None~~		12.0 EER 12.2 IEER	
		All other~~Non-Electric[c]~~		11.8 EER 12.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric resistance (or none)~~None~~		11.9 EER 12.1 IEER	
		All other~~Non-Electric[c]~~		11.7 EER 11.9 IEER	
	≥ 760,000 Btu/h	Electric resistance (or none)~~None~~		11.7 EER 11.9 IEER	
		All other~~Non-Electric[c]~~		11.5 EER 11.7 IEER	
Condensing units, air cooled	≥ 135,000 Btu/h	—	—	10.5 EER 11.8 IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h	—	—	13.5 EER 14.0 IEER	AHRI 365
Condensing units, evaporatively cooled	≥ 135,000 Btu/h	—	—	13.5 EER 14.0 IEER	AHRI 365

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the reference year version of the test procedure.

~~b. Single-phase, air-cooled air conditioners less than 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.~~

~~c. Electric resistance space heating is prohibited per Section C403.2.3. Use "None" Heating Section Type category for exceptions to Section C403.2.3.~~

b. Single-phase, US air-cooled air conditioners less than 65,000 Btu/h are regulated as consumer products by the US Department of Energy Code of Federal Regulations DOE 10 CFR 430. SEER and SEER2 values for single-phase products are set by the US Department of Energy.

c. DOE 10 CFR 430 Subpart B Appendix M1 includes the test procedure updates effective 1/1/2023 that will be incorporated in AHRI 210/240—2023.

d. This table is a replica of ASHRAE 90.1 Table 6.8.1-1 Electrically Operated Unitary Air Conditioners and

Condensing Units—Minimum Efficiency Requirements.

TABLE C403.3.2(2)
~~MINIMUM EFFICIENCY REQUIREMENTS:~~
ELECTRICALLY OPERATED AIR-COOLED UNITARY ~~AND APPLIED~~ HEAT PUMPS - MINIMUM EFFICIENCY REQUIREMENTS[c, d]

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (cooling mode)	< 66~~5~~,000 Btu/h[~~b~~]	All	Split s~~S~~ystem, three phase and applications outside US single phase[b]	14.0 SEER before 1/1/2023 14.3 SEER2 after 1/1/2023	AHRI 210/240 – 2017 before 1/1/2023 AHRI 210/240 – 2023 after 1/1/2023
			Single p~~P~~ackage, three phase and applications outside US single phase[b]	14.0 SEER before 1/1/2023 13.4 SEER2 after 1/1/2023	
Space constrained, air cooled (cooling mode)~~Through-the-wall, air cooled~~	≤ 30,000 Btu/h[~~b~~]	All	Split system, three phase and applications outside US single phase[b]~~Split System~~	12.0 SEER before 1/1/2023 11.7 SEER2 after 1/1/2023	
			Single package, three phase and applications outside US single phase[b]~~Single Package~~	12.0 SEER before 1/1/2023 11.7 SEER2 after 1/1/2023	
Single-duct, high-velocity, air cooled (cooling mode)	< 65,000 Btu/h[~~b~~]	All	Split system, three phase and applications outside US single phase[b]~~Split System~~	12.0 SEER before 1/1/2023 12.0 SEER2 after 1/1/2023~~11.0 SEER~~	
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	~~None~~Electric resistance (or none)	~~Split System and Single Package Split System and Single Package Split System and Single Package Split System and Single Package Split System and Single Package~~ Split system and single package	11.0 EER 12.2~~0~~ IEER before 1/1/2023 14.1 IEER after 1/1/2023	AHRI 340/360
		All other~~Non-Electric~~[~~c~~]		10.8 EER ~~11.8~~12.0 IEER before 1/1/2023 13.9 IEER after 1/1/2023	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)~~None~~		10.6 EER 11.6 IEER before 1/1/2023	

				13.5 IEER after 1/1/2023	
		All other~~Non-Electric[c]~~		10.4 EER 11.4 IEER before 1/1/2023 13.3 IEER after 1/1/2023	
	≥ 240,000 Btu/h	Electric resistance (or none)~~None~~		9.5 EER 10.6 IEER before 1/1/2023 12.5 IEER after1/1/2023	
		All other~~Non-Electric[c]~~		9.3 EER 10.4~~9.4~~ IEER before 1/1/2023 12.3 IEER after 1/1/2023	
Air cooled (heating mode)	<65,000 Btu/hr	All	Split system, three phase and applications outside US single phase[b]	8.2 HSPF before 1/1/2023 7.5 HSPF2 after 1/1/2023	AHRI 210/240 – 2017 before 1//2023 AHRI 210/240-2023 after 1/1/2023
			Single package, three phase and applications outside US single phase[b]	8.0 HSPF before 1/1/2023 6.7 HSPF2 after 1/1/2023	
Space constrained, air cooled (heating mode)	≤30,000 Btu/hr	All	Split system, three phase and applications outside US single phase[b]	7.4 HSPF before 1/1/2023 6.3 HSPF2 after 1/1/2023	AHRI 210/240 – 2017 before 1//2023 AHRI 210/240-2023 after 1/1/2023
			Single package, three phase and applications outside US single phase[b]	7.4 HSPF before 1/1/2023 6.3 HSPF2 after 1/1/2023	
Small duct, high velocity, air cooled (heating mode)	<65,000 Btu/hr	All	Split system, three phase and applications outside US single phase[b]	3.30 COP_H before 1/1/2023 3.40 COP_H after 1/1/2023	AHRI 210/240 – 2017 before 1//2023 AHRI 210/240-2023 after 1/1/2023
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling Capacity)	All	47°F db/43°F wb outdoor air	3.30 COP_H before 1/1/2023 3.40 COP_H after 1/1/2023	AHRI 340/360
			17°F db/15°F wb outdoor air	2.25 COP_H	

	≥ 135,000 Btu/h and < 240,000 Btu/h (cooling capacity)		47°F db/43°F wb outdoor air	3.20 COP_H before 1/1/2023 3.30 C~~S~~OP$_H$ after 1/1/2023	
			17°F db/15°F wb outdoor air	2.05 COP_H	
	≥ 240,000 Btu/h (cooling capacity)		47°F db/43°F wb outdoor air	3.20 COP_H	
			17°F db/15°F wb outdoor air	2.05 COP_H	
~~Water to Air: Water Loop (cooling mode)~~	~~< 17,000 Btu/h~~	~~All~~	~~86°F entering water~~	~~12.2 EER~~	~~ISO 13256-1~~
	~~≥ 17,000 Btu/h and < 65,000 Btu/h~~	~~All~~	~~86°F entering water~~	~~13.0 EER~~	
	~~≥ 65,000 Btu/h and < 135,000 Btu/h~~	~~All~~	~~86°F entering water~~	~~13.0 EER~~	
~~Water to Air: Ground Water (cooling mode)~~	~~< 135,000 Btu/h~~	~~All~~	~~59°F entering water~~	~~18.0 EER~~	~~ISO 13256-1~~
~~Brine to Air: Ground Loop (cooling mode)~~	~~< 135,000 Btu/h~~	~~All~~	~~77°F entering water~~	~~14.1 EER~~	~~ISO 13256-1~~
~~Water to Water: Water Loop (cooling mode)~~	~~< 135,000 Btu/h~~	~~All~~	~~86°F entering water~~	~~10.6 EER~~	~~ISO 13256-2~~
~~Water to Water: Ground Water (cooling mode)~~	~~< 135,000 Btu/h~~	~~All~~	~~59°F entering water~~	~~16.3 EER~~	
~~Brine to Water: Ground Loop (cooling mode)~~	~~< 135,000 Btu/h~~	~~All~~	~~77°F entering fluid~~	~~12.1 EER~~	

~~*(continued)*~~

TABLE C403.3.2(2)—continued
MINIMUM EFFICIENCY REQUIREMENTS: ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
~~Air cooled (heating mode)~~	~~< 65,000 Btu/h[b]~~	—	~~Split System~~	~~10.0 HSPF~~	~~AHRI 210/240~~
		—	~~Single Package~~	~~10.0 HSPF~~	
~~Through-the-wall, (air cooled, heating mode)~~	~~≤ 30,000 Btu/h[b] (cooling capacity)~~	—	~~Split System~~	~~10.0 HSPF~~	
		—	~~Single Package~~	~~10.0 HSPF~~	
~~Small-duct high velocity (air cooled, heating mode)~~	~~< 65,000 Btu/h[b]~~	—	~~Split System~~	~~10.0 HSPF~~	
~~Air cooled (heating mode)~~	~~≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)~~	—	~~47ºF db/43ºF wb outdoor air~~	~~3.3 COP~~	~~AHRI 340/360~~
			~~17ºF db/15ºF wb outdoor air~~	~~2.25 COP~~	
	~~≥ 135,000 Btu/h (cooling capacity)~~	—	~~47ºF db/43ºF wb outdoor air~~	~~3.2 COP~~	
			~~17ºF db/15ºF wb outdoor air~~	~~2.05 COP~~	
~~Water to Air: Water Loop (heating mode)~~	~~< 135,000 Btu/h (cooling capacity)~~	—	~~68°F entering water~~	~~4.3 COP~~	~~ISO 13256-1~~
~~Water to Air: Ground Water (heating mode)~~	~~< 135,000 Btu/h (cooling capacity)~~	—	~~50°F entering water~~	~~3.7 COP~~	
~~Brine to Air: Ground Loop (heating mode)~~	~~< 135,000 Btu/h (cooling capacity)~~	—	~~32°F entering fluid~~	~~3.2 COP~~	
~~Water to Water: Water Loop (heating mode)~~	~~< 135,000 Btu/h (cooling capacity)~~	—	~~68°F entering water~~	~~3.7 COP~~	~~ISO 13256-2~~
~~Water to Water: Ground Water (heating mode)~~	~~< 135,000 Btu/h (cooling capacity)~~	—	~~50°F entering water~~	~~3.1 COP~~	
~~Brine to Water: Ground Loop (heating mode)~~	~~< 135,000 Btu/h (cooling capacity)~~	—	~~32°F entering fluid~~	~~2.5 COP~~	

~~For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) - 32]/1.8.~~

~~a. Chapter 6 contains a complete specification of the referenced test procedure, including the reference year version of the test procedure.~~

~~b. Single-phase, air-cooled heat pumps less than 65,000 Btu/h are regulated by NAECA. SEER and HSPF values are those set by NAECA.~~

~~c. Electric resistance space heating is prohibited per Section C403.2.3. Use "None" Heating Section Type category for exceptions to Section C403.2.3.~~

For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) – 32]/1.8, wb = wet bulb, db = dry bulb.

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. Single-phase, US air-cooled heat pumps less than 65,000 Btu/h are regulated as consumer products by the US Department of Energy Code of Federal Regu- lations DOE 10 CFR 430. SEER, SEER2 and HSPF values for single-phase products are set by the US Department of Energy.

c. DOE 10 CFR 430 Subpart B Appendix M1 includes the test procedure updates effective 1/1/2023 that will be incorporated in AHRI 210/240—2023.

d. This table is a replica of ASHRAE 90.1 Table 6.8.1-2 Electrically Operated Air-Cooled Unitary Heat Pumps Minimum Efficiency Requirements.

TABLE C403.3.2(3~~7~~)
WATER CHILLING PACKAGES – EFFICIENCY REQUIREMENTS[a, b, d]

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	Path A	Path B	TEST PROCEDURE[c]
Air-cooled chillers	< 150 Tons	EER (Btu/W)	≥ 10.100 FL ≥ 13.700 IPLV.IP	≥ 9.700 FL ≥ 15,800 IPLV.IP	AHRI 550/590
	≥ 150 Tons		≥ 10.100 FL ≥ 14.000 IPLV	≥ 9.700 FL ≥ 16.100 IPLV	
Air cooled without condenser, electrically operated	All capacities	EER (Btu/W)	Air-cooled chillers without condenser shall be rated with matching condensers and complying with air-cooled chiller efficiency requirements.		AHRI 550/590
Water cooled, electrically operated positive displacement	< 75 Tons	kW/ton	≤ 0.750 FL ≤ 0.600 IPLV.IP	≤ 0.780 FL ≤ 0.500 IPLV.IP	AHRI 550/590
	≥ 75 tons and < 150 tons		≤ 0.720 FL ≤ 0.560 IPLV.IP	≤ 0.750 FL ≤ 0.490 IPLV.IP	
	≥ 150 tons and < 300 tons		≤ 0.660 FL ≤ 0.540 IPLV.IP	≤ 0.680 FL ≤ 0.440 IPLV.IP	
	≥ 300 tons and < 600 tons		≤ 0.610 FL ≤ 0.520 IPLV.IP	≤ 0.625 FL ≤ 0.410 IPLV.IP	
	≥ 600 tons		≤ 0.560 FL ≤ 0.500 IPLV.IP	≤ 0.585 FL ≤ 0.380 IPLV.IP	
Water cooled, electrically operated centrifugal	< 150 Tons	kW/ton	≤ 0.610 FL ≤ 0.550 IPLV.IP	≤ 0.695 FL ≤ 0.440 IPLV.IP	AHRI 550/590
	≥ 150 tons and < 300 tons		≤ 0.610 FL ≤ 0.550 IPLV.IP	≤ 0.635 FL ≤ 0.400 IPLV.IP	
	≥ 300 tons and < 400 tons		≤ 0.560 FL ≤ 0.520 IPLV.IP	≤ 0.595 FL ≤ 0.390 IPLV.IP	
	≥ 400 tons and < 600 tons		≤ 0.560 FL ≤ 0.500 IPLV.IP	≤ 0.585 FL ≤ 0.380 IPLV.IP	
	≥ 600 Tons		≤ 0.560 FL ≤ 0.500 IPLV.IP	≤ 0.585 FL ≤ 0.380 IPLV.IP	
Air cooled, absorption, single effect	All capacities	COP (W/W)	≥ 0.600 FL	NA[c]	AHRI 560

Water cooled absorption, single effect	All capacities	COP (W/W)	≥ 0.700 FL	NA[c]	AHRI 560
Absorption, double effect, indirect fired	All capacities	COP (W/W)	≥ 1.000 FL ≥ ~~1~~.050 IPLV.IP	NA[c]	AHRI 560
Absorption double effect direct fired	All capacities	COP (W/W)	≥ 1.000 FL ≥ 1.000~~50~~ IPLV	NA[c]	AHRI 560

~~a. The requirements for centrifugal chiller shall be adjusted for nonstandard rating conditions in accordance with Section C403.3.2.1 and are only applicable for the range of conditions listed in Section C403.3.2.1. The requirements for air-cooled, water-cooled positive displacement and absorption chillers are at standard rating conditions defined in the reference test procedure.~~

~~b. Both the full-load and IPLV requirements shall be met or exceeded to comply with this standard. Where there is a Path B, compliance can be with either Path A or Path B for any application.~~

~~c. NA means the requirements are not applicable for Path B and only Path A can be used for compliance.~~

~~d. FL represents the full-load performance requirements and IPLV the part-load performance requirements.~~

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. The requirements for centrifugal chillers shall be adjusted for nonstandard rating conditions per Section C403.3.2.1 and are applicable only for the range of conditions listed there. The requirements for air-cooled, water-cooled positive displacement and absorption chillers are at standard rating conditions defined in the reference test procedure.

c. Both the full-load and IPLV.IP requirements must be met or exceeded to comply with this standard. When there is a Path B, compliance can be with either Path A or Path B for any application.

d. NA means the requirements are not applicable for Path B, and only Path A can be used for compliance.

e. FL is the full-load performance requirements, and IPLV.IP is for the part-load performance requirements.

f. This table is a replica of ASHRAE 90.1 Table 6.8.1-3 Water-Chilling Packages—Minimum Efficiency Requirements.

TABLE C403.3.2(4~~3~~)
~~MINIMUM EFFICIENCY REQUIREMENTS:~~
ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGE VERTICAL AIR CONDITIONERS, SINGLE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONER HEAT PUMPS - MINIMUM EFFICIENCY REQUIREMENTS[e]

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
PTAC (cooling mode) standard size~~new construction~~	~~All Capacities~~<7,000 Btu/h	95°F db/75°F wb – outdoor air[c]	11.9 EER	AHRI 310/380
	≥7,000 Btu/h and ≤15,000 Btu/h		14.0 – (0.300 × Cap/1000) EER[d]	
	>15,000 Btu/h		9.5 EER	
PTAC (cooling mode) nonstandard size[a] ~~replacements[b]~~	~~All Capacities~~<7,000 Btu/h	95°F db/75°F wb outdoor air[c]	9.4 EER	AHRI 310/380
	≥7,000 Btu/h and ≤15,000 Btu/h		10.9 - (0.213 × Cap/1000) EER[d]	
	>15,000 Btu/h		7.7 EER	
PTHP (cooling mode) ~~new construction~~standard size	~~All Capacities~~<7,000 Btu/h	95°F db/75°F wb outdoor air[c]	11.9 EER	AHRI 310/380
	≥7,000 Btu/h and ≤15,000 Btu/h		14.0 - (0.300 × Cap/1000) EER[d]	
	>15,000 Btu/h		9.5 EER	

PTHP (cooling mode) nonstandard size[b] ~~– replacements[b]~~	~~All Capacities~~ <7,000 Btu/h	95°F db/75°F wb outdoor air[c]	9.3 EER	AHRI 310/380
	≥7,000 Btu/h and ≤15,000 Btu/h		10.8 - (0.213 × Cap/1000) EER[d]	
	>15,000 Btu/h		7.6 EER	
PTHP (heating mode) standard size ~~new construction~~	~~All Capacities~~ <7,000 Btu/h	47°F db/43°F wb outdoor air[c] ~~—~~	3.3 COP_H	AHRI 310/380
	≥7,000 Btu/h and ≤15,000 Btu/h		3.7~~2~~ - (0.052~~26~~ × Cap/1000) COP_H[d]	
	>15,000 Btu/h		2.9 COP_H	
PTHP (heating mode) nonstandard size[b] ~~– replacements[b]~~	~~All Capacities~~ <7,000 Btu/h	47°F db/43°F wb outdoor air[c] ~~—~~	2.7 COP_H	AHRI 310/380
	≥7,000 Btu/h and ≤15,000 Btu/h		2.9 - (0.026 × Cap/1000) COP_H[d]	
	>15,000 Btu/h		2.5 COP_H	
SPVAC (cooling mode) single and three phase	< 65,000 Btu/h	95°F db/ 75°F wb outdoor air	~~9.0~~11.0 EER	AHRI 390
	≥ 65,000 Btu/h and < 135,000 Btu/h	~~95°F db/ 75°F wb outdoor air~~	~~8.9~~10.0 EER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	~~95°F db/ 75°F wb outdoor air~~	~~8.6~~10.0 EER	
SPVHP (cooling mode)	< 65,000 Btu/h	95°F db/ 75°F wb outdoor air	~~9.0~~11.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	~~95°F db/ 75°F wb outdoor air~~	~~8.9~~10.0 EER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	~~95°F db/ 75°F wb outdoor air~~	~~8.6~~10.1 EER	
SPVHP (heating mode)	< 65,000 Btu/h	47°F db/ 43°F wb outdoor air	3.3~~0~~ COP_H	AHRI 390
	≥ 65,000 Btu/h and < 135,000 Btu/h	~~47°F db/ 43°F wb outdoor air~~	3.0 COP_H	
	≥ 135,000 Btu/h and < 240,000 Btu/h	~~47°F db/ 75°F wb outdoor air~~	~~2.9~~3.0 COP_H	
Room air conditioners without reverse cycle with louvered sides ~~– for applications outside US~~, ~~with louvered sides~~	< 6,000 Btu/h	—	11.0 CEER	ANSI/ AHAM RAC-1
	≥ 6,000 Btu/h and < 8,000 Btu/h	—	11.0 CEER	
	≥ 8,000 Btu/h and < 14,000 Btu/h	—	10.9 CEER	
	≥ 14,000 Btu/h and < 20,000 Btu/h	—	10.7 CEER	
	≥ 20,000 Btu/h and ≤ 28~~5~~,000 Btu/h	—	9.4 CEER	
	> 28~~5~~,000 Btu/h	—	9.0 CEER	
Room air conditioners~~,~~ without louvered sides	< 6,000 Btu/h	—	10.0 CEER	ANSI/ AHAM RAC-1
	≥ 6,000 Btu/h and < 8,000 Btu/h	—	10.0 CEER	
	≥ 8,000 Btu/h and < 11,000 Btu/h	—	9.6 CEER	
	≥ 11,000 Btu/h and < 14,000 Btu/h	—	9.5 CEER	
	≥ 14,000 Btu/h and < 20,000 Btu/h	—	9.3 CEER	
	≥ 20,000 Btu/h	—	9.4 CEER	
Room air~~-~~ conditioners with reverse cycle, with louvered sides for applications	< 20,000 Btu/h	—	9.8 CEER	ANSI/ AHAM RAC-1
	≥ 20,000 Btu/h	—	9.3 CEER	

outside US ~~heat pumps with louvered sides~~				
Room air-conditioners with reverse cycle without louvered sides for applications outside US ~~heat pumps without louvered sides~~	< 14,000 Btu/h	—	9.3 CEER	ANSI/ AHAM RAC-1
	≥ 14,000 Btu/h	—	8.7 CEER	

(continued)

TABLE C403.3.2(4~~3~~)—continued
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGE VERTICAL AIR CONDITIONERS, SINGLE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONER HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Room air conditioners, casement only for applications outside US	All ~~capacities~~	—	9.5 CEER	ANSI/ AHAM RAC-1
Room air conditioners, ~~casement-slider~~casement slider for applications outside US	All ~~capacities~~	—	10.4 CEER	

~~For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) - 32]/1.8, wb = wet bulb, db = dry bulb.~~
~~"Cap" = The rated cooling capacity of the project in Btu/h. Where the unit's capacity is less than 7000 Btu/h, use 7000 Btu/h in the calculation. Where the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculations.~~
~~a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.~~
~~b. Replacement unit shall be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY: NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16 inches (406 mm) in height and less than 42 inches (1067 mm) in width.~~
For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) – 32]/1.8, wb = wet bulb, db = dry bulb. "Cap" = The rated cooling capacity of the project in Btu/h. Where the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. Where the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculations.
a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.
b. Nonstandard size units must be factory labeled as follows: "MANUFACTURED FOR NONSTANDARD SIZE APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW STANDARD PROJECTS." Nonstandard size efficiencies apply only to units being installed in existing sleeves having an external wall opening of less than 16 inches (406 mm) high or less than 42 inches (1067 mm) wide and having a cross-sectional area less than 670 square inches (0.43 m2).
c. The cooling-mode wet bulb temperature requirement only applies for units that reject condensate to the condenser

coil.

d. "Cap" in EER and COPH equations for PTACs and PTHPs means cooling capacity in Btu/h at 95°F outdoor dry-bulb temperature.

e. This table is a replica of ASHRAE 90.1 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.

TABLE C403.3.2(5~~4~~)
WARM-AIR FURNACES AND COMBINATION WARM-AIR FURNACES/AIR-CONDITIONING UNITS, WARM-AIR DUCT FURNACES AND UNIT HEATERS - ~~,~~ MINIMUM EFFICIENCY REQUIREMENTS[g]

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[d, e]	TEST PROCEDURE[a]
Warm-air furnaces, gas fired	< 225,000 Btu/h	Maximum capacity[c] —	80% E_t[b,d] ~~AFUE~~ ~~or~~ before 1/1/2023 81~~0~~%E_t[d] after 1/1/2023 ~~E_t[c]~~	~~DOE 10 CFR Part 430 or ANSI Z21.47~~ Section 2.39, Thermal Efficiency, ANSI Z21.47
	~~≥ 225,000 Btu/h~~	~~Maximum capacity[c]~~	~~80%E_t[f]~~	~~ANSI Z21.47~~
Warm-air furnaces, oil fired	< 225,000 Btu/h	—Maximum capacity[c]	80% E_t before 1/1/2023 82%E_t[d] after 1/1/2023 ~~83% AFUE or 80%E_t[c]~~	~~DOE 10 CFR Part 430 or UL 727~~ Section 42, Combustion, UL 727
	~~≥ 225,000 Btu/h~~	~~Maximum capacity[b]~~	~~81%E_t[g]~~	~~UL 727~~
Warm-air duct furnaces, gas fired	All capacities	Maximum ~~capacity[b]~~ capacity[c]	80%E_c[e]	Section 2.10, Efficiency, ANSI Z83.8
Warm-air unit heaters, gas fired	All capacities	Maximum ~~capacity[b]~~ capacity[c]	80%E_c[e,f]	Section 2.10, Efficiency, ANSI Z83.8
Warm-air unit heaters, oil fired	All capacities	Maximum ~~capacity[b]~~ capacity[c]	80%E_c[e,f]	Section 40, Combustion, UL 731

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

~~b. Minimum and maximum ratings as provided for and allowed by the unit's controls.~~

~~c. Combination units not covered by the National Appliance Energy Conservation Act of 1987 (NAECA) (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h [19 kW]) shall comply with either rating.~~

~~d. E_t = Thermal efficiency. See test procedure for detailed discussion.~~

~~e. E_c = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.~~

~~f. E_c = Combustion efficiency. Units shall also include an IID, have jackets not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.~~

~~g. E_t = Thermal efficiency. Units shall also include an IID, have jacket losses not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.~~

b. Combination units (i.e., furnaces contained within the same cabinet as an air conditioner) not covered by DOE 10 CFR 430 (i.e., three-phase power or with cooling capacity greater than or equal to 65,000 Btu/h) may comply with either rating. All other units greater than 225,000 Btu/h sold in the US must meet the AFUE standards for consumer products and test using USDOE's AFUE test procedure at DOE 10 CFR 430, Subpart B, Appendix N.
c. Compliance of multiple firing rate units shall be at the maximum firing rate.
d. Et = thermal efficiency. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
e. Ec = combustion efficiency (100 percent less flue losses). See test procedure for detailed discussion.
f. Units must also include an interrupted or intermittent ignition device (IID) and have either power venting or an automatic flue damper.
g. This table is a replica of ASHRAE 90.1 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.

TABLE C403.3.2(6~~5~~)
~~MINIMUM EFFICIENCY REQUIREMENTS:~~ GAS- AND OIL-FIRED BOILERS: MINIMUM EFFICIENCY REQUIREMENTS[i]

EQUIPMENT TYPE[a]	SUBCATEGORY OR RATING CONDITION	SIZE CATEGORY (INPUT)	MINIMUM EFFICIENCY[d, e]	EFFICIENCY AS OF 3/2/2022	TEST PROCEDURE
Boilers, hot water	Gas-fired	< 300,000 Btu/h[g, h~~f, g~~]	82% AFUE	82% AFUE	DOE 10 CFR 430 Appendix N ~~Part 430~~
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[eb]	80% E_t[d]	80% E_t[d]	DOE 10 CFR ~~Part 431~~ 431.86
		> 2,500,000 Btu/h[ba]	82% E_c[c]	82% E_c[c]	
	Oil-fired[fc]	< 300,000 Btu/h[g]	84% AFUE	84% AFUE	DOE 10 CFR ~~Part~~ 430 Appendix N
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	82% E_t[d] ~~E_t~~	82% E_t[d]	DOE 10 CFR ~~Part~~ 431.86
		> 2,500,000 Btu/h[a]	84% E_c[c] ~~E_c~~	84% E_c[c]	
Boilers, steam	Gas-fired	< 300,000 Btu/h[gf]	80% AFUE	80% AFUE	DOE 10 CFR ~~Part~~ 430 Appendix N
	Gas-fired- all, except natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[eb]	79% ~~E_t~~ V	79% E_t[d]	DOE 10 CFR ~~Part~~ 431.86
		> 2,500,000 Btu/h[ba]	79% E_t[d] ~~E_t~~	79% E_t[d]	
	Gas-fired-natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[eb]	77% E_t[d] ~~E_t~~	79% E_t[d]	
		> 2,500,000 Btu/h[ba]	77% E_t[d] ~~E_t~~	79% E_t[d]	
	Oil-fired[fc]	< 300,000 Btu/h[g]	82% AFUE	82% AFUE	DOE 10 CFR ~~Part~~ 430 Appendix N
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[eb]	81% E_t[d] ~~E_t~~	81% E_t[d]	DOE 10 CFR ~~Part~~ 431.86
		> 2,500,000 Btu/h[ba]	81% E_t[a] ~~E_t~~	81% E_t[a]	

For SI: 1 British thermal unit per hour = 0.2931 W.

~~a. These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.~~
~~b. Maximum capacity – minimum and maximum ratings as provided for and allowed by the unit's controls.~~
~~c. Includes oil-fired (residual).~~
~~d. E_c = Combustion efficiency (100 percent less flue losses).~~
~~e. E_t = Thermal efficiency. See referenced standard for detailed information.~~
~~f. Boilers shall not be equipped with a constant-burning ignition pilot.~~
~~g. A boiler not equipped with a tankless domestic water heating coil shall be equipped with an automatic means for adjusting the temperature of the water such that an incremental change in inferred heat load produces a corresponding incremental change in the temperature of the water supplied.~~
a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers and to all packaged boilers. Minimum effi- ciency requirements for boilers cover all capacities of packaged boilers.
c. Ec = Combustion efficiency (100 percent less flue losses).
d. Et = Thermal efficiency.
e. Maximum capacity—minimum and maximum ratings as provided for and allowed by the unit's controls.
f. Includes oil-fired (residual).
g. Boilers shall not be equipped with a constant burning pilot light.
h. A boiler not equipped with a tankless domestic water-heating coil shall be equipped with an automatic means for adjusting the temperature of the water such that an incremental change in inferred heat load produces a corresponding incremental change in the temperature of the water supplied.
i. This table is a replica of ASHRAE 90.1 Table 6.8.1-6 Gas- and Oil-Fired Boilers—Minimum Efficiency Requirements.

~~TABLE C403.3.2(6)~~
~~MINIMUM EFFICIENCY REQUIREMENTS:~~
~~CONDENSING UNITS, ELECTRICALLY OPERATED~~

~~EQUIPMENT TYPE~~	~~SIZE CATEGORY~~	~~MINIMUM EFFICIENCY~~[b]	~~TEST PROCEDURE~~[a]
~~Condensing units, air cooled~~	~~≥ 135,000 Btu/h~~	~~10.1 EER~~ ~~11.2 IPLV~~	~~AHRI 365~~
~~Condensing units, water or evaporatively cooled~~	~~≥ 135,000 Btu/h~~	~~13.1 EER~~ ~~13.1 IPLV~~	

~~For SI: 1 British thermal unit per hour = 0.2931 W.~~

~~a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.~~

~~b. IPLVs are only applicable to equipment with capacity modulation.~~

~~TABLE C403.3.2(7)~~
~~WATER CHILLING PACKAGES – EFFICIENCY REQUIREMENTS~~[a, b, d]

~~EQUIPMENT TYPE~~	~~SIZE CATEGORY~~	~~UNITS~~	~~Path A~~	~~Path B~~	~~TEST PROCEDURE~~[c]
~~Air-cooled chillers~~	~~< 150 Tons~~	~~EER (Btu/W)~~	~~≥ 10.100 FL~~ ~~≥ 13.700 IPLV~~	~~≥ 9.700 FL~~ ~~≥ 15,800 IPLV~~	~~AHRI 550/590~~
	~~≥ 150 Tons~~		~~≥ 10.100 FL~~ ~~≥ 14.000 IPLV~~	~~≥ 9.700 FL~~ ~~≥ 16.100 IPLV~~	
~~Air cooled without condenser, electrically operated~~	~~All capacities~~	~~EER (Btu/W)~~	~~Air-cooled chillers without condenser shall be rated with matching condensers and complying with air-cooled chiller efficiency requirements.~~		
~~Water cooled, electrically operated positive displacement~~	~~< 75 Tons~~	~~kW/ton~~	~~≤ 0.750 FL~~ ~~≤ 0.600 IPLV~~	~~≤ 0.780 FL~~ ~~≤ 0.500 IPLV~~	
	~~≥ 75 tons and < 150 tons~~		~~≤ 0.720 FL~~ ~~≤ 0.560 IPLV~~	~~≤ 0.750 FL~~ ~~≤ 0.490 IPLV~~	
			~~≤ 0.660 FL~~	~~≤ 0.680 FL~~	

	~~≥ 150 tons and < 300 tons~~		~~≤ 0.540 IPLV~~	~~≤ 0.440 IPLV~~	
	~~≥ 300 tons and < 600 tons~~		~~≤ 0.610 FL~~ ~~≤ 0.520 IPLV~~	~~≤ 0.625 FL~~ ~~≤ 0.410 IPLV~~	
	~~≥ 600 tons~~		~~≤ 0.560 FL~~ ~~≤ 0.500 IPLV~~	~~≤ 0.585 FL~~ ~~≤ 0.380 IPLV~~	
~~Water cooled, electrically operated centrifugal~~	~~< 150 Tons~~	~~kW/ton~~	~~≤ 0.610 FL~~ ~~≤ 0.550 IPLV~~	~~≤ 0.695 FL~~ ~~≤ 0.440 IPLV~~	
	~~≥ 150 tons and < 300 tons~~		~~≤ 0.610 FL~~ ~~≤ 0.550 IPLV~~	~~≤ 0.635 FL~~ ~~≤ 0.400 IPLV~~	
	~~≥ 300 tons and < 400 tons~~		~~≤ 0.560 FL~~ ~~≤ 0.520 IPLV~~	~~≤ 0.595 FL~~ ~~≤ 0.390 IPLV~~	
	~~≥ 400 tons and < 600 tons~~		~~≤ 0.560 FL~~ ~~≤ 0.500 IPLV~~	~~≤ 0.585 FL~~ ~~≤ 0.380 IPLV~~	
	~~≥ 600 Tons~~		~~≤ 0.560 FL~~ ~~≤ 0.500 IPLV~~	~~≤ 0.585 FL~~ ~~≤ 0.380 IPLV~~	
~~Air cooled, absorption, single effect~~	~~All capacities~~	~~COP~~	~~≥ 0.600 FL~~	~~NA~~[c]	~~AHRI 560~~
~~Water cooled absorption, single effect~~	~~All capacities~~	~~COP~~	~~≥ 0.700 FL~~	~~NA~~[c]	
~~Absorption, double effect, indirect fired~~	~~All capacities~~	~~COP~~	~~≥ 1.000 FL~~ ~~≥ 1.050 IPLV~~	~~NA~~[c]	
~~Absorption double effect direct fired~~	~~All capacities~~	~~COP~~	~~≥ 1.000 FL~~ ~~≥ 1.050 IPLV~~	~~NA~~[c]	

~~a. The requirements for centrifugal chiller shall be adjusted for nonstandard rating conditions in accordance with Section C403.3.2.1 and are only applicable for the range of conditions listed in Section C403.3.2.1. The requirements for air-cooled, water-cooled positive displacement and absorption chillers are at standard rating conditions defined in the reference test procedure.~~

~~b. Both the full-load and IPLV requirements shall be met or exceeded to comply with this standard. Where there is a Path B, compliance can be with either Path A or Path B for any application.~~

~~c. NA means the requirements are not applicable for Path B and only Path A can be used for compliance.~~

~~d. FL represents the full-load performance requirements and IPLV the part-load performance requirements.~~

TABLE C403.3.2(7~~8~~)
~~MINIMUM EFFICIENCY REQUIREMENTS:~~
PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT – MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE[a]	TOTAL SYSTEM HEAT REJECTION CAPACITY AT RATED CONDITIONS	SUBCATEGORY OR RATING CONDITION[i]	PERFORMANCE REQUIRED[b, c, d, g, h]	TEST PROCEDURE[e, f]
Propeller or axial fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	≥ 40.2 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Centrifugal fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Propeller or axial fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥ 16.1 gpm/hp	CTI ATC-105S and CTI STD-201 RS
Centrifugal fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥ 7.0 gpm/hp	CTI ATC-105S and CTI STD-201 RS
Propeller or axial fan dry coolers (Air-cooled fluid coolers)	All	115°F entering water 105°F leaving water 95°F entering wb	≥ 4.5 gpm/hp	CTI ATC-105DS
Propeller or axial fan evaporative condensers	All	R-448A Test Fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb	≥ 160,000 Btu/hr x hp	CTI ATC-106
Propeller or axial fan evaporative condensers	All	Ammonia Test Fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb	≥ 134,000 Btu/h × hp	CTI ATC-106
Centrifugal fan evaporative condensers	All	~~Ammonia~~ R-448A Test Fluid ~~140~~165°F entering gas temperature ~~96.3~~105°F condensing temperature 75°F entering wb	≥137~~10~~,000 Btu/h × hp	CTI ATC-106
~~Propeller or axial fan~~	~~All~~	~~R-507A Test Fluid~~ ~~165°F entering gas temperature~~	~~≥ 157,000 Btu/h × hp~~	~~CTI ATC-106~~

~~evaporative condensers~~		~~105°F condensing temperature~~ ~~75°F entering wb~~		
Centrifugal fan evaporative condensers	All	~~R-507A~~Ammonia Test Fluid 140~~65~~°F entering gas temperature ~~105~~96.3°F condensing temperature 75°F entering wb	≥ 110~~35~~,000 Btu/h × hp	CTI ATC-106
Air-cooled condensers	All	125°F Condensing Temperature 190°F Entering Gas Temperature 15°F subcooling 95°F entering db	≥ 176,000 Btu/h × hp	AHRI 460

~~For SI: °C = [(°F) - 32]/1.8, L/s • kW = (gpm/hp)/(11.83), COP = (Btu/h • hp)/(2550.7),~~
~~db = dry bulb temperature, °F, wb = wet bulb temperature, °F.~~

~~a. The efficiencies and test procedures for both open- and closed-circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of wet and dry heat exchange sections.~~

~~b. For purposes of this table, open circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition, divided by the fan nameplate-rated motor power.~~

~~c. For purposes of this table, closed-circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition, divided by the sum of the fan nameplate-rated motor power and the spray pump nameplate-rated motor power.~~

~~d. For purposes of this table, air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan nameplate-rated motor power.~~

~~e. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure. The certification requirements do not apply to field-erected cooling towers.~~

~~f. Where a certification program exists for a covered product and it includes provisions for verification and challenge of equipment efficiency ratings, then the product shall be listed in the certification program; or, where a certification program exists for a covered product, and it includes provisions for verification and challenge of equipment efficiency ratings, but the product is not listed in the existing certification program, the ratings shall be verified by an independent laboratory test report.~~

~~g. Cooling towers shall comply with the minimum efficiency listed in the table for that specific type of tower with the capacity effect of any project-specific accessories or options included in the capacity of the cooling tower.~~

~~h. For purposes of this table, evaporative condenser performance is defined as the heat rejected at the specified rating condition in the table divided by the sum of the fan motor nameplate power and the integral spray pump nameplate power.~~

~~i. Requirements for evaporative condensers are listed with ammonia (R-717) and R-507A as test fluids in the table. Evaporative condensers intended for use with halocarbon refrigerants other than R-507A shall meet the minimum efficiency requirements listed in this table with R-507A as the test fluid.~~

For SI: °C = [(°F) – 32]/1.8, L/s × kW = (gpm/hp)/(11.83), COP = (Btu/h × hp)/(2550.7), db = dry bulb temperature, wb = wet bulb temperature.

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. For purposes of this table, open-circuit cooling tower performance is defined as the water-flow rating of the tower at the thermal rating condition listed in the table divided by the fan motor nameplate power.

c. For purposes of this table, closed-circuit cooling tower performance is defined as the process water-flow rating of the tower at the thermal rating condition listed in the table divided by the sum of the fan motor nameplate power and the integral spray pump motor nameplate power.

d. For purposes of this table, dry-cooler performance is defined as the process water-flow rating of the unit at the thermal rating condition listed in the table divided by the total fan motor nameplate power of the unit, and air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the total fan motor nameplate power of the unit.

e. The efficiencies and test procedures for both open- and closed-circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of separate wet and dry heat exchange sections. The certification requirements do not apply to field-erected cooling towers.

f. All cooling towers shall comply with the minimum efficiency listed in the table for that specific type of tower with the capacity effect of any project-specific accessories and/or options included in the capacity of the cooling tower.

g. For purposes of this table, evaporative condenser performance is defined as the heat rejected at the specified rating condition in the table, divided by the sum of the fan motor nameplate power and the integral spray pump nameplate power.

h. Requirements for evaporative condensers are listed with ammonia (R-717) and R-448A as test fluids in the table. Evaporative condensers intended for use with halocarbon refrigerants other than R-448A must meet the minimum efficiency requirements listed with R-448A as the test fluid. For ammonia, the condensing temperature is defined as the saturation temperature corresponding to the refrigerant pressure at the condenser entrance. For R-448A, which is a zeotropic refrigerant, the condensing temperature is defined as the arithmetic average of the dew point and the bubble point temperatures corresponding to the refrigerant pressure at the condenser entrance.

i. This table is a replica of ASHRAE 90.1 Table 6.8.1-7 Performance Requirements for Heat Rejection Equipment—Minimum Efficiency Requirements.

TABLE C403.3.2(8~~10~~)
~~MINIMUM EFFICIENCY~~ ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR CONDITIONERS – MINIMUM EFFICIENCY REQUIREMENTS[b]

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE
VRF air conditioners, air cooled	< 65,000 Btu/h	All	VRF multisplit system	13.0 SEER	AHRI 1230
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or n~~N~~one)	VRF multisplit system	11.2 EER 15.5 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or n~~N~~one)	VRF multisplit system	11.0 EER 14.9 IEER	
	≥ 240,000 Btu/h	Electric resistance (or n~~N~~one)	VRF multisplit system	10.0 EER 13.9~~0~~ IEER	

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. This table is a replica of ASHRAE 90.1 Table 6.8.1-8 Electrically Operated Variable-Refrigerant-Flow Air Conditioners—Minimum Efficiency Requirements.

TABLE C403.3.2(9~~11~~)
MINIMUM EFFICIENCY ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR-TO-AIR AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE
VRF air cooled (cooling mode)	< 65,000 Btu/h	All	VRF multisplit system	13.0 SEER	AHRI 1230
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or n~~N~~one) ~~None~~	VRF multisplit system	11.0 EER 14.6 IEER	
	~~≥ 65,000 Btu/h~~	~~None~~	VRF multisplit	10.8 EER	

	~~and~~ ~~< 135,000 Btu/h~~	~~None~~ ~~None~~ ~~None~~	system with heat recovery	14.4 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h ~~≥ 135,000 Btu/h and < 240,000 Btu/h~~		VRF multisplit system	10.6 EER 13.9 IEER	
			VRF multisplit system with heat recovery	10.4 EER 13.7 IEER	
	≥ 240,000 Btu/h ~~≥ 240,000 Btu/h~~		VRF multisplit system	~~12.7 IEER~~ 9.5 EER ~~11.0 IEER~~ 12.7 IEER	
			VRF multisplit system with heat recovery	9.3 EER 12.5 IEER	
VRF water source (cooling mode)	< 65,000 Btu/h ~~< 65,000 Btu/h~~	AllAll ~~All~~ ~~All~~ ~~All~~ ~~All~~ ~~All~~ ~~All~~ ~~All~~	VRF multisplit system 86°F entering water	12.0 EER ~~15.8~~16.0 IEER	AHRI 1230
			VRF multisplit system with heat recovery 86°F entering water	11.8 EER 15.8 IEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h ~~≥ 65,000 Btu/h and < 135,000 Btu/h~~		VRF multisplit system 86°F entering water	12.0 EER 16.0 IEER	
			VRF multisplit system with heat recovery 86°F entering water	~~15.8 IEER~~ 11.8 EER 15.8 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h ~~≥ 135,000 Btu/h and < 240,000 Btu/h~~		VRF multisplit system 86°F entering water	10.0 EER 14.0 IEER	
			VRF multisplit system with heat recovery 86°F entering water	9.8 EER 13.8 IEER ~~9.8 EER~~	
	≥ 240,000 Btu/h ~~≥ 240,000 Btu/h~~		VRF multisplit system 86°F entering water	10.0 EER 12.0 IEER ~~10.0 EER~~	
			VRF multisplit system with heat recovery 86°F entering water	9.8 EER 11.8 IEER	

VRF groundwater source (cooling mode)	< 135,000 Btu/h ~~< 135,000 Btu/h~~	All ~~All~~ ~~All~~ ~~All~~	VRF multisplit system 59°F entering water	16.2 EER	AHRI 1230
			VRF multisplit system with heat recovery 59°F entering water	16.0 EER	
	≥ 135,000 Btu/h ~~≥ 135,000 Btu/h~~		VRF multisplit system 59°F entering water	13.8 EER	
			VRF multisplit system with heat recovery 59°F entering water	13.6 EER	
VRF ground source (cooling mode)	< 135,000 Btu/h ~~< 135,000 Btu/h~~		VRF multisplit system 77°F entering water	13.4 EER	AHRI 1230
			VRF multisplit system with heat recovery 77°F entering water	13.2 EER	
	≥ 135,000 Btu/h ~~≥ 135,000 Btu/h~~		VRF multisplit system 77°F entering water	11.0 EER	
		All ~~All~~ ~~All~~ ~~All~~	VRF multisplit system with heat recovery 77°F entering water	10.8 EER	
VRF air cooled (heating mode)	< 65,000 Btu/h (cooling capacity)	— — — —	VRF multisplit system	~~10.0~~7.7 HSPF	AHRI 1230
	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)		VRF multisplit system 47°F db/43°F wb outdoor air	3.3 COPh	
			17°F db/15°F wb outdoor air	2.25 COPh	
	≥ 135,000 Btu/h (cooling capacity)		VRF multisplit system 47°F db/43°F wb outdoor air	3.2 COPh	
			17°F db/15°F wb outdoor air	2.05 COPh	
VRF water	<65,000 Btu/hr		VRF multisplit	4.2 COPh	AHRI 1230

source (heating mode)	(cooling capacity)		system 68°F entering water	4.3 COPh	
	≥ 65,000 Btu/hr and < 135,000 Btu/h (cooling capacity)		VRF multisplit system 68°F entering water	4.2 COPh ~~4.3 COPh~~	
	≥ 135,000 Btu/h and <240,000 Btu/h (cooling capacity)		VRF multisplit system 68°F entering water	3.9 COPh ~~4.0 COPh~~	
	≥240,000 Btu/h (cooling capacity)		VRF multisplit system 68°F entering water	3.9 COPh	

~~*(continued)*~~

TABLE C403.3.2(9~~11~~)—(continued)
MINIMUM EFFICIENCY ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR-TO-AIR AND APPLIED HEAT PUMPS

EQUIPMENT aTYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE
VRF groundwater source (heating mode)	< 135,000 Btu/h (cooling capacity)	All~~—~~	VRF multisplit system 50°F entering water	3.6 COPh	AHRI 1230
	≥ 135,000 Btu/h (cooling capacity)	~~—~~	VRF multisplit system 50°F entering water	3.3 COPh	
VRF groundwater source (heating mode)	< 135,000 Btu/h (cooling capacity)	~~—~~	VRF multisplit system 32°F entering water	3.1 COPh	AHRI 1230
	≥ 135,000 Btu/h (cooling capacity)	~~—~~	VRF multisplit system 32°F entering water	2.8 COPh	

For SI: °C = [(°F) – 32]/1.8, 1 British thermal unit per hour = 0.2931 W, db = dry bulb temperature, wb = wet bulb temperature.
a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.
b. This table is a replica of ASHRAE 90.1 Table 6.8.1-9 Electrically Operated Variable-Refrigerant-Flow and Applied Heat Pumps—Minimum Efficiency Requirements.

TABLE C403.3.2(10~~9~~)
FLOOR MOUNTED ~~MINIMUM EFFICIENCY~~ AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS – MINIMUM EFFICIENCY REQUIREMENTS[b]

EQUIPMENT TYPE	STANDARD MODEL	NET SENSIBLE COOLING CAPACITY	MINIMM NET SENSIBLE COP	RATING CONDITIONS RETURN AIR (dry bulb/dew point)	TEST PROCEDURE[a]

Air cooled	Downflow	<80,000 Btu/h	2.70	85°F/52°F (Class 1)	AHRI 1360
		≥80,000 Btu/h and <295,000 Btu/h	2.58		
		≥295,000 Btu/h	2.36		
	Upflow-ducted	<80,000 Btu/h	2.67		
		≥80,000 Btu/h and <295,000 Btu/h	2.55		
		≥295,000 Btu/h	2.33		
	Upflow-nonducted	65,000 Btu/h	2.16	75°F/52°F (Class 1)	
		≥65,000 Btu/h and <240,000 Btu/h	2.04		
		≥240,000 Btu/h	1.89		
	Horizontal	<65,000 Btu/h	2.65	95°F/52°F (Class 3)	
		≥65,000 Btu/h and <240,000 Btu/h	2.55		
		≥240,000 Btu/h	2.47		
Air cooled with fluid economizer	Downflow	<80,000 Btu/h	2.70	85°F/52°F (Class 1)	AHRI 1360
		≥80,000 Btu/h and <295,000 Btu/h	2.58		
		≥295,000 Btu/h	2.36		
	Upflow-ducted	<80,000 Btu/h	2.67		
		≥80,000 Btu/h and <295,000 Btu/h	2.55		
		≥295,000 Btu/h	2.33		
	Upflow-nonducted	65,000 Btu/h	2.16	75°F/52°F (Class 1)	
		≥65,000 Btu/h and <240,000 Btu/h	2.04		
		≥240,000 Btu/h	1.89		
	Horizontal	<65,000 Btu/h	2.65	95°F/52°F (Class 3)	
		≥65,000 Btu/h and <240,000 Btu/h	2.55		
		≥240,000 Btu/h	2.47		
Water cooled	Downflow	<80,000 Btu/h	2.82	85°F/52°F (Class 1)	AHRI 1360
		≥80,000 Btu/h and <295,000 Btu/h	2.73		
		≥295,000 Btu/h	2.67		
	Upflow-ducted	<80,000 Btu/h	2.79		
		≥80,000 Btu/h and <295,000 Btu/h	2.70		
		≥295,000 Btu/h	2.64		
	Upflow-nonducted	65,000 Btu/h	2.43	75°F/52°F (Class 1)	
		≥65,000 Btu/h and <240,000 Btu/h	2.32		
		≥240,000 Btu/h	2.20		
	Horizontal	<65,000 Btu/h	2.79	95°F/52°F (Class 3)	
		≥65,000 Btu/h and <240,000 Btu/h	2.70		
		≥240,000 Btu/h	2.64		
Water cooled with fluid economizer	Downflow	<80,000 Btu/h	2.77	85°F/52°F (Class 1)	AHRI 1360
		≥80,000 Btu/h and <295,000 Btu/h	2.68		
		≥295,000 Btu/h	2.61		
	Upflow-ducted	<80,000 Btu/h	2.74		
		≥80,000 Btu/h and <295,000 Btu/h	2.65		
		≥295,000 Btu/h	2.58		
	Upflow-nonducted	65,000 Btu/h	2.35	75°F/52°F (Class 1)	
		≥65,000 Btu/h and <240,000 Btu/h	2.24		
		≥240,000 Btu/h	2.12		
	Horizontal	<65,000 Btu/h	2.71		

		≥65,000 Btu/h and <240,000 Btu/h	2.60	95°F/52°F (Class 3)	
		≥240,000 Btu/h	2.54		
Glycol cooled	Downflow	<80,000 Btu/h	2.56	85°F/52°F (Class 1)	AHRI 1360
		≥80,000 Btu/h and <295,000 Btu/h	2.24		
		≥295,000 Btu/h	2.21		
	Upflow-ducted	<80,000 Btu/h	2.53		
		≥80,000 Btu/h and <295,000 Btu/h	2.21		
		≥295,000 Btu/h	2.18		
	Upflow-nonducted	65,000 Btu/h	2.08	75°F/52°F (Class 1)	
		≥65,000 Btu/h and <240,000 Btu/h	1.90		
		≥240,000 Btu/h	1.81		
	Horizontal	<65,000 Btu/h	2.48	95°F/52°F (Class 3)	
		≥65,000 Btu/h and <240,000 Btu/h	2.18		
		≥240,000 Btu/h	2.18		
Glycol cooled with fluid economizer	Downflow	<80,000 Btu/h	2.51	85°F/52°F (Class 1)	AHRI 1360
		≥80,000 Btu/h and <295,000 Btu/h	2.19		
		≥295,000 Btu/h	2.15		
	Upflow-ducted	<80,000 Btu/h	2.48		
		≥80,000 Btu/h and <295,000 Btu/h	2.16		
		≥295,000 Btu/h	2.12		
	Upflow-nonducted	65,000 Btu/h	2.00	75°F/52°F (Class 1)	
		≥65,000 Btu/h and <240,000 Btu/h	1.82		
		≥240,000 Btu/h	1.73		
	Horizontal	<65,000 Btu/h	2.44	95°F/52°F (Class 3)	
		≥65,000 Btu/h and <240,000 Btu/h	2.10		
		≥240,000 Btu/h	2.10		

For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) – 32]/1.8, COP = (Btu/h × hp)/(2,550.7).
a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.
b. This table is a replica of ASHRAE 90.1 Table 6.8.1-10 Floor-Mounted Air Conditioners and Condensing Units Serving Computer Rooms—Minimum Effi- ciency Requirements.

~~EQUIPMENT TYPE~~	~~NET SENSIBLE COOLING CAPACITY~~ [a]	~~MINIMUM SCOP-127~~ [b] ~~EFFICIENCY DOWNFLOW UNITS / UPFLOW UNITS~~	~~TEST PROCEDURE~~
~~Air conditioners, air cooled~~	~~< 65,000 Btu/h~~	~~2.20 / 2.09~~	~~ANSI/ASHRAE 127~~
	~~≥ 65,000 Btu/h and < 240,000 Btu/h~~	~~2.10 / 1.99~~	
	~~≥ 240,000 Btu/h~~	~~1.90 / 1.79~~	
~~Air conditioners, water cooled~~	~~< 65,000 Btu/h~~	~~2.60 / 2.49~~	
	~~≥ 65,000 Btu/h and < 240,000 Btu/h~~	~~2.50 / 2.39~~	
	~~≥ 240,000 Btu/h~~	~~2.40 /2.29~~	
~~Air conditioners, water cooled with fluid economizer~~	~~< 65,000 Btu/h~~	~~2.55 /2.44~~	
	~~≥ 65,000 Btu/h and < 240,000 Btu/h~~	~~2.45 / 2.34~~	

	~~≥ 240,000 Btu/h~~	~~2.35 / 2.24~~	
~~Air conditioners, glycol cooled (rated at 40% propylene glycol)~~	~~< 65,000 Btu/h~~	~~2.50 / 2.39~~	
	~~≥ 65,000 Btu/h and < 240,000 Btu/h~~	~~2.15 / 2.04~~	
	~~≥ 240,000 Btu/h~~	~~2.10 / 1.99~~	
~~Air conditioners, glycol cooled (rated at 40% propylene glycol) with fluid economizer~~	~~< 65,000 Btu/h~~	~~2.45 / 2.34~~	
	~~≥ 65,000 Btu/h and < 240,000 Btu/h~~	~~2.10 / 1.99~~	
	~~≥ 240,000 Btu/h~~	~~2.05 / 1.94~~	

~~For SI: 1 British thermal unit per hour = 0.2931 W.~~

~~a. Net sensible cooling capacity: the total gross cooling capacity less the latent cooling less the energy to the air movement system. (Total Gross – latent – Fan Power).~~

~~b. Sensible coefficient of performance (SCOP-127): a ratio calculated by dividing the net sensible cooling capacity in watts by the total power input in watts (excluding reheaters and humidifiers) at conditions defined in ASHRAE Standard 127. The net sensible cooling capacity is the gross sensible capacity minus the energy dissipated into the cooled space by the fan system.~~

~~TABLE C403.3.2(12)~~
~~HEAT TRANSFER EQUIPMENT~~

~~EQUIPMENT TYPE~~	~~SUBCATEGORY~~	~~MINIMUM EFFICIENCY~~	~~TEST PROCEDURE~~[a]
~~Liquid-to-liquid heat exchangers~~	~~Plate type~~	~~NR~~	~~AHRI 400~~

~~NR = No Requirement.~~

~~a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.~~

Table C403.3.2(11)
VAPOR-COMPRESSION BASED INDOOR POOL DEHUMIDIFIERS – MINIMUM EFFICIENCY REQUIREMENTS[b]

EQUIPMENT TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[b]
Single package indoor (with or without economizer)	Rating Conditions: A or C	3.5 MRE	AHRI 910
Single package indoor water cooled (with or without economizer)	Rating Conditions: A, B or C	3.5 MRE	
Single package indoor air cooled (with or without economizer)	Rating Conditions: A, B or C	3.5 MRE	
Single package indoor air cooled (with or without economizer)	Rating Conditions: A, B or C	2.5 MRE	

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. This table is a replica of ASHRAE 90.1 Table 6.8.1-12 Vapor-Compression-Based Indoor Pool Dehumidifiers—Minimum Efficiency Requirements.

TABLE C403.3.2(12)

ELECTRICALLY OPERATED DX-DOAS UNITS, SINGLE-PACKAGE AND REMOTE CONDENSER, WITHOUT ENERGY RECOVERY– MINIMUM EFFICIENCY REQUIREMENTS[b]

EQUIPMENT TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (dehumidification mode)	-	4.0 ISMRE	AHRI 920
Air-source heat pumps (dehumidification mode)	-	4.0 ISMRE	AHRI 920
Water cooled (dehumidification mode)	Cooling tower condenser water	4.9 ISMRE	AHRI 920
	Chilled water	6.0 ISMRE	
Air-source heat pump (dehumidification mode)	-	2.7 ISCOP	AHRI 920
Water-source heat pump (dehumidification mode)	Ground source, closed loop	4.8 ISMRE	AHRI 920
	Ground-water source	5.0 ISMRE	
	Water source	4.0 ISMRE	
Water-source heat pump (heating mode)	Ground source, closed loop	2.0 ISCOP	AHRI 920
	Ground-water source	3.2 ISCOP	
	Water source	3.5 ISCOP	

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. This table is a replica of ASHRAE 90.1 Table 6.8.1-13 Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, without Energy Recovery—Minimum Efficiency Requirements.

Table C403.3.2(13)
ELECTRICALLY OPERATED DX-DOAS UNITS, SINGLE-PACKAGE AND REMOTE CONDENSER, WITH ENERGY RECOVERY– MINIMUM EFFICIENCY REQUIREMENTS[b]

EQUIPMENT TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (dehumidification mode)	-	5.2 ISMRE	AHRI 920
Air-source heat pumps (dehumidification mode)	-	5.2 ISMRE	AHRI 920
Water cooled (dehumidification mode)	Cooling tower condenser water	5.3 ISMRE	AHRI 920
	Chilled water	6.6 ISMRE	
Air-source heat pump (dehumidification mode)	-	3.3 ISCOP	AHRI 920
Water-source heat pump (dehumidification mode)	Ground source, closed loop	5.2 ISMRE	AHRI 920
	Ground-water source	5.8 ISMRE	
	Water source	4.8 ISMRE	
Water-source heat pump (heating mode)	Ground source, closed loop	3.8 ISCOP	AHRI 920
	Ground-water source	4.0 ISCOP	
	Water source	4.8 ISCOP	

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.
b. This table is a replica of ASHRAE 90.1 Table 6.8.1-14 Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, with Energy Recovery—Minimum Efficiency Requirements.

TABLE C403.3.2(14)
ELECTRICALLY OPERATED WATER-SOURCE HEAT PUMPS– MINIMUM EFFICIENCY REQUIREMENTS[c]

EQUIPMENT TYPE	SIZE CATEGORY[b]	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Water-to-air, water loop (cooling mode)	<17,000 Btu/h	All	86°F entering water	12.2 EER	**ISO 13256-1**
	≥17,000 Btu/h and <65,000 Btu/h			13.0 EER	
	≥65,000 Btu/h and <135,000 Btu/h			13.0 EER	
Water-to-air, ground water (cooling mode)	<135,000 Btu/h (cooling capacity)	All	59°F entering water	18.0 EER	**ISO 13256-1**
Brine-to-air, ground loop (cooling mode)	<135,000 Btu/h (cooling capacity)	All	77°F entering water	14.1 EER	**ISO 13256-1**
Water-to-water, water loop (cooling mode)	<135,000 Btu/h (cooling capacity)	All	86°F entering water	10.6 EER	**ISO 13256-2**
Water-to-water, ground water (cooling mode)	<135,000 Btu/h (cooling capacity)	All	59°F entering water	16.3 EER	**ISO 13256-2**
Brine-to-water, ground loop (cooling mode)	<135,000 Btu/h (cooling capacity)	All	77°F entering water	12.1 EER	**ISO 13256-2**
Water-to-water, water loop (heating mode)	<135,000 Btu/h (cooling capacity)	-	68°F entering water	4.3 COP_H	**ISO 13256-1**
Water-to-air, ground water (heating mode)	<135,000 Btu/h (cooling capacity)	-	50°F entering water	3.7 COP_H	**ISO 13256-1**
Brine-to-air, ground loop (heating mode)	<135,000 Btu/h (cooling capacity)	-	32°F entering water	3.2 COP_H	**ISO 13256-1**
Water-to-water, water loop (heating mode)	<135,000 Btu/h (cooling capacity)	-	68°F entering water	3.7 COP_H	**ISO 13256-1**
Water-to-water, ground water (heating mode)	<135,000 Btu/h (cooling capacity)	-	50°F entering water	3.1 COP_H	**ISO 13256-1**
Brine-to-water, ground loop (heating mode)	<135,000 Btu/h (cooling capacity)	-	32°F entering water	2.5 COP_H	**ISO 13256-1**

For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) – 32]/1.8.

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. Single-phase, US air-cooled heat pumps less than 19 kW are regulated as consumer products by DOE 10 CFR 430. SCOPC, SCOP2C, SCOPH and SCOP2H values for single-phase products are set by the USDOE.

c. This table is a replica of ASHRAE 90.1 Table 6.8.1-15 Electrically Operated Water-Source Heat Pumps—Minimum Efficiency Requirements.

TABLE C403.3.2(15)
HEAT-PUMP AND HEAT RECOVERY CHILLER PACKAGES – MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY, ton_R	COOLING-ONLY OPERATION COOLING EFFICIENCY[c] AIR SOURCE EET (FL/IPLV), Btu/W x h WATER-SOURCE POWER INPUT PER CAPACITY (FL/IPLV), kW/ton_R		HEATING SOURCE CONDITIONS (entering/ leaving water) OR OAT (db/wb), °F	Heating Operation: HEAT-PUMP HEATING FULL-LOAD EFFICIENCY (COPH)b, W/W — Leaving Heating Water Temperature				Heating Operation: HEAT RECOVERY CHILLER FULL-LOAD EFFICIENCY (COPHR)c,d, W/W SIMULTANEOUS COOLING AND HEATING FULL-LOAD EFFICIENCY (COPSHC)c, W/W — Leaving Heating Water Temperature				Test Procedure[a]
					Low	Medium	High	Boost	Low	Medium	High	Boost	
		Path A	Path B		105°F	120°F	140°F	140°F	105°F	120°F	140°F	140°F	
Air source	All sizes	≥ 9.595 FL	≥ 9.595 FL	47 db	≥ 3.290	≥ 2.770	≥ 2.310	NA	NA	NA	NA	NA	AHRI 550/590
		≥ 13.02 IPLV.IP	≥ 13.02 IPLV.IP	43 wb[e]	≥ 2.230	≥ 1.950	≥ 1.630	NA	NA	NA	NA	NA	
Water-source electrically operated positive displacement	<75	≤ 0.7885 FL	≤ 0.7875 FL ≤ 0.5145 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	AHRI 550/590
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	6.150	
	≥75 and <150	≤ 0.6316 IPLV.IP	≤ 0.7140 FL ≤ 0.4620 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	6.150	
	≥150 and<300	≤ 0.7579 FL ≤ 0.5895 IPLV.IP	≤ 0.7140 FL ≤ 0.4620 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	6.150	
	≥300 and <600	≤ 0.6947 FL ≤ 0.5684 IPLV.IP	≤ 0.6563 FL ≤ 0.4305 IPLV.IP	54/44[f]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	
				75/65[f]	NA	NA	NA	≥ 3.900	NA	NA	NA	≥ 6.850	
	≥600	≤ 0.6421 FL ≤ 0.5474 IPLV.IP	≤ 0.6143 FL ≤ 0.3990 IPLV.IP	54/44[f]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000		
				75/65[f]	NA	NA	NA	≥ 3.900	NA	NA	NA	≥ 6.850	
Water-source electrically operated centrifugal	<75	≤ 0.6421 FL ≤ 0.5789 IPLV.IP	≤ 0.7316 FL ≤ 0.4632 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	AHRI 550/590
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	
	≥75 and <150	≤ 0.5895 FL ≤ 0.5474 IPLV.IP	≤ 0.6684 FL ≤ 0.4211 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	
	≥150 and<300	≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6263 FL ≤ 0.4105 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	
	≥300 and <600	≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6158 FL ≤ 0.4000 IPLV.IP	54/44[f]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	
				75/65[f]	NA	NA	NA	≥ 3.900	NA	NA		≥ 6.850	
	≥600			54/44[f]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	

		≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6158 FL ≤ 0.4000 IPLV.IP	75/65[f]	NA	NA	NA	≥ 3.900	NA	NA	NA	≥ 6.850	

For SI: °C = [(°F) – 32]/1.8.

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. Cooling-only rating conditions are standard rating conditions defined in AHRI 550/590, Table 1.

c. Heating full-load rating conditions are at rating conditions defined in AHRI 550/590, Table 1.

d. For water-cooled heat recovery chillers that have capabilities for heat rejection to a heat recovery condenser and a tower condenser, the COPHR applies to operation at full load with 100 percent heat recovery (no tower rejection). Units that only have capabilities for partial heat recovery shall meet the requirements of Table C403.3.2(3).

e. Outdoor air entering dry-bulb (db) temperature and wet-bulb (wb) temperature.

f. Source-water entering and leaving water temperature.

g. This table is a replica of ASHRAE 90.1 Table 6.8.1-16 Heat-Pump and Heat Recovery Chiller Packages—Minimum Efficiency Requirements.

TABLE C403.3.2(16) CEILING-MOUNTED COMPUTER-ROOM AIR CONDITIONERS-MINIMUM ~~EFFICNECY~~EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	STANDARD MODEL	NET SENSIBLE COOLING CAPACITY	MINIMM NET SENSIBLE COP	RATING CONDITIONS RETURN AIR (dry bulb/dew point)	TEST PROCEDURE[a]
Air cooled with freeair discharge condenser	Ducted	<29,000 Btu/h	2.05	75°F/52°F (Class 1)	AHRI 1360
		≥29,000 Btu/h and <65,000 Btu/h	2.02		
		≥65,000 Btu/h	1.92		
		<29,000 Btu/h	2.08		
		≥29,000 Btu/h and <65,000 Btu/h	2.05		
		≥65,000 Btu/h	1.94		
	Nonducted	<29,000 Btu/h	2.01		
		≥29,000 Btu/h and <65,000 Btu/h	1.97		
		≥65,000 Btu/h	1.87		
		<29,000 Btu/h	2.04		
		≥29,000 Btu/h and <65,000 Btu/h	2.00		
		≥65,000 Btu/h	1.89		
Air cooled with freeair discharge condenser with fluid economizer	Ducted	<29,000 Btu/h	1.86	75°F/52°F (Class 1)	AHRI 1360
		≥29,000 Btu/h and <65,000 Btu/h	1.83		
		≥65,000 Btu/h	1.73		
		<29,000 Btu/h	1.89		
		≥29,000 Btu/h and <65,000 Btu/h	1.86		
		≥65,000 Btu/h	1.75		
	Nonducted	<29,000 Btu/h	1.82		
		≥29,000 Btu/h and <65,000 Btu/h	1.78		

		≥65,000 Btu/h	1.68		
		<29,000 Btu/h	1.85		
		≥29,000 Btu/h and <65,000 Btu/h	1.81		
		≥65,000 Btu/h	1.70		
Air cooled with ducted condenser	Ducted	<29,000 Btu/h	2.38	75°F/52°F (Class 1)	AHRI 1360
		≥29,000 Btu/h and <65,000 Btu/h	2.28		
		≥65,000 Btu/h	2.18		
		<29,000 Btu/h	2.41		
		≥29,000 Btu/h and <65,000 Btu/h	2.31		
		≥65,000 Btu/h	2.20		
	Nonducted	<29,000 Btu/h	2.05		
		≥29,000 Btu/h and <65,000 Btu/h	2.02		
		≥65,000 Btu/h	1.92		
		<29,000 Btu/h	2.08		
		≥29,000 Btu/h and <65,000 Btu/h	2.05		
		≥65,000 Btu/h	1.94		
Air cooled with fluid economizer and ducted condenser	Ducted	<29,000 Btu/h	2.01	75°F/52°F (Class 1)	AHRI 1360
		≥29,000 Btu/h and <65,000 Btu/h	1.97		
		≥65,000 Btu/h	1.87		
		<29,000 Btu/h	2.04		
		≥29,000 Btu/h and <65,000 Btu/h	2.00		
		≥65,000 Btu/h	1.89		
	Nonducted	<29,000 Btu/h	1.86		
		≥29,000 Btu/h and <65,000 Btu/h	1.83		
		≥65,000 Btu/h	1.73		
		<29,000 Btu/h	1.89		
		≥29,000 Btu/h and <65,000 Btu/h	1.86		
		≥65,000 Btu/h	1.75		
Water cooled	Ducted	<29,000 Btu/h	1.82	75°F/52°F (Class 1)	AHRI 1360
		≥29,000 Btu/h and <65,000 Btu/h	1.78		
		≥65,000 Btu/h	1.68		
		<29,000 Btu/h	1.85		
		≥29,000 Btu/h and <65,000 Btu/h	1.81		
		≥65,000 Btu/h	1.70		
	Nonducted	<29,000 Btu/h	2.38		
		≥29,000 Btu/h and <65,000 Btu/h	2.28		

		≥65,000 Btu/h	2.18		
		<29,000 Btu/h	2.41		
		≥29,000 Btu/h and <65,000 Btu/h	2.31		
		≥65,000 Btu/h	2.20		
Water cooled with fluid economizer	Ducted	<29,000 Btu/h	2.33	75°F/52°F (Class 1)	AHRI 1360
		≥29,000 Btu/h and <65,000 Btu/h	2.23		
		≥65,000 Btu/h	2.13		
		<29,000 Btu/h	2.36		
		≥29,000 Btu/h and <65,000 Btu/h	2.26		
		≥65,000 Btu/h	2.16		
	Nonducted	<29,000 Btu/h	1.97		
		≥29,000 Btu/h and <65,000 Btu/h	1.93		
		≥65,000 Btu/h	1.78		
		<29,000 Btu/h	2.00		
		≥29,000 Btu/h and <65,000 Btu/h	1.98		
		≥65,000 Btu/h	1.81		
Glycol cooled	Ducted	<29,000 Btu/h	1.92	75°F/52°F (Class 1)	AHRI 1360
		≥29,000 Btu/h and <65,000 Btu/h	1.88		
		≥65,000 Btu/h	1.73		
Glycol cooled with fluid economizer	Nonducted	<29,000 Btu/h	1.95		
		≥29,000 Btu/h and <65,000 Btu/h	1.93		
		≥65,000 Btu/h	1.76		

For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) – 32]/1.8, COP = (Btu/h × hp)/(2,550.7).

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. This is a replica of ASHRAE 90.1 Table 6.8.1-17 Ceiling-Mounted Computer-Room Air Conditioners—Minimum Efficiency Requirements.

C403.3.2.1 Water-cooled centrifugal chilling packages ~~(Mandatory).~~

Equipment not designed for operation at AHRI Standard 550/590 test conditions of 44°F (7°C) leaving chilled-water temperature and 2.4 gpm/ton evaporator fluid flow and 85°F (29°C) entering condenser water temperature with 3 gpm/ton (0.054 I/s • kW) condenser water flow shall have maximum full-load kW/ton (FL) and part-load ratings requirements adjusted using Equations 4-5 and 4-6.

$$FL_{adj} = FL/K_{adj}$$ **(Equation 4-5)**

PLV_{adj} = $IPLV.IP/K_{adj}$ **(Equation 4-6)**

K_{adj}	=	A × B
FL	=	Full-load kW/ton value as specified in Table C403.3.2(3~~7~~).
FL_{adj}	=	Maximum full-load kW/ton rating, adjusted for nonstandard conditions.
IPLV.IP	=	IPLV.IP ~~V~~value ~~as specified in~~from Table C403.3.2(2~~7~~).
PLV_{adj}	=	Maximum *NPLV* rating, adjusted for nonstandard conditions.
A	=	$0.00000014592 \times (LIFT)^4 - 0.0000346496 \times (LIFT)^3 + 0.00314196 \times (LIFT)^2 - 0.147199 \times (LIFT) + 3.93073$~~2~~
B	=	$0.0015 \times L_{vg}E_{vap} + 0.934$
LIFT	=	$L_{vg}Cond - L_{vg}E_{vap}$
$L_{vg}Cond$	=	Full-load condenser leaving fluid temperature (°F).
$L_{vg}E_{vap}$	=	Full-load evaporator leaving temperature (°F).

The FL_{adj} and PLV_{adj} values are only applicable for centrifugal chillers meeting all of the following full-load design ranges:

~~1. Minimum evaporator leaving temperature: 36°F.~~

1. $36.00°F \le L_{vg}E_{vap} \le 60.00°F$

2. Maximum condenser leaving temperature: 115°F.

3. 20°F ≤ LIFT ≤ 80°F.

Manufacturers shall calculate the FL_{adj} and PLV_{adj} before determining whether to label the chiller. Centrifugal chillers designed to operate outside of these ranges are not covered by this code.

C403.3.2.2 Positive Displacement (Air- and water-cooled) chilling packages

Equipment with a leaving fluid temperature higher than 32°F (0°C) and water-cooled positive displacement chilling packages with a condenser leaving fluid temperature below 115°F (46°C) shall meet the requirements of Table C403.3.2(7) when tested or certified with water at standard rating conditions, in accordance with the referenced test procedure.

C403.3.3 Hot gas bypass limitation.

~~The use of hot gas bypass is prohibited in all systems.~~ Cooling systems shall not use hot gas bypass or other evaporator pressure control systems unless the system is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot gas bypass shall be limited as indicated in Table C403.3.3. as limited by Section 403.5.1.

Table C403.3.3
MAXIMUM HOT GAS BYPASS CAPACITY

RATED CAPACITY	MAXIMUM HOT GAS BYPASS CAPACITY (% of total capacity)
≤ 240,000 Btu/h	50
> 240,000 Btu/h	25

~~**C403.3.4 Boiler Turndown**~~

C403.4 Heating and cooling system controls ~~(Mandatory).~~

Each heating and cooling system shall be provided with controls in accordance with Sections C403.4.1 through C403.4.5.

C403.4.1 Thermostatic controls ~~(Mandatory).~~

The supply of heating and cooling energy to each *zone* shall be controlled by individual thermostatic controls capable of responding to temperature within the *zone*. Where humidification or dehumidification or both is provided, not fewer than one humidity control device shall be provided for each humidity control system.

Exception: Independent perimeter systems that are designed to offset only building envelope heat losses, gains or both serving one or more perimeter *zones* also served by an interior system provided that both of the following conditions are met:

1. The perimeter system includes not fewer than one thermostatic control *zone* for each building exposure having exterior walls facing only one orientation (within ± 45 degrees) (0.8 rad) for more than 50 contiguous feet (15 240 mm).

2. The perimeter system heating and cooling supply is controlled by thermostats located within the *zones* served by the system.

C403.4.1.1 Heat pump supplementary heat ~~(Mandatory).~~

Heat pumps having supplementary electric resistance heat shall have controls that limit supplemental heat operation to only those times when one of the following applies: ~~(integral to the unit) are prohibited, except for use during defrost. Heat pumps with supplementary electric resistance heat inside the building envelope shall be certified *cold-climate heat pumps* meeting the requirements of Section C403.2.3.~~

1. The vapor compression cycle cannot provide the necessary heating energy to satisfy the thermostat setting.
2. The heat pump is operating in defrost mode.
3. Only for buildings that require heat for health and safety: t~~T~~he vapor compression cycle malfunctions.
4. Only for buildings that require heat for health and safety: t~~T~~he thermostat malfunctions.

C403.4.1.2 Deadband ~~(Mandatory).~~
Where used to control both heating and cooling, *zone* thermostatic controls shall be configured to provide a temperature range or deadband of not less than 5°F (2.8°C) within which the supply of heating and cooling energy to the *zone* is shut off or reduced to a minimum.

Exceptions:

1. Thermostats requiring manual changeover between heating and cooling modes.

2. Occupancies or applications requiring precision in indoor temperature control as *approved* by the *code official*.

C403.4.1.3 Setpoint overlap restriction ~~(Mandatory).~~
Where a *zone* has a separate heating and a separate cooling thermostatic control located within the *zone*, a limit switch, mechanical stop or direct digital control system with software programming shall be configured to prevent the heating setpoint from exceeding the cooling setpoint and to maintain a deadband in accordance with Section C403.4.1.2.

C403.4.1.4 Heated ~~or cooled~~ vestibules ~~(Mandatory).~~
The heating system for heated vestibules and air curtains with integral heating shall be provided with controls configured to shut off the source of heating when the outdoor air temperature is greater than 55°F (12.8°C). Vestibule heating systems shall be controlled by a thermostat located in the vestibule configured to limit heating to a temperature not greater than 55°F (12.8°C). Cooling of the vestibule is prohibited.

Exception: Control of heating or cooling provided by site-recovered energy or transfer air that would otherwise be exhausted.

C403.4.1.5 Hot water boiler outdoor temperature setback control ~~(Mandatory).~~
Hot water boilers that supply heat to the building through one- or two-pipe heating systems shall have a setback control that lowers the boiler water temperature based on the outdoor temperature or based on building terminal loads.

C403.4.2 Off-hour controls ~~(Mandatory).~~
Each *zone* shall be provided with thermostatic setback controls that are controlled by either an automatic time clock or programmable control system.

Exceptions:

1. *Zones* that will be operated continuously.

2. *Zones* with a full HVAC load demand not exceeding 6,800 Btu/h (2 kW) and having a manual shutoff switch located with *ready access*.

C403.4.2.1 Thermostatic setback ~~(Mandatory).~~
Thermostatic setback controls shall be configured to set back or temporarily operate the system to maintain zone temperatures down to 60°F (16°C) or up to 80°F (27°C).

Exceptions: Zones served exclusively by cold-climate heat pumps.

C403.4.2.2 Automatic setback and shutdown~~ (Mandatory).~~
Automatic time clock or programmable controls shall be capable of starting and stopping the system for seven different daily schedules per week and retaining their programming and time setting during a loss of power for not fewer than 10 hours. Additionally, the controls shall have a manual override that allows temporary operation of the system for up to 2 hours; a manually operated timer configured to operate the system for up to 2 hours; or an occupancy sensor.

C403.4.2.3 Automatic start and stop ~~(Mandatory).~~
Automatic start controls shall be provided for each HVAC system. The automatic start controls shall be configured to automatically adjust the daily start time of the HVAC system in order to bring each space to the desired occupied temperature immediately prior to scheduled occupancy. Automatic stop controls shall be provided for each HVAC system with direct digital control of individual zones. The automatic stop controls shall be configured to reduce the HVAC system's heating temperature setpoint and increase the cooling temperature setpoint by not less than 2°F (0.555°C) before scheduled unoccupied periods based on the thermal lag and acceptable drift in space temperature that is within comfort limits.

Exception: Cold-climate heat pump systems

C403.4.3 Hydronic systems controls.
The heating of fluids that have been previously mechanically cooled and the cooling of fluids that have been previously mechanically heated shall be limited in accordance with Sections C403.4.3.1 through C403.4.3.3. Hydronic heating systems comprised of multiple-packaged boilers and designed to deliver conditioned water or steam into a common distribution system shall include automatic controls configured to sequence operation of the boilers. Hydronic heating systems composed of a single boiler and greater than 500,000 Btu/h (146.5 kW) input design capacity shall include either a multistaged or modulating burner.

C403.4.3.1 Three-pipe system.
Hydronic systems that use a common return system for both hot water and chilled water are prohibited.

C403.4.3.2 Two-pipe changeover system.
Systems that use a common distribution system to supply both heated and chilled water shall be designed to allow a deadband between changeover from one mode to the other of not less than 15°F (8.3°C) outside air temperatures; be designed to and provided with controls that will allow operation in one mode for not less than 4 hours before changing over to the other mode; and be provided with controls that allow heating and cooling supply temperatures at the changeover point to be not more than 30°F (16.7°C) apart.

C403.4.3.3 Hydronic (water loop) heat pump systems.
Hydronic heat pump systems shall comply with Sections C403.4.3.3.1 through C403.4.3.3.3.

C403.4.3.3.1 Temperature deadband.
Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition shall have controls that are configured to

provide a heat pump water supply temperature deadband of not less than 20°F (11°C) between initiation of heat rejection and heat addition by the central devices.

> **Exception:** Where a system loop temperature optimization controller is installed and can determine the most efficient operating temperature based on real-time conditions of demand and capacity, deadbands of less than 20°F (11°C) shall be permitted.

C403.4.3.3.2 Heat rejection.
The following shall apply to hydronic water loop heat pump systems:

1. Where a closed-circuit cooling tower is used directly in the heat pump loop, either an automatic valve shall be installed to bypass the flow of water around the closed-circuit cooling tower, except for any flow necessary for freeze protection, or low-leakage positive-closure dampers shall be provided.

2. Where an open-circuit cooling tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the open-circuit cooling tower.

3. Where an open-circuit or closed-circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the open-circuit cooling tower from the heat pump loop, heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

> **Exception:** Where it can be demonstrated that a heat pump system will be required to reject heat throughout the year.

C403.4.3.3.3 Two-position valve.
Each hydronic heat pump on the hydronic system shall have a two-position automatic valve interlocked to shut off the water flow when the compressor is off.

C403.4.4 Part-load controls.
Hydronic systems greater than or equal to 300,000 Btu/h (87.9 kW) in design output capacity supplying heated or chilled water to comfort conditioning systems shall include controls that are configured to do all of the following:

1. Automatically reset the supply-water temperatures in response to varying building heating and cooling demand using coil valve position, zone-return water temperature, building-return water temperature or outside air temperature. The temperature shall be reset by not less than 25 percent of the design supply-to-return water temperature difference.

2. Automatically vary fluid flow for hydronic systems with a combined pump motor capacity of 2 hp (1.5 kW) or larger with three or more control valves or other devices by reducing the system design flow rate by not less than 50 percent or the maximum reduction allowed by the equipment manufacturer for proper operation of equipment by valves that modulate or step open and close, or pumps that modulate or turn on and off as a function of load.

3. Automatically vary pump flow on heating-water systems, chilled-water systems and heat rejection loops serving water-cooled unitary air conditioners as follows:

    3.1. Where pumps operate continuously or operate based on a time schedule, pumps with nominal output motor power of 1 hp (0.75 kW) or more shall have a variable speed drive.

    3.2. Where pumps have automatic direct digital control (DDC) configured to operate pumps only when zone heating or cooling is required, a variable speed drive shall be provided. for pumps with nominal output motor power of 2 hp (1.5 kW) or more.

4. Where a variable speed drive is required by Item 3 of this section, pump motor power input shall be not more than 30 percent of design wattage at 50 percent of the design water flow. Pump flow shall be controlled to maintain one control valve nearly wide open. In systems where pump speed is controlled by a differential pressure setpoint, that setpoint shall be incrementally indexed down to maintain at least one valve nearly wide open. There shall be no lower limit to the differential pressure except to remain within the tolerances and accuracy of the controlling sensor.

Exceptions:

1. Supply-water temperature reset is not required for chilled-water systems supplied by off-site district chilled water or chilled water from ice storage systems.

2. Variable pump flow is not required on dedicated coil circulation pumps where needed for freeze protection.

3. Variable pump flow is not required on dedicated equipment circulation pumps where configured in primary/secondary design to provide the minimum flow requirements of the equipment manufacturer for proper operation of equipment.

4. For renovations, variable speed drives are not required on heating water pumps where more than 50 percent of annual heat is generated by a pre-existing electric boiler.

C403.4.5 Pump isolation.
Chilled water plants including more than one chiller shall be capable of and configured to reduce flow automatically through the chiller plant when a chiller is shut down. Chillers piped in series for the purpose of increased temperature differential shall be considered as one chiller.

Boiler systems including more than one boiler shall be capable of and configured to reduce flow automatically through the boiler system when a boiler is shut down.

C403.5 Economizers ~~(Prescriptive)~~.
Economizers shall comply with Sections C403.5.1 through C403.5.5.

An air or water economizer shall be provided for the following cooling systems:

1. Chilled water systems with a total cooling capacity, less cooling capacity provided with air economizers, as specified in Table C403.5.

2. Individual fan systems with cooling capacity greater than or equal to 54,000 Btu/h (15.8 kW) in buildings having other than a *Group R* occupancy.

3. Individual fan systems with cooling capacity greater than or equal to 270,000 Btu/h (79.1 kW) in buildings having a *Group R* occupancy.

Exception: Economizers are not required for the following systems.

1. In hospitals and ambulatory surgery centers, where more than 75 percent of the air designed to be supplied by the system is to spaces that are required to be humidified above 35°F (1.7°C) dew-point temperature to comply with applicable codes or accreditation standards.

2. Where more than 25 percent of the air designed to be supplied by the system is to spaces that are designed to be humidified above 35°F (1.7°C) dew-point temperature to satisfy process needs.

3. Systems expected to operate less than 20 hours per week.

4. Systems that include a heat recovery system in accordance with Section C403.9.5.

~~1.~~5. VRF systems installed with a dedicated outdoor air system.

TABLE C403.5
MINIMUM CHILLED-WATER SYSTEM COOLING CAPACITY FOR DETERMINING ECONOMIZER COOLING REQUIREMENTS

TOTAL CHILLED-WATER SYSTEM CAPACITY LESS CAPACITY OF COOLING UNITS WITH AIR ECONOMIZERS	
Local Water-cooled Chilled-water Systems	**Air-cooled Chilled-water Systems or District Chilled-Water Systems**
1,320,000 Btu/h	1,720,000 Btu/h

For SI: 1 British thermal unit per hour = 0.2931 W.

C403.5.1 Integrated economizer control.

Economizer systems shall be integrated with the mechanical cooling system and be configured to provide partial cooling even where additional mechanical cooling is required to provide the remainder of the cooling load. Controls shall not be capable of creating a false load in the mechanical cooling systems by limiting or disabling the economizer or any other means, except at the lowest stage of mechanical cooling.

Units that include an air economizer shall comply with the following:

1. Unit controls shall have the mechanical cooling capacity control interlocked with the air economizer controls such that the outdoor air damper is at the 100-percent open

position when mechanical cooling is on and the outdoor air damper does not begin to close to prevent coil freezing due to minimum compressor run time until the leaving air temperature is less than 45°F (7°C).

2. Direct expansion (DX) units that control 75,000 Btu/h (22 kW) or greater of rated capacity of the capacity of the mechanical cooling directly based on occupied space temperature shall have not fewer than three stages (off/1st stage/2nd stage) of mechanical cooling capacity.

3. Other DX units, including those that control space temperature by modulating the airflow to the space, shall be in accordance with Table C403.5.1.

   Exception: Direct expansion (DX) units with one variable displacement compressor can have fewer than three stages provided the constant displacement compressor is no more than the percent of full load in accordance with Table C403.5.1.

TABLE C403.5.1
DX COOLING STAGE REQUIREMENTS FOR MODULATING AIRFLOW UNITS

RATING CAPACITY	MINIMUM NUMBER OF MECHANICAL COOLING STAGES	MINIMUM COMPRESSOR DISPLACEMENT[a]
≥ 75,000 Btu/h and < 240,000 Btu/h	3 stages	≤ 35% of full load
≥ 240,000 Btu/h	4 stages	≤ 25% full load

For SI: 1 British thermal unit per hour = 0.2931 W.
a. For mechanical cooling stage control that does not use variable compressor displacement, the percent displacement shall be equivalent to the mechanical cooling capacity reduction evaluated at the full load rating conditions for the compressor.

C403.5.2 Economizer heating system impact.
HVAC system design and economizer controls shall be such that economizer operation does not increase building heating energy use during normal operation.

Exception: Economizers on variable air volume (VAV) systems that cause zone level heating to increase because of a reduction in supply air temperature.

C403.5.3 Air economizers.
Where economizers are required by Section C403.5, air economizers shall comply with Sections C403.5.3.1 through C403.5.3.5.

C403.5.3.1 Design capacity.
Air economizer systems shall be configured to modulate *outdoor air* and return air dampers to provide up to 100 percent of the design supply air quantity as *outdoor air* for cooling.

C403.5.3.2 Control signal.
Economizer controls and dampers shall be configured to sequence the dampers with the mechanical cooling equipment and shall not be controlled by only mixed-air temperature.

Exception: The use of mixed-air temperature limit control shall be permitted for systems controlled from space temperature (such as single-*zone* systems).

C403.5.3.3 High-limit shutoff.
Air economizers shall be configured to automatically reduce *outdoor air* intake to the design minimum *outdoor air* quantity when *outdoor air* intake will not reduce cooling energy usage. High-limit shutoff control types for specific climates shall be chosen from Table C403.5.3.3. High-limit shutoff control settings for these control types shall be those specified in Table C403.5.3.3.

TABLE C403.5.3.3

HIGH-LIMIT SHUTOFF CONTROL SETTING FOR AIR ECONOMIZERS[b]

DEVICE TYPE	REQUIRED HIGH LIMIT (ECONOMIZER OFF WHEN):	
	Equation	**Description**
Fixed dry bulb	$T_{OA} > 70°F$	Outdoor air temperature exceeds 70°F
Differential dry bulb	$T_{OA} > T_{RA}$	Outdoor air temperature exceeds return air temperature
Fixed enthalpy with fixed dry-bulb temperatures	$h_{OA} > 28$ Btu/lb[a] or $T_{OA} > 75°F$	Outdoor air enthalpy exceeds 28 Btu/lb of dry air[a] or Outdoor air temperature exceeds 75°F
Differential enthalpy with fixed dry-bulb temperature	$h_{OA} > h_{RA}$ or $T_{OA} > 75°F$	Outdoor air enthalpy exceeds return air enthalpy or Outdoor air temperature exceeds 75°F

For SI: 1 foot = 305 mm, °C = (°F - 32)/1.8, 1 Btu/lb = 2.33 kJ/kg.

a. At altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at 75°F and 50-percent relative humidity. As an example, at approximately 6,000 feet elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.

b. Devices with selectable setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.

C403.5.3.4 Relief of excess outdoor air.
Systems shall be capable of relieving excess *outdoor air* during air economizer operation to prevent overpressurizing the building. The relief air outlet shall be located to avoid recirculation into the building.

C403.5.3.5 Economizer dampers.
Return, exhaust/relief and outdoor air dampers used in economizers shall comply with Section C403.7.7.

C403.5.4 Water-side economizers.
Where economizers are required by Section C403.5, water-side economizers shall comply with Sections C403.5.4.1 and C403.5.4.2.

C403.5.4.1 Design capacity.
Water economizer systems shall be configured to cool supply air by indirect evaporation and providing up to 100 percent of the expected system cooling load at *outdoor air* temperatures of not greater than 50°F (10°C) dry bulb/45°F (7°C) wet bulb.

Exceptions:

1. Systems primarily serving computer rooms in which 100 percent of the expected system cooling load at 40°F (4°C) dry bulb/35°F (1.7°C) wet bulb is met with evaporative water economizers.

2. Systems primarily serving computer rooms with dry cooler water economizers that satisfy 100 percent of the expected system cooling load at 35°F (1.7°C) dry bulb.

3. Systems where dehumidification requirements cannot be met using outdoor air temperatures of 50°F (10°C) dry bulb/45°F (7°C) wet bulb and where 100 percent of the expected system cooling load at 45°F (7°C) dry bulb/40°F (4°C) wet bulb is met with evaporative water economizers.

C403.5.4.2 Maximum pressure drop.
Precooling coils and water-to-water heat exchangers used as part of a water economizer system shall either have a water-side pressure drop of less than 15 feet (45 kPa) of water or a secondary loop shall be created so that the coil or heat exchanger pressure drop is not seen by the circulating pumps when the system is in the normal cooling (noneconomizer) mode.

C403.5.5 Economizer fault detection and diagnostics ~~(Mandatory)~~.
Air-cooled unitary direct-expansion units listed in ~~Tables C403.3.2(1) through C403.3.2(3) and Tables C403.3.2(10) and C403.3.2(11)~~ the tables in Section C403.3.2 and variable refrigerant flow (VRF) units that are 1~~5~~0 tons (1~~8~~20,000 Btu/h) or greater and equipped with an economizer in accordance with Section C403.5 through C403.5.4 shall include a fault detection and diagnostics system complying with the following:

1. The following temperature sensors shall be permanently installed to monitor system operation:

   1.1. Outside air.

   1.2. Supply air.

   1.3. Return air.

2. Indoor temperature sensors shall have an accuracy of ±2°F (1.1°C) over the range of 40°F to 80°F (4°C to 26.7°C). Outdoor temperature sensors shall have an accuracy of ±2°F (1.1°C) over the range of -40°F to 100°F (-40°C to 37.8°C).

3. Refrigerant pressure sensors, where used, shall have an accuracy of ±3 percent of full scale.

4. The unit controller shall be configured to provide system status by indicating the following:

    4.1. Free cooling available.

    4.2. Economizer enabled.

    4.3. Compressor enabled.

    4.4. Heating enabled.

    4.5. Mixed air low limit cycle active.

    4.6. The current value of each sensor.

5. The unit controller shall be capable of manually initiating each operating mode so that the operation of compressors, economizers, fans and the heating system can be independently tested and verified.

6. The unit shall be configured to report faults to a fault management application available for *access* by day-to-day operating or service personnel or annunciated locally on zone thermostats.

7. The fault detection and diagnostics system shall be configured to detect the following faults:

    7.1. Air temperature sensor failure/fault.

    7.2. Not economizing when the unit should be economizing.

    7.3. Economizing when the unit should not be economizing.

    7.4. Damper not modulating.

    7.5. Excess outdoor air.

C403.6 Requirements for mechanical systems serving multiple zones.
Sections C403.6.1 through C403.6.9 shall apply to mechanical systems serving multiple zones.

C403.6.1 Variable air volume and multiple-zone systems.
Supply air systems serving multiple zones shall be variable air volume (VAV) systems that have zone controls configured to reduce the volume of air that is reheated, recooled or mixed in each zone to one of the following:

1. Twenty percent of the zone design peak supply for systems with direct digital control (DDC) and 30 percent for other systems.

2. Systems with DDC where all of the following apply:

2.1. The airflow rate in the deadband between heating and cooling does not exceed 20 percent of the zone design peak supply rate or higher allowed rates under Items 3, 4 and 5 of this section.

2.2. The first stage of heating modulates the zone supply air temperature setpoint up to a maximum setpoint while the airflow is maintained at the deadband flow rate.

2.3. The second stage of heating modulates the airflow rate from the deadband flow rate up to the heating maximum flow rate that is less than 50 percent of the zone design peak supply rate.

3. The outdoor airflow rate required to meet the minimum ventilation requirements of ASHRAE Standard 62.1.

4. Any higher rate that can be demonstrated to reduce overall system annual energy use by offsetting reheat/recool energy losses through a reduction in outdoor air intake for the system as approved by the code official.

5. The airflow rate required to comply with applicable codes or accreditation standards such as pressure relationships or minimum air change rates.

6. Zones where special humidity levels are required to satisfy process needs.

Exception: The following individual zones or entire air distribution systems are exempted from the requirement for VAV control:

1. *Zones* or supply air systems where not less than 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered, including condenser heat, or site-solar energy source.

2. Systems that prevent reheating, recooling, mixing or simultaneous supply of air that has been previously cooled, either mechanically or through the use of economizer systems, and air that has been previously mechanically heated.

C403.6.2 Single-duct VAV systems, terminal devices.
Single-duct VAV systems shall use terminal devices capable of and configured to reduce the supply of primary supply air before reheating or recooling takes place.

C403.6.3 Supply-air temperature reset controls.
Multiple-*zone* HVAC systems shall include controls that are capable of and configured to automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperature. The controls shall be configured to reset the supply air temperature not less than 25 percent of the difference between the design supply-air temperature and the design room air temperature. Controls that adjust the reset based on zone humidity are allowed ~~in Climate Zones 0B, 1B, 2B, 3B, 3C and 4 through 8~~. HVAC zones that are expected to experience relatively constant loads, shall have maximum airflow designed to accommodate the fully reset supply-air temperature.

Exceptions:

1. Systems that prevent reheating, recooling or mixing of heated and cooled supply air.

2. Seventy-five percent of the energy for reheating is from site-recovered or site-solar energy sources.

3. ~~Systems in Z*Climate Zones* with peak supply air quantities of 300 cfm (142 L/s) or lessless than 3,000 cfm (1500 L/s) of design outside air.~~

C403.6.4 Multiple-zone VAV system ventilation optimization control.
Multiple-zone VAV systems with direct digital control of individual zone boxes reporting to a central control panel shall have automatic controls configured to reduce outdoor air intake flow below design rates in response to changes in system *ventilation* efficiency (E_v).

Exceptions:

1. VAV systems with zonal transfer fans that recirculate air from other zones without directly mixing it with outdoor air, dual-duct dual-fan VAV systems, and VAV systems with fan-powered terminal units.

2. Systems where total design exhaust airflow is more than 70 percent of total design outdoor air intake flow requirements.

C403.6.5 Parallel-flow fan-powered VAV air terminal control.
Parallel-flow fan-powered VAV air terminals shall have automatic controls configured to:

1. Turn off the terminal fan except when space heating is required or where required for ventilation.

2. Turn on the terminal fan as the first stage of heating before the heating coil is activated.

3. During heating for warmup or setback temperature control, either:

   3.1. Operate the terminal fan and heating coil without primary air.

   3.2. Reverse the terminal damper logic and provide heating from the central air handler by primary air.

C403.6.6 Setpoints for direct digital control.
For systems with direct digital control of individual zones reporting to the central control panel, the static pressure setpoint shall be reset based on the *zone* requiring the most pressure. In such case, the setpoint is reset lower until one *zone* damper is nearly wide open. The direct digital controls shall be capable of monitoring zone damper positions or shall have an alternative method of indicating the need for static pressure that is configured to provide all of the following:

1. Automatic detection of any *zone* that excessively drives the reset logic.

2. Generation of an alarm to the system operational location.

3. Allowance for an operator to readily remove one or more *zones* from the reset algorithm.

C403.6.7 Static pressure sensor location.
Static pressure sensors used to control VAV fans shall be located such that the controller setpoint is not greater than 1.2 inches w.g. (299 Pa), or 1.7 w.g. (423 Pa) in systems with HEPA or ULPA filters. Where this results in one or more sensors being located downstream of major duct splits, not less than one sensor shall be located on each major branch to ensure that static pressure can be maintained in each branch. Location of the static pressure sensor near the supply fan discharge would result in noncompliance.

C403.7 Ventilation and exhaust systems ~~(Mandatory)~~.
In addition to other requirements of Section C403 applicable to the provision of ventilation air or the exhaust of air, ventilation and exhaust systems shall be in accordance with Sections C403.7.1 through C403.7.7.

C403.7.1 Demand control ventilation ~~(Mandatory)~~.
Demand control ventilation (DCV) shall be provided for all single-zone systems required to comply with Sections C403.5 through C403.5.3 and spaces larger than 500 square feet (46.5 m^2) and with an average occupant load of ~~25~~ 15 people or greater per 1,000 square feet (93 m^2) of floor area, as established in Table 6.1 of ASHRAE 62.1, and served by systems with one or more of the following:

1. An air-side economizer.

2. Automatic modulating control of the outdoor air damper.

3. A design outdoor airflow greater than 3,000 cfm (1416 L/s).

Exceptions:

1. Systems with energy recovery complying with ~~Section C403.7.4~~Section C403.7.4.2.

2. Multiple-zone systems without direct digital control of individual zones communicating with a central control panel.

3. Spaces where more than 75 percent of the space design outdoor airflow is required for makeup air that is exhausted from the space or transfer air that is required for makeup air that is exhausted from other spaces.~~Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1,200 cfm (566 L/s).~~

4. Spaces with one of the following occupancy classifications as defined in Table 403.3.1.1 of the International Mechanical Code: correctional cells, education laboratories, barber, beauty and nail salons, and bowling alley seating areas.~~Ventilation provided only for process loads.~~

C403.7.2 Enclosed parking garage ventilation controls ~~(Mandatory)~~.
Enclosed parking garages used for storing or handling automobiles operating under their own power shall employ ~~contamination-sensing devices~~ carbon monoxide detectors applied in conjunction with nitrogen dioxide detectors and automatic controls configured to stage fans or modulate fan average airflow rates as stipulated in the Vermont Fire and Building Safety Code enforced by the Vermont Department of Public Safety's Division of Fire Safety. Failure of contamination-sensing devices shall cause the exhaust fans to operate continuously at design airflow.

Exceptions:

1. Garages with a total exhaust capacity less than 4,000 cfm (1,888 L/s) with ventilation systems that do not utilize heating or mechanical cooling.
2. Garages that have a garage area to ventilation system motor nameplate power ratio that exceeds 1,125 cfm/hp (710 L/s/kW) and do not utilize heating or mechanical cooling.

C403.7.3 Ventilation air heating control ~~(Mandatory)~~.
Units that provide ventilation air to multiple zones and operate in conjunction with zone heating and cooling systems shall not use heating to warm supply air to a temperature greater than 60°F (16°C) when representative building loads or outdoor air temperatures indicate that the majority of zones require cooling.

C403.7.4 Energy recovery ventilation systems. Energy recovery ventilation systems shall be provided as specified in either Section C403.7.4.1 or C403.7.4.2, as applicable.

C403.7.4.1 Nontransient dwelling units. Nontransient dwelling units shall be provided with outdoor air energy recovery ventilation systems with an enthalpy recovery ratio of not less than ~~50~~60 percent at cooling design condition and not less than ~~60~~70 percent at heating design condition.

~~**Exceptions:**~~

~~**1.** Enthalpy recovery ratio requirements at cooling design condition~~.

C403.7.4.2 ~~Energy recovery ventilation systems (Mandatory)~~Spaces other than nontransient dwelling units.
Where the supply airflow rate of a fan system serving a space other than a nontransient dwelling unit exceeds the values specified in Tables C403.7.4.2~~(1) and C403.7.4.2(2)~~, the system shall include an energy recovery system. The energy recovery system shall ~~Where the supply airflow rate of an air system exceeds the values specified in Table C403.7.4, the system shall include an energy recovery system. The energy recovery system shall be configured to~~ provide ~~a change in the~~an enthalpy recovery ~~of the outdoor air supply~~ ratio of not less than 50 percent of the difference between the outdoor air and return air enthalpies, at design conditions. Where an air economizer is required, the energy recovery system shall include a bypass or controls that permit operation of the economizer as required by Section C403.5.

> **Exception:** An energy recovery ventilation system shall not be required in any of the following conditions:
>
> 1. Where energy recovery systems are prohibited by ASHRAE Standard 62.1.

2. Laboratory fume hood systems that include not fewer than one of the following features:

   2.1. Variable-air-volume hood exhaust and room supply systems configured to reduce exhaust and makeup air volume to 50 percent or less of design values.

   2.2. Direct makeup (auxiliary) air supply equal to or greater than 75 percent of the exhaust rate, heated not warmer than 2°F (1.1°C) above room setpoint, cooled to not cooler than 3°F (1.7°C) below room setpoint, with no humidification added, and no simultaneous heating and cooling used for dehumidification control.

3. Systems serving spaces that are heated to less than 60°F (15.5°C) and that are not cooled.

4. Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site-solar energy.

5. Systems requiring dehumidification that employ energy recovery in series with the cooling coil.

6. Systems expected to operate less than 20 hours per week at the *outdoor air* percentage covered by Table C403.7.4.

7. Systems exhausting toxic, flammable, paint or corrosive fumes or dust.

8. Commercial kitchen hoods used for collecting and removing grease vapors and smoke.

TABLE C403.7.4
ENERGY RECOVERY REQUIREMENT
(~~Air~~ Ventilation systems operating not less than 3,000 hours per year

PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE							
≥ 10% and < 20%	**≥ 20% and < 30%**	**≥ 30% and < 40%**	**≥ 40% and < 50%**	**≥ 50% and < 60%**	**□ ≥ 60% and < 70%**	**≥ 70% and < 80%**	**□ ≥ 80%**
Design Supply Fan Airflow Rate (cfm)							
≥ 10,500	≥ 6,500	≥ 5,500	≥ 4,500	≥ 3,500	≥ 2,000	≥ 1,000	> 120

For SI: 1 cfm = 0.4719 L/s.

C403.7.5 Kitchen exhaust systems ~~(Mandatory)~~.
Replacement air introduced directly into the exhaust hood cavity shall not be greater than 10 percent of the hood exhaust airflow rate. Conditioned supply air delivered to any space shall not exceed the greater of the following:

1. The ventilation rate required to meet the space heating or cooling load.

2. The hood exhaust flow minus the available transfer air from adjacent space where available transfer air is considered to be that portion of outdoor ventilation air not required to satisfy other exhaust needs, such as restrooms, and not required to maintain pressurization of adjacent spaces.

Where total kitchen hood exhaust airflow rate is greater than 5,000 cfm (2360 L/s), each hood shall be a factory-built commercial exhaust hood listed by a nationally recognized testing laboratory in compliance with UL 710. Each hood shall have a maximum exhaust rate as specified in Table C403.7.5 and shall comply with one of the following:

1. Not less than 50 percent of all replacement air shall be transfer air that would otherwise be exhausted.

2. Demand ventilation systems on not less than 75 percent of the exhaust air that are configured to provide not less than a 50-percent reduction in exhaust and replacement air system airflow rates, including automatic controls necessary to modulate airflow in response to appliance operation and to maintain full capture and containment of smoke, effluent and combustion products during cooking and idle.

3. Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40 percent on not less than 50 percent of the total exhaust airflow.

Where a single hood, or hood section, is installed over appliances with different duty ratings, the maximum allowable flow rate for the hood or hood section shall be based on the requirements for the highest appliance duty rating under the hood or hood section.

Exception: Where not less than 75 percent of all the replacement air is transfer air that would otherwise be exhausted.

TABLE C403.7.5
MAXIMUM NET EXHAUST FLOW RATE,
CFM PER LINEAR FOOT OF HOOD LENGTH

TYPE OF HOOD	LIGHT-DUTY EQUIPMENT	MEDIUM-DUTY EQUIPMENT	HEAVY-DUTY EQUIPMENT	EXTRA-HEAVY-DUTY EQUIPMENT
Wall-mounted canopy	140	210	280	385
Single island	280	350	420	490
Double island (per side)	175	210	280	385
Eyebrow	175	175	NA	NA
Backshelf/Pass-over	210	210	280	NA

For SI:1 cfm = 0.4719 L/s; 1 foot = 305 mm.
NA = Not Allowed.

C403.7.6 Automatic control of HVAC systems serving guestrooms ~~(Mandatory)~~.
In *Group R-1* buildings containing more than 50 guestrooms, each guestroom shall be provided with controls complying with the provisions of Sections C403.7.6.1 and C403.7.6.2. Card key controls comply with these requirements.

C403.7.6.1 Temperature setpoint controls.
Controls shall be provided on each HVAC system that are capable of and configured ~~to automatically raise the cooling setpoint and lower the heating setpoint by not less than 4°F (2°C) from the occupant setpoint within 30 minutes after the occupants have left the guestroom. The controls shall be capable of and configured to automatically raise the cooling setpoint to not lower than 80°F (27°C) and lower the heating setpoint to not higher than 60°F (16°C) when the guestroom is unrented or has not been continuously occupied for more than 16 hours or a *networked guestroom control system* indicates that the guestroom is unrented and the guestroom is unoccupied for more than 30 minutes. A *networked guestroom control system* that is capable of returning the thermostat setpoints to default occupied setpoints 60 minutes prior to the time a guestroom is scheduled to be occupied is not precluded by this section. Cooling that is capable of limiting relative humidity with a setpoint not lower than 65-percent relative humidity during unoccupied periods is not precluded by this section~~with three modes of temperature control.

1. When the guestroom is rented but unoccupied, the controls shall automatically raise the cooling setpoint and lower the heating setpoint by not less than 4°F (2°C) from the occupant setpoint within 30 minutes after the occupants have left the guestroom.
2. When the guestroom is unrented and unoccupied, the controls shall automatically raise the cooling setpoint to not lower than 80°F (27°C) and lower the heating setpoint to not higher than 60°F (16°C). Unrented and unoccupied guestroom mode shall be initiated within 16 hours of the guestroom being continuously occupied or where a networked guestroom control system indicates that the guestroom is unrented and the guestroom is unoccupied for more than 20 minutes. A networked guestroom control system that is capable of returning the thermostat setpoints to default occupied setpoints 60 minutes prior to the time a guestroom is scheduled to be occupied is not precluded by this section. Cooling that is capable of limiting relative humidity with a setpoint not lower than 65- percent relative humidity during unoccupied periods is not precluded by this section.

3. When the guestroom is occupied, HVAC setpoints shall return to their occupied setpoints once occupancy is sensed.

C403.7.6.2 Ventilation controls.
Controls shall be provided on each HVAC system that are capable of and configured to automatically turn off the ventilation and exhaust fans within ~~30~~ 20 minutes of the occupants leaving the guestroom, or *isolation devices* shall be provided to each guestroom that are capable of automatically shutting off the supply of outdoor air to and exhaust air from the guestroom.

Exception: Guestroom ventilation systems are not precluded from having an automatic daily pre-occupancy purge cycle that provides daily outdoor air ventilation during unrented periods at the design ventilation rate for 60 minutes, or at a rate and duration equivalent to one air change.

C403.7.7 Shutoff dampers ~~(Mandatory)~~.
Outdoor air intake and exhaust openings and stairway and shaft vents shall be provided with Class I motorized dampers. The dampers shall have an air leakage rate not greater than 4 cfm/ft^2 (20.3 L/s • m^2) of damper surface area at 1.0 inch water gauge (249 Pa) and shall be labeled by an approved agency when tested in accordance with AMCA 500D for such purpose.

Outdoor air intake and exhaust dampers shall be installed with automatic controls configured to close when the systems or spaces served are not in use or during unoccupied period warm-up and setback operation, unless the systems served require outdoor or exhaust air in accordance with ASHRAE Standard 62.1 or the dampers are opened to provide intentional economizer cooling.

Stairway and shaft vent dampers shall be installed with automatic controls configured to open upon the activation of any fire alarm initiating device of the building's fire alarm system or the interruption of power to the damper.

Exception: Nonmotorized gravity dampers shall be an alternative to motorized dampers for exhaust and relief openings where the design exhaust capacity is not greater than 300 cfm (142 L/s).

Nonmotorized gravity dampers shall have an air leakage rate not greater than 20 cfm/ft^2 (101.6 L/s • m^2) where not less than 24 inches (610 mm) in either dimension and 40 cfm/ft^2 (203.2 L/s • m^2) where less than 24 inches (610 mm) in either dimension. The rate of air leakage shall be determined at 1.0 inch water gauge (249 Pa) when tested in accordance with AMCA 500D for such purpose. The dampers shall be labeled by an approved agency.

C403.8 Fans and fan controls.
Fans in HVAC systems shall comply with Sections C403.8.1 through C403.8.5.1.

C403.8.1 Allowable fan horsepower ~~(Mandatory)~~.
Each HVAC system having a total fan system motor nameplate horsepower exceeding 5 hp (3.7 kW) at fan system design conditions shall not exceed the allowable *fan system motor nameplate hp* (Option 1) or *fan system bhp* (Option 2) shown in Table C403.8.1(1). This

includes supply fans, exhaust fans, return/relief fans, and fan-powered terminal units associated with systems providing heating or cooling capability. Single-zone variable air volume systems shall comply with the constant volume fan power limitation.

Exceptions:

1. Hospital, vivarium and laboratory systems that utilize flow control devices on exhaust or return to maintain space pressure relationships necessary for occupant health and safety or environmental control shall be permitted to use variable volume fan power limitation.

2. Individual exhaust fans with motor nameplate horsepower of 1 hp (0.746 kW) or less are exempt from the allowable fan horsepower requirement.

TABLE C403.8.1(1)
FAN POWER LIMITATION

	LIMIT	CONSTANT VOLUME	VARIABLE VOLUME
Option 1: Fan system motor nameplate hp	Allowable nameplate motor hp	$hp \leq CFM_S \times 0.0011$	$hp \leq CFM_S \times 0.0015$
Option 2: Fan system bhp	Allowable fan system bhp	$bhp \leq CFM_S \times 0.00094 + A$	$bhp \leq CFM_S \times 0.0013 + A$

For SI: 1 bhp = 735.5 W, 1 hp = 745.5 W, 1 cfm = 0.4719 L/s.

where:

CFM_S = The maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minut

hp = The maximum combined motor nameplate horsepower.

bhp = The maximum combined fan brake horsepower.

A = Sum of [$PD \times CFM_D$ / 4131].

where:

PD = Each applicable pressure drop adjustment from Table C403.8.1(2) in. w.c.

CFM_D = The design airflow through each applicable device from Table C403.8.1(2) in cubic feet per minute.

TABLE C403.8.1(2)
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT

DEVICE	ADJUSTMENT
Credits	
Return air or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms	0.5 inch w.c. (2.15 inches w.c. for laboratory and vivarium systems)
Return and exhaust airflow control devices	0.5 inch w.c.
Exhaust filters, scrubbers or other exhaust treatment	The pressure drop of device calculated at fan system design condition
Particulate filtration credit: MERV 9 thru 12	0.5 inch w.c.
Particulate filtration credit: MERV 13 thru 15	0.9 inch w.c.
Particulate filtration credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2x clean filter pressure drop at fan system design condition.
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition.
Biosafety cabinet	Pressure drop of device at fan system design condition.
Energy recovery device, other than coil runaround loop	For each airstream, (2.2 × energy recovery effectiveness – 0.5) inch w.c.
Coil runaround loop	0.6 inch w.c. for each airstream.
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design conditions.
Sound attenuation section (fans serving spaces with design background noise goals below NC35)	0.15 inch w.c.
Exhaust system serving fume hoods	0.35 inch w.c.
Laboratory and vivarium exhaust systems in high-rise buildings	0.25 inch w.c./100 feet of vertical duct exceeding 75 feet.

Deductions	
Systems without central cooling device	- 0.6 inch w.c.
Systems without central heating device	- 0.3 inch w.c.
Systems with central electric resistance heat	- 0.2 inch w.c.

For SI: 1 inch w.c. = 249 Pa, 1 inch = 25.4 mm.
w.c. = water column, NC = Noise criterion.

C403.8.2 Motor nameplate horsepower ~~(Mandatory)~~.
For each fan, the fan brake horsepower shall be indicated on the construction documents and the selected motor shall be not larger than the first available motor size greater than the following:

1. For fans less than 6 bhp (~~4413~~ 4476 W), 1.5 times the fan brake horsepower.
2. For fans 6 bhp (~~4413~~ 4476 W) and larger, 1.3 times the fan brake horsepower.
3. ~~Systems complying with Section C403.8.1 *fan system motor nameplate hp* (Option 1).~~

~~**Exception: Fans with motor nameplate horsepower less than 1 hp (746 W) are exempt from this section.**~~
Exceptions:

1. Fans equipped with electronic speed control devices to vary the fan airflow as a function of load.
2. Fans with a fan nameplate electrical input power of less than 0.89 kW.
3. Systems complying with Section C403.8.1 fan system motor nameplate hp (Option 1).
4. Fans with motor nameplate horsepower less than 1 hp (746 W)

C403.8.3 Fan efficiency ~~(Mandatory)~~.
~~Fans~~ Each fan and fan array shall have a fan ~~efficiency grade (FEG)~~energy index (FEI) of not less than ~~70~~1.00 at the design point of operation, as determined in accordance with AMCA 20~~5~~8 by an *approved*, independent testing laboratory and labeled by the manufacturer. ~~The total efficiency of the fan~~Each fan and fan array used for a variable-air-volume system shall have an FEI of not less than 0.95 at the design point of operation ~~shall be within 15 percentage points of the maximum total efficiency of the fan~~as determined in accordance with the AMCA 208 by an approved independent testing laboratory and labeled by the manufacturer. The FEI for fan arrays shall be calculated in accordance with AMCA 208 Annex C.

Exceptions: The following fans are not required to have a fan ~~efficiency grade~~energy index:

1. Fans that are not embedded fans with motor nameplate horsepower of less than 1.0 hp (0.75 kW) or with a nameplate electrical input power of less than 0.89 kW. ~~Fans of 1 hp (0.75 kW) or less as follows:~~

   1.1. ~~Individual fans with a motor nameplate horsepower of 1 hp (0.75 kW) or less, unless Exception 1.2 applies.~~

~~1.2. Multiple fans in series or parallel that have a combined motor nameplate horsepower of 2 hp (1.5 kW) or less and are operated as the functional equivalent of a single fan.~~

2. ~~2.~~ Embedded fans that have a motor nameplate horsepower of 5 hp (3.7 kW) or less, or with a fan system electrical input power of 4.1 kW or less

3. Multiple fans operated in series or parallel as the functional equivalent of a single fan that have a combined motor nameplate horsepower of 5 hp (3.7 kW) or less or with a fan system electrical input power of 4.1 kW or less.

4. Fans that are part of equipment covered in Section C403.3.2.

~~3.~~ 5. Fans included in an equipment package certified by an *approved agency* for air or energy performance.

~~4. Powered wall/roof ventilators.~~

6. Ceiling fans, which are defined as nonportable devices suspended from a ceiling or overhead structure for circulating air via the rotation of the blades.

7. Fans used for moving gases at temperatures above 425°F (250°C)

8. Fans used for operation in explosive atmospheres.

9. Reversible fans used for tunnel ventilation.

~~5. Fans outside the scope of AMCA 205.~~

10. ~~6.~~ Fans that are intended to operate only during emergency conditions.

11. Fans outside the scope of AMCA 208.

C403.8.4 Fractional hp fan motors ~~(Mandatory)~~.

Motors for fans that are not less than $^{1}/_{12}$ hp (0.062 kW) and less than 1 hp (0.746 kW) shall be electronically commutated motors or NEMA Premium efficiency motors rated in accordance with DOE 10 CFR 431. These motors shall have the means to adjust motor speed for either balancing or remote control. The use of belt-driven fans to sheave adjustments for airflow balancing instead of a varying motor speed shall be permitted.

Exceptions: The following motors are not required to comply with this section:

1. Motors that are an integral part of specialized process equipment.

2. Where the motor is integral to a listed piece of equipment for which no complying motor has been approved.

3. Motors in the airstream within fan coils and terminal units that only provide heating to the space served.

4. Motors in space-conditioning equipment that comply with Section C403.3.2 or Sections C403.8.1. through C403.8.3.

5. Motors that comply with Section C405.7.

C403.8.5 Low-capacity ventilation fans. Mechanical ventilation system fans with motors less than 1/12 hp (0.062 kW) in capacity shall meet the efficacy requirements of Table C403.8.5 at one or more rating points.

Exceptions:

1. Where ventilation fans are a component of a listed heating or cooling appliance.
2. Dryer exhaust duct power ventilators, domestic range hoods, and domestic range booster fans that operate intermittently.

TABLE C403.8.5 LOW-CAPACITY VENTILATION FAN EFFICACYa

FAN LOCATION	AIRFLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)	AIRFLOW RATE MAXIMUM (CFM)
HRV or ERV	Any	1.2 cfm/watt	Any
In-line fan	Any	3.8 cfm/watt	Any
Bathroom, utility room	10	2.8 cfm/watt	<90
Bathroom, utility room	90	3.5 cfm/watt	Any

For SI: 1 cfm/ft = 47.82 W.

a. Airflow shall be tested in accordance with HVI 916 and listed. Efficacy shall be listed or shall be derived from listed power and airflow. Fan efficacy for fully ducted HRV, ERV, balanced and in-line fans shall be determined at a static pressure not less than 0.2 inch w.c. Fan efficacy for ducted range hoods, bathroom and utility room fans shall be determined at a static pressure not less than 0.1 inch w.c.

C403.8.~~5~~6 Fan control.
Controls shall be provided for fans in accordance with Section C403.8.5.1 and as required for specific systems provided in Section C403.

C403.8.6~~5~~.1 Fan airflow control.
Each cooling system listed in Table C403.8.~~5~~6.1 shall be designed to vary the indoor fan airflow as a function of load and shall comply with the following requirements:

1. Direct expansion (DX) and chilled water cooling units that control the capacity of the mechanical cooling directly based on space temperature shall have not fewer than two stages of fan control. Low or minimum speed shall not be greater than 66 percent of full speed. At low or minimum speed, the fan system shall draw not more than 40 percent of the fan power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and ventilation-only operation.

2. Other units including DX cooling units and chilled water units that control the space temperature by modulating the airflow to the space shall have modulating fan control. Minimum speed shall be not greater than 50 percent of full speed. At minimum speed the fan system shall draw not more than 30 percent of the power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and ventilation-only operation.

3. Units that include an air-side economizer in accordance with Section C403.5 shall have modulating fan control during economizer operation.

Exceptions:

1. Modulating fan control is not required for chilled water and evaporative cooling units with fan motors of less than 1 hp (0.746 kW) where the units are not used to provide *ventilation air* and the indoor fan cycles with the load.
2. Where the volume of outdoor air required to comply with the ventilation requirements of ASHRAE Standard 62.1 at low speed exceeds the air that would be delivered at the speed defined in Section C403.8.5, the minimum speed shall be selected to provide the required v*entilation air*.

TABLE C403.8.~~5~~6.1
COOLING SYSTEMS

COOLING SYSTEM TYPE	FAN MOTOR SIZE	MECHANICAL COOLING CAPACITY
DX cooling	Any	≥ 24,000 Btu/h
Chilled water and evaporative cooling	≥ $^1/_4$ hp	Any

For SI: 1 British thermal unit per hour = 0.2931 W; 1 hp = 0.746 kW.

C403.9 Large-diameter ceiling fans. Where provided, large-diameter ceiling fans shall be tested and labeled in accordance with AMCA 230.

C403.10~~9~~ Heat rejection equipment.
Heat rejection equipment, including air-cooled condensers, dry coolers, open-circuit cooling towers, closed-circuit cooling towers and evaporative condensers, shall comply with this section.

Exception: Heat rejection devices where energy usage is included in the equipment efficiency ratings listed in Tables C403.3.2(6) and C403.3.2(7).

C403.10~~9~~.1 Fan speed control.
Each fan system powered by an individual motor or array of motors with connected power, including the motor service factor, totaling 2 hp (1.5 kW) or more shall have controls and devices configured to automatically modulate the fan speed to control the leaving fluid temperature or condensing temperature and pressure of the heat rejection device. Fan motor power input shall be not more than 30 percent of design wattage at 50 percent of the design airflow.

Exceptions:

1. Fans serving multiple refrigerant or fluid cooling circuits.
2. Condenser fans serving flooded condensers.

C403.~~9~~10.2 Multiple-cell heat rejection equipment.
Multiple-cell heat rejection equipment with variable speed fan drives shall be controlled to

operate the maximum number of fans allowed that comply with the manufacturer’s requirements for all system components and so that all fans operate at the same fan speed required for the instantaneous cooling duty, as opposed to staged on and off operation. The minimum fan speed shall be the minimum allowable speed of the fan drive system in accordance with the manufacturer’s recommendations.

C403.10~~9~~.3 Limitation on centrifugal fan open-circuit cooling towers.
Centrifugal fan open-circuit cooling towers with a combined rated capacity of 550 gpm (2081 L/m) or greater at 95°F (35°C) condenser water return, 85°F (29°C) condenser water supply, and 75°F (24°C) outdoor air wet-bulb temperature shall meet the energy efficiency requirement for axial fan open-circuit cooling towers listed in Table C403.3.2(8).

Exception: Centrifugal open-circuit cooling towers that are designed with inlet or discharge ducts or require external sound attenuation.

C403.10~~9~~.4 Tower flow turndown.
Open-circuit cooling towers used on water-cooled chiller systems that are configured with multiple- or variable-speed condenser water pumps shall be designed so that all open- circuit cooling tower cells can be run in parallel with the larger of the flow that is produced by the smallest pump at its minimum expected flow rate or at 50 percent of the design flow for the cell.

C403.10~~9~~.5 Heat recovery for service water heating.
Condenser heat recovery shall be installed for heating or reheating of service hot water provided that the facility operates 24 hours a day, the total installed heat capacity of water-cooled systems exceeds 6,000,000 Btu/hr (1758 kW) of heat rejection, and the design service water heating load exceeds 1,000,000 Btu/h (293 kW).

The required heat recovery system shall have the capacity to provide the smaller of the following:

1. Sixty percent of the peak heat rejection load at design conditions.
2. The preheating required to raise the peak service hot water draw to 85°F (29°C).

Exceptions:

1. Facilities that employ condenser heat recovery for space heating or reheat purposes with a heat recovery design exceeding 30 percent of the peak water-cooled condenser load at design conditions.
2. Facilities that provide 60 percent of their service water heating from site solar or site recovered energy or from other sources.
3. If compliance with Section C403.9.5 will be detrimental to chiller operating efficiency due to conflicts with optimized chiller head pressure control.

C403.11~~0~~ Refrigeration equipment performance.
Refrigeration equipment ~~shall have an energy use in kWh/day not greater than the values of Tables C403.10.1(1) through C403.10.1(5) when tested and rated in accordance with AHRI Standard 1200.~~performance shall be determined in accordance with Sections C403.11.1 and C403.11.2 for

commercial refrigerators, freezers, refrigerator-freezers, walk-in coolers, walk-in freezers and refrigeration equipment. The energy use shall be verified through certification under an approved certification program or, where a certification program does not exist, the energy use shall be supported by data furnished by the equipment manufacturer.

Exception: Walk-in coolers and walk-in freezers regulated under federal law in accordance with Subpart R of DOE 10 CFR 431

C403.11~~0~~.1 ~~**Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers (Mandatory)**~~**Commercial refrigerators, refrigerator-freezers and refrigeration.**

Refrigeration equipment, defined in DOE 10 CFR Part 431.62, shall have an energy use in kWh/day not greater than the values of Table C403.11.1 when tested and rated in accordance with AHRI Standard 1200.

~~*Refrigerated warehouse coolers, refrigerated warehouse freezers, walk-in coolers* and *walk-in freezers* shall comply with the following:~~

1. ~~Be equipped with automatic door-closers that firmly close walk-in doors that have been closed to within 1 inch (25 mm) of full closure.~~

~~**Exception:** Automatic closers are not required for doors more than 45 inches (1143 mm) in width or more than 84 inches (2134 mm) in height.~~

~~2. Doorways shall have strip doors, curtains, springhinged doors or other method of minimizing infiltration when doors are open.~~

~~3. *Walk-in coolers* and *refrigerated warehouse coolers* shall contain wall, ceiling, and door insulation of not less than R-25 and *walk-in freezers* and *refrigerated warehouse freezers* shall contain wall, ceiling and door insulation of not less than R-32.~~

~~**Exception:** Glazed portions of doors or structural members need not be insulated.~~

~~4. *Walk-in freezers* shall contain floor insulation of not less than R-28.~~

~~5. Transparent reach-in doors for *walk-in freezers* and windows in opaque *walk-in freezer* doors shall be of triple-pane glass, either filled with inert gas or with heat-reflective treated glass.~~

~~6. Windows and transparent reach-in doors for *walk-in coolers* shall be of double-pane or triple-pane, inert gas-filled, heat-reflective treated glass.~~

~~7. Evaporator fan motors that are less than 1 hp (0.746 kW) and less than 460 volts shall use electronically commutated motors, brushless direct-current motors, or 3-phase motors.~~

~~8. Condenser fan motors that are less than 1 hp (0.746 kW) shall use electronically commutated motors, permanent split capacitor-type motors or 3-phase motors.~~

~~9. Antisweat heaters shall have a total door rail, glass and frame heater power draw of not more than 7.1 W/ft^2 (76 W/m^2) of door opening for *walk-in freezers* and 3.0 W/ft^2 (32 W/m^2) of door opening for *walk-in coolers*.~~

~~10. Antisweat heaters shall have controls that reduce the energy use of the antisweat heater as a function of the relative humidity in the air outside the door or to the condensation on the inner glass pane.~~

~~11. Lights in *walk-in coolers, walk-in freezers*, *refrigerated warehouse coolers* and *refrigerated warehouse freezers* shall be LED with an efficacy of 90 lpw or more and have occupancy controls that turns off the lights within 15 minutes when the space is not occupied.~~

TABLE C403.11.1
MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS AND REFRIGERATION

EQUIPMENT CATEGORY	CONDENSING UNIT CONFIGURATION	EQUIPMENT FAMILY	RATING TEMP., °F	OPERATING TEMP., °F	EQUIPMENT CLASSIFICATION[a,c]	MAXIMUM DAILY ENERGY CONSUMPTION, kWh/day[d,e]	TEST STANDARD
Remote condensing commercial refrigerators and commercial freezers	Remote (RC)	Vertical open (VOP)	38 (M)	≥32	VOP.RC.M	0.64 x TDA + 4.07	AHRI 1200
			0 (L)	<32	VOP.RC.L	2.20 x TDA + 6.85	
		Semivertical open (SVO)	38 (M)	≥32	SVO.RC.M	0.66 x TDA + 3.18	
			0 (L)	<32	SVO.RC.L	2.20 x TDA + 6.85	
		Horizontal open (HZO)	38 (M)	≥32	HZO.RC.M	0.35 x TDA + 2.88	
			0 (L)	<32	HZO.RC.L	0.55 x TDA + 6.88	
		Vertical closed transparent (VCT)	38 (M)	≥32	VCT.RC.M	0.15 x TDA + 1.95	
			0 (L)	<32	VCT.RC.L	0.49 x TDA + 2.61	
		Horizontal closed transparent (HCT)	38 (M)	≥32	HCT.RC.M	0.16 x TDA + 0.13	
			0 (L)	<32	HCT.RC.L	0.34 x TDA + 0.26	
		Vertical closed solid (VCS)	38 (M)	≥32	VCS.RC.M	0.10 x V + 0.26	
			0 (L)	<32	VCS.RC.L	0.21 x V + 0.54	
		Horizontal closed solid (HCS)	38 (M)	≥32	HCS.RC.M	0.10 x V + 0.26	
			0 (L)	<32	HCS.RC.L	0.21 x V + 0.54	
		Service over counter (SOC)	38 (M)	≥32	SOC.RC.M	0.44 x TDA + 0.11	
			0 (L)	<32	SOC.RC.L	0.93 x TDA + 0.22	
Self-contained commercial refrigerators and commercial freezers with and without doors	Self-contained (SC)	Vertical open (VOP)	38 (M)	≥32	VOP.SC.M	0.64 x TDA + 4.07	AHRI 1200
			0 (L)	<32	VOP.SC.L	2.20 x TDA + 6.85	
		Semivertical open (SVO)	38 (M)	≥32	SVO.SC.M	0.66 x TDA + 3.18	
			0 (L)	<32	SVO.SC.L	2.20 x TDA + 6.85	
		Horizontal open (HZO)	38 (M)	≥32	HZO.SC.M	0.35 x TDA + 2.88	
			0 (L)	<32	HZO.SC.L	0.55 x TDA + 6.88	
		Vertical closed transparent (VCT)	38 (M)	≥32	VCT.SC.M	0.15 x TDA + 1.95	
			0 (L)	<32	VCT.SC.L	0.49 x TDA + 2.61	
		Horizontal closed transparent (HCT)	38 (M)	≥32	HCT.SC.M	0.16 x TDA + 0.13	
			0 (L)	<32	HCT.SC.L	0.34 x TDA + 0.26	
		Vertical closed solid (VCS)	38 (M)	≥32	VCS.SC.M	0.10 x V + 0.26	
			0 (L)	<32	VCS.SC.L	0.21 x V + 0.54	
		Horizontal closed solid (HCS)	38 (M)	≥32	HCS.SC.M	0.10 x V + 0.26	
			0 (L)	<32	HCS.SC.L	0.21 x V + 0.54	
		Service over counter (SOC)	38 (M)	≥32	SOC.SC.M	0.44 x TDA + 0.11	
			0 (L)	<32	SOC.SC.L	0.93 x TDA + 0.22	
Self-contained commercial refrigerators with transparent doors for pull-down temperature applications	Self-contained (SC)	Pull-down (PD)	38 (M)	≥32	PD.SC.M	0.11 x V + 0.81	AHRI 1200
Commercial ice cream freezers	Remote (RC)	Vertical open (VOP)	-15 (I)	≤-5[b]	VOP.RC.I	2.79 x TDA + 8.70	AHRI 1200
		Semivertical open (SVO)			SVO.RC.I	2.79 x TDA + 8.70	
		Horizontal open (HZO)			HZO.RC.I	0.70 x TDA + 8.74	
		Vertical closed transparent (VCT			VCT.RC.I	0.58 x TDA + 3.05	
		Horizontal closed transparent (HCT)			HCT.RC.I	0.40 x TDA + 0.31	
		Vertical closed solid (VCS)			VCS.RC.I	0.25 x V + 0.63	
		Horizontal closed solid (HCS			HCS.RC.I	0.25 x V + 0.63	
		Service over counter (SOC)			SOC.SC.I	1.09 x TDA + 0.26	
	Self-contained (SC)	Vertical open (VOP)			VOP.SC.I	5.40 x TDA + 15.02	AHRI 1200

		Semivertical open (SVO)			SVO.SC.I	5.41 x TDA + 14.63	
		Horizontal open (HZO)			HZO.SC.I	2.42 x TDA + 9.00	
		Vertical closed transparent (VCT			VCT.SC.I	0.62 x TDA + 3.29	
		Horizontal closed transparent (HCT)			HCT.SC.I	0.56 x TDA + 0.43	
		Vertical closed solid (VCS)			VCS.SC.I	0.34 x V + 0.88	
		Horizontal closed solid (HCS			HCS.SC.I	0.34 x V + 0.88	
		Service over counter (SOC)			SOC.SC.I	1.53 x TDA + 0.36	

For SI: 1 square foot = 0.0929 m2, 1 cubic foot = 0.02832 m3, °C = (°F – 32)/1.8.
a. The meaning of the letters in this column is indicated in the columns to the left.
b. Ice cream freezer is defined in DOE 10 CFR 431.62 as a commercial freezer that is designed to operate at or below -5 °F and that the manufacturer designs, markets or intends for the storing, displaying or dispensing of ice cream.
c. Equipment class designations consist of a combination [in sequential order separated by periods (AAA).(BB).(C)] of the following:
- (AAA)—An equipment family code (VOP = vertical open, SVO = semivertical open, HZO = horizontal open, VCT = vertical closed transparent doors, VCS = vertical closed solid doors, HCT = horizontal closed transparent doors, HCS = horizontal closed solid doors, and SOC = service over counter);
- (BB)—An operating mode code (RC = remote condensing and SC = self-contained); and
- (C)—A rating temperature code [M = medium temperature (38°F), L = low temperature (0°F), or I = ice cream temperature (-15°F)].
- For example, "VOP.RC.M" refers to the "vertical open, remote condensing, medium temperature" equipment class.

d. V is the volume of the case (ft3) as measured in AHRI 1200, Appendix C.
e. TDA is the total display area of the case (ft2) as measured in AHRI 1200, Appendix D.

C403.11.2 Walk-in coolers and walk-in freezers.

Walk-in cooler and walk-in freezer refrigeration systems, except for walk-in process cooling refrigeration systems as defined in DOE 10 CFR 431.302, shall meet the requirements of Tables C403.11.2.1(1), C403.11.2.1(2), and C403.11.2.1(3).

C403.11.2.1 Performance standards.

Walk-in coolers and walk-in freezers shall meet the requirements of Tables C403.11.2.1(1), C403.11.2.1(2) and C403.11.2.1(3).

~~TABLE C403.101.1(1)~~
~~MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATION~~

~~EQUIPMENT TYPE~~	~~APPLICATION~~	~~ENERGY USE LIMITS (kWh per day)[a]~~	~~TEST PROCEDURE~~
~~Refrigerator with solid doors~~	~~Holding Temperature~~	~~0.10 × V + 2.04~~	~~AHRI 1200~~
~~Refrigerator with transparent doors~~		~~0.12 × V + 3.34~~	
~~Freezers with solid doors~~		~~0.40 × V + 1.38~~	
~~Freezers with transparent doors~~		~~0.75 × V + 4.10~~	
~~Refrigerators/freezers with solid doors~~		~~the greater of 0.12 × V + 3.34 or 0.70~~	
~~Commercial refrigerators~~	~~Pulldown~~	~~0.126 × V + 3.51~~	

a. V = volume of the chiller or frozen compartment as defined in AHAM-HRF-1.

~~TABLE C403.101.1(2)~~
~~MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS~~

~~EQUIPMENT TYPE~~				~~ENERGY USE LIMITS (kWh/day)~~[a, b]	~~TEST PROCEDURE~~
~~Equipment Class~~[c]	~~Family Code~~	~~Operating Mode~~	~~Rating Temperature~~		
~~VOP.RC.M~~	~~Vertical open~~	~~Remote condensing~~	~~Medium~~	~~0.82 × TDA + 4.07~~	~~AHRI 1200~~
~~SVO.RC.M~~	~~Semivertical open~~	~~Remote condensing~~	~~Medium~~	~~0.83 × TDA + 3.18~~	
~~HZO.RC.M~~	~~Horizontal open~~	~~Remote condensing~~	~~Medium~~	~~0.35 × TDA + 2.88~~	
~~VOP.RC.L~~	~~Vertical open~~	~~Remote condensing~~	~~Low~~	~~2.27 × TDA + 6.85~~	
~~HZO.RC.L~~	~~Horizontal open~~	~~Remote condensing~~	~~Low~~	~~0.57 × TDA + 6.88~~	
~~VCT.RC.M~~	~~Vertical transparent door~~	~~Remote condensing~~	~~Medium~~	~~0.22 × TDA + 1.95~~	
~~VCT.RC.L~~	~~Vertical transparent door~~	~~Remote condensing~~	~~Low~~	~~0.56 × TDA + 2.61~~	
~~SOC.RC.M~~	~~Service over counter~~	~~Remote condensing~~	~~Medium~~	~~0.51 × TDA + 0.11~~	
~~VOP.SC.M~~	~~Vertical open~~	~~Self-contained~~	~~Medium~~	~~1.74 × TDA + 4.71~~	
~~SVO.SC.M~~	~~Semivertical open~~	~~Self-contained~~	~~Medium~~	~~1.73 × TDA + 4.59~~	
~~HZO.SC.M~~	~~Horizontal open~~	~~Self-contained~~	~~Medium~~	~~0.77 × TDA + 5.55~~	
~~HZO.SC.L~~	~~Horizontal open~~	~~Self-contained~~	~~Low~~	~~1.92 × TDA + 7.08~~	
~~VCT.SC.I~~	~~Vertical transparent door~~	~~Self-contained~~	~~Ice cream~~	~~0.67 × TDA + 3.29~~	
~~VCS.SC.I~~	~~Vertical solid door~~	~~Self-contained~~	~~Ice cream~~	~~0.38 × V + 0.88~~	
~~HCT.SC.I~~	~~Horizontal transparent door~~	~~Self-contained~~	~~Ice cream~~	~~0.56 × TDA + 0.43~~	
~~SVO.RC.L~~	~~Semivertical open~~	~~Remote condensing~~	~~Low~~	~~2.27 × TDA + 6.85~~	
~~VOP.RC.I~~	~~Vertical open~~	~~Remote condensing~~	~~Ice cream~~	~~2.89 × TDA + 8.7~~	

~~(continued)~~

~~TABLE C403.101.1(2)—continued~~
~~MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS~~

~~EQUIPMENT TYPE~~				~~ENERGY USE LIMITS (kWh/day)~~[a, b]	~~TEST PROCEDURE~~
~~Equipment Class~~[c]	~~Family Code~~	~~Operating Mode~~	~~Rating Temperature~~		
~~SVO.RC.I~~	~~Semivertical open~~	~~Remote condensing~~	~~Ice cream~~	~~2.89 × TDA + 8.7~~	
~~HZO.RC.I~~	~~Horizontal open~~	~~Remote condensing~~	~~Ice cream~~	~~0.72 × TDA + 8.74~~	
~~VCT.RC.I~~	~~Vertical transparent door~~	~~Remote condensing~~	~~Ice cream~~	~~0.66 × TDA + 3.05~~	
~~HCT.RC.M~~	~~Horizontal transparent door~~	~~Remote condensing~~	~~Medium~~	~~0.16 × TDA + 0.13~~	
~~HCT.RC.L~~	~~Horizontal transparent door~~	~~Remote condensing~~	~~Low~~	~~0.34 × TDA + 0.26~~	~~AHRI 1200~~
~~HCT.RC.I~~	~~Horizontal transparent door~~	~~Remote condensing~~	~~Ice cream~~	~~0.4 × TDA + 0.31~~	
~~VCS.RC.M~~	~~Vertical solid door~~	~~Remote condensing~~	~~Medium~~	~~0.11 × V + 0.26~~	
~~VCS.RC.L~~	~~Vertical solid door~~	~~Remote condensing~~	~~Low~~	~~0.23 × V + 0.54~~	
~~VCS.RC.I~~	~~Vertical solid door~~	~~Remote condensing~~	~~Ice cream~~	~~0.27 × V + 0.63~~	
~~HCS.RC.M~~	~~Horizontal solid door~~	~~Remote condensing~~	~~Medium~~	~~0.11 × V + 0.26~~	
~~HCS.RC.L~~	~~Horizontal solid door~~	~~Remote condensing~~	~~Low~~	~~0.23 × V + 0.54~~	
~~HCS.RC.I~~	~~Horizontal solid door~~	~~Remote condensing~~	~~Ice cream~~	~~0.27 × V + 0.63~~	
~~HCS.RC.I~~	~~Horizontal solid door~~	~~Remote condensing~~	~~Ice cream~~	~~0.27 × V + 0.63~~	
~~SOC.RC.L~~	~~Service over counter~~	~~Remote condensing~~	~~Low~~	~~1.08 × TDA + 0.22~~	
~~SOC.RC.I~~	~~Service over counter~~	~~Remote condensing~~	~~Ice cream~~	~~1.26 × TDA + 0.26~~	
~~VOP.SC.L~~	~~Vertical open~~	~~Self-contained~~	~~Low~~	~~4.37 × TDA + 11.82~~	
~~VOP.SC.I~~	~~Vertical open~~	~~Self-contained~~	~~Ice cream~~	~~5.55 × TDA + 15.02~~	
~~SVO.SC.L~~	~~Semivertical open~~	~~Self-contained~~	~~Low~~	~~4.34 × TDA + 11.51~~	
~~SVO.SC.I~~	~~Semivertical open~~	~~Self-contained~~	~~Ice cream~~	~~5.52 × TDA + 14.63~~	
~~HZO.SC.I~~	~~Horizontal open~~	~~Self-contained~~	~~Ice cream~~	~~2.44 × TDA + 9.0~~	
~~SOC.SC.I~~	~~Service over counter~~	~~Self-contained~~	~~Ice cream~~	~~1.76 × TDA + 0.36~~	
~~HCS.SC.I~~	~~Horizontal solid door~~	~~Self-contained~~	~~Ice cream~~	~~0.38 × V + 0.88~~	

~~a. V = Volume of the case, as measured in accordance with Appendix C of AHRI 1200.~~
~~b. TDA = Total display area of the case, as measured in accordance with Appendix D of AHRI 1200.~~
~~c. Equipment class designations consist of a combination [in sequential order separated by periods (AAA).(BB).(C)] of:~~

~~(AAA)~~ ~~An equipment family code where:~~
~~VOP~~ = ~~vertical open~~
~~SVO~~ = ~~semivertical open~~

~~HZO = horizontal open~~
~~HCT = horizontal transparent doors~~
~~HCS = horizontal solid doors~~
~~SOC = service over counter~~

~~(BB) An operating mode code:~~
~~RC = remote condensing~~
~~SC = self-contained~~

~~(C) A rating temperature code:~~
~~M = medium temperature (38°F)~~
~~L = low temperature (0°F)~~
~~I = ice-cream temperature (15°F)~~

~~For example, "VOP.RC.M" refers to the "vertical open, remote condensing, medium temperature" equipment class~~.

TABLE C403.11~~0~~.1(3)

WALK-IN COOLER AND FREEZER DISPLAY DOOR EFFICIENCY REQUIREMENTS[a]

CLASS DESCRIPTOR	CLASS	MAXIMUM ENERGY CONSUMPTION (kWh/day)[a]
Display door, medium temperature	DD, M	$0.04 \times A_{dd} + 0.41$
Display door, low temperature	DD, L	$0.15 \times A_{dd} + 0.29$

a. A_{dd} is the surface area of the display door.

TABLE C403.11~~0~~.1(2~~4~~)

WALK-IN COOLER AND FREEZER NONDISPLAY DOOR EFFICIENCY REQUIREMENTS[a]

CLASS DESCRIPTOR	CLASS	MAXIMUM ENERGY CONSUMPTION (kWh/day)[a]
Passage door, medium temperature	PD, M	$0.05 \times A_{nd} + 1.7$
Passage door, low temperature	PD, L	$0.14 \times A_{nd} + 4.8$
Freight door, medium temperature	FD, M	$0.04 \times A_{nd} + 1.9$
Freight door, low temperature	FD, L	$0.12 \times A_{nd} + 5.6$

a. A_{nd} is the surface area of the nondisplay door.

TABLE C403.~~10~~11.1(3~~5~~)
WALK-IN COOLER AND FREEZER REFRIGERATION SYSTEM EFFICIENCY REQUIREMENTS

CLASS DESCRIPTOR	CLASS	MINIMUM ANNUAL WALK-IN ENERGY FACTOR AWEF (Btu/W-h)[a]	TEST PROCEDURE
Dedicated condensing, medium temperature, indoor system	DC.M.I	5.61	AHRI 1250
~~Dedicated condensing, medium temperature, indoor system, > 9,000 Btu/h capacity~~	~~DC.M.I, > 9,000~~	~~5.61~~	
Dedicated condensing, medium temperature, outdoor system	DC.M.O~~I~~	7.60	
~~Dedicated condensing, medium temperature, outdoor system, > 9,000 Btu/h capacity~~	~~DC.M.I, > 9,000~~	~~7.60~~	
Dedicated condensing, low temperature, indoor system, net capacity (q_{net}) <6,500 Btu/h	DC.L.I, <6,500	$9.091 \times 10^{-5} \times q_{net} + 1.81$	
Dedicated condensing, low temperature, indoor system, net capacity (q_{net}) ≥6,500 Btu/h	DC.L.I, ≥6,500	2.40	
Dedicated condensing, low temperature, outdoor system, net capacity (q_{net}) <6,500 Btu/h	DC.L.O, <6,500	$6.522 \times 10^{-5} \times q_{net} + 2.73$	
Dedicated condensing, low temperature, outdoor system, net capacity (q_{net}) ≥6,500 Btu/h	DC.L.O, ≥6,500	3.15	
Unit cooler, medium	UC.M	9.00	
Unit cooler, low temperature, net capacity (q_{net}) <15,500 Btu/h	UC.L, < 15,500	$1.575 \times 10^{-5} \times q_{net} + 3.91$	
Unit cooler, low temperature, net capacity (q_{net}) ≥15,500 Btu/h	UC.L, ≥15,500	4.15	

For SI: 1 British thermal unit per hour = 0.2931 W.

a. q_{net} is net capacity (Btu/h) as determined in accordance with **AHRI 1250**.

~~**C403.10.2 Refrigerated display cases (Mandatory).**~~
~~Site-assembled or site-constructed refrigerated display cases shall comply with the following:~~

1. ~~Lighting and glass doors in refrigerated display cases shall be controlled by one of the following:~~
   1.1. ~~Time-switch controls to turn off lights during nonbusiness hours. Timed overrides for display cases shall turn the lights on for up to 1 hour and shall automatically time out to turn the lights off.~~
   1.2. ~~Motion sensor controls on each display case section that reduce lighting power by not less than 50 percent within 3 minutes after the area within the sensor range is vacated.~~
2. ~~Low-temperature display cases shall incorporate temperature-based defrost termination control with a time-limit default. The defrost cycle shall terminate first on an upper temperature limit breach and second upon a time limit breach.~~
3. ~~Antisweat heater controls shall reduce the energy use of the antisweat heater as a function of the relative humidity in the air outside the door or to the condensation on the inner glass pane.~~

C403.11~~0~~.3 Refrigeration systems.
Refrigerated display cases, *walk-in coolers* or *walk-in freezers* that are served by remote compressors and remote condensers not located in a condensing unit, shall comply with Sections C403.11~~0~~.3.1 and C403.11~~0~~.3.2.

> **Exception:** Systems where the working fluid in the refrigeration cycle goes through both subcritical and super-critical states (transcritical) or that use ammonia refrigerant are exempt.

C403.11~~0~~.3.1 Condensers serving refrigeration systems.
Fan-powered condensers shall comply with the following:

1. The design *saturated condensing temperatures* for air-cooled condensers shall not exceed the design dry-bulb temperature plus 10°F (5.6°C) for *low-temperature refrigeration systems*, and the design dry- bulb temperature plus 15°F (8°C) for *medium temperature refrigeration systems* where the *saturated condensing temperature* for blend refrigerants shall be determined using the average of liquid and vapor temperatures as converted from the condenser drain pressure.
2. Condenser fan motors that are less than 1 hp (0.75 kW) shall use electronically commutated motors, permanent split-capacitor-type motors or 3-phase motors.
3. Condenser fans for air-cooled condensers, evaporatively cooled condensers, air- or water-cooled fluid coolers or cooling towers shall reduce fan motor demand to not more than 30 percent of design wattage at 50 percent of design air volume, and incorporate one of the following continuous variable speed fan control approaches:

3.1. Refrigeration system condenser control for air-cooled condensers shall use variable setpoint control logic to reset the condensing temperature setpoint in response to ambient dry-bulb temperature.

3.2. Refrigeration system condenser control for evaporatively cooled condensers shall use variable setpoint control logic to reset the condensing temperature setpoint in response to ambient wet-bulb temperature.

4. Multiple fan condensers shall be controlled in unison.

5. The minimum condensing temperature setpoint shall be not greater than 70°F (21°C).

C403.11~~0~~.3.2 Compressor systems.
Refrigeration compressor systems shall comply with the following:

1. Compressors and multiple-compressor system suction groups shall include control systems that use floating suction pressure control logic to reset the target suction pressure temperature based on the temperature requirements of the attached refrigeration display cases or walk-ins.

   Exception: Controls are not required for the following:

   1. Single-compressor systems that do not have variable capacity capability.

   2. Suction groups that have a design saturated suction temperature of 30°F (-1.1°C) or higher, suction groups that comprise the high stage of a two-stage or cascade system, or suction groups that primarily serve chillers for secondary cooling fluids.

2. Liquid subcooling shall be provided for all low-temperature compressor systems with a design cooling capacity equal to or greater than 100,000 Btu/hr (29.3 kW) with a design-saturated suction temperature of -10°F (-23°C) or lower. The sub-cooled liquid temperature shall be controlled at a maximum temperature setpoint of 50°F (10°C) at the exit of the subcooler using either compressor economizer (interstage) ports or a separate compressor suction group operating at a saturated suction temperature of 18°F (-7.8°C) or higher.

   2.1. Insulation for liquid lines with a fluid operating temperature less than 60°F (15.6°C) shall comply with Table C403.11.3.

3. Compressors that incorporate internal or external crankcase heaters shall provide a means to cycle the heaters off during compressor operation.

C403.12~~1~~ Construction of HVAC system elements ~~(Mandatory)~~.
Ducts, plenums, piping and other elements that are part of an HVAC system shall be constructed and insulated in accordance with Sections C403.11.1 through C403.11.3.1.

C403.12~~1~~.1 Duct and plenum insulation and sealing ~~(Mandatory)~~.
Supply and return air ducts and plenums shall be insulated with not less than R-~~8~~12 insulation where located in unconditioned spaces and where located outside the building with not less than R-~~12~~20 insulation. ~~Ducts located underground beneath buildings shall be insulated as required in this section or have an equivalent thermal distribution efficiency. Underground ducts utilizing the thermal distribution efficiency method shall be listed and labeled to indicate the R-value equivalency.~~Where located ~~within a building envelope assembly~~in conditioned space or semi-conditioned space, any duct that will transport or hold air at temperature differentials greater than 40F between inside and outside the duct shall be insulated with ~~the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by~~ not less than R-12 insulation. Buried ducts shall be insulated to a minimum of R-6.

Exceptions:

1. Where located within equipment.
2. Where the design temperature difference between the interior and exterior of the duct or plenum is not greater than 15°F (8°C).

Ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with the ANSI/SMACNA 006 HVAC Duct Construction Standards.

C403.1~~1~~2.2 Duct construction ~~(Mandatory2)~~.
Ductwork shall be constructed and erected in accordance with the ANSI/SMACNA 006 HVAC Duct Construction.

C403.1~~1~~2.2.1 Low-pressure duct systems ~~(Mandatory)~~.
Longitudinal and transverse joints, seams and connections of supply and return ducts operating at a static pressure less than or equal to 2 inches water gauge (w.g.) (498 Pa) shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes installed in accordance with the manufacturer's instructions. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the ANSI/SMACNA 006 HVAC Duct Construction.

Exception: Locking-type longitudinal joints and seams, other than the snap-lock and button-lock types, need not be sealed as specified in this section.

C403.1~~1~~2.2.2 Medium-pressure duct systems ~~(Mandatory)~~.
Ducts and plenums designed to operate at a static pressure greater than 2 inches water gauge (w.g.) (498 Pa) but less than 3 inches w.g. (747 Pa) shall be insulated and sealed in accordance with Section C403.11.1. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the ANSI/SMACNA 006 HVAC Duct Construction.

C403.1~~1~~2.2.3 High-pressure duct systems ~~(Mandatory)~~.
Ducts and plenums designed to operate at static pressures equal to or greater than 3 inches water gauge (747 Pa) shall be insulated and sealed in accordance with Section C403.11.1. In addition, ducts and plenums shall be leak tested in accordance with the

SMACNA HVAC Air Duct Leakage Test Manual and shown to have a rate of air leakage (CL) less than or equal to 4.0 as determined in accordance with Equation 4-7.

$$CL = F/P^{0.65}$$ **(Equation 4-7)**

where:

F = The measured leakage rate in cfm per 100 square feet of duct surface.
P = The static pressure of the test.

Documentation shall be furnished ~~by the designer~~ demonstrating that representative sections totaling not less than 25 percent of the duct area have been tested and that all tested sections comply with the requirements of this section.

C403.1~~1~~2.3 Piping insulation ~~(Mandatory)~~.
Piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table C403.1~~1~~2.3.

Exceptions:

1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this code.

2. Factory-installed piping within room fan-coils and unit ventilators tested and rated according to AHRI 440 (except that the sampling and variation provisions of Section 6.5 shall not apply) and AHRI 840, respectively.

3. Piping that conveys fluids that have a design operating temperature range between 60°F (15°C) and 85°F (29°C).

4. Strainers, control valves, and balancing valves associated with piping 1 inch (25 mm) or less in diameter.

5. Direct buried piping that conveys fluids at or below 60°F (15°C).

5. ~~6.~~ In radiant heating systems, sections of piping intended by design to radiate heat.

~~1.~~6. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power.

TABLE C403.12~~1~~.3
MINIMUM PIPE INSULATION THICKNESS (in inches)[a, c]

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	INSULATION CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE (inches)				
	Conductivity Btu • in./(h • ft^2 • °F)[b]	Mean Rating Temperature, °F	< 1	1 to < 1$^1/_2$	1$^1/_2$ to < 4	4 to < 8	≥ 8

> 350	0.32 – 0.34	250	4.5	5.0	5.0	5.0	5.0
251 – 350	0.29 – 0.32	200	3.0	4.0	4.5	4.5	4.5
201 – 250	0.27 – 0.30	150	2.5	2.5	2.5	3.0	3.0
141 – 200	0.25 – 0.29	125	1.5	1.5	2.0	2.0	2.0
85 – 140	0.21 – 0.28	100	1.0	1.0	1.5	1.5	1.5
40 – 60	0.21 – 0.27	75	0.5	0.5	1.0	1.0	1.0
< 40	0.20 – 0.26	50	0.5	1.0	1.0	1.0	1.5

For SI: 1 inch = 25.4 mm, °C = [(°F) - 32]/1.8.

a. For piping smaller than $1^1/_2$ inches and located in partitions within conditioned spaces, reduction of these thicknesses by 1 inch shall be permitted (before thickness adjustment required in footnote b) but not to a thickness less than 1 inch.

b. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

$T = r\,[(1 + t/r)^{K/k} - 1]$

where:

T = minimum insulation thickness,

r = actual outside radius of pipe,

t = insulation thickness listed in the table for applicable fluid temperature and pipe size,

K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu • in/h • ft^2 • °F) and

k = the upper value of the conductivity range listed in the table for the applicable fluid temperature.

c. For direct-buried heating and hot water system piping, reduction of these thicknesses by $1^1/_2$ inches (38 mm) shall be permitted (before thickness adjustment required in footnote b) but not to thicknesses less than 1 inch.

C403.12~~1~~.3.1 Protection of piping insulation ~~(Mandatory)~~.
Piping insulation exposed to the weather shall be protected from damage, including that caused by sunlight, moisture, equipment maintenance and wind, and shall provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall not be permitted. Piping insulation shall comply with both of the following requirements:

1. Insulation exposed to weather shall be suitable for outdoor service and shall be protected by aluminum, sheet metal, painted canvas, plastic cover, or other similar materials approved by the building official. Cellular foam insulation shall be protected as above or painted with a coating that is water-retardant and provides shielding from solar radiation.

2. Unless the insulation is vapor-retardant, insulation covering chilled-water piping or refrigerant suction piping located outside the conditioned space shall include a vapor retardant located outside the insulation. All penetrations and joints shall be sealed.

C403.1~~2~~3 Mechanical systems located outside of the building thermal envelope ~~(Mandatory)~~.
Mechanical systems providing heat outside of the thermal envelope of a building shall comply with Sections C403.12.1 through C403.12.3.

C403.13~~2~~.1 Heating outside a building.
Systems installed to provide heat outside a building shall be radiant systems. Electric resistance heating is prohibited for heating spaces outside a building.

Such heating systems shall be controlled by an occupancy sensing device or a timer switch, so that the system is automatically de-energized when occupants are not present.

C403.13~~2~~.2 Snow- and ice-melt system controls.
Snow- and ice-melting systems shall include automatic controls configured to shut off the system when the outdoor temperature is above 40°F (4°C) and the slab temperature as measured not less than 2 inches below the surface is 50°F (10°C).

C403.1~~2~~3.3 Freeze protection system controls.
Freeze protection systems, such as heat tracing of outdoor piping and heat exchangers, including self-regulating heat tracing, shall include automatic controls configured to shut off the systems when outdoor air temperatures are above 40°F (4°C) or when the conditions of the protected fluid will prevent freezing.

C403.14 Operable opening interlocking controls. The heating and cooling systems shall have controls that will interlock these mechanical systems to the set temperatures of 90ºF (32ºC) for cooling and 55ºF (12.7ºC) for heating when the conditions of Section C402.4.6 exist. The controls shall configure to shut off the systems entirely when the outdoor temperatures are below 90ºF (32ºC) or above 55ºF (12.7ºC).

Exceptions:

1. Separately zoned areas associated with the preparation of food that contain appliances that contribute to the HVAC loads of a restaurant or similar type of occupancy.
2. Warehouses that utilize overhead doors for the function of the occupancy.
3. The first entrance doors where located in the exterior wall and are part of a vestibule system.

SECTION C404
SERVICE WATER HEATING ~~(MANDATORY)~~

C404.1 General.
In addition to the service water heating requirements of Section C404, projects must achieve the required number of credits based on building occupancy group as outlined in Table C406.1.1 and Table C406.1.2. To achieve the required credits, service water heating enhancements may be needed ~~to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406~~.

The requirements of C404 that may be affected and the corresponding C406 references are summarized in Table C404.1(1). For a full list of potential measures see Table C406.2.1 and Table C406.3.1.

TABLE C404.1(1): C406 MEASURES AFFECTING SERVICE WATER HEATING

ID	C406 Measure Title	C404 Reference	C406 Section
W01	SHW preheat recovery	C403.10.5	C406.2.3.1.1

W02	Heat pump water heater	n/a	C406.2.3.1.2
W04	SHW pipe insulation	C404.4	C406.2.3.3.1
W05	Point of use water heaters	n/a	C406.2.3.3.2
W06	Thermostatic bal. valves	n/a	C406.2.3.3.3
W07	SHW heat trace system	C404.6.2	C406.2.3.3.4
W08	SHW submeters	n/a	C406.2.3.4
W09	SHW distribution sizing	n/a	C406.2.3.5
W10	Shower heat recovery	C404.7	C406.2.3.6
G06	SHW Energy Storage	n/a	C406.3.7

This section covers the minimum efficiency of, and controls for, service water-heating equipment and insulation of service hot water piping.

C404.1.1 Electrical water heating limitation.
Individual electric service water heating units shall be limited to a maximum of 7.5 kW total power input.

Exception:

1. Instantaneous electric water heaters used to serve emergency showers and emergency eye wash stations.
2. Hybrid heat pump service water heaters which utilize supplemental electric resistance elements and meeting the following requirements:
    a. No less than 60 percent of maximum heating demand can be met with the heat pump alone.
    b. For new buildings, if serving showers, the shower heads must have a maximum flow rate of no greater than 2.0 gpm.
    c. For new buildings, if serving dishwashing equipment, this equipment must be ENERGY STAR labeled.

C404.2 Service water-heating equipment performance efficiency.
Water-heating equipment and hot water storage tanks shall meet the requirements of Table C404.2. The efficiency shall be verified through data furnished by the manufacturer of the equipment or through certification under an *approved* certification program. Water-heating equipment intended to be used to provide space heating shall meet the applicable provisions of Table C404.2.

TABLE C404.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a, b]	TEST PROCEDURE

Water heaters, electric	≤ 7.5 kW	Tabletop[e] Resistance Grid-enabled[f] > 75 gallons and ≤ 120 gallons	0.93 - 0.00132V, EF 0.960 - 0.0003V, EF 1.061 - 0.00168V, EF	DOE 10 CFR Part 430
	≤ 24 amps and ≤ 250 volts	Heat pump > 55 gallons and ≤ 120 gallons	2.057 - 0.00113V, EF	DOE 10 CFR Part 430
Storage water heaters, gas	≤ 75,000 Btu/h	≥ 20 gallons and ≤ 55 gallons > 55 gallons and ≤ 100 gallons	0.675 - 0.0015V, EF 0.8012 - 0.00078V, EF	DOE 10 CFR Part 430
	> 75,000 Btu/h and ≤ 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t $(Q/800 + 110\sqrt{V})SL$, Btu/h	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t $(Q/800 + 110\sqrt{V})SL$, Btu/h	
Instantaneous water heaters, gas	> 50,000 Btu/h and < 200,000 Btu/h[c]	≥ 4,000 Btu/h/gal and < 2 gal	0.82 - 0.00 19V, EF	DOE 10 CFR Part 430
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E_t $(Q/800 + 110\sqrt{V})SL$, Btu/h	
Storage water heaters, oil	≤ 105,000 Btu/h	≥ 20 gal and ≤ 50 gallons	0.68 - 0.0019V, EF	DOE 10 CFR Part 430
	≥ 105,000 Btu/h	< 4,000 Btu/h/gal	80% E_t $(Q/800 + 110\sqrt{V})SL$, Btu/h	ANSI Z21.10.3
Instantaneous water heaters, oil	≤ 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 2 gal	0.59 - 0.0019V, EF	DOE 10 CFR Part 430
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	78% E_t $(Q/800 + 110\sqrt{V})SL$, Btu/h	
Hot water supply boilers, gas and oil	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3

Hot water supply boilers, gas	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E_t $(Q/800 + 110\sqrt{V})SL$, Btu/h	
Hot water supply boilers, oil	> 300,000 Btu/h and < 12,500,000 Btu/h	> 4,000 Btu/h/gal and > 10 gal	78% E_t $(Q/800 + 110\sqrt{V})SL$, Btu/h	
Pool heaters, gas and oil	All	—	82% E_t	ASHRAE 146
Heat pump pool heaters	All	—	4.0 COP	AHRI 1160

(continued)

TABLE C404.2—continued
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a, b]	TEST PROCEDURE
Unfired storage tanks	All	—	Minimum insulation requirement R-12.5 $(h \cdot ft^2 \cdot °F)/Btu$	(none)

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2,°C = [(°F) - 32]/1.8, 1 British thermal unit per hour = 0.2931 W, 1 gallon = 3.785 L, 1 British thermal unit per hour per gallon = 0.078 W/L.

a. Energy factor (EF) and thermal efficiency (E_t) are minimum requirements. In the EF equation, *V* is the rated volume in gallons.

b. Standby loss (SL) is the maximum Btu/h based on a nominal 70°F temperature difference between stored water and ambient requirements. In the SL equation, *Q* is the nameplate input rate in Btu/h. In the equations for electric water heaters, V is the rated volume in gallons and V_m is the measured volume in gallons. In the SL equation for oil and gas water heaters and boilers, *V* is the rated volume in gallons.

c. Instantaneous water heaters with input rates below 200,000 Btu/h shall comply with these requirements where the water heater is designed to heat water to temperatures 180°F or higher.

d. A tabletop water heater is a water heater that is enclosed in a rectangular cabinet with a flat top surface not more than 3 feet in height.

e. A grid-enabled water heater is an electric resistance water heater that meets all of the following:
   1. Has a rated storage tank volume of more than 75 gallons.
   2. Was manufactured on or after April 16, 2015.
   3. Is equipped at the point of manufacture with an activation lock.
   4. Bears a permanent label applied by the manufacturer that complies with all of the following:
      4.1. Is made of material not adversely affected by water.
      4.2. Is attached by means of nonwater-soluble adhesive.
      4.3. Advises purchasers and end users of the intended and appropriate use of the product with the following notice printed in 16.5 point Arial Narrow Bold font: “IMPORTANT INFORMATION: This water heater is intended only for use as part of an electric thermal storage or demand response program. It will not provide adequate hot water unless enrolled in such a program and activated by your utility company or another program operator. Confirm the availability of a program in your local area before purchasing or installing this product.”

C404.2.1 High input service water-heating systems.
Gas-fired water-heating equipment installed in new buildings shall be in compliance with this section. Where a singular piece of water-heating equipment serves the entire building and is 1,000,000 Btu/h (293 kW) or greater, such equipment shall have a thermal efficiency, E_t , of not less than 92 percent. Where multiple pieces of water-heating equipment serve the building and the combined input rating of the water-heating equipment is 1,000,000 Btu/h (293 kW) or greater, the combined input-capacity-weighted-average thermal efficiency, E_t, shall be not less than 92 percent.

Exceptions:

1. Where not less than 25 percent of the annual *service water-heating* requirement is provided by *on-site renewable energy* or site-recovered energy, the minimum thermal efficiency requirements of this section shall not apply.

2. The input rating of water heaters installed in individual dwelling units shall not be required to be included in the total input rating of *service water-heating* equipment for a building.

3. The input rating of water heaters with an input rating of not greater than 100,000 Btu/h (29.3 kW) shall not be required to be included in the total input rating of *service water-heating* equipment for a building.

C404.3 Heat traps for hot water storage tanks.
Vertical pipe risers serving storage water heaters and storage tanks not having integral heat traps and serving a nonrecirculating system shall have heat traps on both the inlet and outlet piping as close as practical to the storage tank. Tank inlets and outlets associated with solar water heating system circulation loops shall not be required to have heat traps.

C404.4 Insulation of piping.
Piping from a water heater to the termination of the heated water fixture supply pipe shall be insulated in accordance with Table C403.12~~1~~.3. On both the inlet and outlet piping of a storage water heater or heated water storage tank, the piping to a heat trap or the first 8 feet (2438 mm) of piping, whichever is less, shall be insulated. Piping that is heat traced shall be insulated in accordance with Table C403.12~~1~~.3 or the heat trace manufacturer's instructions. Tubular pipe insulation shall be installed in accordance with the insulation manufacturer's instructions. Pipe insulation shall be continuous except where the piping passes through a framing member. The minimum insulation thickness requirements of this section shall not supersede any greater insulation thickness requirements necessary for the protection of piping from freezing temperatures or the protection of personnel against external surface temperatures on the insulation.

Exception: Tubular pipe insulation shall not be required on the following:

1. The tubing from the connection at the termination of the fixture supply piping to a plumbing fixture or plumbing appliance.

2. Valves, pumps, strainers and threaded unions in piping that is 1 inch (25 mm) or less in nominal diameter.

3. Piping from user-controlled shower and bath mixing valves to the water outlets.

4. Cold-water piping of a demand recirculation water system.

5. Tubing from a hot drinking-water heating unit to the water outlet.

6. Piping at locations where a vertical support of the piping is installed.

7. Piping surrounded by building insulation with a thermal resistance (*R*-value) of not less than R-3.

C404.5 Heated water supply piping.
Heated water supply piping shall be in accordance with Section C404.5.1 or C404.5.2. The flow rate through $^{1}/_{4}$-inch (6.4 mm) piping shall be not greater than 0.5 gpm (1.9 L/m). The flow rate through $^{5}/_{16}$-inch (7.9 mm) piping shall be not greater than 1 gpm (3.8 L/m). The flow rate through $^{3}/_{8}$-inch (9.5 mm) piping shall be not greater than 1.5 gpm (5.7 L/m).

C404.6 Heated-water circulating and temperature maintenance systems.
Heated-water circulation systems shall be in accordance with Section C404.6.1. Heat trace temperature maintenance systems shall be in accordance with Section C404.6.2. Controls for hot water storage shall be in accordance with Section C404.6.3. Automatic controls, temperature sensors and pumps shall be in a location with *access*. Manual controls shall be in a location with *ready access*.

C404.6.1 Circulation systems.
Heated-water circulation systems shall be provided with a circulation pump. The system return pipe shall be a dedicated return pipe or a cold water supply pipe. Gravity and thermo-syphon circulation systems shall be prohibited. Systems designed to maintain usage temperatures in hot-water pipes, such as recirculating hot-water systems or heat trace, shall comply with either of the following:

1. Be equipped with automatic time switches that can be set to switch off the usage temperature maintenance system during periods when hot water is not required.

2. Use a modulating pump, controlled by an aquastat at the return side of the pump, to maintain the minimum hot water temperature.

Exception: In healthcare and other facilities with immunocompromised populations in accordance with ASHRAE Standard 188 – Legionellosis: Risk Management for Building Water Systems.

C404.6.2 Heat trace systems.
Electric heat trace systems shall comply with IEEE 515.1. Controls for such systems shall be able to automatically adjust the energy input to the heat tracing to maintain the desired water temperature in the piping in accordance with the times when heated water is used in the occupancy. Heat trace shall be arranged to be turned off automatically when there is not a demand for hot water.

C404.6.3 Controls for hot water storage.
The controls on pumps that circulate water between a water heater and a heated-water storage tank shall limit operation of the pump from heating cycle startup to not greater than 5 minutes after the end of the cycle.

~~**C404.7 Demand recirculation controls.**~~
~~Demand recirculation water systems shall have controls that comply with both of the following:~~

~~1. The controls shall start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture or sensing the flow of hot or tempered water to a fixture fitting or appliance.~~

~~2. The controls shall limit the temperature of the water entering the cold-water piping to not greater than 104°F (40°C).~~

C404.~~8~~7 Drain water heat recovery units.
Drain water heat recovery units shall comply with CSA B55.2. Potable water-side pressure loss shall be less than 10 psi (69 kPa) at maximum design flow. For *Group R* occupancies, the efficiency of drain water heat recovery unit efficiency shall be in accordance with CSA B55.1.

C404.8~~9~~ Energy consumption of pools and permanent spas ~~(Mandatory)~~.
The energy consumption of pools and permanent spas shall be controlled by the requirements in Sections C404.9.1 through C404.9.3.

C404.~~9~~8.1 Heaters.
The electric power to all heaters shall be controlled by an on-off switch that is an integral part of the heater, mounted on the exterior of the heater, or external to and within 3 feet (914 mm) of the heater in a location with *ready access*. Operation of such switch shall not change the setting of the heater thermostat. Such switches shall be in addition to a circuit breaker for the power to the heater. Gas-fired heaters shall not be equipped with continuously burning ignition pilots.

C404.8~~9~~.2 Time switches.
Time switches or other control methods that can automatically turn off and on heaters and pump motors according to a preset schedule shall be installed for heaters and pump motors. Heaters and pump motors that have built-in time switches shall be in compliance with this section.

Exceptions:

1. Where public health standards require 24-hour pump operation.

2. Pumps that operate solar- and waste-heat-recovery pool heating systems.

C404.8~~9~~.3 Covers.
Outdoor heated pools and outdoor permanent spas shall be provided with a vapor-retardant cover or other *approved* vapor-retardant means. Hot tubs and spas capable of being heated to more than 90°F (32°C) shall be provided with a cover having a minimum insulation value of R-12.

Exception: Where more than 75 percent of the energy for heating, computed over an operating season of not fewer than 3 calendar months, is from ~~site-recovered energy such as from~~ a heat pump or an on-site renewable energy system, covers or other vapor-retardant means shall not be required.

C404.9~~10~~ ~~Energy consumption of p~~Portable spas ~~(Mandatory)~~.
The energy consumption of electric-powered portable spas shall be controlled by the requirements of the Association of Pool & Spa Professionals (APSP) 14-2014.

C404.10~~1~~ Service water-heating system commissioning and completion requirements.
Service water-heating systems, swimming pool water-heating systems, spa water-heating systems and the controls for those systems shall be commissioned and completed in accordance with Section C407.2.

SECTION C405
ELECTRICAL POWER AND LIGHTING SYSTEMS

C405.1 General ~~(Mandatory)~~.
In addition to the electrical power and lighting systems requirements of Section C405, projects must achieve the required number of credits based on building occupancy group as outlined in Table C406.1.1 and Table C406.1.2. To achieve the required credits, electrical power and lighting enhancements may be needed ~~to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406~~.

The requirements of C405 that may be affected and the corresponding C406 references are summarized in Table C405.1. For a full list of potential measures see Table C406.2.1 and Table C406.3.1.

TABLE C405.1: C406 MEASURES AFFECTING ELECTRICAL POWER AND LIGHTING SYSTEMS

ID	C406 Measure Title	C405 Reference	C406 Section
P01	Energy monitoring	C405.12	C406.2.4
L02	Enhanced digital lighting controls	C405.2	C406.2.5.2
L03	Increase occupancy sensor	C405.2.1, C405.2.2	C406.2.5.3
L04	Increase daylight area	C405.2.3	C406.2.5.4
L05	Residential light control	C405.2.1.1	C406.2.5.5
L06	Reduced lighting power	C405.3.2.2, C405.2	C406.2.5.6
Q01	Efficient elevator equipment	C405.9	C406.2.6.1
Q02	Commercial kitchen equip.	n/a	C406.2.6.2
Q03	Residential kitchen equip.	n/a	C406.2.6.3
R01	On-Site Renewable Energy	n/a	C406.3.1
G01	Lighting Load Management	n/a	C406.3.2
G04	Electric Energy Storage	n/a	C406.3.5

~~This section covers l~~Lighting system controls, the maximum lighting power for interior and exterior applications and electrical energy consumption shall comply with this section. *Sleeping units* shall comply with Section C405.2.5 and with either Section C405.1.1 or C405.3. *General lighting* shall consist of all lighting included when calculating the total connected interior lighting power in accordance with Section C405.3.1 and which does not require specific application controls in accordance with Section C405.2.5.

~~*Dwelling units* and *Sleeping Units* within Group R-2 buildings (see "Occupancy classifications" in Section C202) shall install lamps or fixtures where not less than 90 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 90 percent of the permanently installed lighting fixtures shall be high-efficacy fixtures or contain only high-efficacy lamps. Lighting installed in walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with the lighting requirements of Section C403.10.1.~~Transformers, uninterruptable power supplies, motors and electrical power processing equipment in data center systems shall comply with Section 8 of ASHRAE 90.4 in addition to this code.

C405.1.1 Lighting for dwelling and sleeping units. All ~~percent of the~~ permanently installed lighting serving dwelling units and sleeping units, excluding kitchen appliance lighting, shall ~~be provided by lamps with an efficacy of not less than 65 lm/W or luminaires with an efficacy of not less than 5 lm/W~~contain only high-efficacy lighting ~~, or~~sources.

Exception: Buildings other than multifamily dwellings –shall comply with Section~~s~~ C405.1.1 or Sections C405.2.4 and C405.3.

C405.2 Lighting controls ~~(Mandatory)~~.
Lighting systems shall be provided with controls that comply with one of the following.

1. Lighting controls as specified in Sections C405.2.1 through C405.2.~~6~~8.

2. Luminaire level lighting controls (LLLC) and lighting controls as specified in Sections C405.2.1, C405.2.~~4~~ 5 and C405.2.~~5~~6. The LLLC luminaire shall be independently capable of:

   2.1. Monitoring occupant activity to brighten or dim lighting when occupied or unoccupied, respectively.

   2.2. Monitoring ambient light, both electric light and daylight, and brighten or dim artificial light to maintain desired light level.

   2.3. For each control strategy, configuration and reconfiguration of performance parameters including; bright and dim setpoints, timeouts, dimming fade rates, sensor sensitivity adjustments, and wireless zoning configurations.

Exceptions: Lighting controls are not required for the following:

1. Areas designated as security or emergency areas that are required to be continuously lighted.

2. Interior exit stairways, interior exit ramps and exit passageways.

3. Emergency egress lighting that is normally off.

4. *Dwelling units* and *sleeping units* within Group R-2 buildings (see *occupancy classifications*).

5. *Dwelling units* within buildings other than Group R-2, provided that ~~not less than 90 percent~~ all of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps ~~or~~ and ~~not less than 90 percent~~all of the permanently installed lighting fixtures shall be high-efficacy fixtures or contain only high-efficacy lamps.

6. Industrial or manufacturing process areas, as may be required for production and safety.

C405.2.1 Occupant sensor controls.
Occupant *sensor controls* shall be installed to control lights in the following space types:

1. Classrooms/lecture/training rooms.
2. Conference/meeting/multipurpose rooms.
3. Copy/print rooms.
4. Lounges/breakrooms.
5. Enclosed offices.
6. Open plan office areas.
7. Restrooms.
8. Storage rooms.
9. Locker rooms.
10. ~~Other spaces 300 square feet (28 m^2) or less that are enclosed by floor-to-ceiling height partitions~~Corridors.
11. Warehouse storage areas.
12. Other spaces 300 square feet (28 m^2) or less that are enclosed by floor-to-ceiling height partitions.

Exception: Luminaires that are required to have specific application controls in accordance with Section C405.2.5.

C405.2.1.1 Occupant sensor control function.

Occupant sensor controls in warehouses shall comply with Section C405.2.1.2. Occupant sensor controls in open plan office areas shall comply with Section C405.2.1.3. Occupant sensor controls in corridors shall comply with Section C405.2.1.4. Occupant sensor controls for egress illumination shall comply with Section C405.2.1.5. Occupant sensor controls for all other spaces specified in Section C405.2.1 shall comply with the following:

1. They shall automatically turn off lights within 20 minutes after all occupants have left the space.

2. They shall be manual on or controlled to automatically turn on the lighting to not more than 50-percent power.

3. They shall incorporate a manual control to allow occupants to turn off lights.

   Exception: Full automatic-on controls with no manual control shall be permitted ~~to control lighting~~ in ~~public~~ corridors, stairways, restrooms, ~~primary building entrance areas and lobbies~~locker rooms, lobbies, library stacks~~,~~ and areas where manual~~-on~~ operation would endanger ~~the safety or security of the room or building occupants~~occupant safety or security.

~~3. They shall incorporate a manual control to allow occupants to turn off lights.~~

C405.2.1.2 Occupant sensor control function in warehouse storage areas.

Lighting in warehouse storage areas shall be controlled as follows: ~~In warehouses, the lighting in aisleways and open areas shall be controlled with occupant sensors that automatically reduce lighting power by not less than 50 percent when the areas are unoccupied. The occupant sensors shall control lighting in each aisleway independently and shall not control lighting beyond the aisleway being controlled by the sensor.~~

1. Lighting in each aisleway shall be controlled independently of lighting in all other aisleways and open areas.

2. Occupant sensors shall automatically reduce lighting power within each controlled area to an occupied setpoint of not more than 50 percent within 20 minutes after all occupants have left the controlled area.

3. Lights that are not turned off by occupant sensors shall be turned off by time-switch control complying with Section C405.2.2.1.

4. A manual control shall be provided to allow occupants to turn off lights in the space.

C405.2.1.3 Occupant sensor control function in open plan office areas.

Occupant sensor controls in open plan office spaces less than 300 square feet (28 m^2) in area shall comply with Section C405.2.1.1. Occupant sensor controls in all other open plan office spaces shall comply with all of the following:

1. The controls shall be configured so that general lighting can be controlled separately in control zones with floor areas not greater than 600 square feet (55 m^2) within the open plan office space.

2. General lighting in each control zone shall be permitted to automatically turn on upon occupancy within the control zone. General lighting in other unoccupied zones within the open plan office space shall be permitted to turn on to not more than 20 percent of full power or remain unaffected.

~~2~~3. The controls shall automatically turn off general lighting in all control zones within 20 minutes after all occupants have left the open plan office space.

   Exception: Where general lighting is turned off by time-switch control complying with Section C405.2.2.1.

~~3~~4. ~~The controls shall be configured so that general lighting power~~General lighting in each control zone ~~is reduced by not less than 80 percent of the full zone general lighting power in a reasonably uniform illumination pattern within 20 minutes of all occupants leaving that control zone. Control functions that switch control zone lights completely off when the zone is vacant meet this requirement.~~shall turn off or uniformly reduce lighting power to an unoccupied setpoint of not more than 20 percent of full power within 20 minutes after all occupants have left the control zone.

~~4. The controls shall be configured such that any daylight responsive control will activate open plan office space general lighting or control zone general lighting only when occupancy for the same area is detected.~~

C405.2.1.4 Occupant sensor control function in corridors. Occupant sensor controls in corridors shall uniformly reduce lighting power to not more than 50 percent of full power within 20 minutes after all occupants have left the space.
Exception: Corridors provided with less than two footcandles of illumination on the floor at the darkest point with all lights on.

C405.2.1.~~4~~ 5 Occupant sensor control function for egress illumination. Luminaires providing means of egress illumination where the means of egress shall be illuminated at all times the room or space is occupied shall be controlled by occupancy sensors, or a signal from another building control system, that automatically reduces the lighting power by at least 50 percent when unoccupied for a period longer than 15 minutes.

Exception:

1. Egress areas not exceeding 50 percent of the space-by-space interior lighting power allowance provided in Table C405.3.2(2).

2. Means of egress illumination that does not exceed 0.02 watts per square foot of building area is exempt from this requirement.

3. Emergency lighting designated to meet National Fire Protection Association (NFPA) 1 or NFPA 101.

C405.2.2 Time-switch controls.
Each area of the building that is not provided with *occupant sensor controls* complying with Section C405.2.1.1 shall be provided with *time-switch controls* complying with Section C405.2.2.1.

Exceptions: ~~Where a *manual control* provides light reduction in accordance with Section C405.2.2.2, *time-switch controls* shall not be required for the following:~~

1. Luminaires that are required to have specific application controls in accordance with Section C405.2.4.

2. Spaces where patient care is directly provided.

~~2~~3. Spaces where an automatic shutoff would endanger occupant safety or security.

~~3~~4. Lighting intended for continuous operation.

~~4~~5. Shop and laboratory classrooms.

C405.2.2.1 Time-switch control function.
~~Each space provided with *time-switch controls* shall be provided with a *manual control* for light reduction in accordance with Section C405.2.2.2.~~ Time-switch con*trols* shall ~~include an override switching device that complies with~~comply with all of the following:

1. Automatically turn off lights when the space is scheduled to be unoccupied.

2. Have a minimum 7-day clock.

~~2~~3. Be capable of being set for seven different day types per week.

~~3~~4. Incorporate an automatic holiday "shutoff" feature, which turns off all controlled lighting loads for not fewer than 24 hours and then resumes normally scheduled operations.

~~4~~5. Have program backup capabilities, which prevent the loss of program and time settings for not fewer than 10 hours, if power is interrupted.

~~5~~6. Include an override switch that complies with the following:

   ~~5~~6.1. The override switch shall be a manual control.

   ~~5~~6.2. The override switch, when initiated, shall permit the controlled lighting to remain on for not more than 2 hours.

   ~~5~~6.3. Any individual override switch shall control the lighting for an area not larger than 5,000 square feet (465 m^2).

Exception~~s~~:

~~1.~~ Within mall concourses, auditoriums, sales areas, manufacturing facilities and sports arenas:

~~1.~~1. The time limit shall be permitted to be greater than 2 hours, provided that the switch is a captive key device.

~~1.~~2. The area controlled by the override switch shall not be limited to 5,000 square feet (465 m^2) provided that such area is less than 20,000 square feet (1860 m^2).

~~2. Where provided with manual control, the following areas are not required to have light reduction control:~~

~~2.1. Spaces that have only one luminaire with a rated power of less than 50 watts.~~

~~2.2. Spaces that use less than 0.3 watts per square foot (3.2 W/m^2).~~

~~2.3. Corridors, lobbies, electrical rooms and or mechanical rooms.~~

C405.2.~~2.2~~3 Light-reduction controls.
Where not provided with occupant sensor controls complying with Section C405.2.1.1, general lighting shall be provided with light-reduction controls complying with Section C405.2.3.1.
~~Spaces required to have light-reduction controls shall have a *manual control* that allows the occupant to reduce the connected lighting load in a reasonably uniform illumination pattern by not less than 50 percent. Lighting reduction shall be achieved by one of the following or another *approved* method:~~

~~1. Controlling all lamps or luminaires.~~

~~2. Dual switching of alternate rows of luminaires, alternate luminaires or alternate lamps.~~

~~3. Switching the middle lamp luminaires independently of the outer lamps.~~

~~4. Switching each luminaire or each lamp.~~

Exceptions:

1. ~~1.~~ Luminaires controlled by daylight responsive controls complying with Section C405.2.4.~~Light reduction controls are not required in *daylight zones* with *daylight responsive controls* complying with Section C405.2.3.~~

2. Luminaires controlled by special application controls complying with Section C405.2.5.~~Where provided with manual control, the following areas are not required to have light reduction control:~~

3. Where provided with manual control, the following areas are not required to have light-reduction control:

~~2~~3.1. Spaces that have only one luminaire with a rated power of less than 50 watts.

~~2~~3.2. Spaces that use less than 0.3 watts per square foot (3.2 W/m^2).

~~2~~3.3. Corridors, ~~equipment rooms, public~~ lobbies, electrical and/or mechanical rooms.

C405.2.3.1 Light-reduction control function.
Spaces required to have light-reduction controls shall have a manual control that allows the occupant to reduce the connected lighting load by not less than 50 percent in a reasonably uniform illumination pattern with an intermediate step in addition to full on or off, or with continuous dimming control, using one of the following or another approved method:

1. Continuous dimming of all luminaires from full output to less than 20 percent of full power.

2. Switching all luminaires to a reduced output of not less than 30 percent and not more than 70 percent of full power.

3. Switching alternate luminaires or alternate rows of luminaires to achieve a reduced output of not less than 30 percent and not more than 70 percent of full power

C405.2.4~~3~~ Daylight-responsive controls.
Daylight-responsive controls complying with Section C405.2.4~~3~~.1 shall be provided to control the ~~electric lights~~ within *daylight zones* in the following spaces:

1. Spaces with a total of more than 150 watts of *general lighting* within sidelit zones complying with Section C405.2.4.2 ~~C405.2.3.2 *General lighting* does not include lighting that is required to have specific application control in accordance with Section C405.2.4~~.

2. Spaces with a total of more than 300 watts of *general lighting* within sidelit daylight zones complying with Section C405.2.4.2.

~~2~~3. Spaces with a total of more than 150 watts of *general lighting* within toplit daylight zones complying with Section C405.2.4~~3~~.3.

Exceptions: Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.

~~2. Lighting that is required to have specific application control in accordance with Section C405.2.4.~~

~~2~~3. Sidelit daylight zones on the first floor above grade in Group A-2 and Group M occupancies. ~~(See *Occupancy classifications* in Section C202.)~~

~~4~~3. Daylight zones where the total proposed lighting power density is less than 35 percent of the lighting power allowance in accordance with Section C405.~~3~~3.2.

~~5~~4. New buildings where the total connected lighting power calculated in accordance with Section C405.3.1 is not greater than the adjusted interior lighting power allowance (LPA_{adj}) calculated in accordance with Equation 4-8:

$$LPA_{adj} = [LPA_{norm} \times (1.0 - 0.4 \times UDZFA / TBFA)]$$ **(Equation 4-8)**

where:

LPA_{adj}	=	Adjusted building interior lighting power allowance in watts.
LPA_{norm}	=	Normal building lighting power allowance in watts calculated in accordance with Section C405.3.2 and reduced in accordance with Section C406.~~3~~ 2.5.6 where reduced lighting power is used to comply with the requirements of Section C406.
UDZFA	=	Uncontrolled daylight zone floor area is the sum of all sidelit and toplit zones, calculated in accordance with Sections C405.2.~~3~~4.2 and C405.2.~~3~~4.3, that do not have daylight responsive controls.
TBFA	=	Total building floor area is the sum of all floor areas included in the lighting power allowance calculation in Section C405.3.2.

C405.2.~~4~~3.1 Daylight-responsive control function.
Where required, *daylight-responsive controls* shall be provided within each space for control of lights in that space and shall comply with all of the following:

1. Lights in *toplit* daylight *zones* in accordance with Section C405.2.~~3~~4.3 shall be controlled independently of lights in sidelit daylight zones in accordance with Section C405.2.~~3~~4.2.

2. Lights in the primary sidelit daylight zone shall be controlled independently of lights in the secondary sidelit daylight zone.

~~2~~3. *Daylight responsive controls* within each space shall be configured so that they can be calibrated from within that space by authorized personnel.

~~3~~4. Calibration mechanisms shall be in a location with *ready access*.

~~4~~5. ~~Where located in offices, classrooms, laboratories and library reading rooms, d~~D*aylight responsive controls* shall dim lights continuously from full light output to 15 percent of full light output or lower.

~~5~~6. *Daylight responsive controls* shall be configured to completely shut off all controlled lights.

~~6~~7. When occupant sensor controls have reduced the lighting power to an unoccupied setpoint in accordance with Sections C405.2.1.2 through C405.2.1.4, daylight responsive controls shall continue to adjust electric light levels in response to available daylight, but shall be configured to not increase the lighting power above the specified unoccupied setpoint.

8. Lights in *sidelit daylight zones* in accordance with Section C405.2.~~3~~4.2 facing different cardinal orientations [within 45 degrees (0.79 rad) of due north, east, south, west] shall be controlled independently of each other.

~~7. Incorporate time-delay circuits to prevent cycling of light level changes of less than three minutes.~~

~~8. The maximum area a single daylight responsive control device serves shall not exceed 2,500 square feet (232 m^2).~~

~~9. Occupant permanent override capability of daylight dimming controls is not permitted, other than a reduction of light output from the level established by the daylighting controls. Occupant temporary override capability is allowed as long as the lighting control automatically resets to the original setting within twelve hours.~~

Exceptions: ~~Up to 150 watts of lighting in each space is permitted to be controlled together with lighting in a daylight zone facing a different cardinal orientation.~~

1. Within each space, up to 150 watts of lighting within the primary sidelit daylight zone is permitted to be controlled together with lighting in a primary sidelit daylight zone facing a different cardinal orientation.

2. Within each space, up to 150 watts of lighting within the secondary sidelit daylight zone is permitted to be controlled together with lighting in a secondary sidelit daylight zone facing a different cardinal orientation.

C405.2.3.1.1 Dimming.

~~*Daylight responsive controls* shall be configured to automatically reduce the power of *general lighting* in the *daylight zone* in response to available daylight, while maintaining *uniform illumination* in the space through one of the following methods:~~

~~1. Continuous dimming using dimming ballasts/dimming drivers and daylight-sensing automatic controls. The system shall reduce lighting power continuously to less than 15 percent of rated power at maximum light output.~~

~~2. Stepped dimming using multi-level switching and daylight-sensing controls. The system shall provide a minimum of two steps of uniform illumination between 0 and 100 percent of rated power at maximum light output. Each step shall be in equal increments of power, plus or minus 10 percent. General lighting within daylight zones in offices, classrooms, laboratories and library reading rooms shall use the continuous dimming method. Stepped dimming is not allowed as a method of daylight zone control in these spaces.~~

C405.2.4~~3~~.2 Sidelit daylight zone.

The sidelit daylight zone is the floor area adjacent to vertical *fenestration* that complies with all of the following:

1. Where the fenestration is located in a wall, the sidelit daylight zone shall extend laterally to the nearest full-height wall, or up to 1.0 times the height from the floor to the top of the fenestration, and longitudinally from the edge of the fenestration to the nearest full-height wall, or up to ~~2 feet (610 mm)~~0.5 times the height from the floor to the top of the fenestration, whichever is less, as indicated in Figure C405.2.~~3~~4.2(1).

2. Where the fenestration is located in a rooftop monitor, the sidelit daylight zone shall extend laterally to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 1.0 times the height from the floor to the bottom of the fenestration, whichever is less, and longitudinally from the edge of the fenestration to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 0.25 times the height from the floor to the bottom of the fenestration, whichever is less, as indicated in Figures C405.2.4.2(2) and C405.2.4.2(3).

3. The secondary sidelit daylight zone is directly adjacent to the primary sidelit daylight zone and shall extend laterally to 2.0 times the height from the floor to the top of the fenestration or to the nearest full height wall, whichever is less, and longitudinally from the edge of the fenestration to the nearest full height wall, or up to 2 feet, whichever is less, as indicated in Figure C405.2.4.2(1). The area of secondary sidelit zones shall not be considered in the calculation of the daylight zones in Section C402.4.1.1.

4. The area of the fenestration is not less than 24 square feet (2.23 m^2).

~~3~~5. The distance from the fenestration to any building or geological formation that would block *access* to daylight is greater than the height from the bottom of the fenestration to the top of the building or geologic formation.

~~4~~6. The visible transmittance of the fenestration is not less than 0.20.

7. The projection factor (determined in accordance with Equation 4-5) for any overhanging projection that is shading the fenestration is not greater than 1.0 for fenestration oriented 45 degrees or less from true north and not greater than

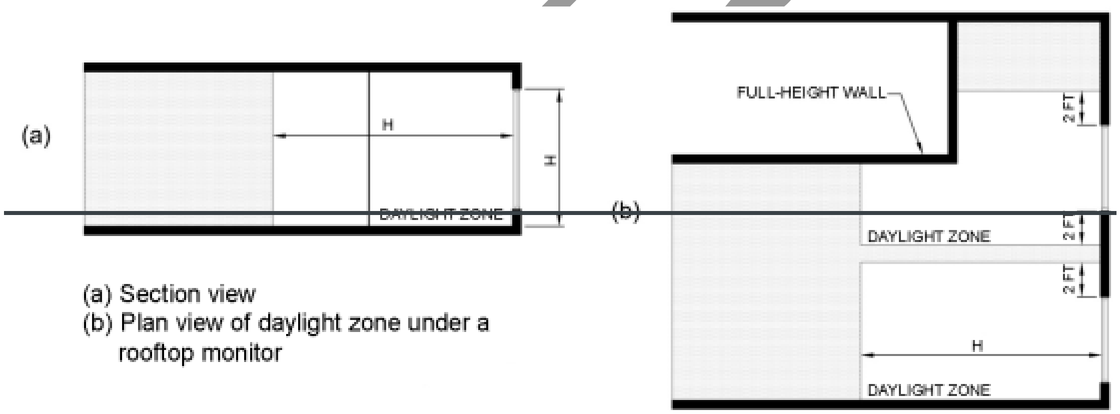
1.5 for all other orientations.

~~5. Where *clerestory* fenestration is located in a wall, the sidelight daylight zone includes a lateral area twice the depth of the clerestory fenestration height, projected upon the floor at a 45-degree angle from the center of the clerestory fenestration. The longitudinal width of the daylight zone is calculated the same as for fenestration located in a wall. Where the 45-degree angle is interrupted by an obstruction greater than 0.7 times the ceiling height, the daylight zone shall remain the same lateral area but be located between the clerestory and the obstruction, as indicated in Figure C405.2.3.3(4).~~

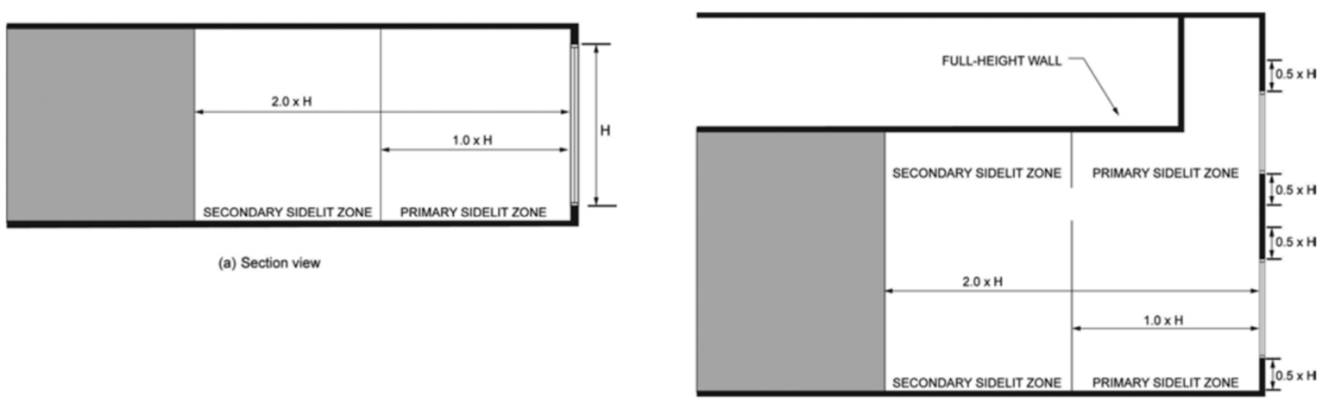
~~6~~8. If the rough opening area of a vertical fenestration assembly is less than 10 percent of the calculated primary daylight zone area for this fenestration, it does not qualify as a daylight zone.

~~7~~9. Where located in existing buildings, the visible transmittance of the fenestration is no less than 0.20.

~~8~~10. In parking garages with floor area adjacent to perimeter wall openings, the daylight zone shall include the area within 20 feet of any portion of a perimeter wall that has a net opening to wall ratio of at least 40 percent.



(a) Section view
(b) Plan view of daylight zone under a rooftop monitor



(a) Section view

(b) Plan view

FIGURE C405.2.4~~3~~.2(1)
PRIMARY AND SECONDARY SIDELIT DAYLIGHT ZONES

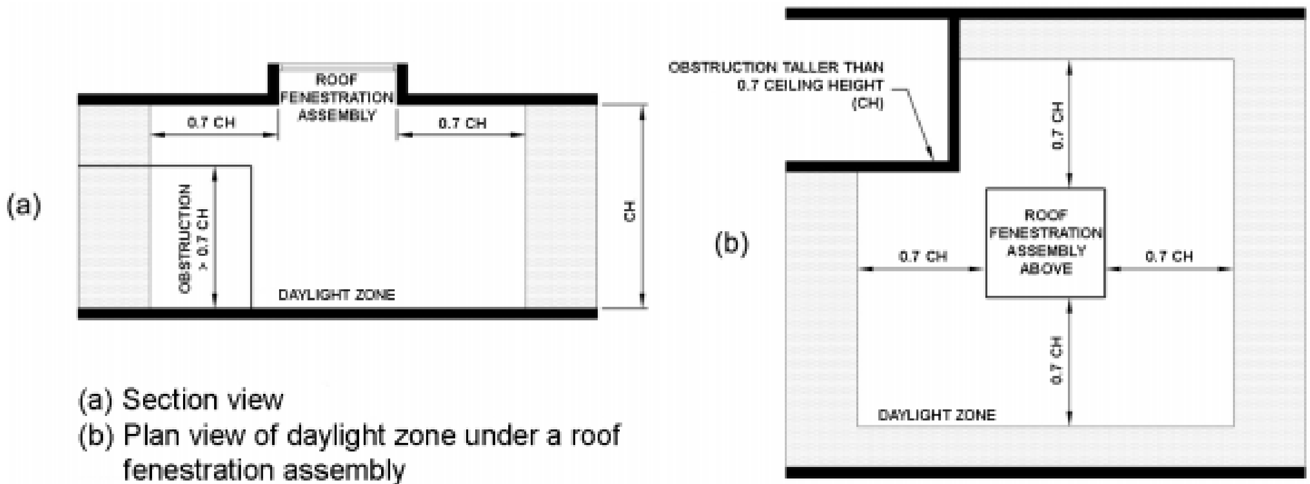


FIGURE C405.2.4.2(2)
DAYLIGHT ZONE UNDER A ROOFTOP MONITOR

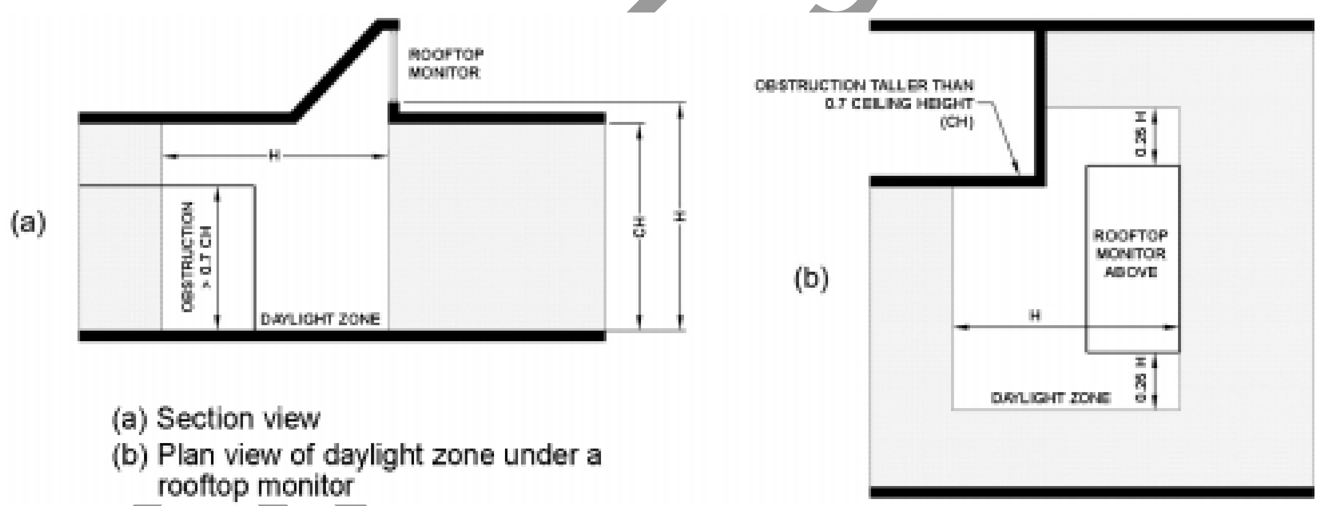


FIGURE C405.2.4.2(3)
DAYLIGHT ZONE UNDER A SLOPED ROOFTOP MONITOR

C405.2.~~3~~4.3 Toplit daylight zone.
The *toplit daylight zone* is the floor area underneath a roof fenestration assembly that complies with all of the following:

1. The *toplit daylight zone* shall extend laterally and longitudinally beyond the edge of the roof fenestration assembly to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 0.7 times the ceiling height, whichever is less, as indicated in Figure C405.2.4~~3~~.3~~(1)~~.

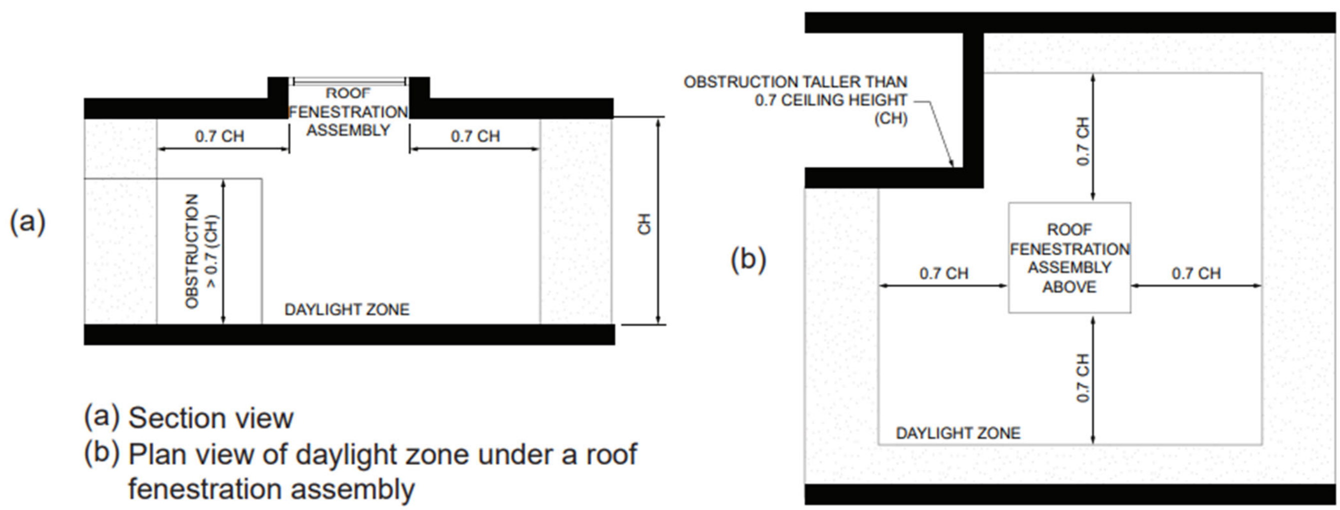
~~2. Where the fenestration is located in a rooftop monitor, the toplit zone shall extend laterally to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 1.0 times the height from the floor to the bottom of the fenestration, whichever is less, and longitudinally from the edge of the fenestration to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 0.25 times the height from the floor to the bottom of the fenestration, whichever is less, as indicated in Figures C405.2.3.3(2) and C405.2.3.3(3).~~

~~3~~2. Direct sunlight is not blocked from hitting the roof fenestration assembly at the peak solar angle on the summer solstice by buildings or geological formations.

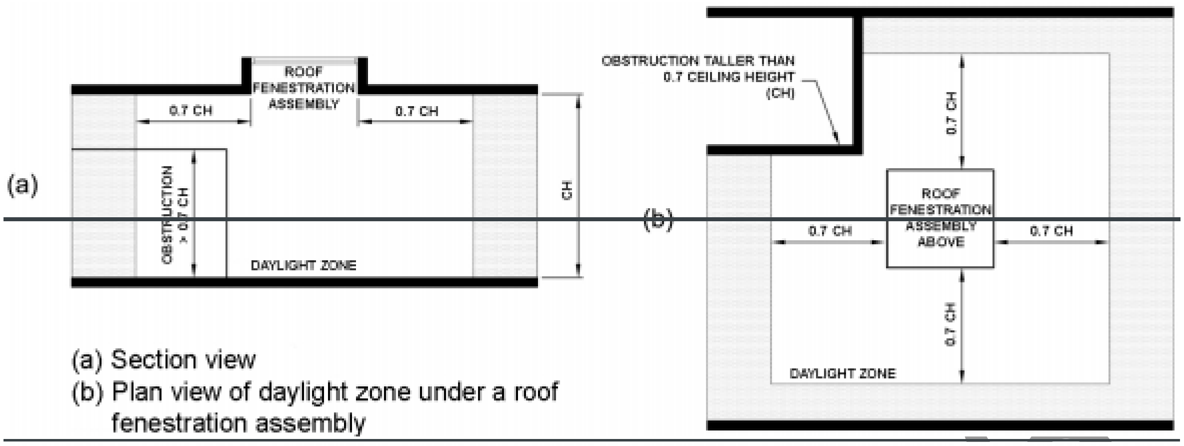
34. The product of the visible transmittance of the roof fenestration assembly and the area of the rough opening of the roof fenestration assembly divided by the area of the *toplit* zone is not less than 0.008.

~~5~~4. Where toplight daylight zones overlap with sidelight daylight zones, lights within the overlapping area shall be assigned to the toplight daylight zone.

C405.2.4.4 Atriums. Daylight zones at atrium spaces shall be established at the top floor surrounding the atrium and at the floor of the atrium space, and not on intermediate floors, as indicated in Figure C405.2.4.4.



(a) Section view
(b) Plan view of daylight zone under a roof fenestration assembly



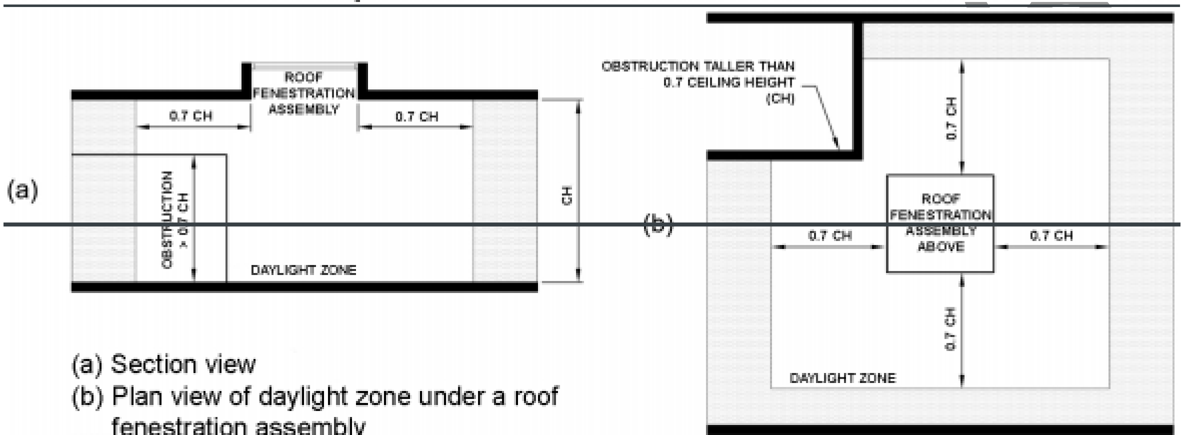
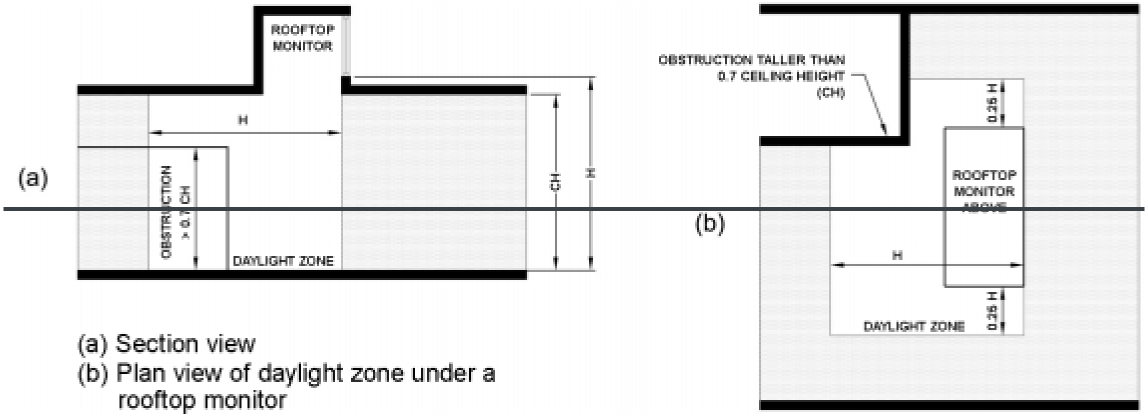


FIGURE C405.2.~~3~~4.3~~(1)~~
TOPLIT DAYLIGHT ZONE



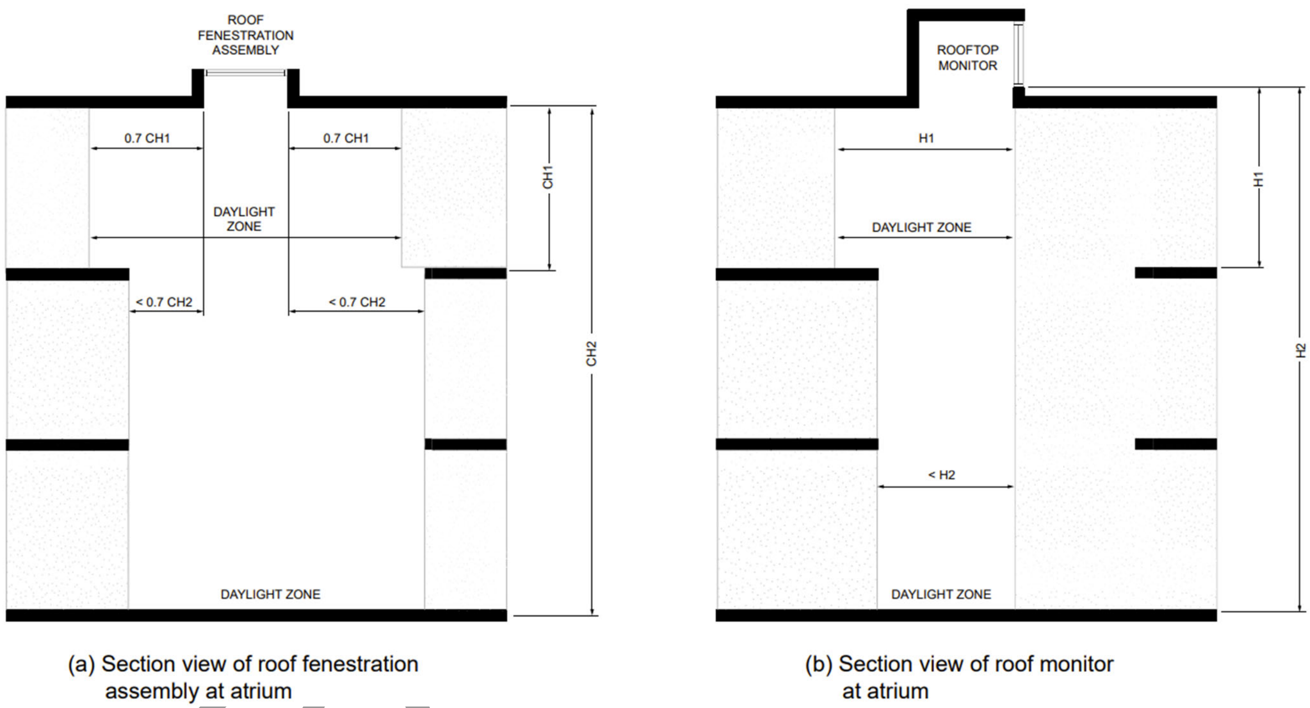
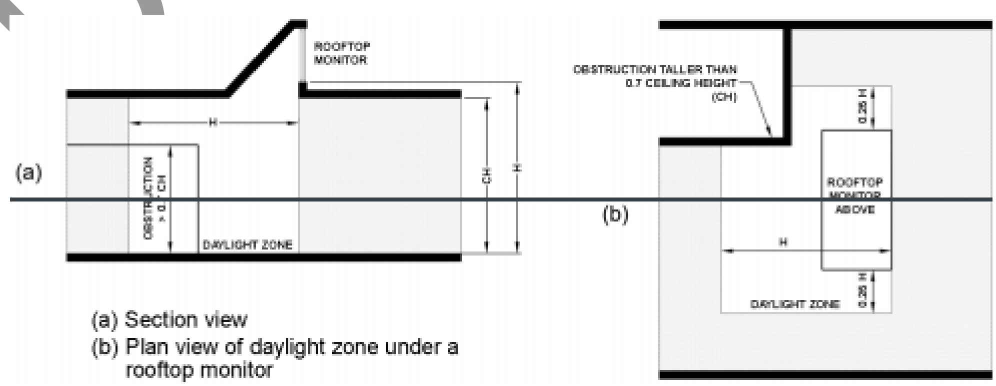
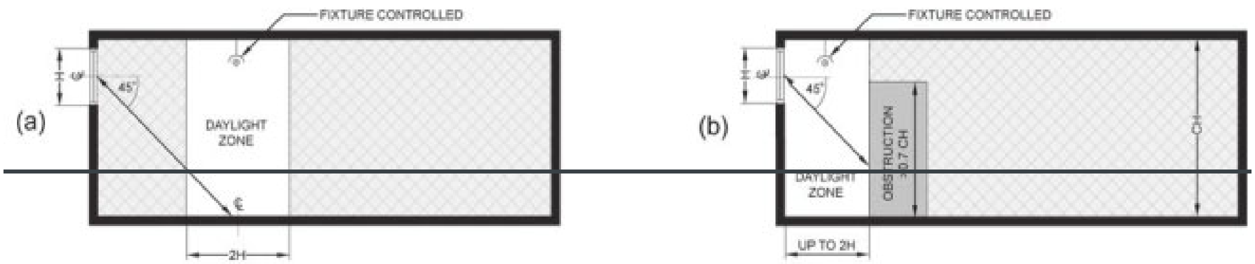


FIGURE C405.2.~~3~~4~~.3(2)~~4
DAYLIGHT ZONES ~~UNDER A ROOFTOP MONITOR~~AT A MULTISTORY ATRIUM



~~FIGURE C405.2.3~~4~~.3(3)~~
~~DAYLIGHT ZONE UNDER A SLOPED ROOFTOP MONITOR~~



(a) Section view
(b) Section view with obstruction

~~FIGURE C405.2.3~~4~~.3(4)~~
~~DAYLIGHT ZONE ADJACENT TO CLERESTORY FENESTRATION IN A WALL~~

C405.2.~~4~~5 Specific application controls.
Specific application controls shall be provided for the following:

1. The following lighting shall be controlled by an occupant sensor complying with Section C405.2.1.1 or a time-switch control complying with Section C405.2.2.1. In addition, a manual control shall be provided to control such lighting separately from the general lighting in the space:

   1.1. Luminaires for which additional lighting power is claimed in accordance with Section C405.3.2.2.1.

   1.2 Display and accent.

   1.3~~2~~. Lighting in display cases.

   1.4~~3~~. Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting.

   1.~~4~~5. Lighting equipment that is for sale or demonstration in lighting education.

   1.6 Display lighting for exhibits in galleries, museums and monuments that is in addition to general lighting.

2. *Sleeping units* shall have control devices or systems that are configured to automatically switch off all permanently installed luminaires and switched receptacles within 20 minutes after all occupants have left the unit.

   Exceptions:

   1. Lighting and switched receptacles controlled by card key controls.

2. Spaces where patient care is directly provided.

3. Permanently installed luminaires within *dwelling units* shall be provided with controls complying with Section C405.2.1.1 or C405.2.3~~2~~.1~~2~~.

4. Lighting for nonvisual applications, such as plant growth and food warming, shall be controlled by a time switch control complying with Section C405.2.2.1 that is independent of the controls for other lighting within the room or space.

5. Task lighting for medical and dental purposes that is in addition to *general lighting* shall be provided with a *manual control*.

C405.2.6~~5~~ Manual controls.
Where required by this code, manual controls for lights shall comply with the following:

1. They shall be in a location with *ready access* to occupants.

2. They shall be located where the controlled lights are visible, or shall identify the area served by the lights and indicate their status.

C405.2.~~6~~7 Exterior lighting controls.
Exterior lighting systems shall be provided with controls that comply with Sections C405.2.7~~6~~.1 through C405.2.7~~6~~.4. ~~Decorative lighting systems shall comply with Sections C405.2.6.1, C405.2.6.2 and C405.2.6.4.~~

Exceptions:

1. Lighting for covered vehicle entrances and exits from buildings and parking structures where required for eye adaptation.

2. Lighting controlled from within dwelling units.

C405.2.~~6~~7.1 Daylight shutoff.
Lights shall be automatically turned off when daylight is present and satisfies the lighting needs.

C405.2.~~6~~7.2 ~~Decorative lighting shutoff~~Building façade and landscape lighting.
Building facade and landscape lighting shall automatically shut off from not later than 1 hour after business closing to not earlier than 1 hour before business opening.

C405.2.~~6~~7.3 Lighting setback.
Lighting that is not controlled in accordance with Section C405.2.~~6~~7.2 shall ~~be controlled so that the total wattage of such lighting is automatically reduced by not less than 30 percent by selectively switching off or dimming luminaires at one of the following times~~comply with the following:

1. ~~From not later than midnight to not earlier than 6 a.m.~~ Be controlled so that the total wattage of such lighting is automatically reduced by not less than 50 percent by selectively switching off or dimming luminaires at one of the

following times:

1.1. From not later than midnight to not earlier than 6 a.m.
1.2. From not later than one hour after business closing to not earlier than one hour before business opening.

1.3. During any time where activity has not been detected for 15 minutes or more.

2. ~~From not later than one hour after business closing to not earlier than one hour before business opening.~~Luminaires serving outdoor parking areas and having a rated input wattage of greater than 78 watts and a mounting height of 24 feet (7315 mm) or less above the ground shall be controlled so that the total wattage of such lighting is automatically reduced by not less than 50 percent during any time where activity has not been detected for 15 minutes or more. Not more than 1,500 watts of lighting power shall be controlled together.

~~3. During any time where activity has not been detected for 15 minutes or more.~~

C405.2.~~6~~7.4 Exterior time-switch control function.
Time-switch controls for exterior lighting shall comply with the following:

1. They shall have a clock capable of being programmed for not fewer than 7 days.

2. They shall be capable of being set for seven different day types per week.

3. They shall incorporate an automatic holiday setback feature.

4. They shall have program backup capabilities that prevent the loss of program and time settings for a period of not less than 10 hours in the event that power is interrupted.

C405.2.8 Parking garage lighting control.
Parking garage lighting shall be controlled by an occupant sensor complying with Section C405.2.1.1 or a *time-switch control* complying with Section C405.2.2.1. Additional lighting controls shall be provided as follows:

1. Lighting power of each luminaire shall be automatically reduced by not less than 30 percent when there is no activity detected within a lighting zone for 20 minutes. Lighting zones for this requirement shall be not larger than 3,600 square feet (334.5 m2).

   Exception: Lighting zones provided with less than 1.5 footcandles of illumination on the floor at the darkest point with all lights on are not required to have automatic light-reduction controls.

2. Where lighting for eye adaptation is provided at covered vehicle entrances and exits from buildings and parking structures, such lighting shall be separately controlled by a device that automatically reduces lighting power by at least 50 percent from sunset to sunrise.

3. The power to luminaires within 20 feet (6096 mm) of perimeter wall openings shall automatically reduce in response to daylight by at least 50 percent.

Exceptions:

1. Where the opening-to-wall ratio is less than 40 percent as viewed from the interior and encompassing the vertical distance from the driving surface to the lowest structural element.

2. Where the distance from the opening to any exterior daylight blocking obstruction is less than one-half the height from the bottom of the opening or fenestration to the top of the obstruction.

~~2.~~3. Where openings are obstructed by permanent screens or architectural elements restricting daylight entering the interiorspace.

C405.3 Interior lighting power requirements ~~(Prescriptive)~~.
A building complies with this section where its total connected interior lighting power calculated under Section C405.3.1 is not greater than the interior lighting power allowance calculated under Section C405.3.2.

~~**Exception:** Neither the floor area nor the wattage of lighting is counted in Sections C405.3.1 and C405.3.2 for the following spaces:~~

~~1. *Dwelling units* and *sleeping units* within Group R-2 buildings (see *occupancy classification*).~~

~~2. *Dwelling units* and *sleeping units* within buildings other than Group R-2, provided that not less than 90 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 90 percent of the permanently installed lighting fixtures shall be high-efficacy fixtures or contain only high-efficacy lamps.~~

C405.3.1 Total connected interior lighting power.
The total connected interior lighting power shall be determined in accordance with Equation 4-9.

TCLP = [*LVL* + *BLL* + *LED* + *TRK* + Other] **(Equation 4-9)**

where:

TCLP	=	Total connected lighting power (watts).
SL	=	Labeled wattage of luminaires for screw-in lamps.
LVL	=	For luminaires with lamps connected directly to building power, such as line voltage lamps, the rated wattage of the lamp.
BLL	=	For luminaires incorporating a ballast or transformer, the rated input wattage of the ballast or transformer when operating that lamp.
LED	=	For light-emitting diode luminaires with either integral or remote drivers, the rated wattage of the luminaire.

TRK = For lighting track, cable conductor, rail conductor, and plug-in busway systems that allow the addition and relocation of luminaires without rewiring, the wattage shall be one of the following:

1. The specified wattage of the luminaires, but not less than 8 W per linear foot (25 W/lin m).
2. The wattage limit of the permanent current-limiting devices protecting the system.
3. The wattage limit of the transformer supplying the system.

Other = The wattage of all other luminaires and lighting sources not covered previously and associated with interior lighting verified by data supplied by the manufacturer or other *approved* sources.

The connected power associated with the following lighting equipment and applications is not included in calculating total connected lighting power. Additionally, for multiple systems installed in circadian rhythm systems, only include the maximum power that would be on at any one time.

1. Television broadcast lighting for playing areas in sports arenas.
2. Emergency lighting automatically off during normal building operation.
3. Lighting in spaces specifically designed for use by occupants with special lighting needs, including those with visual impairment and other medical and age-related issues.
4. Casino gaming areas.
5. Mirror lighting in dressing rooms.
6. Task lighting for medical and dental purposes that is in addition to general lighting ~~and controlled by an independent control device~~.
7. Display lighting for exhibits in galleries, museums and monuments that is in addition to general lighting ~~and controlled by an independent control device~~.
8. Lighting for theatrical purposes, including performance, stage, film production and video production.
9. Lighting for photographic processes.
10. Lighting integral to equipment or instrumentation and installed by the manufacturer.
11. Task lighting for plant growth or maintenance provided it is limited to no more than 75 W per square foot of Canopy Area.

12. Advertising signage or directional signage.

13. Lighting for food warming.

14. Lighting equipment that is for sale.

15. Lighting demonstration equipment in lighting education facilities.

16. Lighting approved because of safety considerations.

17. Lighting in retail display windows, provided that the display area is enclosed by ceiling-height partitions.

18. Furniture-mounted supplemental task lighting that is controlled by automatic shutoff.

19. Exit signs.

20. Antimicrobial lighting used for the sole purpose of disinfecting a space.

C405.3.2 Interior lighting power allowance.
The total interior lighting power allowance (watts) ~~is~~ for an entire building shall be determined according to Table C405.3.2(1) using the Building Area Method, or ~~Table C405.3.2(2) using the Space-by-Space Method, for all areas of the building covered in this permit.~~ Table C405.3.2(2) using the Space-by-Space Method. The interior lighting power allowance for projects that involve only portions of a building shall be determined according to Table C405.3.2(2) using the Space-by-Space Method. Buildings with unfinished spaces shall use the Space-by-Space Method.

TABLE C405.3.2(1)
INTERIOR LIGHTING POWER ALLOWANCES:
BUILDING AREA METHOD

BUILDING AREA TYPE	LPD (w/ft^2)
Automotive facility	0.~~60~~56
Convention center	0.~~70~~55
Courthouse	0.~~76~~64
Dining: bar lounge/leisure	0.~~76~~64
Dining: cafeteria/fast food	0.~~67~~59
Dining: family	0.~~69~~58
~~Dormitory~~[c] Dormitory[a,b]	0.~~47~~41
Exercise center	0.~~59~~54
Fire station[a]	0.~~48~~43
Gymnasium	0.~~64~~58

Health care clinic	0.~~69~~62
Hospital[a]	0.~~84~~74
Hotel/Motel[a, b]	0.~~65~~50
Library	0.~~78~~66
Manufacturing facility	0.~~82~~68
Motion picture theater	0.~~44~~64
Multifamily[c]	0.~~48~~38
Museum	0.~~55~~83
Office	0.~~64~~53
Parking garage	0.~~14~~13
Penitentiary	0.~~62~~54
Performing arts theater	~~1.02~~0.77
Police station	0.~~67~~55
Post office	0.~~61~~52
Religious building	0.~~77~~60
Retail	0.~~92~~73
School/university	0.~~67~~57
Sports arena	0.~~71~~61
Town hall	0.~~67~~56
Transportation	0.~~52~~42
Warehouse	0.~~43~~36
Workshop	0.~~83~~72

For SI: 1 watt per square foot = 10.76 W/m2.

a. Where sleeping units are excluded from lighting power ~~calculations when 90% of the sleeping units' lamps or fixtures is high-efficacy~~by application of Section C405.1.1, neither the area of the sleeping units nor the wattage of lighting in the sleeping units is counted.

b. Where dwelling units are excluded from lighting power ~~calculations when 90% of the sleeping units' lamps or fixtures is high-efficacy~~by application of Section C405.1.1, neither the area of the dwelling units nor the wattage of lighting in the dwelling units is counted.

c. Dwelling units and sleeping units are excluded. Neither the area of the dwelling units nor the wattage of lighting in the dwelling units is counted.

All permanently installed lighting serving dwelling units, excluding kitchen appliance lighting, shall contain only high-efficacy lighting sources

TABLE C405.3.2(2)
INTERIOR LIGHTING POWER ALLOWANCES:
SPACE-BY-SPACE METHOD

COMMON SPACE TYPES[a]	LPD (watts/~~sq.~~ft^2)
Atrium	

Less than 40 feet in height	0.48~~0.03 per foot in total height~~
Greater than 40 feet in height	~~0.40 + 0.02 per foot in total height~~0.60
Audience seating area	
In an auditorium	0.~~50~~46
In a gymnasium	0.23~~52~~
In a motion picture theater	0.27~~91~~
In a penitentiary	0.22
In a performing arts theater	1.16~~77~~
In a religious building	0.72~~1.22~~
In a sports arena	0.~~34~~28
Otherwise	0.~~34~~28
Banking activity area	0.~~74~~56
Breakroom (See Lounge/breakroom)	
Classroom/lecture hall/training room	
In a penitentiary	~~1.07~~0.81
Otherwise	0.~~87~~65
Computer room, data center~~–~~	~~1.21~~0.89
Conference/meeting/multipurpose room	0.~~92~~78
Copy/print room	0.31~~51~~
Corridor	
In a facility for the visually impaired (and not used primarily by the staff)[b]	0.71~~92~~
In a hospital	0.~~79~~62
Otherwise	0.41~~66~~
Courtroom	1.~~24~~01
Dining area	
In bar/lounge or leisure dining	0.~~80~~68
In cafeteria or fast food dining	0.~~51~~38
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.27~~56~~
In family dining	0.~~64~~51
In a penitentiary	0.42~~77~~
Otherwise	0.~~51~~39
Electrical/mechanical room	0.43
Emergency vehicle garage	0.~~38~~37
Food preparation area	0.~~90~~82

Guestroom[c, d]	0.~~47~~36
Laboratory	
In or as a classroom	~~1.05~~0.89
Otherwise	1.~~30~~08
Laundry/washing area	0.~~41~~39
Loading dock, interior	0.42

(continued)

TABLE C405.3.2(2)—continued
INTERIOR LIGHTING POWER ALLOWANCES:
SPACE-BY-SPACE METHOD

COMMON SPACE TYPES[a]	LPD (watts/sq.ft)
Lobby	
For an elevator	0.~~53~~49
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.54
In a hotel	0.51~~85~~
In a motion picture theater	0.23~~41~~
In a performing arts theater	1.~~47~~12
Otherwise	0.~~76~~66
Locker room	0.~~48~~41
Lounge/breakroom	
In a healthcare facility	0.42~~68~~
Otherwise	0.~~54~~47
Office	
Enclosed	0.~~81~~64
Open plan	0.~~71~~55
Parking area, interior	0.~~13~~12
Pharmacy area	1.~~20~~17
Restroom	
In a facility for the visually impaired (and not used primarily by the staff[b])	~~0.86~~1.26
Otherwise	0.~~73~~56
Sales area	~~1.11~~0.89
Seating area, general	0.23~~38~~
Stairway (see Space containing stairway)	
Stairwell	0.~~51~~41
Storage room	0.~~43~~33
Vehicular maintenance area	0.~~49~~45
Workshop	~~1.08~~0.96
BUILDING TYPE SPECIFIC SPACE TYPESa	**LPD (watts/sq.ft)**
Automotive (see Vehicular maintenance area)	
Convention Center—exhibit space	0.61~~88~~
Dormitory – living quarters[c,d]	0.50

Facility for the visually impaired[b]	
In a chapel (and not used primarily by the staff)	0.70~~1.06~~
In a recreation room (and not used primarily by the staff)	1.~~67~~42
Fire Station—sleeping quarters[c]	0.~~17~~16
Gymnasium/fitness center	
In an exercise area	0.48
In a playing area	0.~~80~~68
Healthcare facility	
In an exam/treatment room	1.~~34~~13
In an imaging room	0.81~~1.02~~
In a medical supply room	0.~~51~~46
In a nursery	0.~~76~~69
In a nurse's station	0.61
In an operating room	1.~~85~~69
In a patient room[c]	0.~~50~~48
In a physical therapy room	0.~~70~~66
In a recovery room	0.87
Library	
In a reading area	0.~~75~~70
In the stacks	~~1.15~~0.96

(continued)

TABLE C405.3.2(2)—continued
INTERIOR LIGHTING POWER ALLOWANCES:
SPACE-BY-SPACE METHOD

BUILDING TYPE SPECIFIC SPACE TYPES[a]	LPD (watts/sq.ft)
Manufacturing facility	
In a detailed manufacturing area	0.~~88~~69
In an equipment room	0.~~55~~54
In an extra-high-bay area (greater than 50 feet floor-to-ceiling height)	0.84
In a high-bay area (25–50 feet floor-to-ceiling height)	0.75
In a low-bay area (less than 25 feet floor-to ceiling height)	0.~~85~~71

Museum	
In a general exhibition area	0.~~84~~31
In a restoration room	0.74
Performing arts theater—dressing room	0.~~36~~32
Post office—sorting area	0.~~64~~58
Religious buildings	
In a fellowship hall	0.~~47~~42
In a worship/pulpit/choir area	0.85~~1.22~~
Retail facilities	
In a dressing/fitting room	0.~~48~~41
In a mall concourse	0.~~80~~67
Sports arena—playing area	
For a Class I facility[e]	2.~~17~~10
For a Class II facility[f]	1.~~55~~46
For a Class III facility[g]	1.~~17~~02
For a Class IV facility[h]	0.~~70~~64
Transportation facility	
In a baggage/carousel area	0.~~39~~37
In an airport concourse	0.27
At a terminal ticket counter	0.~~56~~34
Warehouse—storage area	
For medium to bulky, palletized items	0.~~35~~28
For smaller, hand-carried items	0.~~65~~55

For SI: 1 foot = 304.8 mm, 1 watt per square foot = 10.76 W/m2

a. In cases where both a common space type and a building area specific space type are listed, the building area specific space type shall apply

b. A 'Facility for the Visually Impaired' is a facility that is licensed or will be licensed by local or state authorities for senior long-term care, adult daycare, senior support or people with special visual needs.

c. Where sleeping units are excluded from lighting power calculations ~~when 90% of the sleeping units' lamps or fixtures is high-efficacy~~by application of Section C405.1.1, neither the area of the sleeping units nor the wattage of lighting in the sleeping units is counted.

d. Where dwelling units are excluded from lighting power calculations ~~when 90% of the sleeping units' lamps or fixtures is high-efficacy~~by application of Section C405.1.1, neither the area of the dwelling units nor the wattage of lighting in the dwelling units is counted.

e. Class I facilities consist of professional facilities; and semiprofessional, collegiate, or club facilities with seating for 5,000 or more spectators.

f. Class II facilities consist of collegiate and semiprofessional facilities with seating for fewer than 5,000 spectators; club facilities with seating for between 2,000 and 5,000 spectators; and amateur league and high-school facilities with seating for more than 2,000 spectators.

g. Class III facilities consist of club, amateur league and high-school facilities with seating for 2,000 or fewer spectators.

h. Class IV facilities consist of elementary school and recreational facilities; and amateur league and high-school facilities without provision for spectators.

C405.3.2.1 Building Area Method.

~~For the Building Area Method, the interior lighting power allowance is the floor area for each building area type listed in Table C405.3.2(1) times the value from Table C405.3.2(1) for that area. For the purposes of this method, an "area" shall be defined as all contiguous spaces that accommodate or are associated with a single building area type, as listed in Table C405.3.2(1). Where this method is used to calculate the total interior lighting power for an entire building, each building area type shall be treated as a separate area.~~
For the Building Area Method, the interior lighting power allowance is calculated as follows:

1. For each building area type inside the building, determine the applicable building area type and the allowed lighting power density for that type from Table C405.3.2(1). For building area types not listed, select the building area type that most closely represents the use of that area. For the purposes of this method, an "area" shall be defined as all contiguous spaces that accommodate or are associated with a single building area type.

2. Determine the floor area for each building area type listed in Table C405.3.2(1) and multiply this area by the applicable value from Table C405.3.2(1) to determine the lighting power (watts) for each building area type.

3. The total interior lighting power allowance (watts) for the entire building is the sum of the lighting power from each building area type.

C405.3.2.2 Space-by-Space Method.

~~For the Space-by-Space Method, the interior lighting power allowance is determined by multiplying the floor area of each space times the value for the space type in Table C405.3.2(2) that most closely represents the proposed use of the space, and then summing the lighting power allowances for all spaces. Tradeoffs among spaces are permitted.~~ Where a building has unfinished spaces, the lighting power allowance for the unfinished spaces shall be the total connected lighting power for those spaces, or 0.2 watts per square foot (10.76 w/m^2), whichever is less. For the Space-by-Space Method, the interior lighting power allowance is calculated as follows:

1. For each space enclosed by partitions that are not less than 80 percent of the ceiling height, determine the applicable space type from Table C405.3.2(2). For space types not listed, select the space type that most closely represents the proposed use of the space. Where a space has multiple functions, that space may be divided into separate spaces.

2. Determine the total floor area of all the spaces of each space type and multiply by the value for the space type in Table C405.3.2(2) to determine the lighting power (watts) for each space type.

3. The total interior lighting power allowance (watts) shall be the sum of the lighting power allowances for all space types.

C405.3.2.2.1 Additional interior lighting power.

Where using the Space-by-Space Method, an increase in the interior lighting power allowance is permitted for specific lighting functions. Additional power shall be permitted only where the specified lighting is installed and ~~automatically controlled separately from the general lighting, to be turned off during nonbusiness hours~~controlled in accordance with Section C405.2.~~4~~5. This additional power shall be used only for the specified luminaires and shall not be used for any other purpose. An increase in the interior lighting power allowance is permitted in the following cases:

1. For lighting equipment to be installed in sales areas specifically to highlight merchandise, the additional lighting power shall be determined in accordance with Equation 4-~~11~~10.

Additional interior lighting power allowance = ~~1000~~ 500 W + (Retail Area 1 × 0.~~45~~ 22 W/ft^2) + (Retail Area 2 × 0.~~45W~~22W/ft^2) + (Retail Area 3 × ~~1.05~~0.52 W/ft^2) + (Retail Area 4 × ~~1.87~~0.93 W/ft^2)

For SI units:

Additional interior lighting power allowance = ~~1000~~ 500 W + (Retail Area 1 × ~~4.8~~2.4 W/m^2) + (Retail Area 2 × ~~4.84~~2.42 W/m2) + (Retail Area 3 × ~~11~~ 5.5 W/m^2) + (Retail Area 4 × ~~20~~ 10 W/m^2) **(Equation 4-10)**

where:

Retail Area 1	=	The floor area for all products not listed in Retail Area 2, 3 or 4.
Retail Area 2	=	The floor area used for the sale of vehicles, sporting goods and small electronics.
Retail Area 3	=	The floor area used for the sale of furniture, clothing, cosmetics and artwork.
Retail Area 4	=	The floor area used for the sale of jewelry, crystal and china.

Exception: Other merchandise categories are permitted to be included in Retail Areas 2 through 4, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is approved by the code official.

C405.4 Lighting for plant growth and maintenance. Not less than 95 percent of the permanently installed luminaires used for plant growth and maintenance shall have a photon efficiency of not less than 1.7 μmol/J for greenhouses or 1.9 μmol/J for indoor facilities as defined in accordance with ANSI/ASABE S640.

C405.5 Exterior lighting power requirements ~~(Mandatory)~~.
The total connected exterior lighting power calculated in accordance with Section C405.~~4~~5.1 shall be not greater than the exterior lighting power allowance calculated in accordance with Section~~s~~ C405.~~4~~5.2~~ and C405.4.3~~. Appropriate exterior lighting designs including maximum exterior illuminance levels may be required by the District Environmental Commission for Act 250 projects.

C405.5~~4~~.1 Total connected exterior building exterior lighting power.
The total exterior connected lighting power shall be the total maximum rated wattage of all lighting that is powered through the energy service for the building.

Exception: Lighting used for the following applications shall not be included.

1. Lighting *approved* because of safety considerations.
2. Emergency lighting automatically off during normal business operation.
3. Exit signs.
4. Specialized signal, directional and marker lighting associated with transportation.
5. Advertising signage or directional signage.
6. Integral to equipment or instrumentation and installed by its manufacturer.
7. Theatrical purposes, including performance, stage, film production and video production.
8. Athletic playing areas.
9. Temporary lighting.
10. Industrial production, material handling, transportation sites and associated storage areas.
11. Theme elements in theme/amusement parks.
12. Used to highlight features of art, public monuments, and the national flag.
13. Lighting for water features and swimming pools.
14. Lighting controlled from within dwelling units, where the lighting complies with Section ~~R404~~C405.1.1.

C405.~~4~~5.2 Exterior lighting power allowance.
The ~~total~~ exterior lighting power allowance (watts) is ~~the sum of the base site allowance plus the individual allowances for areas that are to be illuminated by lighting that is powered through the energy service for the building. Lighting power allowances are as specified in Table C405.4.2(2). The lighting zone for the building exterior is determined in accordance with Table C405.4.2(1) unless otherwise specified by the *code official*.~~ calculated as follows:

1. Determine the Lighting Zone (LZ) for the building according to Table C405.5.2(1), unless otherwise specified by the code official.
2. For each exterior area that is to be illuminated by lighting that is powered through the energy service for the building, determine the applicable area type from Table C405.5.2(2). For area types not listed, select the area type that most closely represents the proposed use of the area.
3. Determine the total area or length of each area type and multiply by the value for the area type in Table C405.5.2(2) to determine the lighting power (watts) allowed for each area type.
4. The total exterior lighting power allowance (watts) is the sum of the base site allowance determined according to Table C405.5.2(2), plus the watts from each area type.

C405.5.2.1 Additional exterior lighting power.
Additional exterior lighting power allowances are available for the specific lighting applications listed in Table C405.5.2(3). These additional power allowances shall be used only for the luminaires serving these specific applications and shall not be used to increase any other lighting power allowance.

TABLE C405.5~~4~~.2(1)
EXTERIOR LIGHTING ZONES

LIGHTING ZONE	DESCRIPTION
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed-use areas
3	All other areas not classified as lighting zone 1 or ~~,~~ 2 ~~or 4~~

TABLE C405.5~~4~~.2(2)
LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

	LIGHTING ZONES		
	Zone 1	**Zone 2**	**Zone 3**
Base Site Allowance	~~250~~ 175 W	~~300~~ 200 W	~~375~~ 250 W
Uncovered Parking Areas			
Parking areas and drives	0.02 W/ft^2	0.~~03~~ 02 W/ft^2	0.~~05~~ 03 W/ft^2
Building Grounds			
Walkways less than 10 feet wide	0.~~35~~ 25 W/linear foot	0.~~35~~ 25 W/linear foot	0.~~40~~ 30 W/linear foot
Walkways, 10 feet wide or greater, plaza areas, special feature areas	0.~~07~~ 05 W/ft^2	0.~~07~~ 05 W/ft^2	0.~~08~~ 06 W/ft^2

Dining areas	0.~~50~~ 35 W/ft^2	0.~~50~~ 35 W/ft^2	0.~~60~~ 40 W/ft^2
Stairways	0.~~40~~ 30 W/ft^2	0.~~50~~ 35 W/ft^2	0.~~50~~ 35 W/ft^2
Pedestrian tunnels	0.~~08~~ 06 W/ft^2	0.~~08~~ 06 W/ft^2	0.~~10~~ 07 W/ft^2
Landscaping	0.02 W/ft^2	0.~~03~~ 02 W/ft^2	0.~~03~~ 02 W/ft^2
Building Entrances and Exits			
Pedestrian and vehicular entrances and exits	~~10~~ 7 W/linear foot of opening	~~10~~ 7 W/linear foot of opening	~~15~~ 11 W/linear foot of opening
Entry canopies	0.10 W/ft^2	0.12 W/ft^2	0.20 W/ft^2
Loading docks	0.~~25~~ 20 W/ft^2	0.~~25~~ 20 W/ft^2	0.~~25~~ 20 W/ft^2
Sales Canopies			
Free-standing and attached	0.~~30~~ 20 W/ft^2	0.~~30~~ 20 W/ft^2	0.~~40~~ 30 W/ft^2
Outdoor Sales			
Open areas (including vehicle sales lots)	0.~~15~~ 10 W/ft^2	0.~~15~~ 10 W/ft^2	0.~~25~~ 18 W/ft^2
Street frontage for vehicle sales lots in addition to “open area” allowance	No allowance	~~5~~ 4 W/linear foot	~~5~~ 4 W/linear foot
Building façades	No allowance	0.~~075~~ 038 W/ft^2 of gross above-grade wall area	0.~~113~~ 057 W/ft^2 of gross above- grade wall area
Automated teller machines (ATM) and night depositories	~~135~~ 70 W per location plus ~~45~~ 25 W per additional ATM per location	~~135~~ 70 W per location plus ~~45~~ 25 W per additional ATM per location	~~135~~ 70 W per location plus ~~45~~ 25 W per additional ATM per location
Entrances and gatehouse inspection stations at guarded facilities	0.25 W/ft^2 of covered and uncovered area	0.25 W/ft^2 of covered and uncovered area	0.25 W/ft2 of covered and uncovered area
Loading areas for law enforcement, fire, ambulance and other emer gency service vehicles	0.~~35~~ 20 W/ft^2 of covered and uncovered area	0.~~35~~ 20 W/ft^2 of covered and uncovered area	0.~~35~~ 20 W/ft^2 of covered and uncovered area
Drive-up windows/doors	~~200~~ 100 W per drive-through	~~200~~ 100 W per drive-through	~~200~~ 100 W per drive-through
Parking near 24-hour retail entrances	~~400~~ 200 W per main entry	~~400~~ 200 W per main entry	~~400~~ 200 W per main entry

For SI: 1 foot = 304.8 mm, 1 watt per square foot = ~~W/0.0929~~10.76 W/~~-~~m^2.~~,~~
W = watts.

TABLE C405.5.2(3)
INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

	LIGHTING ZONES		
	Zone 1	**Zone 2**	**Zone 3**
Building façades	No allowance	0.038 W/ft^2 of gross above-grade wall area	0.057 W/ft^2 of gross above- grade wall area
Automated teller machines (ATM) and night depositories	70 W per location plus 25 W per additional ATM per location	70 W per location plus 25 W per additional ATM per location	70 W per location plus 25 W per additional ATM per location
Entrances and gatehouse inspection stations at guarded facilities	0.25 W/ft^2 of covered and uncovered area	0.25 W/ft^2 of covered and uncovered area	0.25 W/ft2 of covered and uncovered area
Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.20 W/ft^2 of covered and uncovered area	0.20 W/ft^2 of covered and uncovered area	0.20 W/ft^2 of covered and uncovered area
Drive-up windows/doors	100 W per drive-through	100 W per drive-through	100 W per drive-through
Parking near 24-hour retail entrances	200 W per main entry	200 W per main entry	200 W per main entry

For SI: 1 watt per square foot = 10.76 W/m^2.
W = watts.

C405.~~4~~5.3 Exterior fixtures.
Exterior lighting shall be *full cut off* fixtures, limiting the light output to less than 10 percent at and below 10 degrees below the horizontal. Fixtures shall be independently certified by manufacturer as full cut ~~off, or~~off or meet the definition of a *fully shielded* light fixture.

C405.5~~4~~.4 Gas lighting ~~(Mandatory)~~.
Gas-fired lighting appliances shall not be ~~equipped with continuously burning pilot ignition systems~~permitted.

C405.~~5~~ 6 Dwelling electrical meter ~~(Mandatory)~~.
Each dwelling unit located in a *Group R*-2 building shall have a separate electrical meter.

Exception: Building constructed and/or operated by non-profit affordable house organizations. Future electrical metering must be considered and planned for in the electrical layout of the buildings.~~Buildings serving low-income occupants.~~

C405.~~6~~ 7 Electrical transformers ~~(Mandatory)~~.
Low-voltage dry-type distribution electric transformers shall meet the minimum efficiency requirements of Table C405.~~6~~ 7 as tested and rated in accordance with the test procedure listed in DOE 10 CFR 431. The efficiency shall be verified through certification under an approved certification program or, where a certification program does not exist, the equipment efficiency ratings shall be supported by data furnished by the transformer manufacturer.

Exception: The following transformers are exempt:

1. Transformers that meet the *Energy Policy Act of 2005* exclusions based on the DOE 10 CFR 431 definition of special purpose applications.
2. Transformers that meet the *Energy Policy Act of 2005* exclusions that are not to be used in general purpose applications based on information provided in DOE 10 CFR 431.
3. Transformers that meet the *Energy Policy Act of 2005* exclusions with multiple voltage taps where the highest tap is not less than 20 percent more than the lowest tap.
4. Drive transformers.
5. Rectifier transformers.
6. Auto-transformers.
7. Uninterruptible power system transformers.
8. Impedance transformers.
9. Regulating transformers.
10. Sealed and nonventilating transformers.
11. Machine tool transformers.
12. Welding transformers.
13. Grounding transformers.
14. Testing transformers.

TABLE C405.~~6~~7
MINIMUM NOMINAL EFFICIENCY LEVELS FOR 10 CFR 431 LOW-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMERS

SINGLE-PHASE TRANSFORMERS		THREE-PHASE TRANSFORMERS	
kVA[a]	**Efficiency (%)[b]**	**kVA[a]**	**Efficiency (%)[b]**
15	97.70	15	97.89
25	98.00	30	98.23
37.5	98.20	45	98.40
50	98.30	75	98.60
75	98.50	112.5	98.74
100	98.60	150	98.83
167	98.70	225	98.94
250	98.80	300	99.02

333	98.90	500	99.14
—	—	750	99.23
—	—	1000	99.28

a. kiloVolt-Amp rating.
b. Nominal efficiencies shall be established in accordance with the DOE 10 CFR 431 test procedure for low-voltage dry-type transformers.

C405.~~7~~8 Electric motors ~~(Mandatory)~~.
Electric motors shall meet the minimum efficiency requirements of Tables C405.~~7~~8(1) through C405.~~7~~8(4) when tested and rated in accordance with the DOE 10 CFR 431. The efficiency shall be verified through certification under an approved certification program or, where a certification program does not exist, the equipment efficiency ratings shall be supported by data furnished by the motor manufacturer.

Exception: The standards in this section shall not apply to the following exempt electric motors:

1. Air-over electric motors.
2. Component sets of an electric motor.
3. Liquid-cooled electric motors.
4. Submersible electric motors.
5. Inverter-only electric motors.

TABLE C405.~~7~~8(1)
MINIMUM NOMINAL FULL-LOAD EFFICIENCY FOR NEMA DESIGN A, NEMA DESIGN B, AND *IEC DESIGN N MOTORS* (EXCLUDING FIRE PUMP) ELECTRIC MOTORS AT 60 HZ[a, b]

MOTOR HORSEPOWER (STANDARD KILOWATT EQUIVALENT)	NOMINAL FULL-LOAD EFFICIENCY (%) AS OF JUNE 1, 2016							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1 (0.75)	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5 (1.1)	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2 (1.5)	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3 (2.2)	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5 (3.7)	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5 (5.5)	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10 (7.5)	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15 (11)	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20 (15)	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25 (18.5)	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30 (22)	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40 (30)	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50 (37)	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60 (45)	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75 (55)	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100 (75)	94.1	93.6	95.4	95.4	95.0	95.0	93.6	94.1
125 (90)	95.0	94.1	95.4	95.4	95.0	95.0	94.1	94.1
150 (110)	95.0	94.1	95.8	95.8	95.8	95.4	94.1	94.1
200 (150)	95.4	95.0	96.2	95.8	95.8	95.4	94.5	94.1
250 (186)	95.8	95.0	96.2	95.8	95.8	95.8	95.0	95.0
300 (224)	95.8	95.4	96.2	95.8	95.8	95.8		
350 (261)	95.8	95.4	96.2	95.8	95.8	95.8		
400 (298)	95.8	95.8	96.2	95.8				
450 (336)	95.8	96.2	96.2	96.2				
500 (373)	95.8	96.2	96.2	96.2				

a. Nominal efficiencies shall be established in accordance with DOE 10 CFR 431.
b. For purposes of determining the required minimum nominal full-load efficiency of an electric motor that has a horsepower or kilowatt rating between two horsepower or two kilowatt ratings listed in this table, each such motor shall be deemed to have a listed horsepower or kilowatt rating, determined as follows:
   1. A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers.
   2. A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers.
   3. A kilowatt rating shall be directly converted from kilowatts to horsepower using the formula: 1 kilowatt = (1/0.746) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with No. 1 or No. 2 above, as applicable.

TABLE C405.~~7~~8(2)
MINIMUM NOMINAL FULL-LOAD EFFICIENCY FOR NEMA DESIGN C AND *IEC DESIGN H MOTORS* AT 60 HZ[a, b]

MOTOR HORSEPOWER (STANDARD KILOWATT EQUIVALENT)	NOMINAL FULL-LOAD EFFICIENCY (%) AS OF JUNE 1, 2016					
	4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open
1 (0.75)	85.5	85.5	82.5	82.5	75.5	75.5
1.5 (1.1)	86.5	86.5	87.5	86.5	78.5	77.0
2 (1.5)	86.5	86.5	88.5	87.5	84.0	86.5
3 (2.2)	89.5	89.5	89.5	88.5	85.5	87.5
5 (3.7)	89.5	89.5	89.5	89.5	86.5	88.5
7.5 (5.5)	91.7	91.0	91.0	90.2	86.5	89.5
10 (7.5)	91.7	91.7	91.0	91.7	89.5	90.2
15 (11)	92.4	93.0	91.7	91.7	89.5	90.2
20 (15)	93.0	93.0	91.7	92.4	90.2	91.0
25 (18.5)	93.6	93.6	93.0	93.0	90.2	91.0
30 (22)	93.6	94.1	93.0	93.6	91.7	91.7
40 (30)	94.1	94.1	94.1	94.1	91.7	91.7
50 (37)	94.5	94.5	94.1	94.1	92.4	92.4
60 (45)	95.0	95.0	94.5	94.5	92.4	93.0
75 (55)	95.4	95.0	94.5	94.5	93.6	94.1
100 (75)	95.4	95.4	95.0	95.0	93.6	94.1
125 (90)	95.4	95.4	95.0	95.0	94.1	94.1
150 (110)	95.8	95.8	95.8	95.4	94.1	94.1
200 (150)	96.2	95.8	95.8	95.4	94.5	94.1

a. Nominal efficiencies shall be established in accordance with DOE 10 CFR 431.

b. For purposes of determining the required minimum nominal full-load efficiency of an electric motor that has a horsepower or kilowatt rating between two horsepower or two kilowatt ratings listed in this table, each such motor shall be deemed to have a listed horsepower or kilowatt rating, determined as follows:
   1. A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers.
   2. A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers.
   3. A kilowatt rating shall be directly converted from kilowatts to horsepower using the formula: 1 kilowatt = (1/0.746) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with No. 1 or No. 2 above, as applicable.

TABLE C405.~~7~~8(3)

MINIMUM AVERAGE FULL-LOAD EFFICIENCY POLYPHASE SMALL ELECTRIC MOTORS[a]

MOTOR HORSEPOWER	OPEN MOTORS			
	Number of Poles	2	4	6
	Synchronous Speed (RPM)	3600	1800	1200
0.25		65.6	69.5	67.5
0.33		69.5	73.4	71.4
0.50		73.4	78.2	75.3
0.75		76.8	81.1	81.7
1		77.0	83.5	82.5
1.5		84.0	86.5	83.8
2		85.5	86.5	N/A
3		85.5	86.9	N/A

a. Average full-load efficiencies shall be established in accordance with DOE 10 CFR 431.

TABLE C405.~~7~~8(4)
MINIMUM AVERAGE FULL-LOAD EFFICIENCY FOR CAPACITOR-START CAPACITOR-RUN AND CAPACITOR-START INDUCTION-RUN SMALL ELECTRIC MOTORS[a]

MOTOR HORSEPOWER	OPEN MOTORS			
	Number of Poles	2	4	6
	Synchronous Speed (RPM)	3600	1800	1200
0.25		66.6	68.5	62.2
0.33		70.5	72.4	66.6
0.50		72.4	76.2	76.2
0.75		76.2	81.8	80.2
1		80.4	82.6	81.1
1.5		81.5	83.8	N/A
2		82.9	84.5	N/A
3		84.1	N/A	N/A

a. Average full-load efficiencies shall be established in accordance with DOE 10 CFR 431.

C405.~~8~~9 Vertical and horizontal transportation systems and equipment.
Vertical and horizontal transportation systems and equipment shall comply with this section.

C405.~~8~~9.1 Elevator cabs.
For the luminaires in each elevator cab, not including signals and displays, the sum of the lumens divided by the sum of the watts shall be not less than 55 lumens per watt. Ventilation fans in elevators that do not have their own air-conditioning system shall not consume more than 0.33 watts/cfm at the maximum rated speed of the fan. Controls shall be provided that will deenergize ventilation fans and lighting systems when the elevator is stopped, unoccupied and with its doors closed for over 15 minutes.

C405.~~8~~9.2 Escalators and moving walks.
Escalators and moving walks shall comply with ASME A17.1/CSA B44 and shall have automatic controls ~~configured to~~that reduce speed ~~to the minimum permitted speed~~as permitted in accordance with ASME A17.1/CSA B44 ~~or~~ and applicable local code ~~when not conveying passengers~~.

> **Exception:** A variable voltage drive system that reduces operating voltage in response to light loading conditions is an alternative to the reduced speed function.

C405.9~~8~~.2.1 ~~Regenerative drive~~Energy recovery.
~~An escalator~~Escalators shall be designed to recover electrical energy when resisting overspeed in the down direction~~either for one-way down operation only or for reversible operation shall have a variable frequency regenerative drive that supplies electrical energy to the building electrical system when the escalator is loaded with passengers whose combined weight exceeds 750 pounds (340 kg)~~. The escalator shall be designed to recover, on average, more power than is consumed by the power recovery feature of its motor controller system.

C405.10~~9~~ Voltage drop ~~in feeders and branch circuits~~.
The total *voltage drop* across the combination of ~~feeders~~ customer-owned service conductors, feeder conductors and branch ~~circuits~~ circuit conductors shall not exceed 5 percent.

C405.11 Automatic receptacle control.
The following shall have automatic receptacle control complying with Section C405.11.1:

1. At least 50 percent of all 125V, 15- and 20-amp receptacles installed in enclosed offices, conference rooms, rooms used primarily for copy or print functions, breakrooms, classrooms, and individual workstations, including those installed in modular partitions and module office workstation systems.

2. At least 25 percent of branch circuit feeders installed for modular furniture not shown on the construction documents.

C405.11.1 Automatic receptacle control function.
Automatic receptacle controls shall comply with the following:

1. Either split controlled receptacles shall be provided with the top receptacle controlled, or a controlled receptacle shall be located within 12 inches (304.8 mm) of each uncontrolled receptacle.

2. One of the following methods shall be used to provide control:

    2.1. A scheduled basis using a time-of-day operated control device that turns receptacle power off at specific programmed times and can be programmed separately for each day of the week. The control device shall be configured to provide an independent schedule for each portion of the building of not more than 5,000 square feet (464.5 m^2) and not more than one floor. The occupant shall be able to manually override an area for not more than 2 hours. Any individual override switch shall control the receptacles of not more than 5,000 feet (1524 m).

2.2. An occupant sensor control that shall turn off receptacles within 20 minutes of all occupants leaving a space.

2.3. An automated signal from another control or alarm system that shall turn off receptacles within 20 minutes after determining that the area is unoccupied.

3. All controlled receptacles shall be permanently marked in accordance with NFPA 70 and be uniformly distributed throughout the space.

4. Plug-in devices shall not comply.

Exceptions: Automatic receptacle controls are not required for the following:

1. Receptacles specifically designated for equipment requiring continuous operation (24 hours per day, 365 days per year).
2. Spaces where an automatic control would endanger the safety or security of the room or building occupants.
3. Within a single modular office workstation, noncontrolled receptacles are permitted to be located more than 12 inches (304.8 mm), but not more than 72 inches (1828 mm) from the controlled receptacles serving that workstation.

C405.12 Energy monitoring.
New buildings with a gross conditioned floor area of 25,000 square feet (2322 m^2) or larger shall be equipped to measure, monitor, record and report energy consumption data in compliance with Sections C405.12.1 through C405.12.5.

Exception:
R-2 occupancies and individual tenant spaces are not required to comply with this section provided that the space has its own utility services and meters and has less than 5,000 square feet (464.5 m^2) of conditioned floor area.

C405.12.1 Electrical energy metering.
For all electrical energy supplied to the building and its associated site, including but not limited to site lighting, parking, recreational facilities and other areas that serve the building and its occupants, meters or other measurement devices shall be provided to collect energy consumption data for each end-use category required by Section C405.12.2.

C405.12.2 End-use metering categories.
Meters or other approved measurement devices shall be provided to collect energy use data for each end-use category indicated in Table C405.12.2. Where multiple meters are used to measure any end-use category, the data acquisition system shall total all of the energy used by that category. Not more than 5 percent of the measured load for each of the end-use categories indicated in Table C405.12.2 shall be permitted to be from a load that is not within that category.

Exceptions:
1. HVAC and water heating equipment serving only an individual dwelling unit shall not require end-use metering.
2. End-use metering shall not be required for fire pumps, stairwell pressurization fans or any system that operates only during testing or emergency.
3. End-use metering shall not be required for an individual tenant space having a floor area not greater than 2,500 square feet (232 m^2) where a dedicated source meter

complying with Section C405.12.3 is provided.

TABLE C405.12.2
ENERGY USE CATEGORIES

Load Category	Description of Energy Use
Total HVAC system	Heating, cooling and ventilation, including but not limited to fans, pumps, boilers, chillers and water heating. Energy used by 120-volt equipment, or by 208/120-volt equipment that is located in a building where the main service is 480/277-volt power, is permitted to be excluded from total HVAC system energy use.
Interior lighting	Lighting systems located within the building.
Exterior lighting	Lighting systems located on the building site but not within the building.
Plug loads	Devices, appliances, and equipment connected to convenience receptacle outlets.
EVSE	Electric vehicle supply equipment.
Process load	Any single load that is not included in an HVAC, lighting, plug load, or EVSE category and that exceeds 5 percent of the peak connected load of the whole building, including, but not limited to data centers, manufacturing equipment and commercial kitchens.
Building operations and other miscellaneous loads	The remaining loads not included elsewhere in this table, including but not limited to vertical transportation systems, automatic doors, motorized shading systems, ornamental fountains, ornamental fireplaces, swimming pools, in-ground spas and snow-melt systems.

C405.12.3 Meters.
Meters or other measurement devices required by this section shall be configured to automatically communicate energy consumption data to the data acquisition system required by Section C405.12.4. Source meters shall be allowed to be any digital-type meter. Lighting, HVAC or other building systems that can monitor their energy consumption shall be permitted instead of meters. Current sensors shall be permitted, provided that they have a tested accuracy of ±2 percent. Required metering systems and equipment shall have the capability to provide at least hourly data that is fully integrated into the data acquisition system and graphical energy report in accordance with Sections C405.12.4 and C405.12.5.

C405.12.4 Data acquisition system.
A data acquisition system shall have the capability to store the data from the required meters and other sensing devices for a minimum of 36 months. The data acquisition system shall have the capability to store real-time energy consumption data and provide hourly, daily, monthly and yearly logged data for each end-use category required by Section C405.12.2.

C405.12.5 Graphical energy report.
A permanent and readily accessible reporting mechanism shall be provided in the building that is accessible by building operation and management personnel. The reporting mechanism shall have the capability to graphically provide the energy consumption for each end-use category required by Section C405.12.2 at least every hour, day, month and year for the previous 36 months.

C405.~~10~~ 13 Electric vehicle Power Transfer Infrastructure.
New parking facilities shall be provided with *electric vehicle* power transfer infrastructure in compliance with Sections C405.13.1 through C405.13.7.

~~**charging stations.**~~

~~New parking lots serving buildings with occupancy groups listed in Table C405.11 shall provide the electrical service capacity to serve the number of Electric Vehicle Charging Parking Spaces in Table C405.11. Electrical service capacity includes use of a listed cabinet, box or enclosure connected to a conduit linking the parking spaces with the electrical service. Parking lots serving multiple occupancy groups shall use the occupancy group with the largest square feet of finished area.~~

C405.13.1 Quantity.

The number of required *EVSE spaces*, *EV capable spaces* and *EV ready spaces* shall be determined in accordance with this Section and Table C405.13.1 based on the total number of *automobile parking spaces* and shall be rounded up to the nearest whole number.

1. Where more than one parking facility is provided on a building site, the number of required *automobile parking spaces* required to have *EV* power transfer infrastructure shall be calculated separately for each parking facility.

2. Where one shared parking facility serves multiple building occupancies, the required number of spaces shall be determined proportionally based on the floor area of each building occupancy.

3. Each installed *EVSE* space with an *EV fast charger* shall count as four (4) *EVSE* spaces in Table C405.13.1.

4. Installed *EVSE* spaces that exceed the minimum requirements of this section may be used to meet minimum requirements for *EV ready spaces* and *EV capable spaces*.

5. Installed *EV ready spaces* that exceed the minimum requirements of this section may be used to meet minimum requirements for *EV capable spaces*.

6. The quantity shall never exceed the number of *automobile parking spaces* or require more *automobile parking spaces* to be constructed.

~~1.~~

Exceptions:

1. Parking facilities, serving occupancies other than R-2 with fewer than 10 automobile parking spaces.

2. Stand-alone retail stores with fewer than 50 spaces are exempt from the requirement to provide EVSE spaces but are still required to provide EV Ready and EV Capable spaces in Table C405.13.1 if there are 10 or more automobile parking spaces.

3. Motor liquid fuel-dispensing facilities including gas stations.

~~1.~~4. Parking spaces are not counted in Table 405.~~11~~ 13.1 if one of the following conditions apply:

    1. ~~1.~~ Parking spaces intended exclusively for storage of vehicles for retail sale or vehicle service.

    2. ~~2.~~ Parking spaces that are separated from the meter by a public right-of-way.

3. ~~—~~Parking spaces that are limited to parking durations of less than an hour.

~~Fifty percent of the parking spaces indicated in Table C405.11, rounded up to the nearest whole number, is the minimum number of electric vehicle supply equipment (EVSE) or receptacles necessary to function as available electric vehicle charging upon building occupancy. The number of parking spaces indicated in Table C405.11 minus the number of installed EVSE parking spaces is the minimum number of parking spaces that are required to be pre-wired, allowing for future installations when they are needed for use by customers, employees or other users (EVSE-ready). If Level 1 service is provided, the required EV Charging Parking Spaces shall also be "Level 2 ready" as defined below in this section. Electrical service capacity includes use of a listed cabinet, box or enclosure connected to a conduit linking the parking spaces with the electrical service. For parking lots with 25 or more parking spaces, Table C405.11 can be satisfied by either Option A or B in the table.~~

~~Parking spaces with EVSE shall be marked for EV use only.~~

~~**Exceptions:**~~

1. ~~In Group R-2 buildings the number of parking spaces with EVSE that are marked for "EV use only" need not exceed the number of EV cars driven by occupants of the building. This exception does not reduce the number of EVSE spaces, just the number that are marked for EV use only.~~

2. ~~In structured parking lots $^{1}/_{2}$ of parking spaces, rounded up, with EVSE shall be marked for "EV use only," while the remainder need not be marked for "EV use only." This exception does not reduce the number of EVSE spaces, just the number that are marked for EV use only.~~

~~Level 1 electric vehicle charging parking requires one 120V 20-amp grounded AC receptacle, NEMA 5- 20R or equivalent, within 5 feet of the centerline of each EV charging parking space.~~

~~Level 2 electric vehicle charging parking requires one 208/240V 40-amp grounded connection for electric vehicle charging through dedicated electric vehicle supply equipment (EVSE) with J1772 connector or AC receptacle, NEMA 14-50, or equivalent, within 5 feet of the centerline for each EV charging parking space.~~

~~DC fast charging, also referred to as Level 3, electric vehicle charging parking requires one, direct-current (DC) plug for electric vehicle charging through dedicated electric vehicle supply equipment (EVSE) with either a CHAdeMO or SAE combined charging system (CCS) format connector, within 5 feet of the centerline for each EV charging parking space. Other DC fast charging plug standards may be accepted as they are developed.~~

~~This section does not stipulate how use of the EVSE is provided. If the design intent is to only provide Level 2 and/or DC Fast Charge charging stations, then the Level 1 and Level 2 requirements should be added together.~~

TABLE C405.~~11~~13.1
~~ELECTRICAL VEHICLE CHARGING PARKING SPACES~~REQUIRED EV POWER TRANSFER INFRASTRUCTURE

COMMERCIAL BUILDING OCCUPANCY[a]	EVSE SPACES	EV READY SPACES	EV CAPABLE SPACES
Groups A, M	2%	0%	20%
Group B	6%	0%	30%
Group E	4%	0%	20%
Groups F, H, S	2%	0%	10%
Groups I, R-3, R-4	3%	0%	10%
Group R-1	8%	7%	50%
Group R-2	0%	0%	Determined in Equation 4-11

a. See *occupancy classification* in Section C202. ~~If more than one occupancy type, use the occupancy type with the most square feet of finished building area.~~
~~b. Fifty percent of the identified EVSE parking spaces, rounded up to the nearest whole number, shall have EVSE or receptacles necessary to function as available electric vehicle charging upon building occupancy. The remainder shall be EVSE-ready.~~
~~c. Motor liquid fuel-dispensing facilities (gas stations) are exempt from the requirement to provide electric vehicle charging parking spaces.~~
~~Stand-alone retail stores with fewer than 50 spaces are exempt from the requirement to provide electric vehicle charging parking spaces.~~

$$R2EVC = D/SU + 0.25 * (APS - D/SU) \qquad \textbf{(Equation 4-11)}$$

where:

R2EVC	=	Total requirement for EV Capable Spaces in R-2 building occupancies.
D/SU	=	Total number of dwelling and sleeping units in the R-2 building.
APS	=	Total number of *automobile parking spaces* provided.

C405.13.2 EV Capable Spaces.

Each *EV capable space* used to meet the requirements of Section C405.13.1 shall comply with all of the following:

1. A continuous raceway or cable assembly shall be installed between an enclosure or outlet located within 3 feet (914 mm) of the *EV capable space* and a suitable panelboard or other onsite electrical distribution equipment.
2. Installed raceway or cable assembly shall be sized and rated to supply a minimum circuit capacity in accordance with C405.13.5.
3. The electrical distribution equipment to which the raceway or cable assembly connects shall have sufficient dedicated space and spare electrical capacity for a 2-pole circuit breaker or set of fuses.
4. The electrical enclosure or outlet and the electrical distribution equipment directory shall be marked: "For future *electric vehicle supply equipment* (EVSE)."

5. Reserved capacity shall be no less than 4.1 kVA (20A 208/240V) for each *EV capable space.*

C405.13.3 EV Ready Spaces.

Each branch circuit serving EV ready spaces used to meet the requirements of Section C405.13.1 shall comply with all of the following:

1. Terminate at an outlet or enclosure, located within 3 feet (914 mm) of each *EV ready space* it serves.
2. Have a minimum circuit capacity in accordance with C405.13.5.
3. The panelboard or other electrical distribution equipment directory shall designate the branch circuit as "For electric vehicle supply equipment (EVSE)" and the outlet or enclosure shall be marked "For electric vehicle supply equipment (EVSE)."

C405.13.4 EVSE Spaces.

An installed *EVSE* with multiple output connections shall be permitted to serve multiple *EVSE spaces*. Each *EVSE* installed to meet the requirements of Section C405.13.1, serving either a single *EVSE space* or multiple *EVSE spaces*, shall comply with all of the following:

1. Have a minimum circuit capacity in accordance with C405.13.5.
2. Have a minimum charging rate in accordance with C405.13.4.1.
3. Be located within 3 feet (914 mm) of each *EVSE space* it serves.
4. Be installed in accordance with Section C405.13.6.

C405.13.4.1 EVSE Minimum Charging Rate.

Each installed EVSE shall comply with one of the following:

1. Be capable of charging at a minimum rate of 6.2 kVA (or 30A at 208/240V).
2. When serving multiple *EVSE spaces* and controlled by an energy management system providing load management, be capable of simultaneously charging each *EVSE space* at a minimum rate of no less than 3.3 kVA.
3. When serving *EVSE spaces* allowed to have a minimum circuit capacity of 2.7 kVA in accordance with C405.13.5.1 and controlled by an energy management system providing load management, be capable of simultaneously charging each *ESVE space* at a minimum rate of no less than 2.1 kVA.

C405.13.5 Circuit Capacity.

The capacity of electrical infrastructure serving each *EV capable space*, *EV ready space*, and *EVSE space* shall comply with one of the following:

1. A branch circuit shall have a rated capacity not less than 8.3 kVA (or 40A at 208/240V) for each *EV ready space* or *EVSE space* it serves.
2. The requirements of C405.13.5.1.

C405.13.5.1 Circuit Capacity Management.

The capacity of each branch circuit serving multiple EVSE spaces, EV ready spaces or EV capable spaces designed to be controlled by an energy management system providing load management in accordance with NFPA 70, shall comply with one of the following:

1. Have a minimum capacity of 4.1 kVA per space.
2. Have a minimum capacity of 2.7 kVA per space when serving *EV ready spaces* or *EVSE space* for R-2 occupancies when all (100%) of the automobile parking spaces designated for R-2 occupancies are designed to be *EV ready spaces* or *EVSE spaces*.
3. Have a minimum capacity of 2.7 kVA per space when serving *EV ready spaces* or *EVSE spaces* for a building site when all (100%) of the *automobile parking spaces* are designed to be *EV ready* or *EVSE spaces*.

C405.13.6 EVSE Installation.

EVSE shall be installed in accordance with NFPA 70 and shall be listed and labeled in accordance with UL 2202 or UL 2594. *EVSE* shall be accessible in accordance with International Building Code Section 1107.

C405.13.7 EVSE Parking Restrictions.

~~P~~*Automobile parking spaces* required by Table C405.13.1 to be equipped with *EVSE* shall be marked for EV use only.

Exceptions:

1. In Group R-2 buildings the number of parking spaces with EVSE that are marked for "EV use only" need not exceed the number of EV cars driven by occupants of the building. This exception does not reduce the number of EVSE spaces, just the number that are marked for EV use only.

2. In structured parking lots 1/2 of parking spaces, rounded up, with EVSE shall be marked for "EV use only," while the remainder need not be marked for "EV use only." This exception does not reduce the number of EVSE spaces, just the number that are marked for EV use only.

C405.14 Additional electric infrastructure. Buildings that contain *combustion equipment* and end-uses shall be required to install electric infrastructure in accordance with this section.

Exception: Buildings with R-2 *occupancy classifications*.

C405.14.1 Combustion space heating. Spaces containing *combustion equipment* for space heating shall comply with either C405.14.1.1 or C405.14.1.2

C405.14.1.1 Low-capacity heating. Spaces containing warm-air furnaces with a capacity less than 225,000 Btu/h and gas- and oil-fired boilers with a capacity less than 400,000 Btu/h shall be provided with a designated exterior location(s) that complies with the following:

1. Natural drainage for condensate from cooling equipment operation or a condensate drain located within 3 feet (914 mm) of the location of the space heating equipment, and

2. A dedicated branch circuit in compliance with NFPA70 Section 424.4 based on heat pump space heating equipment sized in accordance with the requirements of Section C403.1.1 and terminating within 3 feet (914 mm) of the location of the space heating equipment with no obstructions. Both ends of the branch circuit shall be labeled "For Future Heat Pump Space Heater."

   Exception: Where an electrical circuit in compliance with NFPA70 Sections 440.4(B) and 440.35 exists for space cooling equipment.

C405.14.1.2 High-capacity heating. Spaces containing all other space heating *equipment* shall be provided with conduit that is continuous between a junction box located within 3 feet (914 mm) of the *equipment* and an electrical panel. The junction box, conduit and bus bar in the electrical panel shall be rated and sized to accommodate a branch circuit with sufficient capacity for an equivalent electric *equipment* with an equivalent equipment capacity. The electrical junction box and electrical panel shall have labels stating, "For Future Electric Space Heating Equipment".

C405.14.2 Combustion water heating. Spaces containing *combustion equipment* for water heating shall comply with either C405.14.2.1 or C405.14.2.2

C405.14.2.1 Low-capacity water heating. Spaces containing water heaters with a capacity less than 300,000 Btu/h (88 kW) shall comply with the following:

1. A dedicated 208/240-volt branch circuit with a minimum capacity of 30 amps terminating within 3 feet (914 mm) from the water heater shall be provided and be accessible to the water heater with no obstructions. Both ends of the branch circuit shall be labeled with the words "For Future Heat Pump Water Heater" and be electrically isolated,

2. A condensate drain that is no more than 2 inches (51 mm) higher than the base of the installed water heater and allows natural draining without pump assistance shall be installed within 3 feet (914 mm) of the water heater,

3. The space shall meet minimum dimensions of 3 feet (914 mm) by 3 feet (914 mm) by 7 feet (2134 mm) high, and

4. The space shall meet a minimum volume of 700 cubic feet (20,000 L) or the equivalent of one 16-inch (406 mm) by 24-inch (610 mm) grill to a heated space and one 8-inch (203 mm) duct of no more than 10 feet (3048 mm) in length for cool exhaust air.

   Exception: Where items 1 and 2 are be provided at an exterior location capable of serving an outdoor compressor for a split-system heat pump water heater and a chase that is sized to accommodate refrigerant lines is provided between the outdoor location and the space required in item 3.

C405.14.2.2 High-capacity water heating. Spaces containing water heaters with a capacity greater than or equal to 300,000 Btu/h (88 kW) shall comply with the following:

1. Conduit that is continuous between a junction box located within 3 feet (914 mm) of the *equipment* and an electrical panel shall be provided. The junction box, conduit and bus bar in the electrical panel shall be rated and sized to accommodate a branch circuit with sufficient capacity for an equivalent electric *equipment* with an equivalent equipment capacity. The electrical junction box and electrical panel shall have labels stating, "For Future Electric Water Heating Equipment", and

2. A condensate drain that is no more than 2 inches (51 mm) higher than the base of the installed water heater and allows natural draining without pump assistance shall be installed within 3 feet (914 mm) of the water heater,

C405.14.3 Combustion cooking. Spaces containing combustion equipment for cooking shall comply with either C405.14.3.1 or C405.14.3.2

C405.14.3.1 Commercial cooking. Spaces containing *commercial cooking appliances* shall be provided with a dedicated branch circuit with a minimum capacity of 12 kVA per 1 kBtu of appliance input capacity. The branch circuit shall terminate within 3 feet (914 mm) of the appliance with no obstructions. Both ends of the branch circuit shall be labeled with the words "For Future Electric Cooking Equipment" and be electrically isolated.

C405.14.3.2 Light and medium duty cooking. Spaces containing light- and medium duty cooking *equipment* not designated as *commercial cooking appliances* shall be provided with a dedicated branch circuit with a minimum capacity of 40 amps in compliance with NFPA 70 Section 422.10. The branch circuit shall terminate within 6 feet (1829 mm) of fossil fuel ranges, cooktops and ovens and be accessible with no obstructions. Both ends of the branch circuit shall be labeled with the words "For Future Electric Cooking Equipment" and be electrically isolated.

C405.14.4 Combustion clothes drying. Spaces containing combustion equipment for clothes drying shall comply with either C405.14.4.1 or C405.14.4.2

C405.14.4.1 Commercial drying. Spaces containing clothes drying *equipment,* and end-uses for commercial laundry applications shall be provided with conduit that is continuous between a junction box located within 3 feet (914 mm) of the *equipment* and an electrical panel. The junction box, conduit and bus bar in the electrical panel shall be rated and sized to accommodate a branch circuit with sufficient capacity for an equivalent electric *equipment* with an equivalent equipment capacity. The electrical junction box and electrical panel shall have labels stating, "For Future Electric Clothes Drying Equipment", and

C405.14.4.2 Residential drying. Spaces containing clothes drying *equipment, appliances,* and end-uses serving multiple *dwelling units* or sleeping areas with a capacity less than or equal to 9.2 cubic feet shall be provided with a dedicated 240-volt branch circuit with a minimum capacity of 30 amps shall terminate within 6 feet (1829 mm) of fossil fuel clothes dryers and shall be accessible with no obstructions. Both ends of the branch circuit shall be labeled with the words “For Future Electric Clothes Drying Equipment” and be electrically isolated.

SECTION C406
ADDITIONAL EFFICIENCY, RENEWABLE, AND LOAD MANAGEMENT ~~PACKAGE OPTIONS~~REQUIREMENTS

C406.1 Compliance.
Buildings shall comply as follows:

1. Buildings with greater than 1000 square feet (190 m2) of floor area shall comply with Section C406.1.1.
2. Buildings with greater than 2500 square feet (465 m2) of conditioned floor area shall comply with Sections C406.1.1 and C406.1.2.
3. Build-out construction greater than 500 square feet (93 m2) of conditioned floor area that does not have final lighting or final HVAC systems installed under a prior building permit shall comply with Section C406.1.3.

Exception: Core and shell buildings where no less than 20 percent of the net floor area is without final lighting or final HVAC that comply with all of the following:

1. Buildings with greater than 2500 square feet (465 m2) of conditioned floor area shall comply with Section C406.1.2
2. Portions of the building where the net floor area is without final lighting or final HVAC shall comply with Section C406.1.3
3. Portions of the building where the net floor area has final lighting and final HVAC systems shall comply with C406.1.1.

C406.1.1 Additional energy efficiency credit requirements.
Buildings shall comply with measures from C406.2 to achieve not less than the number of required efficiency credits from Table C406.1.1 based on building occupancy group. Where a project contains multiple occupancies, credits in Table C406.1.1 from each building occupancy shall be weighted by the gross conditioned floor area to determine the weighted average project energy credits required. Accessory occupancies shall be included with the primary occupancy group for purposes of Section C406.
Exceptions:

1. Unconditioned parking garages that achieve 50% of the credits required for use groups S-1 and S-2 in Table C406.1.1.
2. Portions of buildings devoted to manufacturing or industrial use.

TABLE C406.1.1
ENERGY CREDIT REQUIREMENTS BY BUILDING OCCUPANCY GROUP

	Building Occupancy Group								
	R-2, R-4, and I-1	I-2	R-1	B	A-2	M	E	S-1 and S-2	All Other

Energy Credit Requirements	79	46	83	~~71~~30	60	75	~~65~~90	~~90~~65	36

C406.1.2 Additional renewable and load management credit requirements.

Buildings shall comply with measures from C406.3 to achieve not less than the number of required renewable and load management credits from Table C406.1.2 based on building occupancy group. Where a project contains multiple occupancies, credits in Table C406.1.2 from each building occupancy shall be weighted by the gross floor area to determine the weighted average project energy credits required. Accessory occupancies shall be included with the primary occupancy group for purposes of Section C406.

TABLE C406.1.2
RENEWABLE AND LOAD MANAGEMENT CREDIT REQUIREMENTS BY BUILDING OCCUPANCY GROUP

	Building Occupancy Group								
	R-2, R-4, and I-1	**I-2**	**R-1**	**B**	**A-2**	**M**	**E**	**S-1 and S-2**	**All Other**
Renewable and Load Management Credit Requirements	16	11	14	24	4	25	22	20	17

C406.1.3 Core and Shell Buildings and Build-Out Construction.

Where separate permits are issued for core and shell buildings and build-out construction, compliance shall be in accordance with the following requirements.

1. Core and shell buildings or portions of buildings shall comply with one of the following:
   1.1. Where the permit includes a central HVAC system or service water heating system with chillers, heat pumps, boilers, service water heating equipment, or loop pumping systems with heat rejection, the project shall achieve not less than 50 percent of the energy credits required in Table C406.1.1 in accordance with Section C406.2.
   1.2. Alternatively, the project shall achieve not less than 33 percent of the energy credits required in Table C406.1.1.
2. For core and shell buildings or portions of buildings the energy credits achieved shall be subject to the following adjustments:
   2.1. Lighting measure credits shall be determined only for areas with final lighting installed.
   2.2. Where HVAC or service water heating systems are designed to serve the entire building, full HVAC or service water heating measure credits shall be achieved
   2.3. Where HVAC or service water heating systems are designed to serve individual areas, HVAC or service water heating measure credits achieved shall be reduced in proportion to the floor area with final HVAC systems or final service water heating systems installed
3. Build-out construction shall be deemed to comply with Section C406.1 where either

3.1. Where heating and cooling generation are provided by a previously installed central system, the energy credits achieved in accordance with Section C406.2 under the build-out project are not less than 33 percent of the credits required in Table C406.1.1

3.2. Where heating and cooling generation are provided by an HVAC system installed in the build out, the energy credits achieved in accordance with Section C406.2 under the build-out project are not less than 50 percent of the credits required in Table C406.1.

~~Where the core and shell building was approved in accordance with C408.~~

C406.2 Additional Energy Efficiency Credits Achieved.

Each energy efficiency credit measure used to meet credit requirements for the project shall have efficiency that is greater than the requirements in Sections C402 through C405. Measures installed in the project that meet the requirements in Sections C406.2.1 through C406.2.7 shall achieve the base credits listed for the measure and occupancy type in Table C406.2.1 or, where calculations required by Sections C406.2.1 through C406.2.~~7~~ 6 create or modify the table credits, the credits achieved shall be based upon the calculations. Energy credits achieved for measures shall be determined by one of the following, as applicable:

1. The measure's energy credit shall be the base energy credit for the measure where no adjustment factor or calculation is included in the description of the measure in Section C406.2.
2. The measure's energy credit shall be the base energy credit for the measure adjusted by a factor or equation as stated in the description of the measure in Section C406.2. Where adjustments are applied, each measure's energy credit shall be rounded to the nearest whole number.
3. The measure's energy credit shall be by calculation as stated in the measure's description in Section C406.2, where each individual measure credit shall be rounded to the nearest whole number.

Energy credits achieved for the project shall be the sum of the individual measure's energy credits. Credits are available for the measures listed in this Section. Where a project contains multiple building occupancy groups:

1. Credits achieved for each occupancy group shall be summed and then weighted by the floor area of each occupancy group to determine the weighted average project energy credits achieved.
2. Credits for improved envelope efficiency and lighting reduction (L06) shall be determined for the building or permitted floor area as a whole. Credits for other measures shall be taken from applicable tables or calculations weighted by the building occupancy group floor area.

TABLE C406.2.1

~~**Renewable and Load Management Credit Requirements by Building Occupancy Group**~~**ENERGY EFFICIENCY MEASURES AND CREDITS BY OCCUPANCY GROUP** [a,b]

ID	**Energy Credit Measure**	**Building Occupancy Group**								
		R-2, R-4, and I-1	**I-2**	**R-1**	**B**	**A-2**	**M**	**E**	**S-1 and S-2**	**All Other**
E01	Envelope Performance	Determined in accordance with Section C406.2.1.1								
E02	UA Reduction	19	5	13	20	33	28	25	37	28

E03	Envelope Leak Reduction	13	9	28	6	42	13	8	68	41
E04	Add Roof Insulation	7	2	3	3	2	24	23	10	9
E05	Add Wall Insulation	13	3	5	8	2	16	7	7	9
E06	Improve Fenestration	42	6	13	21	4	10	34	6	17
H01	HVAC Performance	~~186~~	~~x6~~	~~x6~~	~~x6~~	x	~~329~~	~~x8~~	x	~~x8~~
H02	Heating Efficiency	14	11	6	9	19	29	15	44	18
H03	Cooling Efficiency	3	x	x	1	x	7	4	x	x
H04	Residential HVAC Control	21	x	x	x	x	x	x	x	x
H05	~~DOAS/Fan Control~~Energy Recovery	46	65	41	114	84	242	43	180	90
W01	SHW Preheat Recovery	93	6	36	12	34	13	13	3	26
W02	Heat Pump Water Heater	81	3	30	5	25	4	10	1	20
W04	SHW Pipe Insulation	6	1	4	4	2	4	4	1	3
W05	Point of Use Water Heaters	x	x	x	18	x	x	4	x	11
W06	Thermostatic Balance Valves	3	0	2	1	1	1	1	1	1
W07	SHW Heat Trace System	11	1	7	5	3	5	5	2	5
W08	SHW Submeters	17	x	x	x	x	x	x	x	17
W09	SHW Distribution Sizing	68	x	26	x	x	x	x	x	47
W10	Shower Heat Recovery	25	1	9	x	x	x	3	x	10
P01	Energy Monitoring	3	3	2	3	2	5	3	5	3
L01	Lighting Performance	x	x	x	x	x	x	x	x	x
L02	Enhanced Digital Lighting Controls	1	4	1	4	1	5	4	3	3
L03	Increase Occupancy Sensors	1	4	2	4	1	6	3	4	3
L04	Increase Daylight Area	2	5	3	6	1	8	5	4	4
L05	Residential Light Control	3	x	x	x	x	x	x	x	x
L06	Reduced Lighting Power	1	5	1	5	1	6	5	4	4
Q01	Efficient Elevator Equipment	4	2	2	4	0	3	4	5	3
Q02	Commercial Kitchen Equipment	x	x	x	x	21	x	x	x	x
Q03	Residential Kitchen Equipment	13	x	10	x	x	x	x	x	x
Q04	Fault Detection	3	3	2	3	3	3	4	6	4

[a]. “x” indicates credit is not available for that measure

[b.] Other occupancy groups include all Groups except for Groups A-2, B, E, I, M, and R.

C406.2.1 More Efficient Building Envelope.

A project shall achieve credits for improved envelope performance by complying with of one of the following measures:

1. Section C406.2.1.1: E01
2. Section C406.2.1.2: E02
3. Section C406.2.1.3: E03

4. Both EO2 and E03

5. Any combination of:

   5.1 Section C406.2.1.3: E03

   5.2 Section C406.2.1.4: E04

   5.3 Section C406.2.1.5: E05

   5.4 Section C406.2.1.6: E06

C406.2.1.1 E01 Improved envelope performance 90.1 Appendix C.

Building envelope measures shall be installed to improve the energy performance of the project. The achieved energy credits shall be determined using Equation 4-13.

ECenv = 1000 X (EPFB - EPFP)/EPFB (Equation 4-13)

where:

EC_{ENV} = E01 energy credits

EPF_B = base envelope performance factor calculated in accordance with ASHRAE 90.1 Appendix C.

EPF_P = proposed envelope performance factor calculated in accordance with ASHRAE 90.1-Appendix C.

C406.2.1.2 E02 Total UA envelope reduction.

Energy credits shall be achieved where the total UA of the building thermal envelope as designed is not less than 15 percent below the total UA of the building thermal envelope in accordance with Section C402.1.3.

C406.2.1.3 E03 Reduced air leakage.

Energy credits shall be achieved where tested building air leakage is not less than 0.15 cfm/ft2 provided the building is tested in accordance with the applicable method in Section C402.4.1.1.

C406.2.1.4 E04 Add Roof Insulation.

Energy credits shall be achieved in conditioned spaces for insulation that is in addition to the required insulation in Table C402.1(2).~~.3.~~ All roof areas in the project shall have additional R-10 continuous insulation included in the roof assembly. For attics this is permitted to be achieved with fill or batt insulation rated at R-10 that is continuous and not interrupted by ceiling or roof joists. Where interrupted by joists, the added insulation shall be not less than R-13. Alternatively, one-half of the base credits shall be achieved where the added R-value is one-half of the additional R-value required by this section.

C406.2.1.5 E05 Added Wall Insulation.

Energy credits shall be achieved in conditioned spaces for insulation applied to not less than 90 percent of all opaque wall area in the project that is in addition to the required insulation in Table C402.1(2)~~.3~~.

Opaque walls shall have additional R-5 continuous insulation included in the wall assembly. Alternatively, one-half of the base credits shall be achieved where the added R-value is R-2.5.

C406.2.1.6 E06 Improve Fenestration

Energy credits shall be achieved for improved energy characteristics of all vertical fenestration in the project meeting this requirement. The area-weighted average U-factor of all vertical fenestration shall be equal to or less than U-0.22.

C406.2.2 More Efficient HVAC Equipment Performance.

All heating and cooling systems shall meet the minimum requirements of Section C403 and efficiency improvements shall be referenced to minimum efficiencies listed in Tables referenced by Section C403.3.2. Where multiple efficiency requirements are listed, equipment shall meet the seasonal or part-load efficiencies including SEER, EER/integrated energy efficiency ratio (IEER), integrated part load value (IPLV), or AFUE. Equipment that is larger than the maximum capacity range indicated in Tables referenced by Section C403.3.2 shall utilize the values listed for the largest capacity equipment for the associated equipment type shown in the table. Where multiple individual heating or cooling systems serve the project, the improvement shall be the weighted average improvement based on individual system capacity.
Systems are permitted to achieve HVAC energy credits by meeting the requirements of either:

1. C406.2.2.1 H01
2. C406.2.2.2 H02
3. C406.2.2.3 H03
4. C406.2.2.4 H04
5. C406.2.2.5 H05
6. Any combination of H02, H03, H04 and H05
7. The combination of H01 and H04

C406.2.2.1 H01 HVAC Performance (TSPR).

H01 energy credits shall be achieved for systems allowed to use Section C403.1.3, HVAC total system performance ratio, where the proposed TSPR exceeds the minimum TSPR requirement by 5 percent. If improvement is greater, base energy credits from Table C406.2.1 are permitted to be prorated up to a 20 percent improvement using Equation 4-15. Energy credits for H01 may not be combined with energy credits from HVAC measures H02, H03 and H05.

H01 energy credit = H01 base energy credit x TSPRs / 0.05 (Equation 4-15)

where:

TSPRs = the lessor of 0.20 and (1 – (TSPRp / TSPRt))

where:

TSPRt	=	TSPRr / MPF
TSPRp	=	HVAC TSPR of the proposed design calculated in accordance with Sections C408.4, C40~~9~~8.5 and C40~~9~~8.6.
TSPRr	=	HVAC TSPR of the reference building design calculated in accordance with Sections C40~~9~~8.4, C40~~9~~8.5 and C408.6.
MPF	=	Mechanical Performance Factor from Table C408~~9~~.4 based on climate zone and building use type. Where a building has multiple building use types, MPF shall be area weighted in accordance with Section C408~~9~~.4

C406.2.2.2 H02 More efficient HVAC equipment heating performance.

No less than 90 percent of the total HVAC capacity serving the total conditioned floor area of the entire building, or tenant space in accordance with Section C406.1.1, shall comply with the requirements of this Section.

1. Equipment installed shall be types that are listed in Tables referenced by Section C403.3.2. Electric resistance heating capacity shall be limited to 20 percent of system capacity, with the exception of heat pump supplemental heating.

2. Equipment shall exceed the minimum heating efficiency requirements listed in Tables referenced by Section C403.3.2 by at least 5 percent. Where equipment exceeds the minimum annual heating efficiency requirements by more than 5 percent, energy efficiency credits for heating shall be determined using Equation 4-16 rounded to the nearest whole number.

$$EEC_{HEH} = EEC_{H5} \times (HEI / 0.05) \qquad \text{(Equation 4-16)}$$

where:

EEC_{HEH} = energy efficiency credits for heating efficiency improvement

EEC_{H5} = C406.2.2.2 credits from Table C406.2.1

HEI = the lesser of: the improvement (as a fraction) above minimum heating efficiency requirements, or 20 percent (0.20). Where heating equipment with different minimum efficiencies are included in the building, a heating capacity weighted average improvement shall be used. Where electric resistance primary heating or reheat is included in the building it shall be included in the weighted average improvement with an HEI of 0. Supplemental gas and electric heat for heat pump systems shall be excluded from the weighted HEI. For heat pumps rated at multiple ambient temperatures, the efficiency at 47 F (8.3 C) shall be used.

For metrics that increase as efficiency increases, HEI shall be calculated as follows:

$HEI = (HM_{DES}/HM_{MIN}) - 1$

Where:

HM_{DES} = Design heating efficiency metric, part-load or annualized where available

HM_{MIN} = Minimum required heating efficiency metric, part-load or annualized where available from Section C403.3.2

C406.2.2.3 H03 More efficient HVAC cooling equipment and fan performance.

No less than 90 percent of the total HVAC cooling capacity serving the total conditioned floor area of the entire building or tenant space in accordance with Section C406.1.1, shall comply with all of the requirements of this section.

1. Equipment installed shall be types that are listed in Tables referenced by Section C403.3.2.

2. Equipment shall exceed the minimum cooling efficiency requirements listed in Tables referenced by Section C403.3.2 by at least 5 percent. For water-cooled chiller plants, heat rejection equipment efficiency shall also be increased by at least

the chiller efficiency improvement. Where equipment exceeds the minimum annual cooling efficiency and heat rejection efficiency requirements by more than 5 percent, energy efficiency credits for cooling shall be determined using Equation 4-17, rounded to the nearest whole number.

3. Where fan energy is not included in packaged equipment rating or it is and the fan size has been increased from the as-rated equipment condition, fan power or horsepower shall be less than 95 percent of the allowed fan power in Section C403.8.1.

$EEC_{HEC} = EEC_5 \times (CEI / 0.05)$ (Equation 4-17)

where:

EEC_{HEC}	=	energy efficiency credits for cooling efficiency improvement
EEC_5	=	C406.2.2.3 base energy credits from Table C406.2.1
CEI	=	the lesser of: the improvement above minimum cooling and heat rejection efficiency requirements expressed as a fraction, or 0.20 (20 percent). Where cooling equipment with different minimum efficiencies are included in the building, a cooling capacity weighted average improvement shall be used. Where multiple cooling performance requirements are provided, the equipment shall exceed the annualized energy or part-load requirement. Meeting both part-load and full-load efficiencies is not required.

For metrics that increase as efficiency increases, CEI shall be calculated as follows:

$CEI = (CM_{DES} / CM_{MIN}) - 1$

For metrics that decrease as efficiency increases, CEI shall be calculated as follows:

$CEI = (CM_{MIN} / CM_{DES}) - 1$

Where:

CM_{DES}	=	Design cooling efficiency metric, part-load or annualized where available
CM_{MIN}	=	Minimum required cooling efficiency metric, part-load or annualized where available from Section C403.3.2

For Data Centers using Standard 90.4, CEI shall be calculated as follows:

$CEI = (AMLC_{MAX} / AMLC_{DES}) - 1$

Where:

$AMLC_{DES}$	=	As-Designed Annualized Mechanical Load Component calculated in accordance with Standard 90.4, Section 6.5
$AMLC_{MAX}$	=	Maximum Annualized Mechanical Load Component from Standard 90.4, Table 6.5

C406.2.2.4 H04 Residential HVAC control.

HVAC systems serving dwelling units or sleeping units shall be controlled to automatically activate a setback at least 5°F (3°C) for both heating and cooling. The temperature controller shall be configured to provide setback during occupied sleep periods. The unoccupied setback mode shall be configured to operate in conjunction with one of the following:

1. A manual main control device by each dwelling unit main entrance that initiates setback and non-ventilation mode for all HVAC units in the dwelling unit and is clearly identified as “Heating/Cooling Master Setback.”
2. Occupancy sensors in each room of the dwelling unit combined with a door switch to initiate setback and non-ventilation mode for all HVAC units in the dwelling within 20 minutes of all spaces being vacant immediately after a door switch operation. Where separate room HVAC units are used, an individual occupancy sensor on each unit that is configured to provide setback shall meet this requirement.
3. An advanced learning thermostat or controller that recognizes occupant presence and automatically creates a schedule for occupancy and provides a dynamic setback schedule based on when the spaces are generally unoccupied.
4. An automated control and sensing system that uses geographic fencing connected to the dwelling unit occupants’ cell phones and initiates the setback condition when all occupants are away from the building.

C406.2.2.5 H05 Energy Recovery.

Credits for this measure are only allowed where single zone HVAC units are not required to have multi-speed or variable-speed fan control in accordance with Section C403.8.6.1. HVAC controls and ventilation systems shall include all of the following:

1. The ventilation system shall have energy recovery with an enthalpy recovery ratio of 75 percent or more at heating design conditions . E~~e~~nergy recovery shall include latent recovery. Where no humidification is provided, heating energy recovery effectiveness is permitted to be based on sensible energy recovery ratio. Where energy recovery effectiveness is less than the 75 percent required for full credit, adjust the credits from Section C406.2 by the factors in Table C406.2.2.5.
2. Where the ventilation system serves multiple zones and the system is not in a latent recovery outside air dehumidification mode. partial economizer cooling through an outdoor air bypass or wheel speed control shall automatically do one of the following:
   a. Set the energy recovery leaving-air temperature 55°F (13°C) or 100 percent outdoor air bypass when a majority of zones require cooling and outdoor air temperature is below 70°F (21°C).
   b. The HVAC ventilation system shall include supply-air temperature controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperatures. The controls shall reset the supply-air temperature not less than 25 percent of the difference between the design supply-air temperature and the design room-air temperature.
3. Ventilation systems providing mechanical dehumidification shall use recovered energy for reheat within the limits of item 4. This shall not limit the use of latent energy recovery for dehumidification.

Where only a portion of the building is permitted to be served by constant air volume units or the enthalpy recovery ratio or sensible energy recovery ratio is less than 65 percent, the base energy credits shown in Section C406.2 shall be prorated as follows:

$$EC_{DOAS} = EC_{base} \times FLOOR_{CAV} \times ERE_{adj} \qquad \text{(Equation 4-18)}$$

where:

EC_{DOAS}	=	Energy credits achieved for H06
EC_{base}	=	H06 base energy credits in Section C406.2
$Floor_{CAV}$	=	Fraction of whole project gross conditioned floor area not required to have variable speed or multi-speed fan airflow control in accordance with Section C403.8.6.
ERE_{adj}	=	The energy recovery adjustment from Table C406.2.2.5 based on the lower of actual cooling or heating enthalpy recovery ratio or sensible energy recovery ratio where required for the climate zone. Where recovery ratios vary, use a weighted average by supply airflow.

T~~able~~ABLE C406.2.2.5 – DOAS Energy Recovery Adjustments

ERE_{adj} based on lower of actual heating or cooling energy recovery effectiveness where required		
Cooling ERR is ≥	Heating *enthalpy recovery ratio* or *sensible energy recovery ratio* is ≥	Energy Recovery Effectiveness Adjustment (ERE_{adj})
65%	65%	1.00
60%	60%	0.67
55%	55% [a]	0.33
50%	50% [a]	0.25

[a] In climate zones where heating recovery is required for this measure, for dwelling units a heating recovery effectiveness below 60 percent is not allowed.

C406.2.3 Reduced Energy Use In-service Water Heating.

Projects with service water-heating equipment that serves the whole building, a building addition or a tenant space shall achieve credits through compliance with the requirements of this section. Systems are permitted to achieve energy credits by meeting the requirements of either:

1. C406.2.3.1 by selecting one allowed measure W01, or W02
2. C406.2.3.2 W03
3. C406.2.3.3 by selecting one allowed measure of W04, W05, or W06
4. C406.2.3.4 W07
5. C406.2.3.5 W08
6. C406.2.3.6 W09

7. Any combination of measures in C402.2.3.1 through C402.2.3.6 as long no more than one allowed measure from C406.2.3.1 and C406.2.3.3 are selected.

C406.2.3.1 Service water-heating system efficiency.

A project is allowed to achieve energy credits from only one of Sections C406.2.3.1.1 through C406.2.3.1.3.

C406.2.3.1.1 W01 Recovered or renewable water heating.

The building service water-heating system shall have one or more of the following that are sized to provide not less than 30 percent of the building's annual hot water requirements, or sized to provide not less than 70 percent of the building's annual hot water requirements if the building is required to comply with Section C403.10.5:

1. Waste heat recovery from SHW, heat recovery chillers, building equipment, or process equipment.
2. A water-to-water heat pump that precools chilled water return for building cooling.
3. On-site renewable energy water-heating systems.

C406.2.3.1.2 W02 Heat pump water heater.

Air-source heat pump water heaters shall be installed according to manufacturer's instructions and at least 30 percent of design end use service water heating requirements shall be met using only heat pump heating at an ambient condition of 67.5 °F, db without supplemental electric resistance or fossil fuel heating. —For a heat pump water heater with supplemental electric resistance heating, the heat pump only capacity shall be deemed at 40 percent of first hour draw. Where the heat pump only capacity exceeds 50 percent of the design end use load excluding recirculating system losses, the credits from the Section C406.2 tables shall be prorated as follows:

$$EC_{HPWH} = (EC_{base} / 0.5) \times \{Cap_{HPWH}/EndLoad \text{ [not greater than 2]}\} \qquad \text{(Equation 4-19)}$$

where:

EC_{HPWH}	=	Energy credits achieved for W02
EC_{base}	=	W02 base energy credits from Table C406.1.1
EndLoad	=	End use peak hot water load, excluding load for heat trace or recirculation, Btu/hr or kW
Cap_{HPWH}	=	the heat pump only capacity at 50°F (10°C) entering air and 70°F (21°C) entering potable water without supplemental electric resistance or fossil fuel heat, Btu/hr or Kw

The heat pump service water heating system shall comply with the following requirements:

1. For systems with an installed total output capacity of more than 100,000 Btu/hr (30 kW) at an ambient condition of 67.5°F (19.7°C), db a preheat storage tank with greater than or equal 0.75 gallons per 1000 Btu/hr (≥9.7 L/kW) of design end use service water heating requirements shall be heated only with heat pump heating when the ambient temperature is greater than 45°F (7.2°C)
2. For systems with piping temperature maintenance, either a heat trace system or a separate water heater in series for recirculating system and final heating shall be installed.

3. Heat pump water heater efficiency shall meet or exceed one of the following:

   a. Output-capacity-weighted-average UEF of 3.0 in accordance with 10 CFR 430 Appendix E.

   b. Output-capacity-weighted-average COP of not less than 4.0 tested at 50°F (10°C) entering air and 70°F (21°C) entering potable water in accordance with AHRI standard 1300.

Where the heat pump capacity at 50°F (10°C) entering air and 70°F (21°C) entering water exceeds 50 percent of the design end-use load excluding recirculating system losses, the base credits from Section C406.2 shall be prorated based on Equation 4-20.

W02 credit = base W02 table credit × (HPLF / 50%) (Equation 4-20)

where:

HPLF = Heat pump capacity as a fraction of the design end-use SHW requirements excluding recirculating system losses, not to exceed 80 percent.

C406.2.3.1.3 Combination service water heating systems

shall achieve credits using one of the measure combinations as follows:

1. (W01 + W02) Where service water heating employs both energy recovery and heat pump water heating, W01 may be combined with W02 and receive the sum of both credits.

C406.2.3.3 Water-heating distribution temperature maintenance.

A project is allowed to achieve energy credits from only one of the following SHW distribution temperature maintenance measures.

C406~~5~~.2.3.3.1 W03: Service Hot Water Piping Insulation Increase.

Where service hot water is provided by a central water heating system, the hot water pipe insulation thickness shall be at least 1.5 times the thickness required in Section C404.4. All service hot water piping shall be insulated from the hot water source to the fixture shutoff. Where no more than 50% of hot water piping does not have increased insulation due to installation in partitions, the credit shall be prorated as a percentage of lineal feet of piping with increased insulation.

C406~~5~~.2.3.3.2 W04 Point of use water heaters.

Credits are available for Group B or E buildings larger than 10,000 ft2 (930 m2). Fixtures requiring hot water shall be supplied from a localized source of hot water with no recirculating system or heat trace piping. Supply piping from the water heater to the termination of the fixture supply pipe shall be insulated to the levels shown in Table C403.12.3 without exception. The volume from the water heater to the termination of the fixture supply pipe shall be limited as follows:

1. Non-residential lavatories: not more than 2 oz (60 mL)

2. All other plumbing fixtures or appliances: not more than 0.25 gallons (0.95 L)

Exception: Where all remotely located hot water uses meet the requirements for measure W04, separate water heaters serving commercial kitchens or showers in locker rooms shall be permitted to have a local recirculating system or heat trace piping.

C4066~~5~~.2.3.3.3 W05 Thermostatic balancing valves.

Credits are available where service water heating is provided centrally and distributed throughout the building and has a recirculating system. Each recirculating system branch return connection to the main SHW supply piping shall have an automatic thermostatic balancing valve set to a minimal return water flow when the branch return temperature is greater than 120°F (49°C).

C4066~~5~~.2.3.3.4 W06 Heat trace system.

Credits are available for projects with gross floor area greater than 10,000 square feet (930 m2) and a central water-heating system. The energy credits achieved shall be from Table C406.2.1. This system shall include self-regulating electric heat cables, connection kits, and electronic controls. The cable shall be installed directly on the hot water supply pipes underneath the insulation to replace standby losses.

C406.2.3.4 W07 Water-heating system submeters.

Each individual dwelling unit in a Group R-2 occupancy served by a central service water-heating system shall be provided with a service hot water meter connected to a reporting system that provides individual dwelling unit reporting of actual domestic hot water use. Preheated water serving the cold water inlet to showers need not be metered.

C406.2.3.5 W08 Service hot water flow reduction.

Dwelling unit, sleeping unit, and guest room plumbing fixtures that are connected to the service water-heating system shall have a flow or consumption rating less than or equal to the values shown in Table C406.2.3.5.

Table C406.2.3.5

Maximum Flow Rating for Residential Plumbing Fixtures with Heated Water

Plumbing Fixture	Maximum Flow Rate
Faucet for private lavatory,[a] hand sinks, or bar sinks	1.2~~50~~ gpm at 60 psi (0.095 L/s at 410 kPa)
Faucet for residential kitchen sink [a,b,c]	1.5~~8~~ gpm at 60 psi 0.11 L/s at 410 kPa)
Shower head (including hand-held shower spray) a, b, d	1.5~~8~~ gpm at 80 psi (0.13 L/s at 550 kPa)

a. Showerheads, lavatory faucets and kitchen faucets are subject to U.S. Federal requirements listed in 10 CFR 430.32(o)- (p).

b. Maximum flow allowed is less than required by flow rates listed in U.S. 10 CFR 430.32(o)-(p) for showerheads and kitchen faucets.

c. Residential kitchen faucet may temporarily increase the flow above the maximum rate, but not above 2.2 gallons per minute at 60 psi (0.14 L/s at 410 kPa) and must default to the maximum flow rate listed.

d. When a shower is served by multiple shower heads, the combined flow rate of all shower heads controlled by a single valve shall not exceed the maximum flow rate listed or the shower shall be designed to allow only one shower head to operate at a time.

C406.2.3.6 W9 Shower drain heat recovery.

Cold water serving building showers shall be preheated by shower drain heat recovery units that comply with Section C404.7. The efficiency of drain heat recovery units shall be 54 percent or greater measured in accordance with CSA B55.1. Full credits are applicable to the following building uses: I-2, I-4, R-1, R-2 and also group E where there are more than eight showers. Partial credits are applicable to buildings where all but ground floor showers are served where the base energy credit from Section C406.2 is adjusted by Equation 4-21.

W10 credit = W10 base energy credit × (showers with drain heat recovery)/(total showers in building) (Equation 4-21)

C406.2.4 P01 Energy Monitoring.

A project not required to comply with C405.12 can achieve energy credits for installing an energy monitoring system that complies with all the requirements of C405.12.1 through C405.12.5.

C406.2.5 Energy Savings in Lighting Systems.

Projects are permitted to achieve energy credits for increased lighting system performance by meeting the requirements of either:

1. C406.2.5.2 L02
2. C406.2.5.3 L03
3. C406.2.5.4 L04
4. C406.2.5.5 L05
5. C406.2.5.6 L06
6. Any combination of L03, L04, L05 and L06
7. Any combination of L02, L03 and L04

C406.2.5.1 L01 Lighting system performance (reserved).

Reserved for future use

C406.2.5.2 L02 Enhanced digital lighting controls.

Measure credits shall be achieved where no less than 50 percent of the gross floor area within the project shall comply with the requirements of this section.

1. Lighting controls function. Interior general lighting shall be located, scheduled and operated in accordance with Section C405.2 and shall be configured with the following enhanced control functions:
   a. Luminaires shall be configured for continuous dimming.
   b. Each luminaire shall be individually addressed.

   Exceptions:
   1. Multiple luminaires mounted on no more than 12 linear feet of a single lighting track and addressed as a single luminaire.
   2. Multiple linear luminaires that are ganged together to create the appearance of a single longer fixture and addressed as a single

luminaire, where the total length of the combined luminaires is not more than 12 feet.

ii. No more than eight luminaires within a daylight zone are permitted to be controlled by a single daylight responsive control.

b. Luminaires shall be controlled by a digital control system configured with the following capabilities:

i. Scheduling and illumination levels of individual luminaires and groups of luminaires are capable of being reconfigured through the system.

ii. Load shedding.

iii. Occupancy sensors and daylight responsive controls are capable of being reconfigured through the system.

c. Construction documents shall include submittal of a Sequence of Operations, including a specification outlining each of the functions required by this section.

d. High-end trim. Luminaires shall be initially configured with the following:

i. High-end trim, setting the maximum light output of individual luminaires or groups of luminaires to support visual needs of a space or area, shall be implemented and construction documents shall state that maximum light output or power of controlled lighting shall be initially reduced by at least 15 percent from full output. The average maximum light output or power of the controlled lighting shall be documented without high-end trim and with high-end trim to verify reduction of light output or power by at least 15 percent when tuned.

ii. Where lumen maintenance control is used, controls shall be configured to limit the initial maximum lumen output or maximum lighting power to 85 percent or less of full light output or full power draw and lumen maintenance controls shall be limited to increasing lighting power by 1 percent per year.

iii. High-end trim and lumen maintenance controls shall be accessible only to authorized personnel.

Where general lighting in more than 50 percent of the gross lighted floor area receives high-end trim, the base credits from Section C406.2 shall be prorated as follows:

[Tuned lighted floor area,%] × [Base energy credits for C406.2.5.2] / 50% –(Equation 4-22)

C406.2.5.3 L03 Increase occupancy sensor.

Lighting controls shall comply with C406.2.5.3.1, C406.2.5.3.2 and C406.2.5.3.3.

C406.2.5.3.1 Occupant Sensor Controls.

Occupant sensor controls shall be installed to control lights in the following space types:

a. Courtroom

b. Electrical / mechanical room

c. Food preparation area

d. Laboratory

e. Elevator lobby

f. Pharmacy Area

g. Vehicular Maintenance Area

h. Workshop

i. Chapel in a facility for the visually impaired

j. Recreation room in a facility for the visually impaired

k. Exercise area in a fitness center

l. Playing area in a fitness center

m. Exam / treatment room in a healthcare facility

n. Imaging room in a healthcare facility

o. Physical therapy room in a healthcare facility

p. Library reading area

q. Library stacks

r. Detailed manufacturing area

s. Equipment room in a manufacturing facility

t. Low-bay area in a manufacturing facility

u. Post office sorting area

v. Religious fellowship hall

w. Religious worship / pulpit / choir area

x. Hair salon

y. Nail salon

a. Banking activity area

b. Computer room, data center

c. Laundry / washing area

d. Medical supply room in a healthcare facility

e. Telemedicine room in a healthcare facility

f. Museum restoration room

C406.2.5.3.2 Occupant Sensor Control Function.

Occupant sensor controls shall automatically turn lights off within 10 minutes after all occupants have left the space. A manual control complying with C405.2.6 shall allow occupants to turn off lights. Time-switch controls are not required.
Exception: In spaces where an automatic shutoff could endanger occupant safety or security occupant sensor controls shall uniformly reduce lighting power to not more than 20 percent of full power within 10 minutes after all occupants have left the space. Time-switch controls complying with C405.2.2.1 shall automatically turn lights off.

C406.2.5.3.3 Occupant Sensor Time Function.

Occupant sensor controls installed in accordance with Sections C405.2.1.1, C405.2.1.2, C405.2.1.3, and C405.2.1.4 shall automatically turn lights off or reduce lighting power within 10 minutes after all occupants have left the space. Where lighting power is reduced, the unoccupied setpoint shall be 20 percent of full power or in egress areas to the power level required to meet egress light levels.

C406.2.5.4 L04 Increase daylight area.

The total daylight area of the project (DLA_{BLDG}) with continuous daylight dimming meeting the requirements of C405.2.4 shall be at least 5 percent greater than the typical daylit area (DLA_{TYP}).
Credits for measure L04 shall be determined based on Equation 4-23:

$$EC_{DL} = EC_{DL5} \times 20 \times [(DLA_{BLDG}/GLFA) - DLA_{TYP}] \qquad \text{(Equation 4-23)}$$

where:

EC_{DL} = C406.2.5.4 L04 measure base energy credits
DLA_{BLDG} = The lesser of actual area of daylight zones in the building with continuous daylight dimming, ft2 or m2 and (GLFA x DLA_{max}) see Table C406.2.5.4. Daylight zones shall meet the criteria in Sections C405.2.4.2 and C405.2.4.3 for primary sidelit daylight zones, secondary sidelit daylight zones, and toplit daylight zones.
GLFA = Project gross lighted floor area, ft2 or m2
DLA_{TYP} = Typical percentage of building area with daylight control (as a fraction) from Table C406.2.5.4
EC_{DL5} = C406.2.5.4 L04 base energy credits from Section C406.2

TABLE C406.2.5.4 ADDED DAYLIGHTING PARAMETERS

Building use type	**DLA_{TYP}**	**DLA_{max}**
Group B; Office ≤ 5000 ft2 (460 m2)	10%	20%
Group B; Office > 5000 ft2 (460 m2)	21%	31%
Group M; Retail with ≤ 1000 ft2 (900 m2) roof area	0%	20%
Group M; Retail with > 1000 ft2 (900 m2) roof area	60%	80%
Group E; Education	42%	52%
Groups S-1 and S-2; Warehouse	50%	70%
Group I-2, R, and other; Medical, hotel, multifamily, dormitory, and other	NA	NA

C406.2.5.5 L05 Residential light control.

In buildings with Group R-2 occupancy spaces, interior lighting systems shall comply with the following:

1. Common area Restrooms, laundry rooms, storage rooms, and utility rooms shall have automatic full OFF occupancy sensor controls that comply with the requirements of C405.2.1.1. Each additional control device shall control no more than 5,000 sq.ft.

2. Each dwelling unit shall have a main control by the main entrance that turns off all the lights and all switched receptacles in the dwelling unit. Two switched receptacles shall be provided in living and sleeping rooms or areas and clearly identified. All switched receptacles shall be located within 12 inches (30 cm) of an unswitched receptacle. The main control shall be permitted to have two controls, one for permanently wired lighting and one for switched receptacles. The main controls should be clearly identified as “lights master off” and “switched outlets master off.”

C406.2.5.6 L06 Reduced lighting power.

Interior lighting within the whole building shall comply with all the requirements of this section. The net connected interior lighting power (LPn) shall be 95 percent or less than the net interior lighting power allowance (LPAn) determined in accordance with Section C405.3.2.2. In R-1 and R-2 occupancies the credit is calculated for all common areas other than dwelling units and sleeping units. All of the permanently installed light fixtures in dwelling units and sleeping units, excluding kitchen appliance lighting, shall be provided by high efficacy lamps with a minimum efficacy of 90 lumens per watt or high efficacy luminaires that have a minimum efficacy of 80 lumens per watt. –Energy credits shall not be greater than four times the L06 base credit from Section C406.2 and shall be determined using Equation 4-24:

$$EC_{LPA} = EC_5 \times 20 \times (LPA_n - LP_n) / LPA_n \qquad \text{(Equation 4-24)}$$

where:

EC_{LPA}	=	additional energy credit for lighting power reduction
LP_n	=	net connected interior lighting power calculated in accordance with Section C405.3.1, watts, excluding any additional lighting power allowed in Section C405.3.2.2.1
LPA_n	=	interior lighting power allowance calculated in accordance with the requirements of Section C405.3.2.2, watts, less any additional interior lighting power allowed in Section C405.3.2.2.1
EC_5	=	L06 base credit from Section C406.2

C406.2.6 Efficient Equipment Credits.

Projects are permitted to achieve energy credits using any combination of Efficient Equipment Credits Q01 through Q04.

C406.2.6.1 Q01 Efficient Elevator Equipment.

Qualifying elevators in the building shall be Energy efficiency class A per ISO 25745-2, Table 7. Only buildings 3 or more floors above grade are permitted to use this credit. Credits shall be prorated based on Equation 4-25, rounded to the nearest whole credit. Projects with a compliance ratio below 0.5 do not qualify for this credit.

$$EC_e = EC_t \times CR_e \qquad \text{(Equation 4-25)}$$

where:

EC_e	=	Elevator energy credit achieved for the building
EC_t	=	C406.2.7.1 Table energy credit
CR_e	=	Compliance Ratio = (FA / FB)

F_A	=	Sum of floors served by class A elevators
F_B	=	Sum of floors served by all building elevators and escalators

C406.2.6.2 Q02 Efficient Commercial Kitchen Equipment.

For buildings and spaces designated as Group A-2, or facilities whose primary business type involves the use of a commercial kitchen where at least one gas or electric fryer is installed before the issuance of the Certificate of Occupancy all fryers, dishwashers, steam cookers and ovens installed before the issuance of the Certificate of Occupancy shall comply with all of the following:

a. Comply with the efficiency levels outlined in the Vermont Appliance Efficiency Standards

b. Achieve performance levels for select equipment that exceed the requirements in the Vermont Appliance Efficiency Standards, as outlined in Tables C406.2.7.2 (1) through C406.2.7.2 (4) when rated in accordance with the applicable test procedure.

c. Have associated performance levels listed on the construction documents submitted for permitting.

TABLE~~able~~ C406.2.7.2(1)
Minimum Efficiency Requirements: Commercial Fryers

	Heavy-Load Cooking Energy Efficiency	Idle Energy Rate	Test Procedure
Standard Open Deep-Fat Electric Fryers	≥ 83%	≤ 800 watts	ASTM F1361

TABLE C406.2.7.2(3)

MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL DISHWASHERS

Machine Type	High Temperature Efficiency Requirements			Low Temperature Efficiency Requirements			Test Procedure
	Idle Energy Rate[a]	Washing Energy	Water Consumption[b]	Idle Energy Rate[a]	Washing Energy	Water Consumption[b]	
Under Counter	≤ 0.30 kW	≤ 0.35 kWh/rack	≤ 0.86 GPR (≤ 3.3 LPR)	≤ 0.25 kW	≤ 0.15 kWh/rack	≤ 1.19 GPR ≤ 4.5 LPR	ASTM F1696 ASTM F1920
Stationary Single Tank Door	≤ 0.55 kW	≤ 0.35 kWh/rack	≤ 0.89 GPR (≤ 3.4 LPR)	≤ 0.30 kW	≤ 0.15 kWh/rack	≤ 1.18 GPR ≤ 4.47 LPR	
Pot, Pan, and Utensil	≤ 0.90 kW	kWh/rack ≤ 0.55 + 0.05 × SF_{rack}[c] (≤ 0.55 + 0.0046 × SM_{rack}[c)])	≤ 0.58 GPSF (≤ 2.2 LPSM)	N/A	N/A	N/A	
Single Tank Conveyor	≤ 1.20 kW	≤ 0.36 kWh/rack	≤ 0.70 GPR (≤ 2.6 LPR	≤ 0.85 kW	≤ 0.16 kWh/rack	≤ 0.79 GPR ≤ 3.0 LPR	
Multiple Tank – Conveyor	≤ 1.85 kW	≤ 0.36 kWh/rack	≤ 0.54 GPR (≤ 2.0 LPR)	≤ 1.00 kW	≤ 0.22 kWh/rack	≤ 0.54 GPR ≤ 2.0 LPR	
~~Single Tank Flight Type~~	~~Reported~~	~~Reported~~	~~GPH ≤ 2.975c + 55.0 (LPH ≤ 0.276d + 208)~~	~~N/A~~	~~N/A~~	~~N/A~~	

~~Multiple Tank Flight Type~~	~~Reported~~	~~Reported~~	~~GPH ≤ 4.96c + 17.00 (LPH ≤ 0.461d + 787)~~	~~N/A~~		~~N/A~~	

a. Idle results should be measured with the door closed and represent the total idle energy consumed by the machine including all tank heaters and controls. The most energy consumptive configuration in the product family shall be selected to test the idle energy rate. Booster heater (internal or external) energy consumption shall be measured and reported separately, if possible, per ASTM F1696 and ASTM F1920 Sections 10.8 and 10.9, respectively. However, if booster energy cannot be measured separately it will be included in the idle energy rate measurements.

b. GPR = gallons per rack, LPR = Liters per rack, GPSF = gallons per square foot of rack, LPSM = liters per square fmeter of rack, GPH = gallons per hour, c = [maximum conveyor belt speed (feet/minute)] × [conveyor belt width (feet)], LPH = liters per hour, d = [maximum conveyor belt speed (m/minute)] × [conveyor belt width (m)]

c. PPU Washing Energy is still in format kWh/rack when evaluated; SF_{rack} (SM_{rack}) is Square Feet of rack area (square meters of rack area), same as in PPU water consumption metric.

Table C406.2.7.2(4)
Minimum Efficiency Requirements: Commercial Ovens

Fuel Type	**Classification**	**Idle Rate**	**Cooking Energy Efficiency, %**	**Test Procedure**
Convection Ovens				
Gas	Full-Size	≤ 12,000 Btu/h (3.5 kW)	≥ 46	ASTM F1496
Electric	Half-Size	≤ 1.0 kW	≥ 71	
	Full-Size	≤ 1.60 kW		
Combination Ovens				
Gas	Steam Mode	≤ 200 P^a + 6,511 Btu/h (≤ 0.059 P^a + 1.9 kW)	≥ 41	ASTM F2861
	Convection Mode	≤ 150 P^a + 5,425 Btu/h (≤ 0.044 P^a + 1.6 kW)	≥ 56	
Electric	Steam Mode	≤ 0.133 P^a + 0.6400 kW	≥ 55	
	Convection Mode	≤ 0.080 P^a + 0.4989 kW	≥ 76	
Rack Ovens				
Gas	Single	≤ 25,000 Btu/h (7.3 kW)	≥ 48	ASTM F2093
	Double	≤ 30,000 Btu/h (8.8 kW)	≥ 52	

[a]*P* = Pan Capacity: the number of steam table pans the combination oven is able to accommodate in accordance with ASTM F1495

C406.2.6.3 Q03 Efficient Residential Kitchen Equipment.

For projects with Group R-1 and R-2 occupancies, energy credits shall be achieved where all dishwashers, refrigerators, and freezers comply with all of the following:

a. Achieve the Energy Star Most Efficient 2021 label in accordance with the specifications current as of:

   i. Refrigerators and freezers 5.0, 9/15/2014

   ii. Dishwashers 6.0, 1/29/2016

b. Be installed before the issuance of the certificate of occupancy.

For Group R-1 where only some guest rooms are equipped with both refrigerators and dishwashers, the table credits shall be prorated as follows:

[Section C406.2 base credits]× (floor area of guest rooms with kitchens)/(total guest room floor area) (Equation 4-26)

C406.2.6.4 Q04 Fault detection and diagnostics system.

A project not required to comply with C403.2.3 can achieve energy credits for installing a fault detection and diagnostics system to monitor the HVAC system's performance and automatically identify faults. The installed system shall comply with items 1 through 6 in Section C403.2.3.

C406.3 Renewable and Load Management Credits Achieved.

Renewable energy and load management measures installed in the building that comply with Sections C406.3.1 through C406.3.8 shall achieve the credits listed for the occupancy group in Table C406.3.1 or where calculations are required in Sections C406.3 to determine credits or modify the table credits, the credits achieved shall be based upon the Section C406.3 calculations. Measure credits achieved shall be determined in one of two ways, depending on the measure:

1. The measure credit shall be the base energy credit for the measure where no adjustment factor or formula is shown in the description of the measure in Section C406.3.
2. The measure credit shall be the base energy credit for the measure adjusted by a factor or formula as stated in the description of the measure in Section C406.3. Where adjustments are applied, each energy credit shall be rounded to the nearest whole number.

Load management and renewable credits achieved for the project shall be the sum of credits for individual measures included in the project. Credits are available for the measures listed in this Section. Where a project contains multiple building use groups credits achieved for each building use group shall be summed and then weighted by the gross floor area of each building use group to determine the weighted average project energy credits achieved.

The load management measures in Sections C406.3.2 (G01) through C406.3.7 (G06) require load management control sequences that are capable of automatically providing the load management operation specified based on indication of a peak period related to high short-term electric prices, grid condition, or peak building load.

TABLE C406.3.1~~2~~
Renewable and Load Management Credit Requirements by Building Occupancy Group

ID	Renewable and Load Management Credit	Building Occupancy Group								
		R-2, R-4, and I-1	I-2	R-1	B	A-2	M	E	S-1 and S-2	All Other
R01	On-Site Renewable Energy	9	6	8	14	2	9	13	24	11
G01	Lighting Load Management	5	14	9	10	4	18	16	36	14
G02	HVAC Load Management	10	12	x	8	16	14	18	14	13
G03	Automated Shading	1	x	1	5	x	8	14	x	5
G04	Electric Energy Storage	14	13	13	16	4	11	20	24	14
G05	Cooling Energy Storage	7	11	12	12	2	9	16	1	9
G06	SHW Energy Storage	18	4	26	6	15	4	7	2	10
G07	Building Thermal Mass	27	26	26	8	6	13	31	20	20
C01	Insulation Embodied Carbon	5	3	4	8	1	8	7	6	5
E01	Additional Electric	16	x	x	x	x	x	x	x	x

	Infrastructure									

C406.3.1 R01 Renewable Energy.

Projects installing on-site renewable energy systems with a capacity of at least 0.1 watts per gross square foot (1.08 W/m2) of building area or securing off-site renewable energy shall achieve energy credits for this measure calculated as follows:

$EC_R = EC_{0.1} \times R_t / (0.1 \times PGFA)$ (Equation 4-27)

where:

EC_R = C406.3.1 R01 energy credits achieved for this project
R_t = actual total rating of on-site renewable energy systems (W)
PGFA = Project gross floor area, ft2
$EC_{0.1}$ = C406.3.1 R01 base credits from Tables C406.3(1) through C406.3(9)

C406.3.2 G01 Lighting Load Management.

Luminaires shall have dimming capability and automatic load management controls that are capable of gradually reduce general lighting power during peak periods. The load management controls shall be capable of reducing lighting power in 75 percent of the building area by at least 20 percent with continuous dimming over a period no longer than 15 minutes. Where less than 75 percent, but at least 50 percent of the project general lighting is controlled, the credits from Tables C406.3 shall be prorated as follows:
[building area with lighting load management, %] x [table credits for C406.3.2] / 75% (Equation 4-28)
Exception: Warehouse or retail storage building areas shall be permitted to achieve this credit by switching off at least 25 percent of lighting power in 75 percent of the building area without dimming, or as adjusted by Equation 4-28.

C~~G~~406.3.3 G02 HVAC Load Management.

Automatic load management controls shall be capable of:

1. Where electric cooling is in use gradually increase the cooling setpoint by at least 3°F (1.7°C) over a minimum of three hours or reduce effective cooling capacity to 60% of installed capacity during the peak period.
2. Where electric heating is in use gradually decrease the heating setpoint by at least 3°F (1.7°C) over a minimum of three hours or reduce effective heating capacity to 60% of installed capacity during the peak period.
3. Where HVAC systems are serving multiple zones and have less than 70 percent outdoor air required, include controls that are capable of providing excess outdoor air preceding the peak period and reduce outdoor air by at least 30 percent during the peak period, in accordance with ASHRAE Standard 62.1 Section 6.2.5.2 Short Term Conditions.

C406.3.4 G03 Automated Shading Load Management.

Where fenestration on east, south, and west exposures exceeds 20 percent of wall area, load management credits shall be achieved as follows:

1. Automatic exterior shading devices or dynamic glazing that are capable of reducing solar gain (SHGC) through sunlit fenestration by at least 50 percent when fully closed shall receive the full credits in Table C406.3.1. The exterior shades shall have fully open and fully closed SHGC determined in accordance with AERC 1.

2. Automatic interior shading devices with a minimum solar reflectance of 0.50 for the surface facing the fenestration shall receive 40 percent of the credits in Table C406.3.1.

3. All shading devices, dynamic glazing, or shading attachments shall:

   a. provide at least 90 percent coverage of the total fenestration on east, south, and west exposures in the building

   b. be automatically controlled and shall modulate in multiple steps or continuously the amount of solar gain and light transmitted into the space in response to peak periods and either daylight levels or solar intensity

   c. include a manual override located in the same enclosed space as the shaded vertical fenestration that shall override operation of automatic controls no longer than four hours. Such override shall be locked out during peak periods.

For this section, directional east, south, or west exposures shall exclude fenestration that is plus or minus 45 degrees of facing true north in the northern hemisphere. In the southern hemisphere, where the south exposure is referred to, it shall be replaced by the north exposure and the referenced south exposure shall be replaced by the north exposure.

C406.3.5 G04 Electric Energy Storage.

Electric storage devices shall be capable of charging and discharging by automatic load management controls to store energy during non-peak periods and use stored energy during peak periods to reduce building demand. Electric storage devices shall have a minimum capacity of 1.5 Wh/ft2 (87 Wh/m2) of gross building area. Base credits in Tables C406.3-1 through C406.3-8 are based on installed electric storage of 5 Wh/ft2 (54 Wh/m2) and shall be prorated for actual installed storage capacity between 1.5 and 15 Wh/ft2 (16 to 160 Wh/m2), as follows:

(electric storage capacity, Wh/ft2 (Wh/m2))/(5 (54)) × [C406.3.5 Credits from C406.3 Tables] (Equation 4-29)

Larger energy storage shall be permitted; however, credits are limited to the range of 1.5 to 15 Wh/ft2 (16 to 160 Wh/m2).

C403.3.6 G05 Cooling Energy Storage.

Automatic load management controls shall be capable of activating ice or chilled water storage equipment to reduce demand during summer peak periods. Storage tank standby loss shall be demonstrated through analysis to be no more than 2 percent of storage capacity over a 24 hour period for the cooling design day.
Base credits in Section C406.3 are based on storage capacity of the design peak hour cooling load with a 1.15 sizing factor. Credits shall be prorated for installed storage systems sized between 0.5 and 4.0 times the design day peak hour cooling load, rounded to the nearest whole credit. Larger storage shall be permitted but the associated credits are limited to the range above. Energy credits shall be determined as follows:

$EC_s = EC_{1.0} \times (1.44 \times SR + 0.71) / 2.15$ (Equation 4-30) where:

ECs = Cooling Storage credit achieved for Project

EC1.0 = G05 base energy credit for building use type and climate zone based on 1.0 ton-hours storage per design day ton (kWh/kW) of cooling load

SR = Storage ratio in Btu storage per peak design day Btu/hr cooling load (kWh/kW) where $0.5 \leqslant SR \leqslant 4.0$

C406.3.7 G06 SWH Energy Storage.

Where SHW is heated by electricity, automatic load management controls that comply with ANSI/CTA-2045-B shall be capable of preheating stored SHW before the peak period and suspend electric water heating during the peak period. Storage capacity shall be provided by either:

1. Preheating water above 140°F (60°C) delivery temperature with at least 1.34 kWh of energy storage per kW of water-heating capacity. Tempering valves shall be provided at the water heater delivery location.

2. Providing additional heated water tank storage capacity above peak SHW demand with equivalent peak storage capacity to item 1. Where heat pump water heating is used, the credits achieved shall be 1/3 of the credits in Tables C406.3.1.

C406.3.8 G07 Building Thermal Mass.

The project shall have additional passive interior mass and a night flush control of the HVAC system. The credit is available to projects that have at least 80 percent of gross floor area unoccupied between midnight and 6:00 a.m. The project shall meet the following requirements:

1. Interior to the building envelope insulation, provide 10 lb/ft2 (50 kg/m2) of project conditioned floor area of passive thermal mass in the building interior wall, the inside of the exterior wall, or interior floor construction. Mass construction shall have mass surfaces directly contacting the air in conditioned spaces with directly attached gypsum panels allowed. Mass with carpet or furred gypsum panels or exterior wall mass that is on the exterior of the insulation layer (e.g., the portion of CMU block on the exterior of insulation filled cell cavities) shall not be included toward the building mass required.

2. HVAC units for 80 percent or more of the supply airflow in the project shall be equipped with outdoor air economizers and fans that have variable or low speed capable of operating at 66 percent or lower airflow and be included in the night flush control sequence.

3. Night flush controls shall be capable of being configured with the following sequence or another night flush strategy shall be permitted where demonstrated to be effective, avoids added morning heating, and is approved by the authority having jurisdiction.

    a. Summer mode shall be activated when outdoor air temperature exceeds 70 F (21 C) and shall continue uninterrupted until deactivated when outdoor air temperature falls below 45 F (7 C). During summer mode, the occupied cooling set point shall be set 1 F (0.6 C) higher than normal and the occupied heating set point shall be reset 2 F (1.1 C) lower than normal.

    b. When all the following conditions exist, night flush shall be activated:

        i. Summer mode is active in accordance with item 3.1

        ii. Outdoor air temperature is 5 F (2.8 C) or more below indoor average zone temperature

iii. Indoor average zone temperature is greater than morning occupied heating set point

iv. In climate zones 0A through 3A, outdoor dewpoint is below 50 F (10 C) or outdoor air enthalpy is less than indoor air enthalpy

v. Local time is between 10:00 pm and 6:00 am.

c. When night flush is active, automatic night flush controls shall operate outdoor air economizers at low fan speed not exceeding 66 percent during the unoccupied period with mechanical cooling and heating locked out.

4. The project shall demonstrate a contractual obligation for post-occupancy commissioning and control tuning in the spring or fall season to tune the summer mode activation setpoints and occupied heating setpoint or other algorithms to achieve minimal morning heating due to night flush activation while maintaining comfort conditions. Commissioning shall include monitoring of time series space temperature, heating, and cooling operation to demonstrate both night cooling and minimization of morning heating along with monitoring of post-tuning operation to verify tuned parameters. Operating manuals shall include recommendations for tuned parameters and narrative training for operating staff on night flush automated settings. ~~Reporting shall be in compliance with C408.~~

C406.3.9 C01 Insulation Embodied Carbon

Complete calculation in Table C406.3.9(1) to summarize estimated embodied emissions from insulation materials used in the project. The output metric for this measure shall be global warming potential (GWP) intensity, capturing insulation GWP per square foot of conditioned floor area. To complete the basic calculation, project teams shall provide the following information for foundation, wall, and roof insulation materials:

1. Insulation material type
2. Product R-value
3. Total surface area covered by the insulation product (sf)
4. Default, industry-average GWP value, from Table ~~XX~~C406.3.9(2) or GWP values from *Type III Product-specific Environmental Product Declaration (EPD)*
5. Total project area (conditioned square feet)

Projects may substitute product-specific data for the default GWP value if the specified product has a lower reported GWP than the default value. Product-specific data shall be substituted in Column G of the calculation Table C406.3.9(1). Substitution of default GWP values is only allowed when type III product-specific EPDs are sourced and noted in Column G. Projects shall use GWP values that include A1-A3 lifecycle stages, as documented in product-specific EPDs, with the exception of SPF and XPS products. For these products, the A5 and B1 values shall be included in the documented GWP value to account for the on-site and off-gassing impact of blowing agents. Projects shall provide the EPDs declaration number in Column G.

TABLE C406.3.9(1)
INSULATION GLOBAL WARMING POTENTIAL CALCULATION

A	B		C		D		E		F	G (Optional)			H		I
Assembly	Material		Product R-Value		Surface Area (gross square feet)		Framing Factor ("1.0" for continuous, "0.8" for cavity)		Default Global Warming Potential (kg CO2e /sq.m. RSI-1)	Project has sourced Type III - Product-specific Environmental Product Declaration (EPD)	Product Specific Global Warming Potential (kg CO2e /sq.m. RSI-1)		Conversion Factor		GWP Result (kg CO2e)
	List insulation material type from Table 2								*Use Default GWP values from Table 2. Leave blank for products where product specific data will be provided.*	*EPD Declaration Number*	*Leave blank unless EPDs have been sourced. Use GWP values from product-specific EPDs.*				
Below grade, slab/slab edge				X		X	1.0	X				X	0.0164	=	
Basement walls				X		X	1.0	X				X	0.0164	=	
Above grade walls, cavity				X		X	0.8	X				X	0.0164	=	
Above grade walls, continuous				X		X	1.0	X				X	0.0164	=	
Roof, flat				X		X	1.0	X				X	0.0164	=	
Roof, sloped, cavity				X		X	0.8	X				X	0.0164	=	
Roof, sloped, continuous				X		X	1.0	X				X	0.0164	=	

	Input for basic calculation
	Inputs for product-specific data
	Calculation outputs

Summary Metrics	Total Insulation GWP (kg CO2e)	
	÷ Conditioned Floor Area (ft2)	
	OUTPUT: Insulation GWP Intensity (kg CO2e/ ft2)	

TABLE C406.3.9(2)
DEFAULT INSULATION GLOBAL WARMING POTENTIAL VALUES.

All values are from Building Emissions Accounting for Materials (BEAM)[a], unless noted.

Material	**Default Global Warming Potential (kg CO2e /sq.m. RSI-1)**
Cellular glass - Aggregate	3.93[b]
Cellulose - Densepack	-2.10
Cellulose - Blown/loosefill	-1.10
Cork - Board	-6.80
EPS/graphite - Board, unfaced, Type II - 15psi	2.80
EPS/graphite - Board, unfaced, Type IX - 25psi, graphite	3.40
EPS - Board, unfaced, Type I - 10psi	2.80
EPS - Board, unfaced, Type II- 15psi	3.80
EPS - Board, unfaced, Type IX- 25psi	4.80
Fiberglass - Batt, unfaced	0.70
Fiberglass - Blown/loosefill	1.00
Fiberglass - Blown/spray	1.93[c]
Hemp - Batt	-0.50
HempCrete	-3.00
Mineral wool - Batt, unfaced	1.70
Mineral wool - Blown	1.60
Mineral wool - Board, unfaced, "light" density	3.30
Mineral wool - Board, unfaced, "heavy" density	8.10
Phenolic foam - Board	1.54[d]
Polyiso - Wall Board	4.10
Polyiso - Roof Board	2.90
SPF – Spray, open cell	1.40
SPF – Spray, closed cell HFO	4.20
SPF – Spray, high density HFO	4.90
SPF – Spray, closed cell HFC	13.10
SPF – Spray, high density HFC	17.00
Straw – Panel	-6.50
Vacuum Insulated Panel	7.40
Wood fiber – Board, unfaced, European	-6.50
Wood fiber – Board, unfaced, North America	-10.30
Wood fiber – Batt, unfaced	-2.40
Wool (Sheep) – Batt	1.00
Wool (Sheep) – Loosefill	0.80
XPS – Board, 25psi HFC	55.50
XPS – Board, 25psi “Low GWP” (HFO/HFC)	4.90

[a] https://www.buildersforclimateaction.org/beam-estimator.html
[b] EPD Declaration Number NEPD-2012-889-EN
[c] EPD Declaration Number 4788647002.102.1
[d] EPD Declaration Number EPD-KSI-20190072-IBC1-EN

Points shall be calculated via Table C406.3.9(3) below.

TABLE C406.3.9(3)
POINTS OPTIONS FOR INSULATION EMBODIED CARBON

COMPONENT		DESCRIPTION	POINTS
Insulation Embodied Carbon	Basic	Report the global warming potential (GWP) impact of project insulation materials as described in Section C406.3.9. Use calculation Table C406.3.9(1) to summarize insulation GWP intensity (kg CO_2e/ ft2) for the project. Default global warming potential (GWP) values for common insulation products are provided in Table C406.3.9(2). The calculation may utilize Type III, product-specific environmental product declaration (EPD) in lieu of default values for insulation products. If EPD values are used for a given insulation product, include the sum of lifecycle stages A1-A3 from the sourced EPD instead of default GWP value when completing the calculation. Include A5 and B1 GWP values for SPF and XPS products.	As listed in Table C406.3.1
	Advanced	Demonstrate a calculated insulation GWP intensity (kg CO_2e/sf) less than 0.5. Product-specific EPDs may be used in place of default values, subject to requirements in C406.3.9	1.5 x points listed in Table C406.3.1
	Stretch	Demonstrate a calculated insulation GWP intensity (kg CO_2e/sf) less than 0. Product-specific EPDs may be used in place of default values, subject to requirements in C406.3.9.	2.0 x points listed in Table C406.3.1

C406.3.10 E01 Additional Electric Infrastructure

For R-2 occupancy only, comply with the requirements of Section C405.14 Additional electric infrastructure.

~~**C406.1 Additional energy efficiency credit requirements.**~~
~~New buildings shall comply with sufficient packages~~achieve a total of 10 credits from Table C406.1 ~~where the table is selected based on the use group of the building and from credit calculations as specified in relevant subsections of Section C406. Where a building contains multiple-use groups, credits from each use group shall be weighted by floor area of each group to determine the weighted average building credit. Credits from the tables or calculation shall be achieved where a building complies with one or more of the following:~~

~~1. More efficient HVAC performance in accordance with Section C406.2.~~
~~2. Reduced lighting power in accordance with Section C406.3.~~

~~3. Enhanced lighting controls in accordance with Section C406.4.~~
~~4. On-site supply of renewable energy in accordance with Section C406.5.~~
~~5. Provision of a dedicated outdoor air system for certain HVAC equipment in accordance with Section C406.6.~~
~~6. High-efficiency service water heating in accordance with Section C406.7.~~
~~7. Enhanced envelope performance in accordance with Section C406.8.~~
~~8. Reduced air infiltration in accordance with Section C406.9.~~
~~9. Where not required by Section C405.12, include an energy monitoring system in accordance with Section C406.10.~~
~~10. Where not required by Section C403.2.3, include a fault detection and diagnostics (FDD) system in accordance with Section C406.11.~~
~~11. Efficient kitchen equipment in accordance with Section C406.12.~~
~~to achieve a minimum number of six credits. Buildings with more than one commercial building occupancy type shall use the "All Other Groups" column in Table C406.1, unless 65 percent or more of the finished square footage is one commercial building occupancy type, in which case the dominant commercial building occupancy type will be used.~~

~~TABLE C406.1~~
~~EFFICIENCY PACKAGE CREDITS~~

~~**CODE SECTION**~~	~~CLIMATE ZONE~~	
	~~6A~~	~~6B~~
~~**C406.2.1**: 5% heating efficiency improvement~~	~~1~~	~~1~~
~~**C406.2.2**: 5% cooling efficiency improvement~~	~~2~~	~~2~~
~~**C406.2.3**: 10% heating efficiency improvement~~	~~2~~	~~2~~
~~**C406.2.4**: 10% cooling efficiency improvement~~	~~4~~	~~3~~
~~**C406.3**: Reduced lighting power~~	~~6~~	~~7~~
~~**C406.4**: Enhanced digital lighting controls~~	~~1~~	~~2~~
~~**C406.5**: On-site renewable energy~~	~~9~~	~~9~~
~~**C406.6**: Dedicated outdoor air~~	~~7~~	~~4~~
~~**C406.7.2**: Recovered or renewable water heating~~	~~NA~~	~~NA~~
~~**C406.7.3**: Efficient fossil fuel water heater~~	~~NA~~	~~NA~~
~~**C406.7.4**: Heat pump water heater~~	~~NA~~	~~NA~~
~~**C406.8**: Enhanced envelope performance~~	~~11~~	~~10~~
~~**C406.9**: Reduced air infiltration~~	~~15~~	~~8~~
~~**C406.10**: Energy monitoring~~	~~2~~	~~2~~
~~**C406.11**: Fault detection and diagnostics system~~	~~1~~	~~1~~

~~**CODE SECTION**~~	~~**COMMERCIAL BUILDING OCCUPANCY**~~

	~~Group R-1~~	~~Group R-2~~	~~Group B~~	~~Group E~~	~~Group M~~	~~All Other Groups~~
	~~**Additional Efficiency Credits**~~					
~~1. More efficient HVAC performance in accordance with Section C406.2.~~	~~2~~	~~2~~	~~5~~	~~2~~	~~6~~	~~3~~
~~2.1. Reduced lighting power: Option 1 in accordance with Section C406.3.1.~~	~~1~~	~~1~~	~~3~~	~~3~~	~~3~~	~~2~~
~~2.2. Reduced lighting power: Option 2 in accordance with Section C406.3.2.~~	~~2~~	~~2~~	~~5~~	~~5~~	~~5~~	~~4~~
~~3. Enhanced lighting controls in accordance with C406.4.~~	~~N/A~~	~~N/A~~	~~2~~	~~1~~	~~2~~	~~1~~
~~4. On-site supply of renewable energy in accordance with C406.5.~~	~~3~~	~~2~~	~~2~~	~~3~~	~~3~~	~~3~~
~~5. Dedicated outdoor air system in accordance with C406.6.~~ [~~a~~]	~~3~~	~~1~~	~~2~~	~~3~~	~~4~~	~~3~~
~~6.1. High-efficiency service water heating in accordance with Sections C406.7.1 and C406.7.2.~~	~~5~~	~~6~~	~~N/A~~	~~N/A~~	~~N/A~~	~~3 (Group I only)~~
~~6.2. High-efficiency service water heating equipment in accordance with Sections C406.7.1 and C406.7.3.~~	~~3~~	~~3~~	~~N/A~~	~~N/A~~	~~N/A~~	~~2 (Group I only)~~
~~6.3. Heat pump water heating equipment in accordance with Sections C406.7.1 and C406.7.4.~~	~~5~~	~~5~~	~~N/A~~	~~N/A~~	~~N/A~~	~~2 (Group I only)~~
~~7. Enhanced envelope performance in accordance with Section C406.8.~~	~~3~~	~~4~~	~~2~~	~~2~~	~~2~~	~~3~~
~~8. Reduced air infiltration in accordance with Section C406.9.~~	~~3~~	~~5~~	~~2~~	~~3~~	~~4~~	~~3~~
~~9. Efficient kitchen appliances in accordance with Section C406.10.2~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5 (Group A-2 only)~~
~~10. Controlled Receptacles in accordance with Section C406.11~~	~~N/A~~	~~N/A~~	~~6~~	~~2~~	~~N/A~~	~~N/A~~

~~This option is only available to buildings equipped with operable commercial kitchens serving a minimum of five meals per week. See Section C406.10.~~

~~**C406.1.1 Tenant spaces.**~~

~~Tenant spaces shall comply with sufficient packages options from Table C406.1 to achieve a minimum number of three 5 credits, where credits are selected from Section C406.2, C406.3, C406.4, C406.6, or C406.7 or 406.10. where applicable. Where an entire building complies using credits from with Section C406.5, C406.8 or C406.9, tenant spaces within the building shall be deemed to comply with this section.~~

~~**Exception:** Previously occupied tenant spaces that comply with this code in accordance with Section C501.~~

~~**C406.2 More efficient HVAC equipment performance.**~~

~~Equipment shall exceed the minimum efficiency requirements listed in the tables in Section C403.3.2. Variable refrigerant flow systems listed in the energy efficiency provisions ofANSI/ASHRAE/IES 90.1 in accordance with Section C406.2.1, C406.2.2, C406.2.3 or C406.2.4 shall also meet applicable requirements of Section C403. Energy efficiency credits for heating shall be selected from Section C406.2.1 or C406.2.3 and energy efficiency credits for cooling shall be selected from Section C406.2.2, C406.2.4 or C406.2.5. Selected credits shall include a heating or cooling energy efficiency credit or both. Equipment not listed in Tables C403.3.2(1) through C403.3.2(9) and variable refrigerant flow systems not listed in the energy efficiency provisions of ANSI/ASHRAE/IES 90.1 shall be limited to 10 percent of the total building system capacity for heating equipment where selecting Section C406.2.1 or C406.2.3 and cooling equipment where selecting Section C406.2.2, C406.2.4 or C406.2.5.~~

~~Buildings shall comply with Sections C406.2.1 through C406.2.3.~~

~~**C406.2.1 Five-percent heating efficiency improvement.**~~

~~Equipment shall exceed the minimum heating efficiency requirements by 5 percent. C406.2.2 Five-percent cooling efficiency improvement. Equipment shall exceed the minimum cooling and heat rejection efficiency requirements by 5 percent. Where multiple cooling performance requirements are provided, the equipment shall exceed the annual energy requirement, including IEER, SEER and IPLV.~~

~~**C406.2.3 Ten-percent heating efficiency improvement.**~~

~~Equipment shall exceed the minimum heating efficiency requirements by 10 percent. C406.2.4 Ten-percent cooling efficiency improvement. Equipment shall exceed the minimum cooling and heat rejection efficiency requirements by 10 percent. where multiple cooling performance requirements are provided, the equipment shall exceed the annual energy requirement, including IEER, SEER and IPLV.~~

~~**C406.2.5 More than 10-percent cooling efficiency improvement.**~~

~~Where equipment exceeds the minimum annual cooling and heat rejection efficiency requirements by more than 10 percent, energy efficiency credits for cooling may be determined using Equation 4-12, rounded to the nearest whole number. Where multiple cooling performance requirements are provided, the equipment shall exceed the annual energy requirement, including IEER, SEER and IPLV.~~

$EEC_{HEC} = EEC_{10}\,[1 + ((CEI - 10\text{ percent}) / 10\text{ percent})]$ **(Equation 4-12)**

~~**where:**~~

~~EEC_{HEC} = Energy efficiency credits for cooling efficiency improvement.~~

~~EEC_{10} = Section C406.2.4 credits from Tables C406.1(1) through C406.1(5).~~

~~CEI = The lesser of: the improvement above minimum cooling and heat rejection efficiency requirements or 15 percent.~~

~~**C406.2.1 HVAC system selection.**~~
~~No less than 90 percent of the total HVAC capacity serving the building shall be provided by equipment that is listed in Tables C403.3.2(1) through C403.3.2(12).~~

~~**Exception:** Air-to-water heat pumps or heat recovery chillers are also permitted to be utilized for all options in accordance with Section C406.2.~~

~~**C406.2.2 Minimum equipment efficiency.**~~
~~Equipment shall exceed the minimum efficiency requirements listed in Tables C403.3.2(1) through C403.3.2(12) by 15 percent, in addition to the requirements of Section C403. Where multiple performance requirements are provided, the equipment shall exceed all requirements by 15 percent.~~

~~**Exception:** Equipment that is larger than the maximum capacity range indicated in Tables C403.3.2(1) through C403.3.2(12) shall utilize the values listed for the largest capacity equipment for the associated equipment type shown in the table.~~

~~**C406.2.3 Minimum fan efficiency.**~~
~~Stand-alone supply, return and exhaust fans designed for operating with motors over 750 watts (1 hp) shall have a fan efficiency grade of not less than FEG 71 as defined in AMCA 205. The total efficiency of the fan at the design point of operation shall be within 10 percentage points of either the maximum total efficiency of the fan or the static efficiency of the fan.~~

~~**C406.3 Reduced lighting power by more than 10 percent.**~~
~~Buildings shall comply with Section C406.3.1 or C406.3.2, and dwelling units and sleeping units within the building shall comply with Section C406.3.3.~~
~~Buildings shall comply with Section C406.3.1 or C406.3.2. Dwelling units and sleeping units within the building shall comply with Section C406.3.3.~~

~~**C406.3.1 Reduced lighting power by more than 10 percentoption 1.**~~
~~The total connected interior lighting power calculated in accordance with Section C405.3.1 shall be less than 90 percent or less of the total interior lighting power value calculated in accordance with Section C405.3.2.1, or by using 90 percent of the total interior lighting power allowance calculated in accordance with Section C405.3.2.2.~~

~~**C406.3.2 Reduced lighting power by more than 15 percentoption 2.**~~
~~Where the total connected interior lighting power calculated in accordance with Section C405.3.1 is less than 85 percent of the total lighting power allowance calculated in accordance with Section C405.3.2, additional energy efficiency credits shall be determined based on Equation 4-13, rounded to the nearest whole number.~~
~~The total connected interior lighting power calculated in accordance with Section C405.3.1 shall be 80 percent or less of the total interior lighting power value calculated in accordance with Section C405.3.2.1, or by using 80 percent of the total interior lighting power allowance calculated in accordance with Section C405.3.2.2.~~

~~$AEEC_{LPA}=AEEC_{10} \times 10 \times (LPA - LPD) / LPA$ **(Equation 4-13)**~~

~~**where:**~~

~~$AEEC_{LPA}$ = Section C406.3.2 additional energy efficiency credits.~~
~~$AEEC_{10}$ = Section C406.3.1 credits from Tables C406.1(1) through C406.1(5).~~
~~LPA = Total lighting power allowance calculated in accordance with Section C405.3.2.~~
~~LPD = Total connected interior lighting power calculated in accordance with Section C405.3.1.~~

~~C406.3.3 Lamp efficacy.~~
~~Not less than 95 percent of the permanently installed lighting, excluding kitchen appliance light fixtures, serving dwelling units and sleeping units shall be provided by lamps with an efficacy of not less than 65 lumens per watt or luminaires with an efficacy of not less than 45 lumens per watt.~~

~~C406.3.3 Reduced lighting power option 3.~~
~~Not less than 95 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 95 percent of the permanently installed lighting fixtures shall be high-efficacy fixtures or contain only high-efficacy lamps.~~

~~C406.4 Enhanced digital lighting controls.~~
~~Interior lighting shall be located, scheduled and operated in accordance with Section C405.2 and no less than 90 percent of the total installed interior lighting power shall be configured with the following enhanced control functions.~~

~~1. Luminaires shall be configured for continuous dimming.~~

~~2. Luminaires shall be addressed individually.~~

~~Exceptions:~~

~~1. Multiple luminaires mounted on no more than 12 linear feet of a single lighting track and addressed as a single luminaire.~~

~~2. Multiple linear luminaires that are ganged together to create the appearance of a single longer fixture and addressed as a single luminaire, where the total length of the combined luminaires is not more than 12 feet.~~

~~3. Not more than eight luminaires within a *daylight zone* are permitted to be controlled by a *daylight* responsive control.~~

~~4. Fixtures shall be controlled through a digital control system that includes the following function:~~
~~Luminaires shall be controlled through a digital control system configured with the following capabilities:~~

~~4.1. Control reconfiguration based on digital addressability.~~
~~Scheduling and illumination levels of individual luminaires and groups of luminaires are capable of being reconfigured through the system.~~

~~4.2. Load shedding.~~

~~4.3. Occupancy sensors shall be capable of being reconfigured through the digital control system.~~
~~In open and enclosed offices, the illumination level of overhead general illumination luminaires are configured to be individually adjusted by occupants.~~

~~4.4. Occupancy sensors and daylight responsive controls are capable of being reconfigured through the system.~~

~~5. Construction documents shall include submittal of a Sequence of Operations, including a specification outlining each of the functions required by this section.~~

~~**C406.5 On-site renewable energy.**~~
~~Buildings shall comply with Section C406.5.1 or C406.5.2.~~
~~Buildings shall be provided with on-site renewable energy systems with a total system rating per square foot of conditioned floor area of the building of not less than the value specified in Table C406.5.~~

~~**C406.5.1 Basic renewable credit.**~~
~~The total minimum ratings of on-site renewable energy systems, not including systems used for credits under Sections C406.7.2, shall be one of the following:~~

~~1. Not less than 0.86 Btu/h per square foot (2.7 W/m²) or 0.25 watts per square foot (2.7 W/m²) of conditioned floor area.~~

~~2. Not less than 2 percent of the annual energy used within the building for building mechanical and service water-heating equipment and lighting regulated in Section C405.~~

~~**C406.5.2 Enhanced renewable credit.**~~
~~Where the total minimum ratings of on-site renewable energy systems exceeds the rating in Section C406.5.1, additional energy efficiency credits shall be determined based on Equation 4-14, rounded to the nearest whole number.~~

$AEEC_{RRa} = AEEC_{2.5} \times RRa / RR_1$

~~where:~~
~~$AEEC_{RRa}$ = Section C406.5.2 additional energy efficiency credits.~~
~~$AEEC_{2.5}$ = Section C406.5 credits from Tables C406.1(1) through C406.1(5).~~
~~RRa = Actual total minimum ratings of on-site renewable energy systems (in Btu/h, watts per square foot or W/m²).~~
~~RR_1 = Minimum ratings of on-site renewable energy systems required by Section C406.5.1 (in Btu/h, watts per square foot or W/m²)~~

~~TABLE C406.5~~
~~EXTERIOR LIGHTING ZONES~~

~~**ON-SITE RENEWABLE ENERGY SYSTEM RATING (PER SQUARE FOOT)**~~		
~~**Building Area Type**~~	~~**kBTU per year**~~	~~**kWh per year**~~
~~Assembly~~	~~1.8~~	~~0.53~~
~~Dining~~	~~10.7~~	~~3.14~~
~~Hospital~~	~~3.6~~	~~1.06~~
~~Hotel/Motel~~	~~2.0~~	~~0.59~~
~~Multifamily residential~~	~~0.50~~	~~0.15~~
~~Office~~	~~0.82~~	~~0.24~~
~~Other~~	~~2.02~~	~~0.59~~
~~Retail~~	~~1.31~~	~~0.38~~
~~School/University~~	~~1.17~~	~~0.34~~
~~Supermarket~~	~~5.0~~	~~1.47~~
~~Warehouse~~	~~0.43~~	~~0.13~~

~~**C406.6 Dedicated outdoor air system.**~~
~~Not less than 90 percent of the building conditioned floor area, excluding floor area of unoccupied spaces that do not require ventilation in accordance with ASHRAE Standard 62.1, shall be served by DOAS. Buildings containing equipment or systems regulated by Section C403.3.4, C403.4.3, C403.4.4, C403.4.5, C403.6, C403.8.4, C403.8.6, C403.8.6.1, C403.10.1, C403.10.2, C403.10.3C403.8.5, C403.8.5.1, C403.9.1, C403.9.2, C403.9.3 or C403.910.4 shall be equipped with an independent ventilation system designed to provide not less than the minimum 100-percent outdoor air to each individual occupied space, as specified by ASHRAE Standard 62.1. The ventilation system shall be capable of total energy recovery. The HVAC system shall include supply-air temperature controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperatures. The controls shall reset the supply-air temperature not less than 25 percent of the difference between the design supply-air temperature and the design room-air temperature.~~

~~**C406.7 Reduced energy use in service water heating.**~~
~~Buildings shall comply with Section C406.7.1 and Section C406.7.2, C406.7.3 or C406.7.4.Buildings shall comply with Sections C406.7.1 and either C406.7.2, C406.7.3 or C406.7.4.~~

~~**C406.7.1 Building type.**~~
~~To qualify for this credit, the building shall contain one of the following use groups, and the additional energy efficiency credit shall be prorated by conditioned floor area of the portion of the building comprised of the following use groups:~~
~~To qualify for this credit, not less than 90 percent of the building conditioned floor area shall be of the following types:~~

~~1. *Group R*-1: Boarding houses, hotels or motels.~~

2. Group I-2: Hospitals, psychiatric hospitals and nursing homes.

3. Group A-2: Restaurants and banquet halls or buildings containing food preparation areas.

4. Group F: Laundries.

5. *Group R*-2.

6. Group A-3: Health clubs and spas.

7. Group E: Schools with full-service kitchens or locker rooms with showers.

8. Buildings showing a service hot water load of 10 percent or more of total building energy loads, as shown with an energy analysis as described in Section C407.

C406.7.2 Recovered or renewable water heatingLoad fraction.
Not less than 60 percent of the annualThe building service hot water energy usewater-heating system shall have one or more of the following that are sized to provide not less than 30 percent of the building's annual hot water requirements, or sized to provide 70 percent of the buildings annual hot water requirements if the building is required to comply with Section C403.10.5: , or not less than 100 percent of the annual building service hot water heating energy use in buildings subject to the requirements of Section C403.9.5, shall be provided by one or more of the following:

1. Waste heat recovery from service hot water, heat-recovery chillers, building equipment or, process equipment, or other *approved* system.

2. *On-site renewable energy* water-heating systems.

C406.7.3 High performance water heating equipmentEfficient fossil fuel water heater.
The combined input-capacity weightedaverage equipment rating of all fossil fuel water-heating equipment in the building shall be not less than 95 percent Et or 0.95 EF. This option shall receive only half the listed credits for buildings required to comply with Section C404.2.1.The combined input-capacity-weighted-average equipment rating of all water heating equipment in the building shall be not less than 95 percent Etor 0.95 EF.

C406.7.4 Heat pump water heater.
Where electric resistance water heaters are allowed, all service hot water system heating requirements shall be met using heat pump technology with a combined input-capacity weighted-average EF of 3.0. Air-source heat pump water heaters shall not draw conditioned air from within the building, except exhaust air that would otherwise be exhausted to the exterior.All service hot water system heating requirements shall be met using heat pump technology with a minimum COP of 3.0. Air-source heat pump water heaters shall not draw conditioned air from within the building, except exhaust air that would otherwise be exhausted to the exterior.

C406.8 Enhanced envelope performance.
The total UA of the building thermal envelope as designed shall be not less than 15 percent below the total UA of the building thermal envelope for a building of identical configuration and fenestration area in accordance with Section C402.1.3.

~~If using Section C402.1.4 building above-grade performance alternative for compliance, UA-Total/Area ≤ 0.030 needs to be met as well as total UA of below-grade walls shall be not less than 15 percent below the total UA of the below-grade thermal envelope in accordance with Section C402.1.3.~~

~~C406.9 Reduced air infiltration.~~

~~Air infiltration shall be verified by whole-building pressurization testing 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 0.25 cfm/ft^2 (2.0 L/s × m^2) under a pressure differential of 0.3 inches water column (75 Pa), with the calculated surface area being the sum of the above- and below-grade building envelope. A report that includes the tested surface area, floor area, air by volume, stories above grade, and leakage rates shall be submitted to the code official and the building owner.~~

~~**Exception:** For buildings having over 250,000 square feet (25 000 m^2) of conditioned floor area, air leakage testing need not be conducted on the whole building where testing is conducted on representative above-grade sections of the building. Tested areas shall total not less than 25 percent of the conditioned floor area and shall be tested in accordance with this section.~~

~~C406.10 Energy monitoring.~~

~~Buildings shall be equipped to measure, monitor, record and report energy consumption data in compliance with Sections C406.10.1 through C406.10.5.~~

~~C406.10.1 Electrical energy metering.~~

~~For all electrical energy supplied to the building and its associated site, including but not limited to site lighting, parking, recreational facilities, and other areas that serve the building and its occupants, meters or other measurement devices shall be provided to collect energy consumption data for each end-use category required by Section C406.10.2.~~

~~C406.10.2 End-use metering categories.~~

~~Meters or other approved measurement devices shall be provided to collect energy use data for each end-use category listed in Table 406.10.2. These meters shall have the capability to collect energy consumption data for the whole building or for each separately metered portion of the building. Where multiple meters are used to measure any end-use category, the data acquisition system shall total all of the energy used by that category. Not more than 5 percent of the measured load for each of the end-use categories listed in Table 406.10.2 is permitted to be from a load not within the category.~~

~~Exceptions:~~

~~1. HVAC and water-heating equipment serving only an individual dwelling unit does not require end-use metering.~~
~~2. End-use metering is not required for fire pumps, stairwell pressurization fans or any system that operates only during testing or emergency.~~

~~TABLE C406.10.2~~
~~ENERGY USE CATEGORIES~~
~~C406.10.3 Meters.~~

~~Meters or other measurement devices required by this section shall be configured to automatically communicate energy consumption data to the data acquisition system required by Section~~

~~C406.10.4. Source meters shall be allowed to be any digital-type meter. Lighting, HVAC, or other building systems that can monitor their energy consumption shall be permitted instead of meters. Current sensors shall be permitted, provided that they have a tested accuracy of ±2 percent. Required metering systems and equipment shall have the capability to provide at least hourly data that is fully integrated into the data acquisition system and graphical energy report in accordance with Sections C406.10.4 and C406.10.5.~~

~~C406.10.4 Data acquisition system.~~

~~A data acquisition system shall have the capability to store the data from the required meters and other sensing devices for a minimum of 36 months. The data acquisition system shall have the capability to store real-time energy consumption data and provide hourly, daily, monthly, and yearly logged data for each end-use category required by Section C406.10.2.~~

~~C406.10.5 Graphical energy report.~~

~~A permanent and readily accessible reporting mechanism shall be provided in the building that is accessible by building operation and management personnel. The reporting mechanism shall have the capability to graphically provide the energy consumption for each end-use category required by Section C406.10.2 at least every hour, day, month and year for the previous 36 months.~~

~~C406.11 Fault detection and diagnostics system.~~

~~A fault detection and diagnostics system shall be installed to monitor the HVAC system's performance and automatically identify faults. The system shall do all of the following:~~

~~1. Include permanently installed sensors and devices to monitor the HVAC system's performance.~~
~~2. Sample the HVAC system's performance at least once every 15 minutes.~~
~~3. Automatically identify and report HVAC system faults.~~
~~4. Automatically notify authorized personnel of identified HVAC system faults.~~
~~5. Automatically provide prioritized recommendations for repair of identified faults based on analysis of data collected from the sampling of the HVAC system performance.~~
~~6. Be capable of transmitting the prioritized fault repair recommendations to remotely located authorized personnel.~~

~~C406.12 Efficient kitchen equipment.~~

~~For buildings and spaces designated as Group A-2 or facilities that include a commercial kitchen with at least one gas or electric fryer, all fryers, dishwashers, steam cookers and ovens shall comply with all of the following:~~

~~1. Achieve performance levels in accordance with the equipment specifications listed in Tables C406.12(1) through C406.12(4) when rated in accordance with the applicable test procedure.~~
~~2. Be installed prior to the issuance of the Certificate of Occupancy.~~
~~3. Have associated performance levels listed on the construction documents submitted for permitting.~~

~~Energy efficiency credits for efficient kitchen equipment shall be independent of climate zone and determined based on Equation 4-15, rounded to the nearest whole number.~~

~~$AEEC_K = 20 \times Area_K / Area_B$~~

~~where:~~
~~$AEEC_K$ = Section C406.12 additional energy efficiency credits.~~

~~Area~~$_{K}$ ~~= Floor area of full-service kitchen (ft² or m²).~~
~~Area~~$_{B}$ ~~= Gross floor area of building (ft² or m²).~~

~~**TABLE C406.12(1)**~~
~~**MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL FRYERS**~~

~~**TABLE C406.12(2)**~~
~~**MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL STEAM COOKERS**~~

~~**TABLE C406.12(3)**~~
~~**MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL DISHWASHERS**~~

~~**TABLE C406.12(4)**~~
~~**MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL OVENS**~~

~~**C406.10 Efficient kitchen appliances.**~~
~~Buildings shall comply with Sections C406.10.1 through C406.10.2 in order to qualify for additional efficiency credits.~~

~~**C406.10.1 Building requirements.**~~
~~The building shall contain an operable commercial kitchen that serves a minimum of five meals per week.~~

~~**C406.10.2 Equipment type.**~~
~~The following pieces of equipment that fall within the scope of the applicable ENERGY STAR program shall comply with the equivalent criteria required to achieve the ENERGY STAR label if installed prior to the issuance of the Certificate of Occupancy:~~

~~1. Commercial fryers~~

~~2. Commercial hot food holding cabinets~~

~~3. Commercial steam cookers~~

~~4. Commercial dishwashers~~

~~5. Commercial griddles~~

~~6. Commercial ovens~~

~~**C406.11 Controlled receptacles.**~~
~~At least 50 percent of all 125 volt 15- and 20-ampere receptacles installed in private offices, open offices, conference rooms, rooms used primarily for printing and/or copying functions, break rooms, individual workstations and classrooms, including those installed in modular partitions and modular office workstation systems, shall be controlled as required by this section. Either split receptacles shall be provided, with the top receptacle(s) controlled, or a controlled receptacle shall be located within 12 inches (305 mm) of each uncontrolled receptacle. Controlled receptacles shall be visibly differentiated from standard receptacles and shall be controlled by one of the following automatic control devices:~~

~~1. An occupant sensor that turns receptacle power off when no occupants have been detected for a maximum of 20 minutes.~~

~~2. A time-of-day operated control device that turns receptacle power off at specific programmed times and can be programmed separately for each day of the week. The control device shall be configured to provide an independent schedule for each portion of the building not to exceed 5,000 square feet (465 m^2) and not to exceed one full floor. The device shall be capable of being overridden for periods of up to 2 hours by a timer accessible to occupants.~~

~~Any individual override switch shall control the controlled receptacles for a maximum area of 5,000 square feet (465 m^2). Override switches for controlled receptacles are permitted to control the lighting within the same area.~~

~~**Exceptions:**~~

~~1. Receptacles designated for specific equipment requiring 24-hour operation, for building maintenance functions, or for specific safety or security equipment are not required to be controlled by an automatic control device and are not required to be located within 12 inches (305 mm) of a controlled receptacle.~~

~~2. Within a single modular office workstation, noncontrolled receptacles are permitted to be located not more than 72 inches from the controlled receptacles serving that workstation.~~

SECTION C407
MAINTENANCE INFORMATION
AND SYSTEM COMMISSIONING

C407.1 General.
This section covers the provision of maintenance information and the commissioning of, and the functional testing requirements for, building systems.

C407.1.1 Qualifications.
The scope shall be completed by the project commissioning authority. The commissioning authority shall:

1. Have experience as a commissioning authority on at least three previous projects, each at least 20,000 square feet or greater.
2. Be an independent third-party entity. The commissioning authority shall not be an employee of the design team, construction team, owner or developer.

C407.1.2 Building operations and maintenance information.
The building operations and maintenance documents shall be provided to the owner and shall consist of manufacturers' information, specifications and recommendations; programming procedures and data points; narratives; and other means of illustrating to the owner how the building, equipment and systems are intended to be installed, maintained and operated. Required regular maintenance actions for equipment and systems shall be clearly stated on a

readily visible label. The label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product.

C407.2 Mechanical systems and service water-heating systems commissioning and completion requirements.
Prior to the final mechanical and plumbing inspections, the *design professional/agency* shall provide evidence of mechanical systems *commissioning* and completion in accordance with the provisions of this section.

Construction document notes shall clearly indicate provisions for *commissioning* and completion requirements in accordance with this section and are permitted to refer to specifications for further requirements. Copies of all documentation shall be given to the owner or owner's authorized agent and made available to the *code official or authority having jurisdiction*, upon request in accordance with Sections C407.2.4 and C407.2.5.

Exception: The following systems are exempt:

1. Mechanical systems and service water heater systems in buildings where the total mechanical equipment capacity is less than 480,000 Btu/h (140.7 kW) cooling capacity and 600,000 Btu/h (175.8 kW) combined service water-heating and space-heating capacity.

2. Systems included in Section C403.5 that serve individual *dwelling units* and *sleeping units*.

C407.2.1 Commissioning plan.
A *commissioning plan* shall be developed by a *design professional/agency* and shall include the following items:

1. A narrative description of the activities that will be accomplished during each phase of *commissioning*, including the personnel intended to accomplish each of the activities.

2. A listing of the specific equipment, appliances or systems to be tested and a description of the tests to be performed.

3. Functions to be tested including, but not limited to, calibrations and economizer controls.

4. Conditions under which the test will be performed. Testing shall affirm winter and summer design conditions and full outside air conditions.

5. Measurable criteria for performance.

C407.2.2 Systems adjusting and balancing.
HVAC systems shall be balanced in accordance with generally accepted engineering standards. Air and water flow rates shall be measured and adjusted to deliver final flow rates within the tolerances provided in the product specifications. Test and balance activities shall include air system and hydronic system balancing.

C407.2.2.1 Air systems balancing.
Each supply air outlet and *zone* terminal device shall be equipped with means for air balancing. Discharge dampers used for air-system balancing are prohibited on constant-volume fans and variable-volume fans with motors 10 hp (7.5 kW) and larger. Air systems shall be balanced in a manner to first minimize throttling losses then, for fans with system power of greater than 1 hp (0.746 kW), fan speed shall be adjusted to meet design flow conditions.

> **Exception:** Fans with fan motors of 1 hp (0.74 kW) or less are not required to be provided with a means for air balancing.

C407.2.2.2 Hydronic systems balancing.
Individual hydronic heating and cooling coils shall be equipped with means for balancing and measuring flow. Hydronic pump speed shall be adjusted to meet design flow conditions. Each hydronic system shall have either the capability to measure pressure across the pump, or test ports at each side of each pump.

C407.2.3 Functional performance testing.
Functional performance testing specified in Sections C407.2.3.1 through C407.2.3.3 shall be conducted.

C407.2.3.1 Equipment.
Equipment functional performance testing shall demonstrate the installation and operation of components, systems, and system-to-system interfacing relationships in accordance with approved plans and specifications such that operation, function, and maintenance serviceability for each of the commissioned systems is confirmed. Testing shall include all modes and *sequence of operation*, including under full-load, part-load and the following emergency conditions:

1. All modes as described in the *sequence* of *operation*.
2. Redundant or *automatic* back-up mode.
3. Performance of alarms.
4. Mode of operation upon a loss of power and restoration of power.

> **Exception:** Unitary or packaged HVAC equipment listed in ~~Tables C403.3.2(1) through C403.3.2(3)~~the tables in Section C403.3.2 that do not require supply air economizers.

C407.2.3.2 Controls.
HVAC and service water-heating control systems shall be tested to document that control devices, components, equipment and systems are calibrated and adjusted and operate in accordance with approved plans and specifications. Sequences of operation shall be functionally tested to document they operate in accordance with *approved* plans and specifications.

C407.2.3.3 Economizers.
Air economizers shall undergo a functional test to determine that they operate in

accordance with manufacturer's specifications.

C407.2.4 Preliminary commissioning report.
A preliminary report of *commissioning* test procedures and results shall be completed and certified by the *design professional/agency* and provided to the building owner or owner's authorized agent. The report shall be organized with mechanical and service hot water findings in separate sections to allow independent review. The report shall be identified as "Preliminary Commissioning Report," shall include the completed Commissioning Compliance Checklist, Figure C407.2.4, and shall identify:

1. Itemization of deficiencies found during testing required by this section that have not been corrected at the time of report preparation.

2. Deferred tests that cannot be performed at the time of report preparation because of climatic conditions.

3. Climatic conditions required for performance of the deferred tests.

4. Results of functional performance tests.

5. Functional performance test procedures used during the commissioning process, including measurable criteria for test acceptance.

Project Information: ___________________________ Project Name:__________________________________

Project Address:____

Commissioning Authority: ____

Commissioning Plan (Section C407.2.1)

☐ Commissioning Plan was used during construction and includes all items required by Section C407.2.1

☐ Systems Adjusting and Balancing has been completed.

☐ HVAC Equipment Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:___________________________

☐ HVAC Controls Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:___________________________

☐ Economizer Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:___________________________

☐ Lighting Controls Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:___________________________

☐ Service Water Heating System Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:___________________________

☐ Manual, record documents and training have been completed or scheduled

☐ Preliminary Commissioning Report submitted to owner and includes all items required by Section C407.2.4

I hereby certify that the commissioning provider has provided me with evidence of mechanical, service water heating and lighting systems commissioning in accordance with the 2020 Vermont CBES.

Signature of Building Owner or Owner's Representative ___________________________ Date______________

FIGURE C407.2.4
COMMISSIONING COMPLIANCE CHECKLIST

~~**C407.2.4.1 Acceptance of report.**~~
~~Buildings, or portions thereof, shall not be considered as acceptable for a final inspection pursuant to Section C105.2.6 until the code official has received the Preliminary Commissioning Report from the building owner or owner's authorized agent.~~

~~**C407.2.4.2 Copy of report.**~~
~~The code officialshall be permitted to require that a copy of the Preliminary Commissioning Report be made available for review by the code official.~~

C407.2.5 Documentation requirements.
The *construction documents* shall specify that the documents described in this section be provided to the building owner or owner's authorized agent within 90 days of the date of

receipt of the *certificate of occupancy*.

C407.2.5.1 System balancing report.
A written report describing the activities and measurements completed in accordance with Section C407.2.2.

C407.2.5.2 Final commissioning report.
A report of test procedures and results identified as "Final Commissioning Report" shall be delivered to the building owner or owner's authorized agent. The report shall be organized with mechanical system and service hot water system findings in separate sections to allow independent review. The report shall include the following:

1. Results of functional performance tests.
2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.
3. Functional performance test procedures used during the commissioning process including measurable criteria for test acceptance, provided herein for repeatability.

Exception: Deferred tests that cannot be performed at the time of report preparation due to climatic conditions.

C407.3 Functional testing of lighting controls.
Automatic lighting controls required by this code shall comply with this section.

C407.3.1 Functional testing.
Prior to passing final inspection, the *design professional* or approved~~/~~*agency* shall provide evidence that the lighting control systems have been 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 instructions. Functional testing shall be in accordance with Sections C407.3.1.1 through C407.3.1.3 for the applicable control type.

C407.3.1.1 Occupant sensor controls.
Where *occupant sensor controls* are provided, the following procedures shall be performed:

1. Certify that the *occupant sensor* has been located and aimed in accordance with manufacturer recommendations.
2. For projects with seven or fewer *occupant sensors*, each sensor shall be tested.
3. For projects with more than seven *occupant sensors*, testing shall be done for each unique combination of sensor type and space geometry. Where multiples of each unique combination of sensor type and space geometry are provided, not less than 10 percent and in no case fewer than one, of each combination shall be tested unless the *code official* or design professional requires a higher percentage to be tested. Where 30 percent or more of the tested controls fail, all remaining identical combinations shall be tested.

For *occupant sensor controls* to be tested, verify the following:

3.1. Where *occupant sensor controls* include status indicators, verify correct operation.

3.2. The controlled lights turn off or down to the permitted level within the required time.

3.3. For auto-on *occupant sensor controls*, the lights turn on to the permitted level when an occupant enters the space.

3.4. For manual-on *occupant sensor controls*, the lights turn on only when manually activated.

3.5. The lights are not incorrectly turned on by movement in adjacent areas or by HVAC operation.

C407.3.1.2 Time-switch controls.
Where *time-switch controls* are provided, the following procedures shall be performed:

1. Confirm that the *time-switch control* is programmed with accurate weekday, weekend and holiday schedules.

2. Provide documentation to the owner of *time-switch controls* programming including weekday, weekend, holiday schedules, and set-up and preference program settings.

3. Verify the correct time and date in the time switch.

4. Verify that any battery back-up is installed and energized.

5. Verify that the override time limit is set to not more than 2 hours.

6. Simulate occupied condition. Verify and document the following:

   6.1. All lights can be turned on and off by their respective area control switch.

   6.2. The switch only operates lighting in the enclosed space in which the switch is located.

7. Simulate unoccupied condition. Verify and document the following:

   7.1. Nonexempt lighting turns off.

   7.2. 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 shutoff occurs.

8. Additional testing as specified by the *registered design professional*.

C407.3.1.3 Daylight responsive controls.
Where *daylight responsive controls* are provided, the following shall be verified:

1. Control devices have been properly located, field calibrated and set for accurate setpoints and threshold light levels.

2. Daylight controlled lighting loads adjust to light level setpoints in response to available daylight.

3. The calibration adjustment equipment is located for *ready access* only by authorized personnel.

C407.3.2 Documentation requirements.
The *construction documents* shall specify that the documents described in this section be provided to the building owner or owner's authorized agent within 90 days of the date of receipt of the *certificate of occupancy*.

C407.3.2.1 Drawings.
Construction documents shall include the location and catalogue number of each piece of equipment.

C407.3.2.2 Manuals.
An operating and maintenance manual shall be provided and include the following:

1. Name and address of not less than one service agency for installed equipment.

2. A narrative of how each system is intended to operate, including recommended setpoints.

3. Submittal data indicating all selected options for each piece of lighting equipment and lighting controls.

4. Operation and maintenance manuals for each piece of lighting equipment. Required routine maintenance actions, cleaning and recommended relamping shall be clearly identified.

5. A schedule for inspecting and recalibrating all lighting controls.

C407.3.2.3 Report.
A report of test results shall be provided and include the following:

1. Results of functional performance tests.

2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.

SECTION C408
CALCULATION OF HVAC TOTAL SYSTEM PERFORMANCE RATIO

C408.1 Purpose. Section 408~~9~~ establishes criteria for demonstrating compliance with the requirements of C403.1.1, HVAC total system performance ratio (HVAC TSPR)

C408.2 Scope. Section C408 applies to new HVAC systems that serve buildings in Section C403.1.3.1 and are not excluded from using HVAC TSPR by Section C403.1.3.
All applicable HVAC systems shall comply with Section C408.

C408.3 Core & Shell / Initial Build-Out, and Future System Construction Analysis. Where the building permit applies to only a portion of the HVAC system in a building and the remaining components will be designed under a future building permit or were previously installed, the future or previously installed components shall be modeled as follows:

1. Where the HVAC zones that do not include HVAC systems in the current permit will be or are served by independent systems, then the block including those zones shall not be included in the model.
2. Where the HVAC zones that do not include complete HVAC systems in the permit are intended to receive HVAC services from systems in the permit, their proposed zonal systems shall be modeled with equipment that meets, but does not exceed, the requirements of C403.
3. Where the zone equipment in the permit receives HVAC services from previously installed systems that are not in the permit, the previously installed systems shall be modeled with equipment matching the certified value of what is installed or equipment that meets the requirements of C403.
4. Where the central plant heating and cooling equipment is completely replaced and HVAC zones with existing systems receive HVAC services from systems in the permit, their proposed zonal systems shall be modeled with equipment that meets, but does not exceed, the requirements of Section C403.

C408.4 HVAC TSPR Compliance. Systems allowed to use HVAC TSPR in accordance with C403.1.3 shall comply with all of the following:

1. Systems shall meet the applicable provisions of Section C403.1.3.3 and Sections within Section C403 that are listed in Table C407.2
2. The HVAC TSPR of the proposed design shall be greater than or equal to the HVAC TSPR of the standard reference design divided by the mechanical performance factor (MPF)using Equation 4-16.

   $TSPR_p > TSPR_r / MPF$ (Equation 4-16)

   where:

   TSPRp= HVAC TSPR of the proposed design calculated in accordance with Sections C408.4, C408.5 and C408.6.

   TSPRr = HVAC TSPR of the reference building design calculated in accordance with Sections C408.4, C408.5 and C408.6.

MPF = Mechanical Performance Factor from Table C408.4 based on climate zone and building use type Where a building has multiple building use types, MPF shall be area weighted using Equation 4-17

MPF = (A1*MPF1 + A2* MPF2+...+An*MPFn)/(A1+A2+...+An) (Equation 4-17)

where:

MPF1, MPF2 through MPFn = Mechanical Performance Factors from Table C408.4 based on climate zone and building use types 1,2, through n

A1, A2through An = Conditioned floor areas for building use types 1, 2, through n

Table C408.4 Mechanical Performance Factors

Building Type	**Occupancy Group**	**Performance Factor**
Office (small and medium)[a]	B	0.865
Office (Large)[a]	B	0.73
Retail	M	0.5
Hotel/Motel	R-1	0.35
Multi-Family/ Dormitory	R-2	0.55
School/ Education and Libraries	E (A-3)	0.89

a Large office (gross conditioned floor area >150,000 ft2 (14,000 m2) or > 5 floors); all other offices are small or medium

C408.4.1 HVAC TSPR. HVAC TSPR is calculated according to Equation 4-18 .
HVAC TSPR = heating and cooling load / building HVAC system energy (Equation 4-18)

where:

building HVAC system energy = sum of the annual site energy consumption for heating, cooling, fans, energy recovery, pumps, and heat rejection in thousands of Btus

heating and cooling load = sum of the annual heating and cooling loads met by the building HVAC system in thousands of Btus

C408.5 General. Projects shall comply with the requirements of this Section when calculating compliance using HVAC Total System Performance Ratio.

C408.5.1 Simulation Program. Simulation tools used to calculate HVAC TSPR of the Standard Reference Design shall comply with the following:

1. The simulation program shall calculate the HVACTSPR based only on the input for the proposed design and the requirements of Section 409. The calculation procedure shall not allow the user to directly modify the building component characteristics of the standard reference design.
2. Performance analysis tools meeting the applicable subsections of Section 409 and tested according to ASHRAE Standard 140, except for Sections 7 and 8 of Standard 140, shall be permitted to be approved. The required tests shall include building thermal envelope and fabric load tests (Sections 5.2.1, 5.2.2, and 5.2.3), ground coupled slab-on-grade analytical verification tests (Section 5.2.4), space-cooling equipment performance tests (Section 5.3), space-heating equipment performance tests (Section 5.4), and air-side HVAC equipment analytical verification tests (Section 5.5), along with the associated reporting (Section 6). Tools are permitted to be approved based on meeting a specified threshold for a jurisdiction. The code official shall be permitted to approve tools for a specified application or limited scope.
3. The test results and modeler reports shall be posted on a publicly available website and shall include the test results of the simulation program and input files used for generating the results along with the results of the other simulation programs included in ASHRAE Standard 140 Annexes B8 and B16. The modeler report in Standard 140 Annex A2 Attachment A2.7 shall be completed for results exceeding the maximum or falling below the minimum of the reference values and for omitted results.
4. The simulation program shall have the ability to explicitly model part-load performance curves or other part-load adjustment methods based on manufacturer's part-load performance data for mechanical equipment.

C408.5.2 Climatic Data. The simulation program shall perform the simulation using hourly values of climatic data, such as temperature and humidity, using TMY3 data for the site as specified here:
https://energycode.pnl.gov/HVACSystemPerformance/resources

C408.5.3 Documentation. Documentation conforming to the provisions of this section shall be provided to the code official.

C408.5.3.1 Compliance Report. Building permit submittals shall include:

1. A report produced by the simulation software that includes the following:
   a. Address of the building.
   b. Name of individual completing the compliance report.
   c. Name and version of the compliance software tool.
   d. The dimensions, floor heights and number of floors for each block.
   e. By block, the U-factor, C-factor, or F-factor for each simulated opaque envelope component and the U-factor and SHGC for each fenestration component.
   f. By block or by surface for each block, the fenestration area.
   g. By block, a list of the HVAC equipment simulated in the proposed design including the equipment type, fuel type, equipment efficiencies and system controls.
   h. Annual site HVAC energy use by end use for the proposed and baseline building
   i. Annual sum of heating and cooling loads for the baseline building.

j. The HVAC total system performance ratio for both the standard reference design and the proposed design.

2. A mapping of the actual building HVAC component characteristics and those simulated in the proposed design showing how individual pieces of HVAC equipment identified above have been combined into average inputs as required by Section C408.6.1.10 including:
    a. Fans
    b. Hydronic pumps
    c. Air handlers
    d. Packaged cooling equipment
    e. Furnaces
    f. Heat pumps
    g. Boilers
    h. Chillers
    i. Heat rejection equipment (open and closed circuit cooling towers; dry coolers)
    j. Electric resistance coils
    k. Condensing units
    l. Motors for fans and pumps
    m. Energy recovery devices
3. For each piece of equipment identified above include the following as applicable:
    a. Equipment name or tag consistent with that found on the design documents.
    b. Rated Efficiency level.
    c. Rated Capacity.
    d. Where not provided by the simulation program report in item a, documentation of the calculation of any weighted equipment efficiencies input into the program
    e. Electrical input power for fans and pumps (before any speed or frequency control device) at design condition and calculation of input value (W/cfm or W/gpm)
4. Floor plan of the building identifying:
    a. How portions of the buildings are assigned to the simulated blocks
    b. Areas of the building that are not covered under the requirements of SectionC403.1.1.

C408.6 Calculation Procedures. Except as specified by this Section, the standard reference design and proposed design shall be configured and analyzed using identical methods and techniques

C408.6.1 Simulation of the proposed building design. The proposed design shall be configured and analyzed as specified in this section.

C408.6.1.1 Block Geometry. The geometry of buildings shall be configured using one or more blocks. Each block shall define attributes including block dimensions, number of floors, floor to floor height and floor to ceiling height. Simulation software may allow the use of simplified shapes (such as rectangle, L shape, H Shape, U shape or T shape) to represent blocks. Where actual building shape does not match these pre-defined shapes, simplifications are permitted providing the following requirements are met:

1. The conditioned floor area and volume of each block shall match the proposed design within 10 percent.
2. The area of each exterior envelope component from Table C402.1.4 is accounted for within 10 percent of the actual design.
3. The area of vertical fenestration and skylights is accounted for within 10 percent of the actual design.
4. The orientation of each component in 2 and 3 above is accounted for within 45 degrees of the actual design.

The creation of additional blocks may be necessary to meet these requirements. A more complex zoning of the building shall be allowed where all thermal zones in the reference and proposed model are the same and rules related to block geometry and HVAC system assignment to blocks are met with appropriate assignment to thermal zones.

Exception: Portions of the building that are unconditioned or served by systems not covered by the requirements of Section C403.1.1 shall be omitted.

C408.6.1.1.1 Number of Blocks. One or more blocks may be required per building based on the following restrictions:

1. Each block can have only one occupancy type (multifamily dwelling unit, multifamily common area, office, library, education, hotel/motel or retail). Therefore, at least one single block shall be created for each unique use type.
2. Each block can be served by only one type of HVAC system. Therefore, a single block shall be created for each unique HVAC system and use type combination. Multiple HVAC units of the same type may be represented in one block. Table D601.10.2 provides directions for combining multiple HVAC units or components of the same type into a single block.
3. Each block can have a single definition of floor to floor or floor to ceiling heights. Where floor heights differ by more than two feet, unique
4. blocks should be created for the floors with varying heights.
5. Each block can include either above grade or below grade floors. For buildings with both above grade and below grade floors, separate blocks should be created for each. For buildings with floors partially above grade and partially below grade, if the total wall area of the floor(s) in consideration is greater than or equal to 50 percent above grade, then it should be simulated as a completely above grade block, otherwise it should be simulated as a below grade block.
6. Each wall on a façade of a block shall have similar vertical fenestration. The product of the proposed design U-factor times the area of windows (UA) on each façade of a given floor cannot differ by more than 15 percent of the average UA for that façade in each block. The product of the proposed design SHGC times the area of windows (SHGCA) on each façade of a given floor cannot differ by more than 15 percent of the average SHGCA for that façade in each block. If either of these conditions are not met, additional blocks shall be created consisting of floors with similar fenestration.

7. For a building model with multiple blocks, the blocks should be configured together to have the same adjacencies as the actual building design.

C408.6.1.2 Thermal Zoning. Each floor in a block shall be modeled as a single thermal zone or as five thermal zones consisting of four perimeter zones and a core zone. Below grade floors shall be modeled as a single thermal block. If any façade in the block is less than 45 feet in length, there shall only be a single thermal zone per floor. Otherwise each floor shall be modeled with five thermal zones. A perimeter zone shall be created extending from each façade to a depth of 15 feet. Where facades intersect, the zone boundary shall be formed by a 45 degree angle with the two facades. The remaining area or each floor shall be modeled as a core zone with no exterior walls.

C408.6.1.3 Occupancy. Building occupancies modeled in the standard reference design and the proposed design shall comply with the following requirements.

C408.6.1.3.1 Occupancy Type. The occupancy type for each block shall be consistent with the building area type as determined in accordance with C405.4.2.1. Portions of the building that are building area types other than multifamily dwelling unit, multifamily common area, office, school (education), library, or retail shall not be included in the simulation. Surfaces adjacent to such building portions shall be modeled as adiabatic in the simulation program.

C408.6.1.3.2 Occupancy schedule, density, and heat gain. The occupant density, heat gain, and schedule shall be for multifamily, office, retail, library, hotel/motel or school as specified by ASHRAE Standard 90.1 Normative Appendix C.

C408.6.1.4 Envelope Components. Building envelope components modeled in the standard reference design and the proposed design shall comply with the requirements of this Section.

C408.6.1.4.1 Roofs. Roofs will be modeled with insulation above a steel roof deck. The roof U-factor and area shall be modeled as in the proposed design. If different roof thermal properties are present in a single block, an area weighted U-factor shall be used. Roof solar absorptance shall be modeled at 0.70 and emittance at 0.90.

C408.6.1.4.2 Above grade walls. Walls will be modeled as steel frame construction. The U-factor and area of above grade walls shall be modeled as in the proposed design. If different wall constructions exist on the façade of a block an area-weighted U-factor shall be used.

C408.6.1.4.3 Below grade walls. The C-factor and area of below grade walls shall be modeled as in the proposed design. If different slab on grade floor constructions exist in a block, an area-weighted C- factor shall be used.

C408.6.1.4.4 Above grade exterior floors. Exterior floors shall be modeled as steel frame. The U-factor and area of floors shall be modeled as in the proposed design. If different wall constructions exist in the block an area-weighted U-factor shall be used.

C408.6.1.4.5 Slab on grade floors. The F-factor and area of slab on grade floors shall be modeled as in the proposed design. If different below grade wall constructions exist in a block, an area-weighted F- factor shall be used.

C408.6.1.4.6 Vertical Fenestration. The window area and area weighted U-factor and SHGC shall be modeled for each façade based the proposed design. Each exterior surface in a block must comply with Section C408.6.1.1.1 item 5. Windows will be combined into a single window centered on each façade based on the area and sill height input by the user. When different U values, SHGC or sill heights exist on a single facade, area weighted average for each shall be input by the user.

C408.6.1.4.7 Skylights. The skylight area and area weighted U-factor and SHGC shall be modeled for each floor based the proposed design. Skylights will be combined into a single skylight centered on the roof of each zone based on the area input by the user

C408.6.1.4.8 Exterior Shading. Permanent window overhangs shall be modeled. When windows with and without overhangs or windows with different overhang projection factors exist on a façade, window width weighted projection factors shall be input by the user as follows.

C408.6.1.5 Lighting. Interior lighting power density shall be equal to the allowance in Table C405.4.2(1) for multifamily, office, retail, library, or school. The lighting schedule shall be for multifamily, office, retail, library, or school as specified by ASHRAE Standard 90.1 Normative Appendix C. The impact of lighting controls is assumed to be captured by the lighting schedule and no explicit controls shall be modeled. Exterior lighting shall not be modeled.

C408.6.1.6 Miscellaneous equipment. The miscellaneous equipment schedule and power shall be for multifamily, office, retail, library, or school as specified by ASHRAE Standard 90.1 Normative Appendix C. The impact of miscellaneous equipment controls is assumed to be captured by the equipment schedule and no explicit controls shall be modeled.

Exceptions:

1. Multifamily dwelling units shall have a miscellaneous load density of 0.42 W/ft2
2. Multifamily common areas shall have a miscellaneous load density of 0 W/ft2

C408.6.1.7 Elevators. Elevators shall not be modeled.

C408.6.1.8 Service water heating equipment. Service water heating shall not be modeled.

C408.6.1.9 On-site renewable energy systems. On-site Renewable Energy Systems shall not be modeled.

C408.6.1.10 HVAC Equipment. HVAC systems shall meet the requirements of Section C403 Mechanical Systems.

C408.6.1.10.1 Supported HVAC systems. At a minimum, the HVAC systems shown in Table C408.6.1.10.1 shall be supported by the simulation program.

Table C408.6.1.10.1 PROPOSED BUILDING HVAC SYSTEMS SUPPORTED BY HVAC TSPR SIMULATION SOFTWARE

System No.	System Name	System Abbreviation
1	Packaged Terminal Air Conditioner	PTAC
2	Packaged Terminal Air Heat Pump	PTHP
3	Packaged Single Zone Gas Furnace	PSZGF
4	Packaged Single Zone Heat Pump (air to air only)	PSZHP
5	Variable Refrigerant Flow (air cooled only)	VRF
6	Four Pipe Fan Coil	FPFC
7	Water Source Heat Pump	WSHP
8	Ground Source Heat Pump	GSHP
9	Packaged Variable Air Volume (DX cooling)	PVAV
10	Variable Air Volume (hydronic cooling)	VAV
11	Variable Air Volume with Fan Powered Terminal Units	VAVFPTU
12	Dedicated Outdoor Air System (in conjunction with systems 1-8)	DOAS

C408.6.1.10.2 Proposed building HVAC system simulation. The HVAC systems shall be modeled as in the proposed design at design conditions unless otherwise stated with clarifications and simplifications as described in Tables C408.6.1.10.2(1) and C408.6.1.10.2(2). System parameters not described in the following sections shall be simulated to meet the minimum requirements of Section C403. All zones within a block shall be served by the same HVAC system type as described in Section C408.6.1.1.1 item 2. Heat loss from ducts and pipes shall not be modeled. Table C408.6.1.10.1 proposed building HVAC parameter requirements are based on input of full-load equipment efficiencies with adjustment using part-load curves integrated in the simulation program. Where other approaches to part-load adjustment are used, it is permitted for specific input parameters to vary.

The simulation program shall model part-load HVAC equipment performance using either:

a. full-load efficiency adjusted for fan power input that is modeled separately and typical part- load performance adjustments for the proposed equipment,
b. part-load adjustments based on input of both full- load and part- load metrics, or
c. equipment- specific adjustments based on performance data provided by the equipment manufacturer for the proposed equipment.

For packaged single-zone air conditioners (cooling only), water-loop heat pumps, ground-source heat pumps and packaged rooftop heat pumps, heating COP and cooling COP, exclusive of fan power, shall be determined using the following equations:

For Systems 4, 7, and 8 heating efficiency

$$COP_{nfheating} = 1.48E\text{-}7 \times COP47 \times Q + 1.062 \times COP47$$

For System 3 heating efficiency

$$COP_{nfheating} = -0.0296 \times HSPF2 + 0.7134 \times HSPF$$

For System 4, 7, 8, and 9 cooling efficiency

$$COP_{nfcooling} = 7.84E\text{-}8 \times EER \times Q + 0.338 \times EER$$

For System 1 and 2 cooling efficiency

$$COP_{nfcooling} = -0.0076 \times SEER2 + 0.3796 \times SEER$$

For System 1 and 2 cooling efficiency

$$COP_{nfcooling} = 0.3322 \times EER - 0.2145$$

For System 2 heating efficiency

$$COP_{nfheating} = 1.1329 \times COP - 0.214$$

Where:

EER, SEER, COP and HSPF shall be at AHRI full load test conditions

Q = AHRI rated cooling capacity in BTU/h. If Q > 760,000BTU/h use 760,000 in the calculation

Where multiple system components serve a block, average values weighed by the appropriate metric as described in this section shall be used.

1. Where multiple fan systems serve a single block, fan power shall be based on weighted average using the design supply air cfm
2. Where multiple cooling systems serve a single block, COP shall be based on a weighted average using cooling capacity. DX coils shall be entered as multi-stage if more than 50% of coil capacity serving the block is multi-stage with staged controls.
3. Where multiple heating systems serve a single block, thermal efficiency or heating COP shall be based on a weighted average using heating capacity.
4. Where multiple boilers or chillers serve a heating water or chilled water loop, efficiency shall be based on a weighted average for using heating or cooling capacity.
5. When multiple cooling towers serving a condenser water loop are combined, the cooling tower efficiency, cooling tower design approach and design range are based on a weighted average of the design water flow rate through each cooling tower.
6. Where multiple pumps serve a heating water, chilled water or condenser water loop, pump power shall be based on a weighted average for using design water flow rate.
7. When multiple system types with and without economizers are combined, the economizer maximum outside air fraction of the

combined system shall be based on weighted average of 100% supply air for systems with economizers and design outdoor air for systems without economizers.

8. Multiple systems with and without ERVs cannot be combined.
9. Systems with and without supply air temperature reset cannot be combined.
10. Systems with different fan control (constant volume, multi-speed or VAV) for supply fans cannot be combined.

TABLE C408.6.1.10.2(1) PROPOSED BUILDING SYSTEM PARAMETERS

Category	Parameter	Fixed or User Defined	Required	Applicable Systems
HVAC System Type	System Type	User Defined	Selected from Table CD105.2.10.1	All
System Sizing	Design Day Information	Fixed	99.6% heating design and 1% dry-bulb and 1% wet-bulb cooling design	All
	Zone Coil Capacity	Fixed	Sizing factors used are 1.25 for heating equipment and 1.15 for cooling equipment	All
	Supply Airflow	Fixed	Based on a supply-air-to-room-air temperature *set-point* difference of 20°F or	1-11
		Fixed	Equal to required outdoor air ventilation	12
Outdoor Ventilation Air	Portion of supply air with proposed Filter ≥MERV 13	User-defined	Percentage of supply air flow subject to higher filtration (Adjusts baseline Fan Power higher. Prorated)	All
	Outdoor Ventilation Air Flow Rate	Fixed	As specified in ASHRAE Standard 90.1 Normative Appendix C, adjusted for proposed DCV control	All
	Outdoor *Ventilation* Supply Air Flow Rate Adjustments	Fixed	Based on ASHRAE Standard 62.1 Section 6.2.4.3 System Ventilation Efficiency (Evs) is 0.75	9-11
		Fixed	System Ventilation Efficiency (Evs) is 1.0	1-8, 12
		Fixed	Basis is 1.0 Zone Air Distribution Effectiveness	All
System Operation	Space temperature Set points	Fixed	As specified in ASHRAE Standard 90.1 Normative Appendix C, except multifamily which shall use 68 deg. F heating and 76 deg. F cooling setpoints	1-11
	Fan Operation – Occupied	User Defined	Runs continuously during occupied hours or cycles to meet load. Multispeed fans reduce airflow related to thermal loads.	1-11
	Fan Operation – Occupied	Fixed	Fan runs continuously during occupied hours	12
	Fan Operation – Night Cycle	Fixed	Fan cycles on to meet setback temperatures	1-11
Packaged Equipment Efficiency	DX Cooling Efficiency	User Defined	Cooling COP without fan energy calculated in accordance with Section CD105.2.10.2	1, 2, 3, 4, 5,7, 8, 9, 11,12
	DX Coil Number of Stages	User-defined	Single Stage or Multistage	3, 4, 9
	Heat Pump Efficiency	User Defined	Heating COP without fan energy calculated in accordance with Section CD105.2.10.2	2, 4, 5, 7, 8
	Furnace Efficiency	User Defined	Furnace thermal efficiency[c]	3, 11
Heat Pump Supplemental Heat	Control	Fixed	Supplemental electric heat locked out above 40°F. Runs In conjunction with compressor between 40°F and 0°F.	2, 4

Category	Parameter	Fixed or User Defined	Required	Applicable Systems
System Fan Power and Controls	Part-load Fan Controls	User-defined	Constant volume or two speed	1-8
	Part-load Fan Controls[a]	User-defined	Constant volume or variable air volume	12
	Part-load Fan Controls[a]	Fixed	Variable air volume. VFD with static pressure reset	9-11
	Design Fan Power (W/cfm)	User Defined	Input electric power for all fans in required to operate at fan system design conditions divided by the supply airflow rate This is a “wire to air” value including all drive, motor efficiency and other losses.	All
	Low-speed fan power	User Defined	Low speed input electric power for all fans required to operate at low speed conditions divided by the low speed supply airflow rate. This is a “wire to air” value including all drive, motor efficiency and other losses.	1-8
Variable Air Volume Systems	Supply Air Temperature (SAT) Controls	User defined	If not SAT reset then constant at 55°F. Options for reset based on outside air temperature (OAT) or warmest zone. If warmest zone, then the user can specify the minimum and maximum temperatures. If OAT reset, SAT is reset higher to 60°F at outdoor low of 50°F. SAT is 55°F at outdoor high of 70°F.	9, 10, 11
	Minimum Terminal Unit airflow percentage	User Defined	Average minimum terminal unit airflow percentage for block weighted by cfm or minimum required for outdoor air ventilation, whichever is higher.	9, 10, 11
	Terminal Unit Heating Source	User Defined	Electric or hydronic	9, 10, 11
	Dual set point minimum VAV damper position	User-defined	Heating maximum airflow fraction	9,10.
	Fan Powered Terminal Unit (FPTU) Type	User Defined	Series or parallel FPTU	11
	Parallel FPTU Fan	Fixed	Sized for 50% peak primary air at 0.35 W/cfm	11
	Series FPTU Fan	Fixed	Sized for 50% peak primary air at 0.35 W/cfm	11
Economizer	Economizer Presence	User Defined	Yes or No	3, 4, 9, 10,11
	Economizer Control Type	Fixed	Differential dry-bulb	3, 4, 9, 10,11
Energy Recovery	Sensible Effectiveness	User Defined	Heat exchanger sensible effectiveness at design heating and cooling conditions	3, 4, 9, 10, 11, 12
	Latent Effectiveness	User Defined	Heat exchanger latent effectiveness at design heating and cooling conditions	3, 4, 9, 10, 11, 12

	Economizer Bypass	User Defined	If ERV is bypassed during economizer conditions	3, 4, 9, 10, 11, 12
	Bypass SAT Setpoint	User Defined	If bypass, target supply air temperature	3, 4, 9, 10, 11, 12
	Fan Power Reduction during Bypass (W/cfm)	User Defined	If ERV system include bypass, static pressure set point and variable speed fan, fan power can be reduced during economizer conditions	3, 4, 9, 10, 11, 12
Demand Controlled Ventilation	DCV Application	User Defined	Percent of block floor area under DCV control	3, 4, 9, 10, 11, 12
DOAS	DOAS Fan Power W/cfm	User Defined	Fan electrical input power in W/cfm of supply airflow[a]	12
	DOAS Supplemental Heating and Cooling	User Defined	Heating source, cooling source	12
	Maximum SAT Set point (Cooling)	User-defined	SAT set point if DOAS includes supplemental cooling	12
	Minimum SAT Set point (Heating)	User-defined	SAT set point if DOAS includes supplemental heating	12
Heating Plant	Boiler Efficiency[d]	User Defined	Boiler thermal efficiency	1, 6, 7, 9, 10, 11, 12
	Heating Water loop Configuration[a]	User-defined	Constant flow primary only; Variable flow primary only; Constant flow primary – variable flow secondary	1, 6, 7, 9, 10, 11, 12
	Heating Water Primary Pump Power (W/gpm)	User-defined	Heating water primary pump input W/gpm heating water flow	1, 6, 7, 9, 10, 11, 12
	Heating Water Secondary Pump Power (W/gpm)	User-defined	Heating water secondary pump input W/gpm heating water flow (if primary/secondary)	1, 6, 7, 9, 10, 11, 12
	Heating Water Loop Temperature	Fixed	180°F supply, 130°F return	1, 6, 9, 10,11
	Boiler Type	Fixed	Non-condensing boiler where input thermal efficiency is less than 86%; Condensing boiler otherwise	1, 6, 7, 9, 10, 11, 12
Chilled Water Plant	Chiller Compressor Type	User Defined	Screw/Scroll, Centrifugal or Reciprocating	6,1 0, 11, 12
	Chiller Condenser Type	User Defined	Air cooled or water cooled	6, 10, 11, 12
	Chiller Full Load Efficiencyd	User Defined	Chiller COP	6, 10, 11, 12
	Chilled Water loop Configuration[a]	User Defined	Variable flow primary only, constant flow primary – variable flow secondary	6, 10, 11, 12
	Chilled Water Primary Pump Power (W/gpm)	User-defined	Primary pump input W/gpm chilled water flow	6, 10, 11,12
	Chilled Water Secondary Pump Power (W/gpm)	User-defined	Secondary Pump input W/gpm chilled water flow (if primary/secondary)	6, 10, 11,12

	Chilled Water Temperature Reset Included	User Defined	Yes/No	6, 10, 11,12
	Chilled Water Temperature Reset Schedule (if included)	Fixed	Outdoor air reset: CHW supply temperature of 44°F at 80°F outdoor air dry bulb and above, CHW supply temperature of 54°F at 60°F outdoor air dry bulb temperature and below, ramped linearly between	6, 10, 11,12
	Condenser Water Pump Power (W/gpm)	User Defined	Pump input W/gpm condenser water flow	6, 7, 8, ,10, 11, 12
	Condenser Water Pump Control	User Defined	Constant speed or variable speed	6, 7, 8, 10, 11,12
	Cooling Tower Efficiency	User Defined	gpm/hp tower fan	6, 7, 10, 11,12
	Cooling Tower Fan Control	User Defined	Constant or variable speed	6, 7, 10, 11,12
	Cooling Tower Approach and Range	User Defined	Design cooling tower approach and range temperature	6, 7, 10, 11,12
Heat Pump Loop Flow Control	Loop flow and Heat Pump Control Valve	Fixed	Two position Valve with VFD on Pump. Loop flow at 3 gpm/ton	7, 8
Heat Pump Loop Temperature Control		Fixed	Set to maintain temperature between 50°F and 70°F	7
GLHP Well Field		Fixed	Bore depth = 250' Bore length 200'/ton for greater of cooling or heating load Bore spacing = 15' Bore diameter = 5" ¾" Polyethylene pipe Ground and grout conductivity = 4.8 Btu-in/h-ft2-0F	8

a. Part load fan power and pump power modified in accordance with Table C408.6.1.10.2(2)

TABLE C408.6.1.10.2(2) FAN AND PUMP Power CURVE COEFFICIENTS

Equation Term	Fan Power Coefficients	Pump Power Coefficients	
	VSD + SP reset	Ride Pump Curve	VSD + DP/valve reset
b	0.0408	0	0
x	0.088	3.2485	0.0205
x^2	-0.0729	-4.7443	0.4101
x^3	0.9437	2.5295	0.5753

C408.6.1.10.3 Demand Control Ventilation. Demand Controlled Ventilation (DCV) shall be modeled using a simplified approach that adjusts the design outdoor supply air flow rate based on the floor area of the building that is covered by DCV. The simplified method shall accommodate both variable DCV and on/off DCV, giving on/off DCV one third the effective floor control area of variable DCV. Outdoor air reduction coefficients shall be as stated in Table C408.6.1.10.3.

Exception: On/off DCV shall receive full effective area adjustment for R-1 and R-2 occupancies.

Table C408.6.1.10.3 DCV Outdoor Air Reduction Curve Coefficients

Equation Term	*DCV* OSA reduction (y) as a function of effective *DCV* control floor area (x)			
	Office	**School**	**Hotel; Motel; Multi-Family; Dormitory**	**Retail**
b	0	0	0	0
x	0.4053	0.2676	0.5882	0.4623
x^2	-0.8489	0.7753	-1.0712	-0.848
x^3	1.0092	-1.5165	1.3565	1.1925
x^4	-0.4168	0.7136	-0.6379	-0.5895

C408.6.2 Simulation of the standard reference design. The standard reference design shall be configured and analyzed as specified in this section.

C408.6.2.1 Utility Rates. Same as proposed design.

C408.6.2.2 Blocks. Same as proposed design.

C408.6.2.3 Thermal zoning. Same as proposed design.

C408.6.2.4 Occupancy type, schedule, density, and heat gain. Same as proposed design.

C408.6.2.5 Envelope components. Same as proposed design.

C408.6.2.6 Lighting. Same as proposed design.

C408.6.2.7 Miscellaneous equipment. Same as proposed design.

C408.6.2.8 Elevators. Not modeled. Same as proposed design.

C408.6.2.9 Service water heating equipment. Not modeled. Same as proposed design.

C408.6.2.10 On-site renewable energy systems. Not modeled. Same as proposed design.

C408.6.2.11 HVAC equipment. The reference building design HVAC equipment consists of separate space conditioning systems as described in Table C408.6.2.11(1) through Table C408.6.2.11(3) for the appropriate building use types.

Table C408.6.2.11(1) Reference Building Design HVAC Complex Systems

Building Type Parameter	**Large Office**	**School**

System Type	*VAV*/ RH Water-cooled Chiller/ Gas *Boiler*	*VAV*/ RH Water-cooled Chiller/ Gas *Boiler*
Fan control	VSD (No SP Reset)	VSD (No SP Reset)
Main fan power (W/CFM (W·s/L) Proposed ≥ MERV13	1.165 (2.468)	1.165 (2.468)
Main fan power (W/CFM (W·s/L) proposed < MERV13	1.066 (2.259)	1.066 (2.259)
Zonal fan power (W/CFM (W·s/L))	NA	NA
Minimum zone airflow fraction	1.5* Voz	1.2 * Voz
Heat/cool sizing factor	1.25/1.15	1.25/1.15
Outdoor air economizer	Yes except 4A	Yes except 4A
Occupied OSA (= proposed)	Sum(Voz)/0.75	Sum(Voz)/0.65
Energy recovery ventilator *efficiency* ERR (Enthalpy Recovery Ratio) ERV bypass SAT *set point*	NA	50% 60°F
DCV	No	No
Cooling Source	(2) Water- cooled Centrifugal Chillers	(2) Water- Cooled Screw Chillers
Cooling *COP* (net of fan)	Path B for profile	Path B for profile
Heating source (reheat)	Gas *Boiler*	Gas *Boiler*
Furnace or *boiler efficiency*	75% Et	80% Et
Condenser heat rejection	Cooling tower	Cooling tower
Cooling tower *efficiency* (gpm/fan-hp)	38.2	38.2
Tower turndown (> 300 ton (1060 *kW*))	50%	50%
Pump (constant flow/variable flow)	Constant Flow; 10°F (5.6°C) range	Constant Flow; 10°F (5.6°C) range
Tower Approach	25.72 – (0.24 x WB), where WB is the 0.4% evaporation design wet-bulb temperature (°F)	
Cooling condenser *pump* power (W/gpm)	19	19
Cooling primary *pump* power (W/gpm)	9	9
Cooling secondary *pump* power (W/gpm)	13	13
Cooling coil chilled water delta- T, °F	12	12
Design chilled water supply temperature, °F	44	44
Chilled water supply temperature (CHWST) reset *set point* vs OAT, °F (°C)	CHWST/OAT :44-54/ 80-60 (6.7-12.2/26.7-15.6)	CHWST/OAT :44-54/ 80-60 (6.7-12.2/26.7-15.6)
CHW cooling loop pumping control	2-way Valves & pump VSD	2-way Valves & pump VSD
Heating pump power (W/gpm)	16.1	19
Heating oil HW dT. °F	50	50
Design Hot Water Supply Temperature (HWST). °F	180	180

HWST reset set point vs OAT, °F	HWST: 180-150/ OAT 20- 50 (82-65.6/ -6.7-10)	HWST: 180-150/ OAT 20- 50 (82-65.6/ -6.7-10)
Heat loop pumping control	2-way Valves & pump VSD	2-way Valves & pump VSD

Table C408.6.2.11(3) TSPR Reference Building Design HVAC Simple Systems

Building Type Parameter	**Hotel**	**Multifamily**
System type	*PTAC*	*PTAC*
Fan control	Constant Volume	Constant Volume
Main fan power (W/CFM (W·s/L))	0.300 (0.636)	0.300 (0.636)
Heat/cool sizing factor	1.25/1.15	1.25/1.15
Supplemental heating availability	NA	NA
Outdoor air economizer	No	No
Occupied OSA source	Packaged unit, occupied damper	Packaged unit, occupied damper
Energy recovery ventilator	No	No
DCV	No	No
Cooling source	DX, 1 stage	DX, 1 stage
Cooling *COP* (net of fan)	3.20	3.20
Heating source	(2) Hydronic *Boiler*	(2) Hydronic *Boiler*
Heating *COP* (net of fan) / furnace or *boiler efficiency*	75% E_t	75% E_t
Heating *pump* power (W/gpm (W·s/L))	19 (300)	19 (300)
Heating coil heating water delta-T, °F (°C)	50 (27.8)	50 (27.8)
Design HWST, °F (°C)	180 (82.2)	180 (82.2)
HWST reset *set point* vs OAT, °F (°C)	HWST: 180-150/ OAT 20-50 (82-65.6/ -6.7-10)	HWST: 180-150 / OAT 20-50 (82-65.6/ -6.7-10)
Heat loop *pump*ing control	2-way Valves & ride *pump* curve	2-way Valves & ride *pump* curve

CHAPTER 5 [CE]
EXISTING BUILDINGS

SECTION C501
GENERAL

C501.1 Scope.
The provisions of this chapter shall control the *alteration, repair, addition* and *change of occupancy* of existing buildings and structures.

C501.1.1~~2~~ Existing buildings.
Except as specified in this chapter, this code shall not be used to require the removal, *alteration* or abandonment of, nor prevent the continued use and maintenance of, an existing *building* or *building* system lawfully in existence at the time of adoption of this code.

C501.2 Compliance.
Additions, alterations, repairs, and changes of occupancy to, or relocation of, existing *buildings* and structures shall comply with Sections C502, C503, C504 and C505 of this code, as applicable, and with the provisions for *alterations, repairs, additions* and changes of occupancy or relocation, respectively, in the *International Building Code, International Existing Building Code, International Fire Code, International Fuel Gas Code, International Plumbing Code, International Property Maintenance Code, International Private Sewage Disposal Code*, ANSI/SMACNA 006 *HVAC Duct Construction Standards*, ASHRAE Standard 62.1, and NFPA 70. Changes where unconditioned space is changed to conditioned space shall comply with Section C502.

Exception: Additions, alterations, repairs or changes of occupancy complying with ANSI/ASHRAE/IESNA 90.1.

C501.3 Maintenance.
Buildings and structures, and parts thereof, shall be maintained in a safe and sanitary condition. Devices and systems required by this code shall be maintained in conformance to the code edition under which they were installed. The owner or the owner's authorized agent shall be responsible for the maintenance of buildings and structures. The requirements of this chapter shall not provide the basis for removal or abrogation of energy conservation, fire protection and safety systems and devices in existing structures.

~~**C501.4 Compliance.**~~
~~*Alterations, repairs, additions* and changes of occupancy to, or relocation of, existing *buildings* and structures shall comply with the provisions for *alterations, repairs, additions* and changes of occupancy or relocation, respectively, in this code and in the *International Building Code, International Existing Building Code, International Fire Code, International Fuel Gas Code, International Plumbing Code, International Property Maintenance Code, International Private Sewage Disposal Code*, ANSI/SMACNA 006 *HVAC Duct Construction Standards*, ASHRAE Standard 62.1, and NFPA 70.~~

C501.4~~5~~ New and replacement materials.
Except as otherwise required or permitted by this code, materials permitted by the applicable code for new construction shall be used. Like materials shall be permitted for *repairs*, provided that

hazards to life, health or property are not created. Hazardous materials shall not be used where the code for new construction would not allow use of these materials in buildings of similar occupancy, purpose and location.

C501.5~~6~~ Historic buildings.
Provisions of this code relating to the construction, *repair, alteration*, restoration and movement of structures, and *change of occupancy* shall not be mandatory for *historic buildings* provided that a "Historic Building Exemption Report" obtained from the State Historic Preservation Office, has been submitted to the State Historic Preservation Office and signed by the owner, an owner's agent, a *registered design professional*, a representative of the State Historic Preservation Office or the historic preservation authority having jurisdiction, demonstrating that compliance with that provision would threaten, degrade or destroy the historic form, fabric or function of the *building*. The State Historic Preservation Office, upon receipt of the report, will review and validate the exemption request. Upon request, a copy of the report shall be provided to the *code official or authority having jurisdiction*.

SECTION C502
ADDITIONS

C502.1 General.
Additions to an existing *building, building* system or portion thereof shall conform to the provisions of this code as those provisions relate to new construction without requiring the unaltered portion of the existing *building* or *building* system to comply with this code. *Additions* shall not create an unsafe or hazardous condition or overload existing *building* systems. An *addition* shall be deemed to comply with this code if the *addition* alone complies or if the existing building and *addition* comply with this code as a single building. *Additions* shall comply with Sections C402, C403, C404, C405 and C502.2.

Additions complying with ANSI/ASHRAE/IESNA 90.1. need not comply with Sections C402, C403, C404 and C405.

C502.2 Change in space conditioning.
Any nonconditioned or low-energy space that is altered to become conditioned space shall be required to comply with Section C502.

Exceptions:

1. Where the component performance alternative in Section C402.1.5 is used to comply with this section, the proposed UA shall be not greater than 110 percent of the target UA.

2. Where the total building performance option in Section C407 is used to comply with this section, the annual energy cost of the proposed design shall be not greater than 110 percent of the annual energy cost otherwise permitted by Section C407.2.

C502.~~2~~3 ~~Prescriptive c~~Compliance.
Additions shall comply with Sections C502.2.1 through C502.2.6.2.

C502.3~~2~~.1 Vertical fenestration.
Additions shall comply with the following:

1. Where an addition has a ~~N~~new *vertical fenestration* area that results in a total building *fenestration* area less than or equal to that ~~specified in~~permitted by Section C402.3.1, the addition shall comply with Section C402.1.3 or C402.3.3.
2. *Where an a~~A~~ddition~~s~~* with *vertical fenestration* that results in a total building *fenestration* area greater than Section C402.3.1 or *additions* that exceed the fenestration area greater than that permitted by Section C402.3.1, the fenestration shall comply with Section C402.3.1.1 for the *addition* only.
3. ~~*Additions*~~ Where an addition has vertical fenestration that results ~~that result~~ in a total building vertical fenestration area exceeding that ~~specified in~~permitted by Section C402.3.1.1, the addition shall comply with Section C402.1.3.

C502.3~~2~~.2 Skylight area.
Skylights shall comply with the following:
1. ~~New~~ Where an addition has a new *skylight* area that results in a total building *fenestration* area less than or equal to that ~~specified in~~permitted by Section C402.3.1, the addition shall comply with shall comply with Section C402.1.3.
2. ~~*Additions* with~~Where an addition has a new *skylight* area that results in a total building *skylight* area greater than C402.3.1 or additions ~~that exceed~~have skylight area greater than that permitted by ~~the *skylight* area shall comply with~~ Section C402.3.1.2 for the *addition* only.
3. ~~*Additions*~~ Where an addition has skylight area that results in a total building skylight area exceeding that ~~specified in~~permitted by Section C402.3.1.2, the addition shall comply with Section C402.1.3.

C502.3~~2~~.3 Building mechanical systems.
New mechanical systems and equipment that are part of the *addition* and serve the building heating, cooling and ventilation needs shall comply with Section C403 and C407.

C502.3~~2~~.4 Service water-heating systems.
New service water-heating equipment, controls and service water heating piping shall comply with Section C404.

C502.3~~2~~.5 Pools and inground permanently installed spas.
New pools and inground permanently installed spas shall comply with Section C404.10.

C502.3~~2~~.6 Lighting power and systems.
New lighting systems that are installed as part of the addition shall comply with Section C405 and C407.

C502.~~2~~3.6.1 Interior lighting power.
The total interior lighting power for the *addition* shall comply with Section C405.3.2 for the *addition* alone, or the existing building and the *addition* shall comply as a single building.

C502.~~2~~3.6.2 Exterior lighting power.
The total exterior lighting power for the *addition* shall comply with Section C405.4.2 for the *addition* alone, or the existing building and the *addition* shall comply as a single building.

SECTION C503
ALTERATIONS

C503.1 General.
Alterations to any *building* or structure shall comply with the requirements of Section C503~~ and the code for new construction~~. *Alterations* shall be such that the existing *building* or structure is not less conforming to the provisions of this code than the *existing building* or structure was prior to the *alteration. Alterations* to an existing *building, building* system or portion thereof shall conform to the provisions of this code as those provisions relate to new construction without requiring the unaltered portions of the existing *building* or *building* system to comply with this code. *Alterations* shall not create an unsafe or hazardous condition or overload existing *building* systems.

Alterations complying with ANSI/ASHRAE/IESNA 90.1. need not comply with Sections C402, C403, C404 and C405.

Exception: The following *alterations* need not comply with the requirements for new construction, provided that the energy use of the building is not increased:

1. Storm windows installed over existing *fenestration*.
2. Surface-applied window film installed on existing single-pane *fenestration* assemblies reducing solar heat gain, provided that the code does not require the glazing or *fenestration* to be replaced.
3. Existing ceiling, wall or floor cavities exposed during construction, provided that these cavities are filled with insulation.
4. Construction where the existing roof, wall or floor cavity is not exposed.
5. Replacement of existing electrical resistance unit.
6. *Roof recover*.
7. *Air barriers* shall not be required for *roof recover* and roof replacement where the *alterations* or renovations to the building do not include *alterations*, renovations or *repairs* to the remainder of the building envelope.

C503.2 Change in space conditioning.
Any nonconditioned or low-energy space that is altered to become *conditioned space* shall be required to be brought into full compliance with this code.

Exception: Where the component performance alternative in Section C402.1.3 is used to comply with this section, the proposed UA shall be not greater than 110 percent of the target UA.

C503.2~~3~~ Building envelope.
New building envelope assemblies that are part of the *alteration* shall comply with Sections C402.1 through C402.4.

Exception: Where the existing building exceeds the fenestration area limitations of Section C402.3.1 prior to alteration, the building is exempt from Section C402.3.1 provided that there is not an increase in fenestration area.

C503.~~3~~2.1 Roof replacement.
Roof replacements shall comply with Section C402.1.1, C402.1.2 or C402.1.3 where the existing roof assembly is part of the *building thermal envelope* and contains insulation entirely above the roof deck. In no case shall the R-value of the roof insulation be reduced or the U-factor of the roof assembly be increased as part of the roof replacement.

C503.2~~3~~.2 Vertical fenestration.
The addition of *vertical fenestration* that results in a total building *fenestration* area less than or equal to that specified in Section C402.3.1 shall comply with Section C402.1.3 or C402.3.3. The addition of *vertical fenestration* that results in a total building *fenestration* area greater than Section C402.3.1 shall comply with Section C402.3.1.1 for the space adjacent to the new fenestration only. *Alterations* that result in a total building *vertical fenestration* area exceeding that specified in Section C402.3.1.1 shall comply with Section C402.1.3.

C503.2.2.1 Application to replacement fenestration products.
Where some or all of an existing fenestration unit is replaced with a new fenestration product, including sash and glazing, the replacement fenestration unit shall meet the applicable requirements for U-factor and SHGC in Table C402.4. If the fenestration involves a historic building consult with SHPO regarding the "Historic Building Exemption Report" (R501.6 Historic buildings).

> **Exception:** An area-weighted average of the U-factor of replacement fenestration products being installed in the building for each fenestration product category listed in Table C402.4 shall be permitted to satisfy the U-factor requirements for each fenestration product category listed in Table C402.4. Individual fenestration products from different product categories listed in Table C402.4 shall not be combined in calculating the area-weighted average U-factor.

C503.~~3~~2.3 Skylight area.
New *skylight* area that results in a total building *skylight* area less than or equal to that specified in Section C402.3.1 shall comply with Section C402.1.3 or C402.3. The addition of *skylight* area that results in a total building skylight area greater than Section C402.3.1 shall comply with Section C402.3.1.2 for the space adjacent to the new skylights. *Alterations* that result in a total building skylight area exceeding that specified in Section C402.3.1.2 shall comply with Section C402.1.3.

C503.4 Heating and cooling systems.
New heating, cooling and duct systems that are part of the *alteration* shall comply with Sections C403 and C407.

C503.4.1 Economizers.
New cooling systems that are part of *alteration* shall comply with Section C403.5.

C503.5 Service hot water systems.
New service hot water systems that are part of the *alteration* shall comply with Section C404 and C407.

C503.6 Lighting systems.
New lighting systems that are part of the *alteration* shall comply with Section C405 and C407.

> **Exception:** *Alterations* that replace less than 10 percent of the luminaires in a space, provided that such *alterations* do not increase the installed interior lighting power.

SECTION C504
REPAIRS

C504.1 General.
Buildings and structures, and parts thereof, shall be repaired in compliance with Section C501.3 and this section. Work on nondamaged components that is necessary for the required *repair* of damaged components shall be considered to be part of the *repair* and shall not be subject to the requirements for *alterations* in this chapter. Routine maintenance required by Section C501.3, ordinary *repairs* exempt from *permit* and abatement of wear due to normal service conditions shall not be subject to the requirements for *repairs* in this section.

Where a building was constructed to comply with ANSI/ASHRAE/IESNA 90.1, repairs shall comply with the standard and need not comply with Sections C402, C403, C404 and C405.

C504.2 Application.
For the purposes of this code, the following shall be considered to be repairs:

1. Glass-only replacements in an existing sash and frame.
2. *Roof repairs*.
3. Air barriers shall not be required for *roof repair* where the repairs to the building do not include *alterations*, renovations or *repairs* to the remainder of the building envelope.
4. Replacement of existing doors that separate conditioned space from the exterior shall not require the installation of a vestibule or revolving door, provided that an existing vestibule that separates a conditioned space from the exterior shall not be removed.
5. *Repairs* where only the bulb, the ballast or both within the existing luminaires in a space are replaced, provided that the replacement does not increase the installed interior lighting power.

SECTION C505
CHANGE OF OCCUPANCY OR USE

C505.1 General.
Spaces undergoing a change in occupancy that would result in an increase in demand for either fossil fuel or electrical energy shall comply with this code. Where the use in a space changes from one use in Table C405.3.2(1) or C405.3.2(2) to another use in Table C405.3.2(1) or C405.3.2(2), the installed lighting wattage shall comply with Section C405.3. Where the space undergoing a change in occupancy or use is in a building with a fenestration area that exceeds the limitations of

Section C402.3.1, the space is exempt from Section C402.3.1 provided that there is not an increase in fenestration area.

> **Exception:** Where the component performance alternative in Section C402.1.3 is used to comply with this section, the proposed UA shall be not greater than 110 percent of the target UA.

CHAPTER 6 [CE]
REFERENCED STANDARDS

AAMA

American Architectural
Manufacturers Association
1827 Walden Office Square
Suite 550
Schaumburg, IL 60173-4268

AAMA/WDMA/CSA 101/I.S.2/A C440—17: North American Fenestration Standard/Specifications for Windows, Doors and Unit Skylights

Table C402.5.2

AHAM

Association of Home
Appliance Manufacturers
1111 19th Street NW, Suite 402
Washington, DC 20036

ANSI/AHAM RAC-1—~~2008~~2015: Room Air Conditioners

Table C403.3.2(3)

AHAM HRF-1—2016: Energy, Performance and Capacity of Household Refrigerators, Refrigerator-Freezers and Freezers

Table C403.10.1

AHRI

Air-Conditioning, Heating, &
Refrigeration Institute
2111 Wilson Blvd, Suite 500
Arlington, VA 22201

ISO/AHRI/ASHRAE 13256-1 (~~1998 RA2014~~2012): Water-to-Air and Brine-to-Air Heat Pumps—Testing and Rating for Performance

Table C403.3.2(2)

ISO/AHRI/ASHRAE 13256-2 (1998 RA2014): Water-to-Water and Brine-to-Water Heat Pumps —Testing and Rating for Performance

Table C403.3.2(2)

210/240—~~2016~~2017 and 2023: Performance Rating of Unitary Air-conditioning and Air-source Heat Pump Equipment

Table C403.3.2(1), Table C403.3.2(2)

310/380—~~2014~~ 2017 (CSA-C744-~~04~~17): Standard for Packaged Terminal Air Conditioners and Heat Pumps

Table C403.3.2(3)

340/360—~~2015~~2019: Performance Rating of Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment
Table C403.3.2(1), Table C403.3.2(2)

365(I-P)—2009: Commercial and Industrial Unitary Air-conditioning Condensing Units
Table C403.3.2(1), Table C403.3.2(6)

390 (I-P)—~~2015~~2003: Performance Rating of Single Package Vertical Air-conditioners and Heat Pumps
Table C403.3.2(3)

400 (I-P)—2015: Performance Rating of Liquid to Liquid Heat Exchangers
Table C403.3.2(10)

440—2008: Performance Rating of Room Fan Coils—with Addendum 1
C403.11.3

460—2005: Performance Rating of Remote Mechanical-draft Air-cooled Refrigerant Condensers
Table C403.3.2(8)

550/590 (I-P)—~~2015~~2018: Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle
C403.3.2.1, Table C403.3.2(7)

560—~~00~~2018: Absorption Water Chilling and Water Heating Packages
Table C403.3.2(7)

910—2014: Performance Rating of Indoor Pool Dehumidifiers
Table C403.3.2(11)
920—2015: Performance Rating of DX-Dedicated Outdoor Air System Units
Table C403.3.2(12), Table C403.3.2(13)
1160 (I-P) —2014: Performance Rating of Heat Pump Pool Heaters (with Addendum 1)
Table C404.2

1200 (I-P)—2013: Performance Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets
C403.10, Table C403.10.1(1), Table C403.10.1(2)

1230—2014: Performance Rating of Variable Refrigerant Flow (VRF) Multi-split Air Conditioning and Heat Pump Equipment (with Addendum 1)
Table C403.3.2(9)
1250 (I-P)—2014: Standard for Performance Rating in Walk-in Coolers and Freezers
Table C403.11.2.1(3)
1360—2017: Performance Rating of Computer and Data Processing Room Air Conditioners
Table C403.3.2(10), Table C403.3.2(16)

AMCA

Air Movement and Control Association International
30 West University Drive
Arlington Heights, IL 60004-1806

208—18: Calculation of the Fan Energy Index~~205—12: Energy Efficiency Classification for Fans~~
C403.8.3

220—~~08 (R2012)~~19: Laboratory Methods of Testing Air Curtain Units for Aerodynamic Performance Rating

C402.5.6

500D—18~~12~~: Laboratory Methods for Testing Dampers for Rating

C403.7.7

230—15: Laboratory Methods of Testing Air Circulating Fans for Rating and Certification

C403.9

ANSI

American National Standards Institute
25 West 43rd Street, 4th Floor
New York, NY 10036

Z21.10.3/CSA 4.3—~~11~~17: Gas Water Heaters, Volume III—Storage Water Heaters with Input Ratings Above 75,000 Btu per Hour, Circulating Tank and Instantaneous
Table C404.2

Z21.47/CSA 2.3—~~12~~16: Gas-fired Central Furnaces
Table C403.3.2(4)

Z83.8/CSA 2.6—~~09~~16: Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters and Gas-fired Duct Furnaces
Table C403.3.2(4)

APSP

The Association of Pool & Spa Professionals
2111 Eisenhower Avenue, Suite 580
Alexandria, VA 22314

14—~~2014~~2019: American National Standard for Portable Electric Spa Energy Efficiency
C404.10

ASABE

American Society of Agricultural and Biological Engineers
2950 Niles Road
St. Joseph, MI 49085

S640—2017: Quantities and Units of Electromagnetic Radiation for Plants (Photosynthetic Organisms)
C405.4

ASHRAE

ASHRAE
1791 Tullie Circle NE
Atlanta, GA 30329

~~**ASHRAE 127-2007: Method of Testing for Rating Computer**~~
~~Table C403.3.2(9)~~

ANSI/ASHRAE/ACCA Standard 183—2007 (RA20~~14~~17): Peak Cooling and Heating Load Calculations in Buildings, Except Low-rise Residential Buildings
C403.1.1

ANSI/ASHRAE Standard 62.1—2016: Ventilation for Acceptable Indoor Air Quality
C201.3, C403.2.2, C403.6.1, C403.7.1, C403.7.4, C403.7.7, C403.8.5.1, C406.6, C501.4

ASHRAE—~~2016~~2020: ASHRAE HVAC Systems and Equipment Handbook—2020

C403.1.1

ISO/AHRI/ASHRAE 13256-1 (1998 RA2014): Water-to-Air and Brine-to-Air Heat Pumps—Testing and Rating for Performance
Table C403.3.2(2)

ISO/AHRI/ASHRAE 13256-2 (1998 RA2014): Water-to-Water and Brine-to-Water Heat Pumps—Testing and Rating for Performance
Table C403.3.2(2)

55—~~2013~~2017: Thermal Environmental Conditions for Human Occupancy
Table C407.5.1

90.1—~~2016~~2019: Energy Standard for Buildings Except Low-rise Residential Buildings
C401.2, Table C402.1.3, Table C402.1.4, C406.2,
Table C407.6.1, C502.1, C503.1, C504.1

90.4—2016: Energy Standard for Data Centers
C403.1.2, C405.2.4

140—2014: Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs
C407.6.1

146—2011: Testing and Rating Pool Heaters
Table C404.2

ASME

American Society of
Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990

ASME A17.1—~~2016~~2019/CSA B44—~~16~~19: Safety Code for Elevators and Escalators
C405.8.2

ASTM

ASTM International
100 Barr Harbor Drive, P.O.
Box C700
West Conshohocken, PA
19428-2959

C90—~~14~~2016A: Specification for Load-bearing Concrete Masonry Units
Table C401.3

C1363—11: Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus
C303.1.4.1, Table C402.1.4, 402.2.7

C1371—15: Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers

Table C402.3

C1549—~~09(2014)~~2016: Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer
Table C402.3

D1003—13: Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics
C402.4.2.2

D8052/D8052M—2017: Standard Test Method for Quantification of Air Leakage in Low-Sloped Membrane Roof Assemblies
C402.5.1.4

E283—2004(2012): Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen
C402.5.1.2.2, Table C402.5.2, C402.5.7

E408—13: Test Methods for Total Normal Emittance of Surfaces Using Inspection-meter Techniques
Table C402.3

E779—10(2018): Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
C402.5

E903—~~12~~2012: Standard Test Method Solar Absorptance, Reflectance and Transmittance of Materials Using Integrating Spheres (Withdrawn 2005)
Table C402.3

E1677—11: Specification for Air Barrier (AB) Material or Systems for Low-rise Framed Building Walls
C402.5.1.2.2

E1827—2011(2017): Standard Test Methods for Determining Airtightness of Building Using an Orifice Blower Door
C402.5, C406.9, C606.4

E1918—06(~~2015~~2016): Standard Test Method for Measuring Solar Reflectance of Horizontal or Low-sloped Surfaces in the Field
Table C402.3

E1980—11: Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-sloped Opaque Surfaces
Table C402.3, C402.3.2

E2178—13: Standard Test Method for Air Permanence of Building Materials
C402.5.1.2.1

E2357—~~11~~2018: Standard Test Method for Determining Air Leakage of Air Barriers Assemblies
C402.5.1.2.2

E3158—2018: Test Method for Measuring the Air Leakage Rate of a Large or Multizone Building
Section C402.5.3

F1281—2017: Specification for Cross-linked Polyethylene/Aluminum/Cross-linked Polyethylene (PEX-AL-PEX) Pressure Pipe
Table C404.5.2.1

F1361—2017: Standard Test Method for Performance of Open Deep Fat Fryers

Table C406.12(1)

F1484—2018: Standard Test Method for Performance of Steam Cookers

Table C406.12(2)

F1495—2014a: Standard Specification for Combination Oven Electric or Gas Fired

Table C406.12(4)

F1496—2013: Standard Test Method for Performance of Convection Ovens

Table C406.12(4)

F1696—2018: Standard Test Method for Energy Performance of Stationary-Rack, Door-Type Commercial Dishwashing Machines

Table C406.12(3)

F1920—2015: Standard Test Method for Performance of Rack Conveyor Commercial Dishwashing Machines

Table C406.12(3)

F2093—2018: Standard Test Method for Performance of Rack Ovens

Table C406.12(4)

F2144—2017: Standard Test Method for Performance of Large Open Vat Fryers

Table C406.12(1)

F2861—2017: Standard Test Method for Enhanced Performance of Combination Oven in Various Modes

Table C406.12(4)

CRRC

Cool Roof Rating Council
~~449 15th Street, Suite 400~~2435 North Lombard Street
~~Oakland~~Portland, ~~CA~~OR ~~94612~~97217

ANSI/CRRC-S100—~~2016~~2020: Standard Test Methods for Determining Radiative Properties of Materials

Table C402.3, C402.3.1

CSA

CSA Group
8501 East Pleasant Valley Road
Cleveland, OH 44131-5516

AAMA/WDMA/CSA 101/I.S.2/A440—17: North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights

Table C402.5.2

CSA B55.1—2015: Test Method for Measuring Efficiency and Pressure Loss of Drain Water Heat Recovery Units

C404.8

CSA B55.2—2015: Drain Water Heat Recovery Units

C404.8

CTI

Cooling Technology Institute
P. O. Box 681807
Houston, TX 77268

ATC 105—2019 ~~(00)~~: Acceptance Test Code for Water Cooling Tower

Table C403.3.2(8)

ATC 105DS—2018 : Acceptance Test Code for Dry Fluid Coolers

Table C403.3.2(7)

ATC 105S—11: Acceptance Test Code for Closed Circuit Cooling Towers
Table C403.3.2(8)

ATC 106—11: Acceptance Test for Mechanical Draft Evaporative Vapor Condensers
Table C403.3.2(8)

STD 201—11: Standard for Certification of Water Cooling Towers Thermal Performances
Table C403.3.2(8)

CTI STD 201 RS(~~15~~17): Performance Rating of Evaporative Heat Rejection Equipment
Table C403.3.2(8)

DASMA

Door & Access Systems Manufacturers Association, International
1300 Sumner Avenue
Cleveland, OH 44115-2851

105—~~2016~~2017: Test Method for Thermal Transmittance and Air Infiltration of Garage Doors and Rolling Doors
C303.1.3, Table C402.5.2

DOE

U.S. Department of Energy
c/o Superintendent of Documents
1000 Independence Avenue SW
Washington, DC 20585

10 CFR, Part 430—2015: Energy Conservation Program for Consumer Products: Test Procedures and Certification and Enforcement Requirement for Plumbing Products; and Certification and Enforcement Requirements for Residential Appliances; Final Rule
Table C403.3.2(4), Table C403.3.2(5), Table C404.2

10 CFR, Part 430, Subpart B, Appendix N—(2015): Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers
C202

10 CFR, Part 431—2015: Energy Efficiency Program for Certain Commercial and Industrial Equipment: Test Procedures and Efficiency Standards; Final Rules
Table C403.3.2(5), C405.6, Table C405.6, C405.7

10 CFR 431 Subpart B App B: Uniform Test Method for Measuring Nominal Full Load Efficiency of Electric Motors
C403.8.4, Table C405.7(1), Table C405.7(2), Table C405.7(3), C405.7(4)

NAECA 87—(88): National Appliance Energy Conservation Act 1987 [Public Law 100-12 (with Amendments of 1988-P.L. 100-357)]
Table C403.3.2(1), Table C403.3.2(2), Table C403.3.2(4)

HVI

Home Ventilating Institute
1740 Dell Range Blvd Ste H, PMB 45
Cheyenne, WY 82009

916-18 : Airflow Test Procedure
C403.8.5

ICC

International Code Council, Inc.
500 New Jersey Avenue NW
6th Floor
Washington, DC 20001

ANSI/RESNET/ICC—19: Standard for Testing Airtightness of Building, Dwelling Unit and Sleeping Unit Enclosures; Airtightness of Heating and Cooling Air Distribution Systems, and Airflow of Mechanical Ventilation Systems
C402.5.2, C402.5.3

IBC—~~18~~21: International Building Code®
C201.3, C303.2, C402.5.3, C501.4

ICC 500—2020: Standard for the Design and Construction of Storm Shelters
C402.4.2

IFC—~~18~~21: International Fire Code®
C201.3, C501.4

IFGC—~~18~~21: International Fuel Gas Code®
C201.3, C501.4

IPC—~~18~~21: International Plumbing Code®
C201.3, C501.4

IPMC—~~18~~21: International Property Maintenance Code®
C501.4

IPSDC—~~18~~21: International Private Sewage Disposal Code®
C501.4

IEEE

Institute of Electrical and Electronic Engineers
3 Park Avenue, 17th Floor
New York, NY 10016

IEEE 515.1—2012: IEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Commercial Applications
C404.6.2

IES

Illuminating Engineering Society
120 Wall Street, 17th Floor
New York, NY 10005-4001

ANSI/ASHRAE/IESNA 90.1—~~2016~~2019: Energy Standard for Buildings, Except Low-rise Residential Buildings
C401.2, Table C402.1.3, Table C402.1.4, C406.2, C502.1, C503.1, C504.1

ISO

International Organization for Standardization
Chemin de Blandonnet 8, CP 401, 1214 Vernier
Geneva, Switzerland

ISO/AHRI/ASHRAE 13256-1(~~1998 RA2014~~2017): Water-to-Air and Brine-to-Air Heat Pumps -Testing and Rating for Performance
Table C403.3.2(2)

ISO/AHRI/ASHRAE 13256-2(~~1998 RA2014~~2017): Water-to-Water and Brine-to-Water Heat Pumps -Testing and Rating for Performance
C403.3.2(2)

NEMA

National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, VA 22209

MG1—~~2014~~2016: Motors and Generators
C202

NFPA

National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02169-7471

70—~~17~~20: National Electrical Code
C501.4

NFRC

National Fenestration Rating Council, Inc.
6305 Ivy Lane, Suite 140
Greenbelt, MD 20770

100—~~2017~~2020: Procedure for Determining Fenestration Products *U-factors*
C303.1.3, C402.2.1.1

200—~~2017~~2020: Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence
C303.1.3, C402.4.1.1

203—2017: Procedure for Determining Translucent Fenestration Product Visible Transmittance at Normal Incidence
C303.1.3

400—~~2017~~2020: Procedure for Determining Fenestration Product Air Leakage
Table C402.5.2

SMACNA

Sheet Metal and Air Conditioning Contractors' National Association, Inc.
4021 Lafayette Center Drive
Chantilly, VA 20151-1219

SMACNA—2012: HVAC Air Duct Leakage Test Manual Second Edition
C403.2.11.2.3

UL

UL LLC
333 Pfingsten Road
Northbrook, IL 60062-2096

710—12: Exhaust Hoods for Commercial Cooking Equipment—with Revisions through November 2013
C403.7.5

727—18~~06~~: Oil-fired Central Furnaces~~—with Revisions through October 2013~~
Table C403.3.2(4)

731—~~95~~18: Oil-fired Unit Heaters~~—with Revisions through October 2013~~
Table C403.3.2(4)

1784—~~01~~15: Air Leakage Tests of Door Assemblies—with Revisions through February 2015
C402.5.3

2202—2009: *Electric Vehicle (EV) Charging System- with revisions through February 2018*
C405.13

2594—2016: Standard for Electric Vehicle Supply Equipment
C405.13

US-FTC

United States-Federal Trade Commission

600 Pennsylvania Avenue NW
Washington, DC 20580

CFR Title 16 (2015): *R*-value Rule
C303.1.4

WDMA

Window and Door
Manufacturers Association
2025 M Street NW, Suite 800
Washington, DC 20036-3309

AAMA/WDMA/CSA 101/I.S.2/A440—17: North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights
Table C402.5.2

APPENDIX CA
BOARD OF APPEALS—COMMERCIAL

The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.

User note:

About this appendix: Appendix CA provides criteria for Board of Appeals members. Also provided are procedures by which the Board of Appeals should conduct its business.

SECTION CA101
GENERAL

CA101.1 Scope.
A board of appeals shall be established within the jurisdiction for the purpose of hearing applications for modification of the requirements of this code pursuant to the provisions of Section C110. The board shall be established and operated in accordance with this section, and shall be authorized to hear evidence from appellants and the code official pertaining to the application and intent of this code for the purpose of issuing orders pursuant to these provisions.

CA101.2 Application for appeal.
Any person shall have the right to appeal a decision of the code official to the board. An application for appeal shall be based on a claim that the intent of this code or the rules legally adopted hereunder have been incorrectly interpreted, the provisions of this code do not fully apply or an equally good or better form of construction is proposed. The application shall be filed on a form obtained from the code official within 20 days after the notice was served.

CA101.2.1 Limitation of authority.
The board shall not have authority to waive requirements of this code or interpret the administration of this code.

CA101.2.2 Stays of enforcement.
Appeals of notice and orders, other than Imminent Danger notices, shall stay the enforcement of the notice and order until the appeal is heard by the board.

CA101.3 Membership of board.
The board shall consist of five voting members appointed by the chief appointing authority of the jurisdiction. Each member shall serve for [INSERT NUMBER OF YEARS] years or until a successor has been appointed. The board member's terms shall be staggered at intervals, so as to provide continuity. The code official shall be an ex officio member of said board but shall not vote on any matter before the board.

CA101.3.1 Qualifications.
The board shall consist of five individuals, who are qualified by experience and training to pass on matters pertaining to building construction and are not employees of the jurisdiction.

CA101.3.2 Alternate members.
The chief appointing authority is authorized to appoint two alternate members who shall be called by the board chairperson to hear appeals during the absence or disqualification of a member. Alternate members shall possess the qualifications required for board membership, and shall be appointed for the same term or until a successor has been appointed.

CA101.3.3 Vacancies.
Vacancies shall be filled for an unexpired term in the same manner in which original appointments are required to be made.

CA101.3.4 Chairperson.
The board shall annually select one of its members to serve as chairperson.

CA101.3.5 Secretary.
The chief appointing authority shall designate a qualified clerk to serve as secretary to the board. The secretary shall file a detailed record of all proceedings which shall set forth the reasons for the board's decision, the vote of each member, the absence of a member and any failure of a member to vote.

CA101.3.6 Conflict of interest.
A member with any personal, professional or financial interest in a matter before the board shall declare such interest and refrain from participating in discussions, deliberations and voting on such matters.

CA101.3.7 Compensation of members.
Compensation of members shall be determined by law.

CA101.3.8 Removal from the board.
A member shall be removed from the board prior to the end of their terms only for cause. Any member with continued absence from regular meeting of the board may be removed at the discretion of the chief appointing authority.

CA101.4 Rules and procedures.
The board shall establish policies and procedures necessary to carry out its duties consistent with the provisions of this code and applicable state law. The procedures shall not require compliance with strict rules of evidence, but shall mandate that only relevant information be presented.

CA101.5 Notice of meeting.
The board shall meet upon notice from the chairperson, within 10 days of the filing of an appeal or at stated periodic intervals.

CA101.5.1 Open hearing.
All hearings before the board shall be open to the public. The appellant, the appellant's representative, the code official and any person whose interests are affected shall be given an opportunity to be heard.

CA101.5.2 Quorum.
Three members of the board shall constitute a quorum.

CA101.5.3 Postponed hearing.

When five members are not present to hear an appeal, either the appellant or the appellant's representative shall have the right to request a postponement of the hearing.

CA101.6 Legal counsel.

The jurisdiction shall furnish legal counsel to the board to provide members with general legal advice concerning matters before them for consideration. Members shall be represented by legal counsel at the jurisdiction's expense in all matters arising from service within the scope of their duties.

CA101.7 Board decision.

The board shall only modify or reverse the decision of the code official by a concurring vote of three or more members.

CA101.7.1 Resolution.

The decision of the board shall be by resolution. Every decision shall be promptly filed in writing in the office of the code official within three days and shall be open to the public for inspection. A certified copy shall be furnished to the appellant or the appellant's representative and to the code official.

CA101.7.2 Administration.

The code official shall take immediate action in accordance with the decision of the board.

CA101.8 Court review.

Any person, whether or not a previous party of the appeal, shall have the right to apply to the appropriate court for a writ of certiorari to correct errors of law. Application for review shall be made in the manner and time required by law following the filing of the decision in the office of the chief administrative officer.

~~APPENDIX CAB~~
~~SOLAR-READY ZONE—COMMERCIAL~~

~~The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.~~

~~User note:~~

> **~~About this appendix:~~** ~~Appendix CA is intended to encourage the installation of renewable energy systems by preparing buildings for the future installation of solar energy equipment,~~
> ~~piping and wiring.~~

~~SECTION CAB101~~
~~SCOPE~~

~~CBA101.1 General.~~
~~These provisions shall be applicable for new construction where solar-ready provisions are required.~~

~~SECTION CBA102~~
~~GENERAL DEFINITION~~

~~SOLAR-READY ZONE.~~ ~~A section or sections of the roof or building overhang designated and reserved for the future installation of a solar photovoltaic or solar thermal system.~~

~~SECTION CBA103~~
~~SOLAR-READY ZONE~~

~~CBA103.1 General.~~
~~A solar-ready zone shall be located on the roof of buildings that are five stories or less in height above grade plane, and are oriented between 110 degrees and 270 degrees of true north or have low-slope roofs. Solar-ready zones shall comply with Sections CA103.2 through CA103.8.~~

~~Exceptions:~~

1. ~~A building with a permanently installed, on-site renewable energy system.~~
2. ~~A building with a solar-ready zone that is shaded for more than 70 percent of daylight hours annually.~~
3. ~~A building where the licensed design professional certifies that the incident solar radiation available to the building is not suitable for a solar-ready zone.~~
4. ~~A building where the licensed design professional certifies that the solar zone area required by Section CA103.3 cannot be met because of extensive rooftop equipment, skylights, vegetative roof areas or other obstructions.~~

CBA103.2 Construction document requirements for a solar-ready zone.
Construction documents shall indicate the solar-ready zone.

CBA103.3 Solar-ready zone area.
The total solar-ready zone area shall be not less than 40 percent of the roof area calculated as the horizontally projected gross roof area less the area covered by skylights, occupied roof decks, vegetative roof areas and mandatory access or set back areas as required by the *International Fire Code*. The solar-ready zone shall be a single area or smaller, separated sub-zone areas. Each sub-zone shall be not less than 5 feet (1524 mm) in width in the narrowest dimension.

CBA103.4 Obstructions.
Solar ready zones shall be free from obstructions, including pipes, vents, ducts, HVAC equipment, skylights and roof-mounted equipment.

CBA103.5 Roof loads and documentation.

A collateral dead load of not less than 5 pounds per square foot (5 psf) (24.41 kg/m^2) shall be included in the gravity and lateral design calculations for the solar-ready zone. The structural design loads for roof dead load and roof live load shall be indicated on the construction documents.

CBA103.6 Interconnection pathway.
Construction documents shall indicate pathways for routing of conduit or piping from the solar-ready zone to the electrical service panel and electrical energy storage system area or service hot water system.

CBA103.7 Electrical energy storage system-ready area.
The floor area of the electrical energy storage system-ready area shall be not less than 2 feet (610 mm) in one dimension and 4 feet (1219 mm) in another dimension, and located in accordance with Section 1207 of the *International Fire Code*. The location and layout diagram of the electrical energy storage system-ready area shall be indicated on the construction documents.

CB103.8 Electrical service reserved space.
The main electrical service panel shall have a reserved space to allow installation of a dual-pole circuit breaker for future solar electric installation and a dual-pole circuit breaker for future electrical energy storage system installation. These spaces shall be labeled "For Future Solar Electric and Storage." The reserved spaces shall be positioned at the end of the panel that is opposite from the panel supply conductor connection.

CBA103.89 Construction documentation certificate.
A permanent certificate, indicating the solar-ready zone and other requirements of this section, shall be posted near the electrical distribution panel, water heater or other conspicuous location by the builder, registered design professional or design professional.

APPENDIX CC
ZERO ENERGY COMMERCIAL BUILDING PROVISIONS

The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.
User note:
About this chapter: Appendix CC provides a model for applying new renewable energy generation when new buildings add electric load to the grid. This renewable energy will avoid the additional emissions that would otherwise occur from conventional power generation.

SECTION CC101
GENERAL

CC101.1 Purpose.
The purpose of this appendix is to supplement the International Energy Conservation Code and require renewable energy systems of adequate capacity to achieve net zero carbon.

CC101.2 Scope.
This appendix applies to new buildings that are addressed by the International Energy Conservation Code.

Exceptions:
1. Detached one- and two-family dwellings and townhouses as well as Group R2 buildings three stories or less in height above grade plane, manufactured homes (mobile dwellings), and manufactured houses (modular dwellings).
2. Buildings that use neither electricity nor fossil fuel.

SECTION CC102
DEFINITIONS

CC102.1 Definitions.
The definitions contained in this section supplement or modify the definitions in the International Energy Conservation Code.

ADJUSTED OFF-SITE RENEWABLE ENERGY. The amount of energy production from offsite renewable energy systems that may be used to offset building energy.

BUILDING ENERGY. All energy consumed at the building site as measured at the site boundary. Contributions from on-site or off-site renewable energy systems shall not be considered when determining the building energy.

ENERGY UTILIZATION INTENSITY (EUI). The site energy for either the baseline building or the proposed building divided by the gross conditioned floor area plus any semiheated floor area of the building. For the baseline building, the EUI can be divided between regulated energy use and unregulated energy use.

OFF-SITE RENEWABLE ENERGY SYSTEM. Renewable energy system not located on the building project.

ON-SITE RENEWABLE ENERGY SYSTEM. Renewable energy systems on the building project.

RENEWABLE ENERGY SYSTEM. Photovoltaic, solar thermal, geothermal energy and wind systems used to generate energy.

SEMIHEATED SPACE. An enclosed space within a building that is heated by a heating system whose output capacity is greater than or equal to 3.4 Btu/h × ft2 of floor area but is not a conditioned space.

ZERO ENERGY PERFORMANCE INDEX (ZEPIPB,EE). The ratio of the proposed building EUI without renewables to the baseline building EUI, expressed as a percentage.

SECTION CC103
MINIMUM RENEWABLE ENERGY

CC103.1 Renewable energy. On-site renewable energy systems shall be installed, or off-site renewable energy shall be procured to offset the building energy as calculated in Equation CC-1.

$RE_{onsite} + RE_{offsite} \geq E_{building}$

where:
RE_{onsite} = Annual site energy production from on-site renewable energy systems (see Section CC103.2).
$RE_{offsite}$ = Adjusted annual site energy production from off-site renewable energy systems that may be credited against building energy use (see Section CC103.3).
$E_{building}$ = Building energy use without consideration of renewable energy systems.

When Section C401.2.1(1) is used for compliance with the International Energy Conservation Code, building energy shall be determined by multiplying the gross conditioned floor area plus the gross semiheated floor area of the proposed building by an EUI selected from Table CC103.1. Use a weighted average for mixed-use buildings.

When Section C401.2.1, Item 2 or Section C401.2.2 is used for compliance with the International Energy Conservation Code, building energy shall be determined from energy simulations.

TABLE CC103.1
ENERGY UTILIZATION INTENSITY FOR BUILDING TYPES (kBtu/ft² – yr)

Building Area Type	kBtu/ft² – yr
Healthcare/hospital (I-2)	126
Hotel/motel (R-1)	77
Multiple-family (R-2)	53
Office (B)	33
Restaurant (A-2)	589
Retail (M)	60
School (E)	44
Warehouse (S)	32
All others	63

CC103.2 Calculation of on-site renewable energy.

The annual energy production from onsite renewable energy systems shall be determined using the PVWatts software or other software approved by the code official.

CC103.3 Off-site renewable energy.

Off-site energy shall comply with Sections CC103.3.1 and CC103.3.2.

CC103.3.1 Qualifying off-site procurement methods.

The following are considered qualifying off-site renewable energy procurement methods:

1. Community renewables: an off-site renewable energy system for which the owner has purchased or leased renewable energy capacity along with other subscribers.
2. Renewable energy investment fund: an entity that installs renewable energy capacity on behalf of the owner.
3. Virtual power purchase agreement: a power purchase agreement for off-site renewable energy where the owner agrees to purchase renewable energy output at a fixed price schedule.
4. Direct ownership: an off-site renewable energy system owned by the building project owner.
5. Direct access to wholesale market: an agreement between the owner and a renewable energy developer to purchase renewable energy.
6. Green retail tariffs: a program by the retail electricity provider to provide 100-percent renewable energy to the owner.
7. Unbundled Renewable Energy Certificates (RECs): certificates purchased by the owner representing the environmental benefits of renewable energy generation that are sold separately from the electric power.

CC103.3.2 Requirements for all procurement methods.

The following requirements shall apply to all off-site renewable energy procurement methods:

1. The building owner shall sign a legally binding contract to procure qualifying offsite renewable energy.
2. The procurement contract shall have duration of not less than 15 years and shall be structured to survive a partial or full transfer of ownership of the property.
3. RECs and other environmental attributes associated with the procured off-site renewable energy shall be assigned to the building project for the duration of the contract.
4. The renewable energy generating source shall include one or more of the following: photovoltaic systems, solar thermal power plants, geothermal power plants and wind turbines.
5. The generation source shall be located where the energy can be delivered to the building site by the same utility or distribution entity, the same independent system operator (ISO) or regional transmission organization (RTO), or within integrated ISOs (electric coordination council).
6. The off-site renewable energy producer shall maintain transparent accounting that clearly assigns production to the building. Records on power sent to or purchased by the building shall be retained by the building owner and made available for inspection by the code official upon request.

CC103.3.3 Adjusted off-site renewable energy.

The process for calculating the adjusted off-site renewable energy is shown in Equation 2.

$$RE_{offsite} = \sum_{i=1}^{n} PF_i \times RE_i = PF_1 \times RE_1 + PF_2 \times RE_2 + ... + PF_n \times RE_n \quad \text{(Equation CC-2)}$$

where:

$RE_{offsite}$ = Adjusted off-site renewable energy.

PF_i = Procurement factor for the i^{th} renewable energy procurement method or class taken from Table CC103.3.3.

RE_i = Annual energy production for the i^{th} renewable energy procurement method or class.

n = The number of renewable energy procurement options or classes considered.

TABLE CC103.3.3
DEFAULT OFF-SITE RENEWABLE ENERGY PROCUREMENT METHODS, CLASSES AND COEFFICIENTS

CLASS	PROCUREMENT FACTOR (PF)	PROCUREMENT OPTIONS	ADDITIONAL REQUIREMENTS (see also Section CC103.3.2)
1	0.75	Community Solar	-
		REIFs	Entity must be managed to prevent fraud or misuse of funds.
		Virtual PPA	-
		Self-owned off-site	Provisions shall prevent the generation from being sold separately from the building.
2	0.55	Green retail tariffs	The offering shall not include the purchase of unbundled RECs.
		Direct access	The offering shall not include the purchase of unbundled RECs.
3	0.20	Unbundled RECs	The vintage of the RECs shall align with building energy use.

INDEX

To be updated at end of Process

A

B

D

F

G

H

I

M

N

O

P

R

T

W

Z