Administrative Procedures – Proposed Rule Filing

Instructions:
In accordance with Title 3 Chapter 25 of the Vermont Statutes Annotated and the “Rule on Rulemaking” (CVR 04-000-001) adopted by the Office of the Secretary of State, this filing will be considered complete upon filing and acceptance of these forms with the Office of the Secretary of State, and the Legislative Committee on Administrative Rules.

All forms requiring a signature shall be original signatures of the appropriate adopting authority or authorized person, and all filings are to be submitted at the Office of the Secretary of State, no later than 3:30 pm on the last scheduled day of the work week. The data provided in text areas of these forms will be used to generate a notice of rulemaking in the portal of “Proposed Rule Postings” online, and the newspapers of record if the rule is marked for publication. Publication of notices will be charged back to the promulgating agency.

PLEASE REMOVE ANY COVERSHEET OR FORM NOT REQUIRED WITH THE CURRENT FILING BEFORE DELIVERY!

Certification Statement: As the adopting Authority of this rule (see 3 V.S.A. § 801 (b) (11) for a definition), I approve the contents of this filing entitled:

Vermont Commercial Building Energy Standards (CBES)

(signature), on 5/14/19.

(date)

Printed Name and Title: June Tierney, Commissioner, Vermont Department of Public Service

RECEIVED BY: ________

☐ Coversheet
☐ Adopting Page
☐ Economic Impact Analysis
☐ Environmental Impact Analysis
☐ Strategy for Maximizing Public Input
☐ Scientific Information Statement (if applicable)
☐ Incorporated by Reference Statement (if applicable)
☐ Clean text of the rule (Amended text without annotation)
☐ Annotated text (Clearly marking changes from previous rule)
☐ ICAR Filing Confirmed

Revised Oct 25, 2018
1. TITLE OF RULE FILING:  
Vermont Commercial Building Energy Standards (CBES)

2. ADOPTING AGENCY:  
Department of Public Service

3. PRIMARY CONTACT PERSON:  
(A PERSON WHO IS ABLE TO ANSWER QUESTIONS ABOUT THE CONTENT OF THE RULE).
   Name: Barry Murphy  
   Agency: PSD  
   Mailing Address: 112 State Street, Montpelier, VT 05620  
   Telephone: 802 828 - 3183  
   Fax: -  
   E-Mail: barry.murphy@vermont.gov  
   Web URL (WHERE THE RULE WILL BE POSTED):  
   http://publicservice.vermont.gov

4. SECONDARY CONTACT PERSON:  
(A SPECIFIC PERSON FROM WHOM COPIES OF FILINGS MAY BE REQUESTED OR WHO MAY ANSWER QUESTIONS ABOUT FORMS SUBMITTED FOR FILING IF DIFFERENT FROM THE PRIMARY CONTACT PERSON).
   Name: Allison Wannop  
   Agency: PSD  
   Mailing Address: 112 State Street, Montpelier, VT 05620  
   Telephone: 802 828 - 5543  
   Fax: -  
   E-Mail: allison.wannop@vermont.gov

5. RECORDS EXEMPTION INCLUDED WITHIN RULE:  
(DOES THE RULE CONTAIN ANY PROVISION DESIGNATING INFORMATION AS CONFIDENTIAL; LIMITING ITS PUBLIC RELEASE; OR OTHERWISE EXEMPTING IT FROM INSPECTION AND COPYING?)  
No

IF YES, CITE THE STATUTORY AUTHORITY FOR THE EXEMPTION:

PLEASE SUMMARIZE THE REASON FOR THE EXEMPTION:

6. LEGAL AUTHORITY / ENABLING LEGISLATION:  
(THE SPECIFIC STATUTORY OR LEGAL CITATION FROM SESSION LAW INDICATING WHO THE ADOPTING ENTITY IS AND THUS WHO THE SIGNATORY SHOULD BE. THIS SHOULD BE A SPECIFIC CITATION NOT A CHAPTER CITATION).  
30 V.S.A. § 53 COMMERCIAL BUILDING ENERGY STANDARDS

7. EXPLANATION OF HOW THE RULE IS WITHIN THE AUTHORITY OF THE AGENCY:
In accordance with 30 V.S.A. § 53(c), the Commissioner of the Department of Public Service is required to amend and update the CBES through administrative rules.

8. **CONCISE SUMMARY (150 WORDS OR LESS):**

The provisions of these standards regulate the design of building envelopes for adequate thermal resistance and low air leakage and the design and selection of mechanical, ventilation, electrical, service water-heating and illumination systems and equipment which will enable effective use of energy in commercial building construction. It is intended that these provisions provide flexibility to permit the use of innovative approaches and techniques to achieve effective utilization of energy.

9. **EXPLANATION OF WHY THE RULE IS NECESSARY:**

The rule is necessary to achieve the effective utilization of energy in commercial buildings. Per 30 V.S.A. § 53(c), the Commissioner of the Department of Public Service is required to amend the commercial building energy standards after the issuance of updated standards for commercial construction under the International Energy Conservation Code (IECC).

10. **EXPLANATION OF HOW THE RULE IS NOT ARBITRARY:**

The Vermont Commercial Building Energy Standards are based on the International Energy Conservation Code (IECC) and are reviewed and commented on by an Advisory Committee made up of Vermont builders, architects, Energy Efficiency Utilities, multi-family housing developers, and low-income housing advocates.

11. **LIST OF PEOPLE, ENTERPRISES AND GOVERNMENT ENTITIES AFFECTED BY THIS RULE:**

The Public Service Department, Division of Historic Preservation/ACCD, Act 250 Commissions, new home (large multi-family) owners/buyers, existing home (large multi-family) owners, builders, building designers, home/building energy raters, building commissioners and municipalities.

12. **BRIEF SUMMARY OF ECONOMIC IMPACT (150 WORDS OR LESS):**

This rule is an update of an adopted commercial building energy standard that has been in effect for all commercial building construction since 2006. Adoption of the rule will have a modest cost impact, relative to the cost of...
construction, on all of the parties involved in commercial new construction, purchase, ownership, operation and existing commercial building renovation. It will assure the benefits of reduced energy costs, reduced environmental impacts, and improved indoor air quality for the lifetime of the building.

13. A HEARING IS SCHEDULED.

14. HEARING INFORMATION

(THE FIRST HEARING SHALL BE NO SOONER THAN 30 DAYS FOLLOWING THE POSTING OF NOTICES ONLINE).

IF THIS FORM IS INSUFFICIENT TO LIST THE INFORMATION FOR EACH HEARING PLEASE ATTACH A SEPARATE SHEET TO COMPLETE THE HEARING INFORMATION NEEDED FOR THE NOTICE OF RULEMAKING.

Date: 6/21/2019
Time: 01:00 PM
Street Address: 115 State Street, Montpelie, Vt
Zip Code: 05633-5501

Date:
Time: AM
Street Address:
Zip Code:

Date:
Time: AM
Street Address:
Zip Code:

Date:
Time: AM
Street Address:
Zip Code:

15. DEADLINE FOR COMMENT (NO EARLIER THAN 7 DAYS FOLLOWING LAST HEARING): 7/10/2019

16. KEYWORDS (PLEASE PROVIDE AT LEAST 3 KEYWORDS OR PHRASES TO AID IN THE SEARCHABILITY OF THE RULE NOTICE ONLINE).

Commercial Building Energy Standards
Instructions:

This form must accompany each filing made during the rulemaking process:

Note: To satisfy the requirement for an annotated text, an agency must submit the entire rule in annotated form with proposed and final proposed filings. Filing an annotated paragraph or page of a larger rule is not sufficient. Annotation must clearly show the changes to the rule.

When possible, the agency shall file the annotated text, using the appropriate page or pages from the Code of Vermont Rules as a basis for the annotated version. New rules need not be accompanied by an annotated text.

1. TITLE OF RULE FILING:
   Vermont Commercial Building Energy Standards (CBES)

2. ADOPTING AGENCY:
   Department of Public Service

3. TYPE OF FILING (PLEASE CHOOSE THE TYPE OF FILING FROM THE DROPDOWN MENU BASED ON THE DEFINITIONS PROVIDED BELOW):

   - AMENDMENT - Any change to an already existing rule, even if it is a complete rewrite of the rule, it is considered an amendment as long as the rule is replaced with other text.

   - NEW RULE - A rule that did not previously exist even under a different name.

   - REPEAL - The removal of a rule in its entirety, without replacing it with other text.

This filing is AN AMENDMENT OF AN EXISTING RULE .

4. LAST ADOPTED (PLEASE PROVIDE THE SOS LOG#, TITLE AND EFFECTIVE DATE OF THE LAST ADOPTION FOR THE EXISTING RULE):

   SOS LOG #: 14-045

   Title: Commercial Building Energy Standards (CBES)

   Effective Date: March 1, 2015
Instructions:
In completing the economic impact analysis, an agency analyzes and evaluates the anticipated costs and benefits to be expected from adoption of the rule; estimates the costs and benefits for each category of people enterprises and government entities affected by the rule; compares alternatives to adopting the rule; and explains their analysis concluding that rulemaking is the most appropriate method of achieving the regulatory purpose.

Rules affecting or regulating schools or school districts must include cost implications to local school districts and taxpayers in the impact statement, a clear statement of associated costs, and consideration of alternatives to the rule to reduce or ameliorate costs to local school districts while still achieving the objectives of the rule (see 3 V.S.A. § 832b for details).

Rules affecting small businesses (excluding impacts incidental to the purchase and payment of goods and services by the State or an agency thereof), must include ways that a business can reduce the cost or burden of compliance or an explanation of why the agency determines that such evaluation isn’t appropriate, and an evaluation of creative, innovative or flexible methods of compliance that would not significantly impair the effectiveness of the rule or increase the risk to the health, safety, or welfare of the public or those affected by the rule.

1. TITLE OF RULE FILING:
   Vermont Commercial Building Energy Standards (CBES)

2. ADOPTING AGENCY:
   Department of Public Service

3. CATEGORY OF AFFECTED PARTIES:
   List categories of people, enterprises, and governmental entities potentially affected by the adoption of this rule and the estimated costs and benefits anticipated:

   The substantive changes to be implemented by this rule in comparison to the existing rule are summarized and listed below along with their impacts on each category of affected parties.

   All of the following design conditions will affect commercial property owners and commercial property developers along with related professionals involved
with the design and construction of the building and installation of the mechanical, lighting and plumbing systems.

Due to the highly varied nature of commercial buildings in terms of use, types, and sizes it is not practical to assign specific dollar values to the changes proposed in this rule. Instead changes associated with each section will be described and economic impact rated on a low to high scale. In order to provide greater insight, specific examples of the impact of the changes to the code were modeled for four building types, and estimates of impact are provided at the end of the section.

The totality of proposed changes to the code are expected to impact commercial property owners and developers by causing moderate initial increases in building construction costs with lifetime savings well in excess of these costs. The simple payback for all building types is expected to be at most 9 years (and often shorter), with returns on investment of at least 11% (and often higher).

This update to the rule primarily focuses on the thermal envelope of the building shell as well as lighting power updates.

Building Envelope

1. The updated CBES includes increased minimum insulation requirements (on average 22%), require under slab insulation for most buildings and improved (on average 15%) minimum fenestration (glazing) requirements, when compared to the existing rule. Many of these proposed minimum value increases are in line with current building practice.

2. Added a semi-condition space option for areas that require heating for reasons other than human comfort as well as an above-grade performance alternative. This entails reducing the number of windows to achieve a compatible reduction of required insulation. This is of particular benefit to warehouses.
3. Requires air barrier performance testing through use of blower doors to 0.30 cfm/ft² at 75 Pa, this brings the testing of commercial buildings into line with national standards. Alternatively building envelop commissioning can be used to reduce air leakage and thermal breaks that cause energy loss through the building shell.

These changes could have a medium initial cost impact but will result in a tested, better performing thermal envelope overall resulting in greater building lifetime energy savings than building envelopes built to the current rule.

Mechanical Systems
There are several changes affecting mechanical systems, including:

1. Economizer fault detection and diagnostics (FDD) for all systems >15 tins in capacity.

2. Electric space heating is now allowed as a supplemental heat source when using a cold climate heat pump, controls that limit the operation of the resistance heat to temperature less than 5 degrees Fahrenheit and the building envelope meets or exceeds 0.20 cfm/ft² at 75 Pa.

3. Electric space heat allowed for multifamily buildings if the heating loads are ≤ 6.0 Btu/hour/square foot at design temperature.

4. Requirements for commissioning of mechanical systems to ensure optimum performance.

5. 10% limit on oversizing of HVAC equipment.

6. Automatic control of HVAC systems serving guestrooms to control temperature and ventilation rates in unoccupied guestrooms.

7. Energy Recovery Ventilation required for buildings with more than 3,000 operating hours a year.

These changes have a low to medium initial cost impact depending on the building use and design choices with
greater building lifetime energy savings than buildings built to the current rule.

Service Water Heating
1. Increased the electrical resistance service hot water power limit from 5 kW to 7.5 kW in line with the next sizing requirement in ASHRAE 90.1 2016. This is in response to multiple stakeholder comments regarding the need to install multiple 5 kW units to provide the hot water a single 7.5 kW unit can.
2. Gas fired single whole building water heating equipment be ≥ 92% thermal efficiency (with some exceptions).
3. Hot water circulation systems with load controls required (with some exceptions).
4. Additional requirements for commissioning of the service hot water elements.
These changes would have a low initial cost impact with greater building lifetime energy savings than buildings built to the current rule.

Electrical Power and Lighting Systems
1. Increased minimum number of high-efficacy lamps required to be installed to 90%.
2. Expanded the definitions of areas exempted for required lighting controls.
3. Additional requirements for occupancy sensors in open plan offices.
4. Exit lighting required to dim to 50% in unoccupied spaces if unoccupied longer than 15 minutes.
5. Added additional exemption to daylight zone requirement if the lighting power density is 35% or less than the allowance.
6. Lighting Power Densities (LPDs) watts per square foot maximum requirements have been reduced for most space and building types.
7. Exterior Lighting Power Densities (LPDs) watts per square foot maximum requirements have been reduced by approximately 50% and tradable surfaces have been removed.

8. Electric Vehicle supply equipment now required. The building type and size of parking lot/structure determines the amount of spaces dedicated to EVs. Most of these changes would have a low initial cost impact dependent on the intended building use and design choices with greater building lifetime energy cost savings than buildings built to the current rule. The EV charging equipment may have a medium impact depending on building type and size of parking lot.

Commissioning/Design

1. Added requirements for building commissioning, testing and reporting inclusive of those elements previously described.

2. In addition modeled buildings now have the option to meet code using the building Performance Cost Index (PCI). This uses an established baseline for building performance relative to the 2004 ASHRAE 90.1 code and contains a methodology to calculate how much better the modeled building needs to be in order to meet code. PCI ranges from 0.39 (39%) to 0.62 (62%) depending on building type. This provides greater flexibility to architects and builders to meet this code.

Additional Packages Code Requirements

This section of code has been redesigned to be a points-based system applicable to more building types, include more options. These changes increase flexibility by providing more options to meet the code requirements. Each option has a building-type specific number of points. A building must achieve 6 points, which can be done through selection of a single measure or multiple measures depending on building type. Options have been increased from 6 to 10.
These measures include
1. More efficient HVAC
2. Reduced lighting power density (LPD)
   a. Further reduced LPD
3. Enhanced lighting controls
4. On-site renewable energy
5. Dedicated outdoor air system
6. High efficiency service water heating
   a. Additional high efficiency service water heating requirements
   b. Heat pump water heating systems
7. Enhanced building envelope measures
8. Reduced air infiltration
9. Efficient kitchen appliances
10. Controlled electrical receptacles.

These code changes would have anything from a negative to a medium/large initial cost impact depending upon the building use and design choices with greater building lifetime energy cost savings than buildings built to the current rule.

The Department of Public Service developed cost-benefit building models for moving from the 2015 CBES to the proposed 2019 CBES. The buildings modeled were a mid-rise apartment, K-12 School, Mid-rise office, and stand-alone retail store. The average costs and paybacks include the costs for EV charging equipment required by the rule.

Mid-rise Apartment (4 story, 31 Apartments, 33,700 square feet)
Average Annual Weighted Savings $8,859
Improvement Package Costs $57,436
Simple Payback (years) 6.48
Return on Investment 15%

K-12 School (3 story, 53,600 square feet)
Average Annual Weighted Savings $14,245
Improvement Package Costs $106,357
Simple Payback (years) 7.47
Return on Investment 13%

Office Mid-Rise (3 Story, 53,600 square feet)
Average Annual Weighted Savings $16,007
Improvement Package Costs $113,899
Simple Payback (years) 7.12
Return on Investment 14%

Stand-Alone Retail (1 story, 24,700 square feet)
Average Annual Weighted Savings $7,665
Improvement Package Costs $67,039
Simple Payback (years) 8.75
Return on Investment 11%

4. IMPACT ON SCHOOLS:

INDICATE ANY IMPACT THAT THE RULE WILL HAVE ON PUBLIC EDUCATION, PUBLIC SCHOOLS, LOCAL SCHOOL DISTRICTS AND/OR TAXPAYERS CLEARLY STATING ANY ASSOCIATED COSTS:

The 2019 CBES does not explicitly single out school building types. Newly constructed schools would have to be built to the 2019 CBES, which should ensure energy efficiency and lower operating costs as compared to construction against previous versions of CBES. As described in the previous section this rule would add additional cost of construction to a typical K-12 school. However after the initial 7.5 years the school would continue to save approximately $14,000 a year, which, if a typical school building was maintained and in operation for 25 years, would result in a net savings of almost $250,000 in operational costs.
5. ALTERNATIVES: **CONSIDERATION OF ALTERNATIVES TO THE RULE TO REDUCE OR AMELIORATE COSTS TO LOCAL SCHOOL DISTRICTS WHILE STILL ACHIEVING THE OBJECTIVE OF THE RULE.**

An alternative to this rule would be to adopt the 2018 IECC code and reference ASHRAE 90.1-2016 as is. The up-front cost of this alternative would likely be less than the proposed rule, though the energy savings would be lower, resulting in a higher cost to the school in the long run through added energy costs.

6. IMPACT ON SMALL BUSINESSES:

**INDICATE ANY IMPACT THAT THE RULE WILL HAVE ON SMALL BUSINESSES (EXCLUDING IMPACTS INCIDENTAL TO THE PURCHASE AND PAYMENT OF GOODS AND SERVICES BY THE STATE OR AN AGENCY THEREOF):**

The 2019 CBES does not explicitly define small business construction types. New construction small business premises would have to be built to the 2019 CBES, which should ensure energy efficiency and lower operating costs as compared to construction under previous versions of CBES. Based upon the modeling, it can be stated that in general the simple payback would be less than 9 years and have a return on investment of greater than 10%.

7. SMALL BUSINESS COMPLIANCE: **EXPLAIN WAYS A BUSINESS CAN REDUCE THE COST/BURDEN OF COMPLIANCE OR AN EXPLANATION OF WHY THE AGENCY DETERMINES THAT SUCH EVALUATION ISN’T APPROPRIATE.**

This rule only impacts part of a building's overall cost and should, in aggregate, result in a positive cashflow for small business overall. The small business can potentially reduce these other costs to offset the cost of meeting this rule.

8. COMPARISON:

**COMPARE THE IMPACT OF THE RULE WITH THE ECONOMIC IMPACT OF OTHER ALTERNATIVES TO THE RULE, INCLUDING NO RULE ON THE SUBJECT OR A RULE HAVING SEPARATE REQUIREMENTS FOR SMALL BUSINESS:**

An alternative to this rule would be to adopt the 2018 IECC code and reference ASHRAE 90.1-2016 as is. The up-front cost of this alternative would likely be less than the proposed rule, though the energy savings would be lower, resulting in a higher cost to the commercial
Economic Impact Analysis

building owner in the long run through added energy costs. 
Adopting no rule would mean significant lost opportunities with a commercial building being built if those additional savings were not captured through an improved energy code.

9. **SUFFICIENCY**: *EXPLAIN THE SUFFICIENCY OF THIS ECONOMIC IMPACT ANALYSIS.* The cost-benefit analysis underlying this economic impact statement was prepared by the Department's contractor and has been reviewed by stakeholders including builders, architects, developers and affordable housing advocates. Feedback from stakeholders was incorporated into the estimates presented here.
Instructions:
In completing the environmental impact analysis, an agency analyzes and evaluates the anticipated environmental impacts (positive or negative) to be expected from adoption of the rule; compares alternatives to adopting the rule; explains the sufficiency of the environmental impact analysis.

Examples of Environmental Impacts include but are not limited to:

- Impacts on the emission of greenhouse gases
- Impacts on the discharge of pollutants to water
- Impacts on the arability of land
- Impacts on the climate
- Impacts on the flow of water
- Impacts on recreation
- Or other environmental impacts

1. TITLE OF RULE FILING:

   Vermont Commercial Building Energy Standards (CBES)

2. ADOPTING AGENCY:

   Department of Public Service

3. GREENHOUSE GAS: EXPLAIN HOW THE RULE IMPACTS THE EMISSION OF GREENHOUSE GASES (E.G. TRANSPORTATION OF PEOPLE OR GOODS; BUILDING INFRASTRUCTURE; LAND USE AND DEVELOPMENT, WASTE GENERATION, ETC.):
   The energy savings from the buildings built to the updated CBES will result in direct reductions in greenhouse gas emissions through reduced on-site fuel consumption and indirect greenhouse gas reductions through reduced electricity demand for the lifetime of the building. This rule promotes weatherization to reduce commercial building heating and cooling demands. This rule also promotes the reduction of greenhouse gases from transportation through the adoption of electric vehicles with the creation of EV charging infrastructure seen as one of the major barriers to adoption of electric vehicles.

4. WATER: EXPLAIN HOW THE RULE IMPACTS WATER (E.G. DISCHARGE / ELIMINATION OF POLLUTION INTO VERMONT WATERS, THE FLOW OF WATER IN THE STATE, WATER QUALITY
Environmental Impact Analysis

5. LAND: EXPLAIN HOW THE RULE IMPACTS LAND (E.G. IMPACTS ON FORESTRY, AGRICULTURE ETC.):
   No Impact

6. RECREATION: EXPLAIN HOW THE RULE IMPACTS RECREATION IN THE STATE:
   No Impact

7. CLIMATE: EXPLAIN HOW THE RULE IMPACTS THE CLIMATE IN THE STATE:
   The energy savings from commercial buildings built to the updated CBES will result in direct and indirect reductions in greenhouse gas emissions and minimize the other negative environmental impacts of energy use.

8. OTHER: EXPLAIN HOW THE RULE IMPACTS OTHER ASPECTS OF VERMONT’S ENVIRONMENT:
   This rule promotes improved insulation and air sealing in new commercial construction and renovations to reduce building heating and cooling demands. This rule also promotes the use of efficient mechanical systems, which will further reduce electricity and fuel consumption. Additionally, the rule will improve building durability, occupant comfort, and indoor air quality in new buildings.

9. SUFFICIENCY: EXPLAIN THE SUFFICIENCY OF THIS ENVIRONMENTAL IMPACT ANALYSIS.
   This environmental impact analysis covers the full range of environmental and climate impacts of the CBES updates.
Administrative Procedures – Public Input

Instructions:

In completing the public input statement, an agency describes the strategy prescribed by ICAR to maximize public input, what it did do, or will do to comply with that plan to maximize the involvement of the public in the development of the rule.

This form must accompany each filing made during the rulemaking process:

1. TITLE OF RULE FILING:
   Vermont Commercial Building Energy Standards (CBES)

2. ADOPTING AGENCY:
   Department of Public Service

3. PLEASE DESCRIBE THE STRATEGY PRESCRIBED BY ICAR TO MAXIMIZE PUBLIC INVOLVEMENT IN THE DEVELOPMENT OF THE PROPOSED RULE:
   No strategy has been prescribed by ICAR.

4. PLEASE LIST THE STEPS THAT HAVE BEEN OR WILL BE TAKEN TO COMPLY WITH THAT STRATEGY:
   The Department of Public Service undertook a broad-based consensus building process to develop this rule. Between July and October 2018, the Department held one online webinar and 3 public meetings around the state to present information on proposed updates to CBES to interested stakeholders, which included builders, architects, multi-family housing developers, low-income housing advocates, electric and gas utilities and energy efficiency utilities.

   At each of the stakeholder meetings, the Department presented a draft of the proposed changes to the 2018 IECC. The Department also convened an Advisory Committee as required by statute to delve deeper into the technical aspects of the code. The full Advisory Committee met in August and October of 2018.

   The Department modified the proposed CBES to incorporate changes recommended by the stakeholders and the Advisory Committee after each round of meetings.
Participants and other stakeholders were also encouraged to comment on each version of the proposed CBES language posted on the PSD website.

PSD developed the proposed rule based on these meetings, public comments and other feedback.

Information is available on the Department of Public Service website at:

https://publicservice.vermont.gov/content/buildingenergy-standards-update

5. BEYOND GENERAL ADVERTISEMENTS, PLEASE LIST THE PEOPLE AND ORGANIZATIONS THAT HAVE BEEN OR WILL BE INVOLVED IN THE DEVELOPMENT OF THE PROPOSED RULE:

Barry Murphy, VT PSD;
Kelly Launder, VT PSD;
Keith Levenson, VT PSD;
Allison Wannop, VT PSD;
Gabrielle Stebbins, Energy Futures Group;
Richard Faesy, Energy Future Group;
Keith Downes, Navigant Consulting;
Stu Slote, Navigant Consulting;
Eveline Killian, Cx Associates;
Jen Chiodo, Cx Associates;
Jim Edelson, New Buildings Institute;
Eric Makela, New Buildings Institute;
Brian Just, Vt. Energy Investment Corp. (VEIC);
Nick Thiltgen, VEIC;
Jacob Racusin, New Frameworks Natural Design/Build,
Jeremy King, Vermont Gas Systems;
Joseph Benard, Division of Fire Safety;
Patrick Strainer, New England Air Systems;
Christina Rohrbacher, Northeast Energy Efficiency Partnership (NEEP);
Robert Schultz, PNNL;
Public Input

Rosemarie Bartlett, PNNL;
Carolyn Sarno, NEEP;
Chris West, Eco Houses of Vermont, HBRA-VT;
Kathy Beyer, Housing Vermont;
Samantha Dunn, Housing Vermont;
Bob Duncan, Duncan-Wisniewski Architects;
Chris Burns, Burlington Electric Dept. (BED);
Brian Reilly, BED;
Craig Peltier, Vt. Housing Conservation Board;
Collin Frisbie, Sterling Homes, HBRA-VT;
Walt Adams, Walter M. Adams Consulting;
Bill Root, GWR Engineering, ASHRAE;
Matt Cota, Vermont Fuel Dealers Association;
Brad Cook, Building Performance Services LLC;
David H. Mann, American Chemistry Council;
Henri Fennell, Henri Fennell Consulting.
Instructions:

In completing the Scientific Information Statement, an agency shall provide a brief summary of the scientific information including reference to any scientific studies upon which the proposed rule is based, for the purpose of validity.

1. TITLE OF RULE FILING:
   Vermont Commercial Building Energy Standards (CBES)

2. ADOPTING AGENCY:
   Department of Public Service

3. BRIEF EXPLANATION OF SCIENTIFIC INFORMATION:

   The primary substantive differences between the 2018 IECC/ASHRAE 90.1-2016 and the proposed Vermont 2019 CBES standards are upgrades to energy equipment and systems. This higher proposed standard is based on a review of standards existing in other jurisdictions and current practices in Vermont and therefore includes requirements in the proposed Vermont CBES that are not included in the 2018 IECC or ASHRAE 90.1-2016, including envelope, mechanical, and lighting requirements.
4. CITATION OF SOURCE DOCUMENTATION OF SCIENTIFIC INFORMATION:


ASHRAE 90.1 2013 published by ASHRAE October, 2016

5. INSTRUCTIONS ON HOW TO OBTAIN COPIES OF THE SOURCE DOCUMENTS OF THE SCIENTIFIC INFORMATION FROM THE AGENCY OR OTHER PUBLISHING ENTITY:

These source documents are available upon request to the Department of Public Service.

Contact Barry Murphy at Barry.Murphy@vermont.gov or call 802-828-3183 for these documents if needed.
PREFACE

Introduction

This document is the 2019 Vermont Commercial Building Energy Standards (CBES). It is based on the 2018 International Energy Conservation Code® (IECC®) and includes many elements of ASHRAE/IESNA Standard 90.1-2016. Amendments have been made to suit Vermont’s climate and special needs.

The Vermont Energy Act of 2009 (Act 45) directed the Commissioner of the Department of Public Service to amend the CBES to ensure that commercial building construction be designed and constructed in a manner that complies with ASHRAE/IESNA Standard 90.1-2007 or the 2009 edition of the IECC.

The Vermont Energy Act of 2009 (Act 45) legislation requires that at least every three years after January 1, 2011 the Commissioner of Public Service shall amend and update the CBES.

30 V.S.A. §53 of the Vermont Statutes requires certification that both the design and the construction of a commercial building is in compliance with the CBES. Certification shall be issued by a completed and signed certificate permanently affixed to the outside of the heating or cooling equipment, to the electrical service panel and located inside the building, or in a visible location in the immediate vicinity of one of these three areas. Copies of the signed certification documents shall be sent to the local town clerk and to the Vermont Department of Public Service.

The Vermont Division of Fire Safety may request completed certificates at the time of inspection, and certificate of occupancy may be withheld until the CBES certificate and affidavits are posted.

Certificates, affidavits and contact information for questions about the energy code can be found at:

http://publicservice.vermont.gov/topics/energy_efficiency/cbes

The statute pertaining to CBES (30 V.S.A. §53) can be found at:

http://tinyurl.com/VT-Statute-CBES

Users of the code are encouraged to view the publicly available interpretations of the ASHRAE 90.1-2016 standard, available online at:

https://ashrae.iwrapper.com/ViewOnline/Standard_90.1-2016_(IP)

Marginal Markings
Solid vertical lines in the margins within the body of the code indicate a State of Vermont amendment has been made to the 2018 *International Energy Conservation Code*. 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.

**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.
EFFECTIVE USE OF THE COMMERCIAL BUILDING ENERGY STANDARDS

Arrangement and Format of the 2019 CBES

Before applying the requirements of the 2019 CBES it is beneficial to understand its arrangement and format. The 2019 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 2019 CBES is divided into five different parts:

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</table>

The following is a chapter-by-chapter synopsis of the scope and intent of the provisions of the 2019 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 building official or the authority having jurisdiction 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*. 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.

Climate has a major impact on the energy use of most buildings. The code establishes many requirements such as wall and roof insulation $R$-values, window and door thermal transmittance ($U$-factors) and provisions that affect the mechanical systems based on the climate where the building is located.

**Chapter 4 Energy Efficiency.** Chapter 4 of each set of provisions contains the technical requirements for energy efficiency.

**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.

**Chapter 5 Existing Buildings.** Chapter 5 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, 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.
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-ft²  Btu per hour per square foot
C-factor  See Chapter 2—Definitions
CDD  Cooling degree days
cfm  Cubic feet per minute
cfm/ft²  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  Ventilation efficiency
E_v  Thermal efficiency
E_t  Combustion 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
ft²  Square foot
ft  Gallons per minute
HDD  Heating degree days
hp  Horsepower
HSPF  Heating seasonal performance factor
HVAC  Heating, ventilating and air conditioning
IEER  Integrated energy efficiency ratio
IPLV  Integrated Part Load Value
Kg/m²  Kilograms per square meter
kW  Kilowatt
LPD  Light power density (lighting power allowance)
L/s  Liters per second
Ls  Liner system
m²  Square meters
MERV  Minimum efficiency reporting value
<table>
<thead>
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<th>Description</th>
</tr>
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<tbody>
<tr>
<td>NAECA</td>
<td>National Appliance Energy Conservation Act</td>
</tr>
<tr>
<td>NPLV</td>
<td>Nonstandard Part Load Value</td>
</tr>
<tr>
<td>Pa</td>
<td>Pascal</td>
</tr>
<tr>
<td>PF</td>
<td>Projection factor</td>
</tr>
<tr>
<td>pcf</td>
<td>Pounds per cubic foot</td>
</tr>
<tr>
<td>psf</td>
<td>Pounds per square foot</td>
</tr>
<tr>
<td>PTAC</td>
<td>Packaged terminal air conditioner</td>
</tr>
<tr>
<td>PTHP</td>
<td>Packaged terminal heat pump</td>
</tr>
<tr>
<td>R-value</td>
<td>See Chapter 2—Definitions</td>
</tr>
<tr>
<td>SCOP</td>
<td>Sensible coefficient of performance</td>
</tr>
<tr>
<td>SEER</td>
<td>Seasonal energy efficiency ratio</td>
</tr>
<tr>
<td>SHGC</td>
<td>Solar Heat Gain Coefficient</td>
</tr>
<tr>
<td>SPVAC</td>
<td>Single packaged vertical air conditioner</td>
</tr>
<tr>
<td>SPVHP</td>
<td>Single packaged vertical heat pump</td>
</tr>
<tr>
<td>SRI</td>
<td>Solar reflectance index</td>
</tr>
<tr>
<td>SWHF</td>
<td>Service water heat recovery factor</td>
</tr>
<tr>
<td>U-factor</td>
<td>See Chapter 2—Definitions</td>
</tr>
<tr>
<td>VAV</td>
<td>Variable air volume</td>
</tr>
<tr>
<td>VRF</td>
<td>Variable refrigerant flow</td>
</tr>
<tr>
<td>VT</td>
<td>Visible transmittance</td>
</tr>
<tr>
<td>W</td>
<td>Watts</td>
</tr>
<tr>
<td>w.c.</td>
<td>Water column</td>
</tr>
<tr>
<td>w.g.</td>
<td>Water gauge</td>
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2019 VERMONT COMMERCIAL BUILDING ENERGY STANDARDS xvi
CHAPTER 1
SCOPE AND ADMINISTRATION

PART 1—SCOPE AND APPLICATION

SECTION C101
SCOPE AND GENERAL REQUIREMENTS

C101.1 Title.
This code shall be known as the 2019 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 requirements for the design and construction, and a plan for operation and maintenance of:

1. New buildings and their systems,
2. New portions of buildings and their systems,
3. New systems and equipment in existing buildings, and
4. New equipment or building systems specifically identified in the standard that are part of industrial or manufacturing processes.

Exception: This code shall not apply to farm structures as defined in 24 V.S.A. § 4413.

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 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,
i. 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.

ii. 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 2019 Residential Building Energy Standards (RBES), and Commercial buildings shall meet the provisions of Commercial Building Energy Standards (CBES).

C101.5.1 Compliance materials.
The code official or other 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 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 · ft² (10.7 W/m²) or 1.0 watt per square foot (10.7 W/m²) of floor area for space conditioning purposes.

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


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:

   A. Buildings that are separate buildings with floor area not more than 500 square feet (50 m²).
B. 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.

C. 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).

D. 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 alternative material, design or method of construction shall be approved where the code official or other authority having jurisdiction finds 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 code official or other authority having jurisdiction shall respond in writing, stating the reasons why the alternative was not approved.

C102.1.1 Above code programs.
The code official or other authority having jurisdiction shall be permitted to deem a national, state or local energy efficiency program to exceed 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 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 other authority having jurisdiction is authorized to require necessary construction documents to be prepared by a registered design professional.

Exception: The code official or other authority having jurisdiction is authorized to waive the requirements for construction documents or other supporting data if the code official or other 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 other 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. Insulation materials and their $R$-values.
2. Fenestration $U$-factors and solar heat gain coefficients (SHGCs).
3. Area-weighted $U$-factor and solar heat gain coefficient (SHGC) calculations.
4. Design ambient temperatures.
5. Interior temperatures for heating and cooling modes.
6. Relative humidity setpoints.
8. Mechanical system design criteria.
9. Mechanical and service water heating systems and equipment types, sizes and efficiencies.
10. Economizer description.
11. Equipment and system controls.
12. Fan motor horsepower (hp) and controls.
13. Duct sealing, duct and pipe insulation and location.
14. Lighting fixture schedule with wattage and control narrative.
15. Location of daylight zones on floor plans.
16. Air sealing details, 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.

C103.3 Examination of documents.
The code official or other 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 other 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 other 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 other 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 other 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 other 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 or other authority having jurisdiction 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 C405.4.

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
INSPECTIONS

C104.1 General.
Where required, construction or work for which a permit is required shall be subject to inspection by the code official or other 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 other 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.

C104.2 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 other authority having jurisdiction. The code official or other 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 other authority having jurisdiction.

C104.2.1 Final inspection.
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.

C104.3 Reinspection.
A building shall be reinspected where determined necessary by the code official or other authority having jurisdiction.

C104.4 Approved inspection agencies.
The code official or other 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.

C104.5 Inspection requests.
It shall be the duty of the holder of the permit or their duly authorized agent to notify the code official or other 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.

C104.6 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 other authority having jurisdiction for inspection and testing.

C104.7 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 other authority having jurisdiction.
C104.7.1 Revocation.
The code official or other 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 C105
VALIDITY

C105.1 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 C106
REFERENCED STANDARDS

C106.1 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 C106.1.1 and C106.1.2.

C106.1.1 Conflicts.
Where conflicts occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.
C106.1.2 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.

C106.2 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.

C106.3 Other laws.
The provisions of this code shall not be deemed to nullify any provisions of local, state or federal law.
CHAPTER 2
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.

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.

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.

APPROVED. Approval by the *code official or other 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 research reports, where such agency has been approved by the *code official or other authority having jurisdiction*.
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”).

BELOW-GRADE WALL. See “Wall, below-grade.”

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)].

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

CAVITY INSULATION. Insulating material located between framing members.

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. The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative. The Vermont Public Service Department is not the code official and shall not be required to conduct inspections of construction or construction documents.

COEFFICIENT OF PERFORMANCE (COP) – COOLING. The ratio of the rate of heat removal to the rate of energy input, in consistent units, for a complete refrigerating system or some specific portion of that system under designated operating conditions.

COEFFICIENT OF PERFORMANCE (COP) – 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 temperatures of 5°F. The indoor and outdoor units must be part of an AHRI matched system.

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

COMMERCIAL BUILDING ENERGY STANDARDS (CBES). The Vermont non-residential Energy Code, based on the 2018 IECC, but modified substantially.

COMPUTER ROOM. A room whose primary function is to house equipment for the processing and storage of electronic data and that has a design electronic data equipment power density of less than 20 watts per square foot (20 watts per 0.092 m²) of conditioned floor area or a connected design electronic data equipment load of less than 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·ft² 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·ft² 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.

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 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.

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 distribution ducts of air-conditioning systems 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.

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 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.

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.

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 BRAKE HORSEPOWER (BHP). The horsepower delivered to the fan’s shaft. Brake horsepower does not include the mechanical drive losses such as 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 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 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.

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 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.

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.

GENERAL LIGHTING. 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.

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.

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

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.
HIGH-EFFICACY LAMPS/LIGHTING. Compact fluorescent lamps, light-emitting diode (LED) lamps, T-8 or smaller diameter linear fluorescent lamps, or other lamps with an efficacy of not less than 65 lumens per watt; or light fixtures of not less than 55 lumens per watt.

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.
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.

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. See “DC Fast Charge”.

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 other 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.

METAL BUILDING ROOF. A roof that:
a. is constructed with a metal, structural, weathering surface;

b. has no ventilated cavity; and

c. 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:

1. metal roofing in direct contact with the steel framing members;

2. metal roofing separated from the steel framing members by insulation; or

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).

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 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, accessible from the front desk or other central location associated with a Group R-1 building, that is capable of identifying the occupancy 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 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, nightclubs, restaurants, cafeterias, taverns, and bars.

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.

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

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 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.

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.

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

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 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 m²).

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 m²).

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. 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.

A. 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.

B. 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.

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

D. 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 2019 IECC.

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 REPLACEMENT.** 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 \((h \cdot ft^2 \cdot °F/Btu)\) \([\text{m}^2 \cdot K/W]\).

**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.

**SEMI-CONDITIONED SPACE.** An enclosed space within a building that is directly or indirectly heated by a heating system whose output capacity is less than or equal to 14 Btu/h·ft² 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·ft² 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.

**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.

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.

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.

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.

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.

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
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.

302.2 Climatic data1.

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

1 Climatic data derived by weighting Burlington 50%, Rutland 25%, and Montpelier 25%.

2019 VERMONT COMMERCIAL BUILDING ENERGY STANDARDS

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2. As approved by the code official or other 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 m²) 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.

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
accorded, 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**

<table>
<thead>
<tr>
<th>FRAME TYPE</th>
<th>WINDOW AND GLASS DOOR</th>
<th>SKYLIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single</td>
<td>Double</td>
</tr>
<tr>
<td>Metal</td>
<td>1.20</td>
<td>0.80</td>
</tr>
<tr>
<td>Metal with Thermal Break</td>
<td>1.10</td>
<td>0.65</td>
</tr>
<tr>
<td>Nonmetal or Metal Clad</td>
<td>0.95</td>
<td>0.55</td>
</tr>
<tr>
<td>Glazed Block</td>
<td></td>
<td>0.60</td>
</tr>
</tbody>
</table>

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

a) The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/h/ft²/°F;
b) The thermal break material must produce a gap in the frame material of not less than 0.210 inches; and
c) All metal framing members of the products exposed to interior and exterior air shall incorporate a thermal break meeting the criteria in a) and b) above.

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

<table>
<thead>
<tr>
<th>DOOR TYPE</th>
<th>OPAQUE U-FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uninsulated Metal</td>
<td>1.20</td>
</tr>
<tr>
<td>Insulated Metal (Rolling)</td>
<td>0.90</td>
</tr>
<tr>
<td>Insulated Metal (Other)</td>
<td>0.60</td>
</tr>
<tr>
<td>Wood</td>
<td>0.50</td>
</tr>
<tr>
<td>Insulated, nonmetal edge, max 45% glazing, any glazing double pane</td>
<td>0.35</td>
</tr>
</tbody>
</table>
TABLE C303.1.3(3)
DEFAULT GLAZED FENESTRATION SHGC AND VT

<table>
<thead>
<tr>
<th></th>
<th>SINGLE GLAZED</th>
<th></th>
<th>DOUBLE GLAZED</th>
<th></th>
<th>GLAZED BLOCK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clear</td>
<td>Tinted</td>
<td>Clear</td>
<td>Tinted</td>
<td></td>
</tr>
<tr>
<td>SHGC</td>
<td>0.8</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>VT</td>
<td>0.6</td>
<td>0.3</td>
<td>0.6</td>
<td>0.3</td>
<td>0.6</td>
</tr>
</tbody>
</table>

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 • ft² • °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
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:

1. 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.

2. 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 2019 CBES and tenant spaces shall comply with Section C406.1.1 in the 2019 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 Applicable provisions to Standard 90.1-2016.

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

2. ASHRAE/IESNA 90.1-2016 Section 4.2.1.1 New Buildings.
   Delete the equation for Performance Cost Index Target (PCI_t) and replace with:
   \[ PCI_t = \left[ BPF \times (BBUEC + BBREC) \right] / BBP. \]
   Delete Table 4.2.1.1 Building Performance Factor (BPF) and replace with:

   **TABLE 4.2.1.1 Building Performance Factor (BPF)**

<table>
<thead>
<tr>
<th>Building Area Type(a)</th>
<th>Vermont BPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multifamily</td>
<td>.62</td>
</tr>
<tr>
<td>Healthcare/hospital</td>
<td>.46</td>
</tr>
<tr>
<td>Hotel/motel</td>
<td>.48</td>
</tr>
<tr>
<td>Office</td>
<td>.43</td>
</tr>
<tr>
<td>Restaurant</td>
<td>.50</td>
</tr>
<tr>
<td>Retail</td>
<td>.44</td>
</tr>
<tr>
<td>School</td>
<td>.39</td>
</tr>
<tr>
<td>Warehouse</td>
<td>.53</td>
</tr>
<tr>
<td>All Others</td>
<td>.45</td>
</tr>
</tbody>
</table>

   \(a\). 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 Section 5.1.4.1 United States Locations. Delete the exception clause and replace with the following:

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, or
   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 code official or other authority having jurisdiction

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

   i. Table C402.1(1), 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(2), Building Envelope Requirements—Metal Building Assembly Descriptions,

   iii. Table C402.3, Building Envelope Fenestration Maximum U-Factor and SHGC Requirements.

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

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

7. ASHRAE/IESNA 90.1-2016 Section 5.5.3.3 Below-Grade Wall Insulation. Delete section in its entirety and replace with Section C402.2.3 Below-grade walls of the 2019 Vermont CBES.

8. ASHRAE/IESNA 90.1-2016 Section 5.5.3.5 Slab-on-Grade Floor Insulation. Add to the end of this section the requirements of section C402.2.6 Slabs-on-grade perimeter insulation of the 2019 Vermont CBES.

9. ASHRAE/IESNA 90.1-2016 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 Section 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 ≤ 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; and  
   b. the building thermal envelope shall be tested in accordance with ASTM E 779 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 cfm/ft² (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 Section 6.3.2(e) Criteria. Delete “an electric resistance heater.”

11. ASHRAE/IESNA 90.1-2016 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 2019 Vermont CBES.

12. ASHRAE/IESNA 90.1-2016 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 Section 6.4.3.9 Heated or Cooled Vestibules. Delete section in its entirety and replace with Section C403.4.1.4 Duct and plenum insulation and sealing of the 2019 Vermont CBES.

14. ASHRAE/IESNA 90.1-2016 Section 6.4.4.1.2 Duct and Plenum Insulation. Delete section in its entirety and replace with Section C403.11.1 Duct and plenum insulation and sealing of the 2019 Vermont CBES.

15. Add new Section 6.4.7 to ASHRAE/IESNA 90.1-2016, titled Economizer Fault Detection and Diagnostics (FDD). Insert Section C403.5.5 Economizer fault detection and diagnostics (FDD) of the 2019 Vermont CBES.

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

17. ASHRAE/IESNA 90.1-2016 Table 6.5.6.1-1 and 6.5.6.1-2 Exhaust Air Energy Recovery Requirements for Ventilation Systems. Both tables shall be greater than or equal to 3000 hours per year rather than 8000 hours.
18. ASHRAE/IESNA 90.1-2016 Table 6.5.6.1-1 and Table 6.5.6.1-2 *Exhaust Air Energy Recovery Requirements*, delete requirement for systems with $\geq 10\%$ and $< 20\%$ outdoor air (second column of tables).

19. ASHRAE/IESNA 90.1-2016 *Section 6.5.6.2 Heat Recovery for Service Water Heating, 6.5.6.2.2.* 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. ASHRAE/IESNA 90.1-2016 *Section 6.7.2.4 System Commissioning.* Delete section in its entirety and replace with Section C407*System Commissioning of the 2019 Vermont CBES.*

21. ASHRAE/IESNA 90.1-2016 *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 5 kW total power input.

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

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

   a. Change first row (Electric table top water heaters) size category to $< 5$ kW, and
   b. Change second row (Electric water heaters) size category to $< 5$ kW, and
   c. Delete entire third row for electric water heaters $> 12$ kW.

23. ASHRAE/IESNA 90.1-2016 *Section 9 Lighting.* All lighting power density (LPD) requirements shall comply with the following tables in the 2019 *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,* and

   iii. *Table C405.4.2(2), 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 Table 9.4.4-2.

24. ASHRAE/IESNA 90.1-2016 *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. ASHRAE/IESNA 90.1-2016 *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. ASHRAE/IESNA 90.1-2016 Section 9.4.4 Dwelling Units. Delete section in its entirety and replace with: 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. ASHRAE/IESNA 90.1-2016 Section 9.6.2 Additional Interior Lighting Power. Amend the exception in part (a) to read that the power shall not exceed 0.6 W/ft² of such spaces instead of 0.75 W/ft². In part (b) Delete the equation for Additional Interior Lighting Power Allowance and replace with:

\[
\text{Additional interior lighting power allowance} = 250 \text{ W} + (\text{Retail Area 1 } \times 0.20 \text{ W/ft}^2) + (\text{Retail Area 2 } \times 0.20 \text{ W/ft}^2) + (\text{Retail Area 3 } \times 0.50 \text{ W/ft}^2) + (\text{Retail Area 4 } \times 0.90 \text{ W/ft}^2)
\]

28. ASHRAE/IESNA 90.1-2016 Section 10.4 Mandatory Provisions. Add the following sections

i. 10.4.6, Renewable energy systems, which will meet the requirements of section C405.10 Renewable energy systems in the 2019 Vermont CBES.

ii. 10.4.7 Electric Vehicle Charging Stations, which will meet the requirements of section C405.11 Electric Vehicle Charging Stations in the 2019 Vermont 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 Certificate 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.

Certification shall be issued by completing and signing a certificate permanently and affixing it to the outside of the heating or cooling equipment, to the electrical service panel and located inside the building, or in a visible location in the immediate vicinity of one of these three areas. Copies of the signed certification documents shall be sent to the local town clerk and to the Vermont Public Service Department.
SECTION C402
BUILDING ENVELOPE REQUIREMENTS

C402.1 General (Prescriptive).
In addition to the envelope requirements of Section C402, envelope enhancements may be needed to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406.

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.

   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.

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 insulation shall be not less than that specified in the “Minimum R-values” columns of Table C402.1(1). Commercial buildings or portions of commercial buildings enclosing conditioned spaces shall use the R-values from the “Conditioned Space” column of Table C402.1(1). Commercial buildings or portions of commercial buildings enclosing semi-conditioned spaces shall use the R-values from the “Semi-conditioned Space” column of Table C402.1(1). Walls between conditioned and semi-conditioned spaces shall use the R-values from the “Semi-conditioned Space” column of Table C402.1(1).

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 C402.1(1). 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 C402.1(1). 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 C402.1(1). Walls between conditioned and semi-conditioned spaces shall use the R-values from the “Semi-conditioned Space” column of Table C402.1(1).
<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>MAXIMUM OVERALL U-FACTOR</th>
<th>MINIMUM R-VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conditioned Space</td>
<td>Semi-conditioned Space</td>
</tr>
<tr>
<td>Roofs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation entirely above deck</td>
<td>U-0.025</td>
<td>U-0.039</td>
</tr>
<tr>
<td>Metal buildings</td>
<td>U-0.026</td>
<td>U-0.037</td>
</tr>
<tr>
<td>Attic and Other</td>
<td>U-0.021</td>
<td>U-0.034</td>
</tr>
<tr>
<td>Walls, Above grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>U-0.048</td>
<td>U-0.104</td>
</tr>
<tr>
<td>Metal building</td>
<td>U-0.044</td>
<td>U-0.060</td>
</tr>
<tr>
<td>Metal-framed</td>
<td>U-0.044</td>
<td>U-0.064</td>
</tr>
<tr>
<td>Wood-framed and other</td>
<td>U-0.042</td>
<td>U-0.064</td>
</tr>
<tr>
<td>Walls, Below Grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below-grade wall</td>
<td>C-0.063</td>
<td>C-0.119</td>
</tr>
<tr>
<td>Floors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>U-0.051</td>
<td>U-0.087</td>
</tr>
<tr>
<td>Joist/Framing—Metal</td>
<td>U-0.032</td>
<td>U-0.052</td>
</tr>
<tr>
<td>Joist/Framing—Wood and Other</td>
<td>U-0.033</td>
<td>U-0.051</td>
</tr>
<tr>
<td>Slab-on-Grade Floors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unheated slabs</td>
<td>F-0.36</td>
<td>F-0.54</td>
</tr>
<tr>
<td>Heated slabs</td>
<td>F-0.373</td>
<td>F-0.55</td>
</tr>
<tr>
<td>Opaque Doors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swinging</td>
<td>U-0.37</td>
<td>N/A</td>
</tr>
<tr>
<td>Non-Swinging</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Upward-acting, Sectional</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Garage door &lt;14% glazing</td>
<td>U-0.31</td>
<td>N/A</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m², 1 pound per cubic foot = 16 kg/m³.

2 = Continuous insulation, NR = No Requirement, LS = Liner System.

a. For all envelope categories, except metal building walls and metal building roofs, attic roofs with wood joists, metal-framed walls and wood-framed walls; the use of opaque assembly U-factors, C-factors, and F-factors from ANSI/ASHRAE/IESNA 90.1-2016 Appendix A shall be permitted, provided the construction, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ASHRAE/IESNA 90.1-2016 Appendix A. Refer to Table C402.1(2) for metal building assembly descriptions, Table C402.1(3) for metal building roof assembly U-factors, Table 402.1(4) for attic roofs with wood joists U-factors, Table 402.1(5) for metal building wall assembly U-
factors, Table 402.1(6) for metal-framed wall assembly U-factors, and Table 402.1(7) for wood-framed wall assembly U-factors.

b. Opaque assembly U-factors based on designs tested in accordance with ASTM C1363 shall be 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-factor requirements for heated slabs.

d. “Mass floors” 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 Appendix A.

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**TABLE C402.1(2)**

**BUILDING ENVELOPE REQUIREMENTS—METAL BUILDING ASSEMBLY DESCRIPTIONS**

<table>
<thead>
<tr>
<th>BUILDING ENVELOPE REQUIREMENTS— METAL BUILDING ASSEMBLY DESCRIPTIONS</th>
<th>DESCRIPTION</th>
<th>REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ROOFS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liner system</td>
<td>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.</td>
<td>ANSI/ASHRAE/IESNA 90.1-2016</td>
</tr>
<tr>
<td>Filled Cavity (Fc)</td>
<td>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.</td>
<td>ANSI/ASHRAE/IESNA 90.1-2016</td>
</tr>
<tr>
<td><strong>WALLS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-13 + R-17ci</td>
<td>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 shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.</td>
<td>ANSI/ASHRAE/IESNA 90.1-2016</td>
</tr>
<tr>
<td>R-22.1ci</td>
<td>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.</td>
<td>ANSI/ASHRAE/IESNA 90.1-2016</td>
</tr>
</tbody>
</table>
### TABLE C402.1(3)

**ASSEMBLY U-FACTORS FOR METAL BUILDING ROOFS**

<table>
<thead>
<tr>
<th>INSULATION SYSTEM</th>
<th>RATED R-VALUE OF INSULATION</th>
<th>OVERALL U-FACTOR FOR ENTIRE BASE ROOF ASSEMBLY</th>
<th>OVERALL U-FACTOR FOR ASSEMBLY OF BASE ROOF PLUS CONTINUOUS INSULATION (UNINTERRUPTED BY FRAMING)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing Seam Roofs with Thermal Spacer Blocks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single layer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1.280</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-10</td>
<td>0.115</td>
<td>0.036</td>
<td>0.032</td>
</tr>
<tr>
<td>R-11</td>
<td>0.107</td>
<td>0.037</td>
<td>0.032</td>
</tr>
<tr>
<td>R-13</td>
<td>0.101</td>
<td>0.035</td>
<td>0.031</td>
</tr>
<tr>
<td>R-16</td>
<td>0.096</td>
<td>0.035</td>
<td>0.031</td>
</tr>
<tr>
<td>R-19</td>
<td>0.082</td>
<td>0.036</td>
<td>0.032</td>
</tr>
<tr>
<td>Double layer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-10 + R-10</td>
<td>0.088</td>
<td>0.037</td>
<td>0.033</td>
</tr>
<tr>
<td>R-10 + R-11</td>
<td>0.086</td>
<td>0.036</td>
<td>0.033</td>
</tr>
<tr>
<td>R-11 + R-11</td>
<td>0.085</td>
<td>0.036</td>
<td>0.033</td>
</tr>
<tr>
<td>R-10 + R-13</td>
<td>0.084</td>
<td>0.036</td>
<td>0.032</td>
</tr>
<tr>
<td>R-11 + R-13</td>
<td>0.082</td>
<td>0.036</td>
<td>0.032</td>
</tr>
<tr>
<td>R-13 + R-13</td>
<td>0.075</td>
<td>0.034</td>
<td>0.031</td>
</tr>
<tr>
<td>R-10 + R-19</td>
<td>0.074</td>
<td>0.034</td>
<td>0.031</td>
</tr>
<tr>
<td>R-11 + R-19</td>
<td>0.072</td>
<td>0.034</td>
<td>0.030</td>
</tr>
<tr>
<td>R-13 + R-19</td>
<td>0.068</td>
<td>0.033</td>
<td>0.030</td>
</tr>
<tr>
<td>R-16 + R-19</td>
<td>0.065</td>
<td>0.032</td>
<td>0.029</td>
</tr>
<tr>
<td>R-19 + R-19</td>
<td>0.060</td>
<td>0.031</td>
<td>0.028</td>
</tr>
<tr>
<td>Liner system</td>
<td>R-25+R-11+R-11 LS</td>
<td>0.026</td>
<td></td>
</tr>
<tr>
<td>Filled cavity</td>
<td>R-10 + R-19 Fc</td>
<td>0.041</td>
<td>0.025</td>
</tr>
</tbody>
</table>

**Thru-fastened Roofs without Thermal Spacer Blocks**

| | | | | | |
| R-10 | 0.184 | | | | | |
| R-11 | 0.182 | | | | | |
| R-13 | 0.174 | | | | | |
| R-16 | 0.157 | | | | | |
| R-19 | 0.151 | | | | | |

(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 thermalspacer block is required.

### TABLE C402.1(4)

**ASSEMBLY U-FACTORS FOR ATTIC ROOFS WITH WOOD JOISTS**

<table>
<thead>
<tr>
<th>RATED R-VALUE OF INSULATION ALONE</th>
<th>OVERALL U-FACTOR FOR ENTIRE ROOF ASSEMBLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood-Framed Attic, Standard Framing</td>
<td></td>
</tr>
<tr>
<td>R-30</td>
<td>U-0.034</td>
</tr>
<tr>
<td>R-38</td>
<td>U-0.027</td>
</tr>
<tr>
<td>R-49</td>
<td>U-0.021</td>
</tr>
<tr>
<td>R-60</td>
<td>U-0.017</td>
</tr>
<tr>
<td>R-71</td>
<td>U-0.015</td>
</tr>
<tr>
<td>RATED R-VALUE OF INSULATION</td>
<td>OVERALL U-FACTOR FOR BASE WALL ASSEMBLY</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td></td>
<td>R-6.5</td>
</tr>
<tr>
<td>Continuous Insulation Only</td>
<td></td>
</tr>
<tr>
<td>R-0</td>
<td>1.180</td>
</tr>
<tr>
<td>R-10</td>
<td>0.186</td>
</tr>
<tr>
<td>R-11</td>
<td>0.185</td>
</tr>
<tr>
<td>R-13</td>
<td>0.162</td>
</tr>
<tr>
<td>R-16</td>
<td>0.155</td>
</tr>
<tr>
<td>R-19</td>
<td>0.147</td>
</tr>
<tr>
<td>Single Layer in Cavity</td>
<td></td>
</tr>
<tr>
<td>R-25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.059</td>
</tr>
<tr>
<td>R-30&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.052</td>
</tr>
<tr>
<td>Double Layer</td>
<td></td>
</tr>
<tr>
<td>R-25 + R-10</td>
<td>0.047</td>
</tr>
<tr>
<td>R-25 + R-16</td>
<td>0.042</td>
</tr>
<tr>
<td>R-25 + R-10&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.039</td>
</tr>
<tr>
<td>R-30 + R-16</td>
<td>0.039</td>
</tr>
</tbody>
</table>

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)
**ASSEMBLY U-FACTORS FOR METAL-FRAMED WALLS**

<table>
<thead>
<tr>
<th>RATED R-VALUE OF CAVITY INSULATION (EFFECTIVE INSTALLED)</th>
<th>OVERALL U-FACTOR FOR BASE WALL ASSEMBLY</th>
<th>OVERALL U-FACTORS FOR ASSEMBLY OF BASE WALL PLUS CONTINUOUS INSULATION (UNINTERRUPTED BY FRAMING)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R-12</td>
<td>R-13</td>
</tr>
<tr>
<td>Steel Framing at 16 in. on Center and 3.5 in. Depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-0 (0.0)</td>
<td>0.352</td>
<td>0.063</td>
</tr>
<tr>
<td>R-11 (5.5)</td>
<td>0.132</td>
<td>0.051</td>
</tr>
<tr>
<td>R-13 (6.0)</td>
<td>0.124</td>
<td>0.050</td>
</tr>
<tr>
<td>R-15 (6.4)</td>
<td>0.118</td>
<td>0.049</td>
</tr>
<tr>
<td>Steel Framing at 16 in. on Center and 6.0 in. Depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-19 (7.1)</td>
<td>0.109</td>
<td>0.047</td>
</tr>
<tr>
<td>R-21 (7.4)</td>
<td>0.106</td>
<td>0.047</td>
</tr>
<tr>
<td>Steel Framing at 24 in. on Center and 3.5 in. Depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-0 (0.0)</td>
<td>0.338</td>
<td>0.063</td>
</tr>
<tr>
<td>R-11 (6.6)</td>
<td>0.116</td>
<td>0.048</td>
</tr>
<tr>
<td>R-13 (7.2)</td>
<td>0.108</td>
<td>0.047</td>
</tr>
<tr>
<td>R-15 (7.8)</td>
<td>0.102</td>
<td>0.046</td>
</tr>
<tr>
<td>Steel Framing at 24 in. on Center and 6.0 in. Depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-19 (8.6)</td>
<td>0.094</td>
<td>0.044</td>
</tr>
<tr>
<td>R-21 (9.0)</td>
<td>0.090</td>
<td>0.043</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>RATED R-VALUE OF CAVITY INSULATION (EFFECTIVE INSTALLED)</th>
<th>OVERALL U-FACTOR FOR BASE WALL ASSEMBLY</th>
<th>OVERALL U-FACTORS FOR ASSEMBLY OF BASE WALL PLUS CONTINUOUS INSULATION (UNINTERRUPTED BY FRAMING)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R-6</td>
<td>R-9</td>
</tr>
<tr>
<td>Wood Studs at 16 in. on Center and 3.5 in. Depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-0 (0.0)</td>
<td>0.292</td>
<td>0.064</td>
</tr>
<tr>
<td>R-11 (11.0)</td>
<td>0.096</td>
<td>0.059</td>
</tr>
<tr>
<td>R-13 (13.0)</td>
<td>0.089</td>
<td>0.056</td>
</tr>
<tr>
<td>R-15 (15.0)</td>
<td>0.083</td>
<td>0.053</td>
</tr>
<tr>
<td>Wood Studs at 16 in. on Center and 5.5 in. Depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-19 (18.0)</td>
<td>0.067</td>
<td>0.046</td>
</tr>
<tr>
<td>R-21 (21.0)</td>
<td>0.063</td>
<td>0.043</td>
</tr>
<tr>
<td>Wood Studs at 16 in. on Center and R-10 Headers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-19 (18.0)</td>
<td>0.063</td>
<td>0.045</td>
</tr>
<tr>
<td>R-21 (21.0)</td>
<td>0.059</td>
<td>0.042</td>
</tr>
<tr>
<td>Wood Studs at 24 in. on Center and 3.5 in. Depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-0 (0.0)</td>
<td>0.298</td>
<td>0.064</td>
</tr>
<tr>
<td>R-11 (11.0)</td>
<td>0.094</td>
<td>0.059</td>
</tr>
<tr>
<td>R-13 (13.0)</td>
<td>0.086</td>
<td>0.055</td>
</tr>
<tr>
<td>R-15 (15.0)</td>
<td>0.080</td>
<td>0.052</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
<th>R-19 (18.0)</th>
<th>R-21 (21.0)</th>
<th>R-19 (18.0)</th>
<th>R-21 (21.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.065</td>
<td>0.060</td>
<td>0.062</td>
<td>0.057</td>
</tr>
<tr>
<td></td>
<td>0.045</td>
<td>0.042</td>
<td>0.044</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>0.039</td>
<td>0.037</td>
<td>0.039</td>
<td>0.036</td>
</tr>
<tr>
<td></td>
<td>0.035</td>
<td>0.033</td>
<td>0.034</td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td>0.032</td>
<td>0.030</td>
<td>0.031</td>
<td>0.029</td>
</tr>
<tr>
<td></td>
<td>0.027</td>
<td>0.026</td>
<td>0.027</td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td>0.024</td>
<td>0.023</td>
<td>0.024</td>
<td>0.023</td>
</tr>
<tr>
<td></td>
<td>0.021</td>
<td>0.020</td>
<td>0.021</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>0.019</td>
<td>0.018</td>
<td>0.019</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>0.018</td>
<td>0.017</td>
<td>0.017</td>
<td>0.017</td>
</tr>
</tbody>
</table>

Shaded areas comply with minimum requirements for semi-conditioned spaces but not conditioned spaces.
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 C402.1(1) 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.

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

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 $\times$ Area.
- **UA Table** = ($U$-factor from Table C402.1(1) or C402.3) $\times$ 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 $\times$ Perimeter length.
- **FL Table** = ($F$-factor specified in Table C402.1(1)) $\times$ 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 $\times$ Area.
- **CA Table** = (Maximum allowable $C$-factor specified in Table C402.1(1)) $\times$ 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** = $(DA \times UV) - (DA \times U Wall)$, 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:
\[ E = (EA \times US) - (EA \times U \text{ Roof}), \text{ but not less than zero.} \]

\[ EA = (\text{Proposed Skylight Area}) - (\text{Allowable Skylight Area as specified in Section C402.3.1}). \]

\[ U \text{ Roof} = \text{Area-weighted average } U\text{-value of all roof assemblies.} \]

\[ UAS = \text{Sum of the (UA Proposed) values for each skylight assembly.} \]

\[ US = \frac{UAS}{\text{total skylight area}}. \]

**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 C402.1(1) 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.

\[
\frac{UA\text{-Total}}{\text{Area}} \leq 0.035 \quad \text{(Equation 4-2)}
\]

where:

\[ UA\text{-Total} = \text{Sum of the (UA) values for each distinct above-grade assembly type of the building thermal envelope including above-grade walls, roofs, doors, vertical fenestration, and skylights.} \]

\[ UA = \text{Proposed } U\text{-value } \times \text{Area.} \]

\[ \text{Area} = \text{Surface area in square feet of the above-grade thermal barrier (above-grade wall area plus roof area).} \]

**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 C402.1(1).

**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 C402.1(1), 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 R-value is equivalent to the R-value specified in Table C402.1(1).

2. A minimum of 60% 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 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 C402.1(1), 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 C402.1(1) except as otherwise noted in the table. In determining compliance with Table C402.1(1), 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 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 C402.1(1), based on construction materials used in the floor assembly.

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, the minimum thermal resistance (R-value) of the insulation around the perimeter of 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 C402.1(1). 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 10 inches (254 mm) of soil.

Exception: Where the slab-on-grade floor is greater than 48 inches (122 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 C402.1(1). 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 C402.1(1). 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 402.1(1).

C402.2.7 Airspaces.
Where the thermal properties of airspaces are used to comply with this code in accordance with Section C401.2, such airspaces 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

<table>
<thead>
<tr>
<th>Vertical fenestration</th>
<th>U-factor</th>
<th>SHGC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed fenestration</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>Operable fenestration</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>Entrance doors</td>
<td>0.68</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Orientation</th>
<th>SEW</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF &lt; 0.2</td>
<td>0.40</td>
<td>0.53</td>
</tr>
<tr>
<td>0.2 ≤ PF &lt; 0.5</td>
<td>0.48</td>
<td>0.58</td>
</tr>
<tr>
<td>PF ≥ 0.5</td>
<td>0.64</td>
<td>0.64</td>
</tr>
</tbody>
</table>

Skylights

<table>
<thead>
<tr>
<th>U-factor</th>
<th>SHGC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.48</td>
<td>0.38</td>
</tr>
</tbody>
</table>

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 zones.
C402.3.2 Minimum skylight fenestration area.

In an enclosed space 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 total toplit daylight zone shall be not less than half the floor area and shall provide 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 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.

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

(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.
- **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 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.
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 toplit 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 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.

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.

$$PF = \frac{A}{B}$$  
_(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 C402.1(1). Opaque nonswinging doors shall comply with Table C402.1(1). Opaque doors shall be considered as part of the gross area of above-grade walls that are part of the building thermal envelope. Other doors shall comply with the provisions of Section C402.3.3 for vertical fenestration.

C402.4 Air leakage—thermal envelope (Mandatory).
The thermal envelope of buildings shall comply with Sections C402.4.1 through C402.4.5.

C402.4.1 Air barriers.
A continuous air barrier shall be provided throughout the building thermal envelope. The air barriers shall be permitted to be located on the inside or outside of the building envelope, located within the assemblies composing the 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.

C402.4.1.1 Air Barrier Performance Testing
The building thermal envelope shall be tested in accordance with ASTM E 779 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).

Exceptions:

1. For buildings having over 50,000 ft² of gross conditioned floor area, air leakage testing shall be permitted to be conducted on less than the whole building, provided the following portions of the building are tested and their measured air leakage is area-weighted by the surface areas of the building envelope:
   a. The entire floor area of all stories that have any spaces directly under a roof.
   b. The entire floor area of all stories that have a building entrance or loading dock.
   c. Representative above-grade wall sections of the building totaling at least 25% of the wall area enclosing the remaining conditioned space; floor area tested per (a) and (b) shall not be included in the 25%.
2. Where the measured air leakage rate exceeds 0.30 cfm/ft² but does not exceed 0.40 cfm/ft², 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, the registered design professional 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 COMMISSIONING CHECKLIST

<table>
<thead>
<tr>
<th>RELATED SYSTEMS, EQUIPMENT, ASSEMBLIES AND COMPONENTS</th>
<th>TASKS/COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundations subsoil drainage system</td>
<td>Verify compliance with approved plans, specifications and construction documents.</td>
</tr>
<tr>
<td>Foundation damp-proofing and waterproofing</td>
<td></td>
</tr>
<tr>
<td>Flashing at: exterior doors, skylights, wall flashing and drainage systems</td>
<td></td>
</tr>
<tr>
<td>Exterior wall coverings</td>
<td>Where applicable meet owner’s project requirements (OPR), Basis of Design (BOD), Cx Specifications.</td>
</tr>
<tr>
<td>Moisture envelopes</td>
<td></td>
</tr>
<tr>
<td>Exterior below-grade walls</td>
<td>Check for proper drainage system at exterior wall perimeter to keep water from entering building.</td>
</tr>
<tr>
<td>External floor and soffits, slab-on grade</td>
<td>Check for thermal resistance or insulation when required. Slabs: Check drainage for moisture penetration.</td>
</tr>
<tr>
<td>Exterior walls</td>
<td>Check drawings for wall assembly requirements.</td>
</tr>
</tbody>
</table>
| Exterior glazed window fenestration: windows, glazed doors and skylights | 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 site, not preformed or cut | Check for compliance with the default U-factor and the default SHGC. | |
| Exterior doors | Check for proper flashing installation at header, walls and floor. | Check for compliance with the default U-factor and the default SHGC. |
| 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/ft² (0.02 L/s • m²) 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 \( \frac{3}{8} \) inch (10 mm).
2. Oriented strand board having a thickness of not less than \( \frac{3}{8} \) inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than \( \frac{1}{2} \) inch (12.7 mm).
4. Foil-back polyisocyanurate insulation board having a thickness of not less than \( \frac{1}{2} \) inch (12.7 mm).
5. Closed-cell spray foam having a minimum density of 1.5pcf (2.4 kg/m³) and having a thickness of not less than \( \frac{1}{2} \) inches (38 mm).
6. Open-cell spray foam with a density between 0.4 and 1.5pcf (0.6 and 2.4 kg/m³) 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 $\frac{1}{2}$ inch (12.7 mm).

8. Cement board having a thickness of not less than $\frac{1}{2}$ inch (12.7 mm).


10. Modified bituminous roof membrane.


12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than $\frac{5}{8}$ inch (15.9 mm).


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 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 $\frac{1}{2}$ 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

<table>
<thead>
<tr>
<th>FENESTRATION ASSEMBLY</th>
<th>MAXIMUM RATE (CFM/FT(^2))</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows</td>
<td>0.20(\textsuperscript{a})</td>
<td>AAMA/WDMA/CSA101/I.S.2/A440 or NFRC 400</td>
</tr>
<tr>
<td>Sliding doors</td>
<td>0.20(\textsuperscript{a})</td>
<td></td>
</tr>
<tr>
<td>Swinging doors</td>
<td>0.20(\textsuperscript{a})</td>
<td></td>
</tr>
<tr>
<td>Skylights – with condensation weepage openings</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Skylights – all other</td>
<td>0.20(\textsuperscript{a})</td>
<td></td>
</tr>
<tr>
<td>Curtain walls</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Storefront glazing</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Commercial glazed swinging entrance doors</td>
<td>1.00</td>
<td>NFRC 400 or ASTM E283 at 1.57 psf (75 Pa)</td>
</tr>
<tr>
<td>Power-operated sliding doors and power-operated folding doors</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Revolving doors</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Garage doors</td>
<td>0.40</td>
<td>ANSI/DASMA 105, NFRC 400, or ASTM E283 at 1.57 psf (75 Pa)</td>
</tr>
<tr>
<td>Rolling doors</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>High-speed doors</td>
<td>1.30</td>
<td></td>
</tr>
</tbody>
</table>

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

\(\textsuperscript{a}\) 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 C402.1(1).

   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 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, weatherstripped 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 unit air infiltration.**
A sampling of dwelling units shall be tested in accordance with ASTM E 779 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 registered design professional. 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 weatherseals.**

Cargo door openings and loading door openings shall be equipped with weatherseals 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 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 per the slab ASTM E283 on grade standard in Table C402.1(1). The spaces between the pit wall and the deck skirts for the leveler shall be weather-stripped.

**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. 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.

*Exceptions:* 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 (298 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

1. Tamper-proof, or

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

Exception: Vestibule spaces served by radiant floor heating may utilize a non-programmable thermostat.
SECTION C403
BUILDING MECHANICAL SYSTEMS

C403.1 General.
In addition to the mechanical requirements of Section C403, mechanical enhancements may be needed to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406.

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

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.

C403.2 System design (Mandatory).
Mechanical systems shall be designed to comply with Sections C403.2.1 through C403.2.4. Where elements of a building’s mechanical systems are addressed in Sections C403.3 through C403.12, 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 m²) 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, shall be provided in accordance with 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 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:

1. 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 ≤ 6.0 Btu/hour/square foot at design temperature.*

5. 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; and b. the building thermal envelope shall be tested in accordance with ASTM E 779 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 cfm/ft² (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 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 ten 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.

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(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 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**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, air cooled</td>
<td>&lt; 65,000 Btu/h</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Through-the-wall (air cooled)</td>
<td>≤ 30,000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>13.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Small-duct high-velocity (air cooled)</td>
<td>&lt; 65,000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>11.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>11.2 EER 12.8 IEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>None</td>
<td>Split System and Single Package</td>
<td>10.8 EER 12.2 IEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Electricc</td>
<td>Split System and Single Package</td>
<td>9.8 EER 11.4 IEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h and &lt; 760,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>9.7 EER 11.2 IEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Electricc</td>
<td>Split System and Single Package</td>
<td>9.5 EER 11.0 IEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td>≥ 760,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>12.1 EER 12.3 IEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Electricc</td>
<td>Split System and Single Package</td>
<td>12.0 EER 13.3 IEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Air conditioners, water cooled</td>
<td>&lt; 65,000 Btu/h</td>
<td>All</td>
<td>Split System and Single Package</td>
<td>12.1 EER 12.3 IEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>12.1 EER 13.9 IEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>None</td>
<td>Split System and Single Package</td>
<td>11.9 EER 13.7 IEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>12.5 EER 13.9 IEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Electricc</td>
<td>Split System and Single Package</td>
<td>12.3 EER 13.7 IEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h and &lt; 760,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>12.4 EER 13.6 IEER</td>
<td>AHRI 340/360</td>
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<td></td>
<td></td>
<td>Non-Electricc</td>
<td>Split System and Single Package</td>
<td>12.2 EER 13.4 IEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td>≥ 760,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>12.2 EER 13.5 IEER</td>
<td>AHRI 340/360</td>
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<tr>
<td></td>
<td></td>
<td>Non-Electricc</td>
<td>Split System and Single Package</td>
<td>12.0 EER 13.3 IEER</td>
<td>AHRI 340/360</td>
</tr>
</tbody>
</table>

(continued)

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

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, evaporatively cooled</td>
<td>&lt; 65,000 Btu/h</td>
<td>All</td>
<td>Split System and Single Package</td>
<td>12.1 EER 12.3 IEER</td>
<td>AHRI 210/240</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Btu/h Range</th>
<th>Type</th>
<th>Hvac Type</th>
<th>EER</th>
<th>IEER</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>12.1</td>
<td>12.3</td>
</tr>
<tr>
<td></td>
<td>Non-Electric</td>
<td>Split System and Single Package</td>
<td>11.9</td>
<td>12.1</td>
</tr>
<tr>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>12.0</td>
<td>12.2</td>
</tr>
<tr>
<td></td>
<td>Non-Electric</td>
<td>Split System and Single Package</td>
<td>11.8</td>
<td>12.0</td>
</tr>
<tr>
<td>≥ 240,000 Btu/h and &lt; 760,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>11.9</td>
<td>12.1</td>
</tr>
<tr>
<td></td>
<td>Non-Electric</td>
<td>Split System and Single Package</td>
<td>11.7</td>
<td>11.9</td>
</tr>
<tr>
<td>≥ 760,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>11.5</td>
<td>11.7</td>
</tr>
<tr>
<td></td>
<td>Non-Electric</td>
<td>Split System and Single Package</td>
<td>11.7</td>
<td>11.9</td>
</tr>
</tbody>
</table>

Condensing units, air cooled
≥ 135,000 Btu/h | — | — | 10.5 EER | 11.8 IEER |

Condensing units, water cooled
≥ 135,000 Btu/h | — | — | 13.5 EER | 14.0 IEER |

Condensing units, evaporatively cooled
≥ 135,000 Btu/h | — | — | 13.5 EER | 14.0 IEER |

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

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled (cooling mode)</td>
<td>&lt; 65,000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>14.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Through-the-wall, air cooled</td>
<td>≤ 30,000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>12.0 SEER</td>
<td></td>
</tr>
<tr>
<td>Single-duct high-velocity air cooled</td>
<td>&lt; 65,000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>11.0 SEER</td>
<td></td>
</tr>
<tr>
<td>Air cooled (cooling mode)</td>
<td>≥ 65,000 Btu/h and ≤ 135,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>11.0 EER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Electric</td>
<td>Split System and Single Package</td>
<td>10.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.8 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h and ≤ 240,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>10.4 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Electric</td>
<td>Split System and Single Package</td>
<td>10.6 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.4 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>9.6 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Electric</td>
<td>Split System and Single Package</td>
<td>9.3 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.4 IEER</td>
<td></td>
</tr>
<tr>
<td>Water to Air: Water Loop (cooling mode)</td>
<td>&lt; 17,000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>12.2 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td></td>
<td>≥ 17,000 Btu/h and &lt; 65,000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>13.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>13.0 EER</td>
<td></td>
</tr>
<tr>
<td>Water to Air: Ground Water (cooling mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>All</td>
<td>59°F entering water</td>
<td>18.0 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Brine to Air: Ground Loop (cooling mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>All</td>
<td>77°F entering water</td>
<td>14.1 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Water to Water: Water Loop (cooling mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>10.6 EER</td>
<td>ISO 13256-2</td>
</tr>
<tr>
<td>Water to Water: Ground Water (cooling mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>All</td>
<td>59°F entering water</td>
<td>16.3 EER</td>
<td></td>
</tr>
<tr>
<td>Brine to Water: Ground Loop (cooling mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>All</td>
<td>77°F entering fluid</td>
<td>12.1 EER</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled (heating mode)</td>
<td>&lt; 65,000 Btu/h</td>
<td>—</td>
<td>Split System</td>
<td>10.0 HSPF</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Through-the-wall, (air cooled, heating mode)</td>
<td>≤ 30,000 Btu/h</td>
<td>—</td>
<td>Split System</td>
<td>10.0 HSPF</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td>Small-duct high velocity (air cooled, heating mode)</td>
<td>&lt; 65,000 Btu/h</td>
<td>—</td>
<td>Split System</td>
<td>10.0 HSPF</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Air cooled (heating mode)</td>
<td>≥ 65,000 Btu/h</td>
<td>47ºF db/43ºF wb</td>
<td>3.3 COP</td>
<td></td>
<td>ISO 13256-2</td>
</tr>
<tr>
<td>Water to Air: Water Loop (heating mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>68ºF entering water</td>
<td>4.3 COP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water to Air: Ground Water (heating mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>50ºF entering water</td>
<td>3.7 COP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brine to Air: Ground Loop (heating mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>32ºF entering fluid</td>
<td>3.2 COP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water to Water: Water Loop (heating mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>68ºF entering water</td>
<td>3.7 COP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water to Water: Ground Water (heating mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>50ºF entering water</td>
<td>3.1 COP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brine to Water: Ground Loop (heating mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>32ºF entering fluid</td>
<td>2.5 COP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.
### TABLE C403.3.2(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

| EQUIPMENT TYPE | SIZE CATEGORY (INPUT) | SUBCATEGORY OR RATING CONDITION | MINIMUM EFFICIENCY | TEST PROEDURE  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PTAC (cooling mode) new construction</td>
<td>All Capacities</td>
<td>95°F db outdoor air</td>
<td>14.0 - (0.300 × Cap/1000) EER</td>
<td>AHRI 310/380</td>
</tr>
<tr>
<td>PTAC (cooling mode) b replacements</td>
<td>All Capacities</td>
<td>95°F db outdoor air</td>
<td>10.9 - (0.213 × Cap/1000) EER</td>
<td></td>
</tr>
<tr>
<td>PTHP (cooling mode) new construction</td>
<td>All Capacities</td>
<td>95°F db outdoor air</td>
<td>14.0 - (0.300 × Cap/1000) EER</td>
<td></td>
</tr>
<tr>
<td>PTHP (cooling mode) b replacements</td>
<td>All Capacities</td>
<td>95°F db outdoor air</td>
<td>10.8 - (0.213 × Cap/1000) EER</td>
<td></td>
</tr>
<tr>
<td>PTHP (heating mode) new construction</td>
<td>All Capacities</td>
<td>—</td>
<td>3.2 - (0.026 × Cap/1000) COP</td>
<td></td>
</tr>
<tr>
<td>PTHP (heating mode) b replacements</td>
<td>All Capacities</td>
<td>—</td>
<td>2.9 - (0.026 × Cap/1000) COP</td>
<td></td>
</tr>
<tr>
<td>SPVAC (cooling mode)</td>
<td>&lt; 65,000 Btu/h</td>
<td>95°F db/ 75°F wb outdoor air</td>
<td>9.0 EER</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>95°F db/ 75°F wb outdoor air</td>
<td>8.9 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>95°F db/ 75°F wb outdoor air</td>
<td>8.6 EER</td>
<td></td>
</tr>
<tr>
<td>SPVHP (cooling mode)</td>
<td>&lt; 65,000 Btu/h</td>
<td>95°F db/ 75°F wb outdoor air</td>
<td>9.0 EER</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>95°F db/ 75°F wb outdoor air</td>
<td>8.9 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>95°F db/ 75°F wb outdoor air</td>
<td>8.6 EER</td>
<td></td>
</tr>
<tr>
<td>SPVHP (heating mode)</td>
<td>&lt; 65,000 Btu/h</td>
<td>47°F db/ 43°F wb outdoor air</td>
<td>3.0 COP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>47°F db/ 43°F wb outdoor air</td>
<td>3.0 COP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>47°F db/ 75°F wb outdoor air</td>
<td>2.9 COP</td>
<td></td>
</tr>
<tr>
<td>Room air conditioners, with louvered sides</td>
<td>&lt; 6,000 Btu/h</td>
<td>—</td>
<td>11.0 CEER</td>
<td>ANSI/ AHAM RAC-1</td>
</tr>
<tr>
<td></td>
<td>≥ 6,000 Btu/h and &lt; 8,000 Btu/h</td>
<td>—</td>
<td>11.0 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 8,000 Btu/h and &lt; 14,000 Btu/h</td>
<td>—</td>
<td>10.9 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 14,000 Btu/h and &lt; 20,000 Btu/h</td>
<td>—</td>
<td>10.7 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 20,000 Btu/h and &lt; 25,000 Btu/h</td>
<td>—</td>
<td>9.4 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 25,000 Btu/h</td>
<td>—</td>
<td>9.0 CEER</td>
<td></td>
</tr>
<tr>
<td>Room air conditioners, without louvered sides</td>
<td>&lt; 6,000 Btu/h</td>
<td>—</td>
<td>10.0 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 6,000 Btu/h and &lt; 8,000 Btu/h</td>
<td>—</td>
<td>10.0 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 8,000 Btu/h and &lt; 11,000 Btu/h</td>
<td>—</td>
<td>9.6 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 11,000 Btu/h and &lt; 14,000 Btu/h</td>
<td>—</td>
<td>9.5 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 14,000 Btu/h and &lt; 20,000 Btu/h</td>
<td>—</td>
<td>9.3 CEER</td>
<td></td>
</tr>
<tr>
<td>EQUIPMENT TYPE</td>
<td>SIZE CATEGORY (INPUT)</td>
<td>SUBCATEGORY OR RATING CONDITION</td>
<td>MINIMUM EFFICIENCY</td>
<td>TEST PROCEDUREa</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------</td>
<td>---------------------------------</td>
<td>--------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Room air conditioner casement only</td>
<td>All capacities</td>
<td>—</td>
<td>9.5 CEER</td>
<td>ANSI/AHAM RAC-1</td>
</tr>
<tr>
<td>Room air conditioner casement-slider</td>
<td>All capacities</td>
<td>—</td>
<td>10.4 CEER</td>
<td></td>
</tr>
</tbody>
</table>

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.
**TABLE C403.3.2(4)**
WARM-AIR FURNACES AND COMBINATION WARM-AIR FURNACES/AIR-CONDITIONING UNITS, WARM-AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY (INPUT)</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm-air furnaces, gas fired</td>
<td>&lt; 225,000 Btu/h</td>
<td>—</td>
<td>80% AFUE or 80%E_t</td>
<td>DOE 10 CFR Part 430 or ANSI Z21.47</td>
</tr>
<tr>
<td></td>
<td>≥ 225,000 Btu/h</td>
<td>Maximum capacity</td>
<td>80%E_t</td>
<td>ANSI Z21.47</td>
</tr>
<tr>
<td>Warm-air furnaces, oil fired</td>
<td>&lt; 225,000 Btu/h</td>
<td>—</td>
<td>83% AFUE or 80%E_t</td>
<td>DOE 10 CFR Part 430 or UL 727</td>
</tr>
<tr>
<td></td>
<td>≥ 225,000 Btu/h</td>
<td>Maximum capacity</td>
<td>81%E_g</td>
<td>UL 727</td>
</tr>
<tr>
<td>Warm-air duct furnaces, gas fired</td>
<td>All capacities</td>
<td>Maximum capacity</td>
<td>80%E_c</td>
<td>ANSI Z83.8</td>
</tr>
<tr>
<td>Warm-air unit heaters, gas fired</td>
<td>All capacities</td>
<td>Maximum capacity</td>
<td>80%E_c</td>
<td>ANSI Z83.8</td>
</tr>
<tr>
<td>Warm-air unit heaters, oil fired</td>
<td>All capacities</td>
<td>Maximum capacity</td>
<td>80%E_c</td>
<td>UL 731</td>
</tr>
</tbody>
</table>

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. \( E_t \) = 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.
**TABLE C403.3.2(5)**
MINIMUM EFFICIENCY REQUIREMENTS: GAS- AND OIL-FIRED BOILERS

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE&lt;sup&gt;a&lt;/sup&gt;</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>SIZE CATEGORY (INPUT)</th>
<th>MINIMUM EFFICIENCY&lt;sup&gt;d, e&lt;/sup&gt;</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boilers, hot water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas-fired</td>
<td></td>
<td>&lt; 300,000 Btu/h&lt;sup&gt;f, g&lt;/sup&gt;</td>
<td>82% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h&lt;sup&gt;b&lt;/sup&gt;</td>
<td>80% &lt;sup&gt;E&lt;sub&gt;t&lt;/sub&gt;&lt;/sup&gt;</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 2,500,000 Btu/h&lt;sup&gt;a&lt;/sup&gt;</td>
<td>82% &lt;sup&gt;E&lt;sub&gt;c&lt;/sub&gt;&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Oil-fired&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td>&lt; 300,000 Btu/h&lt;sup&gt;g&lt;/sup&gt;</td>
<td>84% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h&lt;sup&gt;b&lt;/sup&gt;</td>
<td>82% &lt;sup&gt;E&lt;sub&gt;t&lt;/sub&gt;&lt;/sup&gt;</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 2,500,000 Btu/h&lt;sup&gt;a&lt;/sup&gt;</td>
<td>84% &lt;sup&gt;E&lt;sub&gt;c&lt;/sub&gt;&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Boilers, steam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas-fired</td>
<td></td>
<td>&lt; 300,000 Btu/h&lt;sup&gt;f&lt;/sup&gt;</td>
<td>80% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td>Gas-fired-all, except natural draft</td>
<td></td>
<td>≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h&lt;sup&gt;b&lt;/sup&gt;</td>
<td>79% &lt;sup&gt;E&lt;sub&gt;t&lt;/sub&gt;&lt;/sup&gt;</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 2,500,000 Btu/h&lt;sup&gt;a&lt;/sup&gt;</td>
<td>79% &lt;sup&gt;E&lt;sub&gt;t&lt;/sub&gt;&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Gas-fired-natural draft</td>
<td></td>
<td>≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h&lt;sup&gt;b&lt;/sup&gt;</td>
<td>77% &lt;sup&gt;E&lt;sub&gt;t&lt;/sub&gt;&lt;/sup&gt;</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 2,500,000 Btu/h&lt;sup&gt;a&lt;/sup&gt;</td>
<td>77% &lt;sup&gt;E&lt;sub&gt;t&lt;/sub&gt;&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Oil-fired&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td>&lt; 300,000 Btu/h&lt;sup&gt;h&lt;/sup&gt;</td>
<td>82% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h&lt;sup&gt;b&lt;/sup&gt;</td>
<td>81% &lt;sup&gt;E&lt;sub&gt;t&lt;/sub&gt;&lt;/sup&gt;</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 2,500,000 Btu/h&lt;sup&gt;a&lt;/sup&gt;</td>
<td>81% &lt;sup&gt;E&lt;sub&gt;t&lt;/sub&gt;&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

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. <sup>E<sub>c</sub></sup> = Combustion efficiency (100 percent less flue losses).

e. <sup>E<sub>t</sub></sup> = 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.
**TABLE C403.3.2(6)**
**MINIMUM EFFICIENCY REQUIREMENTS:**
**CONDENSING UNITS, ELECTRICALLY OPERATED**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>MINIMUM EFFICIENCY&lt;sup&gt;b&lt;/sup&gt;</th>
<th>TEST PROCEDURE&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensing units, air cooled</td>
<td>≥ 135,000 Btu/h</td>
<td>10.1 EER</td>
<td>AHRI 365</td>
</tr>
<tr>
<td>Condensing units, water or evaporatively cooled</td>
<td>≥ 135,000 Btu/h</td>
<td>11.2 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.1 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.1 IPLV</td>
<td></td>
</tr>
</tbody>
</table>

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

- Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
- IPLVs are only applicable to equipment with capacity modulation.
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>UNITS</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air-cooled chillers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 150 Tons</td>
<td>EER (Btu/W)</td>
<td>Path A ≥ 10.100 FL, Path B ≥ 9.700 FL</td>
<td>AHRI 550/590</td>
</tr>
<tr>
<td>≥ 150 Tons</td>
<td>EER (Btu/W)</td>
<td>Path A ≥ 13.700 IPLV, Path B ≥ 15,800 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Path A ≥ 10.100 FL, Path B ≥ 9.700 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Path A ≥ 14.000 IPLV, Path B ≥ 16.100 IPLV</td>
<td></td>
</tr>
<tr>
<td><strong>Air cooled without condenser, electrically operated</strong></td>
<td>All capacities</td>
<td>EER (Btu/W)</td>
<td>Air-cooled chillers without condenser shall be rated with matching condensers and complying with air-cooled chiller efficiency requirements.</td>
</tr>
<tr>
<td>&lt; 75 Tons</td>
<td>kW/ton ≤ 0.750 FL</td>
<td>≤ 0.720 FL, ≤ 0.560 IPLV</td>
<td></td>
</tr>
<tr>
<td>≥ 75 tons and &lt; 150 tons</td>
<td>kW/ton ≤ 0.750 FL</td>
<td>≤ 0.660 FL, ≤ 0.440 IPLV</td>
<td></td>
</tr>
<tr>
<td>≥ 150 tons and &lt; 300 tons</td>
<td>kW/ton ≤ 0.600 FL</td>
<td>≤ 0.610 FL, ≤ 0.410 IPLV</td>
<td></td>
</tr>
<tr>
<td>≥ 300 tons and &lt; 600 tons</td>
<td>kW/ton ≤ 0.560 FL</td>
<td>≤ 0.560 FL, ≤ 0.585 IPLV</td>
<td></td>
</tr>
<tr>
<td>≥ 600 tons</td>
<td>kW/ton ≤ 0.500 IPLV</td>
<td>≤ 0.500 IPLV, ≤ 0.380 IPLV</td>
<td></td>
</tr>
<tr>
<td><strong>Water cooled, electrically operated positive displacement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 150 Tons</td>
<td>kW/ton ≤ 0.610 FL</td>
<td>≤ 0.695 FL, ≤ 0.440 IPLV</td>
<td></td>
</tr>
<tr>
<td>≥ 150 tons and &lt; 300 tons</td>
<td>kW/ton ≤ 0.610 FL</td>
<td>≤ 0.635 FL, ≤ 0.400 IPLV</td>
<td></td>
</tr>
<tr>
<td>≥ 300 tons and &lt; 400 tons</td>
<td>kW/ton ≤ 0.550 IPLV</td>
<td>≤ 0.550 IPLV, ≤ 0.390 IPLV</td>
<td></td>
</tr>
<tr>
<td>≥ 400 tons and &lt; 600 tons</td>
<td>kW/ton ≤ 0.560 FL</td>
<td>≤ 0.560 FL, ≤ 0.585 FL</td>
<td></td>
</tr>
<tr>
<td>Compressor Type</td>
<td>Range of Conditions</td>
<td>COP Requirement</td>
<td>FL Requirement</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>---------------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Air cooled, absorption, single effect</td>
<td>≥ 600 Tons</td>
<td>≤ 0.500 IPLV</td>
<td>≤ 0.560 FL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 0.585 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 0.500 IPLV</td>
<td>≤ 0.380 FL</td>
</tr>
<tr>
<td>Water cooled absorption, single effect</td>
<td>All capacities</td>
<td>COP</td>
<td>≥ 0.600 FL</td>
</tr>
<tr>
<td>Absorption, double effect, indirect fired</td>
<td>All capacities</td>
<td>COP</td>
<td>≥ 0.700 FL</td>
</tr>
<tr>
<td>Absorption, double effect, direct fired</td>
<td>All capacities</td>
<td>COP</td>
<td>≥ 1.000 FL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥ 1.050 IPLV</td>
</tr>
</tbody>
</table>

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(8)
MINIMUM EFFICIENCY REQUIREMENTS:
HEAT REJECTION EQUIPMENT

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>TOTAL SYSTEM HEAT REJECTION CAPACITY AT RATED CONDITIONS</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>PERFORMANCE REQUIRED g. h</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propeller or axial fan open-circuit cooling towers</td>
<td>All</td>
<td>95°F entering water 85°F leaving water 75°F entering wb</td>
<td>≥ 40.2 gpm/hp</td>
<td>CTI ATC-105 and CTI STD-201 RS</td>
</tr>
<tr>
<td>Centrifugal fan open-circuit cooling towers</td>
<td>All</td>
<td>95°F entering water 85°F leaving water 75°F entering wb</td>
<td>≥ 20.0 gpm/hp</td>
<td>CTI ATC-105 and CTI STD-201 RS</td>
</tr>
<tr>
<td>Propeller or axial fan closed-circuit cooling towers</td>
<td>All</td>
<td>102°F entering water 90°F leaving water 75°F entering wb</td>
<td>≥ 16.1 gpm/hp</td>
<td>CTI ATC-105S and CTI STD-201 RS</td>
</tr>
<tr>
<td>Centrifugal fan closed-circuit cooling towers</td>
<td>All</td>
<td>102°F entering water 90°F leaving water 75°F entering wb</td>
<td>≥ 7.0 gpm/hp</td>
<td>CTI ATC-105S and CTI STD-201 RS</td>
</tr>
<tr>
<td>Propeller or axial fan evaporative condensers</td>
<td>All</td>
<td>Ammonia Test Fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb</td>
<td>≥ 134,000 Btu/h × hp</td>
<td>CTI ATC-106</td>
</tr>
<tr>
<td>Centrifugal fan evaporative condensers</td>
<td>All</td>
<td>Ammonia Test Fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb</td>
<td>≥ 110,000 Btu/h × hp</td>
<td>CTI ATC-106</td>
</tr>
<tr>
<td>Propeller or axial fan evaporative condensers</td>
<td>All</td>
<td>R-507A Test Fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb</td>
<td>≥ 157,000 Btu/h × hp</td>
<td>CTI ATC-106</td>
</tr>
<tr>
<td>Centrifugal fan evaporative condensers</td>
<td>All</td>
<td>R-507A Test Fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb</td>
<td>≥ 135,000 Btu/h × hp</td>
<td>CTI ATC-106</td>
</tr>
<tr>
<td>Air-cooled condensers</td>
<td>All</td>
<td>125°F Condensing Temperature 190°F Entering Gas Temperature 15°F subcooling 95°F entering db</td>
<td>≥ 176,000 Btu/h × hp</td>
<td>AHRI 460</td>
</tr>
</tbody>
</table>
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.
**TABLE C403.3.2(9)**
MINIMUM EFFICIENCY AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>NET SENSIBLE COOLING CAPACITY&lt;sup&gt;a&lt;/sup&gt;</th>
<th>MINIMUM SCOP-127&lt;sup&gt;b&lt;/sup&gt;</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, air cooled</td>
<td>&lt; 65,000 Btu/h</td>
<td>2.20 / 2.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>2.10 / 1.99</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>1.90 / 1.79</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, water cooled</td>
<td>&lt; 65,000 Btu/h</td>
<td>2.60 / 2.49</td>
<td>ANSI/ASHRAE 127</td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>2.50 / 2.39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>2.40 / 2.29</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, water cooled with fluid economizer</td>
<td>&lt; 65,000 Btu/h</td>
<td>2.55 / 2.44</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>2.45 / 2.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>2.35 / 2.24</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, glycol cooled (rated at 40% propylene glycol)</td>
<td>&lt; 65,000 Btu/h</td>
<td>2.50 / 2.39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>2.15 / 2.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>2.10 / 1.99</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, glycol cooled (rated at 40% propylene glycol) with fluid economizer</td>
<td>&lt; 65,000 Btu/h</td>
<td>2.45 / 2.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>2.10 / 1.99</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>2.05 / 1.94</td>
<td></td>
</tr>
</tbody>
</table>

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(10)**
MINIMUM EFFICIENCY ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR CONDITIONERS

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF air conditioners, air cooled</td>
<td>&lt; 65,000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system</td>
<td>13.0 SEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>None</td>
<td>VRF multisplit system</td>
<td>11.2 EER 15.5 EER</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>□ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>None</td>
<td>VRF multisplit system</td>
<td>11.0 EER 14.9 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ 240,000 Btu/h</td>
<td>None</td>
<td>VRF multisplit system</td>
<td>10.0 EER 13.9 IEER</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE C403.3.2(11)**
MINIMUM EFFICIENCY ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR-TO-AIR AND APPLIED HEAT PUMPS

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### VRF air cooled (cooling mode)

<table>
<thead>
<tr>
<th>&lt; 65,000 Btu/h</th>
<th>All</th>
<th>VRF multisplit system</th>
<th>13.0 SEER</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>None</td>
<td>VRF multisplit system</td>
<td>11.0 EER &lt;br&gt; 14.6 IEER</td>
</tr>
<tr>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>None</td>
<td>VRF multisplit system with heat recovery</td>
<td>10.6 EER &lt;br&gt; 13.9 IEER</td>
</tr>
<tr>
<td>≥ 240,000 Btu/h</td>
<td>None</td>
<td>VRF multisplit system</td>
<td>9.5 EER &lt;br&gt; 12.7 IEER</td>
</tr>
</tbody>
</table>

### VRF multisplit system with heat recovery

| ≥ 135,000 Btu/h and < 240,000 Btu/h | None | VRF multisplit system | 10.4 EER <br> 13.7 IEER |
| ≥ 240,000 Btu/h | None | VRF multisplit system | 9.3 EER <br> 12.5 IEER |

### VRF water source (cooling mode)

| < 65,000 Btu/h | All | VRF multisplit system 86°F entering water | 12.0 EER <br> 16.0 IEER |
| < 65,000 Btu/h | All | VRF multisplit system with heat recovery 86°F entering water | 11.8 EER <br> 15.8 IEER |
| ≥ 65,000 Btu/h and < 135,000 Btu/h | All | VRF multisplit system 86°F entering water | 12.0 EER <br> 16.0 IEER |
| ≥ 65,000 Btu/h and < 135,000 Btu/h | All | VRF multisplit system with heat recovery 86°F entering water | 11.8 EER <br> 15.8 IEER |
| ≥ 135,000 Btu/h and < 240,000 Btu/h | All | VRF multisplit system 86°F entering water | 10.0 EER <br> 14.0 IEER |
| ≥ 135,000 Btu/h and < 240,000 Btu/h | All | VRF multisplit system with heat recovery 86°F entering water | 9.8 EER <br> 13.8 IEER |
| ≥ 240,000 Btu/h | All | VRF multisplit system 86°F entering water | 10.0 EER <br> 12.0 IEER |
| ≥ 240,000 Btu/h | All | VRF multisplit system with heat recovery 86°F entering water | 9.8 EER <br> 11.8 IEER |

### VRF groundwater source (cooling mode)

| < 135,000 Btu/h | All | VRF multisplit system 59°F entering water | 16.2 EER |
### TABLE C403.3.2(12)
HEAT TRANSFER EQUIPMENT

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SUBCATEGORY</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid-to-liquid heat exchangers</td>
<td>Plate type</td>
<td>NR</td>
<td>AHRI 400</td>
</tr>
</tbody>
</table>

NR = No Requirement.

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

\[
FL_{adj} = \frac{FL}{K_{adj}} \quad \text{(Equation 4-5)}
\]

\[
PLV_{adj} = \frac{IPLV}{K_{adj}} \quad \text{(Equation 4-6)}
\]

where:

\[
K_{adj} = A \times B
\]

\[
FL = \text{Full-load kW/ton value as specified in Table C403.3.2(7).}
\]

\[
FL_{adj} = \text{Maximum full-load kW/ton rating, adjusted for nonstandard conditions.}
\]

\[
IPLV = \text{Value as specified in Table C403.3.2(7).}
\]

\[
PLV_{adj} = \text{Maximum NPLV rating, adjusted for nonstandard conditions.}
\]

\[
A = 0.00000014592 \times (LIFT)^4
\]

\[
+ 0.0000346496 \times (LIFT)^3
\]

\[
+ 0.00314196 \times (LIFT)^2
\]

\[
- 0.147199 \times (LIFT) + 3.9302
\]

\[
B = 0.0015 \times L_{vg} \frac{E_{vap}}{vg} + 0.934
\]

\[
LIFT = L_{vg \text{Cond}} - L_{vg \text{vap}}
\]

\[
L_{vg \text{Cond}} = \text{Full-load condenser leaving fluid temperature (°F)}.
\]

\[
L_{vg \text{vap}} = \text{Full-load evaporator leaving temperature (°F)}.
\]

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.
2. Maximum condenser leaving temperature: 115°F.
3. \(20°F \leq LIFT \leq 80°F\).
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.
The use of hot gas bypass is prohibited in all systems.

C403.3.4 Boiler turndown.
Boiler systems with design input of greater than 1,000,000 Btu/h (293 kW) shall comply with the turndown
ratio specified in Table C403.3.4.

The system turndown requirement shall be met through the use of multiple single-input boilers, one or
more modulating boilers or a combination of single-input and modulating boilers.

<table>
<thead>
<tr>
<th>BOILER SYSTEM DESIGN INPUT (Btu/h)</th>
<th>MINIMUM TURNDOWN RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 1,000,000 and less than or equal to 5,000,000</td>
<td>3 to 1</td>
</tr>
<tr>
<td>&gt; 5,000,000 and less than or equal to 10,000,000</td>
<td>4 to 1</td>
</tr>
<tr>
<td>&gt; 10,000,000</td>
<td>5 to 1</td>
</tr>
</tbody>
</table>

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

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 be certified cold-climate heat pumps
meeting the requirements of section C403.2.3.

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 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 (16°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 (16°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 (13°C) or up to 80°F (29°C).

Exceptions:

1. 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 (Mandatory).
Automatic start controls shall be provided for each HVAC system. The 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.

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 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 Two-position valve.
Each hydronic heat pump on the hydronic system shall have a two-position valve.

C403.4.4 Part-load controls.
Hydronic systems greater than or equal to 300,000 Btu/h (146.5 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 or more shall have a variable speed drive.
   3.2. Where pumps have automatic direct digital control 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 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.

Exceptions: Economizers are not required for the following systems.

1. In hospitals and ambulatory surgery centers, where more than 75% of the air designed to be supplied by the system is to spaces that are required to be humidified above 35°F (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.

### TABLE C403.5

<table>
<thead>
<tr>
<th>TOTAL CHILLED-WATER SYSTEM CAPACITY LESS CAPACITY OF COOLING UNITS WITH AIR ECONOMIZERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Water-cooled Chilled-water Systems</td>
</tr>
<tr>
<td>Air-cooled Chilled-water Systems or District Chilled-water Systems</td>
</tr>
<tr>
<td>1,320,000 Btu/h</td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>RATING CAPACITY</th>
<th>MINIMUM NUMBER OF MECHANICAL COOLING STAGES</th>
<th>MINIMUM COMPRESSOR DISPLACEMENT(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 75,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>3 stages</td>
<td>≤ 35% of full load</td>
</tr>
<tr>
<td>≥ 240,000 Btu/h</td>
<td>4 stages</td>
<td>≤ 25% full load</td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>DEVICE TYPE</th>
<th>REQUIRED HIGH LIMIT (ECONOMIZER OFF WHEN):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed dry bulb</td>
<td>$T_{OA} &gt; 70^\circ F$ or $T_{OA} &gt; 75^\circ F$</td>
</tr>
<tr>
<td>Differential dry bulb</td>
<td>$T_{OA} &gt; T_{RA}$</td>
</tr>
<tr>
<td>Fixed enthalpy with fixed dry-bulb temperatures</td>
<td>$h_{OA} &gt; 28$ Btu/lb or $h_{OA} &gt; 30.7$ Btu/lb</td>
</tr>
<tr>
<td>Differential enthalpy with fixed dry-bulb temperature</td>
<td>$h_{OA} &gt; h_{RA}$ or $T_{OA} &gt; 75^\circ F$</td>
</tr>
</tbody>
</table>

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) through C403.3.2(11) that are 15 tons (180,000 Btu/h) or greater and equipped with an economizer in accordance with Section C403.5 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 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:

5.1 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.

5.2 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.

C403.6.5 Supply-air temperature reset controls.
Multiple-zone HVAC systems shall include controls that 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.

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. Zones with peak supply air quantities of 300 cfm (142 L/s) or less.

C403.6.6 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.

C403.6.7 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.

C403.6.8 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.

C403.6.9 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. (432.4 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 non-compliance.

C403.7 Ventilation and exhaust systems.
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 spaces larger than 500 square feet (46.5 m²) and with an average occupant load of 25 people or greater per 1,000 square feet (93 m²) 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.
2. Multiple-zone systems without direct digital control of individual zones communicating with a central control panel.
3. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is
less than 1,200 cfm (566 L/s).

4. 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 and automatic controls configured to stage fans or modulate fan average airflow rates as stipulated in the Vermont Fire & 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.

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 systems (Mandatory).
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 enthalpy of the outdoor air supply 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 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.

8. Systems exhausting toxic, flammable, paint or corrosive fumes or dust.

9. Commercial kitchen hoods used for collecting and removing grease vapors and smoke.
TABLE C403.7.4
ENERGY RECOVERY REQUIREMENT
(Air systems operating not less than 3,000 hours per year)

<table>
<thead>
<tr>
<th>PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE</th>
<th>DESIGN SUPPLY FAN AIRFLOW RATE (cfm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 10% and &lt; 20%</td>
<td>≥ 10,500</td>
</tr>
<tr>
<td>≥ 20% and &lt; 30%</td>
<td>≥ 6,500</td>
</tr>
<tr>
<td>≥ 30% and &lt; 40%</td>
<td>≥ 5,500</td>
</tr>
<tr>
<td>≥ 40% and &lt; 50%</td>
<td>≥ 4,500</td>
</tr>
<tr>
<td>≥ 50% and &lt; 60%</td>
<td>≥ 3,500</td>
</tr>
<tr>
<td>≥ 60% and &lt; 70%</td>
<td>≥ 2,000</td>
</tr>
<tr>
<td>≥ 70% and &lt; 80%</td>
<td>≥ 1,000</td>
</tr>
<tr>
<td>≥ 80%</td>
<td>&gt; 120</td>
</tr>
</tbody>
</table>

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
<table>
<thead>
<tr>
<th>TYPE OF HOOD</th>
<th>LIGHT-DUTY EQUIPMENT</th>
<th>MEDIUM-DUTY EQUIPMENT</th>
<th>HEAVY-DUTY EQUIPMENT</th>
<th>EXTRA-HEAVY-DUTY EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall-mounted canopy</td>
<td>140</td>
<td>210</td>
<td>280</td>
<td>385</td>
</tr>
<tr>
<td>Single island</td>
<td>280</td>
<td>350</td>
<td>420</td>
<td>490</td>
</tr>
<tr>
<td>Double island (per side)</td>
<td>175</td>
<td>210</td>
<td>280</td>
<td>385</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>175</td>
<td>175</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Backshelf/Pass-over</td>
<td>210</td>
<td>210</td>
<td>280</td>
<td>NA</td>
</tr>
</tbody>
</table>

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.

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 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/ft² (20.3 L/s • m²) 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

| Option 1: Fan system motor nameplate hp | Allowable nameplate motor hp | \(\text{hp} \leq \frac{\text{CFM}}{S} \times 0.0011\) | \(\text{hp} \leq \frac{\text{CFM}}{S} \times 0.0015\) |
| Option 2: Fan system bhp | Allowable fan system bhp | \(\text{bhp} \leq \frac{\text{CFM}}{S} \times 0.00094 + A\) | \(\text{bhp} \leq \frac{\text{CFM}}{S} \times 0.0013 + A\) |

For SI: 1 bhp = 735.5 W, 1 hp = 745.5 W, 1 cfm = 0.4719 L/s.

where:

\(\text{CFM}_S\) = The maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute.

\(\text{hp}\) = The maximum combined motor nameplate horsepower.

\(\text{bhp}\) = The maximum combined fan brake horsepower.

\(A\) = Sum of \([PD \times \frac{\text{CFM}}{D} / 4131]\).

where:

\(PD\) = Each applicable pressure drop adjustment from Table C403.8.1(2) in. w.c.

\(\text{CFM}_D\) = 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**

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>ADJUSTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>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</td>
<td>Credits 0.5 inch w.c. (2.15 inches w.c. for laboratory and vivarium systems)</td>
</tr>
<tr>
<td>Return and exhaust airflow control devices</td>
<td>0.5 inch w.c.</td>
</tr>
<tr>
<td>Exhaust filters, scrubbers or other exhaust treatment</td>
<td>The pressure drop of device calculated at fan system design condition</td>
</tr>
<tr>
<td>Particulate filtration credit: MERV 9 thru 12</td>
<td>0.5 inch w.c.</td>
</tr>
<tr>
<td>Particulate filtration credit: MERV 13 thru 15</td>
<td>0.9 inch w.c.</td>
</tr>
<tr>
<td>Particulate filtration credit: MERV 16 and greater and electronically enhanced filters</td>
<td>Pressure drop calculated at 2x clean filter pressure drop at fan system design condition.</td>
</tr>
<tr>
<td>Carbon and other gas-phase air cleaners</td>
<td>Clean filter pressure drop at fan system design condition.</td>
</tr>
<tr>
<td>Biosafety cabinet</td>
<td>Pressure drop of device at fan system design condition.</td>
</tr>
<tr>
<td>Energy recovery device, other than coil runaround loop</td>
<td>For each airstream, (2.2 × energy recovery effectiveness − 0.5) inch w.c.</td>
</tr>
<tr>
<td>Coil runaround loop</td>
<td>0.6 inch w.c. for each airstream.</td>
</tr>
<tr>
<td>Evaporative humidifier/cooler in series with another cooling coil</td>
<td>Pressure drop of device at fan system design conditions.</td>
</tr>
<tr>
<td>Sound attenuation section (fans serving spaces with design background noise goals below NC35)</td>
<td>0.15 inch w.c.</td>
</tr>
<tr>
<td>Exhaust system serving fume hoods</td>
<td>0.35 inch w.c.</td>
</tr>
<tr>
<td>Laboratory and vivarium exhaust systems in high-rise buildings</td>
<td>0.25 inch w.c./100 feet of vertical duct exceeding 75 feet.</td>
</tr>
</tbody>
</table>

#### 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 W), 1.5 times the fan brake horsepower.
2. For fans 6 bhp (4413 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.

#### C403.8.3 Fan efficiency (Mandatory).
Fans shall have a fan efficiency grade (FEG) of not less than 70, as determined in accordance with AMCA 205 by an approved, independent testing laboratory and labeled by the manufacturer. The total efficiency of the fan at the design point of operation shall be within 15 percentage points of the maximum total efficiency of the fan.
Exception: The following fans are not required to have a fan efficiency grade:

1. 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. Fans that are part of equipment covered in Section C403.3.2.

3. Fans included in an equipment package certified by an approved agency for air or energy performance.

4. Powered wall/roof ventilators.

5. Fans outside the scope of AMCA 205.

6. Fans that are intended to operate only during emergency conditions.

C403.8.4 Fractional hp fan motors (Mandatory).
Motors for fans that are not less than $\frac{1}{12}$ hp (0.082 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 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.

C403.8.5.1 Fan airflow control.
Each cooling system listed in Table C403.8.5.1 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 ventilation air.

**TABLE C403.8.5.1 COOLING SYSTEMS**

<table>
<thead>
<tr>
<th>COOLING SYSTEM TYPE</th>
<th>FAN MOTOR SIZE</th>
<th>MECHANICAL COOLING CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>DX cooling</td>
<td>Any</td>
<td>≥ 24,000 Btu/h</td>
</tr>
<tr>
<td>Chilled water and evaporative cooling</td>
<td>≥ 1/4 hp</td>
<td>Any</td>
</tr>
</tbody>
</table>

For SI: 1 British thermal unit per hour = 0.2931 W; 1 hp = 0.746 kW.

**C403.9 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).

**C403.9.1 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 or 50 percent of the design airflow.

**Exceptions:**

1. Fans serving multiple refrigerant or fluid cooling circuits.
2. Condenser fans serving flooded condensers.

C403.9.2 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.

C403.9.3 Limitation on centrifugal fan open-circuit cooling towers.
Centrifugal fan open-circuit cooling towers with a combined rated capacity of 550gpm (2032L/min) 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.

C403.9.4 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.

C403.9.5 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 (1 758 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.

C403.10 Refrigeration equipment performance.
Refrigeration equipment shall have an energy use in kWh/day not greater than the values of Tables C403.10.1(1) and C403.10.1(5) when tested and rated in accordance with AHRI Standard 1200. 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.

C403.10.1 Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers (Mandatory).
Refrgerated 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 7 feet (2134 mm) in height.

2. Doorways shall have strip doors, curtains, spring-hinged 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/ft² (76 W/m²) of door opening for walk-in freezers and 3.0 W/ft² (32 W/m²) 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 C403.10.1(1)
MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATION

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>APPLICATION</th>
<th>ENERGY USE LIMITS</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
</table>

2019 VERMONT COMMERCIAL BUILDING ENERGY STANDARDS
### TABLE C403.10.1(2)

**MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS**

<table>
<thead>
<tr>
<th>Equipment Class</th>
<th>Family Code</th>
<th>Operating Mode</th>
<th>Rating Temperature</th>
<th>ENERGY USE LIMITS $^a, b$ (kWh/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOP.RC.M</td>
<td>Vertical open</td>
<td>Remote condensing</td>
<td>Medium</td>
<td>$0.82 \times \text{TDA} + 4.07$</td>
</tr>
<tr>
<td>SVO.RC.M</td>
<td>Semivertical open</td>
<td>Remote condensing</td>
<td>Medium</td>
<td>$0.83 \times \text{TDA} + 3.18$</td>
</tr>
<tr>
<td>HZO.RC.M</td>
<td>Horizontal open</td>
<td>Remote condensing</td>
<td>Medium</td>
<td>$0.35 \times \text{TDA} + 2.88$</td>
</tr>
<tr>
<td>VOP.RC.L</td>
<td>Vertical open</td>
<td>Remote condensing</td>
<td>Low</td>
<td>$2.27 \times \text{TDA} + 6.85$</td>
</tr>
<tr>
<td>HZO.RC.L</td>
<td>Horizontal open</td>
<td>Remote condensing</td>
<td>Low</td>
<td>$0.57 \times \text{TDA} + 6.88$</td>
</tr>
<tr>
<td>VCT.RC.M</td>
<td>Vertical transparent door</td>
<td>Remote condensing</td>
<td>Medium</td>
<td>$0.22 \times \text{TDA} + 1.95$</td>
</tr>
<tr>
<td>VCT.RC.L</td>
<td>Vertical transparent door</td>
<td>Remote condensing</td>
<td>Low</td>
<td>$0.56 \times \text{TDA} + 2.61$</td>
</tr>
<tr>
<td>SOC.RC.M</td>
<td>Service over counter</td>
<td>Remote condensing</td>
<td>Medium</td>
<td>$0.51 \times \text{TDA} + 0.11$</td>
</tr>
<tr>
<td>VOP.SC.M</td>
<td>Vertical open</td>
<td>Self-contained</td>
<td>Medium</td>
<td>$1.74 \times \text{TDA} + 4.71$</td>
</tr>
<tr>
<td>SVO.SC.M</td>
<td>Semivertical open</td>
<td>Self-contained</td>
<td>Medium</td>
<td>$1.73 \times \text{TDA} + 4.59$</td>
</tr>
<tr>
<td>HZO.SC.M</td>
<td>Horizontal open</td>
<td>Self-contained</td>
<td>Medium</td>
<td>$0.77 \times \text{TDA} + 5.55$</td>
</tr>
<tr>
<td>HZO.SC.L</td>
<td>Horizontal open</td>
<td>Self-contained</td>
<td>Low</td>
<td>$1.92 \times \text{TDA} + 7.08$</td>
</tr>
<tr>
<td>VCT.SC.I</td>
<td>Vertical transparent door</td>
<td>Self-contained</td>
<td>Ice cream</td>
<td>$0.67 \times \text{TDA} + 3.29$</td>
</tr>
<tr>
<td>VCS.SC.I</td>
<td>Vertical solid door</td>
<td>Self-contained</td>
<td>Ice cream</td>
<td>$0.38 \times V + 0.88$</td>
</tr>
<tr>
<td>HCT.SC.I</td>
<td>Horizontal transparent door</td>
<td>Self-contained</td>
<td>Ice cream</td>
<td>$0.56 \times \text{TDA} + 0.43$</td>
</tr>
<tr>
<td>SVO.RC.L</td>
<td>Semivertical open</td>
<td>Remote condensing</td>
<td>Low</td>
<td>$2.27 \times \text{TDA} + 6.85$</td>
</tr>
<tr>
<td>VOP.RC.I</td>
<td>Vertical open</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>$2.89 \times \text{TDA} + 8.7$</td>
</tr>
<tr>
<td>SVO.RC.I</td>
<td>Semivertical open</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>$2.89 \times \text{TDA} + 8.7$</td>
</tr>
<tr>
<td>HZO.RC.I</td>
<td>Horizontal open</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>$0.72 \times \text{TDA} + 8.74$</td>
</tr>
<tr>
<td>VCT.RC.I</td>
<td>Vertical transparent door</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>$0.66 \times \text{TDA} + 3.05$</td>
</tr>
<tr>
<td>HCT.RC.M</td>
<td>Horizontal transparent door</td>
<td>Remote condensing</td>
<td>Medium</td>
<td>$0.16 \times \text{TDA} + 0.13$</td>
</tr>
</tbody>
</table>

$^a$ $V =$ volume of the chiller or frozen compartment as defined in AHAM-HRF-1.

(continued)
### TABLE C403.10.1(2)—continued

**MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS**

<table>
<thead>
<tr>
<th>Equipment Class</th>
<th>Family Code</th>
<th>Operating Mode</th>
<th>Rating Temperature</th>
<th>ENERGY USE LIMITS (kWh/day) a, b</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCT.RC.L</td>
<td>Horizontal transparent door</td>
<td>Remote condensing</td>
<td>Low</td>
<td>0.34 × TDA + 0.26</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HCT.RC.I</td>
<td>Horizontal transparent door</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>0.4 × TDA + 0.31</td>
<td></td>
</tr>
<tr>
<td>VCS.RC.M</td>
<td>Vertical solid door</td>
<td>Remote condensing</td>
<td>Medium</td>
<td>0.11 × V + 0.26</td>
<td></td>
</tr>
<tr>
<td>VCS.RC.L</td>
<td>Vertical solid door</td>
<td>Remote condensing</td>
<td>Low</td>
<td>0.23 × V + 0.54</td>
<td></td>
</tr>
<tr>
<td>VCS.RC.I</td>
<td>Vertical solid door</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>0.27 × V + 0.63</td>
<td></td>
</tr>
<tr>
<td>HCS.RC.M</td>
<td>Horizontal solid door</td>
<td>Remote condensing</td>
<td>Medium</td>
<td>0.11 × V + 0.26</td>
<td></td>
</tr>
<tr>
<td>HCS.RC.L</td>
<td>Horizontal solid door</td>
<td>Remote condensing</td>
<td>Low</td>
<td>0.23 × V + 0.54</td>
<td></td>
</tr>
<tr>
<td>HCS.RC.I</td>
<td>Horizontal solid door</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>0.27 × V + 0.63</td>
<td></td>
</tr>
<tr>
<td>HCS.RC.I</td>
<td>Horizontal solid door</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>0.27 × V + 0.63</td>
<td></td>
</tr>
<tr>
<td>SOC.RC.L</td>
<td>Service over counter</td>
<td>Remote condensing</td>
<td>Low</td>
<td>1.08 × TDA + 0.22</td>
<td></td>
</tr>
<tr>
<td>SOC.RC.I</td>
<td>Service over counter</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>1.26 × TDA + 0.26</td>
<td></td>
</tr>
<tr>
<td>VOP.SC.L</td>
<td>Vertical open</td>
<td>Self-contained</td>
<td>Low</td>
<td>4.37 × TDA + 11.82</td>
<td></td>
</tr>
<tr>
<td>VOP.SC.I</td>
<td>Vertical open</td>
<td>Self-contained</td>
<td>Ice cream</td>
<td>5.55 × TDA + 15.02</td>
<td></td>
</tr>
<tr>
<td>SVO.SC.L</td>
<td>Semivertical open</td>
<td>Self-contained</td>
<td>Low</td>
<td>4.34 × TDA + 11.51</td>
<td></td>
</tr>
<tr>
<td>SVO.SC.I</td>
<td>Semivertical open</td>
<td>Self-contained</td>
<td>Ice cream</td>
<td>5.52 × TDA + 14.63</td>
<td></td>
</tr>
<tr>
<td>HZO.SC.I</td>
<td>Horizontal open</td>
<td>Self-contained</td>
<td>Ice cream</td>
<td>2.44 × TDA + 9.0</td>
<td></td>
</tr>
<tr>
<td>SOC.SC.I</td>
<td>Service over counter</td>
<td>Self-contained</td>
<td>Ice cream</td>
<td>1.76 × TDA + 0.36</td>
<td></td>
</tr>
<tr>
<td>HCS.SC.I</td>
<td>Horizontal solid door</td>
<td>Self-contained</td>
<td>Ice cream</td>
<td>0.38 × V + 0.88</td>
<td></td>
</tr>
</tbody>
</table>

| 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 C403.10.1(3)**
WALK-IN COOLER AND FREEZER DISPLAY DOOR EFFICIENCY REQUIREMENTS

<table>
<thead>
<tr>
<th>CLASS DESCRIPTOR</th>
<th>CLASS</th>
<th>MAXIMUM ENERGY CONSUMPTION (kWh/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display door, medium temperature</td>
<td>DD, M</td>
<td>0.04 × A&lt;sub&gt;dd&lt;/sub&gt; + 0.41</td>
</tr>
<tr>
<td>Display door, low temperature</td>
<td>DD, L</td>
<td>0.15 × A&lt;sub&gt;dd&lt;/sub&gt; + 0.29</td>
</tr>
</tbody>
</table>

a. A<sub>dd</sub> is the surface area of the display door.

TABLE C403.10.1(4)
WALK-IN COOLER AND FREEZER NONDISPLAY DOOR EFFICIENCY REQUIREMENTS

<table>
<thead>
<tr>
<th>CLASS DESCRIPTOR</th>
<th>CLASS</th>
<th>MAXIMUM ENERGY CONSUMPTION (kWh/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passage door, medium temperature</td>
<td>PD, M</td>
<td>0.05 × A&lt;sub&gt;nd&lt;/sub&gt; + 1.7</td>
</tr>
<tr>
<td>Passage door, low temperature</td>
<td>PD, L</td>
<td>0.14 × A&lt;sub&gt;nd&lt;/sub&gt; + 4.8</td>
</tr>
<tr>
<td>Freight door, medium temperature</td>
<td>FD, M</td>
<td>0.04 × A&lt;sub&gt;nd&lt;/sub&gt; + 1.9</td>
</tr>
<tr>
<td>Freight door, low temperature</td>
<td>FD, L</td>
<td>0.12 × A&lt;sub&gt;nd&lt;/sub&gt; + 5.6</td>
</tr>
</tbody>
</table>

a. A<sub>nd</sub> is the surface area of the nondisplay door.

TABLE C403.10.1(5)
WALK-IN COOLER AND FREEZER REFRIGERATION SYSTEM EFFICIENCY REQUIREMENTS

<table>
<thead>
<tr>
<th>CLASS DESCRIPTOR</th>
<th>CLASS</th>
<th>MINIMUM ANNUAL WALK-IN ENERGY FACTOR AWEF (Btu/W-h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedicated condensing, medium temperature, indoor system</td>
<td>DC.M.I</td>
<td>5.61</td>
</tr>
<tr>
<td>Dedicated condensing, medium temperature, indoor system, &gt; 9,000 Btu/h capacity</td>
<td>DC.M.I, &gt; 9,000</td>
<td>5.61</td>
</tr>
<tr>
<td>Dedicated condensing, medium temperature, outdoor system</td>
<td>DC.M.I</td>
<td>7.60</td>
</tr>
<tr>
<td>Dedicated condensing, medium temperature, outdoor system, &gt; 9,000 Btu/h capacity</td>
<td>DC.M.I, &gt; 9,000</td>
<td>7.60</td>
</tr>
</tbody>
</table>

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.

C403.10.3 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 C403.10.3.1 and C403.10.3.2.

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.

C403.10.3.1 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).

C403.10.3.2 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:

1.1 Single-compressor systems that do not have variable capacity capability.

1.2 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.

**C403.11 Construction of HVAC system elements.**

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.

**C403.11.1 Duct and plenum insulation and sealing (Mandatory).**

Supply and return air ducts and plenums shall be insulated with not less than R-8 insulation where located in unconditioned spaces and where located outside the building with not less than R-12 insulation. Where located within a building envelope assembly, 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.

**C403.11.2 Duct construction (Mandatory).**

Ductwork shall be constructed and erected in accordance with the ANSI/SMACNA 006 HVAC Duct Construction.

**C403.11.2.1 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), mas-tic-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.

### C403.11.2.2 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.

### C403.11.2.3 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.

\[
CL = \frac{F}{P^{0.65}} \quad \text{ (Equation 4-7)}
\]

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.

### C403.11.3 Piping insulation (Mandatory).

Piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table C403.11.3.

**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).
### TABLE C403.11.3
MINIMUM PIPE INSULATION THICKNESS (in inches)

| FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F) | INSULATION CONDUCTIVITY
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conductivity Btu • in./(h • ft² • °F)b</td>
</tr>
<tr>
<td></td>
<td>Mean Rating Temperature, °F</td>
</tr>
<tr>
<td></td>
<td>&lt; 1</td>
</tr>
<tr>
<td>&gt; 350</td>
<td>0.32 – 0.34</td>
</tr>
<tr>
<td>251 – 350</td>
<td>0.29 – 0.32</td>
</tr>
<tr>
<td>201 – 250</td>
<td>0.27 – 0.30</td>
</tr>
<tr>
<td>141 – 200</td>
<td>0.25 – 0.29</td>
</tr>
<tr>
<td>85 – 140</td>
<td>0.21 – 0.28</td>
</tr>
<tr>
<td>40 – 60</td>
<td>0.21 – 0.27</td>
</tr>
<tr>
<td>&lt; 40</td>
<td>0.20 – 0.26</td>
</tr>
</tbody>
</table>

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:

\[
T = r \left(1 + \frac{t}{r}\right) \frac{K}{k} - 1
\]

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 • ft² • °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.

### C403.11.3.1 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; and

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.
C403.12 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.

C403.12.1 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.

C403.12.2 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” below the surface is 50°F (10°C).

C403.12.3 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.

SECTION C404
SERVICE WATER HEATING (MANDATORY)

C404.1 General.
In addition to the service water heating requirements of Section C404, service water heating enhancements may be needed to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406.

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.

Exceptions:
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% 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

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY (input)</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>PERFORMANCE a, b REQUIRED</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water heaters, electric</td>
<td>≤ 7.5 kW</td>
<td>e Tabletop Resistance</td>
<td>0.93 - 0.00132V, EF</td>
<td>DOE 10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>≤ 24 amps and ≤ 250 volts</td>
<td>Heat pump &gt; 55 gallons and ≤ 120 gallons</td>
<td>2.057 - 0.00113V, EF</td>
<td>DOE 10 CFR Part 430</td>
</tr>
<tr>
<td>Storage water heaters, gas</td>
<td>≤ 75,000 Btu/h</td>
<td>g ≥ 20 gallons and ≤ 55 gallons</td>
<td>0.675 - 0.0015V, EF</td>
<td>DOE 10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>&gt; 75,000 Btu/h and ≤ 155,000 Btu/h</td>
<td>&lt; 4,000 Btu/h/gal</td>
<td>80% E (Q/800 + 110√V)SL, Btu/h</td>
<td>ANSI Z21.10.3</td>
</tr>
<tr>
<td>Instantaneous water heaters, gas</td>
<td>&gt; 200,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and &lt; 10 gal</td>
<td>0.82 - 0.00 19V, EF</td>
<td>DOE 10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>≥ 200,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and ≥ 10 gal</td>
<td>80% E (Q/800 + 110√V)SL, Btu/h</td>
<td>ANSI Z21.10.3</td>
</tr>
<tr>
<td>Storage water heaters, oil</td>
<td>≤ 105,000 Btu/h</td>
<td>≥ 20 gal and ≤ 50 gallons</td>
<td>0.68 - 0.0019V, EF</td>
<td>DOE 10 CFR Part 430</td>
</tr>
<tr>
<td>Instantaneous water heaters, oil</td>
<td>≤ 210,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and &lt; 2 gal</td>
<td>0.59 - 0.0019V, EF</td>
<td>DOE 10 CFR Part 430</td>
</tr>
<tr>
<td>Hot water supply boilers, gas and oil</td>
<td>≥ 300,000 Btu/h and ≤ 12,500,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and &lt; 10 gal</td>
<td>80% E (Q/800 + 110√V)SL, Btu/h</td>
<td>ANSI Z21.10.3</td>
</tr>
<tr>
<td>Hot water supply boilers, gas</td>
<td>≥ 300,000 Btu/h and ≤ 12,500,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and ≥ 10 gal</td>
<td>78% E (Q/800 + 110√V)SL, Btu/h</td>
<td>ANSI Z21.10.3</td>
</tr>
<tr>
<td>Hot water supply boilers, oil</td>
<td>≥ 300,000 Btu/h and ≤ 12,500,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and &gt; 10 gal</td>
<td>78% E (Q/800 + 110√V)SL, Btu/h</td>
<td>ANSI Z21.10.3</td>
</tr>
<tr>
<td>Pool heaters, gas and oil</td>
<td>All</td>
<td>—</td>
<td>82% E t (Q/800 + 110√V)SL, Btu/h</td>
<td>ASHRAE 146</td>
</tr>
</tbody>
</table>

(continued)
Unfired storage tanks | All | — | Minimum insulation requirement R-12.5² (h • ft² • °F)/Btu | (none)

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m², °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 (Et) 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 Vm 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, such equipment shall have a thermal efficiency, Et, 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, Et, 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.
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 C403.11.3. 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 C403.11.3 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 \( \frac{1}{4} \) -inch (6.4 mm) piping shall be not greater than 0.5 gpm (1.9 L/m). The flow rate through \( \frac{5}{16} \)-inch (7.9 mm) piping shall be not greater than 1 gpm (3.8 L/m). The flow rate through \( \frac{3}{8} \)-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:

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, or
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 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.

**C404.9 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.

   **C404.9.1 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.

   **C404.9.2 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.
C404.9.3 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 on-site renewable energy system, covers or other vapor-retardant means shall not be required.

C404.10 Energy consumption of 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.

C404.11 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, electrical power and lighting enhancements may be needed to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406.

This section covers lighting system controls, the maximum lighting power for interior and exterior applications and electrical energy consumption.

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.

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.

2. Luminaire level lighting controls (LLLC) and lighting controls as specified in Sections C405.2.1, C405.2.4 and C405.2.5. 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 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.
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 \((28\text{ m}^2)\) or less that are enclosed by floor-to-ceiling height partitions.
11. Warehouse storage areas.

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 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.

   **Exception:** Full automatic-on controls shall be permitted to control lighting in public corridors, stairways, restrooms, primary building entrance areas and lobbies, and areas where manual-on operation would endanger the safety or security of the room or building occupants.

3. They shall incorporate a manual control to allow occupants to turn off lights.
C405.2.1.2 Occupant sensor control function in warehouses.
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.

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 m²) 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 m²) within the open plan office space.

2. 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.

3. The controls shall be configured so that general lighting power 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.

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 for egress illumination.
Luminaire 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. Egress areas not exceeding 50% 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.

Exception: 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. Spaces where patient care is directly provided.
2. Spaces where an automatic shutoff would endanger occupant safety or security.
3. Lighting intended for continuous operation.
4. 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 controls shall include an override switching device that complies with the following:

1. Have a minimum 7-day clock.
2. Be capable of being set for seven different day types per week.
3. 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. Have program backup capabilities, which prevent the loss of program and time settings for not fewer than 10 hours, if power is interrupted.
5. Include an override switch that complies with the following:
   5.1. The override switch shall be a manual control.
   5.2. The override switch, when initiated, shall permit the controlled lighting to remain on for not more than 2 hours.
   5.3. Any individual override switch shall control the lighting for an area not larger than 5,000 square feet (465 m²).

Exceptions:

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 m²) provided that such area is less than 20,000 square feet (1860 m²).

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/m²).
2.3. Corridors, lobbies, electrical rooms and or mechanical rooms.
C405.2.2.2 Light-reduction controls.
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. Light reduction controls are not required in *daylight zones* with *daylight responsive controls* complying with Section C405.2.3.
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, equipment rooms, public lobbies, electrical or mechanical rooms.

C405.2.3 Daylight-responsive controls.
*Daylight-responsive controls* complying with Section C405.2.3.1 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 C405.2.3.2. *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 150 watts of *general lighting* within toplit zones complying with Section C405.2.3.3.

**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.
3. Sidelit zones on the first floor above grade in Group A-2 and Group M occupancies. (See *Occupancy classifications* in Section C202.)
4. Daylight zones where the total proposed lighting power density is less than 35 percent of the lighting power allowance per Section C405.3.2.
5 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:
\[ LPA_{\text{adj}} = [LPA_{\text{norm}} \times (1.0 - 0.4 \times UDZFA/TBFA)] \]  
\((\text{Equation 4-8})\)

where:

- \(LPA_{\text{adj}}\) = Adjusted building interior lighting power allowance in watts.
- \(LPA_{\text{norm}}\) = Normal building lighting power allowance in watts calculated in accordance with Section C405.3.2 and reduced in accordance with Section C406.3 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 C405.2.3.2 and C405.2.3.3, 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.

C405.2.3.1 Daylight-responsive control function.
Where required, \textit{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 \textit{toplit} zones in accordance with Section C405.2.3.3 shall be controlled independently of lights in sidelit zones in accordance with Section C405.2.3.2.

2. \textit{Daylight responsive controls} within each space shall be configured so that they can be calibrated from within that space by authorized personnel.

3. Calibration mechanisms shall be in a location with \textit{ready access}.

4. Where located in offices, classrooms, laboratories and library reading rooms, \textit{daylight responsive controls} shall dim lights continuously from full light output to 15 percent of full light output or lower.

5. \textit{Daylight responsive controls} shall be configured to completely shut off all controlled lights.

6. Lights in \textit{sidelit zones} in accordance with Section C405.2.3.2 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 m²).

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.
**Exception:** 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.

**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.

**C405.2.3.2 Sidelit zone.**
The sidelit 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 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), whichever is less, as indicated in Figure C405.2.3.2.

2. The area of the fenestration is not less than 24 square feet (2.23 m$^2$).

3. 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. The visible transmittance of the fenestration is not less than 0.20.

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. 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. Where located in existing buildings, the visible transmittance of the fenestration is no less than 0.20.
8. 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.

C405.2.3.3 Toplit zone.
The *toplit* zone is the floor area underneath a roof fenestration assembly that complies with all of the following:

1. The *toplit* 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 C405.2.3.3(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. 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.

4. 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. Where toplit daylight zones overlap with sidelight daylight zones, lights within the overlapping area shall be assigned to the toplit daylight zone.

---

**FIGURE C405.2.3.3(1)**

TOPLIT ZONE
C405.2.4 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. Display and accent.

   1.2. Lighting in display cases.
1.3. Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting.

1.4. Lighting equipment that is for sale or demonstration in lighting education.

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 C405.2.2.2.

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.

**C405.2.5 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 Exterior lighting controls.**
Exterior lighting systems shall be provided with controls that comply with Sections C405.2.6.1 through C405.2.6.4. 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.

**C405.2.6.1 Daylight shutoff.**
Lights shall be automatically turned off when daylight is present and satisfies the lighting needs.

**C405.2.6.2 Decorative lighting shutoff.**
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.

**C405.2.6.3 Lighting setback.**
Lighting that is not controlled in accordance with Section C405.2.6.2 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:
1. From not later than midnight to not earlier than 6 a.m.

2. From not later than one hour after business closing to not earlier than one hour before business opening.

3. During any time where activity has not been detected for 15 minutes or more.
C405.2.6.4 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.

C405.3 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.

Exceptions: 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).
- **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.


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 1.5 W per square foot.

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.

**C405.3.2 Interior lighting power allowance.**
The total interior lighting power allowance (watts) is 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(1)**
**INTERIOR LIGHTING POWER ALLOWANCES:**
**BUILDING AREA METHOD**

<table>
<thead>
<tr>
<th>BUILDING AREA TYPE</th>
<th>LPD (w/ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive facility</td>
<td>0.60</td>
</tr>
<tr>
<td>Convention center</td>
<td>0.70</td>
</tr>
<tr>
<td>Courthouse</td>
<td>0.76</td>
</tr>
<tr>
<td>Dining: bar lounge/leisure</td>
<td>0.76</td>
</tr>
<tr>
<td>Dining: cafeteria/fast food</td>
<td>0.67</td>
</tr>
<tr>
<td>Dining: family</td>
<td>0.69</td>
</tr>
<tr>
<td>Dormitory c</td>
<td>0.47</td>
</tr>
<tr>
<td>Exercise center</td>
<td>0.59</td>
</tr>
<tr>
<td>Fire station a</td>
<td>0.48</td>
</tr>
<tr>
<td>Gymnasium</td>
<td>0.64</td>
</tr>
<tr>
<td>Health care clinic</td>
<td>0.69</td>
</tr>
<tr>
<td>Hospital a</td>
<td>0.84</td>
</tr>
<tr>
<td>Hotel/Motel a,b</td>
<td>0.65</td>
</tr>
<tr>
<td>Library</td>
<td>0.78</td>
</tr>
<tr>
<td>Manufacturing facility</td>
<td>0.82</td>
</tr>
<tr>
<td>Motion picture theater</td>
<td>0.64</td>
</tr>
<tr>
<td>Multifamily c</td>
<td>0.48</td>
</tr>
<tr>
<td>Museum</td>
<td>0.83</td>
</tr>
<tr>
<td>Office</td>
<td>0.64</td>
</tr>
<tr>
<td>Parking garage</td>
<td>0.14</td>
</tr>
<tr>
<td>Penitentiary</td>
<td>0.62</td>
</tr>
<tr>
<td>Performing arts theater</td>
<td>1.02</td>
</tr>
<tr>
<td>Police station</td>
<td>0.67</td>
</tr>
<tr>
<td>Post office</td>
<td>0.61</td>
</tr>
<tr>
<td>Religious building</td>
<td>0.77</td>
</tr>
<tr>
<td>Retail</td>
<td>0.92</td>
</tr>
<tr>
<td>School/university</td>
<td>0.67</td>
</tr>
<tr>
<td>Sports arena</td>
<td>0.71</td>
</tr>
<tr>
<td>Town hall</td>
<td>0.67</td>
</tr>
<tr>
<td>Transportation</td>
<td>0.52</td>
</tr>
<tr>
<td>Warehouse</td>
<td>0.43</td>
</tr>
<tr>
<td>Workshop</td>
<td>0.83</td>
</tr>
</tbody>
</table>
a. Where sleeping units are excluded from lighting power calculations when 90% of the sleeping units' lamps or fixtures is high-efficiency, 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-efficiency, 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.

TABLE C405.3.2(2)
INTERIOR LIGHTING POWER ALLOWANCES:
SPACE-BY-SPACE METHOD

<table>
<thead>
<tr>
<th>COMMON SPACE TYPES a</th>
<th>LPD (watts/sq.ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Atrium</strong></td>
<td></td>
</tr>
<tr>
<td>Less than 40 feet in height</td>
<td>0.03 per foot in total height</td>
</tr>
<tr>
<td>Greater than 40 feet in height</td>
<td>0.40 + 0.02 per foot in total height</td>
</tr>
<tr>
<td><strong>Audience seating area</strong></td>
<td></td>
</tr>
<tr>
<td>In an auditorium</td>
<td>0.50</td>
</tr>
<tr>
<td>In a convention center</td>
<td>0.66</td>
</tr>
<tr>
<td>In a gymnasium</td>
<td>0.52</td>
</tr>
<tr>
<td>In a motion picture theater</td>
<td>0.91</td>
</tr>
<tr>
<td>In a penitentiary</td>
<td>0.22</td>
</tr>
<tr>
<td>In a performing arts theater</td>
<td>1.77</td>
</tr>
<tr>
<td>In a religious building</td>
<td>1.22</td>
</tr>
<tr>
<td>In a sports arena</td>
<td>0.34</td>
</tr>
<tr>
<td>Otherwise</td>
<td>0.34</td>
</tr>
<tr>
<td>anking activity area</td>
<td>0.74</td>
</tr>
<tr>
<td><strong>Breakroom (See Lounge/breakroom)</strong></td>
<td></td>
</tr>
<tr>
<td>Classroom/lecture hall/training room</td>
<td></td>
</tr>
<tr>
<td>In a penitentiary</td>
<td>1.07</td>
</tr>
<tr>
<td>Otherwise</td>
<td>0.87</td>
</tr>
<tr>
<td>Computer room</td>
<td>1.21</td>
</tr>
<tr>
<td>Conference/meeting/multipurpose room</td>
<td>0.92</td>
</tr>
<tr>
<td>Copy/print room</td>
<td>0.51</td>
</tr>
<tr>
<td><strong>Corridor</strong></td>
<td></td>
</tr>
<tr>
<td>In a facility for the elderly or visually impaired (and not used primarily by the staff)</td>
<td>0.92</td>
</tr>
<tr>
<td>In a hospital</td>
<td>0.79</td>
</tr>
<tr>
<td>In a manufacturing facility</td>
<td>0.29</td>
</tr>
<tr>
<td>Otherwise</td>
<td>0.66</td>
</tr>
<tr>
<td><strong>Courtroom</strong></td>
<td>1.24</td>
</tr>
<tr>
<td><strong>Dining area</strong></td>
<td></td>
</tr>
<tr>
<td>In bar/lounge or leisure dining</td>
<td>0.80</td>
</tr>
<tr>
<td>In cafeteria or fast food dining</td>
<td>0.51</td>
</tr>
<tr>
<td>In a facility for the visually impaired (and not used primarily by the staff)</td>
<td>1.56</td>
</tr>
<tr>
<td>In family dining</td>
<td>0.64</td>
</tr>
<tr>
<td>In a penitentiary</td>
<td>0.77</td>
</tr>
</tbody>
</table>
(continued)

**TABLE C405.3.2(2)—continued**
**INTERIOR LIGHTING POWER ALLOWANCES:**
**SPACE-BY-SPACE METHOD**

<table>
<thead>
<tr>
<th>COMMON SPACE TYPES</th>
<th>LPD (watts/sq.ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food preparation area</td>
<td>0.90</td>
</tr>
<tr>
<td>Guestroom</td>
<td>0.47</td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
</tr>
<tr>
<td>In or as a classroom</td>
<td>1.05</td>
</tr>
<tr>
<td>Otherwise</td>
<td>1.30</td>
</tr>
<tr>
<td>Laundry/washing area</td>
<td>0.41</td>
</tr>
<tr>
<td>Loading dock, interior</td>
<td>0.42</td>
</tr>
<tr>
<td>Lobby</td>
<td></td>
</tr>
<tr>
<td>For an elevator</td>
<td>0.53</td>
</tr>
<tr>
<td>In a facility for the elderly or visually impaired (and not used primarily by the staff)</td>
<td>1.54</td>
</tr>
<tr>
<td>In a hotel</td>
<td>0.85</td>
</tr>
<tr>
<td>In a motion picture theater</td>
<td>0.41</td>
</tr>
<tr>
<td>In a performing arts theater</td>
<td>1.47</td>
</tr>
<tr>
<td>Otherwise</td>
<td>0.76</td>
</tr>
<tr>
<td>Locker room</td>
<td>0.48</td>
</tr>
<tr>
<td>Lounge/breakroom</td>
<td></td>
</tr>
<tr>
<td>In a healthcare facility</td>
<td>0.68</td>
</tr>
<tr>
<td>Otherwise</td>
<td>0.54</td>
</tr>
<tr>
<td>Office</td>
<td></td>
</tr>
<tr>
<td>Enclosed</td>
<td>0.81</td>
</tr>
<tr>
<td>Open plan</td>
<td>0.71</td>
</tr>
<tr>
<td>Parking area, interior</td>
<td>0.13</td>
</tr>
<tr>
<td>Pharmacy area</td>
<td>1.20</td>
</tr>
<tr>
<td>Restroom</td>
<td></td>
</tr>
<tr>
<td>In a facility for the elderly or visually impaired (and not used primarily by the staff)</td>
<td>0.86</td>
</tr>
<tr>
<td>Otherwise</td>
<td>0.73</td>
</tr>
<tr>
<td>Sales area</td>
<td>1.11</td>
</tr>
<tr>
<td>Seating area, general</td>
<td>0.38</td>
</tr>
<tr>
<td>Stairway (see Space containing stairway)</td>
<td></td>
</tr>
<tr>
<td>Stairwell</td>
<td>0.51</td>
</tr>
<tr>
<td>Storage room</td>
<td>0.43</td>
</tr>
<tr>
<td>Vehicular maintenance area</td>
<td>0.49</td>
</tr>
<tr>
<td>Workshop</td>
<td>1.08</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BUILDING TYPE SPECIFIC SPACE TYPES</th>
<th>LPD (watts/sq.ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive (see Vehicular maintenance area)</td>
<td></td>
</tr>
<tr>
<td>Convention Center—exhibit space</td>
<td>0.88</td>
</tr>
<tr>
<td>Facility for the elderly or visually impaired</td>
<td></td>
</tr>
<tr>
<td>In a chapel (and not used primarily by the staff)</td>
<td>1.06</td>
</tr>
<tr>
<td>In a recreation room (and not used primarily by the staff)</td>
<td>1.67</td>
</tr>
<tr>
<td>Fire Station—sleeping quarters</td>
<td>0.17</td>
</tr>
<tr>
<td>Gymnasium/fitness center</td>
<td></td>
</tr>
<tr>
<td>In an exercise area</td>
<td>0.48</td>
</tr>
<tr>
<td>In a playing area</td>
<td>0.80</td>
</tr>
</tbody>
</table>

(continued)

**TABLE C405.3.2(2)—continued**

**INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD**

<table>
<thead>
<tr>
<th>BUILDING TYPE SPECIFIC SPACE TYPES</th>
<th>LPD (watts/sq.ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare facility</td>
<td></td>
</tr>
<tr>
<td>In an exam/treatment room</td>
<td>1.34</td>
</tr>
<tr>
<td>In an imaging room</td>
<td>1.02</td>
</tr>
<tr>
<td>In a medical supply room</td>
<td>0.51</td>
</tr>
<tr>
<td>In a nursery</td>
<td>0.76</td>
</tr>
<tr>
<td>In a nurse’s station</td>
<td>0.61</td>
</tr>
<tr>
<td>In an operating room</td>
<td>1.85</td>
</tr>
<tr>
<td>In a patient room</td>
<td>0.50</td>
</tr>
<tr>
<td>In a physical therapy room</td>
<td>0.70</td>
</tr>
<tr>
<td>In a recovery room</td>
<td>0.87</td>
</tr>
<tr>
<td>Library</td>
<td></td>
</tr>
<tr>
<td>In a reading area</td>
<td>0.75</td>
</tr>
<tr>
<td>In the stacks</td>
<td>1.15</td>
</tr>
<tr>
<td>Manufacturing facility</td>
<td></td>
</tr>
<tr>
<td>In a detailed manufacturing area</td>
<td>0.88</td>
</tr>
<tr>
<td>In an equipment room</td>
<td>0.55</td>
</tr>
<tr>
<td>In an extra-high-bay area (greater than 50’ floor-to-ceiling height)</td>
<td>0.84</td>
</tr>
<tr>
<td>In a high-bay area (25-50’ floor-to-ceiling height)</td>
<td>0.75</td>
</tr>
<tr>
<td>In a low-bay area (less than 25’ floor-to-ceiling height)</td>
<td>0.85</td>
</tr>
<tr>
<td>Museum</td>
<td></td>
</tr>
<tr>
<td>In a general exhibition area</td>
<td>0.84</td>
</tr>
<tr>
<td>In a restoration room</td>
<td>0.74</td>
</tr>
<tr>
<td>Performing arts theater—dressing room</td>
<td>0.36</td>
</tr>
<tr>
<td>Post office—sorting area</td>
<td>0.64</td>
</tr>
<tr>
<td>Religious buildings</td>
<td></td>
</tr>
<tr>
<td>In a fellowship hall</td>
<td>0.47</td>
</tr>
<tr>
<td>In a worship/pulpit/choir area</td>
<td>1.22</td>
</tr>
<tr>
<td>Retail facilities</td>
<td></td>
</tr>
<tr>
<td>Location/Activity</td>
<td>Value</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>In a dressing/fitting room</td>
<td>0.48</td>
</tr>
<tr>
<td>In a mall concourse</td>
<td>0.80</td>
</tr>
<tr>
<td>Sports arena—playing area</td>
<td></td>
</tr>
<tr>
<td>For a Class I facility</td>
<td>2.17</td>
</tr>
<tr>
<td>For a Class II facility</td>
<td>1.55</td>
</tr>
<tr>
<td>For a Class III facility</td>
<td>1.17</td>
</tr>
<tr>
<td>For a Class IV facility</td>
<td>0.70</td>
</tr>
</tbody>
</table>

(continued)
TABLE C405.3.2(2)—continued
INTERIOR LIGHTING POWER ALLOWANCES:
SPACE-BY-SPACE METHOD

<table>
<thead>
<tr>
<th>BUILDING TYPE SPECIFIC SPACE TYPES&lt;sup&gt;a&lt;/sup&gt;</th>
<th>LPD (watts/sq.ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation facility</td>
<td></td>
</tr>
<tr>
<td>In a baggage/carousel area</td>
<td>0.39</td>
</tr>
<tr>
<td>In an airport concourse</td>
<td>0.27</td>
</tr>
<tr>
<td>At a terminal ticket counter</td>
<td>0.56</td>
</tr>
<tr>
<td>Warehouse—storage area</td>
<td></td>
</tr>
<tr>
<td>For medium to bulky, palletized items</td>
<td>0.35</td>
</tr>
<tr>
<td>For smaller, hand-carried items</td>
<td>0.65</td>
</tr>
</tbody>
</table>

<sup>a</sup> 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, 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, 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.
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.

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. 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 4-10.

\[
\text{Additional interior lighting power allowance} = 250 \text{ W} + (\text{Retail Area 1} \times 0.20 \text{ W/ft}^2) + (\text{Retail Area 2} \times 0.20 \text{ W/ft}^2) + (\text{Retail Area 3} \times 0.50 \text{ W/ft}^2) + (\text{Retail Area 4} \times 0.90 \text{ W/ft}^2)
\]

SI units:

\[
\text{Additional interior lighting power allowance} = 250 \text{ W} + (\text{Retail Area 1} \times 0.20 \text{ W/m}^2) + (\text{Retail Area 2} \times 0.20 \text{ W/m}^2) + (\text{Retail Area 3} \times 0.50 \text{ W/m}^2) + (\text{Retail Area 4} \times 0.90 \text{ W/m}^2)
\]

(Equation 4-10)

where:

\[
\text{Retail Area 1} = \text{The floor area for all products not listed in Retail Area 2, 3 or 4.}

\text{Retail Area 2} = \text{The floor area used for the sale of vehicles, sporting goods and small electronics.}

\text{Retail Area 3} = \text{The floor area used for the sale of furniture, clothing, cosmetics and artwork.}

\text{Retail Area 4} = \text{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 or authority having jurisdiction.

2.

C405.4 Exterior lighting power requirements (Mandatory).
The total connected exterior lighting power calculated in accordance with Section C405.4.1 shall be not greater than the exterior lighting power allowance calculated in accordance with Section C405.4.2 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.

C405.4.1 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.
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 R404.1.

C405.4.2 Exterior lighting power allowance.
The total exterior lighting power allowance 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.
TABLE C405.4.2(1)
EXTERIOR LIGHTING ZONES

<table>
<thead>
<tr>
<th>LIGHTING ZONE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Developed areas of national parks, state parks, forest land, and rural areas</td>
</tr>
<tr>
<td>2</td>
<td>Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed-use areas</td>
</tr>
<tr>
<td>3</td>
<td>All other areas not classified as lighting zone 1 or 2</td>
</tr>
</tbody>
</table>

TABLE C405.4.2(2)
INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

<table>
<thead>
<tr>
<th>LIGHTING ZONE</th>
<th>LIGHTING ZONES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zone 1</td>
</tr>
<tr>
<td>Base Site Allowance</td>
<td>250 W</td>
</tr>
<tr>
<td>Uncovered Parking Areas</td>
<td>0.02 W/ft²</td>
</tr>
<tr>
<td>Building Grounds</td>
<td></td>
</tr>
<tr>
<td>Walkways less than 10 feet wide</td>
<td>0.35 W/linear foot</td>
</tr>
<tr>
<td>Walkways 10 feet wide or greater, plaza areas special feature areas</td>
<td>0.07 W/ft²</td>
</tr>
<tr>
<td>Dining areas</td>
<td>0.50 W/ft²</td>
</tr>
<tr>
<td>Stairways</td>
<td>0.40 W/ft²</td>
</tr>
<tr>
<td>Pedestrian tunnels</td>
<td>0.08 W/ft²</td>
</tr>
<tr>
<td>Landscaping</td>
<td>0.02 W/ft²</td>
</tr>
<tr>
<td>Building Entrances and Exits</td>
<td></td>
</tr>
<tr>
<td>Pedestrian and vehicular entrances and exits</td>
<td>10 W/linear foot of door width</td>
</tr>
<tr>
<td>Entry canopies</td>
<td>0.10 W/ft²</td>
</tr>
<tr>
<td>Loading Docks</td>
<td>0.25 W/ft²</td>
</tr>
<tr>
<td>Sales Canopies</td>
<td></td>
</tr>
<tr>
<td>Free-standing and attached</td>
<td>0.30 W/ft²</td>
</tr>
<tr>
<td>Outdoor Sales</td>
<td></td>
</tr>
<tr>
<td>Open areas (including vehicle sales lots)</td>
<td>0.15 W/ft²</td>
</tr>
<tr>
<td>Street frontage for vehicle sales lots in addition to “open area” allowance</td>
<td>No allowance</td>
</tr>
<tr>
<td>Building facades</td>
<td>No allowance</td>
</tr>
</tbody>
</table>
Automated teller machines (ATM) and night depositories | 135 W per location plus 45 W per additional ATM per location | 135 W per location plus 45 W per additional ATM per location | 135 W per location plus 45 W per additional ATM per location

Entrances and gatehouse inspection stations at guarded facilities | 0.5 W/ft² of covered and uncovered area | 0.5 W/ft² of covered and uncovered area | 0.5 W/ft² of covered and uncovered area

Loading areas for law enforcement, fire, ambulance and other emergency service vehicles | 0.35 W/ft² of covered and uncovered area | 0.35 W/ft² of covered and uncovered area | 0.35 W/ft² of covered and uncovered area

Drive-up windows/doors | 200 W per drive-through | 200 W per drive-through | 200 W per drive-through

Parking near 24-hour retail entrances | 400 W per main entry | 400 W per main entry | 400 W per main entry

For SI: 1 watt per square foot = W/0.0929 m².  
W = watts.

C405.4.3 Exterior fixtures.  
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.

C405.4.4 Gas lighting (Mandatory).  
Gas-fired lighting appliances shall not be equipped with continuously burning pilot ignition systems.

C405.5 Dwelling electrical meter (Mandatory).  
Each dwelling unit located in a Group R-2 building (see occupancy classification) shall have a separate electrical meter.

C405.6 Electrical transformers (Mandatory).  
Low-voltage dry-type distribution electric transformers shall meet the minimum efficiency requirements of Table C405.6 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.

Exceptions: The following transformers are exempt:


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.
12. Welding transformers.
### TABLE C405.6
MINIMUM NOMINAL EFFICIENCY LEVELS FOR 10 CFR 431 LOW-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMERS

<table>
<thead>
<tr>
<th>SINGLE-PHASE TRANSFORMERS</th>
<th>THREE-PHASE TRANSFORMERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>kVA&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Efficiency (%)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>15</td>
<td>97.70</td>
</tr>
<tr>
<td>25</td>
<td>98.00</td>
</tr>
<tr>
<td>37.5</td>
<td>98.20</td>
</tr>
<tr>
<td>50</td>
<td>98.30</td>
</tr>
<tr>
<td>75</td>
<td>98.50</td>
</tr>
<tr>
<td>100</td>
<td>98.60</td>
</tr>
<tr>
<td>167</td>
<td>98.70</td>
</tr>
<tr>
<td>250</td>
<td>98.80</td>
</tr>
<tr>
<td>333</td>
<td>98.90</td>
</tr>
<tr>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

---

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 Electric motors (Mandatory).

Electric motors shall meet the minimum efficiency requirements of Tables C405.7(1) through C405.7(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(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\(^a, b\)

<table>
<thead>
<tr>
<th>MOTOR HORSEPOWER (STANDARD KILOWATT EQUIVALENT)</th>
<th>NOMINAL FULL-LOAD EFFICIENCY (%) AS OF JUNE 1, 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 Pole</td>
</tr>
<tr>
<td></td>
<td>Enclosed</td>
</tr>
<tr>
<td>1 (0.75)</td>
<td>77.0</td>
</tr>
<tr>
<td>1.5 (1.1)</td>
<td>84.0</td>
</tr>
<tr>
<td>2 (1.5)</td>
<td>85.5</td>
</tr>
<tr>
<td>3 (2.2)</td>
<td>86.5</td>
</tr>
<tr>
<td>5 (3.7)</td>
<td>88.5</td>
</tr>
<tr>
<td>7.5 (5.5)</td>
<td>89.5</td>
</tr>
<tr>
<td>10 (7.5)</td>
<td>90.2</td>
</tr>
<tr>
<td>15 (11)</td>
<td>91.0</td>
</tr>
<tr>
<td>20 (15)</td>
<td>91.0</td>
</tr>
<tr>
<td>25 (18.5)</td>
<td>91.7</td>
</tr>
<tr>
<td>30 (22)</td>
<td>91.7</td>
</tr>
<tr>
<td>40 (30)</td>
<td>92.4</td>
</tr>
<tr>
<td>50 (37)</td>
<td>93.0</td>
</tr>
<tr>
<td>60 (45)</td>
<td>93.6</td>
</tr>
<tr>
<td>75 (55)</td>
<td>93.6</td>
</tr>
<tr>
<td>100 (75)</td>
<td>94.1</td>
</tr>
<tr>
<td>125 (90)</td>
<td>95.0</td>
</tr>
<tr>
<td>150 (110)</td>
<td>95.0</td>
</tr>
<tr>
<td>200 (150)</td>
<td>95.4</td>
</tr>
<tr>
<td>250 (186)</td>
<td>95.8</td>
</tr>
<tr>
<td>300 (224)</td>
<td>95.8</td>
</tr>
<tr>
<td>350 (261)</td>
<td>95.8</td>
</tr>
<tr>
<td>400 (298)</td>
<td>95.8</td>
</tr>
<tr>
<td>450 (336)</td>
<td>95.8</td>
</tr>
<tr>
<td>500 (373)</td>
<td>95.8</td>
</tr>
</tbody>
</table>

\(^a\) 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(2)
MINIMUM NOMINAL FULL-LOAD EFFICIENCY FOR NEMA DESIGN C AND IEC DESIGN H MOTORS AT 60 HZ\textsuperscript{a, b}

<table>
<thead>
<tr>
<th>MOTOR HORSEPOWER (STANDARD KILOWATT EQUIVALENT)</th>
<th>NOMINAL FULL-LOAD EFFICIENCY (%) AS OF JUNE 1, 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 Pole</td>
</tr>
<tr>
<td></td>
<td>Enclosed</td>
</tr>
<tr>
<td>1 (0.75)</td>
<td>85.5</td>
</tr>
<tr>
<td>1.5 (1.1)</td>
<td>86.5</td>
</tr>
<tr>
<td>2 (1.5)</td>
<td>86.5</td>
</tr>
<tr>
<td>3 (2.2)</td>
<td>89.5</td>
</tr>
<tr>
<td>5 (3.7)</td>
<td>89.5</td>
</tr>
<tr>
<td>7.5 (5.5)</td>
<td>91.7</td>
</tr>
<tr>
<td>10 (7.5)</td>
<td>91.7</td>
</tr>
<tr>
<td>15 (11)</td>
<td>92.4</td>
</tr>
<tr>
<td>20 (15)</td>
<td>93.0</td>
</tr>
<tr>
<td>25 (18.5)</td>
<td>93.6</td>
</tr>
<tr>
<td>30 (22)</td>
<td>93.6</td>
</tr>
<tr>
<td>40 (30)</td>
<td>94.1</td>
</tr>
<tr>
<td>50 (37)</td>
<td>94.5</td>
</tr>
<tr>
<td>60 (45)</td>
<td>95.0</td>
</tr>
<tr>
<td>75 (55)</td>
<td>95.4</td>
</tr>
<tr>
<td>100 (75)</td>
<td>95.4</td>
</tr>
<tr>
<td>125 (90)</td>
<td>95.4</td>
</tr>
<tr>
<td>150 (110)</td>
<td>95.8</td>
</tr>
<tr>
<td>200 (150)</td>
<td>96.2</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Nominal efficiencies shall be established in accordance with DOE 10 CFR 431.
\textsuperscript{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(3)
**MINIMUM AVERAGE FULL-LOAD EFFICIENCY POLYPHASE SMALL ELECTRIC MOTORS**

<table>
<thead>
<tr>
<th>MOTOR HORSEPOWER</th>
<th>OPEN MOTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Poles</td>
</tr>
<tr>
<td></td>
<td>Synchronous Speed (RPM)</td>
</tr>
<tr>
<td>0.25</td>
<td>65.6</td>
</tr>
<tr>
<td>0.33</td>
<td>69.5</td>
</tr>
<tr>
<td>0.50</td>
<td>73.4</td>
</tr>
<tr>
<td>0.75</td>
<td>76.8</td>
</tr>
<tr>
<td>1</td>
<td>77.0</td>
</tr>
<tr>
<td>1.5</td>
<td>84.0</td>
</tr>
<tr>
<td>2</td>
<td>85.5</td>
</tr>
<tr>
<td>3</td>
<td>85.5</td>
</tr>
</tbody>
</table>

*Average full-load efficiencies shall be established in accordance with DOE 10 CFR 431.*

### TABLE C405.7(4)
**MINIMUM AVERAGE FULL-LOAD EFFICIENCY FOR CAPACITOR-START CAPACITOR-RUN AND CAPACITOR-START INDUCTION-RUN SMALL ELECTRIC MOTORS**

<table>
<thead>
<tr>
<th>MOTOR HORSEPOWER</th>
<th>OPEN MOTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Poles</td>
</tr>
<tr>
<td></td>
<td>Synchronous Speed (RPM)</td>
</tr>
<tr>
<td>0.25</td>
<td>66.6</td>
</tr>
<tr>
<td>0.33</td>
<td>70.5</td>
</tr>
<tr>
<td>0.50</td>
<td>72.4</td>
</tr>
<tr>
<td>0.75</td>
<td>76.2</td>
</tr>
<tr>
<td>1</td>
<td>80.4</td>
</tr>
<tr>
<td>1.5</td>
<td>81.5</td>
</tr>
<tr>
<td>2</td>
<td>82.9</td>
</tr>
<tr>
<td>3</td>
<td>84.1</td>
</tr>
</tbody>
</table>

*Average full-load efficiencies shall be established in accordance with DOE 10 CFR 431.*

### C405.8 Vertical and horizontal transportation systems and equipment.
Vertical and horizontal transportation systems and equipment shall comply with this section.
C405.8.1 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 de-energize ventilation fans and lighting systems when the elevator is stopped, unoccupied and with its doors closed for over 15 minutes.

C405.8.2 Escalators and moving walks.
Escalators and moving walks shall comply with ASME A17.1/CSA B44 and shall have automatic controls configured to reduce speed to the minimum permitted speed in accordance with ASME A17.1/CSA B44 or 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.

C405.8.2.1 Regenerative drive.
An escalator designed 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).

C405.9 Voltage drop in feeders and branch circuits.
The total voltage drop across the combination of feeders and branch circuits shall not exceed 5 percent.

C405.10 Electric Vehicle Charging Stations
New parking lots serving buildings with occupancy groups listed in Table 405.11 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.

Exception: Parking spaces are not counted in Table 405.11 if one of the following conditions apply:
1. Parking spaces intended exclusively for storage of vehicles for retail sale or vehicle service.
2. Parking spaces are separated from the meter by a public right-of-way.
3. Parking spaces which are limited to parking durations of less than an hour.

50% 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). 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.

Exception:
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 ½ 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.

**TABLE C405.11 ELECTRIC VEHICLE CHARGING PARKING SPACES**

<table>
<thead>
<tr>
<th>Commercial Building Occupancy&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Minimum Number of EVSE and EVSE-ready Parking Spaces&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Whole numbers represent actual number of required spaces. Fractional percentages shall be rounded up to nearest whole number.</td>
</tr>
<tr>
<td></td>
<td>&lt;25 Parking Spaces in Lot</td>
</tr>
<tr>
<td></td>
<td>Level 1</td>
</tr>
<tr>
<td>Groups A &amp; M&lt;sup&gt;c,d&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td>Groups B, E, F, &amp; H</td>
<td>1</td>
</tr>
<tr>
<td>Groups I-1, I-2, I-3, &amp; R-4</td>
<td>1</td>
</tr>
<tr>
<td>Group R-1</td>
<td>0</td>
</tr>
<tr>
<td>Group R-2</td>
<td>1</td>
</tr>
</tbody>
</table>

<sup>a</sup> 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.

<sup>b</sup> 50% of the 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.

<sup>c</sup> Motor liquid fuel-dispensing facilities (gas stations) are exempt from the requirement to provide electric vehicle charging parking spaces.

<sup>d</sup> Stand-alone retail stores with fewer than 50 spaces are exempt from the requirement to provide electric vehicle charging parking spaces.
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.

SECTION C406
ADDITIONAL EFFICIENCY PACKAGE OPTIONS

C406.1 Additional Energy Efficiency Credit Requirements. New buildings shall comply with sufficient packages from Table C406.1 to achieve a minimum number of 6 credits. Building with more than one commercial building occupancy type shall use the “All Other Groups” column in Table 406.1, unless 65% 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

<table>
<thead>
<tr>
<th>Code Section</th>
<th>Commercial Building Occupancy</th>
<th>Group R-1</th>
<th>Group R-2</th>
<th>Group B</th>
<th>Group E</th>
<th>Group M</th>
<th>All Other Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. More efficient HVAC performance in accordance with Section C406.2.</td>
<td></td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>2.1 Reduced lighting power: Option 1 in accordance with Section C406.3.1.</td>
<td></td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2.2 Reduced lighting power: Option 2 in accordance with Section C406.3.2.</td>
<td></td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>3. Enhanced lighting controls in accordance with C406.4.</td>
<td></td>
<td>N/A</td>
<td>N/A</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4. On-site supply of renewable energy in accordance with C406.5.</td>
<td></td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>5. Dedicated outdoor air system in accordance with C406.6.</td>
<td></td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>6.1 High-efficiency service water heating in accordance with Section C406.7.1 and C406.7.2.</td>
<td></td>
<td>5</td>
<td>6</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>3 (Group I only)</td>
</tr>
<tr>
<td>6.2 High-efficiency service water heating equipment in accordance with Section C406.7.1 and C406.7.3.</td>
<td></td>
<td>3</td>
<td>3</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>2 (Group I only)</td>
</tr>
<tr>
<td>6.3. Heat pump water heating equipment in accordance with Sections C406.7.1 and C406.7.4.</td>
<td></td>
<td>5</td>
<td>5</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>2 (Group I only)</td>
</tr>
<tr>
<td>7. Enhanced envelope performance in accordance with</td>
<td></td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
Section C406.8.
8. Reduced air infiltration in accordance with Section C406.9.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

9. Efficient kitchen appliances in accordance with C406.10.¹

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>5</td>
</tr>
</tbody>
</table>

(Grupo A-2 only)

10. Controlled Receptacles in accordance with C406.11

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>N/A</td>
<td>6</td>
<td>2</td>
<td>N/A</td>
</tr>
</tbody>
</table>

1. This option is only available to building equipped with operable commercial kitchens serving a minimum of 5 meals per week.

C406.1.1 Tenant spaces.
Tenant spaces shall comply with sufficient packages from Table C406.1 to achieve a minimum number of 3 credits from Sections C406.2, C406.3, C406.4, C406.6 or C406.7 where applicable. Where an entire building complies 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 and fan performance.
Buildings shall comply with Sections C406.2.1 through C406.2.3.

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 Option 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.
Buildings shall comply with Sections C406.3.1 or C406.3.2. Dwelling units and sleeping units within the building shall comply with C406.3.3.

C406.3.1 Reduced lighting power option 1. The total connected interior lighting power calculated in accordance with Section C405.3.1 shall be 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 option 2. 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.
C406.3.3 Lamp fraction. 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. Luminaires shall be controlled through a digital control system configured with the following capabilities:
   4.1. 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. 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 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.

<table>
<thead>
<tr>
<th>TABLE C406.5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ON-SITE RENEWABLE ENERGY SYSTEM RATING</strong></td>
</tr>
<tr>
<td>(PER SQUARE FOOT) Building Area Type</td>
</tr>
<tr>
<td>Assembly</td>
</tr>
<tr>
<td>Dining</td>
</tr>
<tr>
<td>Building Type</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Hospital</td>
</tr>
<tr>
<td>Hotel/Motel</td>
</tr>
<tr>
<td>Multi-family residential</td>
</tr>
<tr>
<td>Office</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>Retail</td>
</tr>
<tr>
<td>School/University</td>
</tr>
<tr>
<td>Supermarket</td>
</tr>
<tr>
<td>Warehouse</td>
</tr>
</tbody>
</table>

**C406.6 Dedicated outdoor air system.**
Not less than 90% of the building conditioned floor area, excluding floor area of unoccupied spaces that do not require ventilation per 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, C403.8.5, C403.8.5.1, C403.9.1, C403.9.2, C403.9.3 or C403.9.4 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 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, 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.

**C406.7.2 Load fraction.**
Not less than 60 percent of the annual building service hot water energy use, 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, process equipment, or other approved system.
2. **On-site renewable energy** water-heating systems.
C406.7.3 High Performance Water Heating Equipment. The combined input-capacity-weighted-average equipment rating of all water heating equipment in the building shall be not less than 95% Et or 0.95 EF.

C406.7.4 Heat pump water heater. All Service hot water system delivering 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 Efficient Kitchen Appliances. 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 (0.30 m) 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 m²) and not to exceed one full floor. The device shall be capable of being overridden for periods of up to two 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 m²). Override switches for controlled receptacles are permitted to control the lighting within the same area.

Exception:

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 (0.30 m) of a controlled receptacle.

2. Within a single modular office workstation, non-controlled 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 (3) previous projects each at least 20,000 square feet or greater, and

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 registered design professional or approved 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 other authority having jurisdiction, upon request in accordance with Sections C407.2.4 and C407.2.5.

Exceptions: 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 registered design professional or approved 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 (18.6 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.
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) 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 registered design professional or approved 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 C408.2.1)
☐ Commissioning Plan was used during construction and includes all items required by Section C408.2.1

☐ 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 C408.2.4

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 2018 IECC.

Signature of Building Owner or Owner’s Representative ___________________________ Date ____________

FIGURE C407.2.4
COMMISSIONING COMPLIANCE CHECKLIST
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 C408.2.2.

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 registered design professional 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.
CHAPTER 5 [CE]  
EXISTING BUILDINGS

User note:

About this chapter: Many buildings are renovated or altered in numerous ways that could affect the energy use of the building as a whole. Chapter 5 requires the application of certain parts of Chapter 4 in order to maintain, if not improve, the conservation of energy by the renovated or altered building.

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.

C501.2 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.

C501.3 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.

C501.5 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.
C501.6 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 owners 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 other 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 Prescriptive compliance.
Additions shall comply with Sections C502.2.1 through C502.2.6.2.

C502.2.1 Vertical fenestration.
New vertical fenestration area 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. Additions with vertical fenestration that result in a total building fenestration area greater than Section C402.3.1 or additions that exceed the fenestration area greater than Section C402.3.1 shall comply with Section C402.3.1.1 for the addition only. Additions 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.

C502.2.2 Skylight area.
New skylight area 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. Additions with skylight area that result in a total building skylight area greater than C402.3.1 or additions that exceed the skylight area shall comply with Section C402.3.1.2 for the addition only. Additions that result in a total building skylight area exceeding that specified in Section C402.3.1.2 shall comply with Section C402.1.3.

C502.2.3 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.

C502.2.4 Service water-heating systems.
New service water-heating equipment, controls and service water heating piping shall comply with Section C404.

C502.2.5 Pools and inground permanently installed spas.
New pools and inground permanently installed spas shall comply with Section C404.10.
C502.2.6 Lighting power and systems.
New lighting systems that are installed as part of the addition shall comply with Section C405.

C502.2.6.1 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.

C502.2.6.2 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.
C503.3 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.

C503.3.1 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.

C503.3.2 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.

C503.3.3 Skylight area.
New *skylight* area that results in a total building skylight area less than or equal to that specified in Section C402.4.1 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 Section C403.

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.

C503.6 Lighting systems.
New lighting systems that are part of the *alteration* shall comply with Section C405.

**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]
REFERENCES STANDARDS
These Referenced standards shall be updated through the copy-editing process.

User note:

About this chapter: Chapter 6 lists the full title, edition year and address of the promulgator for all standards that are referenced in the code. The section numbers in which the standards are referenced are also listed.

This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the section or sections of this document that reference the standard. The application of the referenced standards shall be as specified in Section 107.

AAMA
American Architectural Manufacturers Association
1827 Walden Office Square
Suite 550
Schaumburg, IL 60173-4268

Table C402.5.2

AHAM
Association of Home Appliance Manufacturers
1111 19th Street NW, Suite 402
Washington, DC 20036

ANSI/AHAM RAC-1—2008: 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
Table C403.3.2(2)

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Table C403.3.2(1), Table C403.3.2(2)

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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: 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: 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: Absorption Water Chilling and Water Heating Packages  
Table C403.3.2(7)

1160 (I-P) —2014: Performance Rating of Heat Pump Pool Heaters  
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)
205—12: Energy Efficiency Classification for Fans  
   C403.8.3

220—08 (R2012): Laboratory Methods of Testing Air Curtain Units for Aerodynamic Performance Rating  
   C402.5.6

500D—12: Laboratory Methods for Testing Dampers for Rating  
   C403.7.7

ANSI

Z21.10.3/CSA 4.3—11: 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: Gas-fired Central Furnaces  
   Table C403.3.2(4)

Z83.8/CSA 2.6—09: Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters and Gas-fired Duct Furnaces  
   Table C403.3.2(4)

APSP

   C404.10
   Table C403.3.2(9)

   C403.1.1

   C403.1.1

   Table C403.3.2(2)

   Table C403.3.2(2)

55—2013: Thermal Environmental Conditions for Human Occupancy
   Table C407.5.1

90.1—2016: 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

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

   C405.8.2
C90—14: Specification for Load-bearing Concrete Masonry Units
Table C401.3

C303.1.4.1, Table C402.1.4, 402.2.7

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C402.4.2.2

E283—04(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
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E779—10: Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
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C402.5.1.2.2

CRRC

Cool Roof Rating Council
449 15th Street, Suite 400
Oakland, CA 94612

Table C402.3, C402.3.1

CSA

CSA Group
8501 East Pleasant Valley Road
Cleveland, OH 44131-5516

Table C402.5.2

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 (00): Acceptance Test Code for Water Cooling Tower
Table C403.3.2(8)

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)
# 2019 Vermont Commercial Building Energy Standards

## DASMA

**STD 201—11: Standard for Certification of Water Cooling Towers Thermal Performances**
- Table C403.3.2(8)

**CTI STD 201 RS(15): Performance Rating of Evaporative Heat Rejection Equipment**
- Table C403.3.2(8)

**105—2016: Test Method for Thermal Transmittance and Air Infiltration of Garage Doors and Rolling Doors**
- C303.1.3, Table C402.5.2

## DOE

- Table C403.3.2(4), Table C403.3.2(5), Table C404.2

- C202

- 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)

- Table C403.3.2(1), Table C403.3.2(2), Table C403.3.2(4)

## ICC

**International Code Council, Inc.**
- 500 New Jersey Avenue NW
- 6th Floor
- Washington, DC 20001

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IBC—18: International Building Code®
C201.3, C303.2, C402.5.3, C501.4

IFC—18: International Fire Code®
C201.3, C501.4

IFGC—18: International Fuel Gas Code®
C201.3, C501.4

IPC—18: International Plumbing Code®
C201.3, C501.4

IPMC—18: International Property Maintenance Code®
C501.4

IPSDC—18: International Private Sewage Disposal Code®
C501.4

IEEE
Institute of Electrical and Electronic Engineers
3 Park Avenue, 17th Floor
New York, NY 10016

C404.6.2
IES
Illuminating Engineering Society
120 Wall Street, 17th Floor
New York, NY 10005-4001

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

Table C403.3.2(2)

C403.3.2(2)

NEMA
National Electrical Manufacturers Association
1300 North 17th Street,
Suite 900
Rosslyn, VA 22209

MG1—2014: Motors and Generators
C202

NFPA
National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02169-7471

70—17: National Electrical Code
C501.4
NFRC

100—2017: Procedure for Determining Fenestration Products \textit{U-factors} 
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C303.1.3, C402.4.1.1

400—2017: Procedure for Determining Fenestration Product Air Leakage 
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SMACNA

C403.2.11.2.3

UL

710—12: Exhaust Hoods for Commercial Cooking Equipment—with Revisions through November 2013 
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727—06: Oil-fired Central Furnaces—with Revisions through October 2013 
Table C403.3.2(4)

731—95: Oil-fired Unit Heaters—with Revisions through October 2013 
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1784—01: Air Leakage Tests of Door Assemblies—with Revisions through February 2015 
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US-FTC

CFR Title 16 (2015): R-value Rule
C303.1.4

WDMA

Table C402.5.2
APPENDIX CA
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 CA101
SCOPE

CA101.1 General.
These provisions shall be applicable for new construction where solar-ready provisions are required.

SECTION CA102
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 CA103
SOLAR-READY ZONE

CA103.1 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.

CA103.2 Construction document requirements for a solar-ready zone.
Construction documents shall indicate the solar-ready zone.
CA103.3 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.

CA103.4 Obstructions.
Solar ready zones shall be free from obstructions, including pipes, vents, ducts, HVAC equipment, skylights and roof-mounted equipment.

CA103.5 Roof loads and documentation.
A collateral dead load of not less than 5 pounds per square foot (5 psf) (24.41 kg/m²) 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.

CA103.6 Interconnection pathway.
Construction documents shall indicate pathways for routing of conduit or piping from the solar-ready zone to the electrical service panel or service hot water system.

CA103.7 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 shall be labeled “For Future Solar Electric.” The reserved space shall be positioned at the end of the panel that is opposite from the panel supply conductor connection.

CA103.8 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 or registered design professional.
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PREFACE

Introduction

This document is the 2015-2019 Vermont Commercial Building Energy Standards (CBES). It is based on the 2015-2018 International Energy Conservation Code® (IECC®) and includes many elements of ASHRAE/IESNA Standard 90.1-2013-2016. Amendments have been made to suit Vermont’s climate and special needs.

The Vermont Energy Act of 2009 (Act 45) directed the Commissioner of the Department of Public Service to amend the CBES to ensure that commercial building construction be designed and constructed in a manner that complies with ASHRAE/IESNA Standard 90.1-2007 or the 2009 edition of the IECC.

The Vermont Energy Act of 2009 (Act 45) legislation requires that at least every three years after January 1, 2011 the Commissioner of Public Service shall amend and update the CBES.

30 V.S.A. §53 of the Vermont Statutes requires certification that both the design and the construction of a commercial building is in compliance with the CBES. Certification shall be issued by a completed and signed certificate permanently affixed to the outside of the heating or cooling equipment, to the electrical service panel and located inside the building, or in a visible location in the immediate vicinity of one of these three areas. Copies of the signed certification documents shall be sent to the local town clerk and to the Vermont Department of Public Service.

The Vermont Division of Fire Safety may request completed certificates at the time of inspection, and certificate of occupancy may be withheld until the CBES certificate and affidavits are posted.

Certificates, affidavits and contact information for questions about the energy code can be found at:

http://publicservice.vermont.gov/topics/energy_efficiency/cbes

The statute pertaining to CBES (30 V.S.A. §53) can be found at:

http://tinyurl.com/VT-Statute-CBES

Users of the code are encouraged to view the publicly available interpretations of the ASHRAE 90.1-2013-2016 standard, available online at:


Marginal Markings
Solid vertical lines in the margins within the body of the code indicate a State of Vermont amendment has been made to the 2015-2018 International Energy Conservation Code. 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.

**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.
EFFECTIVE USE OF THE COMMERCIAL BUILDING ENERGY STANDARDS

Arrangement and Format of the 2015–2019 CBES

Before applying the requirements of the 2015–2019 CBES it is beneficial to understand its arrangement and format. The 2015–2019 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 2015–2019 CBES is divided into five different parts:

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The following is a chapter-by-chapter synopsis of the scope and intent of the provisions of the 2015–2019 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 building official or the authority having jurisdiction 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.

Climate has a major impact on the energy use of most buildings. The code establishes many requirements such as wall and roof insulation $R$-values, window and door thermal transmittance requirement ($U$-factors) as well as provisions that affect the mechanical systems based on the climate where the building is located.

**Chapter 4 Energy Efficiency.** Chapter 4 of each set of provisions contains the technical requirements for energy efficiency.

**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 and the service water heating system of the building.

**Chapter 5 Existing Buildings.** Chapter 5 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, 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 numerical order.
order based _upon_ 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.
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.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>AFUE</td>
<td>Annual fuel utilization efficiency</td>
</tr>
<tr>
<td>bhp</td>
<td>Brake horsepower (fans)</td>
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<tr>
<td>Btu</td>
<td>British thermal unit</td>
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<td>Btu/h-ft²</td>
<td>Btu per hour per square foot</td>
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<td>C-factor</td>
<td>See Chapter 2—Definitions</td>
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<td>CDD</td>
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<td>cfm/ft²</td>
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<td>Fault detection and diagnostics</td>
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<td>Horsepower</td>
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<td>Heating seasonal performance factor</td>
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<td>Heating, ventilating and air conditioning</td>
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CHAPTER 1
SCOPE AND ADMINISTRATION

PART 1—SCOPE AND APPLICATION

SECTION C101
SCOPE AND GENERAL REQUIREMENTS

C101.1 Title.
This code shall be known as the 20152019 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 requirements for the design and construction, and a plan for operation and maintenance of:

1. New buildings and their systems,
2. New portions of buildings and their systems,
3. New systems and equipment in existing buildings, and
4. New equipment or building systems specifically identified in the standard that are part of industrial or manufacturing processes.

Exception: This code shall not apply to farm structures as defined in 24 V.S.A. § 4413.

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 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 and is a mixed-use building that shares residential and commercial users.
i. 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.

ii. 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 2015 Residential Building Energy Standards (RBES), and Commercial buildings shall meet the provisions of Commercial Building Energy Standards (CBES).

C101.5.1 Compliance materials.
The code official or other 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 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 · ft² (10.7 W/m²) or 1.0 watt per square foot (10.7 W/m²) of floor area for space conditioning purposes.

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


4. Inflatable buildings. The above-ground portions that are Temporary air-supported structures, when constructed for temporary purposes, 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:
A. Buildings that are separate buildings with floor area not more than 500 square feet (50 m²).

B. Buildings that are intended to house electronic equipment with installed equipment power totaling not less than 7 watts per square foot (75 W/m²) and not intended for human occupancy.

C. 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).

D. Buildings that have an average wall and roof $U$-factor less than 0.120.

SECTION C102
ALTERNATIVE MATERIALS—METHOD, DESIGN AND METHODS OF CONSTRUCTION, DESIGN OR INSULATING SYSTEMS AND EQUIPMENT

C102.1 General.
This provisions of this code is are not intended to prevent the use installation of any material— or to prohibit any design or method of construction, design or insulating system not specifically prescribed hereby this code, provided that any such construction, design or insulating system alternative has been approved by. An alternative material, design or method of construction shall be approved where the code official or other authority having jurisdiction as meeting finds that the proposed design is satisfactory and complies with the intent of this code, 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 code official or other authority having jurisdiction shall respond in writing, stating the reasons why the alternative was not approved.

C102.1.1 Above code programs.
The code official or other authority having jurisdiction shall be permitted to deem a national, state or local energy efficiency program to exceed 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 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 other authority having jurisdiction is authorized to require necessary construction documents to be prepared by a registered design professional.
Exception: The code official or other authority having jurisdiction is authorized to waive the requirements for construction documents or other supporting data if the code official or other 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 upon suitable material. Electronic media documents are permitted to be submitted where approved by the code official or other 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. Insulation materials and their $R$-values.
2. Fenestration $U$-factors and solar heat gain coefficients (SHGCs).
3. Area-weighted $U$-factor and solar heat gain coefficient (SHGC) calculations.
4. Design ambient temperatures.
5. Interior temperatures for heating and cooling modes.
6. Relative humidity setpoints.
8. Mechanical system design criteria.
9. Mechanical and service water heating systems and equipment types, sizes and efficiencies.
10. Economizer description.
11. Equipment and system controls.
12. Fan motor horsepower (hp) and controls.
13. Duct sealing, duct and pipe insulation and location.
14. Lighting fixture schedule with wattage and control narrative.
15. Location of daylight zones on floor plans.

16. Air sealing details.

16. Air sealing details, 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’s thermal envelope shall be represented on the construction drawings.

C103.3 Examination of documents.
The code official or other 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 other 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 other 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 other 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 other 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 other 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 or other authority having jurisdiction 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 C405.4.

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.
C104.1 General.
Where required, construction or work for which a permit is required shall be subject to inspection by the code official or other authority having jurisdiction, or his or her designated agent or an approved agency, and such construction or work shall remain accessible visible and exposed 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 accessible visible and exposed to be accessed for inspection purposes. Neither the code official or other 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.

C104.2 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 other authority having jurisdiction. The code official or other 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 other authority having jurisdiction.

C104.2.1 Final inspection.
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.

C104.3 Reinspection.
A building shall be reinspected where determined necessary by the code official or other authority having jurisdiction.

C104.4 Approved inspection agencies.
The code official or other 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.

C104.5 Inspection requests.
It shall be the duty of the holder of the permit or their duly authorized agent to notify the code official or other 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.

C104.6 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 other authority having jurisdiction for inspection and testing.

C104.7 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 other authority having jurisdiction.
C104.7.1 Revocation. The code official or other authority having jurisdiction is authorized to, in writing, 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 C105
VALIDITY

C105.1 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 C106
REFERENCED STANDARDS

C106.1 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 C106.1.1 and C106.1.2.

C106.1.1 Conflicts. Where conflicts occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.
C106.1.2 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.

C106.2 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.

C106.3 Other laws.
The provisions of this code shall not be deemed to nullify any provisions of local, state or federal law.
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 the International Residential 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.

SECTION C202
GENERAL DEFINITIONS

ABOVE-GRADE WALL. See “Wall, above-grade.”

ACCESSIBLE. Admitting close approach as a result of not being guarded by locked doors, elevation or other effective means (see “Readily accessible”).

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. Materials assembled and joined together to provide a barrier in a continuous manner to restrict or prevent the passage of air leakage through the building thermal envelope. An air barrier may be a single material or a combination of materials 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.

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.
APPROVED. Approval by the code official or other 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 research reports, where such agency has been approved by the code official or other authority having jurisdiction.

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”).

BELOW-GRADE WALL. See “Wall, below-grade.”

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 (see “metal 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, door way, 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, floor, roof, ceilings, roofs and any other building elements 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 • ft2 • °F) [W/(m2 • K)].

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

CAVITY INSULATION. Insulating material located between framing members.

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.** The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative. The Vermont Public Service Department is not the code official and shall not be required to conduct inspections of construction or construction documents.

**Coefficient of Performance (COP) – Cooling.** The ratio of the rate of heat removal to the rate of energy input, in consistent units, for a complete refrigerating system or some specific portion of that system under designated operating conditions.

**Coefficient of Performance (COP) – 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 temperatures of 5°F. The indoor and outdoor units must be part of an AHRI matched system.

**Commercial Building.** For this code, all buildings that are not included in the definition of “Residential building,” excluding “Mobile homes.”

**Commercial Building Energy Standards (CBES).** The Vermont non-residential Energy Code, based on the [2015-2018 IECC](https://www.iaee.org/), but modified substantially.

**Computer Room.** A room whose primary function is to house equipment for the processing and storage of electronic data and that has a design electronic data equipment power density exceeding [20 watts per square foot](https://www.iaee.org/) of conditioned floor area or a connected design electronic data equipment load of less than 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 or cooled by a heating system whose output capacity is greater than 14 Btu/h-ft² 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-ft² 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 AIR BARRIER. A combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.

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.

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 known 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 where having one or more recirculation pumps prime the service hot that pump water piping with from a heated water upon demand for hot supply pipe back to the heated water source through a cold water supply pipe.

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 distribution ducts of air-conditioning systems 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.

[8]-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.

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 RECOVERY VENTILATION SYSTEM. Systems that employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of preheating, pre-cooling, 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.

ENTRANCE DOOR. A vertical fenestration product used for occupant ingress, egress and access in nonresidential buildings, including, but not limited to, exterior entrances that utilize latching hardware and automatic closers and contain over 50 percent glass glazing specifically designed to withstand heavy use and abuse duty usage.

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 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, etc.).

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 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 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.

FENESTRATION. Products classified as either skylights or vertical fenestration or skylights.
**Skylight/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 and sloped walls.

**Vertical fenestration.** Windows (that are fixed or moveable), 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 at least 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 \(\times\) ft \(\times\) °F) [W/(m \(\times\) K)].

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

**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 DUCT.** A furnace normally installed in distribution ducts of air-conditioning systems to supply warm air for heating and which depends on a blower not furnished as part of the duct furnace for air circulation.

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

**GENERAL LIGHTING.** 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.

**GENERAL PURPOSE ELECTRIC MOTOR (SUBTYPE I).** A motor that is designed in standard ratings with either of the following:

1. Standard operating characteristics and standard mechanical construction for use under usual service conditions, such as those specified in NEMA MG1, paragraph 14.02, “Usual Service Conditions,” and without restriction to a particular application or type of application.

2. Standard operating characteristics or standard mechanical construction for use under unusual service conditions, such as those specified in NEMA MG1, paragraph 14.03, “Unusual Service Conditions,” or for a particular type of application, and that can be used in most general purpose applications.

General purpose electric motors (Subtype I) are constructed in NEMA T-frame sizes or IEC metric equivalent, starting at 143T.
GENERAL PURPOSE ELECTRIC MOTOR (SUBTYPE II). A motor incorporating the design elements of a general purpose electric motor (Subtype I) that is configured as one of the following:

1. A U-frame motor.
2. A Design C motor.
3. A close-coupled pump motor.
5. A vertical, solid-shaft, normal-thrust motor (as tested in a horizontal configuration).
6. An 8-pole motor (900 rpm).
7. A polyphase motor with voltage of not more than 600 volts (other than 230 or 460 volts).

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.

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

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.
**HIGH-EFFICACY LAMPS/LIGHTING.** Compact fluorescent lamps, light-emitting diode (LED) lamps, T-8 or smaller diameter linear fluorescent lamps, or other lamps with an efficacy of not less than 65 lumens per watt; or light fixtures of not less than 55 lumens per watt.

**HIGH SPEED DOOR.** A nonswinging 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.
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.

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, inspection approved agency or other organization concerned with product evaluation that maintains periodic inspection of the production of the above-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 and takes 11 to 20 hours to charge a depleted EV.

LEVEL 2 ELECTRIC VEHICLE CHARGING. Level 2 uses a 240 volt AC charging for faster charging than 240V alternating current outlet.

LEVEL 3 ELECTRIC VEHICLE CHARGING. See “DC Fast Charge”.

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 other 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.

LOW-VOLTAGE LIGHTING. Lighting equipment powered through a transformer such as a cable conductor, a rail conductor and track lighting.

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.

METAL BUILDING ROOF. A roof that:

a. is constructed with a metal, structural, weathering surface;

b. has no ventilated cavity; and

c. 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:

   1. metal roofing in direct contact with the steel framing members;

   2. metal roofing separated from the steel framing members by insulation; or

   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).

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 horsepower 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, accessible from the front desk or other central location associated with a Group R-1 building, that is capable of identifying the occupancy 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 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, nightclubs, restaurants, cafeterias, taverns, and bars.

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.

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

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 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.

The next group R-2 is R-2. R-2 is used most often for residences occupying 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 conveys and monasteries. Congregate housing or congregate living facilities with 16 or fewer occupants go into group R-3.

R-3 is for permanent occupancies that are not R-1, R-2, or R-4. Adult facilities and child care facilities that provide accommodation for five or less people less than 24 hours a day are R-3.

R-4 is for residential care/assisted living facilities including occupancies for more than five and but not more than 16 occupants, 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 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.

READILY ACCESSIBLE. Capable of being reached quickly for operation, renewal or inspection without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders or access equipment (see "Accessible").

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 m²).

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 m²).

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. 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.

A. 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.

B. 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.

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

D. 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) as well as 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 2019 IECC.

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 (see “metal building roof”).

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 REPLACEMENT. 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 \( (h \cdot \text{ft}^2 \cdot ^\circ\text{F/Btu}) \) or \( (m^2 \cdot K)/W \).

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.

SCREW LAMP HOLDERS. A lamp base that requires a screw-in-type lamp, such as a compact-fluorescent, incandescent or tungsten-halogen bulb.

SEMI-CONDITIONED SPACE. An enclosed space within a building that is directly or indirectly heated by a heating system whose output capacity is less than or equal to 14 Btu/h·ft² 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·ft² of floor area.

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

[S]LEEPING UNIT. A room or space in which people sleep, which can also include permanent provisions for living, eating, and either sanitation or kitchen facilities but not both. Such rooms and spaces that are also 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 which is then reradiated, conducted or convected into the space.

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 nonresidential 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.

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

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

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 °F) [W/(m² 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.

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

[M] 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.

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 m²).

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 m²).

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 (see “metal building wall”).

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.

302.2 Climatic data.

- Heating Design Temperature, 99.6%: -119°F (ASHRAE/IESNA 90.1-2013 Table D-1 Standard 169)
- Cooling Design Temperature Dry-Bulb, 1.0%: 84°F (ASHRAE/IESNA 90.1-2013 Table D-1 Standard 169)
- Cooling Design Temperature Wet-Bulb, 1.0%: 69°F (ASHRAE/IESNA 90.1-2013 Table D-1 Standard 169)
- Heating Degree Days, 65° Base: 7,771,626 (ASHRAE/IESNA 90.1-2013 Table D-1 Standard 169)
- Cooling Degree Days, 50° Base: 2,228,183 (ASHRAE/IESNA 90.1-2013 Table D-1 Standard 169)

Adjustments may be made only in the following cases:

1. Winter heating design temperatures for projects either:
   i. Located at an elevation of 1,500 feet or higher, or
   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/.

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1 Climatic data derived by weighting Burlington 50%, Rutland 25%, and Montpelier 25%.
2. As approved by the code official or other 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 insulation (fiberglass and cellulose), 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.

C303.1.1.1 Blown or sprayed Exception: For roof/ceiling 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 (fiberglass or cellulose) shall be written in inches (mm) on markers that are installed at least one or more of such markers shall be installed for every 300 square feet (28 m²) 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.

C303.1.3 Fenestration product rating.
U-factors of fenestration products (windows, doors and skylights) shall be determined in accordance with NFRC 100 as follows:

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

2. Where required, for garage 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 FENESTRATION WINDOW, GLASS DOOR AND SKYLIGHT U-FACTORS**

<table>
<thead>
<tr>
<th>FRAME TYPE</th>
<th>SINGLE PANEWINDOW AND GLASS DOOR</th>
<th>DOUBLE PANANE</th>
<th>SKYLIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SINGLE PANEWINDOW AND GLASS DOOR</td>
<td>DOUBLE PANANE</td>
<td>SKYLIGHT</td>
</tr>
<tr>
<td>Metal</td>
<td>1.20</td>
<td>0.80</td>
<td>2.00</td>
</tr>
<tr>
<td>Metal with Thermal Break</td>
<td>1.10</td>
<td>0.65</td>
<td>1.10</td>
</tr>
<tr>
<td>Nonmetal or Metal Clad</td>
<td>0.95</td>
<td>0.55</td>
<td>1.05</td>
</tr>
</tbody>
</table>

Glazed Block 0.60

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

a) The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/h/ft²/°F;

b) The thermal break material must produce a gap in the frame material of not less than 0.210 inches; and

c) All metal framing members of the products exposed to interior and exterior air shall incorporate a thermal break meeting the criteria in a) and b) above.

### TABLE C303.1.3(2)
**DEFAULT OPAQUE DOOR U-FACTORS**
<table>
<thead>
<tr>
<th>DOOR TYPE</th>
<th>OPAQUE U-FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uninsulated Metal</td>
<td>1.20</td>
</tr>
<tr>
<td>Insulated Metal (Rolling)</td>
<td>0.90</td>
</tr>
<tr>
<td>Insulated Metal (Other)</td>
<td>0.60</td>
</tr>
<tr>
<td>Wood</td>
<td>0.50</td>
</tr>
<tr>
<td>Insulated, nonmetal edge, max 45% glazing, any glazing double pane</td>
<td>0.35</td>
</tr>
</tbody>
</table>
TABLE C303.1.3(3)
DEFAULT GLAZED FENESTRATION SHGC AND VT

<table>
<thead>
<tr>
<th></th>
<th>SINGLE GLAZED</th>
<th>DOUBLE GLAZED</th>
<th>GLAZED BLOCK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clear</td>
<td>Tinted</td>
<td>Clear</td>
</tr>
<tr>
<td>SHGC</td>
<td>0.8</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>VT</td>
<td>0.6</td>
<td>0.3</td>
<td>0.6</td>
</tr>
</tbody>
</table>

**C303.1.4 Insulation product rating.**
The thermal resistance \((R\text{-value})\) of insulation shall be determined in accordance with the U.S. Federal Trade Commission \(R\text{-value}\) 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 \((R\text{-value})\) 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.

**C303.3 Maintenance information.**
Maintenance instructions shall be furnished for equipment and systems that require preventive maintenance. Required regular maintenance actions shall be clearly stated and incorporated on a readily accessible label. The label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product.
CHAPTER 4
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:

1. 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.

2. The requirements of ANSI/ASHRAE/IESNA 90.1-2013. New buildings using ANSI/ASHRAE/IESNA 90.1-2013 compliance paths (a) or (b) (see ANSI/ASHRAE/IESNA 90.1-2013 section 4.2.1.1 New Buildings) shall comply with Section C406 in the 2019 CBES and tenant spaces shall comply with Section C406.1.1 in the 2019 CBES. Commercial building projects utilizing the alternative compliance path of ANSI/ASHRAE/IESNA 90.1-2013 must follow all applicable provisions listed in Section 401.2.1.

C401.2.1 Applicable provisions to Standard 90.1-2013.

1. All instances of the term building official in ASHRAE/IESNA 90.1-2013 shall be replaced with the terms code official or other authority having jurisdiction.

2. ASHRAE/IESNA 90.1-2013 Section 4.2.1.1 New Buildings.
   Delete the equation for Performance Cost Index Target (PCI) and replace with:
   \[ PCI = \frac{\text{BPF} \times (\text{BBUEC} + \text{BBREC})}{\text{BBP}}. \]
   Delete Table 4.2.1.1 Building Performance Factor (BPF) and replace with:

<table>
<thead>
<tr>
<th>Building Area Type*</th>
<th>Vermont BPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multifamily</td>
<td>.62</td>
</tr>
<tr>
<td>Healthcare/hospital</td>
<td>.46</td>
</tr>
<tr>
<td>Hotel/motel</td>
<td>.48</td>
</tr>
<tr>
<td>Office</td>
<td>.43</td>
</tr>
<tr>
<td>Restaurant</td>
<td>.50</td>
</tr>
<tr>
<td>Retail</td>
<td>.44</td>
</tr>
<tr>
<td>School</td>
<td>.39</td>
</tr>
<tr>
<td>Warehouse</td>
<td>.53</td>
</tr>
<tr>
<td>All Others</td>
<td>.45</td>
</tr>
</tbody>
</table>

   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 Section 5.1.4.1 United States Locations.** Delete the exception clause and replace with the following:

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, or
   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 code official or other authority having jurisdiction

34. **ASHRAE/IESNA 90.1-20132016 Section 5 Building Envelope.** All envelope requirements shall comply with the following tables in the 20152019 Vermont Commercial Building Energy Standards (CBES):

   i. *Table C402.1.(1)*, 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(2)*, Building Envelope Requirements—Metal Building Assembly Descriptions, and

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

45. **ASHRAE/IESNA 90.1-20132016 Section 5.4.3 Air Leakage.** Delete section in its entirety and replace with Section C402.4 Air leakage—thermal envelope of the 20152019 Vermont CBES.

56. **ASHRAE/IESNA 90.1-2013 Section 5.4.3.4 Vestibules.** Delete section in its entirety and replace with Section C402.4.7 Vestibules of the 2015 Vermont CBES.

6. **ASHRAE/IESNA 90.1-20132016 Section 5.5.3.1 Roof Insulation.** Delete section in its entirety and replace with Section C402.2.1 Roof assembly of the 2019 Vermont CBES.

7. **ASHRAE/IESNA 90.1-2016 Section 5.5.3.3 Below-Grade Wall Insulation.** Delete section in its entirety and replace with Section C402.2.2 Roof assembly3 Below-grade walls of the 20152019 Vermont CBES.

7. **ASHRAE/IESNA 90.1-20138. ASHRAE/IESNA 90.1-2016 Section 5.5.3.5 Slab-on-Grade Floor Insulation.** Add to the end of this section the requirements of section C402.2.6 Slabs-on-grade perimeter insulation of the 2019 Vermont CBES.

9. **ASHRAE/IESNA 90.1-2016 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 Section 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 ≤ 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; and

b. the building thermal envelope shall be tested in accordance with ASTM E 779 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 cfm/ft2 (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.

810. ASHRAE/IESNA 90.1-2013 Section 6.3.2(e) Criteria. Delete “an electric resistance heater.”

911. ASHRAE/IESNA 90.1-2013 Section 6.4.3.5 Heat Pump Auxiliary Heat Control. Delete section in its entirety and replace with Section C403.2.4.1.1 Heat pump supplementary heat of the 2015 Victorian Vermont CBES.

4912. ASHRAE/IESNA 90.1-2013 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 Section 6.4.3.9 Heated or Cooled Vestibules. Delete section in its entirety and replace with Section C403.4.1.4 Duct and plenum insulation and sealing of the 2019 Vermont CBES.

14. ASHRAE/IESNA 90.1-11. ASHRAE/IESNA 90.1-2013 Section 6.4.4.1.2 Duct and Plenum Insulation. Delete section in its entirety and replace with Section C403.2.911.1 Duct and plenum insulation and sealing of the 2015 Victorian Vermont CBES.

4215. Add new Section 6.4.7 to ASHRAE/IESNA 90.1-2013, titled Economizer Fault Detection

2015 Vermont Commercial Building Energy Standards

2019 VERMONT COMMERCIAL BUILDING ENERGY STANDARDS
and Diagnostics (FDD). Insert Section C403.2.4.75.5 Economizer fault detection and diagnostics (FDD) of the 20152019 Vermont CBES.

4316. ASHRAE/IESNA 90.1-20142016 Section 6.5.1 Economizers. Delete section in its entirety and replace with Section C403.35 Economizers of the 20152019 Vermont CBES.

17. ASHRAE/IESNA 90.1-2016 Table 6.5.6.1-1 and 6.5.6.1-2 Exhaust Air Energy Recovery Requirements for Ventilation Systems. Both tables shall be greater than or equal to 3000 hours per year rather than 8000 hours.

18. ASHRAE/IESNA 90.1-2016 Table 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).

4519. ASHRAE/IESNA 90.1-20132016 Section 6.5.6.2 Heat Recovery for Service Water Heating, 6.5.6.2.2. 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.

4620. ASHRAE/IESNA 90.1-20132016 Section 6.7.2.4 System Commissioning. Delete section in its entirety and replace with Section C407 System Commissioning of the 20152019 Vermont CBES.

4721. ASHRAE/IESNA 90.1-20132016 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 5 kW total power input.

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

4822. ASHRAE/IESNA 90.1-20132016 Table 7.8 Performance Requirements for Water Heating Equipment.

   a. Change first row (Electric table top water heaters) size category to ≥ 5 kW, and delete

   b. Change second row (Electric water heaters) size category to < 5 kW, and

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

4923. ASHRAE/IESNA 90.1-20132016 Section 9 Lighting. All lighting power density (LPD) requirements shall comply with the following tables in the 2019 Vermont Commercial Building Energy Standards (CBES):

i. Table 9.5.C405.3.2(1), Interior Lighting Power Densities Using the Allowances: Building Area Method.

ii. Replace Warehouse LPD with Table C405.3.2(2), Interior Lighting Power Allowances: Space-by-Space Method, and

iii. Table C405.4.2(2), 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 Table 9.4.4-2.
24. ASHRAE/IESNA 90.1-2016 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. ASHRAE/IESNA 90.1-2016 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. ASHRAE/IESNA 90.1-2016 Section 9.4.4 Dwelling Units. Delete section in its entirety and replace with: 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. ASHRAE/IESNA 90.1-2016 Section 9.6.2 Additional Interior Lighting Power. Amend the exception in part (a) to read that the power shall not exceed 0.6 W/ft² of such spaces instead of 0.75 W/ft². In part (b) Delete the equation for Additional Interior Lighting Power Allowance and replace with:

\[
\text{Additional interior lighting power allowance} = 250 \text{ W} + (\text{Retail Area 1} \times 0.20 \text{ W/ft}^2) + (\text{Retail Area 2} \times 0.20 \text{ W/ft}^2) + (\text{Retail Area 3} \times 0.50 \text{ W/ft}^2) + (\text{Retail Area 4} \times 0.90 \text{ W/ft}^2)
\]

28. ASHRAE/IESNA 90.1-2016 Section 10.4 Mandatory Provisions. Add the following sections

i. 10.4.6, Renewable energy systems, which will meet the requirements of section C405.10 Renewable energy systems in the 2019 Vermont CBES.

ii. 10.4.7 Electric Vehicle Charging Stations, which will meet the requirements of section C405.11 Electric Vehicle Charging Stations in the 2019 Vermont 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 Certificate 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.
Certification shall be issued by completing and signing a certificate permanently and affixing it to the outside of the heating or cooling equipment, to the electrical service panel and located inside the building, or in a visible location in the immediate vicinity of one of these three areas. Copies of the signed certification documents shall be sent to the local town clerk and to the Vermont Public Service Department.
C402.1 General (Prescriptive).

In addition to the envelope requirements of Section C402, envelope enhancements may be needed to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406.

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 21 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; or the component performance alternative of Section 402C402.1.3; 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.

   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 1 or Section C401.2, Item 32.

   Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.2.15 or C403.2.1610.1.

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 insulation shall be not less than that specified in the “Minimum R-values” columns of Table C402.1(1). Commercial buildings or portions of commercial buildings enclosing conditioned spaces shall use the R-values from the “Conditioned Space” column of Table C402.1(1). Commercial buildings or portions of commercial buildings enclosing semi-conditioned spaces shall use the R-values from the “Semi-conditioned Space” column of Table C402.1(1). Walls between conditioned and semi-conditioned spaces shall use the R-values from the “Semi-conditioned Space” column of Table C402.1(1).

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 C402.1(1). 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 C402.1(1). 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 C402.1(1). Walls between conditioned and semi-conditioned spaces shall use the $R$-values from the “Semi-conditioned Space” column of Table C402.1(1).
### TABLE C402402.1

(1)
**BUILDING ENVELOPE REQUIREMENTS—OPAQUE ASSEMBLIES AND ELEMENTS**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>MAXIMUM OVERALL U-FACTOR</th>
<th>MINIMUM R-VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All-</td>
<td>Group R Semi-</td>
</tr>
<tr>
<td></td>
<td>other Conditioned Space</td>
<td>conditioned Space</td>
</tr>
<tr>
<td><strong>Roofs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation entirely above deck</td>
<td>U-0.0326025</td>
<td>U-0.039</td>
</tr>
<tr>
<td>Metal buildings&lt;sup&gt;a&lt;/sup&gt;</td>
<td>U-0.034026</td>
<td>U-0.037</td>
</tr>
<tr>
<td>Attic and Other</td>
<td>U-0.021</td>
<td>U-0.034</td>
</tr>
<tr>
<td><strong>Walls, Above grade</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>U-0.080048</td>
<td>U-0.074104</td>
</tr>
<tr>
<td>Metal building&lt;sup&gt;a&lt;/sup&gt;</td>
<td>U-0.052044</td>
<td>U-0.060</td>
</tr>
<tr>
<td>Metal-framed</td>
<td>U-0.044</td>
<td>U-0.064</td>
</tr>
<tr>
<td>Wood-framed and other</td>
<td>U-0.054042</td>
<td>U-0.064</td>
</tr>
<tr>
<td><strong>Walls, Below Grade</strong>&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below-grade wall</td>
<td>C-0.992063</td>
<td>R-10ciC-0.119</td>
</tr>
<tr>
<td><strong>Floors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass&lt;sup&gt;d&lt;/sup&gt;</td>
<td>U-0.064051</td>
<td>U-0.057087</td>
</tr>
<tr>
<td>Joist/Framing—Metal</td>
<td>U-0.032</td>
<td>U-0.052</td>
</tr>
<tr>
<td>Joist/Framing—Wood and Other</td>
<td>U-0.033</td>
<td>U-0.051</td>
</tr>
<tr>
<td><strong>Slab-on-Grade Floors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unheated slabs</td>
<td>F-0.4836</td>
<td>F-0.4554</td>
</tr>
<tr>
<td>Heated slabs&lt;sup&gt;e&lt;/sup&gt;</td>
<td>F-0.373</td>
<td>F-0.55</td>
</tr>
<tr>
<td><strong>Opaque Doors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swinging</td>
<td>U-0.37</td>
<td>N/A</td>
</tr>
<tr>
<td>Non-Swinging</td>
<td>N/A</td>
<td>R-4.75</td>
</tr>
<tr>
<td>Upward-acting, Sectional</td>
<td>N/A</td>
<td>R-10</td>
</tr>
<tr>
<td>Garage door &lt;14%, glazing</td>
<td>U-0.31</td>
<td>N/A</td>
</tr>
</tbody>
</table>
For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m², 1 pound per cubic foot = 16 kg/m³.

ci = Continuous insulation, LS = Liner system,

ci = Continuous insulation, NR = No Requirement, LS = Liner System.

a. For all envelope categories, except metal building walls and metal building roofs, attic roofs with wood joists, metal-framed walls and wood-framed walls; the use of opaque assembly U-factors, C-factors, and F-factors from ANSI/ASHRAE/IESNA 90.1-2013 Appendix A shall be permitted, provided the construction, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ASHRAE/IESNA 90.1-2013 Appendix A. Refer to Table C402.1(2) for metal building assembly descriptions, Table C402.1(3) for metal building roof assembly U-factors, and Table C402.1(4) for metal building wall assembly U-factors.

b. Opaque assembly U-factors based on designs tested in accordance with ASTM C1363 shall be 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-factor requirements for heated slabs. Refer to Table C402.1(3) for metal building roof assembly U-factors, and Table C402.1(4) for metal building wall assembly U-factors.

d. "Mass floors" 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 90.1-2013 Appendix A.

f. Insulation placed under entire heated slab, and around perimeter.

<table>
<thead>
<tr>
<th>TABLE 402.1(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING ENVELOPE REQUIREMENTS—METAL BUILDING ASSEMBLY DESCRIPTIONS</td>
</tr>
<tr>
<td>BUILDING ENVELOPE REQUIREMENTS—METAL BUILDING ASSEMBLY DESCRIPTIONS</td>
</tr>
<tr>
<td>ROOFS</td>
</tr>
<tr>
<td>Liner system (LS) R-25 + R-11 LS</td>
</tr>
<tr>
<td>Filled Cavity (Fc) (See Table C402.1(3) for Qualifying Assemblies)</td>
</tr>
</tbody>
</table>

2015 Vermont Commercial Building Energy Standards 2019 VERMONT COMMERCIAL BUILDING ENERGY STANDARDS
accommodate the full thickness of the second layer of insulation. A supporting structure retains the bottom of the first layer at the prescribed depth required for the full thickness of the second layer of insulation being installed above it. A minimum R-5 thermal spacer block between the purlins and the metal building roof panels is required; unless compliance is shown by the overall assembly U-factor.

WALLS

R-13 + R-13ci

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 shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.

ANSI/ASHRAE/IESNA 90.1-20132016

R-19.5ci

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 90.1-20132016

### TABLE C402.1(3)

**ASSEMBLY U-FACTORS FOR METAL BUILDING ROOFS**

<table>
<thead>
<tr>
<th>INSULATION SYSTEM</th>
<th>RATED R-VALUE OF INSULATION</th>
<th>OVERALL U-FACTOR FOR ENTIRE BASE ROOF ASSEMBLY</th>
<th>OVERALL U-FACTOR FOR ASSEMBLY OF BASE ROOF PLUS CONTINUOUS INSULATION (UNINTERRUPTED BY FRAMING)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing Seam Roofs with Thermal</td>
<td></td>
<td></td>
<td>Rated R-Value of Continuous Insulation</td>
</tr>
<tr>
<td>Spacer Blocks</td>
<td></td>
<td></td>
<td>1.280</td>
</tr>
<tr>
<td>Single layer</td>
<td></td>
<td></td>
<td>1.280</td>
</tr>
<tr>
<td>None</td>
<td></td>
<td></td>
<td>1.280</td>
</tr>
<tr>
<td>R-13</td>
<td>1.280</td>
<td>1.280</td>
<td>1.280</td>
</tr>
<tr>
<td>None</td>
<td></td>
<td></td>
<td>1.280</td>
</tr>
<tr>
<td>R-13ci</td>
<td>1.280</td>
<td>1.280</td>
<td>1.280</td>
</tr>
<tr>
<td>Single layer</td>
<td></td>
<td></td>
<td>1.280</td>
</tr>
<tr>
<td>None</td>
<td></td>
<td></td>
<td>1.280</td>
</tr>
<tr>
<td>R-13</td>
<td>1.280</td>
<td>1.280</td>
<td>1.280</td>
</tr>
<tr>
<td>None</td>
<td></td>
<td></td>
<td>1.280</td>
</tr>
<tr>
<td>R-13ci</td>
<td>1.280</td>
<td>1.280</td>
<td>1.280</td>
</tr>
<tr>
<td>Layer</td>
<td>R-10 + R-10</td>
<td>0.088</td>
<td>0.056037</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
<td>-------</td>
<td>-----------</td>
</tr>
<tr>
<td></td>
<td>R-10 + R-11</td>
<td>0.086</td>
<td>0.055036</td>
</tr>
<tr>
<td></td>
<td>R-11 + R-11</td>
<td>0.085</td>
<td>0.055036</td>
</tr>
<tr>
<td></td>
<td>R-10 + R-13</td>
<td>0.084</td>
<td>0.054036</td>
</tr>
<tr>
<td></td>
<td>R-11 + R-13</td>
<td>0.082</td>
<td>0.053036</td>
</tr>
<tr>
<td></td>
<td>R-13 + R-13</td>
<td>0.075</td>
<td>0.050034</td>
</tr>
<tr>
<td></td>
<td>R-10 + R-19</td>
<td>0.074</td>
<td>0.050034</td>
</tr>
<tr>
<td></td>
<td>R-11 + R-19</td>
<td>0.072</td>
<td>0.049034</td>
</tr>
<tr>
<td></td>
<td>R-13 + R-19</td>
<td>0.068</td>
<td>0.047033</td>
</tr>
<tr>
<td></td>
<td>R-16 + R-19</td>
<td>0.065</td>
<td>0.046032</td>
</tr>
<tr>
<td></td>
<td>R-19 + R-19</td>
<td>0.060</td>
<td>0.043031</td>
</tr>
</tbody>
</table>

### Double Layer Liner System

<table>
<thead>
<tr>
<th>Layer</th>
<th>R-19 + R-11 LS</th>
<th>0.037</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R-25 + R-8 LS</td>
<td>0.037</td>
</tr>
<tr>
<td></td>
<td>R-25 + R-11 LS</td>
<td>0.034</td>
</tr>
<tr>
<td></td>
<td>R-30 + R-11 LS</td>
<td>0.029</td>
</tr>
</tbody>
</table>

### Liner System Filled cavity

<table>
<thead>
<tr>
<th>Layer</th>
<th>R-25 + R-11 + R-11 LS</th>
<th>0.026</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-10 + R-19 Fc</td>
<td>0.041</td>
<td>0.032025</td>
</tr>
</tbody>
</table>
Standing Seam Roofs without Thermal Spacer Blocks

<table>
<thead>
<tr>
<th>Liner System</th>
<th>R-19 + R-11 LS</th>
<th>0.040</th>
</tr>
</thead>
</table>

Thru-fastened Roofs without Thermal Spacer Blocks

<table>
<thead>
<tr>
<th>Liner System</th>
<th>R-10</th>
<th>R-13</th>
<th>R-16</th>
<th>R-19</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-10</td>
<td>0.184</td>
<td>0.174</td>
<td>0.157</td>
<td>0.151</td>
</tr>
<tr>
<td>R-13</td>
<td>0.036</td>
<td>0.036</td>
<td>0.035</td>
<td>0.035</td>
</tr>
<tr>
<td>R-16</td>
<td>0.033</td>
<td>0.033</td>
<td>0.032</td>
<td>0.032</td>
</tr>
<tr>
<td>R-19</td>
<td>0.027</td>
<td>0.027</td>
<td>0.026</td>
<td>0.023</td>
</tr>
</tbody>
</table>

(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)

ASSEMBLY U-FACTORS FOR METAL BUILDING WALLS ATTIC ROOFS WITH WOOD JOISTS

<table>
<thead>
<tr>
<th>INSULATION SYSTEM</th>
<th>RATED R-VALUE OF INSULATION ALONE</th>
<th>OVERALL CONTINUOUS ASSEMBLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood-Framed Attic, Standard Framing</td>
<td>Rated R-value of Continuous Insulation R-30</td>
<td>R-438</td>
</tr>
<tr>
<td>Single Layer</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R-438</td>
</tr>
<tr>
<td>Wood-Framed Attic, Advanced Framing</td>
<td></td>
<td>R-1130</td>
</tr>
</tbody>
</table>
a. 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.

table c402.1(6)
assembly u-factors for metal-framed walls

<table>
<thead>
<tr>
<th>rated r-value of cavity insulation (effective installed)</th>
<th>overall u-factor for base wall assembly</th>
<th>overall u-factors for assembly of base wall plus continuous insulation (uninterrupted by framing)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R-0.0 (0.0)</td>
<td>R-0.352 0.063 0.059 0.056 0.044 0.036 0.030 0.026 0.023</td>
</tr>
<tr>
<td>steel framing at 16 in. on center and 3.5 in. depth</td>
<td>R-0 (0.0)</td>
<td>0.352 0.063 0.059 0.056 0.044 0.036 0.030 0.026 0.023</td>
</tr>
</tbody>
</table>

2015 vermont commercial building energy standards
<table>
<thead>
<tr>
<th>RATED R-VALUE OF CAVITY INSULATION (EFFECTIVE INSTALLED)</th>
<th>OVERALL U-FACTOR FOR WOOD-FRAMED WALL ASSEMBLY</th>
<th>OVERALL U-FACTORS FOR ASSEMBLY OF BASE WALL PLUS CONTINUOUS INSULATION (UNINTERRUPTED BY FRAMING)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>R-6</td>
</tr>
<tr>
<td>Wood Studs at 16 in. on Center and 3.5 in. Depth</td>
<td></td>
<td>0.292</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.096</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.089</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.083</td>
</tr>
<tr>
<td>Wood Studs at 16 in. on Center and 5.5 in. Depth</td>
<td></td>
<td>0.067</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.063</td>
</tr>
<tr>
<td>Wood Studs at 16 in. on Center and R-10 Headers</td>
<td></td>
<td>0.054</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.059</td>
</tr>
<tr>
<td>Wood Studs at 24 in. on Center and 3.5 in. Depth</td>
<td></td>
<td>0.298</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.094</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.086</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.080</td>
</tr>
<tr>
<td>Wood Studs at 24 in. on Center and 5.5 in. Depth</td>
<td></td>
<td>0.065</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.060</td>
</tr>
<tr>
<td>Wood Studs at 24 in. on Center and R-10 Headers</td>
<td></td>
<td>0.062</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.057</td>
</tr>
</tbody>
</table>

Shaded areas comply with minimum requirements for semi-conditioned spaces but not conditioned spaces.
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 C402.1(1) 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.

\[ A + B + C + D + E \leq \text{Zero} \quad \text{(Equation 4-1)} \]

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.
- \( \text{UA Dif} \) = \( \text{UA Proposed} - \text{UA Table} \).
- \( \text{UA Proposed} \) = Proposed \( U \)-value \( \times \) Area.
- \( \text{UA Table} \) = \((U\text{-factor from Table C402.1(1) or C402.3}) \times \text{Area}\).
- \( B \) = Sum of the (FL Dif) values for each distinct slab on-grade perimeter condition of the building thermal envelope.
- \( \text{FL Dif} \) = \( \text{FL Proposed} - \text{FL Table} \).
- \( \text{FL Proposed} \) = Proposed \( F \)-value \( \times \) Perimeter length.
- \( \text{FL Table} \) = \((F\text{-factor specified in Table C402.1(1)}) \times \text{Perimeter length}\).
- \( C \) = Sum of the (CA Dif) values for each distinct below-grade wall assembly type of the building thermal envelope.
- \( \text{CA Dif} \) = \( \text{CA Proposed} - \text{CA Table} \).
- \( \text{CA Proposed} \) = Proposed \( C \)-value \( \times \) Area.
- \( \text{CA Table} \) = \((\text{Maximum allowable C-factor specified in Table C402.1(1)}) \times \text{Area}\).

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:

- \( D \) = \( \frac{(DA \times UV)}{\text{Total vertical glazing area}} - \frac{(DA \times U\text{Wall})}{\text{Total vertical glazing area}} \), but not less than zero.
- \( \text{DA} \) = \((\text{Proposed Vertical Glazing Area}) - (\text{Vertical Glazing Area allowed by Section C402.3.1})\).
- \( \text{UA Wall} \) = Sum of the (UA Proposed) values for each opaque assembly of the exterior wall.
- \( \text{U Wall} \) = Area-weighted average \( U \)-value of all above-grade wall assemblies.
- \( \text{UAV} \) = Sum of the (UA Proposed) values for each vertical glazing assembly.
- \( \text{UV} \) = \( \text{UAV} \)/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:
\[ E = (EA \times US) - (EA \times U_{\text{Roof}}), \text{ but not less than zero.} \]

\[ EA = (\text{Proposed Skylight Area}) - (\text{Allowable Skylight Area as specified in Section C402.3.1}). \]

\[ U_{\text{Roof}} = \text{Area-weighted average } U\text{-value of all roof assemblies.} \]

\[ U_{\text{AS}} = \text{Sum of the (UA Proposed) values for each skylight assembly.} \]

\[ US = U_{\text{AS}}/\text{total skylight area}. \]

**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 C402.1(1) 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. \textit{Fenestration} shall meet the applicable SHGC requirements of Section C402.3.3.

\[
\text{UA-Total / Area} \leq 0.035 \quad \text{(Equation 4-2)}
\]

where:

\[ \text{UA-Total} = \text{Sum of the (UA) values for each distinct above-grade assembly type of the building thermal envelope including above-grade walls, roofs, doors, vertical fenestration, and skylights.} \]

\[ \text{UA} \times \text{Area} = \text{Proposed } U\text{-value } \times \text{Area.} \]

\[ \text{Area} = \text{Surface area in square feet of the above-grade thermal barrier (above-grade wall area plus roof area).} \]

**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 C402.1(1).

**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 C402.1(1), 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 \( R\)-value is equivalent to the \( R\)-value specified in Table C402.1(1).

2. A minimum of 60% 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 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 C402.1(1), 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 C402.1(1) except as otherwise noted in the table. In determining compliance with Table C402.1(1), 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/m²) of wall surface area.
2. Weigh not less than 25 pounds per square foot (122 kg/m²) of wall surface area where the material weight is not more than 120 pcf (1900 kg/m³).
3. Have a heat capacity exceeding 7 Btu/ft² • °F (144 kJ/m² • K).
4. Have a heat capacity exceeding 5 Btu/ft² • °F (103 kJ/m² • K), where the material weight is not more than 120 pcf (1900 kg/m³).

C402.2.3 Floors 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 C402.1(1), based on construction materials used in the floor assembly.

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, the minimum thermal resistance (R-value) of the insulation around the perimeter of 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 C402.1(1). 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 10 inches (254 mm) of soil.

**Exception:** Where the slab-on-grade floor is greater than 48 inches (122 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 C402.1(1). The **C402.1.1 Insulation component R-value-based method.** Building thermal envelope opaque assemblies shall meet 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 insulation in framing cavities, where required, and for continuous insulation, where required, shall be not less than that specified in Table C402.1. Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the R-values from the “Group R” column of Table C402.1. Commercial buildings or portions of commercial buildings enclosing occupancies other than Group R shall use the R-values from the “Group R” column of Table C402.1.
Group R shall use the R-values from the “All other” column of Table C402.1. The thermal resistance or 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 C402.1. 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. Opaque doors shall comply with Table C402.1.

C402.1.2 Assembly U-factor, C-factor or F-factor-based method.
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 Table C402.1. Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the U-, C- or F-factor from the “Group R” column of Table C402.1. Commercial buildings or portions of commercial buildings enclosing occupancies other than Group R shall use the U-, C- or F-factor from the “All other” column of Table C402.1. The C-factor for the below-grade exterior walls of the building envelope, as required in accordance with Table C402.1, shall extend to a depth of 10 feet (3048 mm) below the outside finished ground level, or to the level of the lowest floor, whichever is less. Opaque doors shall comply with Table C402.1.

C402.1.3 Component performance alternative.
Building envelope values and fenestration areas determined in accordance with Equation 4-1 shall be permitted in lieu of compliance with the U-, F- and C-factors in Table C402.1.3 and the maximum allowable fenestration areas in Section C402.3.1.

\[ A + B + C + D + E \leq \text{Zero} \]  
(Equation 4-1)

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

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** = \((DA - UV) - (DA - U_{\text{Wall}})\), but not less than zero.
  \[ DA = (\text{Proposed Vertical Glazing Area}) - (\text{Vertical Glazing Area allowed by Section C402.3.1}). \]
  \[ U_{\text{Wall}} = \text{Area-weighted average } U\text{-value of all above-grade wall assemblies}. \]
  \[ UA = \text{Sum of the } (UA \text{ Proposed}) \text{ values for each vertical glazing assembly}. \]
  \[ UV = UA / \text{Total vertical glazing area}. \]
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:

$$E = (EA - US) - (EA - U_{Roof}), \text{ but not less than zero.}$$

$EA = (\text{Proposed Skylight Area}) - (\text{Allowable Skylight Area as specified in Section C402.3.1}).$

$U_{Roof} = \text{Area-weighted average } U\text{-value of all roof assemblies.}$

$UAS = \text{Sum of the } (UA\text{ Proposed}) \text{ values for each skylight assembly.}$

$US = UAS/\text{total skylight area.}$

**C402.2 Specific building thermal envelope insulation requirements (Prescriptive).**

Insulation in building thermal envelope opaque assemblies shall comply with Sections C402.2.1 through C402.2.6 and Table C402.1.

**C402.2.1 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.

**C402.2.2 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 C402.1, based on construction materials used in the roof assembly. Skylight curbs shall be insulated to the level of roofs with insulation entirely above deck or $R-5$, whichever is less. Mechanical curbs shall be insulated to the level of roofs with insulation entirely above deck or $R-5$, whichever is less.

**Exceptions:**

1. Continuously insulated roof assemblies where the area-weighted $U$-factor is equivalent to the same assembly with the $R$-value specified in Table C402.1.

2. Unit skylight curbs included as a component of a skylight listed and labeled in accordance with NFRC 100 shall not require additional insulation.

Insulation installed on a suspended ceiling with removable ceiling tiles shall not be considered part of the minimum thermal resistance of the roof insulation.

**C402.2.3 Thermal resistance of 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 C401.3, 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 C402.1.

"Mass walls" shall include walls:

1. Weighing not less than 35 psf (170 kg/m$^2$) of wall surface area.

2. Weighing not less than 25 psf (120 kg/m$^2$) of wall surface area where the material weight is not more than 120 pcf (1900 kg/m$^3$).
3. Having a heat capacity exceeding 7 Btu/ft$^2 \cdot ^\circ$F (144 cage/m$^2 \cdot ^\circ$K).

4. Having a heat capacity exceeding 5 Btu/ft$^2 \cdot ^\circ$F (103 kJ/m$^2 \cdot ^\circ$K), where the material weight is not more than 120 pcf (1900 kg/m$^3$).

C402.2.4 Floors.
The thermal properties (component R-values or assembly $U$, $C$, or $F$-factors) of floor assemblies over outdoor air or unconditioned space shall be as specified in Table C402.1 based on the 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.

**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 R-value in Table C402.1 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.

C402.2.5 Slabs-on-grade perimeter insulation.
Where the slab on grade is in contact with the ground, the minimum thermal resistance (R-value) of the insulation around the perimeter of unheated or heated slab-on-grade floors designed in accordance with the R-value method of Section C402.1.3 shall be as specified in Table C402.1. The insulation shall be placed on the outside of the foundation or on the inside of the foundation wall. The insulation shall extend downward from the top of the slab for a minimum distance as shown in the table or to the top of the footing, whichever is less, or downward to at least 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.

**Exception:** Where the slab on-grade floor is greater than 48 inches (122 mm) below the finished exterior grade, perimeter insulation is not required.

C402.2.6 Insulation of radiant heating systems.
Radiant heating system panels, and their associated components that are installed in interior or exterior non-slab assemblies shall be insulated with a minimum to an R-value of not less than R-3.5 (0.62 m$^2 \cdot ^\circ$K/W) 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 C402.1.42.

**Exception:** Heated slabs on grade insulated in accordance with the “Heated slabs” row of Table 402.1(1).

C402.2.7 Airspaces.
Where the thermal properties of airspaces are used to comply with this code in accordance with Section C402.2.5, such airspaces 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 C402.3.45 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**

<table>
<thead>
<tr>
<th>Vertical fenestration</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U-factor</strong></td>
<td></td>
</tr>
<tr>
<td>Fixed fenestration</td>
<td>0.3629</td>
</tr>
<tr>
<td>Operable fenestration</td>
<td>0.4337</td>
</tr>
<tr>
<td>Entrance doors</td>
<td>0.7768</td>
</tr>
<tr>
<td><strong>SHGC</strong></td>
<td></td>
</tr>
<tr>
<td>Orientation&lt;sup&gt;a&lt;/sup&gt;</td>
<td>SEW</td>
</tr>
<tr>
<td>PF &lt; 0.2</td>
<td>0.40</td>
</tr>
<tr>
<td>0.2 ≤ PF &lt; 0.5</td>
<td>0.48</td>
</tr>
<tr>
<td>PF ≥ 0.5</td>
<td>0.64</td>
</tr>
<tr>
<td><strong>Skylights</strong></td>
<td></td>
</tr>
<tr>
<td><strong>U-factor</strong></td>
<td>0.5048</td>
</tr>
<tr>
<td><strong>SHGC</strong></td>
<td>0.4038</td>
</tr>
</tbody>
</table>

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 not be greater than 30 percent of the gross above-grade wall area. The skylight area shall not be 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 permitted to 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 permitted to be not more than 56 percent of the roof area provided that daylight responsive controls complying with Section C405.2.3.1 are installed in daylight zones under skylights.
C402.3.2 Minimum skylight fenestration area.

In an enclosed space greater than 2,500 square feet (232 m²) 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 total \textit{toplit daylight zone under skylights} shall be not less than half the floor area and shall provide one of the following:

1. A minimum skylight area to \textit{toplit daylight zone under skylights} of not less than 3 percent where all skylights have a VT of at least 0.40 as determined in accordance with Section C303.1.3.

2. A minimum skylight effective aperture of at least 1 percent, determined in accordance with Equation 4-2.3.

\[
\text{Skylight Effective Aperture} = \frac{0.85 \times \text{Skylight Area} \times \text{Skylight VT}}{\text{Daylight zone under skylight}} \quad \text{(Equation 4-23)}
\]

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.
- **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 \textit{general lighting power densities} are less than 0.5 W/ft² (5.4 W/m²).

2. Areas where it is documented that existing structures or natural objects block direct beam sunlight on at least 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 \textit{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 daylight zones** adjacent to vertical fenestration is less than 2,500 square feet (232 m²), and where the lighting is controlled according to Section C405.2.53.

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

#### 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 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.

#### 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 4-34:

\[
PF = \frac{A}{B} \quad \text{(Equation 4-34)}
\]

where:

- \(PF\) = Projection factor (decimal).
- \(A\) = Distance measured horizontally from the furthest 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 0.6057 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 0.7572 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 the applicable requirements for doors as specified in Table C402.1 and (1). Opaque nonswinging doors shall comply with Table C402.1(1). Opaque doors shall be considered as part of the gross area of above-grade walls that are part of the building thermal envelope. Other doors shall comply with the provisions of Section C402.3.3 for vertical fenestration.

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

The thermal envelope of buildings shall comply with Sections C402.4.1 through C402.4.8, or the building thermal envelope shall be tested 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 0.50 cfm/per square foot of shell area (excluding area of slab and below grade walls) at 50 Pa in accordance with ASTM E779 or an equivalent method approved by the code official or other authority having jurisdiction. Where compliance is based on such testing, the building shall also comply with Sections C402.4.5, C402.4.6 and C402.4.7.5.

#### C402.4.1 Air barriers.

A continuous air barrier shall be provided throughout the building thermal envelope. The air barriers shall be permitted to be located on the inside or outside of the building envelope, located within the assemblies composing the envelope, or any combination thereof. The air barrier shall either comply with Section C402.4.1.1 or Sections C402.4.1.1 and 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 E 779 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).

**Exceptions:**

1. For buildings having over 50,000 ft² of gross conditioned floor area, air leakage testing shall be permitted to be conducted on less than the whole building, provided the following portions of the building are tested and their measured air leakage is area-weighted by the surface areas of the building envelope:
   a. The entire floor area of all stories that have any spaces directly under a roof.
   b. The entire floor area of all stories that have a building entrance or loading dock.
c. Representative above-grade wall sections of the building totaling at least 25% of the wall area enclosing the remaining conditioned space; floor area tested per (a) and (b) shall not be included in the 25%.

2. Where the measured air leakage rate exceeds 0.30 cfm/ft² but does not exceed 0.40 cfm/ft², 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, the registered design professional 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 COMMISSIONING CHECKLIST**

<table>
<thead>
<tr>
<th>RELATED SYSTEMS, EQUIPMENT, ASSEMBLIES AND COMPONENTS</th>
<th>TASKS/COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundations subsoil drainage system</td>
<td>Verify compliance with approved plans, specifications and construction documents.</td>
</tr>
<tr>
<td>Foundation damp-proofing and waterproofing</td>
<td></td>
</tr>
<tr>
<td>Flashing at: exterior doors, skylights, wall flashing and drainage systems</td>
<td></td>
</tr>
<tr>
<td>Exterior wall coverings</td>
<td></td>
</tr>
<tr>
<td>Moisture envelopes</td>
<td>Where applicable meet owner’s project requirements (OPR), Basis of Design (BOD), Cx Specifications.</td>
</tr>
<tr>
<td>Exterior below-grade walls</td>
<td>Check for proper drainage system at exterior wall perimeter to keep water from entering building.</td>
</tr>
<tr>
<td>External floor and soffits, slab-on grade</td>
<td>Check for thermal resistance or insulation when</td>
</tr>
<tr>
<td>Exterior walls</td>
<td>Slabs: Check drainage for moisture penetration. Check drawings for wall assembly requirements.</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Exterior glazed window fenestration: windows, glazed doors and skylights | 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 site, not preformed or cut | Check for compliance with the default U-factor and the 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 or covered with moisture vapor-permeable wrapping material. Sealing materials shall be appropriate to the construction materials being sealed and 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 C402.4.71.8. 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.

**C402.4.1.24 Air barrier compliance options.**
A continuous air barrier for the opaque building envelope shall comply with Section C402.4.1.24.1 or C402.4.1.24.2.

**C402.4.1.24.1 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 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 $\frac{3}{8}$ inch (10 mm).

2. Oriented strand board having a thickness of not less than $\frac{3}{8}$ inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than $\frac{1}{2}$ inch (12.7 mm).

4. Foil-back polyisocyanurate insulation board having a thickness of not less than $\frac{1}{2}$ inch (12.7 mm).

5. Closed-cell spray foam having a minimum density of 1.5 pcf ($2.4 \text{ kg/m}^3$) and having a thickness of not less than $1\frac{1}{2}$ inches (38 mm).

6. Open-cell spray foam with a density between 0.4 and 1.5 pcf ($0.6 \text{ and } 2.4 \text{ kg/m}^3$) 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 $\frac{1}{2}$ inch (12.7 mm).

8. Cement board having a thickness of not less than $\frac{1}{2}$ inch (12.7 mm).


10. Modified bituminous roof membrane.


12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than $\frac{5}{8}$ inch (15.9 mm).


15. Sheet steel or aluminum.

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

**C402.4.1.24.2 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 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 C402.4.1.43 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 parget, stucco or plaster not less than \( \frac{1}{2} \) inch (12.7 mm) in thickness.

**C402.4.21.5 Air leakage of fenestration.**

The air leakage of fenestration assemblies shall meet the provisions of Table C402.4.21.5. Testing shall be in accordance with the applicable reference test standard in Table C402.4.21.5 by an accredited independent testing laboratory and labeled by the manufacturer.

**Exception: Exceptions:**

- Field-fabricated fenestration assemblies that are sealed in accordance with Section C402.4.1.
- Fenestration in buildings that comply with the testing alternative of Section C402.4 are not required to meet the air leakage requirements in Table C402.4.2.

---

**TABLE C402.4.21.5**

**MAXIMUM AIR LEAKAGE RATE FOR FENESTRATION ASSEMBLIES**

<table>
<thead>
<tr>
<th>FENESTRATION ASSEMBLY</th>
<th>MAXIMUM RATE (CFM/FT²)</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows</td>
<td>0.20 (^a)</td>
<td>AAMA/WDMA/CSA101/I.S.2/A440 or NFRC 400</td>
</tr>
<tr>
<td>Sliding doors</td>
<td>0.20 (^a)</td>
<td></td>
</tr>
<tr>
<td>Swinging doors</td>
<td>0.20 (^a)</td>
<td></td>
</tr>
<tr>
<td>Skylights – with condensation openings</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Skylights – all other</td>
<td>0.20 (^a)</td>
<td></td>
</tr>
<tr>
<td>Curtain walls</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Storefront glazing</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Commercial glazed swinging entrance doors</td>
<td>1.00</td>
<td>NFRC 400 or ASTM E283 at 1.57 psf (75 Pa)</td>
</tr>
<tr>
<td>Power-operated sliding doors and power-operated folding doors</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Revolving doors</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Garage doors</td>
<td>0.40</td>
<td>ANSI/DASMA 105, NFRC 400, or ASTM E283 at 1.57 psf (75 Pa)</td>
</tr>
<tr>
<td>Rolling doors</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>High-speed doors</td>
<td>1.30</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 cubic foot per minute = 0.47 L/s, 1 square foot = 0.093 m².

\( a\) 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).
C402.4.31.6 Rooms containing fuel-burning appliances that are not direct vented.
Where open-combustion air ducts provide combustion air to open combustion is supplied through openings in an exterior wall to a room or space containing a space-conditioning fuel-burning appliances, the appliances and combustion air openings appliance, one of the following shall apply:

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

2. The room or space containing the appliance shall be enclosed in a room and isolated from conditioned spaces inside the building thermal envelope. Such rooms shall be sealed and insulated in accordance with all of the envelope requirements of 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 C402.1, where the (1).

   2.2. The walls, floors and shall meet the minimum of the below-grade wall R-ceilings value requirement. The door 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 shall be fully gasketed, and any water.

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

   2.5. Where an air duct supplying combustion air duct shall be insulated, where it to the enclosed room or space passes through conditioned space, to a minimum of the duct shall be insulated to an R-value of not less than R-810.

Exceptions:

Exception: 1. Direct vent appliances with both intake and exhaust pipes installed continuous to the outside.

2. Fireplaces and stoves complying with Sections 901 through 905 of the International Mechanical Code, and Section 2111.1314 of the International Building Code.

C402.4.41.7 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 C402.4.21.5 shall be gasketed, weatherstripped or sealed.

Exceptions:

Exceptions:

1. Door openings required to comply with Section 716 or 716.4 of the International Building Code.

2. Doors and door openings required by 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.

C402.4.5 Dwelling unit air infiltration.
A sampling of dwelling units shall be tested in accordance with ASTM E 779 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 registered design professional. 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 C403.2.4.37.7.

C402.4.64 Loading dock weatherseals and thermal requirements.
Cargo doors, door openings and loading dock doors, door openings shall be equipped with weatherseals that restrict infiltration when and provide direct contact along the top and sides of vehicles that are parked in the opening. If equipped with an interior dock leveler, the deck of the leveler and rear pit wall 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 per the slab ASTM E283 on grade standard in Table C402.1.(1). The spaces between the pit wall and the deck skirts for the leveler shall be weather-stripped.

C402.4.75 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. 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.

Exceptions: 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, or intended solely for employee use.
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 (298 m²) 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.

C402.4.75.1 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.

C402.4.75.2 Vestibule construction.
Vestibules meeting the requirements of Section C402.4.7.1 shall be constructed according to the building envelope requirements of Section C402.1.
C402.4.7.3 Vestibule thermostatic controls.  
Vestibules meeting the requirements of Section C402.4.7.5 shall be zoned separately from the conditioned building. Thermostats located inside vestibules shall be programmable, and

1. Tamper-proof, or

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

Exception: Vestibule spaces served by radiant floor heating may utilize a non-programmable thermostat.

C402.4.8 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 at a 1.57 psf (75 Pa) pressure differential.

3. --
SECTION C403
BUILDING MECHANICAL SYSTEMS

C403.1 General.
In addition to the mechanical requirements of Section C403, mechanical enhancements may be needed to meet
the requirements of Section C406, Additional Efficiency Package Options. See Section C406.

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

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.

Section C403.2 and System design (Mandatory).
Mechanical systems shall be designed to comply with Sections C403.2.1 through C403.2.4. Where elements of
a building's mechanical systems are addressed in Sections C403.3 and C403.4 based on the equipment and
systems provided through C403.12, 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 m2) 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, shall be provided in accordance with 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 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.

Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.2.15 or C403.2.16.

C403.1.2Exception:

1. 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, domestic hot water heaters, 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. Replacement of existing electrical resistance unit.

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

4. 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).

5. Multifamily buildings with heating loads ≤ 6.0 Btu/hour/square foot at design temperature.

   a. the full heating demand can be met with the heat pump at an outside air temperature of 5°F; and

   b. the building thermal envelope shall be tested in accordance with ASTM E 779 at a pressure differential of 0.3 inch water heaters less 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 5 kW in total unit input capacity, 0.20 cfm/ft² (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 Provisions applicable to all.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 (Mandatory). Mechanical systems and equipment serving the building heating, cooling or ventilating needs shall comply with Sections C403.2 through shall be sized in accordance with Section C403.2.173.1 and shall be not less efficient in the use of energy than as specified in Section C403.3.2.

C403.2.1 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. The design loads shall account for the building envelope, lighting, ventilation and occupancy loads based on the project design. 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.

C403.2.23.1 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 C403.2.1. 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 ten 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.

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 have the capability are configured to sequence the operation of each unit based on load.

C403.3.2.3 HVAC equipment performance requirements. (Mandatory). Equipment shall meet the minimum efficiency requirements of Tables C403.3.2.3(1) through C403.3.2.3(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 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 C403.3.2.3(1)
**MINIMUM EFFICIENCY REQUIREMENTS:**
**ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS**

| EQUIPMENT TYPE | SIZE CATEGORY | HEATING SECTION TYPE | SUBCATEGORY OR RATING CONDITION | MINIMUM EFFICIENCY | TEST PROCEDURE
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, air cooled</td>
<td>&lt; 65,000 Btu/hb</td>
<td>All</td>
<td>Split System</td>
<td>13.0 SEER</td>
<td>14.0 SEER</td>
</tr>
<tr>
<td>Through-the-wall (air cooled)</td>
<td>≤&lt; 30,000 Btu/hb</td>
<td>All</td>
<td>Split System</td>
<td>12.0 SEER</td>
<td>12.0 SEER</td>
</tr>
<tr>
<td>Small-duct high-velocity (air cooled)</td>
<td>&lt; 65,000 Btu/hb</td>
<td>All</td>
<td>Split System</td>
<td>11.0 SEER</td>
<td>11.0 SEER</td>
</tr>
<tr>
<td>Air conditioners, air cooled</td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>11.2 EER</td>
<td>11.2 EER</td>
</tr>
<tr>
<td>Non-Electricc</td>
<td></td>
<td></td>
<td>Single Package</td>
<td>11.4 IEER</td>
<td>12.8 IEER</td>
</tr>
<tr>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>11.0 EER</td>
<td>11.0 EER</td>
<td></td>
</tr>
<tr>
<td>Non-Electricc</td>
<td></td>
<td></td>
<td>Single Package</td>
<td>11.2 IEER</td>
<td>12.4 IEER</td>
</tr>
<tr>
<td>≥ 240,000 Btu/h and &lt; 760,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>10.1 EER</td>
<td>10.0 EER</td>
<td></td>
</tr>
<tr>
<td>Non-Electricc</td>
<td></td>
<td></td>
<td>Single Package</td>
<td>10.2 IEER</td>
<td>11.6 IEER</td>
</tr>
<tr>
<td>≥ 760,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>9.7 EER</td>
<td>9.7 EER</td>
<td></td>
</tr>
<tr>
<td>Non-Electricc</td>
<td></td>
<td></td>
<td>Single Package</td>
<td>9.8 IEER</td>
<td>11.2 IEER</td>
</tr>
</tbody>
</table>

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### TABLE  C403.3.2.3(1)—continued

**MINIMUM EFFICIENCY REQUIREMENTS:**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING</th>
<th>SUB-CATEGORY OR MINIMUM</th>
<th>TEST-</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air conditioners, water cooled</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 65,000 Btu/hb</td>
<td>All</td>
<td>Single Package</td>
<td>9.6 IEER</td>
<td>11.0 IEER</td>
</tr>
<tr>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>None</td>
<td>Single Package</td>
<td>12.1 EER</td>
<td>13.9 IEER</td>
</tr>
<tr>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>None</td>
<td>Single Package</td>
<td>12.5 EER</td>
<td>13.9 IEER</td>
</tr>
<tr>
<td>≥ ≥ 240,000 Btu/h and &lt; 760,000 Btu/h</td>
<td>None</td>
<td>Single Package</td>
<td>12.4 EER</td>
<td>13.6 IEER</td>
</tr>
<tr>
<td>≥ ≥ 760,000 Btu/h</td>
<td>None</td>
<td>Single Package</td>
<td>12.2 EER</td>
<td>13.5 IEER</td>
</tr>
<tr>
<td>Non-Electric</td>
<td>Split System and Single Package</td>
<td>12.1 EER</td>
<td>13.9 IEER</td>
<td></td>
</tr>
<tr>
<td>Non-Electric</td>
<td>Split System and Single Package</td>
<td>12.5 EER</td>
<td>13.9 IEER</td>
<td></td>
</tr>
<tr>
<td>Non-Electric</td>
<td>Split System and Single Package</td>
<td>12.4 EER</td>
<td>13.6 IEER</td>
<td></td>
</tr>
<tr>
<td>Non-Electric</td>
<td>Split System and Single Package</td>
<td>12.2 EER</td>
<td>13.5 IEER</td>
<td></td>
</tr>
<tr>
<td>Non-Electric</td>
<td>Split System and Single Package</td>
<td>12.0 EER</td>
<td>13.3 IEER</td>
<td></td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>SECTION TYPE</th>
<th>RATING CONDITION</th>
<th>EFFICIENCY</th>
<th>PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 65,000 Btu/hb</td>
<td>All</td>
<td>12.1 EER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.3 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single Package</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>42.3 IEER</td>
</tr>
<tr>
<td>65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>None</td>
<td>12.1 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.3 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single Package</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>42.3 IEER</td>
</tr>
<tr>
<td>135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>None</td>
<td>12.0 EER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.2 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single Package</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>42.2 IEER</td>
</tr>
<tr>
<td>240,000 Btu/h and &lt; 760,000 Btu/h</td>
<td>None</td>
<td>11.9 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.1 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single Package</td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td>42.1 IEER</td>
</tr>
<tr>
<td>≥ 760,000 Btu/h</td>
<td>None</td>
<td>11.7 EER</td>
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<td>11.9 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single Package</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>41.9 IEER</td>
</tr>
<tr>
<td>Condensing units, air cooled</td>
<td>≥ 135,000 Btu/h</td>
<td>10.5 EER</td>
<td>AHRI 365</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.8 IEER</td>
<td></td>
</tr>
<tr>
<td>Condensing units, water cooled</td>
<td>≥ 135,000 Btu/h</td>
<td>13.5 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.0 IEER</td>
<td></td>
</tr>
<tr>
<td>Condensing units, evaporatively cooled</td>
<td>≥ 135,000 Btu/h</td>
<td>13.5 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.0 IEER</td>
<td></td>
</tr>
</tbody>
</table>

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 C403.4-2.3. Use “None” Heating Section Type category for exceptions to Section C403.4-2.3.
### Table C403.3.2.3(2)
**Minimum Efficiency Requirements:**
**Electrically Operated Unitary and Applied Heat Pumps**

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Size Category</th>
<th>Heating Section Type</th>
<th>Subcategory or Rating Condition</th>
<th>Minimum Efficiency Before 1/1/2016</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled (cooling mode)</td>
<td>&lt; 65,000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>13.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14.0 SEER</td>
<td></td>
</tr>
<tr>
<td>Through-the-wall, air cooled</td>
<td>≤&lt;30,000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>12.0 SEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.0 SEER</td>
<td></td>
</tr>
<tr>
<td>Single-duct high-velocity</td>
<td>&lt; 65,000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>11.0 SEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td>air cooled</td>
<td></td>
<td></td>
<td></td>
<td>11.0 SEER</td>
<td></td>
</tr>
<tr>
<td>Air cooled (cooling mode)</td>
<td>≥≥65,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>11.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥≥135,000 Btu/h</td>
<td>None</td>
<td>Split System and Single Package</td>
<td>10.6 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10.6 EER</td>
<td></td>
</tr>
<tr>
<td>Water to Air: Water Loop</td>
<td>&lt; 17,000 Btu/h</td>
<td>All</td>
<td></td>
<td>12.2 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>86°F entering water</td>
<td>12.2 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 17,000 Btu/h</td>
<td>All</td>
<td></td>
<td>13.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 65,000 Btu/h</td>
<td></td>
<td>86°F entering water</td>
<td>13.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>All</td>
<td></td>
<td>13.0 EER</td>
<td></td>
</tr>
<tr>
<td>Water to Air: Ground Water</td>
<td>&lt; 135,000 Btu/h</td>
<td>All</td>
<td></td>
<td>18.0 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>59°F entering water</td>
<td>18.0 EER</td>
<td></td>
</tr>
<tr>
<td>Brine to Air: Ground Loop</td>
<td>&lt; 135,000 Btu/h</td>
<td>All</td>
<td></td>
<td>14.1 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>77°F entering water</td>
<td>14.1 EER</td>
<td></td>
</tr>
</tbody>
</table>

ISO 13256-1
<table>
<thead>
<tr>
<th>System Type</th>
<th>Input Capacity (Btu/h)</th>
<th>Application Temperature (F)</th>
<th>EER</th>
<th>EER</th>
<th>Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water to Water: Water Loop (cooling mode)</td>
<td>&lt; 135,000</td>
<td>All</td>
<td>86°F</td>
<td>10.6</td>
<td>ISO 13256-2</td>
</tr>
<tr>
<td>Water to Water: Ground Water (cooling mode)</td>
<td>&lt; 135,000</td>
<td>All</td>
<td>59°F</td>
<td>16.3</td>
<td>ISO 13256-2</td>
</tr>
<tr>
<td>Brine to Water: Ground Loop (cooling mode)</td>
<td>&lt; 135,000</td>
<td>All</td>
<td>77°F</td>
<td>12.1</td>
<td>ISO 13256-2</td>
</tr>
</tbody>
</table>

(continued)
## TABLE C403.3.2.3(2)—continued
### MINIMUM EFFICIENCY REQUIREMENTS:
**ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled (heating mode)</td>
<td>&lt; 65,000 Btu/hb</td>
<td>—</td>
<td>7.7 HSPF&lt;sup&gt;6&lt;/sup&gt;</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Through-the-wall, (air cooled, heating mode)</td>
<td>&lt;= 30,000 Btu/hb (cooling capacity)</td>
<td>—</td>
<td>7.4 HSPF</td>
<td>7.4 HSPF&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Small-duct high velocity (air cooled, heating mode)</td>
<td>&lt; 65,000 Btu/hb</td>
<td>—</td>
<td>6.8 HSPF</td>
<td>6.8 HSPF</td>
</tr>
<tr>
<td>Air cooled (heating mode)</td>
<td>&gt;= 65,000 Btu/h and &lt; 135,000 Btu/h (cooling capacity)</td>
<td>—</td>
<td>3.3 COP</td>
<td>3.3 COP&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>&gt;= 135,000 Btu/h (cooling capacity)</td>
<td>—</td>
<td>3.2 COP</td>
<td>3.2 COP</td>
</tr>
<tr>
<td></td>
<td>&lt;= 47ºF db/43ºF wb outdoor air</td>
<td>3.2 COP</td>
<td>3.2 COP</td>
<td></td>
</tr>
<tr>
<td>Water to Air: Water Loop (heating mode)</td>
<td>&lt; 135,000 Btu/h (cooling capacity)</td>
<td>—</td>
<td>68ºF entering water</td>
<td>4.3 COP</td>
</tr>
<tr>
<td>Water to Air: Ground Water (heating mode)</td>
<td>&lt; 135,000 Btu/h (cooling capacity)</td>
<td>—</td>
<td>50ºF entering water</td>
<td>3.7 COP</td>
</tr>
<tr>
<td>Brine to Air: Ground Loop (heating mode)</td>
<td>&lt; 135,000 Btu/h (cooling capacity)</td>
<td>—</td>
<td>32ºF entering fluid</td>
<td>3.2 COP</td>
</tr>
<tr>
<td>Water to Water: Water Loop (heating mode)</td>
<td>&lt; 135,000 Btu/h (cooling capacity)</td>
<td>—</td>
<td>68ºF entering water</td>
<td>3.7 COP</td>
</tr>
<tr>
<td>Water to Water: Ground Water (heating mode)</td>
<td>&lt; 135,000 Btu/h (cooling capacity)</td>
<td>—</td>
<td>50ºF entering water</td>
<td>3.1 COP</td>
</tr>
<tr>
<td>Brine to Water: Ground Loop (heating mode)</td>
<td>&lt; 135,000 Btu/h (cooling capacity)</td>
<td>—</td>
<td>32ºF entering fluid</td>
<td>2.5 COP</td>
</tr>
</tbody>
</table>

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

<sup>a</sup>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 and HSPF values are those set by NAECA.

c. Electric resistance space heating is prohibited per Section C403.4-2.3. Use “None” Heating Section Type category for exceptions to Section C403.4-2.3.
TABLE C403.3.2(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

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY (INPUT)</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDUREa</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTAC (cooling mode)</td>
<td>new construction</td>
<td>All Capacities</td>
<td>95°F db outdoor air</td>
<td>14.0 – (0.300 × Cap/1000) EER</td>
</tr>
<tr>
<td>PTAC (cooling mode)</td>
<td>replacementsb</td>
<td>All Capacities</td>
<td>95°F db outdoor air</td>
<td>10.9 – (0.213 × Cap/1000) EER</td>
</tr>
<tr>
<td>PTHP (cooling mode)</td>
<td>new construction</td>
<td>All Capacities</td>
<td>95°F db outdoor air</td>
<td>14.0 – (0.300 × Cap/1000) EER</td>
</tr>
<tr>
<td>PTHP (cooling mode)</td>
<td>replacementsb</td>
<td>All Capacities</td>
<td>95°F db outdoor air</td>
<td>10.8 – (0.213 × Cap/1000) EER</td>
</tr>
<tr>
<td>PTHP (heating mode)</td>
<td>new construction</td>
<td>All Capacities</td>
<td>—</td>
<td>3.2 – (0.026 × Cap/1000) COP</td>
</tr>
<tr>
<td>PTHP (heating mode)</td>
<td>replacementsb</td>
<td>All Capacities</td>
<td>—</td>
<td>2.9 – (0.026 × Cap/1000) COP</td>
</tr>
<tr>
<td>SPVAC (cooling mode)</td>
<td>&lt; 65,000 Btu/h</td>
<td>95°F db/ 75°F wb outdoor air</td>
<td>9.0 EER</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>95°F db/ 75°F wb outdoor air</td>
<td>8.9 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>95°F db/ 75°F wb outdoor air</td>
<td>8.6 EER</td>
<td></td>
</tr>
<tr>
<td>SPVHP (cooling mode)</td>
<td>&lt; 65,000 Btu/h</td>
<td>95°F db/ 75°F wb outdoor air</td>
<td>9.0 EER</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>95°F db/ 75°F wb outdoor air</td>
<td>8.9 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>95°F db/ 75°F wb outdoor air</td>
<td>8.6 EER</td>
<td></td>
</tr>
<tr>
<td>SPVHP (heating mode)</td>
<td>&lt; 65,000 Btu/h</td>
<td>47°F db/ 43°F wb outdoor air</td>
<td>3.0 COP</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>47°F db/ 43°F wb outdoor air</td>
<td>3.0 COP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>47°F db/ 75°F wb outdoor air</td>
<td>2.9 COP</td>
<td></td>
</tr>
<tr>
<td>Room air conditioners,</td>
<td>&lt; 6,000 Btu/h</td>
<td>—</td>
<td>9.7 SEER11.0 CEER</td>
<td>ANSI/ AHAM RAC-1</td>
</tr>
<tr>
<td>with louvered sides</td>
<td>≥ 6,000 Btu/h and &lt; 8,000 Btu/h</td>
<td>—</td>
<td>9.7 SEER11.0 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 8,000 Btu/h and &lt; 14,000 Btu/h</td>
<td>—</td>
<td>10.9 SEER11.0 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 14,000 Btu/h and &lt; 20,000 Btu/h</td>
<td>—</td>
<td>9.10 SEER11.0 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 20,000 Btu/h and &lt; 25,000 Btu/h</td>
<td>—</td>
<td>8.5 SEER9.4 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 25,000 Btu/h</td>
<td>—</td>
<td>9.0 CEER</td>
<td></td>
</tr>
<tr>
<td>Room air conditioners,</td>
<td>&lt; 85,000 Btu/h</td>
<td>—</td>
<td>9.10 CEER</td>
<td>2019 VERMONT COMMERCIAL BUILDING ENERGY STANDARDS</td>
</tr>
<tr>
<td>with without louvered sides</td>
<td>≥ 6,000 Btu/h and &lt; 8,000 Btu/h and &lt; 20,000 Btu/h</td>
<td>—</td>
<td>8.5 SEER11.0 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 8,000 Btu/h and &lt; 11,000 Btu/h</td>
<td>—</td>
<td>9.6 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 11,000 Btu/h and &lt; 14,000 Btu/h</td>
<td>—</td>
<td>9.5 CEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 14,000 Btu/h and</td>
<td>—</td>
<td>9.3 CEER</td>
<td></td>
</tr>
<tr>
<td>EQUIPMENT TYPE</td>
<td>SIZE CATEGORY (INPUT)</td>
<td>SUBCATEGORY OR RATING CONDITION</td>
<td>MINIMUM EFFICIENCY</td>
<td>TEST PROCEDURE a</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------</td>
<td>--------------------------------</td>
<td>---------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Room air conditioner casement only</td>
<td>All capacities</td>
<td></td>
<td>8.7 EER9.5 CEER</td>
<td>ANSI/AHAM RAC-1</td>
</tr>
<tr>
<td>Room air conditioner casement-slider</td>
<td>All capacities</td>
<td></td>
<td>9.5 EER10.4 CEER</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) - 32]/1.8, wb = wet bulb, db = wet-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.
### Table 403.3.2.3(4)
Warm-Air Furnaces and Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces and Unit Heaters, Minimum Efficiency Requirements

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Size Category (Input)</th>
<th>Subcategory or Rating Condition</th>
<th>Minimum Efficiency d, e</th>
<th>Test Procedure a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm-air furnaces, gas fired</td>
<td>&lt; 225,000 Btu/h</td>
<td>—</td>
<td>7880% AFUE or 80% Et &lt;</td>
<td>DOE 10 CFR Part 430 or ANSI Z21.47</td>
</tr>
<tr>
<td></td>
<td>≥ 225,000 Btu/h</td>
<td>Maximum capacity c</td>
<td>80% Et f</td>
<td>ANSI Z21.47</td>
</tr>
<tr>
<td>Warm-air furnaces, oil fired</td>
<td>&lt; 225,000 Btu/h</td>
<td>—</td>
<td>7883% AFUE or 80% Et &lt;</td>
<td>DOE 10 CFR Part 430 or UL 727</td>
</tr>
<tr>
<td></td>
<td>≥ ≥ 225,000 Btu/h</td>
<td>Maximum capacity c</td>
<td>81% Et g</td>
<td>UL 727</td>
</tr>
<tr>
<td>Warm-air duct furnaces, gas fired</td>
<td>All capacities</td>
<td>Maximum capacity b</td>
<td>80% Et c</td>
<td>ANSI Z83.8</td>
</tr>
<tr>
<td>Warm-air unit heaters, gas fired</td>
<td>All capacities</td>
<td>Maximum capacity b</td>
<td>80% Ec</td>
<td>ANSI Z83.8</td>
</tr>
<tr>
<td>Warm-air unit heaters, oil fired</td>
<td>All capacities</td>
<td>Maximum capacity b</td>
<td>80% Ec</td>
<td>UL 731</td>
</tr>
</tbody>
</table>

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. Et = Thermal efficiency. See test procedure for detailed discussion.
e. Ec = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.
f. Ec = Combustion efficiency. Units shall also include an IBD, 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. Et = Thermal efficiency. Units shall also include an IBD, 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.
## TABLE C403.3.2.3(5)

**MINIMUM EFFICIENCY REQUIREMENTS: GAS- AND OIL-FIRED BOILERS**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE&lt;sup&gt;a&lt;/sup&gt;</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>SIZE CATEGORY (INPUT)</th>
<th>MINIMUM EFFICIENCY&lt;sup&gt;d, e&lt;/sup&gt;</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boilers, hot water</td>
<td>Gas-fired</td>
<td>&lt; 300,000 Btu/h&lt;sup&gt;f, g&lt;/sup&gt;</td>
<td>8082% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h</td>
<td>80% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 2,500,000 Btu/h</td>
<td>82% Ec</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td>Oil-fired&lt;sup&gt;c&lt;/sup&gt;</td>
<td>&lt; 300,000 Btu/h&lt;sup&gt;g&lt;/sup&gt;</td>
<td>8084% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h</td>
<td>82% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 2,500,000 Btu/hh</td>
<td>84% Ec</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td>Boilers, steam</td>
<td>Gas-fired</td>
<td>&lt; 300,000 Btu/h&lt;sup&gt;f&lt;/sup&gt;</td>
<td>7580% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h</td>
<td>79% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 2,500,000 Btu/h</td>
<td>79% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td>Gas-fired-natural draft</td>
<td>≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h</td>
<td>77% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 2,500,000 Btu/h</td>
<td>77% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td>Oil-fired&lt;sup&gt;c&lt;/sup&gt;</td>
<td>&lt; 300,000 Btu/h</td>
<td>8082% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h</td>
<td>81% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 2,500,000 Btu/h</td>
<td>81% Et</td>
<td>10 CFR Part 431</td>
</tr>
</tbody>
</table>

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.
### TABLE C403.3.2.3(7)
**WATER CHILLING PACKAGES—(6)**
**MINIMUM EFFICIENCY REQUIREMENTS**
**REQUIREMENTS: CONDENSING UNITS, ELECTRICALLY OPERATED**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>UNITS</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-Condensing units, air cooled-chillers</td>
<td>&lt; 150 Tons</td>
<td>EER (≥ 135,000 Btu/h)</td>
<td>≥ 10.100 FL</td>
<td>≥ 9.700 FL</td>
</tr>
<tr>
<td></td>
<td>≥ 150 Tons</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air-Condensing units, water or evaporatively cooled without condenser, electrically operated</td>
<td>All capacities</td>
<td>13.1 EER (Btu/h)13.1 IPLV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water-cooled, electrically operated positive displacement</td>
<td>≤ 75 Tons</td>
<td>kW/ton</td>
<td>≤ 0.750 FL</td>
<td>≤ 0.780 FL</td>
</tr>
<tr>
<td></td>
<td>≥ 75 tons and &lt; 150 tons</td>
<td></td>
<td>≤ 0.800 FL</td>
<td>≤ 0.500 IPLV</td>
</tr>
<tr>
<td></td>
<td>≥ 150 tons and &lt; 300 tons</td>
<td>kW/ton</td>
<td>≤ 0.660 FL</td>
<td>≤ 0.680 FL</td>
</tr>
<tr>
<td></td>
<td>≥ 300 tons and &lt; 600 tons</td>
<td></td>
<td>≤ 0.610 FL</td>
<td>≤ 0.625 FL</td>
</tr>
<tr>
<td></td>
<td>≥ 600 tons</td>
<td>kW/ton</td>
<td>≤ 0.560 FL</td>
<td>≤ 0.585 FL</td>
</tr>
</tbody>
</table>

*Note: AHRI 550/590365 for all capacities.*
<table>
<thead>
<tr>
<th>Water-cooled, electrically operated centrifugal</th>
<th>≤ 150-Tons</th>
<th>≤ 0.550-FL ≤ 0.440-IPLV</th>
<th>≤ 0.550-IPLV</th>
<th>≤ 0.440-IPLV</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 150-tons and ≤ 300-tonst</td>
<td>≥ 0.610-FL ≥ 0.635-FL</td>
<td>≤ 0.550-IPLV</td>
<td>≤ 0.400-IPLV</td>
<td></td>
</tr>
<tr>
<td>≥ 300-tons and ≤ 400-tonst</td>
<td>≤ 0.560-FL ≤ 0.595-FL</td>
<td>≤ 0.520-IPLV</td>
<td>≤ 0.390-IPLV</td>
<td></td>
</tr>
<tr>
<td>≥ 400-tons and ≤ 600-tonst</td>
<td>≤ 0.560-FL ≤ 0.585-FL</td>
<td>≤ 0.500-IPLV</td>
<td>≤ 0.380-IPLV</td>
<td></td>
</tr>
<tr>
<td>≥ 600-Tons</td>
<td>≤ 0.560-FL ≤ 0.585-FL</td>
<td>≤ 0.500-IPLV</td>
<td>≤ 0.380-IPLV</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Air-cooled, absorption, single effect</th>
<th>All capacities</th>
<th>COP ≥ 0.600-FL</th>
<th>NA&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-cooled absorption, single effect</td>
<td>All capacities</td>
<td>COP ≥ 0.700-FL</td>
<td>NA&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Absorption, double effect, indirect fired</td>
<td>All capacities</td>
<td>COP ≥ 1.000-FL</td>
<td>NA&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>UNITS</th>
<th>PATH A</th>
<th>PATH B</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-cooled chillers</td>
<td>&lt; 150 Tons</td>
<td>EER (Btu/W)</td>
<td>≥ 10.100 FL</td>
<td>≥ 9.700 FL</td>
<td>AHRI 550/590</td>
</tr>
<tr>
<td></td>
<td>≥ 150 Tons</td>
<td></td>
<td>≥ 13.700 IPLV</td>
<td>≥ 15.800 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥ 10.100 FL</td>
<td>≥ 9.700 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥ 14.000 IPLV</td>
<td>≥ 16.100 IPLV</td>
<td></td>
</tr>
<tr>
<td>Air cooled without condenser, electrically operated</td>
<td>All capacities</td>
<td>EER (Btu/W)</td>
<td>Air-cooled chillers without condenser shall be rated with matching condensers and complying with air-cooled chiller efficiency requirements.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water cooled, electrically operated, positive displacement</td>
<td>&lt; 75 Tons</td>
<td>kW/ton</td>
<td>≤ 0.750 FL</td>
<td>≤ 0.780 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 75 tons and &lt; 150 tons</td>
<td>kW/ton</td>
<td>≤ 0.720 FL</td>
<td>≤ 0.750 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 150 tons and &lt; 300 tons</td>
<td>kW/ton</td>
<td>≤ 0.560 IPLV</td>
<td>≤ 0.490 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 300 tons and &lt; 600 tons</td>
<td>kW/ton</td>
<td>≤ 0.660 FL</td>
<td>≤ 0.680 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 600 tons</td>
<td>kW/ton</td>
<td>≤ 0.540 IPLV</td>
<td>≤ 0.440 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>kW/ton</td>
<td>≤ 0.610 FL</td>
<td>≤ 0.625 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>kW/ton</td>
<td>≤ 0.520 IPLV</td>
<td>≤ 0.410 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>kW/ton</td>
<td>≤ 0.560 FL</td>
<td>≤ 0.585 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>kW/ton</td>
<td>≤ 0.500 IPLV</td>
<td>≤ 0.380 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>kW/ton</td>
<td>≤ 0.560 FL</td>
<td>≤ 0.390 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 400 tons and &lt;</td>
<td>kW/ton</td>
<td>≤ 0.560 FL</td>
<td>≤ 0.585</td>
<td></td>
</tr>
<tr>
<td>Water cooled, electrically operated, centrifugal</td>
<td>&lt; 150 Tons</td>
<td>kW/ton</td>
<td>≤ 0.610 FL</td>
<td>≤ 0.695 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 150 tons and &lt; 300 tons</td>
<td>kW/ton</td>
<td>≤ 0.610 FL</td>
<td>≤ 0.635 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 300 tons and &lt; 400 tons</td>
<td>kW/ton</td>
<td>≤ 0.550 IPLV</td>
<td>≤ 0.440 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 400 tons and &lt;</td>
<td>kW/ton</td>
<td>≤ 0.560 FL</td>
<td>≤ 0.585</td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td>FL Performance Requirements</td>
<td>IPLV Performance Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------------------</td>
<td>-------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 600 tons</td>
<td>FL ≤ 0.500 IPLV</td>
<td>≤ 0.380</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 600 Tons</td>
<td>FL ≤ 0.560 FL</td>
<td>≤ 0.585</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FL ≤ 0.500 IPLV</td>
<td>≤ 0.380</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chiller Type</th>
<th>COP Requirements</th>
<th>FL Performance Requirements</th>
<th>IPLV Performance Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled, absorption, single effect</td>
<td>≥ 0.600 FL</td>
<td>NA&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Water cooled absorption, single effect</td>
<td>≥ 0.700 FL</td>
<td>NA&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Absorption, double effect, indirect fired</td>
<td>≥ 1.000 FL</td>
<td>≥ 1.050 IPLV</td>
<td>NA&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Absorption double effect direct fired</td>
<td>≥ 1.000 FL</td>
<td>≥ ≥ 1.050 IPLV</td>
<td>NAc</td>
</tr>
</tbody>
</table>

a. The requirements for centrifugal chiller shall be adjusted for nonstandard rating conditions in accordance with Section C403.3.2.3.1 and are only applicable for the range of conditions listed in Section C403.3.2.3.1. 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 C403.3.2.3(8)
#### MINIMUM EFFICIENCY REQUIREMENTS:
#### HEAT REJECTION EQUIPMENT

<table>
<thead>
<tr>
<th>EQUIPMENT TYPEa</th>
<th>TOTAL SYSTEM HEAT REJECTION CAPACITY AT RATED CONDITIONS</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>PERFORMANCE REQUIREDb, c, d, g, h</th>
<th>TEST PROCEDUREe, f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propeller or axial fan</td>
<td>open-circuit cooling towers</td>
<td>All</td>
<td>95°F entering water 85°F leaving water 75°F entering wb</td>
<td>≥ 40.2 gpm/hp</td>
</tr>
<tr>
<td>Centrifugal fan</td>
<td>open-circuit cooling towers</td>
<td>All</td>
<td>95°F entering water 85°F leaving water 75°F entering wb</td>
<td>≥ 20.0 gpm/hp</td>
</tr>
<tr>
<td>Propeller or axial fan</td>
<td>closed-circuit cooling towers</td>
<td>All</td>
<td>102°F entering water 90°F leaving water 75°F entering wb</td>
<td>≥ 14.0 gpm/hp</td>
</tr>
<tr>
<td>Centrifugal fan</td>
<td>closed-circuit cooling towers</td>
<td>All</td>
<td>102°F entering water 90°F leaving water 75°F entering wb</td>
<td>≥ 7.0 gpm/hp</td>
</tr>
<tr>
<td>Propeller or axial fan</td>
<td>evaporative condensers</td>
<td>All</td>
<td>Ammonia Test Fluid 96.3°F condensing temperature 75°F entering wb</td>
<td>≥ 134,000 Btu/h·hp</td>
</tr>
<tr>
<td>Centrifugal fan</td>
<td>evaporative condensers</td>
<td>All</td>
<td>Ammonia Test Fluid 96.3°F condensing temperature 75°F entering wb</td>
<td>≥ 110,000 Btu/h·hp</td>
</tr>
<tr>
<td>Propeller or axial fan</td>
<td>evaporative condensers</td>
<td>All</td>
<td>R-507A Test Fluid 105°F condensing temperature 75°F entering wb</td>
<td>≥ 157,000 Btu/h·hp</td>
</tr>
<tr>
<td>Centrifugal fan</td>
<td>evaporative condensers</td>
<td>All</td>
<td>R-507A Test Fluid 105°F condensing temperature 75°F entering wb</td>
<td>≥ 135,000 Btu/h·hp</td>
</tr>
<tr>
<td>Air-cooled condensers</td>
<td>All</td>
<td></td>
<td>125°F Condensing Temperature 190°F Entering Gas Temperature 15°F subcooling 95°F entering db</td>
<td>≥ 176,000 Btu/h·hp</td>
</tr>
</tbody>
</table>
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 listed in Table 403.2.3(8), 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 listed in Table 403.2.3(8), 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 and/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.
### TABLE C403.2.3(9)  
**MINIMUM EFFICIENCY AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>NET SENSIBLE COOLING CAPACITY (^{b})</th>
<th>MINIMUM SCOP-127 (^{c}) 127 (^{b}) EFFICIENCY DOWNFLOW UNITS / UPFLOW UNITS</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, air cooled</td>
<td>(\leq 65,000 \text{ Btu/h})</td>
<td>2.20 / 2.09</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, air cooled</td>
<td>(\geq 65,000 \text{ Btu/h and &lt; 240,000 Btu/h})</td>
<td>2.10 / 1.99</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, air cooled</td>
<td>(\geq 240,000 \text{ Btu/h})</td>
<td>1.90 / 1.79</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>NET SENSIBLE COOLING CAPACITY (^{b})</th>
<th>MINIMUM SCOP-127 (^{c}) 127 (^{b}) EFFICIENCY DOWNFLOW UNITS / UPFLOW UNITS</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, water cooled</td>
<td>(\leq 65,000 \text{ Btu/h})</td>
<td>2.60 / 2.49</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, water cooled</td>
<td>(\geq 65,000 \text{ Btu/h and &lt; 240,000 Btu/h})</td>
<td>2.50 / 2.39</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, water cooled</td>
<td>(\geq 240,000 \text{ Btu/h})</td>
<td>2.40 / 2.29</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>NET SENSIBLE COOLING CAPACITY (^{b})</th>
<th>MINIMUM SCOP-127 (^{c}) 127 (^{b}) EFFICIENCY DOWNFLOW UNITS / UPFLOW UNITS</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, water cooled with fluid economizer</td>
<td>(\leq 65,000 \text{ Btu/h})</td>
<td>2.55 / 2.44</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, water cooled with fluid economizer</td>
<td>(\geq 65,000 \text{ Btu/h and &lt; 240,000 Btu/h})</td>
<td>2.45 / 2.34</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, water cooled with fluid economizer</td>
<td>(\geq 240,000 \text{ Btu/h})</td>
<td>2.35 / 2.24</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>NET SENSIBLE COOLING CAPACITY (^{b})</th>
<th>MINIMUM SCOP-127 (^{c}) 127 (^{b}) EFFICIENCY DOWNFLOW UNITS / UPFLOW UNITS</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, glycol cooled (rated at 40% propylene glycol)</td>
<td>(\leq 65,000 \text{ Btu/h})</td>
<td>2.50 / 2.39</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, glycol cooled (rated at 40% propylene glycol)</td>
<td>(\geq 65,000 \text{ Btu/h and &lt; 240,000 Btu/h})</td>
<td>2.15 / 2.04</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, glycol cooled (rated at 40% propylene glycol)</td>
<td>(\geq 240,000 \text{ Btu/h})</td>
<td>2.10 / 1.99</td>
<td></td>
</tr>
</tbody>
</table>

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

\(a\) Air conditioners primarily serving computer rooms and covered by ASHRAE Standard 127 shall meet the requirements in Table C403.2.3(9). All other air conditioners shall meet the requirements of Table C403.2.3(1).

\(b\) 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).

\(c\) 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 reheat 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 C403.2.3(10)  
**MINIMUM EFFICIENCY ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR CONDITIONERS**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF air conditioners, air cooled</td>
<td>(\leq 65,000 \text{ Btu/h})</td>
<td>All</td>
<td>VRF multisplit system</td>
<td>13.0 SEER</td>
<td></td>
</tr>
<tr>
<td>VRF air conditioners, air cooled</td>
<td>(\geq 65,000 \text{ Btu/h and &lt; 135,000 Btu/h})</td>
<td>None</td>
<td>VRF multisplit system</td>
<td>11.2 EER</td>
<td></td>
</tr>
<tr>
<td>VRF air conditioners, air cooled</td>
<td>(\geq 135,000 \text{ Btu/h and &lt; 240,000 Btu/h})</td>
<td>None</td>
<td>VRF multisplit system</td>
<td>11.0 EER</td>
<td></td>
</tr>
<tr>
<td>VRF air conditioners, air cooled</td>
<td>(\geq 240,000 \text{ Btu/h})</td>
<td>None</td>
<td>VRF multisplit system</td>
<td>10.0 EER</td>
<td></td>
</tr>
</tbody>
</table>

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

\(a\) Air conditioners primarily serving computer rooms and covered by ASHRAE Standard 127 shall meet the requirements in Table C403.2.3(9). All other air conditioners shall meet the requirements of Table C403.2.3(1).

\(b\) 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).

\(c\) 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 reheat 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.
### Electrically Operated Variable-Refrigerant-Flow Air-to-Air and Applied Heat Pumps

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Size Category</th>
<th>Heating Section Type</th>
<th>Subcategory or Rating Condition</th>
<th>Minimum Efficiency</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VRF air cooled (cooling mode)</strong></td>
<td>&lt; 65,000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system</td>
<td>13.0 SEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>None</td>
<td>VRF multisplit system</td>
<td>11.0 EER</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>None</td>
<td>VRF multisplit system with heat recovery</td>
<td>10.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>None</td>
<td>VRF multisplit system with heat recovery</td>
<td>10.4 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>None</td>
<td>VRF multisplit system with heat recovery</td>
<td>9.5 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>None</td>
<td>VRF multisplit system with heat recovery</td>
<td>9.3 EER</td>
<td></td>
</tr>
<tr>
<td><strong>VRF water source (cooling mode)</strong></td>
<td>&lt; 65,000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system 86°F entering water</td>
<td>12.0 EER</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>&lt; 65,000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system with heat recovery 86°F entering water</td>
<td>11.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system 86°F entering water</td>
<td>12.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system with heat recovery 86°F entering water</td>
<td>11.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system 86°F entering water</td>
<td>10.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system with heat recovery 86°F entering water</td>
<td>9.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system 86°F entering water</td>
<td>10.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system with heat recovery 86°F entering water</td>
<td>9.8 EER</td>
<td></td>
</tr>
<tr>
<td><strong>VRF groundwater</strong></td>
<td>&lt; 135,000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system 59°F entering water</td>
<td>16.2 EER</td>
<td>AHRI 1230</td>
</tr>
</tbody>
</table>
### TABLE C403.2.3(11)—continued
**MINIMUM EFFICIENCY ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR-TO-AIR AND APPLIED HEAT PUMPS**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF ground source (cooling mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system with heat recovery 77°F entering water</td>
<td>13.4 EER</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system with heat recovery 77°F entering water</td>
<td>13.2 EER</td>
<td></td>
</tr>
<tr>
<td>VRF air cooled (heating mode)</td>
<td>&lt; 65,000 Btu/h (cooling capacity)</td>
<td>—</td>
<td>VRF multisplit system</td>
<td>7.7\textsuperscript{10.0} HSPF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>—</td>
<td>VRF multisplit system 47°F db/43°F wb outdoor air 17°F db/15°F wb outdoor air</td>
<td>3.3 COP\textsubscript{H} 2.25 COP\textsubscript{H}</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h (cooling capacity)</td>
<td>—</td>
<td>VRF multisplit system 47°F db/43°F wb outdoor air 17°F db/15°F wb outdoor air</td>
<td>3.2 COP\textsubscript{H} 2.005 COP\textsubscript{H}</td>
<td></td>
</tr>
<tr>
<td>VRF air-cooledwater source (heating mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>—</td>
<td>VRF multisplit system 68°F entering water</td>
<td>4.23 COP\textsubscript{H}</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h</td>
<td>—</td>
<td>VRF multisplit system 68°F entering water</td>
<td>3.94 COP\textsubscript{H}</td>
<td></td>
</tr>
<tr>
<td>VRF groundwater source (heating mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>—</td>
<td>VRF multisplit system 50°F entering water</td>
<td>3.6 COP\textsubscript{H}</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h</td>
<td>—</td>
<td>VRF multisplit system 50°F entering water</td>
<td>3.3 COP\textsubscript{H}</td>
<td></td>
</tr>
<tr>
<td>VRF groundwater</td>
<td>&lt; 135,000 Btu/h</td>
<td>—</td>
<td>VRF multisplit system 32°F entering water</td>
<td>3.1 COP\textsubscript{H}</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td>EQUIPMENT TYPE</td>
<td>SUBCATEGORY</td>
<td>MINIMUM EFFICIENCY</td>
<td>TEST PROCEDURE&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------</td>
<td>--------------------</td>
<td>-----------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid-to-liquid heat exchangers</td>
<td>Plate type</td>
<td>NR</td>
<td>AHRI 400</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NR = No Requirement.**

<sup>a</sup> Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
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 l/s • kW) condenser water flow shall have maximum full-load kW/ton (FL) and part-load ratings requirements adjusted using Equations 4-45 and 4-56.

\[
\begin{align*}
FL_{adj} & = \frac{FL_{adj}}{K_{adj}} & \text{(Equation 4-45)} \\
PLV_{adj} & = \frac{IPLV/K_{adj}}{K_{adj}} & \text{(Equation 4-5)} \\
PLV_{adj} & = \frac{IPLV/K_{adj}}{K_{adj}} & \text{(Equation 4-6)}
\end{align*}
\]

Where:

- \( K_{adj} = A \times B \)
- \( FL_{adj} = \) Maximum full-load kW/ton rating, adjusted for nonstandard conditions.
- \( IPLV = \) Value as specified in Table C403.3.2.3(7).
- \( PLV_{adj} = \) Maximum NPLV rating, adjusted for nonstandard conditions.
- \( A = 0.0000014592 \times (LIFT)^4 - 0.000346496 \times (LIFT)^3 + 0.0314196 \times (LIFT)^2 - 0.147199 \times (LIFT) + 3.9302 \)
- \( B = 0.0015 \times LvgEvap + 0.934 \)
- \( LIFT = LvgCond - LvgEvap \)
- \( LvgCond = \) Full-load condenser leaving fluid temperature (°F).
- \( LvgEvap = \) 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.
2. Maximum condenser leaving temperature: 115°F.
3. $20^\circ \text{F} \leq \text{LIFT} \leq 80^\circ \text{F}$.
C403.3.2 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 C403.3.2.3 when tested or certified with water at standard rating conditions, in accordance with the referenced test procedure.

C403.23.3 Hot gas bypass. The use of hot gas bypass is prohibited in all systems.

C403.3.4 HVAC Boiler turndown. Boiler systems with design input of greater than 1,000,000 Btu/h (293 kW) shall comply with the turndown ratio specified in Table C403.3.4.

The system turndown requirement shall be met through the use of multiple single-input boilers, one or more modulating boilers or a combination of single-input and modulating boilers.

**TABLE C403.3.4**

<table>
<thead>
<tr>
<th>BOILER SYSTEM DESIGN INPUT (Btu/h)</th>
<th>MINIMUM TURNDOWN RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 1,000,000 and less than or equal to 5,000,000</td>
<td>3 to 1</td>
</tr>
<tr>
<td>&gt; 5,000,000 and less than or equal to 10,000,000</td>
<td>4 to 1</td>
</tr>
<tr>
<td>&gt; 10,000,000</td>
<td>5 to 1</td>
</tr>
</tbody>
</table>

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

C403.4 Heating and cooling system controls. (Mandatory).

Each heating and cooling system shall be provided with thermostatic controls as specified in Section C403.2.4.1, C403.2.4.1.3, C403.2.4.2, C403.2.4.3, C403.3.1, in accordance with Sections C403.4.1 through C403.4.5.

C403.4.1 or C403.4.4.

**C403.2.4.1** 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, at least 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 at least 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); and

2. The perimeter system heating and cooling supply is controlled by thermostats located within the zones served by the system.

C403.2.4.1.1 Heat pump supplementary heat. (Mandatory).

Heat pumps having supplementary electric resistance heat (integral to the unit) are prohibited, except for use during defrost. Heat shall be certified cold-climate heat pumps having supplementary electric...
resistance heat shall have controls that, except during defrost, prevent supplementary heat operation meeting the requirements of section C403.2.3.

C403.2.4.1.2 Deadband. (Mandatory). Where used to control both heating and cooling, zone thermostatic controls shall be capable of providing a temperature range or deadband of at least not less than 5°F (2.8°C) within which the supply of heating and cooling energy to the zone is capable of being 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 or other authority having jurisdiction.

C403.2.4.1.3 Set point 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 provided with the capability configured to prevent the heating setpoint from exceeding the cooling setpoint and to maintain a deadband in accordance with Section C403.2.4.1.2.

C403.4.1.4 Heated 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 30°F (16°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 (16°C). Cooling of the vestibule is prohibited.

Exception: C403.2.4.2 Off-hour controls. 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 readily accessible manual shutoff switch located with ready access.

C403.2.4.2.1 Thermostatic setback capabilities. (Mandatory). Thermostatic setback controls shall have the capability configured to set back or temporarily operate the system to maintain zone temperatures down to 55°F (13°C) or up to 80°F (29°C).

Exceptions:
1. Zones served exclusively by cold-climate heat pumps.

C403.2.4.2.2 Automatic setback and shutdown capabilities. (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 at least 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 capable of being adjusted/configured to operate the system for up to 2 hours; or an occupancy sensor.

C403.4.2.3 Automatic start (Mandatory).
Automatic start controls shall be provided for each HVAC system. The 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.

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 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.

**C403.2.4.3.3 Two-position valve.**

Each hydronic heat pump on the hydronic system shall have a two-position valve.

**C403.4.4 Part-load controls.**

Hydronic systems greater than or equal to 300,000 Btu/h (146.5 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 or more shall have a variable speed drive.

   3.2. Where pumps have automatic direct digital control 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 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.

Exceptions: Economizers are not required for the following systems.

1. In hospitals and ambulatory surgery centers, where more than 75% of the air designed to be supplied by the system is to spaces that are required to be humidified above 35°F (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.
TABLE C403.5

MINIMUM CHILLED-WATER SYSTEM COOLING CAPACITY FOR DETERMINING ECONOMIZER COOLING REQUIREMENTS

<table>
<thead>
<tr>
<th>TOTAL CHILLED-WATER SYSTEM CAPACITY LESS CAPACITY OF COOLING UNITS WITH AIR ECONOMIZERS</th>
<th>Local Water-cooled Chilled-water Systems</th>
<th>Air-cooled Chilled-water Systems or District Chilled-Water Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,320,000 Btu/h</td>
<td>1,720,000 Btu/h</td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>RATING CAPACITY</th>
<th>MINIMUM NUMBER OF MECHANICAL COOLING STAGES</th>
<th>MINIMUM COMPRESSOR DISPLACEMENT a</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 75,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>3 stages</td>
<td>≤ 35% of full load</td>
</tr>
<tr>
<td>≥ 240,000 Btu/h</td>
<td>4 stages</td>
<td>≤ 25% full load</td>
</tr>
</tbody>
</table>

   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>
<thead>
<tr>
<th>DEVICE TYPE</th>
<th>REQUIRED HIGH LIMIT (ECONOMIZER OFF WHEN):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed dry bulb</td>
<td>( T_{OA} &gt; 70^\circ\text{F} ) or ( T_{OA} &gt; 75^\circ\text{F} )</td>
</tr>
<tr>
<td>Differential dry bulb</td>
<td>( T_{OA} &gt; T_{RA} ) or ( T_{OA} &gt; 75^\circ\text{F} )</td>
</tr>
<tr>
<td>Fixed enthalpy with</td>
<td>( h_{OA} &gt; 28 \text{ Btu/lb} ) or ( h_{OA} &gt; 30.7 \text{ Btu/lb} ) or</td>
</tr>
<tr>
<td>fixed dry-bulb temperatures</td>
<td>( T_{OA} &gt; 75^\circ\text{F} ) or ( T_{OA} &gt; 75^\circ\text{F} )</td>
</tr>
<tr>
<td>Differential enthalpy with</td>
<td>( h_{OA} &gt; h_{RA} ) or ( h_{OA} &gt; 28 \text{ Btu/lb} ) or ( h_{OA} &gt; 30.7 \text{ Btu/lb} )</td>
</tr>
<tr>
<td>fixed dry-bulb temperature</td>
<td>( T_{OA} &gt; 75^\circ\text{F} ) or ( T_{OA} &gt; 75^\circ\text{F} )</td>
</tr>
</tbody>
</table>

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) through C403.3.2(11) that are 15 tons (180,000 Btu/h) or greater and equipped with an economizer in accordance with Section C403.5 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 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:

5.1 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.

5.2 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.

**C403.6.5 Supply-air temperature reset controls.**
Multiple-zone HVAC systems shall include controls that 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.

**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. Zones with peak supply air quantities of 300 cfm (142 L/s) or less.

**C403.6.6 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.

**C403.6.7 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.

C403.6.8 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.

C403.6.9 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. (432.4 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 non-compliance.

C403.7 Ventilation and exhaust systems.
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 spaces larger than 500 square feet (46.5 m$^2$) and with an average occupant load of 25 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.
2. Multiple-zone systems without direct digital control of individual zones communicating with a central control panel.

3. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1,200 cfm (566 L/s).

4. 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 and automatic controls configured to stage fans or modulate fan average airflow rates as stipulated in the Vermont Fire & 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.

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 systems (Mandatory).
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 enthalpy of the outdoor air supply 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 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.

7. Systems expected to operate less than 20 hours per week at the outdoor air percentage covered by Table C403.7.4.
8. Systems exhausting toxic, flammable, paint or corrosive fumes or dust.

9. Commercial kitchen hoods used for collecting and removing grease vapors and smoke.

TABLE C403.7.4
ENERGY RECOVERY REQUIREMENT
(Air systems operating not less than 3,000 hours per year)

<table>
<thead>
<tr>
<th>PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE</th>
<th>DESIGN SUPPLY FAN AIRFLOW RATE (cfm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 10% and &lt; 20%</td>
<td>&gt; 20% and &lt; 30%</td>
</tr>
<tr>
<td>≥ 10,500</td>
<td>≥ 6,500</td>
</tr>
</tbody>
</table>

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...
TABLE C403.7.5
MAXIMUM NET EXHAUST FLOW RATE, CFM PER LINEAR FOOT OF HOOD LENGTH

<table>
<thead>
<tr>
<th>TYPE OF HOOD</th>
<th>LIGHT-DUTY EQUIPMENT</th>
<th>MEDIUM-DUTY EQUIPMENT</th>
<th>HEAVY-DUTY EQUIPMENT</th>
<th>EXTRA-HEAVY-DUTY EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall-mounted canopy</td>
<td>140</td>
<td>210</td>
<td>280</td>
<td>385</td>
</tr>
<tr>
<td>Single island</td>
<td>280</td>
<td>350</td>
<td>420</td>
<td>490</td>
</tr>
<tr>
<td>Double island (per side)</td>
<td>175</td>
<td>210</td>
<td>280</td>
<td>385</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>175</td>
<td>175</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Backshelf/Pass-over</td>
<td>210</td>
<td>210</td>
<td>280</td>
<td>NA</td>
</tr>
</tbody>
</table>

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.

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 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/ft2 (20.3 L/s · m2) 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 the International Mechanical Code/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:** Gravity (nonmotorized) Nonmotorized gravity dampers shall be permitted an alternative to be used as follows:

1. In buildings less than three stories in height above grade plane.
2. Where motorized dampers for exhaust and relief openings where the design exhaust capacity is not greater than 300 cfm (142 L/s).

Gravity (nonmotorized) Nonmotorized gravity dampers shall have an air leakage rate not greater than 20 cfm/ft2 (101.6 L/s · m²) where not less than 24 inches (610 mm) in either dimension and 40 cfm/ft2 (203.2 L/s · m²) 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**

<table>
<thead>
<tr>
<th>Option 1: Fan system motor nameplate hp</th>
<th>LIMIT</th>
<th>CONSTANT VOLUME</th>
<th>VARIABLE VOLUME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allowable nameplate motor hp</td>
<td>hp ≤ CFM × 0.0011</td>
<td>hp ≤ CFM × 0.0015</td>
<td></td>
</tr>
</tbody>
</table>

| Option 2: Fan system bhp | Allowable fan system bhp | bhp ≤ CFM × 0.00094 + A | bhp ≤ CFM × 0.0013 + A |

---

2015 Vermont Commercial Building Energy Standards

2019 Vermont Commercial Building Energy Standards
For SI: 1 bhp = 735.5 W, 1 hp = 745.5 W, 1 cfm = 0.4719 L/s.

where:

\[
\begin{align*}
\text{CFM}_s &= \text{The maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute.} \\
hp &= \text{The maximum combined motor nameplate horsepower.} \\
bhp &= \text{The maximum combined fan brake horsepower.} \\
A &= \text{Sum of } \left( \frac{PD \times \text{CFM}_D}{4131} \right).
\end{align*}
\]

where:

\[
\begin{align*}
PD &= \text{Each applicable pressure drop adjustment from Table C403.8.1(2) in w.c.} \\
\text{CFM}_D &= \text{The design airflow through each applicable device from Table C403.8.1(2) in cubic feet per minute.}
\end{align*}
\]

### TABLE C403.8.1(2)
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>ADJUSTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>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</td>
<td>0.5 inch w.c. (2.15 inches w.c. for laboratory and vivarium systems)</td>
</tr>
<tr>
<td>Return and exhaust airflow control devices</td>
<td>0.5 inch w.c.</td>
</tr>
<tr>
<td>Exhaust filters, scrubbers or other exhaust treatment</td>
<td>The pressure drop of device calculated at fan system design condition</td>
</tr>
<tr>
<td>Particulate filtration credit: MERV 9 thru 12</td>
<td>0.5 inch w.c.</td>
</tr>
<tr>
<td>Particulate filtration credit: MERV 13 thru 15</td>
<td>0.9 inch w.c.</td>
</tr>
<tr>
<td>Particulate filtration credit: MERV 16 and greater and electronically enhanced filters</td>
<td>Pressure drop calculated at 2x clean filter pressure drop at fan system design condition.</td>
</tr>
<tr>
<td>Carbon and other gas-phase air cleaners</td>
<td>Clean filter pressure drop at fan system design condition.</td>
</tr>
<tr>
<td>Biosafety cabinet</td>
<td>Pressure drop of device at fan system design condition.</td>
</tr>
<tr>
<td>Energy recovery device, other than coil runaround loop</td>
<td>For each airstream, ((2.2 \times \text{energy recovery effectiveness} - 0.5)) inch w.c.</td>
</tr>
<tr>
<td>Coil runaround loop</td>
<td>0.6 inch w.c. for each airstream.</td>
</tr>
<tr>
<td>Evaporative humidifier/cooler in series with another cooling coil</td>
<td>Pressure drop of device at fan system design conditions.</td>
</tr>
<tr>
<td>Sound attenuation section (fans serving spaces with design background noise goals below NC35)</td>
<td>0.15 inch w.c.</td>
</tr>
<tr>
<td>Exhaust system serving fume hoods</td>
<td>0.35 inch w.c.</td>
</tr>
<tr>
<td>Laboratory and vivarium exhaust systems in high-rise buildings</td>
<td>0.25 inch w.c./100 feet of vertical duct exceeding 75 feet.</td>
</tr>
</tbody>
</table>

### 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 2015 Vermont Commercial Building Energy Standards
motor shall be not larger than the first available motor size greater than the following:

1. For fans less than 6 bhp (4413 W), 1.5 times the fan brake horsepower.
2. For fans 6 bhp (4413 W) and larger, 1.3 times the fan brake horsepower.

C403.2.4.4 Zone isolation.
HVAC systems serving zones that are over 25,000 square feet (2323 m²) 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 C403.2.4.2.2. 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.

C403.2.4.5 Snow- and ice-melt system controls.
Snow- and ice-melting systems shall include automatic controls capable of shutting off the system when the pavement temperature is above 50°F (10°C) and no precipitation is falling and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F (4°C).

C403.2.4.6 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.

C403.2.4.7 Economizer fault detection and diagnostics (FDD).
Air-cooled unitary direct-expansion units listed in Tables C403.2.3(1) through C403.2.3(3) and variable-refrigerant flow (VRF) units that are 20 tons (240,000 Btu/h) or greater and equipped with an economizer in accordance with Section C403.3, shall include a fault detection and diagnostics (FDD) 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. 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).
3. Refrigerant pressure sensors, where used, shall have an accuracy of ±3 percent of full scale.

4. The unit controller shall be capable of providing 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 capable of reporting faults to a fault management application accessible by day-to-day operating or service personnel, or annunciated locally on zone thermostats.

7. The FDD system shall be capable of detecting 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.

**C403.2.5 Hot water boiler outdoor temperature setback control.**
Hot water boilers that supply heat to the building through one- or two-pipe heating systems shall have an outdoor setback control that lowers the boiler water temperature based on the outdoor temperature.

**C403.2.6 Ventilation.**
Ventilation, either natural or mechanical, shall be provided in accordance with ASHRAE Standard 62.1-2013. Where mechanical ventilation is provided, the system shall provide the capability to reduce the outdoor air supply to the minimum required by ASHRAE Standard 62.1-2013. 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.

**C403.2.6.1 Demand control ventilation.**
Demand control ventilation (DCV) shall be provided for spaces meeting the following three criteria:

1. Spaces larger than 500 square feet (46.5 m²), and
2. Spaces with a design occupancy for ventilation of ≥ 25 people per 1,000 square feet (93 m²) of floor area (as established in Table 6.1 of ASHRAE 62.1-2013), and.

3. Spaces served by systems with one or more of the following:

   i. An air-side economizer.

   ii. Automatic modulating control of the outdoor air damper.

   iii. A design outdoor airflow greater than 3,000 cfm (1416 L/s).

**Exception:** Demand control ventilation is not required for systems and spaces as follows:

1. Systems with an energy recovery complying with Section C403.2.7 motor nameplate horsepower less than 1 hp (746 W) are exempt from this section.

2. Multiple-zone systems without direct digital control of individual zones communicating with a central control panel.

3. Systems with a design outdoor airflow less than 1,200 cfm (566 L/s).

4. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1,200 cfm (566 L/s).

5. Ventilation provided for process loads only.

**C403.2.6.2 Enclosed parking garage ventilation controls.** Enclosed parking garages used for storing or handling automobiles operating under their own power.

**8.3 Fan efficiency (Mandatory).** Fans shall employ contamination-sensing devices and automatic controls configured to stage fans or modulate have a fan efficiency grade (FEG) of not less than 70, as determined in accordance with AMCA 205 by an approved, independent testing laboratory and labeled by the manufacturer. The total efficiency of the fan at the design point of operation shall be within 15 percentage points of the maximum total efficiency of the fan.

**Exception:** The following fans are not required to have a fan efficiency grade:

   - Average airflow rates to 50 percent or less of design capacity, or intermittently operate.

   1. 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. Fans that are part of equipment covered in Section C403.3.2.

   3. Fans included in an equipment package certified by an approved agency for air or energy.
4. Powered wall/roof ventilators.

5. Fans outside the scope of AMCA 205.

6. Fans that are intended to operate only during emergency conditions.

**C403.8.4 Fractional hp fan motors (Mandatory).**

Motors for fans that are not less than \( \frac{1}{12} \) hp (0.082 kW) and less than 20 percent of the occupied time 1 hp (0.746 kW) shall be electronically commutated motors or as required to maintain acceptable contaminant levels. 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 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.

**C403.8.5.1 Fan airflow control.**

Each cooling system listed in Table C403.8.5.1 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 ventilation air.

**TABLE C403.8.5.1 COOLING SYSTEMS**

<table>
<thead>
<tr>
<th>COOLING SYSTEM TYPE</th>
<th>FAN MOTOR SIZE</th>
<th>MECHANICAL COOLING CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>DX cooling</td>
<td>Any</td>
<td>≥ 24,000 Btu/h</td>
</tr>
<tr>
<td>Chilled water and evaporative cooling</td>
<td>≥ 1/4 hp</td>
<td>Any</td>
</tr>
</tbody>
</table>

For SI: 1 British thermal unit per hour = 0.2931 W; 1 hp = 0.746 kW.

-2013 provisions. Failure of contamination sensing.

**C403.9 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).

**C403.9.1 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 shall cause the exhaust fans to operate continuously 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 or 50 percent of the design airflow.

**Exceptions:**

1. Fans serving multiple refrigerant or fluid cooling circuits.

2. Condenser fans serving flooded condensers.

**Garages**

**C403.9.2 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.

C403.9.3 Limitation on centrifugal fan open-circuit cooling towers. Centrifugal fan open-circuit cooling towers with a total exhaust combined rated capacity of 550gpm (2032L/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.

C403.9.4 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.

C403.9.5 Heat recovery for service water heating. Condenser heat recovery shall be installed for heating or reheat 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 (1,758 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.

C403.10 Refrigeration equipment performance. Refrigeration equipment shall have an energy use in kWh/day not greater than the values of Tables C403.10.1(1) and C403.10.1(5) when tested and rated in accordance with AHRI Standard 1200. 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.

C403.10.1 Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers (Mandatory). 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 7 feet (2134 mm) in height.

2. Doorways shall have strip doors, curtains, spring-hinged 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.


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/ft² (76 W/m²) of door opening for *walk-in freezers* and 3.0 W/ft² (32 W/m²) 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 turn off the lights within 15 minutes when the space is not occupied.

### TABLE C403.10.1(1)
**MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATION**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>APPLICATION</th>
<th>ENERGY USE LIMITS (kWh per day)a</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerator with solid doors</td>
<td>Holding Temperature</td>
<td>0.10 × V + 2.04</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>Refrigerator with transparent doors</td>
<td></td>
<td>0.12 × V + 3.34</td>
<td></td>
</tr>
<tr>
<td>Freezers with solid doors</td>
<td></td>
<td>0.40 × V + 1.38</td>
<td></td>
</tr>
<tr>
<td>Freezers with transparent doors</td>
<td></td>
<td>0.75 × V + 4.10</td>
<td></td>
</tr>
<tr>
<td>Refrigerators/freezeers with solid doors</td>
<td></td>
<td>the greater of 0.12 × V + 3.34 or 0.70</td>
<td></td>
</tr>
</tbody>
</table>
TABLE C403.10.1(2) MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>ENERGY USE LIMITS (kWh/day)</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOP.RC.M</td>
<td>0.82 × TDA + 4.07</td>
<td></td>
</tr>
<tr>
<td>SVO.RC.M</td>
<td>0.83 × TDA + 3.18</td>
<td></td>
</tr>
<tr>
<td>HZO.RC.M</td>
<td>0.35 × TDA + 2.88</td>
<td></td>
</tr>
<tr>
<td>VOP.RC.L</td>
<td>2.27 × TDA + 6.85</td>
<td></td>
</tr>
<tr>
<td>HZO.RC.L</td>
<td>0.57 × TDA + 6.88</td>
<td></td>
</tr>
<tr>
<td>VCT.RC.M</td>
<td>0.22 × TDA + 1.95</td>
<td></td>
</tr>
<tr>
<td>VCT.RC.L</td>
<td>0.56 × TDA + 2.61</td>
<td></td>
</tr>
<tr>
<td>SOC.RC.M</td>
<td>0.51 × TDA + 0.11</td>
<td></td>
</tr>
<tr>
<td>VOP.SC.M</td>
<td>1.74 × TDA + 4.71</td>
<td></td>
</tr>
<tr>
<td>SVO.SC.M</td>
<td>1.73 × TDA + 4.59</td>
<td></td>
</tr>
<tr>
<td>HZO.SC.M</td>
<td>0.77 × TDA + 5.55</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HZO.SC.L</td>
<td>1.92 × TDA + 7.08</td>
<td></td>
</tr>
<tr>
<td>VCT.SC.I</td>
<td>0.67 × TDA + 3.29</td>
<td></td>
</tr>
<tr>
<td>VCS.SC.I</td>
<td>0.38 × TDA + 0.88</td>
<td></td>
</tr>
<tr>
<td>HCT.SC.I</td>
<td>0.56 × TDA + 0.43</td>
<td></td>
</tr>
<tr>
<td>SVO.RC.L</td>
<td>2.27 × TDA + 6.85</td>
<td></td>
</tr>
<tr>
<td>VOP.RC.I</td>
<td>2.89 × TDA + 8.7</td>
<td></td>
</tr>
<tr>
<td>SVO.RC.I</td>
<td>2.89 × TDA + 8.7</td>
<td></td>
</tr>
<tr>
<td>HZO.RC.I</td>
<td>0.72 × TDA + 8.74</td>
<td></td>
</tr>
<tr>
<td>VCT.RC.I</td>
<td>0.66 × TDA + 3.05</td>
<td></td>
</tr>
<tr>
<td>HCT.RC.M</td>
<td>0.16 × TDA + 0.13</td>
<td></td>
</tr>
</tbody>
</table>

(continued)

TABLE C403.10.1(2)—continued MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>ENERGY USE LIMITS (kWh/day)</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
</table>

a. V = volume of the chiller or frozen compartment as defined in AHAM-HRF-1.
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:

<table>
<thead>
<tr>
<th>CLASS DESCRIPTOR</th>
<th>CLASS</th>
<th>MAXIMUM ENERGY CONSUMPTION (kWh/da)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display door, medium temperature</td>
<td>DD, M</td>
<td>(0.04 \times A_{dd} + 0.41)</td>
</tr>
</tbody>
</table>

For example, “VOP.RC.M” refers to the “vertical-open, remote-condensing, medium-temperature” equipment class.
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 C403.10.1(4)

**WALK-IN COOLER AND FREEZER NONDISPLAY DOOR EFFICIENCY REQUIREMENTS**

<table>
<thead>
<tr>
<th>CLASS DESCRIPTOR</th>
<th>CLASS</th>
<th>MAXIMUM ENERGY CONSUMPTION (kWh/day)(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passage door, medium temperature</td>
<td>PD, M</td>
<td>(0.05 \times A_{nd} + 1.7)</td>
</tr>
<tr>
<td>Passage door, low temperature</td>
<td>PD, L</td>
<td>(0.14 \times A_{nd} + 4.8)</td>
</tr>
<tr>
<td>Freight door, medium temperature</td>
<td>FD, M</td>
<td>(0.04 \times A_{nd} + 1.9)</td>
</tr>
<tr>
<td>Freight door, low temperature</td>
<td>FD, L</td>
<td>(0.12 \times A_{nd} + 5.6)</td>
</tr>
</tbody>
</table>

\(a\) \(A_{nd}\) is the surface area of the nondisplay door.

### TABLE C403.10.1(5)

**WALK-IN COOLER AND FREEZER REFRIGERATION SYSTEM EFFICIENCY REQUIREMENTS**

<table>
<thead>
<tr>
<th>CLASS DESCRIPTOR</th>
<th>CLASS</th>
<th>MINIMUM ANNUAL WALK-IN ENERGY FACTOR AWEF (Btu/W-h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedicated condensing, medium temperature, indoor system</td>
<td>DC.M.I</td>
<td>5.61</td>
</tr>
<tr>
<td>Dedicated condensing, medium temperature, indoor system, &gt; 9,000 Btu/h capacity</td>
<td>DC.M.I, &gt; 9,000</td>
<td>5.61</td>
</tr>
<tr>
<td>Dedicated condensing, medium temperature, outdoor system</td>
<td>DC.M.I</td>
<td>7.60</td>
</tr>
<tr>
<td>Dedicated condensing, medium temperature, outdoor system, &gt; 9,000 Btu/h capacity</td>
<td>DC.M.I, &gt; 9,000</td>
<td>7.60</td>
</tr>
</tbody>
</table>

**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.

C403.10.3 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 C403.10.3.1 and C403.10.3.2.

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.

C403.10.3.1 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).

C403.10.3.2 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:
22,500 cfm (10,620 L/s) with ventilation.

1.1 Single-compressor 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 1.25 cfm/hp (710 L/s/kW) and do not utilize heating or mechanical cooling.

**C403.2.7 Energy recovery ventilation systems.**

Where the supply airflow rate of a fan system meets or exceeds the values specified in Table C403.2.7(1) or for ventilation systems operating not less than 8,000 hours per year, the system shall include an energy recovery system. The energy recovery system shall have the variable capacity capability to provide a change in the enthalpy of the outdoor air supply 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 which permit operation of the economizer as required by Section C403.3.

1.2 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.

**Exception:** An energy recovery ventilation system shall not be required in any of the following conditions:

1. Where energy recovery systems are prohibited by the International Mechanical Code elements.

2. Laboratory fume hood systems that include at least one of the following features:

   2.1 Variable-air-volume hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to 50 percent or less of design values.

   2.2 Direct makeup (auxiliary) air supply equal to at least 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, 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 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. Where the largest source of air exhausted at a single location at the building exterior is less than 75 percent of the design outdoor air flow rate.

7. Systems expected to operate less than 20 hours per week at the outdoor air percentage covered by Table C403.2.7(1).

8. Systems exhausting toxic, flammable, paint or corrosive fumes or dust.

9. Commercial kitchen hoods used for collecting and removing grease vapors and smoke.

**Table**

A part of an HVAC system shall be constructed and insulated in accordance with Sections C403.2.7(1)

**Energy Recovery Requirement**

(Ventilation systems operating less than 8,000 hours per year)

<table>
<thead>
<tr>
<th>Percent (%) Outdoor Air at Full Design Airflow Rate</th>
<th>Design Supply Fan Airflow Rate (cfm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 10% and &lt; 20%</td>
<td>NR</td>
</tr>
<tr>
<td>≥ 20% and &lt; 30%</td>
<td>≥ 16,000</td>
</tr>
<tr>
<td>≥ 30% and &lt; 40%</td>
<td>≥ 5,500</td>
</tr>
<tr>
<td>≥ 40% and &lt; 50%</td>
<td>≥ 4,500</td>
</tr>
<tr>
<td>≥ 50% and &lt; 60%</td>
<td>≥ 3,500</td>
</tr>
<tr>
<td>≥ 60% and &lt; 70%</td>
<td>≥ 2,000</td>
</tr>
<tr>
<td>≥ 70% and &lt; 80%</td>
<td>≥ 1,000</td>
</tr>
<tr>
<td>≥ 80% and &lt; 90%</td>
<td></td>
</tr>
<tr>
<td>≥ 90% and &lt; 100%</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 cfm = 0.4719 L/s.
NR = Not Required.

11.1 through C403.2.8 Kitchen exhaust systems. 11.3.1.
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 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 C403.2.8 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 capable of not less than a 50-percent reduction in exhaust and replacement air system airflow rates, including 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 C403.2.8
**MAXIMUM NET EXHAUST FLOW RATE, CFM PER LINEAR FOOT OF HOOD LENGTH**

<table>
<thead>
<tr>
<th>TYPE OF HOOD</th>
<th>LIGHT-DUTY EQUIPMENT</th>
<th>MEDIUM-DUTY EQUIPMENT</th>
<th>HEAVY-DUTY EQUIPMENT</th>
<th>EXTRA HEAVY-DUTY EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall-mounted canopy</td>
<td>140</td>
<td>210</td>
<td>280</td>
<td>385</td>
</tr>
<tr>
<td>Single island</td>
<td>280</td>
<td>350</td>
<td>420</td>
<td>490</td>
</tr>
<tr>
<td>Double island (per side)</td>
<td>375</td>
<td>410</td>
<td>280</td>
<td>385</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>475</td>
<td>475</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Backshelf/Pass-over</td>
<td>240</td>
<td>210</td>
<td>280</td>
<td>NA</td>
</tr>
</tbody>
</table>

For SI: 1 cfm = 0.4719 L/s; 1 foot = 305 mm. NA = Not Allowed.

C403.2.9C403.11.1 Duct and plenum insulation and sealing. (Mandatory). Supply and return air ducts and plenums shall be insulated with a minimum of not less than R-8 insulation where located in unconditioned spaces and where located outside the building with a minimum of not less than R-12 insulation. Where located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by a minimum of not less than R-12 insulation. Buried ducts shall be insulated to a minimum of R-3.5.6

**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 Section 603.9 of the International Mechanical Code.

C403.2.9.1 the ANSI/SMACNA 006 HVAC Duct Construction Standards.

C403.11.2 Duct construction. (Mandatory).
Ductwork shall be constructed and erected in accordance with the International Mechanical Code ANSI/SMACNA 006 HVAC Duct Construction.

C403.11.2.9.1 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-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 International Mechanical Code 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.

C403.11.2.9.1.2 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 C403.2.911.1. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the International Mechanical Code ANSI/SMACNA 006 HVAC Duct Construction.

C403.11.2.9.1.3 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 C403.2.811.1. 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 64.0 as determined in accordance with Equation 4-67.

\[
C = \frac{CL}{F/P0.65} \quad \text{(Equation 4-67)}
\]

where:

\[F\] = The measured leakage rate in cfm per 100 square feet of duct surface.

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 at least not less than 25 percent of the duct area have been tested and that all tested sections comply with the requirements of this section.

C403.2.10.1.3 Piping insulation. *(Mandatory).*

Piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table C403.2.1011.3.

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 405°F (213°C).

4. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power.

5. Strainers, control valves, and balancing valves associated with piping 1 inch (25 mm) or less in diameter.

6. Direct buried piping that conveys fluids at or below 60°F (15°C).

**TABLE C403.2.1011.3**

**MINIMUM PIPE INSULATION THICKNESS (in inches)**

<table>
<thead>
<tr>
<th>FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)</th>
<th>INSULATION CONDUCTIVITY</th>
<th>NOMINAL PIPE OR TUBE SIZE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conductivity Btu in./(h ft² °F)</td>
<td>Mean Rating Temperature, °F</td>
</tr>
<tr>
<td>&gt; 350</td>
<td>0.32 – 0.34</td>
<td>250</td>
</tr>
<tr>
<td>251 – 350</td>
<td>0.29 – 0.32</td>
<td>200</td>
</tr>
<tr>
<td>201 – 250</td>
<td>0.27 – 0.30</td>
<td>150</td>
</tr>
<tr>
<td>141 – 200</td>
<td>0.25 – 0.29</td>
<td>125</td>
</tr>
<tr>
<td>105 – 140</td>
<td>0.21 – 0.28</td>
<td>100</td>
</tr>
<tr>
<td>40 – 60</td>
<td>0.21 – 0.27</td>
<td>75</td>
</tr>
<tr>
<td>&lt; 40</td>
<td>0.20 – 0.26</td>
<td>50</td>
</tr>
</tbody>
</table>

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:

\[ T = \frac{T_0(1 + \mu)k/k_p - 1}{\mu} \]

**2015 Vermont Commercial Building Energy Standards**

**2019 Vermont Commercial Building Energy Standards**
\[ T = \text{minimum insulation thickness}, \]
\[ r_T = \text{actual outside radius of pipe}, \]
\[ t = \text{insulation thickness listed in the table for applicable fluid temperature and pipe size}, \]
\[ K = \text{conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature} \]
\[ k = \text{the upper value of the conductivity range listed in the table for the applicable fluid temperature}. \]

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 • °F) and
- \( k \) = the upper value of the conductivity range listed in the table for the applicable fluid temperature.

C403.2.11 Mechanical systems performance, verification and completion.
New buildings of 50,000 gross square feet of conditioned space or greater shall meet the provisions of Section C407:

C403.2.12 Air system design and control.
Each HVAC system having a total fan system motor nameplate horsepower (hp) exceeding 5 hp (3.7 kW) shall comply with the provisions C403.11.3.1 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; and

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.
C403.12 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 C403.2.12.1 through C403.2.12.3.

C403.2.12.1 Allowable fan floor horsepower.
Each HVAC system at fan system design conditions shall not exceed the allowable fan system motor nameplate hp (Option 1) or fan system bhp (Option 2) as shown in Table C403.2.12.1(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 C403.2.12.1(1)
FAN POWER LIMITATION

<table>
<thead>
<tr>
<th>LIMIT</th>
<th>CONSTANT VOLUME</th>
<th>VARIABLE VOLUME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1: Fan system motor nameplate hp</td>
<td>Allowable nameplate motor hp</td>
<td>hp ≤ CFMS × 0.0011</td>
</tr>
<tr>
<td>Option 2: Fan system bhp</td>
<td>Allowable fan system bhp</td>
<td>bhp ≤ CFMS × 0.00094 + A</td>
</tr>
</tbody>
</table>

For SI: 1 bhp = 735.5 W, 1 hp = 745.5 W, 1 cfm = 0.4719 L/s.

where:

CFMS = The maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute.
hp = The maximum combined motor nameplate horsepower.
bhp = The maximum combined fan brake horsepower.
A = Sum of \( PD × CFM \) / 4131

where:

PD = Each applicable pressure drop adjustment from Table C403.2.12.1(2) in w.c.
CFMD = The design airflow through each applicable device from Table C403.2.12.1(2) in cubic feet per minute.

TABLE C403.2.12.1(2)
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>ADJUSTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits</td>
<td></td>
</tr>
<tr>
<td>Component Description</td>
<td>Pressure Drop</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Fully ducted return and/or exhaust air systems</td>
<td>0.5 inch w.c. (2.15 in w.c. for laboratory and vivarium systems)</td>
</tr>
<tr>
<td>Return and/or exhaust airflow control devices</td>
<td>0.5 inch w.c.</td>
</tr>
<tr>
<td>Exhaust filters, scrubbers or other exhaust treatment</td>
<td>The pressure drop of device calculated at fan system design condition</td>
</tr>
<tr>
<td>Particulate filtration credit: MERV 9 thru 12</td>
<td>0.5 inch w.c.</td>
</tr>
<tr>
<td>Particulate filtration credit: MERV 13 thru 15</td>
<td>0.9 inch w.c.</td>
</tr>
<tr>
<td>Particulate filtration credit: MERV 16 and greater and electronically enhanced filters</td>
<td>Pressure drop calculated at 2x clean filter pressure drop at fan system design condition.</td>
</tr>
<tr>
<td>Carbon and other gas-phase air cleaners</td>
<td>Clean filter pressure drop at fan system design condition.</td>
</tr>
<tr>
<td>Biosafety cabinet</td>
<td>Pressure drop of device at fan system design condition.</td>
</tr>
<tr>
<td>Energy recovery device, other than coil runaround loop</td>
<td>(2.2 x energy recovery effectiveness) – 0.5 inch w.c. for each airstream.</td>
</tr>
<tr>
<td>Coil runaround loop</td>
<td>0.6 inch w.c. for each airstream.</td>
</tr>
<tr>
<td>Evaporative humidifier/cooler in series with another cooling coil</td>
<td>Pressure drop of device at fan system design conditions.</td>
</tr>
<tr>
<td>Sound attenuation section (fans serving spaces with design background noise goals below NC35)</td>
<td>0.15 inch w.c.</td>
</tr>
<tr>
<td>Exhaust system serving fume hoods</td>
<td>0.35 inch w.c.</td>
</tr>
<tr>
<td>Laboratory and vivarium exhaust systems in high-rise buildings</td>
<td>0.25 inch w.c./100 feet of vertical duct exceeding 75 feet.</td>
</tr>
</tbody>
</table>

**Deductions**

- Systems without central cooling device: -0.6 in. w.c.
- Systems without central heating device: -0.3 in. w.c.
- Systems with central electric resistance heat: -0.2 in. w.c.

For SI: 1 inch w.c. = 249 Pa, 1 inch = 25.4 mm. w.c. = water column, NC = Noise criterion.

**C403.2.12.2 Motor nameplate horsepower.**

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 W), 1.5 times the fan brake horsepower.
2. For fans 6 bhp (4413 W) and larger, 1.3 times the fan brake horsepower.
3. Systems complying with Section C403.2.12.1 fan system motor nameplate hp (Option 1).

**C403.2.12.3 Fan efficiency.**

Fans shall have a fan efficiency grade (FEG) of not less than 67 when determined in accordance with AMCA 205 by an approved, independent testing laboratory and labeled by the manufacturer. The total efficiency of the fan at the design point of operation shall be within 15 percentage points of the maximum total efficiency of the fan.

**Exception:** The following fans are not required to have a fan efficiency grade:

1. Fans of 5 hp (3.7 kW) or less as follows:
   1.1. Single fan with a motor nameplate horsepower of 5 hp (3.7 kW) or less, unless Exception 1.2 applies.
1.2. Multiple fans in series or parallel that have a combined motor nameplate horsepower of 5 hp (3.7 kW) or less and are operated as the functional equivalent of a single fan.

2. Fans that are part of equipment covered under Section C403.2.3.

3. Fans included in an equipment package certified by an approved agency for air or energy performance.

4. Powered wall/roof ventilators.

5. Fans outside the scope of AMCA 205.

6. Fans that are intended to operate only during emergency conditions.

**C403.2.13 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 deenergized when no occupants are present.

**C403.12.2 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” below the surface is 50°F (10°C).

**C403.12.3 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.

**C403.2.14 Refrigeration equipment performance.**

Refrigeration equipment shall have an energy use in kWh/day not greater than the values of Tables C403.2.14(1) and C403.2.14(2) when tested and rated in accordance with AHRI Standard 1200. 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.

**TABLE C403.2.14(1)**

**MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATION**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>APPLICATION</th>
<th>ENERGY USE LIMITS (kWh per day)</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerator with solid doors</td>
<td>Holding Temperature</td>
<td>0.10 - V + 2.04</td>
<td>AHRI-1200</td>
</tr>
<tr>
<td>Refrigerator with transparent doors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freezers with solid doors</td>
<td></td>
<td>0.75 - V + 4.10</td>
<td></td>
</tr>
<tr>
<td>Freezers with transparent doors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerators/freezers with solid doors</td>
<td></td>
<td>the greater of 0.12 - V + 3.34 or 0.70</td>
<td></td>
</tr>
<tr>
<td>Commercial refrigerators</td>
<td>Pulldown</td>
<td>0.126 - V + 3.51</td>
<td></td>
</tr>
</tbody>
</table>

a. V = volume of the chiller or frozen compartment as defined in AHAM HRF-1.
### TABLE C403.2.14(2)
#### MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS

<table>
<thead>
<tr>
<th>FAMILY CODE</th>
<th>OPERATING MODE</th>
<th>RATING TEMPERATURE</th>
<th>ENERGY USE LIMITS (kWh/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical-open</td>
<td>Remote-condensing</td>
<td>Medium</td>
<td>0.82 TDA + 4.07</td>
</tr>
<tr>
<td>Vertical-open</td>
<td>Remote-condensing</td>
<td>Medium</td>
<td>0.83 TDA + 4.18</td>
</tr>
<tr>
<td>Horizontal-open</td>
<td>Remote-condensing</td>
<td>Medium</td>
<td>0.35 TDA + 2.88</td>
</tr>
<tr>
<td>Vertical-open</td>
<td>Remote-condensing</td>
<td>Low</td>
<td>2.27 TDA + 6.85</td>
</tr>
<tr>
<td>Horizontal-open</td>
<td>Remote-condensing</td>
<td>Low</td>
<td>0.57 TDA + 6.88</td>
</tr>
<tr>
<td>Vertical-transparent-door</td>
<td>Remote-condensing</td>
<td>Medium</td>
<td>0.22 TDA + 1.95</td>
</tr>
<tr>
<td>Vertical-transparent-door</td>
<td>Remote-condensing</td>
<td>Low</td>
<td>0.56 TDA + 2.61</td>
</tr>
<tr>
<td>Service-over-counter</td>
<td>Remote-condensing</td>
<td>Medium</td>
<td>0.51 TDA + 0.14</td>
</tr>
<tr>
<td>Vertical-open</td>
<td>Self-contained</td>
<td>Medium</td>
<td>1.74 TDA + 4.71</td>
</tr>
<tr>
<td>Semivertical-open</td>
<td>Self-contained</td>
<td>Medium</td>
<td>1.73 TDA + 4.59</td>
</tr>
<tr>
<td>Horizontal-open</td>
<td>Self-contained</td>
<td>Medium</td>
<td>0.77 TDA + 5.55</td>
</tr>
<tr>
<td>Horizontal-open</td>
<td>Self-contained</td>
<td>Low</td>
<td>1.92 TDA + 7.08</td>
</tr>
<tr>
<td>Vertical-transparent-door</td>
<td>Self-contained</td>
<td>Ice cream</td>
<td>0.67 TDA + 3.29</td>
</tr>
<tr>
<td>Vertical-solid-door</td>
<td>Self-contained</td>
<td>Ice cream</td>
<td>0.38 TDA + 0.88</td>
</tr>
<tr>
<td>Horizontal-transparent-door</td>
<td>Self-contained</td>
<td>Ice cream</td>
<td>0.56 TDA + 0.43</td>
</tr>
<tr>
<td>Semivertical-open</td>
<td>Remote-condensing</td>
<td>Low</td>
<td>2.27 TDA + 6.85</td>
</tr>
<tr>
<td>Vertical-open</td>
<td>Remote-condensing</td>
<td>Ice cream</td>
<td>2.89 TDA + 8.7</td>
</tr>
<tr>
<td>Semivertical-open</td>
<td>Remote-condensing</td>
<td>Ice cream</td>
<td>2.89 TDA + 8.7</td>
</tr>
<tr>
<td>Horizontal-open</td>
<td>Remote-condensing</td>
<td>Ice cream</td>
<td>0.72 TDA + 8.74</td>
</tr>
<tr>
<td>Vertical-transparent-door</td>
<td>Remote-condensing</td>
<td>Ice cream</td>
<td>0.66 TDA + 3.05</td>
</tr>
<tr>
<td>Horizontal-transparent-door</td>
<td>Remote-condensing</td>
<td>Medium</td>
<td>0.16 TDA + 0.13</td>
</tr>
</tbody>
</table>

*(continued)*

**TABLE C403.2.14(2)—continued**

**MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS**
<table>
<thead>
<tr>
<th>Equipment Class</th>
<th>Family Code</th>
<th>Operating Mode</th>
<th>Rating Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCT.RC.L</td>
<td>Horizontal transparent door</td>
<td>Remote-condensing</td>
<td>Low</td>
</tr>
<tr>
<td>HCT.RC.I</td>
<td>Horizontal transparent door</td>
<td>Remote-condensing</td>
<td>Ice-cream</td>
</tr>
<tr>
<td>VCS.RC.M</td>
<td>Vertical solid door</td>
<td>Remote-condensing</td>
<td>Medium</td>
</tr>
<tr>
<td>VCS.RC.L</td>
<td>Vertical solid door</td>
<td>Remote-condensing</td>
<td>Low</td>
</tr>
<tr>
<td>VCS.RC.I</td>
<td>Vertical solid door</td>
<td>Remote-condensing</td>
<td>Ice cream</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------</td>
<td>-------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>HCS.RC.M</td>
<td>Horizontal solid door</td>
<td>Remote-condensing</td>
<td>Medium</td>
</tr>
<tr>
<td>HCS.RC.L</td>
<td>Horizontal solid door</td>
<td>Remote-condensing</td>
<td>Low</td>
</tr>
<tr>
<td>HCS.RC.I</td>
<td>Horizontal solid door</td>
<td>Remote-condensing</td>
<td>Ice cream</td>
</tr>
<tr>
<td>HCS.RC.I</td>
<td>Horizontal solid door</td>
<td>Remote-condensing</td>
<td>Ice cream</td>
</tr>
<tr>
<td>Equipment Type</td>
<td>Service Type</td>
<td>Condensing Type</td>
<td>Temperature</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------</td>
<td>-----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>SOC.RC.L</td>
<td>Service over-counter</td>
<td>Remote-condensing</td>
<td>Low</td>
</tr>
<tr>
<td>SOC.RC.I</td>
<td>Service over-counter</td>
<td>Remote-condensing</td>
<td>Ice cream</td>
</tr>
<tr>
<td>VOP.SC.L</td>
<td>Vertical-open</td>
<td>Self-contained</td>
<td>Low</td>
</tr>
<tr>
<td>VOP.SC.I</td>
<td>Vertical-open</td>
<td>Self-contained</td>
<td>Ice cream</td>
</tr>
<tr>
<td>Type</td>
<td>Description</td>
<td>Equipment Type</td>
<td>Application</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------</td>
<td>----------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>SVO.SC.L</td>
<td>Semivertical open</td>
<td>Self-contained</td>
<td>Low</td>
</tr>
<tr>
<td>SVO.SC.I</td>
<td>Semivertical open</td>
<td>Self-contained</td>
<td>Ice cream</td>
</tr>
<tr>
<td>HZO.SC.I</td>
<td>Horizontal-open</td>
<td>Self-contained</td>
<td>Ice cream</td>
</tr>
<tr>
<td>SOC.SC.I</td>
<td>Service over counter</td>
<td>Self-contained</td>
<td>Ice cream</td>
</tr>
</tbody>
</table>
C403.2.15 Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers.

Refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with this section. Walk-in coolers and walk-in freezers that are not either site assembled or site constructed 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 7 feet (2134 mm) in height.

2. Doorways shall have strip doors, curtains, spring hinged 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.

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
   - VCT = vertical transparent doors
   - VCS = vertical solid doors
   - 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.
5. Transparent reach-in doors for walk-in freezers and windows in 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 doors 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. Where antisweat heaters without antisweat heater controls are provided, they 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. Where antisweat heater controls are provided, they 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.

11. Lights in walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall either use light sources with an efficacy of not less than 40 lumens per watt, including ballast losses, or shall use light sources with an efficacy of not less than 40 lumens per watt, including ballast losses, in conjunction with a device that turns off the lights within 15 minutes when the space is not occupied.

C403.2.16 Walk-in coolers and walk-in freezers.
Site-assembled or site-constructed walk-in coolers and walk-in freezers shall comply with the following:

1. Automatic door closers shall be provided that fully close walk-in doors that have been closed to within 1 inch (25 mm) of full closure.

   **Exception:** Closers are not required for doors more than 45 inches (1143 mm) in width or more than 7 feet (2134 mm) in height.

2. Doorways shall be provided with strip doors, curtains, spring-hinged doors or other method of minimizing infiltration when the doors are open.

3. Walls shall be provided with insulation having a thermal resistance of not less than R-25, ceilings shall be provided with insulation having a thermal resistance of not less than R-25 and doors of walk-in coolers and walk-in freezers shall be provided with insulation having a thermal resistance of not less than R-32.

   **Exception:** Insulation is not required for glazed portions of doors or at structural members associated with the walls, ceiling or door frame.

4. The floor of walk-in freezers shall be provided with insulation having a thermal resistance of not less than R-28.
5. Transparent reach-in doors for and windows in opaque walk-in freezer doors shall be provided with triple-pane glass having the interstitial spaces filled with inert gas or provided with heat-reflective treated glass.

6. Transparent reach-in doors for and windows in opaque walk-in cooler doors shall be double-pane heat-reflective treated glass having the interstitial-space gas-filled.

7. Evaporator fan motors that are less than 1 hp (0.746 kW) and less than 460 volts shall be electronically commutated motors or 3-phase motors.

8. Condenser fan motors that are less than 1 hp (0.746 kW) in capacity shall be of the electronically commutated or permanent split capacitor type or shall be 3-phase motors.

Exception: Fan motors in walk-in coolers and walk-in freezers combined in a single enclosure greater than 3,000 square feet (279 m²) in floor area are exempt.

9. Antisweat heaters that are not provided with antisweat heater controls shall have a total door rail, glass and frame heater power draw not greater than 7.1 W/ft² (76 W/m²) of door opening for walk-in freezers, and not greater than 3.0 W/ft² (32 W/m²) of door opening for walk-in coolers.

10. Antisweat heater controls shall be capable of reducing 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. Light sources shall have an efficacy of not less than 40 lumens per Watt, including any ballast losses, or shall be provided with a device that automatically turns off the lights within 15 minutes of when the walk-in cooler or walk-in freezer was last occupied.

C403.2.17 Refrigerated display cases.
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 at least 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.

C403.3 Economizers (Prescriptive).
Each cooling system that has a fan shall include either an air or water economizer complying with Sections C403.3.1 through C403.3.4. The total supply capacity of all fan-cooling units without economizers shall not.
exceed 20 percent of the total supply capacity of all fan-cooling units in the building or 300,000 Btu/h (88 kW), whichever is greater.

 Exceptions: Economizers are not required for the systems listed below.

 1. Where individual cooling units have a capacity of less than 54,000 Btu/h (15.8 kW) and meet one of the following:
   a. Have direct expansion cooling coils.
   b. The total chilled water system capacity less the capacity of fan units with air economizers is less than the minimum specified in Table C403.3(1).

 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 that serve residential spaces where the system capacity is less than five times the minimum requirement (< 270,000 Btu/h).

 4. Systems expected to operate less than 20 hours per week.

 5. Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems.

 6. Where the cooling efficiency meets or exceeds a 50% efficiency improvement in cooling equipment performance (EER or IPLV).

 7. Chilled-water cooling systems that are passive (without a fan) or use induction where the total chilled water system capacity less the capacity of fan units with air economizers is less than the minimum specified in Table C403.3(1).

 8. Systems that include a heat recovery system in accordance with Section C403.4.5.

 9. Systems serving primarily computer rooms where:
   a. The total design cooling load of all computer rooms in the building is less than 3,000,000 Btu/h and the building in which they are located is not served by a centralized chilled water plant;
   b. The room total design cooling load is less than 600,000 Btu/h and the building in which they are located is served by a centralized chilled water plant;
   c. The local water authority does not allow cooling towers; or
   d. Less than 600,000 Btu/h of computer-room cooling equipment capacity is being added to an existing building.

### Table C403.3(1)

**minimum chilled-water system cooling capacity for determining economizer**
COOLING REQUIREMENTS

TOTAL CHILLED-WATER SYSTEM CAPACITY LESS CAPACITY OF COOLING UNITS WITH AIR ECONOMIZERS

<table>
<thead>
<tr>
<th>Local Water-cooled Chilled-water Systems</th>
<th>Air-cooled Chilled-water Systems or District Chilled-water Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,320,000 Btu/h</td>
<td>1,720,000 Btu/h</td>
</tr>
</tbody>
</table>

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

C403.3.1 Integrated economizer control.
Economizer systems shall be integrated with the mechanical cooling system and be capable of providing 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, such as hot gas bypass, except at the lowest stage of mechanical cooling.

Exceptions:

1. Direct expansion systems that include controls that reduce the quantity of outdoor air required to prevent coil frosting at the lowest step of compressor unloading, provided this lowest step is no greater than 25% of the total system capacity.

2. Individual direct expansion units that have a rated cooling capacity less than 54,000 Btu/h and use non-integrated economizer controls that preclude simultaneous operation of the economizer and 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:
   i. the outdoor air damper is at the 100 percent open position when mechanical cooling is on and
   ii. the outdoor air damper does not begin to close until the leaving air temperature is less than 45°F (7°C) (to prevent coil freezing due to minimum compressor run time).

2. Direct expansion (DX) units that control 75,000 Btu/h (22 kW) or greater of rated capacity of the mechanical cooling directly based on occupied space temperature shall have not fewer than two stages 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 C403.3.1.

C403.3.2 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 due to a reduction in supply air temperature.
**C403.3.3 Air economizers.**
Air economizers shall comply with Sections C403.3.3.1 through C403.3.3.5.

**C403.3.3.1 Design capacity.**
Air economizer systems shall be capable of modulating outdoor air and return air dampers to provide up to 100 percent of the design supply air quantity as outdoor air for cooling.

**TABLE C403.3.1**
**DX COOLING STATESTAGE REQUIREMENTS FOR MODULATING AIRFLOW UNITS**

<table>
<thead>
<tr>
<th>RATING CAPACITY</th>
<th>MINIMUM NUMBER OF MECHANICAL COOLING STAGES</th>
<th>MINIMUM COMPRESSOR DISPLACEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 65,000 Btu/h and ≤ 240,000 Btu/h</td>
<td>3 stages</td>
<td>≤ 35% of full load</td>
</tr>
<tr>
<td>≥ 240,000 Btu/h</td>
<td>4 stages</td>
<td>≤ 25% of full load</td>
</tr>
</tbody>
</table>

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.

**C403.3.3.2 Control signal.**
Economizer dampers shall be capable of being sequenced 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).

**C403.3.3.3 High-limit shutoff.**
Air economizers shall be capable of automatically reducing outdoor air intake to the design minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage. High-limit shutoff control types shall be chosen from Table C403.3.3.3. High-limit shutoff control settings for these control types shall be those specified in Table C403.3.3.3.

**TABLE C403.3.3.3**
**HIGH-LIMIT SHUTOFF CONTROL SETTING FOR AIR ECONOMIZERS**

<table>
<thead>
<tr>
<th>DEVICE TYPE</th>
<th>REQUIRED HIGH LIMIT (ECONOMIZER OFF WHEN):</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed dry-bulb</td>
<td>$T_{OA} &gt; 70^\circ \text{F}$</td>
<td>Outdoor air temperature exceeds 70°F</td>
</tr>
<tr>
<td>Differential dry-bulb</td>
<td>$T_{OA} &gt; T_{RA}$</td>
<td>Outdoor air temperature exceeds return air temperature</td>
</tr>
</tbody>
</table>
Fixed enthalpy with fixed dry-bulb temperatures

\[ h_{OA} > 28 \text{ Btu/lb} \text{ or } T_{OA} > 70^\circ \text{F} \]

Outdoor air enthalpy exceeds 28 Btu/lb of dry air or Outdoor air temperature exceeds 70°F

Differential enthalpy with fixed dry-bulb temperature

\[ h_{OA} > h_{RA} \text{ or } T_{OA} > 70^\circ \text{F} \]

Outdoor air enthalpy exceeds return air enthalpy or Outdoor air temperature exceeds 70°F

For SI: 1 foot = 305 mm, °C = (°F - 32)/1.8, 1 Btu/lb = 2.33 kJ/kg.

a. Devices with selectable setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.

C403.3.4 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.

C403.3.5 Economizer dampers.
Return, exhaust/relief and outdoor air dampers used in economizers shall comply with Section C403.2.4.3.

C403.3.4 Water-side economizers.
Water-side economizers shall comply with Sections C403.3.4.1 and C403.3.4.2.

C403.3.4.1 Design capacity.
Water economizer systems shall be capable of cooling 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 which 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.

C403.3.4.2 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.

C403.4 Hydronic and multiple-zone HVAC systems controls and equipment. (Prescriptive).
Hydronic and multiple-zone HVAC system controls and equipment shall comply with this section.

C403.4.1 Fan control.
Controls shall be provided for fans in accordance with Sections C403.4.1.1 through C403.4.1.3.

C403.4.1.1 Fan airflow control.
Each cooling system listed in Table C403.4.1.1 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 airside economizer in accordance with Section C403.3 shall have not fewer than two speeds of 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 62.1-2013 at low speed exceeds the air that would be delivered at the speed defined in Section C403.4.1, the minimum speed shall be selected to provide the required ventilation air.

<table>
<thead>
<tr>
<th>COOLING SYSTEM TYPE</th>
<th>FAN MOTOR SIZE</th>
<th>MECHANICAL COOLING CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>DX-cooling</td>
<td>Any</td>
<td>≥75,000 Btu/h (before 1/1/2016)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥65,000 Btu/h (after 1/1/2016)</td>
</tr>
<tr>
<td>≥5 hp</td>
<td>Any</td>
<td></td>
</tr>
</tbody>
</table>
For SI: 1 British thermal unit per hour = 0.2931 W; 1 hp = 0.746 kW.

### C403.4.1.2 Static pressure sensor location.
Static pressure sensors used to control VAV fans shall be located such that the controller set point is not greater than 1.2 inches w.c. (299 Pa). 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 non-compliance.

### C403.4.1.3 Set points for direct digital control.
For systems with direct digital control of individual zone boxes reporting to the central control panel, the static pressure set point shall be reset based on the zone requiring the most pressure. In such case, the set point 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 capable of all of the following:

1. Automatically detecting any zone that excessively drives the reset logic.
2. Generating an alarm to the system operational location.
3. Allowing an operator to readily remove one or more zones from the reset algorithm.

### C403.4.2 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 C403.4.2.1 through C403.4.2.3. 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 capable of sequencing operation of the boilers. Hydronic heating systems comprised 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.

#### C403.4.2.1 Three-pipe system.
Hydronic systems that use a common return system for both hot water and chilled water are prohibited.

#### C403.4.2.2 Two-pipe changeover system.
Systems that use a common distribution system to supply both heated and chilled water shall be designed to allow a dead band 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.

#### C403.4.2.3 Hydronic (water loop) heat pump systems.
Hydronic heat pump systems shall comply with Sections C403.4.2.3.1 through C403.4.2.3.2.

##### C403.4.2.3.1 Temperature dead band.
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 capable of providing a heat pump water-
supply temperature dead band 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 realtime conditions of demand and capacity, dead bands of less than 20°F (11°C) shall be permitted.

C403.4.2.3.2 Heat rejection.
If an open- or closed-circuit cooling tower is used, a separate heat exchanger shall be provided to isolate the cooling tower from the heat pump loop, and heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop and providing an automatic valve to stop the flow of fluid.

**Exception:** Where it can be demonstrated that a heat pump system will be required to reject heat throughout the year.

C403.4.2.3.3 Two-position valve.
Each hydronic heat pump on the hydronic system having a total pump system power exceeding 10 hp (7.5 kW) shall have a two-position valve.

C403.4.2.4 Part-load controls.
Hydronic systems greater than or equal to 500,000 Btu/h (146.5 kW) in design output capacity supplying heated or chilled water to comfort conditioning systems shall include controls that have the capability 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 capable of being 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 motor capacity of 5 hp (3.75 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 by designed 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 chilled-water systems and heat rejection loops serving water-cooled unitary air conditioners with a combined motor capacity of 5 hp (3.75 kW) or larger by reducing pump design flow by not less than 50 percent, utilizing adjustable speed drives on pumps, or multiple-staged pumps where not less than one-half of the total pump horsepower is capable of being automatically turned off. Pump flow shall be controlled to maintain one control valve nearly wide open or to satisfy the minimum differential pressure.

**Exceptions:**

1. Supply-water temperature reset for chilled-water systems supplied by off-site district chilled water or chilled water from ice storage systems.

2. Minimum flow rates other than 50 percent as required by the equipment manufacturer for proper operation of equipment where using flow bypass or end-of-line 3-way valves.
3. Variable pump flow 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.

C403.4.2.5 Boiler turndown.
Boiler systems with design input of greater than 1,000,000 Btu/h (293 kW) shall comply with the turndown ratio specified in Table C403.4.2.5.

The system turndown requirement shall be met through the use of multiple single input boilers, one or more modulating boilers or a combination of single input and modulating boilers.

<table>
<thead>
<tr>
<th>BOILER SYSTEM DESIGN INPUT (Btu/h)</th>
<th>MINIMUM TURNDOWN RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 1,000,000 and less than or equal to 5,000,000</td>
<td>3 to 1</td>
</tr>
<tr>
<td>&gt; 5,000,000 and less than or equal to 10,000,000</td>
<td>4 to 1</td>
</tr>
<tr>
<td>&gt; 10,000,000</td>
<td>5 to 1</td>
</tr>
</tbody>
</table>

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

C403.4.2.6 Pump isolation.
Chilled water plants including more than one chiller shall have the capability 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 plants including more than one boiler shall have the capability to reduce flow automatically through the boiler plant when a boiler is shut down.

C403.4.2.7 Pipe Sizing.
All chilled-water and condenser water piping shall be designed such that the design flow rate in each piping segment shall not exceed the values listed in Table C403.4.2.7 for the appropriate total annual hours of operation. Piping size selections for systems that operate under variable flow conditions (e.g., modulating two-way control valves at coils) and that contain variable-speed pump motors are allowed to be made from the “Variable Flow/Variable Speed” columns. All others shall be made from the “Other” columns.

Exceptions:
1. Design flow rates exceeding the values in Table C403.4.2.7 are allowed in specific sections of piping if the piping in question is not in the critical circuit at design conditions and is not predicted to be in the critical circuit during more than 30% of operating hours.

2. Piping systems that have equivalent or lower total pressure drop than the same system constructed with standard weight steel pipe with piping and fittings sized per Table C403.4.2.7.

TABLE C403.4.2.7
### PIPING SYSTEM DESIGN MAXIMUM FLOW RATE IN GPM

<table>
<thead>
<tr>
<th>OPERATING HOURS/ YEAR</th>
<th>≤ 2,000 HOURS/ YEAR</th>
<th>&gt; 2,000 AND ≤ 4,400 HOURS/ YEAR</th>
<th>&gt; 4,400 HOURS/ YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Pipe Size (inches)</td>
<td>Other</td>
<td>Variable Flow/ Variable Speed</td>
<td>Other</td>
</tr>
<tr>
<td>1 1/2</td>
<td></td>
<td>1020</td>
<td>180</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>180</td>
<td>270</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>350</td>
<td>530</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>410</td>
<td>620</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>740</td>
<td>1,100</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>1,200</td>
<td>1,800</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>1,800</td>
<td>2,700</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>2,500</td>
<td>3,800</td>
</tr>
<tr>
<td>Maximum velocity for pipes over 14–24 inches in size</td>
<td></td>
<td>8.5 ft/s</td>
<td>13.0 ft/s</td>
</tr>
</tbody>
</table>

#### C403.4.3 Heat rejection equipment.
Heat rejection equipment such as air-cooled condensers, dry coolers, open-circuit cooling towers, closed-circuit cooling towers and evaporative condensers used for comfort cooling applications shall comply with this section.

**Exception:** Heat rejection devices where energy usage is included in the equipment efficiency ratings listed in Table C403.2.3(6).

#### C403.4.3.1 Fan speed control.
The fan speed shall be controlled as provided in Sections C403.4.3.2.1 and C403.4.3.2.2.

##### C403.4.3.1.1 Fan motors not less than 7.5 hp.
Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at two-thirds of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

**Exception:** The following fan motors over 7.5 hp (5.6 kW) are exempt:

1. Condenser fans serving multiple refrigerant circuits.
2. Condenser fans serving flooded condensers.

##### C403.4.3.1.2 Multiple-cell heat rejection equipment.
Multiple-cell heat rejection equipment with variable speed fan drives shall be controlled in both of the following manners:

1. To operate the maximum number of fans allowed that comply with the manufacturer’s requirements for all system components.
2. So all fans can operate at the same fan speed required for the instantaneous cooling duty, as opposed to staged (on/off) operation.

Minimum fan speed shall be the minimum allowable speed of the fan drive system in accordance with the manufacturer’s recommendations.

C403.4.3.2 Limitation on centrifugal fan open-circuit cooling towers.
Centrifugal fan open-circuit cooling towers with a combined rated capacity of 1,100 gpm (4164 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 C403.2.3(8).

Exception: Centrifugal open-circuit cooling towers that are designed with inlet or discharge ducts or require external sound attenuation.

C403.4.3.3 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.

C403.4.4 Requirements for complex mechanical systems serving multiple zones.
Sections C403.4.4.1 through C403.4.6.4 shall apply to complex mechanical systems serving multiple zones. Supply air systems serving multiple zones shall be variable air volume (VAV) systems that, during periods of occupancy, are designed and capable of being controlled to reduce primary air supply to each zone to one of the following before reheating, recooling or mixing takes place:

1. Thirty percent of the maximum supply air to each zone.
2. Three hundred cfm (142 L/s) or less where the maximum flow rate is less than 10 percent of the total fan system supply airflow rate.
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 or other authority having jurisdiction.
5. The airflow rate required to comply with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates.

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 or site-solar energy source.
2. Zones where special humidity levels are required to satisfy process needs.
3. Zones with a peak supply air quantity of 300 cfm (142 L/s) or less and where the flow rate is less than 10 percent of the total fan system supply airflow rate.

4. Zones where the volume of air to be reheated, recooling or mixed is not greater than the volume of outside air required to provide the minimum ventilation requirements of ASHRAE Standard 62.1-2013.

5. Zones or supply air systems with thermostatic and humidistatic controls capable of operating in sequence the supply of heating and cooling energy to the zones and which are capable of preventing 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.

C403.4.4.1 Single-duct VAV systems, terminal devices.
Single-duct VAV systems shall use terminal devices capable of reducing the supply of primary supply air before reheating or recooling takes place.

C403.4.4.2 Dual-duct and mixing VAV systems, terminal devices.
Systems that have one warm air duct and one cool air duct shall use terminal devices that are capable of reducing the flow from one duct to a minimum before mixing of air from the other duct takes place.

C403.4.4.3 Single-fan dual-duct and mixing VAV systems, economizers.
Individual dual-duct or mixing heating and cooling systems with a single fan and with total capacities greater than 90,000 Btu/h [(26.4 kW) 7.5 tons] shall not be equipped with air economizers.

C403.4.4.4 Fractional hp fan motors.
Motors for fans are not less than \( \frac{1}{12} \) hp (0.082 kW) and less than 1 hp (0.746 kW) shall be electronically commutated motors or shall have a minimum motor efficiency of 70 percent, rated in accordance with DOE 10 CFR 431. These motors shall also 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 in the airstream within fan coils and terminal units that only provide heating to the space served.

2. Motors in space-conditioning equipment that comply with Section 403.2.3 or C403.2.12.

3. Motors that comply with Section C405.8.

C403.4.4.5 Supply-air temperature reset controls.
Multiple-zone HVAC systems shall include controls that automatically reset the supply-air temperature in response to representative building loads or to outdoor air temperature. The controls shall be capable of resetting the supply-air temperature not less than 25 percent of the difference between the design supply-air temperature and the design room 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. Zones with peak supply air quantities of 300 cfm (142 L/s) or less.

C403.4.4.6 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 ($E_v$) as defined by the ASHRAE Standard 62.1-2013.

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 having exhaust air energy recovery complying with Section C403.2.7.

3. Systems where total design exhaust airflow is more than 70 percent of total design outdoor air intake flow requirements.

C403.4.5 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 C403.4.5 will be detrimental to chiller operating efficiency due to conflicts with optimized chiller head pressure control.

C403.4.6 Hot gas bypass limitation.
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 C403.4.6, as limited by Section C403.3.1.

### Table C403.4.6

<table>
<thead>
<tr>
<th>RATED CAPACITY</th>
<th>MAXIMUM HOT GAS BYPASS CAPACITY (% of total capacity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 240,000 Btu/h</td>
<td>50</td>
</tr>
<tr>
<td>&gt; 240,000 Btu/h</td>
<td>25</td>
</tr>
</tbody>
</table>

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

**C403.5 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 C403.5.1 and C403.5.2.

**Exception:** Systems where the working fluid in the refrigeration cycle goes through both subcritical and supercritical states (transcritical) or that use ammonia refrigerant are exempt.

**C403.5.1 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).
C403.5.2 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 C403.2.10.

3. Compressors that incorporate internal or external crankcase heaters shall provide a means to cycle the heaters off during compressor operation.

SECTION C404
SERVICE WATER HEATING (MANDATORY)

C404.1 General.
In addition to the service water heating requirements of Section C404, service water heating enhancements may be needed to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406.

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 5 kW total power input. Individual electric service water heating units shall be limited to a maximum of 7.5 kW total power input.

**Exceptions:**

1. **Exception:** 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% 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 also 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

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY - (input)</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>PERFORMANCE REQUIRED</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water heaters, electric</td>
<td>≤ 7.5 kW</td>
<td>Tabletop</td>
<td>0.9793 - 0.00132V</td>
<td>DOE 10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resistance Grid-enabled</td>
<td>0.960 - 0.0003V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 75 gallons and &lt; 120 gallons</td>
<td>1.061 - 0.00168V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≤ 24 amps and ≤ 250 volts</td>
<td>Heat pump &gt; 55 gallons and ≤ 120 gallons</td>
<td>2.057 - 0.93 - 0.00113V</td>
<td>DOE 10 CFR Part 430</td>
</tr>
<tr>
<td>Storage water heaters, gas</td>
<td>≤ 75,000 Btu/h and ≤ 155,000 Btu/h</td>
<td>≥ 20 gallons and ≤ 55 gallons</td>
<td>0.67675 - 0.0019V</td>
<td>DOE 10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 55 gallons and ≤ 100 gallons</td>
<td>0.8102 - 0.00078V</td>
<td></td>
</tr>
<tr>
<td>Instantaneous water heaters, gas</td>
<td>&gt; 50,000 Btu/h and ≤ 200,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and &lt; 2 gal</td>
<td>0.6292 - 0.0019V</td>
<td>DOE 10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>≥ 200,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and &lt; 10 gal</td>
<td>80% Et (Q/800 + 110√V)SL, Btu/h</td>
<td>ANSI Z21.10.3</td>
</tr>
<tr>
<td></td>
<td>≥ 200,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and ≥ 10 gal</td>
<td>80% Et (Q/800 + 110√V)SL, Btu/h</td>
<td></td>
</tr>
<tr>
<td>Storage water heaters, oil</td>
<td>≤ 105,000 Btu/h</td>
<td>≥ 20 gal and ≤ 50 gallons</td>
<td>0.5968 - 0.0019V</td>
<td>DOE 10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>≥ 105,000 Btu/h</td>
<td>&lt; 4,000 Btu/h/gal</td>
<td>78% Et (Q/800 + 110√V)SL, Btu/h</td>
<td>ANSI Z21.10.3</td>
</tr>
<tr>
<td>Instantaneous water heaters, oil</td>
<td>≤ 210,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and &lt; 2 gal</td>
<td>0.59 - 0.0019V</td>
<td>DOE 10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>&gt; 210,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and &lt; 10 gal</td>
<td>80% Et (Q/800 + 110√V)SL, Btu/h</td>
<td>ANSI Z21.10.3</td>
</tr>
<tr>
<td></td>
<td>&gt; 210,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and ≥ 10 gal</td>
<td>78% Et (Q/800 + 110√V)SL, Btu/h</td>
<td></td>
</tr>
<tr>
<td>Hot water supply boilers, gas and oil</td>
<td>&gt; 300,000 Btu/h and ≤ 12,500,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and &lt; 10 gal</td>
<td>80% Et (Q/800 + 110√V)SL, Btu/h</td>
<td>ANSI Z21.10.3</td>
</tr>
</tbody>
</table>
### TABLE C404.2—continued

**MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY (input)</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>PERFORMANCE REQUIRED</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat pump pool heaters</td>
<td>All</td>
<td>—</td>
<td>Minimum insulation requirement R-12.5 (h•ft²•°F)/Btu</td>
<td>AHRI 1160</td>
</tr>
<tr>
<td>Unfired storage tanks</td>
<td>All</td>
<td>—</td>
<td>—</td>
<td>(none)</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m², 1°F = [(°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-rated 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 the input rating of the equipment is 1,000,000 Btu/h (293 kW) or greater, such equipment shall have a thermal efficiency, $E_t$, of not less than 90.92 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 90% percent.

Exceptions:

1. Where not less than 25 percent of the annual service water-heating requirement is provided by on-site-solar 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.

Water-heating equipment for hot water storage tanks. Vertical pipe risers serving storage water heaters and storage tanks not supplied with integral heat-traps and serving noncirculating systems shall be provided with heat traps on both the supply inlet and discharge outlet piping associated with as close as practical to the equipment storage tank.

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 C403.2.1011.3. 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 C403.2.1011.3 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 Efficient 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).

C404.5.1 Maximum allowable pipe length method.
The maximum allowable piping length from the nearest source of heated water to the termination of the fixture supply pipe shall be in accordance with the following. Where the piping contains more than one size of pipe, the largest size of pipe within the piping shall be used for determining the maximum allowable length of the piping in Table C404.5.1:

1. For a public lavatory faucet, use the “Public lavatory faucets” column in Table C404.5.1.

2. For all other plumbing fixtures and plumbing appliances, use the “Other fixtures and appliances” column in Table C404.5.1.

<table>
<thead>
<tr>
<th>NOMINAL PIPE SIZE (inches)</th>
<th>VOLUME (liquid ounces per foot length)</th>
<th>MAXIMUM PIPING LENGTH (feet)</th>
<th>Public lavatory faucets</th>
<th>Other fixtures and appliances</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>0.33</td>
<td>6</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>5/16</td>
<td>0.5</td>
<td>4</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>3/8</td>
<td>0.75</td>
<td>3</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>1.5</td>
<td>2</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>5/8</td>
<td>2</td>
<td>4</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>7/8</td>
<td>3</td>
<td>0.5</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>1/4</td>
<td>4</td>
<td>0.5</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>3/4</td>
<td>5</td>
<td>0.5</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>8</td>
<td>0.5</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>11</td>
<td>0.5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>2 or larger</td>
<td>18</td>
<td>0.5</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 liquid ounce = 0.030 L, 1 gallon = 128 ounces.
C404.5.2 Maximum allowable pipe volume method.
The water volume in the piping shall be calculated in accordance with Section C404.5.2.1. Water heaters, circulating water systems and heat trace temperature maintenance systems shall be considered sources of heated water.

The volume from the nearest source of heated water to the termination of the fixture supply pipe shall be as follows:

1. For a public lavatory faucet: not more than 2 ounces (0.06 L).
2. For other plumbing fixtures or plumbing appliances: not more than 0.5 gallon (1.89 L).

C404.5.2.1 Water volume determination.
The volume shall be the sum of the internal volumes of pipe, fittings, valves, meters and manifolds between the nearest source of heated water and the termination of the fixture supply pipe. The volume in the piping shall be determined from the "Volume" column in Table C404.5.1. The volume contained within fixture shutoff valves, within flexible water supply connectors to a fixture fitting and within a fixture fitting shall not be included in the water volume determination. Where heated water is supplied by a recirculating system or heat-traced piping, the volume shall include the portion of the fitting on the branch pipe that supplies water to the fixture.

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 accessible in a location with access. Manual controls shall be readily accessible 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. Controls for circulating hot Systems designed to maintain usage temperatures in hot-water system pumps shall start the pump based on the identification of a demand for pipes such as recirculating hot water within the occupancy. The systems or heat trace, shall: be equipped with automatic time switches or other controls shall automatically turn that can be set to switch off the pump when the water in the circulation loop is at the desired usage temperature and maintenance system during periods when there is no demand for hot water. Is not required.

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, or
2. Use a modulating pump, controlled by an aquastat at the return side of the pump, to maintain the minimum hot water temperature


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 demand.
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.
A water distribution system having one or more Demand recirculation pumps that pump water from a heated-water supply pipe back to the heated-water source through a cold-water supply pipe shall be a demand recirculation water system. Pumps in 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 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.

C404.9 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.

C404.9.1 Heaters.
The electric power to all heaters shall be controlled by a readily accessible 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. Natural-gas- or propane-Gas-fired heaters shall not be equipped with continuously burning ignition pilots.

C404.9.2 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.

C404.9.3 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 7075 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 solar-on-site renewable energy source system, covers or other vapor-retardant means shall not be required.
C404.10 Energy consumption of 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.

C404.11 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, electrical power and lighting enhancements may be needed to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406.

This section covers lighting system controls, the maximum lighting power for interior and exterior applications and electrical energy consumption.

Exception: Dwelling units and Sleeping Units within commercial Group R-2 buildings (see occupancy classifications in section C202) shall not be required to comply with Sections C405.2 through C405.5, provided that install lamps or fixtures where not less than 7590 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 7590 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.

Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.2.15 or C403.2.16.

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 C405.2.2, C405.2.36.

2. Luminaire level lighting controls (LLLC) and lighting controls as specified in Sections C405.2.1, C405.2.4 and C405.2.5. The LLC 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 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.
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. Employee lunch and break rooms.
6. Private offices.
7. Open plan office areas.
8. Restrooms.
11. Locker rooms.
12. Other spaces 300 square feet (28 m²) or less that are enclosed by floor-to-ceiling height partitions.
13. Warehouses.
14. Warehouse storage areas.

C405.2.1.1 Occupant sensor control function.
Occupant sensor controls in spaces other than 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 for all other spaces specified in Section C405.2.1 shall comply with the following:

1. Automatically they shall automatically turn off lights within 30 minutes after all occupants have left the space.
2. Be they shall be manual on or controlled to automatically turn on the lighting on to not more than 50 percent power.

Exception: Full automatic-on controls shall be permitted to control lighting in public corridors, stairways, restrooms, primary building entrance areas and lobbies, and areas where manual-on operation would endanger the safety or security of the room or building occupants.

3. Shall they shall incorporate a manual control to allow occupants to turn off lights.
C405.2.1.2 Occupant sensor control function in warehouses.
In warehouses, the lighting in aisles 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.

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 m²) 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 m²) within the open plan office space.

2. 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.

3. The controls shall be configured so that general lighting power 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.

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 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% when unoccupied for a period longer than 15 minutes.

Exceptions:

1. Egress areas not exceeding 50% 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.

Exception: Where a manual control provides light reduction in accordance with Section C405.2.2.2, automatic time-switch controls shall not be required for the following:
1. **Sleeping units.**

21. Spaces where patient care is directly provided.

32. Spaces where an automatic shutoff would endanger occupant safety or security.

43. Lighting intended for continuous operation.

54. Shop and laboratory classrooms.

**C405.2.2.1 Time-switch control function.**

Each space provided with *time-switch controls* shall also be provided with a *manual control* for light reduction in accordance with Section C405.2.2.2. Time-switch controls shall *comply* including an override switching device that complies with the following:

1. Have a minimum 7-day clock.

2. Be capable of being set for seven different day types per week.

3. Incorporate an automatic holiday “shutoff” feature, which turns off all controlled lighting loads for at least not fewer than 24 hours and then resumes normally scheduled operations.

4. Have program backup capabilities, which prevent the loss of program and time settings for at least not fewer than 10 hours, if power is interrupted.

5. Include an override switch that complies with the following:

   5.1. The override switch shall be a manual control.

   5.2. The override switch, when initiated, shall permit the controlled lighting to remain on for not more than 2 hours.

   5.3. Any individual override switch shall control the lighting for an area not larger than 5,000 square feet (465 m²).

**Exceptions:**

1. Within malls, arcades, small concourses, auditoriums, single-tenant retail spaces, industrial sales areas, manufacturing facilities and sports arenas:

   1.1. The time limit shall be permitted to be greater than 2 hours, provided that the override switch is a captive key device.

   1.2. The area controlled by the override switch is permitted shall not be limited to be greater than 5,000 square feet (465 m²), but shall not be greater provided that such area is less than 20,000 square feet (1860 m²).
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 ($3.2 \text{ W/m}^2$).

2.3. Corridors, lobbies, electrical rooms and or mechanical rooms.
C405.2.2.2 Light-reduction controls.
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 at least 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. Light reduction controls are not required in daylight zones with daylight responsive controls complying with Section C405.2.3.
2. Where provided with manual control, the following areas are not required to have light reduction control:
   - Spaces that have only one luminaire with a rated power of less than 4050 watts.
   - Spaces that use less than 0.36 watts per square foot (3.26.5 W/m²).
   - Corridors, equipment rooms, public lobbies, electrical or mechanical rooms.

C405.2.2.3 Manual controls.
Manual controls for lights shall comply with the following:

1. Shall be readily accessible to occupants.
2. Shall be located where the controlled lights are visible, or shall identify the area served by the lights and indicate their status.

C405.2.3 Daylight-responsive controls.
Daylight-responsive controls complying with Section C405.2.3.1 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 sidelight zones complying with Section 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 150 watts of general lighting within toplight zones complying with Section C405.2.3.3.

Exceptions: Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. Dwelling units and sleeping units.

32. Lighting that is required to have specific application control in accordance with Section C405.2.4.

4. Sidelight daylit zones on the first floor above grade in Group A-2 (such as restaurants and banquet halls or buildings containing food preparation areas) and Group M (Mercantile, such as grocery stores, department stores, gas stations, etc.) occupancies. (See Occupancy classifications in Section C202.)

4. Daylight zones where the total proposed lighting power density is less than 35 percent of the lighting power allowance per Section C405.3.2.

5. 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 (LPAdj) calculated in accordance with Equation 4-8:
\[ LPA_{\text{adj}} = \left( LPA_{\text{norm}} \times (1.0 - 0.4 \times \frac{UDZFA}{TBFA}) \right) \]  
(Equation 4-8)

where:

- \( LPA_{\text{adj}} \): Adjusted building interior lighting power allowance in watts.
- \( LPA_{\text{norm}} \): Normal building lighting power allowance in watts calculated in accordance with Section C405.3.2 and reduced in accordance with Section C406.3 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 C405.2.3.2 and C405.2.3.3, 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.

C405.2.3.1 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 \( dayligthtoplit \) zones in accordance with Section C405.2.3.3 shall be controlled independently of lights in sidelit \( dayligthsidelit \) zones in accordance with Section C405.2.3.2.

2. Daylight responsive controls within each space shall be configured so that they can be calibrated from within that space by authorized personnel.

3. Calibration mechanisms shall be readily accessible in a location with ready access.

4. Where located in offices, classrooms, laboratories and library reading rooms, daylight responsive controls shall dim lights continuously from full light output to 15 percent of full light output or lower.

5. Daylight responsive controls shall be capable of a complete shutoff of all controlled lights.

6. Lights in sidelit \( dayligthsidelit \) zones in accordance with Section C405.2.3.2 facing different cardinal orientations [i.e., 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 m²).

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.

Exception: 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.

C405.2.3.2 Sidelight 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 sidelight 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.

C405.2.3.2 Sidelit Zone.

The sidelite zone is the floor area adjacent to vertical fenestration which complies with all of the following:

1. Where the fenestration is located in a wall, the 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), whichever is less, as indicated in Figure C405.2.3.2(4).

2. The area of the fenestration is not less than 24 square feet (2.23 m²).

3. 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. The visible transmittance of the fenestration is not less than 0.20.

5. Where clerestory fenestration is located in a wall, the sidelite 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. 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. Where located in existing buildings, the visible transmittance of the fenestration is no less than 0.20.

8. 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.

---

**FIGURE C405.2.3.2 SIDELIT ZONE**

**C405.2.3.3 Toplit zone.**
The toplit zone is the floor area underneath a roof fenestration assembly that complies with all of the following:

1. The toplit 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 C405.2.3.3(1).
2. Where the fenestration is located in a rooftop monitor, the daylight\textsuperscript{top}lit 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 C405.2.3.23(2) and C405.2.3.23(3).

3. **Direct** The area of the fenestration is not less than 24 square feet (2.23 m\textsuperscript{2}).

4. The distance from the fenestration to any building or geological formation which 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.

5. Where located in existing buildings, the visible transmittance of the fenestration is not less than 0.20.

---

**FIGURE C405.2.3.2(1)**

**DAYLIGHT ZONE ADJACENT TO FENESTRATION IN A WALL**

**FIGURE C405.2.3.2(2)**

**DAYLIGHT ZONE UNDER A ROOFTOP MONITOR**
C405.2.3.3 Toplight daylight zone.
The toplight daylight zone is the floor area underneath a roof fenestration assembly which complies with all of the following:

1. The 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 C405.2.3.3.

2. No building or geological formation blocks 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.

3. Where located in existing buildings, 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 daylight zone is not less than 0.008.

5. Where toplight daylight zones overlap with sidelight daylight zones, lights within the overlapping area shall be assigned to the toplight daylight zone.
FIGURE C405.2.3.3(1)
TOPLIT ZONE

(a) Section view
(b) Plan view of daylight zone under a roof fenestration assembly

FIGURE C405.2.3.3(2)
DAYLIGHT ZONE UNDER A ROOFTOP MONITOR

(a) Section view
(b) Plan view of daylight zone under a rooftop monitor
C405.2.4 Specific application controls.
Specific application controls shall be provided for the following:

**ASSEMBLY**

1. **Display and accent light** The following lighting shall be controlled by a dedicated occupant sensor complying with Section C405.2.1.1 or a time-switch control that is independent of complying with Section C405.2.2.1. In addition, a manual control shall be provided to control such lighting separately from the controls for other general lighting within the room or space.
1.1. Display and accent.

1.2. Lighting in cases used for display purposes.

1.3. Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting.

1.4. Lighting equipment that is for sale or demonstration in lighting education.

2. Sleeping units shall be controlled by a dedicated control device or systems that is independent of the controls for other lighting within the room or space.

3. Hotel and motel sleeping units and guest suites shall have a master control device that is capable of being configured to automatically switch off all permanently installed luminaires and switched receptacles within 20 minutes after all occupants have left the room.

Exceptions:

Exception:

1. Lighting and switched receptacles controlled by captive card key systems.

4. Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting, shall have a control device integral to the luminaires or be controlled by a wall-mounted control device provided that the control device is readily accessible.

52. 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 C405.2.2.2.

4. Lighting for non-visual applications, such as plant growth and food warming, shall be controlled by a dedicated control that is independent of the controls for other lighting within the room or space.

6. Lighting equipment that is for sale or for demonstrations in lighting education shall be controlled by a dedicated control or time switch control complying with Section C405.2.2.1 that is independent of the controls for other lighting within the room or space.

C405.2.5 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 Exterior lighting controls.
Exterior lighting systems shall be provided with controls that comply with Sections C405.2.6.1 through C405.2.6.4. Decorative lighting systems shall comply with Sections C405.2.6.1, C405.2.6.2 and C405.2.6.4.

Exceptions:
1. Lighting for exterior applications other than emergency lighting that is intended to cover vehicle entrances and exits from buildings and parking structures where required for eye adaptation.

2. Lighting controlled from within dwelling units.

**C405.2.6.1 Daylight shutoff.**
Lights shall be automatically turned off during building operation, lighting specifically required to meet health and life safety requirements or decorative gas lighting systems shall: when daylight is present and satisfies the lighting needs.

1. Be provided with a control that automatically turns off the **C405.2.6.2 Decorative lighting** as a function of available daylight.

2. Where lighting the building façade or shutoff, building facade and landscape, the lighting shall have controls that automatically shut off the lighting as a function of dawn/dusk and a set opening and closing time from not later than 1 hour after business closing to not earlier than 1 hour before business opening.

**C405.2.6.3 Lighting setback.**
Lighting that is not covered controlled in Item 2, according with Section C405.2.6.2 shall be controlled so that the total wattage of such lighting shall have controls configured to automatically reduce the connected lighting power by not less than 30 percent from by selectively switching off or dimming luminaires at one of the following times:

1. From not later than midnight to not earlier than 6 a.m., from...

2. From not later than one hour after business closing to not earlier than one hour before business opening or during...

3. From any period when activity has not been detected for a time of longer than 15 minutes or more.

-All
**C405.2.6.4 Exterior time switches-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 able to retain programming 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 the time setting during loss of power settings for a period of at least not less than 10 hours in the event that power is interrupted.

**Exception:** Lighting for covered vehicle entrances or exits from buildings or parking structures where required for safety, security or eye adaptation.

**C405.3 Exit signs (Mandatory).**

Internally illuminated exit signs shall not be more than 5 watts per side.

**C405.43 Interior lighting power requirements (Prescriptive).**

A building complies with this section where its total connected interior lighting power calculated under Section C405.43.1 is not greater than the interior lighting power allowance calculated under Section C405.43.2.

**C405.4 Exceptions:** 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 4-79.

\[
TCLP = [SLLVL + LV + LTPB + Other]
\]  \hspace{1cm} \text{(Equation 4-7)}

\[
TCLP = [LVL + BLL + LED + TRK + Other]
\]  \hspace{1cm} \text{(Equation 4-9)}

where:

\[
TCLP = \text{Total connected lighting power (watts)}. \\
SLLVL = \text{Labeled wattage of For luminaires for screw-in with lamps connected directly to building power, such as line voltage lamps, the rated wattage of the lamp}. \\
LV = \text{Wattage of the transformer supplying low-voltage lighting For luminaires incorporating a ballast or transformer, the rated input wattage of}
\]
the ballast or transformer when operating that lamp.

\[
\text{LED} = \text{For light-emitting diode luminaires with either integral or remote drivers, the rated wattage of the luminaire.}
\]

\[
\text{LTPBT RK} = \text{Wattage of line-voltage for lighting track, cable conductor, rail conductor, and plug-in busways as busway systems that allow the specified addition and relocation of luminaires without rewiring, the wattage shall be one of the luminaires, but at least 30 W/lin. ft. (100 W/lin m), or the wattage limit of the system’s circuit breaker, or the wattage limit of other permanent current-limiting devices on the system following:}
\]

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.

\[
\text{Other} = \text{The wattage of all other luminaires and lighting sources not covered previously and associated with interior lighting verified by data supplied by the manufacturer or other approved sources.}
\]

**Exceptions:**

1. The connected power associated with the following lighting equipment and applications is not included in calculating total connected lighting power.
   1.1. Professional sports arena playing field lighting.
   1.2. Lighting Additionally, for multiple systems installed in sleeping units, provided circadian rhythm systems only include the maximum power that the lighting complies with Section R404.1 would be on at any one time.
   1.3. Television broadcast lighting for playing areas in sports arenas.
   1.4. Emergency lighting automatically off during normal building operation.
   1.5. 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.
   1.6. Casino gaming areas.
1.75. Mirror lighting in dressing rooms.

2. Lighting equipment used for the following shall be exempt provided it is in addition to general lighting and is controlled by an independent control device:

2.1. Task lighting for medical and dental purposes.

2.2. Display lighting for exhibits in galleries, museums and monuments that is in addition to general lighting and controlled by an independent control device.

3. Lighting for theatrical purposes, including performance, stage, film production and video production.

4. Lighting for photographic processes.

5. Lighting integral to equipment or instrumentation and installed by the manufacturer.

6. Task lighting for plant growth or maintenance provided it is limited to no more than 1.5 W per square foot.

7. Advertising signage or directional signage.

8. In restaurant buildings and areas, lighting for food warming or integral to food preparation equipment.

9. Lighting equipment that is for sale.

10. Lighting demonstration equipment in lighting education facilities.

11. Lighting approved because of safety or emergency considerations, inclusive of exit lights.

12. Lighting integral to both open and glass-enclosed refrigerator and freezer cases.

13. Lighting in retail display windows, provided that the display area is enclosed by ceiling-height partitions.

14. Furniture-mounted supplemental task lighting that is controlled by automatic shutoff.

15. Exit signs.

C405.43.2 Interior lighting power allowance.
The total interior lighting power allowance (watts) is determined according to Table C405.43.2(1) using the Building Area Method, or Table C405.43.2(2) using the Space-by-Space Method, for all areas of the building covered in this permit.
### TABLE C405.43.2(1)
**INTERIOR LIGHTING POWER ALLOWANCES: BUILDING AREA METHOD**

<table>
<thead>
<tr>
<th>BUILDING AREA TYPE</th>
<th>LPD (w/ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive facility</td>
<td>0.8060</td>
</tr>
<tr>
<td>Convention</td>
<td>1.040.70</td>
</tr>
<tr>
<td>Courthouse</td>
<td>1.040.76</td>
</tr>
<tr>
<td>Dining: bar lounge/leisure</td>
<td>1.040.76</td>
</tr>
<tr>
<td>Dining: cafeteria/fast food</td>
<td>0.8057</td>
</tr>
<tr>
<td>Dining: family</td>
<td>0.8569</td>
</tr>
<tr>
<td>Dormitory</td>
<td>0.5747</td>
</tr>
<tr>
<td>Exercise center</td>
<td>0.8459</td>
</tr>
<tr>
<td>Fire station</td>
<td>0.6748</td>
</tr>
<tr>
<td>Gymnasium</td>
<td>0.8464</td>
</tr>
<tr>
<td>Health care clinic</td>
<td>0.9069</td>
</tr>
<tr>
<td>Hospital</td>
<td>1.050.84</td>
</tr>
<tr>
<td>Hotel/Motel</td>
<td>0.8765</td>
</tr>
<tr>
<td>Library</td>
<td>1.190.78</td>
</tr>
<tr>
<td>Manufacturing facility</td>
<td>1.170.82</td>
</tr>
<tr>
<td>Motion picture theater</td>
<td>0.7664</td>
</tr>
<tr>
<td>Multifamily</td>
<td>0.8448</td>
</tr>
<tr>
<td>Museum</td>
<td>1.020.83</td>
</tr>
<tr>
<td>Office</td>
<td>0.8264</td>
</tr>
<tr>
<td>Parking garage</td>
<td>0.2414</td>
</tr>
<tr>
<td>Penitentiary</td>
<td>0.8462</td>
</tr>
<tr>
<td>Performing arts theater</td>
<td>1.3902</td>
</tr>
<tr>
<td>Police station</td>
<td>0.8767</td>
</tr>
<tr>
<td>Post office</td>
<td>0.8761</td>
</tr>
<tr>
<td>Religious building</td>
<td>1.000.77</td>
</tr>
<tr>
<td>Retail</td>
<td>1.260.92</td>
</tr>
<tr>
<td>School/university</td>
<td>0.8767</td>
</tr>
<tr>
<td>Sports arena</td>
<td>0.8471</td>
</tr>
<tr>
<td>Town hall</td>
<td>0.8967</td>
</tr>
<tr>
<td>Transportation</td>
<td>0.7052</td>
</tr>
<tr>
<td>Warehouse</td>
<td>0.8043</td>
</tr>
<tr>
<td>Workshop</td>
<td>1.190.83</td>
</tr>
</tbody>
</table>

- **a.** Where sleeping units are excluded from lighting power calculations when 90% of the sleeping units’ lamps or fixtures is high-efficiency, 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-efficiency, 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.

### TABLE C405.43.2(2)
# INTERIOR LIGHTING POWER ALLOWANCES:
## SPACE-BY-SPACE METHOD

<table>
<thead>
<tr>
<th>COMMON SPACE TYPESa</th>
<th>LPD (watts/sq.ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Atrium</strong></td>
<td></td>
</tr>
<tr>
<td>Less than 40 feet in height</td>
<td>0.03 per foot in total height</td>
</tr>
<tr>
<td>Greater than 40 feet in height</td>
<td>0.40 + 0.02 per foot in total height</td>
</tr>
<tr>
<td><strong>Audience seating area</strong></td>
<td></td>
</tr>
<tr>
<td>In an auditorium</td>
<td>0.6552</td>
</tr>
<tr>
<td>In a convention center</td>
<td>0.8266</td>
</tr>
<tr>
<td>In a gymnasium</td>
<td>0.6552</td>
</tr>
<tr>
<td>In a motion picture theater</td>
<td>4.440.91</td>
</tr>
<tr>
<td>In a penitentiary</td>
<td>0.2822</td>
</tr>
<tr>
<td>In a performing arts theater</td>
<td>2.491.77</td>
</tr>
<tr>
<td>In a religious building</td>
<td>1.5322</td>
</tr>
<tr>
<td>In a sports arena</td>
<td>0.4334</td>
</tr>
<tr>
<td>Otherwise</td>
<td>0.4334</td>
</tr>
<tr>
<td><strong>Banking/processing activity area</strong></td>
<td>4.040.74</td>
</tr>
<tr>
<td><strong>Breakroom (See Lounge/Breakroom)</strong></td>
<td></td>
</tr>
<tr>
<td>In a penitentiary</td>
<td>1.3407</td>
</tr>
<tr>
<td>Otherwise</td>
<td>4.240.87</td>
</tr>
<tr>
<td><strong>Computer room</strong></td>
<td>1.21</td>
</tr>
<tr>
<td><strong>Conference/meeting/multipurpose room</strong></td>
<td>1.230.92</td>
</tr>
<tr>
<td><strong>Copy/print room</strong></td>
<td>0.7251</td>
</tr>
<tr>
<td><strong>Corridor</strong></td>
<td></td>
</tr>
<tr>
<td>In a facility for the elderly or visually impaired (and not used primarily by the staff) b</td>
<td>0.92</td>
</tr>
<tr>
<td>In a hospital</td>
<td>0.79</td>
</tr>
<tr>
<td>In a manufacturing facility</td>
<td>0.4129</td>
</tr>
<tr>
<td>Otherwise</td>
<td>0.66</td>
</tr>
<tr>
<td><strong>Courtroom</strong></td>
<td>1.7224</td>
</tr>
<tr>
<td><strong>Computer room</strong></td>
<td>1.71</td>
</tr>
<tr>
<td><strong>Dining area</strong></td>
<td></td>
</tr>
<tr>
<td>In a penitentiary</td>
<td>In bar/lounge or leisure dining</td>
</tr>
<tr>
<td>In cafeteria or fast food dining</td>
<td>0.51</td>
</tr>
<tr>
<td>In a facility for the visually impaired (and not used primarily by the staff) b</td>
<td>1.9956</td>
</tr>
<tr>
<td>In a sports facility (and not used primarily by the staff)</td>
<td>1.97</td>
</tr>
<tr>
<td>In cafeteria or fast food dining</td>
<td>0.65</td>
</tr>
<tr>
<td>In family dining</td>
<td>0.8964</td>
</tr>
<tr>
<td>In a penitentiary</td>
<td>0.77</td>
</tr>
<tr>
<td>Otherwise</td>
<td>0.6551</td>
</tr>
<tr>
<td><strong>Electrical/mechanical room</strong></td>
<td>0.9543</td>
</tr>
<tr>
<td><strong>Emergency vehicle garage</strong></td>
<td>0.5638</td>
</tr>
<tr>
<td><strong>Food preparation area</strong></td>
<td>4.24</td>
</tr>
</tbody>
</table>

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2015 Vermont Commercial Building Energy Standards

2019 VERMONT COMMERCIAL BUILDING ENERGY STANDARDS
**TABLE C405.43.2(2)—continued**

**INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD**

<table>
<thead>
<tr>
<th>COMMON SPACE TYPES</th>
<th>LPD (watts/sq.ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food preparation area</td>
<td>0.90</td>
</tr>
<tr>
<td>Guest room</td>
<td>0.47</td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
</tr>
<tr>
<td>In or as a classroom</td>
<td>1.05</td>
</tr>
<tr>
<td>Otherwise</td>
<td>1.30</td>
</tr>
<tr>
<td>Laundry/washing area</td>
<td>0.41</td>
</tr>
<tr>
<td>Loading dock, interior</td>
<td>0.42</td>
</tr>
<tr>
<td>Lobby</td>
<td></td>
</tr>
<tr>
<td>In a facility for the visually impaired (and not used primarily by the staff)</td>
<td>1.21</td>
</tr>
<tr>
<td>For an elevator</td>
<td>1.80</td>
</tr>
<tr>
<td>In a facility for the elderly or visually impaired (and not used primarily by the staff)</td>
<td>0.64</td>
</tr>
<tr>
<td>In a hotel</td>
<td>4.06</td>
</tr>
<tr>
<td>In a motion picture theater</td>
<td>0.59</td>
</tr>
<tr>
<td>In a performing arts theater</td>
<td>2.00</td>
</tr>
<tr>
<td>Otherwise</td>
<td>0.90</td>
</tr>
<tr>
<td>Locker room</td>
<td>0.75</td>
</tr>
<tr>
<td>Lounge/breakroom</td>
<td>0.92</td>
</tr>
<tr>
<td>In a healthcare facility</td>
<td></td>
</tr>
<tr>
<td>Otherwise</td>
<td>0.73</td>
</tr>
<tr>
<td>Office</td>
<td></td>
</tr>
<tr>
<td>Enclosed</td>
<td>4.14</td>
</tr>
<tr>
<td>Open plan</td>
<td>0.98</td>
</tr>
<tr>
<td>Parking area, interior</td>
<td>0.49</td>
</tr>
<tr>
<td>Pharmacy area</td>
<td>1.68</td>
</tr>
<tr>
<td>Restroom</td>
<td></td>
</tr>
<tr>
<td>In a facility for the elderly or visually impaired (and not used primarily by the staff)</td>
<td>1.21</td>
</tr>
<tr>
<td>Otherwise</td>
<td>0.99</td>
</tr>
<tr>
<td>Sales area</td>
<td>1.59</td>
</tr>
<tr>
<td>Seating area, general</td>
<td>0.54</td>
</tr>
<tr>
<td>Stairway (See space containing stairway)</td>
<td></td>
</tr>
<tr>
<td>Stairwell</td>
<td>0.69</td>
</tr>
<tr>
<td>Building Type Specific Space Types</td>
<td>LPD (watts/sq.ft)</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Storage room</td>
<td>0.6343</td>
</tr>
<tr>
<td>Vehicular maintenance area</td>
<td>0.8749</td>
</tr>
<tr>
<td>Workshop</td>
<td>1.6908</td>
</tr>
<tr>
<td><strong>Building Type Specific Space Types</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Facility for the visually impaired</strong></td>
<td></td>
</tr>
<tr>
<td>Automotive (see Vehicular maintenance area)</td>
<td></td>
</tr>
<tr>
<td>Convention Center—exhibit space</td>
<td>2.2108</td>
</tr>
<tr>
<td>In a recreation room (and not used primarily by the staff)</td>
<td>2.41</td>
</tr>
<tr>
<td><strong>Automotive (See Vehicular Maintenance Area above)</strong></td>
<td></td>
</tr>
<tr>
<td>In a chapel (and not used primarily by the staff)</td>
<td>1.4506</td>
</tr>
<tr>
<td><strong>Dormitory—living quarters</strong></td>
<td>0.38167</td>
</tr>
<tr>
<td>In a recreation room (and not used primarily by the staff)</td>
<td>0.2217</td>
</tr>
<tr>
<td><strong>Gymnasium/fitness center</strong></td>
<td>1.4506</td>
</tr>
<tr>
<td>In an exercise area</td>
<td>0.7248</td>
</tr>
<tr>
<td>In a playing area</td>
<td>4.290.80</td>
</tr>
<tr>
<td><strong>Healthcare Facility</strong></td>
<td>1.4506</td>
</tr>
<tr>
<td>In an exam/treatment room</td>
<td>1.66</td>
</tr>
<tr>
<td>In an imaging room</td>
<td>1.51</td>
</tr>
<tr>
<td>In a medical supply room</td>
<td>0.74</td>
</tr>
<tr>
<td>In a nursery</td>
<td>0.88</td>
</tr>
<tr>
<td>In a nurse’s station</td>
<td>0.71</td>
</tr>
<tr>
<td>(continued)</td>
<td></td>
</tr>
<tr>
<td><strong>TABLE C405.43.2(2)—continued</strong></td>
<td></td>
</tr>
<tr>
<td><strong>INTERIOR LIGHTING POWER ALLOWANCES:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SPACE-BY-SPACE METHOD</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Building Type Specific Space Types</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Healthcare Facility—continued</strong></td>
<td></td>
</tr>
<tr>
<td>In an exam/treatment room</td>
<td>1.34</td>
</tr>
<tr>
<td>In an imaging room</td>
<td>1.02</td>
</tr>
<tr>
<td>In a medical supply room</td>
<td>0.51</td>
</tr>
<tr>
<td>In a nursery</td>
<td>0.76</td>
</tr>
<tr>
<td>In a nurse’s station</td>
<td>0.61</td>
</tr>
<tr>
<td>In an operating room</td>
<td>2.481.85</td>
</tr>
<tr>
<td>In a patient room</td>
<td>0.6250</td>
</tr>
<tr>
<td>In a physical therapy room</td>
<td>0.9470</td>
</tr>
<tr>
<td>In a recovery room</td>
<td>4.450.87</td>
</tr>
<tr>
<td>Library</td>
<td>4.060.75</td>
</tr>
<tr>
<td>In a reading area</td>
<td></td>
</tr>
<tr>
<td>In the stacks</td>
<td>1.7115</td>
</tr>
<tr>
<td>Manufacturing facility</td>
<td></td>
</tr>
<tr>
<td>In a detailed manufacturing area</td>
<td>4.290.88</td>
</tr>
<tr>
<td>In an equipment room</td>
<td>0.7455</td>
</tr>
<tr>
<td>Area Description</td>
<td>U-value</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>In an extra-high-bay area (greater than 50’ floor-to-ceiling height)</td>
<td>0.841.05</td>
</tr>
<tr>
<td>In a high-bay area (25-50’ floor-to-ceiling height)</td>
<td>1.230.75</td>
</tr>
<tr>
<td>In a low-bay area (less than 25’ floor-to-ceiling height)</td>
<td>1.190.85</td>
</tr>
<tr>
<td>Museum</td>
<td>1.050.84</td>
</tr>
<tr>
<td>In a general exhibition area</td>
<td></td>
</tr>
<tr>
<td>In a restoration room</td>
<td>0.744.02</td>
</tr>
<tr>
<td>Performing arts theater—dressing room</td>
<td>0.6436</td>
</tr>
<tr>
<td>Post Office—Sorting Area</td>
<td>0.9464</td>
</tr>
<tr>
<td>Religious buildings</td>
<td></td>
</tr>
<tr>
<td>In a fellowship hall</td>
<td>0.6447</td>
</tr>
<tr>
<td>In a worship/pulpit/choir area</td>
<td>1.6922</td>
</tr>
<tr>
<td>Retail facilities</td>
<td></td>
</tr>
<tr>
<td>In a dressing/fitting room</td>
<td>0.7448</td>
</tr>
<tr>
<td>In a mall concourse</td>
<td>1.190.80</td>
</tr>
<tr>
<td>Sports arena—playing area</td>
<td></td>
</tr>
<tr>
<td>For a Class I facility</td>
<td>2.173.00</td>
</tr>
<tr>
<td>For a Class II facility</td>
<td>1.9055</td>
</tr>
<tr>
<td>For a Class III facility</td>
<td>1.2017</td>
</tr>
<tr>
<td>For a Class IV facility</td>
<td>0.70</td>
</tr>
</tbody>
</table>

(continued)
TABLE C405.3.2(2)—continued
INTERIOR LIGHTING POWER ALLOWANCES:
SPACE-BY-SPACE METHOD

<table>
<thead>
<tr>
<th>BUILDING TYPE SPECIFIC SPACE TYPES(^a)</th>
<th>LPD (watts/sq.ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation facility</td>
<td></td>
</tr>
<tr>
<td>In a baggage/carousel area</td>
<td>0.6339</td>
</tr>
<tr>
<td>In an airport concourse</td>
<td>0.3627</td>
</tr>
<tr>
<td>At a terminal ticket counter</td>
<td>0.8056</td>
</tr>
<tr>
<td>Warehouse—storage area</td>
<td></td>
</tr>
<tr>
<td>For medium to bulky, palletized items</td>
<td>0.6835</td>
</tr>
<tr>
<td>For smaller, hand-carried items</td>
<td>0.9565</td>
</tr>
</tbody>
</table>

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-efficiency, 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-efficiency, 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.

C405.43.2.1 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 C405.43.2(1) times the value from Table C405.43.2(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 C405.43.2(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.
C405.4.3.2.2 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 C405.4.3.2(2) that most closely represents the proposed use of the space, and then summing the lighting power allowances for all spaces. Trade-offs among spaces are permitted.

405.4C405.3.2.2.1 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. 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 4-810.

   Additional interior lighting power allowance = 250 W + (Retail Area 1 × 2.13 W/m²) + (Retail Area 2 × 2.15 W/m²) + (Retail Area 3 × 5.24 W/m²) + (Retail Area 4 × 9.63 W/m²) (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.

   SI units:

   Additional interior lighting power allowance = 250 W + (Retail Area 1 × 0.620 W/ft²) + (Retail Area 2 × 0.620 W/ft²) + (Retail Area 3 × 1.4 × 0.50 W/ft²) + (Retail Area 4 × 2.5 × 0.90 W/ft²)
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 or other authority having jurisdiction.

2. For spaces in which lighting is specified to be installed in addition to the general lighting for the purpose of decorative appearance or for highlighting art or exhibits, provided that the additional lighting power shall be not more than 10.7 w/ft$^2$ of such spaces.

C405.54 Exterior lighting power requirements (Mandatory).
Where the power for the total connected exterior lighting is supplied through the energy service to the building, all exterior lighting shall comply with Section C405.54.1 shall be not greater than the exterior lighting power allowance calculated in accordance with Section C405.4.2 and C405.5.24.3. Appropriate exterior lighting designs including maximum exterior illuminance levels may be required by the District Environmental Commission for Act 250 projects.

C405.4.1 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: Where lighting used for the following applications shall not be included.

1. Lighting approved because of historical, safety, signage or emergency 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.
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 R404.1.
C405.5.14.2 Exterior building lighting power.  
The total exterior lighting power allowance for all exterior building applications 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 permitted as specified in Table C405.54.2(2) for the applicable lighting zone. Trade-offs are allowed only among exterior lighting applications listed in Table C405.5.2(2), in the Tradable Surfaces section. The lighting zone for the building exterior is determined from Table C405.54.2(1) unless otherwise specified by the local jurisdiction code official.

Exception: Lighting used for the following exterior applications is exempt where equipped with a control device independent of the control of the nonexempt lighting:

1. Specialized signal, directional and marker lighting associated with transportation.
2. Advertising signage or directional signage.
3. Integral to equipment or instrumentation and is installed by its manufacturer.
4. Theatrical purposes, including performance, stage, film production and video production.
5. Athletic playing areas.
6. Temporary lighting.
7. Industrial production, material handling, transportation sites and associated storage areas.
8. Theme elements in theme/amusement parks.
9. Used to highlight features of public monuments and registered historic landmark structures or buildings.

C405.5.2 Exterior fixtures.  
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.

<table>
<thead>
<tr>
<th>LIGHTING ZONE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Developed areas of national parks, state parks, forest land, and rural areas</td>
</tr>
<tr>
<td>2</td>
<td>Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed-use areas</td>
</tr>
<tr>
<td>3</td>
<td>All other areas not classified as lighting zone 1–2 or 42</td>
</tr>
<tr>
<td>4</td>
<td>High-activity commercial districts in major metropolitan areas as designated by the local land-use planning authority</td>
</tr>
</tbody>
</table>
# TABLE C405.54.2(2)
## INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

<table>
<thead>
<tr>
<th>LIGHTING ZONES</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base Site Allowance</strong></td>
<td>500 W</td>
<td>600 W</td>
<td>700 W</td>
<td>1300 W</td>
</tr>
<tr>
<td><strong>Uncovered Parking Areas</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parking areas and drives</td>
<td>0.04 W/ft²</td>
<td>0.06 W/ft²</td>
<td>0.08 W/ft²</td>
<td>0.13 W/ft²</td>
</tr>
<tr>
<td>Walkways less than 10 feet wide</td>
<td>0.735 W/linear foot</td>
<td>0.735 W/linear foot</td>
<td>0.840 W/linear foot</td>
<td>4.0 W/linear foot</td>
</tr>
<tr>
<td>Walkways 10 feet wide or greater, plaza areas special feature areas</td>
<td>0.407 W/ft²</td>
<td>0.407 W/ft²</td>
<td>0.460 W/ft²</td>
<td></td>
</tr>
<tr>
<td><strong>Dining areas</strong></td>
<td>0.50 W/ft²</td>
<td>0.50 W/ft²</td>
<td>0.60 W/ft²</td>
<td></td>
</tr>
<tr>
<td><strong>Stairways</strong></td>
<td>0.754 W/ft²</td>
<td>1.05 W/ft²</td>
<td>1.05 W/ft²</td>
<td>1.05 W/ft²</td>
</tr>
<tr>
<td><strong>Pedestrian tunnels</strong></td>
<td>0.15 W/ft²</td>
<td>0.15 W/ft²</td>
<td>0.21 W/ft²</td>
<td></td>
</tr>
<tr>
<td><strong>Landscaping</strong></td>
<td>0.02 W/ft²</td>
<td>0.03 W/ft²</td>
<td>0.03 W/ft²</td>
<td></td>
</tr>
<tr>
<td><strong>Building Entrances and Exits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedestrian and vehicular entrances and exits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main entries</td>
<td>2010 W/linear foot of door width</td>
<td>2010 W/linear foot of door width</td>
<td>3015 W/linear foot of door width</td>
<td>30 W/linear foot of door width</td>
</tr>
<tr>
<td>Other doors, 0.10 W/ft²</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loading docks</td>
<td>0.25 W/ft²</td>
<td>0.25 W/ft²</td>
<td>0.25 W/ft²</td>
<td></td>
</tr>
<tr>
<td><strong>Sales Canopies</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free-standing and attached</td>
<td>0.63 W/ft²</td>
<td>0.63 W/ft²</td>
<td>0.84 W/ft²</td>
<td>1.0 W/ft²</td>
</tr>
<tr>
<td><strong>Outdoor Sales</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open areas (including vehicle sales lots)</td>
<td>0.25 W/ft²</td>
<td>0.15 W/ft²</td>
<td>0.25 W/ft²</td>
<td></td>
</tr>
<tr>
<td>Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas are tradable)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nontradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting.) The following allowances are in addition to any allowance otherwise permitted in the “Tradable Surfaces” section of this table.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Street frontage for vehicle sales lots in addition to &quot;open area&quot; allowance</td>
<td>No allowance</td>
<td><strong>105 W/linear foot</strong></td>
<td><strong>105 W/linear foot</strong></td>
<td><strong>30 W/linear foot</strong></td>
</tr>
<tr>
<td>Building facades</td>
<td>No allowance</td>
<td>0.075 W/ft² of gross above-grade wall area</td>
<td>0.113 W/ft² of gross above-grade wall area</td>
<td></td>
</tr>
<tr>
<td>Automated teller machines (ATM) and night depositories</td>
<td>279135 W per location plus 9045 W per additional ATM per location</td>
<td>279135 W per location plus 9045 W per additional ATM per location</td>
<td>279135 W per location plus 9045 W per additional ATM per location</td>
<td></td>
</tr>
<tr>
<td>Entrances and gatehouse inspection stations at guarded facilities</td>
<td>0.755 W/ft² of covered and uncovered area</td>
<td>0.755 W/ft² of covered and uncovered area</td>
<td>0.755 W/ft² of covered and uncovered area</td>
<td></td>
</tr>
<tr>
<td>Loading areas for law enforcement, fire, ambulance and other emergency service vehicles</td>
<td>0.535 W/ft² of covered and uncovered area</td>
<td>0.535 W/ft² of covered and uncovered area</td>
<td>0.535 W/ft² of covered and uncovered area</td>
<td></td>
</tr>
<tr>
<td>Drive-up windows/doors</td>
<td>400200 W per drive-through</td>
<td>400200 W per drive-through</td>
<td>400200 W per drive-through</td>
<td></td>
</tr>
<tr>
<td>Parking near 24-hour retail entrances</td>
<td>890400 W per main entry</td>
<td>809400 W per main entry</td>
<td>809400 W per main entry</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m². 
W = watts.

\[ W = \text{watts}. \]

**C405.4.3 Exterior fixtures.**
Exterior lighting shall be full cut off fixtures, limiting the light output to less than 10% at and below 10 degrees below the horizontal. **C405.6 Electrical energy consumption** Fixtures shall be independently certified by manufacturer as full cut off, or meet the definition of a fully shielded light fixture.

**C405.4 Gas lighting (Mandatory).**
Gas-fired lighting appliances shall not be equipped with continuously burning pilot ignition systems.

**C405.5 Dwelling electrical meter** (Mandatory).
Each dwelling unit located in a Group R-2 building (see occupancy classification) shall have a separate electrical meter.
C405.76 Electrical transformers (Mandatory).
Electric low-voltage dry-type distribution electric transformers shall meet the minimum efficiency requirements of Table C405.76 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.

### Table C405.7
**Minimum Nominal Efficiency Levels for 10 CFR 431 Low-Voltage Dry-Type Distribution Transformers**

<table>
<thead>
<tr>
<th>Single-Phase Transformers</th>
<th>Three-Phase Transformers</th>
</tr>
</thead>
<tbody>
<tr>
<td>kVA</td>
<td>Efficiency (%)</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>15</td>
<td>97.7</td>
</tr>
<tr>
<td>25</td>
<td>98.0</td>
</tr>
<tr>
<td>37.5</td>
<td>98.2</td>
</tr>
<tr>
<td>50</td>
<td>98.3</td>
</tr>
<tr>
<td>75</td>
<td>98.5</td>
</tr>
<tr>
<td>100</td>
<td>98.6</td>
</tr>
<tr>
<td>167</td>
<td>98.7</td>
</tr>
<tr>
<td>250</td>
<td>98.8</td>
</tr>
<tr>
<td>333</td>
<td>98.9</td>
</tr>
<tr>
<td>500</td>
<td>98.9</td>
</tr>
<tr>
<td>1000</td>
<td>98.9</td>
</tr>
</tbody>
</table>

**Note:** After January 1, 2016, refer to the updated version of 10 CFR 431.
b. Nominal efficiencies shall be established in accordance with the DOE 10 CFR 431 test procedure for low-voltage dry-type transformers.

Exceptions: The following transformers are exempt:


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 at least \textit{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.


12. Welding transformers.


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.
12. Welding transformers.
### TABLE C405.6
MINIMUM NOMINAL EFFICIENCY LEVELS FOR 10 CFR 431 LOW-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMERS

<table>
<thead>
<tr>
<th>SINGLE-PHASE TRANSFORMERS</th>
<th>THREE-PHASE TRANSFORMERS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>kVA</strong></td>
<td><strong>Efficiency (%)</strong></td>
</tr>
<tr>
<td>15</td>
<td>97.70</td>
</tr>
<tr>
<td>25</td>
<td>98.00</td>
</tr>
<tr>
<td>37.5</td>
<td>98.20</td>
</tr>
<tr>
<td>50</td>
<td>98.30</td>
</tr>
<tr>
<td>75</td>
<td>98.50</td>
</tr>
<tr>
<td>100</td>
<td>98.60</td>
</tr>
<tr>
<td>167</td>
<td>98.70</td>
</tr>
<tr>
<td>250</td>
<td>98.80</td>
</tr>
<tr>
<td>333</td>
<td>98.90</td>
</tr>
<tr>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

*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.

8-Electrical C405.7 Electric motors (Mandatory).

Electric motors shall meet the minimum efficiency requirements of Tables C405.87(1) through C405.87(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 C405.87(1)
MINIMUM NOMINAL FULL-LOAD EFFICIENCY FOR 60-HZ NEMA GENERAL PURPOSE DESIGN A, NEMA DESIGN B, AND IEC DESIGN N MOTORS (EXCLUDING FIRE PUMP) ELECTRIC MOTORS (SUBTYPE I) RATED 600-VOLTS OR LESS (Random Wound) \(^a\) AT 60 HZ \(^{a,b}\)

<table>
<thead>
<tr>
<th>MOTOR HORSEPOWER (STANDARD KILOWATT EQUIVALENT)</th>
<th>NUMBER-OF-POLES</th>
<th>NOMINAL FULL-LOAD EFFICIENCY (%) AS OF JUNE 1, 2016</th>
<th>OPEN-Drip-PROOF-MOTORS</th>
<th>TOTALLY-ENCLOSED-FAN-COOLED-MOTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 Pole</td>
<td>4 Pole</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6 Pole</td>
<td>8 Pole</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10 Pole</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Pole</td>
<td>4 Pole</td>
<td>6 Pole</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3600 Open</td>
<td>3600 Encl.</td>
<td>1200 Open</td>
<td>1800 Encl.</td>
<td>3600 Encl.</td>
</tr>
<tr>
<td>Synchronous Speed (RPM) Enclosed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (0.75)</td>
<td>77.0</td>
<td>85.5</td>
<td>82.5</td>
<td>85.75</td>
</tr>
<tr>
<td>1.5 (1.1)</td>
<td>84.0</td>
<td>86.5</td>
<td>86.5</td>
<td>87.78</td>
</tr>
<tr>
<td>2 (1.5)</td>
<td>85.5</td>
<td>86.5</td>
<td>86.5</td>
<td>88.86</td>
</tr>
<tr>
<td>3 (2.2)</td>
<td>86.5</td>
<td>85.5</td>
<td>89.5</td>
<td>86.5</td>
</tr>
<tr>
<td>5 (3.7)</td>
<td>88.5</td>
<td>88.5</td>
<td>89.5</td>
<td>88.5</td>
</tr>
<tr>
<td>7.5 (5.5)</td>
<td>89.5</td>
<td>89.5</td>
<td>91.7</td>
<td>89.0</td>
</tr>
</tbody>
</table>

\(^a\) AT 60 HZ

\(^b\) Excluding Fire Pump
<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10 (7.5)</td>
<td>90.2</td>
<td>89.5</td>
<td>91.7</td>
<td>91.0</td>
<td>91.7</td>
</tr>
<tr>
<td>15 (11)</td>
<td>91.0</td>
<td>90.2</td>
<td>92.4</td>
<td>93.0</td>
<td>91.7</td>
</tr>
<tr>
<td>20 (15)</td>
<td>91.0</td>
<td>91.0</td>
<td>93.0</td>
<td>93.0</td>
<td>91.7</td>
</tr>
<tr>
<td>25 (18.5)</td>
<td>91.7</td>
<td>91.7</td>
<td>93.6</td>
<td>93.6</td>
<td>91.7</td>
</tr>
<tr>
<td>30 (22)</td>
<td>91.7</td>
<td>91.7</td>
<td>93.6</td>
<td>93.6</td>
<td>91.7</td>
</tr>
<tr>
<td>40 (30)</td>
<td>92.4</td>
<td>92.4</td>
<td>94.1</td>
<td>94.1</td>
<td>91.7</td>
</tr>
<tr>
<td>50 (37)</td>
<td>93.0</td>
<td>93.0</td>
<td>94.5</td>
<td>94.5</td>
<td>92.4</td>
</tr>
<tr>
<td>60 (45)</td>
<td>93.6</td>
<td>93.6</td>
<td>94.5</td>
<td>94.5</td>
<td>93.0</td>
</tr>
<tr>
<td>75 (55)</td>
<td>93.6</td>
<td>93.6</td>
<td>95.4</td>
<td>95.4</td>
<td>94.1</td>
</tr>
<tr>
<td>100 (75)</td>
<td>94.1</td>
<td>94.1</td>
<td>95.4</td>
<td>95.4</td>
<td>94.1</td>
</tr>
<tr>
<td>125 (90)</td>
<td>95.0</td>
<td>95.0</td>
<td>95.4</td>
<td>95.4</td>
<td>94.1</td>
</tr>
<tr>
<td>150 (110)</td>
<td>95.0</td>
<td>95.0</td>
<td>95.8</td>
<td>95.8</td>
<td>94.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>200 (150)</td>
<td></td>
<td>95.4</td>
<td>95.0</td>
<td>96.2</td>
<td>95.8</td>
</tr>
<tr>
<td>250 (186)</td>
<td></td>
<td>95.8</td>
<td>95.0</td>
<td>96.2</td>
<td>95.8</td>
</tr>
<tr>
<td>300 (224)</td>
<td></td>
<td>95.8</td>
<td>95.4</td>
<td>96.2</td>
<td>95.8</td>
</tr>
<tr>
<td>350 (261)</td>
<td></td>
<td>95.8</td>
<td>95.4</td>
<td>96.2</td>
<td>95.8</td>
</tr>
<tr>
<td>400 (298)</td>
<td></td>
<td>95.8</td>
<td>95.4</td>
<td>96.2</td>
<td>95.8</td>
</tr>
<tr>
<td>450 (336)</td>
<td></td>
<td>95.8</td>
<td>96.2</td>
<td>96.2</td>
<td>96.2</td>
</tr>
<tr>
<td>500 (373)</td>
<td></td>
<td>95.8</td>
<td>96.2</td>
<td>96.2</td>
<td>96.2</td>
</tr>
</tbody>
</table>

**NOTE:** After January 1, 2016, refer to the updated version of 10 CFR 431.

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 C405.87(2)
MINIMUM NOMINAL FULL-LOAD EFFICIENCY OF GENERAL PURPOSE ELECTRIC FOR NEMA DESIGN C AND IEC DESIGN H MOTORS (SUBTYPE II) AND ALL DESIGN B MOTORS GREATER THAN 200 HORSEPOWER AT 60 HZ

<table>
<thead>
<tr>
<th>MOTOR HORSEPOWER (STANDARD KILOWATT EQUIVALENT)</th>
<th>NUMBER OF POLES</th>
<th>NOMINAL FULL-LOAD EFFICIENCY (%) AS OF JUNE 1, 2016</th>
<th>OPEN-Drip-Proof Motors</th>
<th>Totally Enclosed Fan-Cooled Motors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Synchronous Speed (RPM)</td>
<td>3600 Open</td>
<td>1800 Enclosed</td>
</tr>
<tr>
<td>2</td>
<td>4 Pole</td>
<td>6 Pole</td>
<td>8 Pole</td>
<td>2 4 6 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (0.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.5 (1.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.53 (2.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>405 (3.7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: NR = Not Required
<table>
<thead>
<tr>
<th></th>
<th>15</th>
<th>40.5</th>
<th>41.0</th>
<th>40.2</th>
<th>40.6</th>
<th>40.2</th>
<th>41.0</th>
<th>40.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>207.5 (5.5)</td>
<td>90.2</td>
<td>91.07</td>
<td>91.0</td>
<td>90.2</td>
<td>90.2</td>
<td>86.5</td>
<td>89.5</td>
<td></td>
</tr>
<tr>
<td>2510 (7.5)</td>
<td>91.0</td>
<td>91.7</td>
<td>91.7</td>
<td>91.0</td>
<td>86.5</td>
<td>89.5</td>
<td>90.2</td>
<td></td>
</tr>
<tr>
<td>3015 (11)</td>
<td>94.7</td>
<td>92.4</td>
<td>93.0</td>
<td>91.7</td>
<td>93.0</td>
<td>92.4</td>
<td>90.2</td>
<td></td>
</tr>
<tr>
<td>4020 (15)</td>
<td>93.0</td>
<td>93.0</td>
<td>91.7</td>
<td>92.4</td>
<td>93.0</td>
<td>93.0</td>
<td>91.0</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>92.4</td>
<td>93.0</td>
<td>93.0</td>
<td>91.7</td>
<td>92.4</td>
<td>93.0</td>
<td>93.0</td>
<td></td>
</tr>
<tr>
<td>6025 (18.5)</td>
<td>93.0</td>
<td>93.6</td>
<td>93.0</td>
<td>93.0</td>
<td>93.6</td>
<td>93.6</td>
<td>91.7</td>
<td></td>
</tr>
<tr>
<td>7530 (22)</td>
<td>93.06</td>
<td>93.0</td>
<td>93.0</td>
<td>93.0</td>
<td>93.0</td>
<td>93.0</td>
<td>91.7</td>
<td></td>
</tr>
<tr>
<td>10040 (30)</td>
<td>93.6</td>
<td>94.1</td>
<td>94.1</td>
<td>94.1</td>
<td>94.1</td>
<td>94.1</td>
<td>91.7</td>
<td></td>
</tr>
<tr>
<td>12550 (37)</td>
<td>93.6</td>
<td>94.5</td>
<td>94.5</td>
<td>94.5</td>
<td>94.5</td>
<td>94.5</td>
<td>92.4</td>
<td></td>
</tr>
<tr>
<td>15060 (45)</td>
<td>93.6</td>
<td>95.0</td>
<td>95.0</td>
<td>95.0</td>
<td>95.0</td>
<td>95.0</td>
<td>92.4</td>
<td></td>
</tr>
<tr>
<td>20075 (55)</td>
<td>94.5</td>
<td>94.5</td>
<td>94.5</td>
<td>94.5</td>
<td>94.5</td>
<td>94.5</td>
<td>94.1</td>
<td></td>
</tr>
<tr>
<td>250100 (75)</td>
<td>95.4</td>
<td>95.4</td>
<td>95.4</td>
<td>95.4</td>
<td>95.4</td>
<td>95.4</td>
<td>94.1</td>
<td></td>
</tr>
<tr>
<td>300125 (90)</td>
<td>95.0</td>
<td>95.0</td>
<td>95.0</td>
<td>95.0</td>
<td>95.0</td>
<td>95.0</td>
<td>94.1</td>
<td></td>
</tr>
<tr>
<td>Power (hp)</td>
<td>95.8</td>
<td>95.08</td>
<td>95.4</td>
<td>95.4</td>
<td>NR</td>
<td>NR</td>
<td>95.4</td>
<td>NR</td>
</tr>
<tr>
<td>-----------</td>
<td>------</td>
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<tr>
<td>350-150</td>
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</tr>
<tr>
<td>400</td>
<td></td>
<td>95.4</td>
<td>NR</td>
<td>NR</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>450</td>
<td></td>
<td>95.8</td>
<td>NR</td>
<td>NR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>500-200</td>
<td></td>
<td>96.2</td>
<td>95.8</td>
<td>95.8</td>
<td>NR</td>
<td>NR</td>
<td>95.4</td>
<td>NR</td>
</tr>
</tbody>
</table>

**NOTE:** After January 1, 2016, refer to the updated version of 10 CFR 431.

NR = No requirement.

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 C405.87(3)

**MINIMUM AVERAGE FULL-LOAD EFFICIENCY POLYPHASE SMALL ELECTRIC MOTORS**

<table>
<thead>
<tr>
<th>MOTOR-HP</th>
<th>number of poles</th>
<th>OPEN MOTORS</th>
<th>2</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>synchronous speed (RPM)</td>
<td>3600</td>
<td>1800</td>
<td>1200</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>65.0</td>
<td>66.5</td>
<td>69.5</td>
<td>67.5</td>
<td></td>
</tr>
<tr>
<td>0.33</td>
<td>69.5</td>
<td>73.4</td>
<td>71.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.50</td>
<td>73.4</td>
<td>78.2</td>
<td>75.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td>76.8</td>
<td>81.4</td>
<td>81.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>77.0</td>
<td>83.3</td>
<td>82.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>84.0</td>
<td>86.9</td>
<td>83.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>85.5</td>
<td>86.9</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>85.5</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** After January 1, 2016, refer to the updated version of 10 CFR 431.

a. Average full-load efficiencies shall be established in accordance with DOE 10 CFR 431.

### TABLE C405.87(4)

**MINIMUM AVERAGE FULL-LOAD EFFICIENCY FOR CAPACITOR-START CAPACITOR-RUN AND CAPACITOR-START INDUCTION-RUN SMALL ELECTRIC MOTORS**

<table>
<thead>
<tr>
<th>MOTOR-HP</th>
<th>number of poles</th>
<th>OPEN MOTORS</th>
<th>2</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>synchronous speed (RPM)</td>
<td>3600</td>
<td>1800</td>
<td>1200</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>66.6</td>
<td>68.5</td>
<td>62.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.33</td>
<td>70.5</td>
<td>72.4</td>
<td>66.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.50</td>
<td>72.4</td>
<td>76.2</td>
<td>76.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td>76.2</td>
<td>81.4</td>
<td>80.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>80.4</td>
<td>82.6</td>
<td>81.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>81.6</td>
<td>83.8</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>82.9</td>
<td>84.5</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>84.1</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** After January 1, 2016, refer to the updated version of 10 CFR 431.

a. Average full-load efficiencies shall be established in accordance with DOE 10 CFR 431.

**C405.98 Vertical and horizontal transportation systems and equipment.**

Vertical and horizontal transportation systems and equipment shall comply with this section.
C405.98.1 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 3555 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 de-energize ventilation fans and lighting systems when
the elevator is stopped, unoccupied and with its doors closed for over 15 minutes.

C405.98.2 Escalators and moving walks.
Escalators and moving walks shall comply with ASME A17.1/CSA B44 and shall have automatic controls
configured to reduce speed to the minimum permitted speed in accordance with ASME A17.1/CSA B44 or
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.

C405.98.2.1 Regenerative drive.
An escalator designed 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).

C405.9 Voltage drop in feeders and branch circuits.
The total voltage drop across the combination of feeders and branch circuits shall not exceed 5 percent.

C405.10 Electric Vehicle Charging Stations
New parking lots serving buildings with occupancy groups listed in Table 405.11 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.

Exception: Parking spaces are not counted in Table 405.11 if one of the following conditions apply:
1. Parking spaces intended exclusively for storage of vehicles for retail sale or vehicle service.
2. Parking spaces are separated from the meter by a public right-of-way.
3. Parking spaces which are limited to parking durations of less than an hour.

50% 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). 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.

Exception:

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.

2015 Vermont Commercial Building Energy Standards
2019 VERMONT COMMERCIAL BUILDING ENERGY STANDARDS
2. In structured parking lots ½ 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.

**TABLE C405.11 ELECTRIC VEHICLE CHARGING PARKING SPACES**

<table>
<thead>
<tr>
<th>Commercial Building Occupancy&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Minimum Number of EVSE and EVSE-ready Parking Spaces&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Whole numbers represent actual number of required spaces.</td>
</tr>
<tr>
<td></td>
<td>&lt;25 Parking Spaces in Lot</td>
</tr>
<tr>
<td>Groups A &amp; M&lt;sup&gt;c,d&lt;/sup&gt;</td>
<td>Level 1</td>
</tr>
<tr>
<td>Groups B, E, F, &amp; H</td>
<td>0</td>
</tr>
<tr>
<td>Groups I-1, I-2, I-3, &amp; R-4</td>
<td>1</td>
</tr>
<tr>
<td>Group R-1</td>
<td>0</td>
</tr>
<tr>
<td>Group R-2</td>
<td>1</td>
</tr>
</tbody>
</table>

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<sup>a</sup> 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.

<sup>b</sup> 50% of the 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.

<sup>c</sup> Motor liquid fuel-dispensing facilities (gas stations) are exempt from the requirement to provide electric vehicle charging parking spaces.

<sup>d</sup> Stand-alone retail stores with fewer than 50 spaces are exempt from the requirement to provide electric vehicle charging parking spaces.
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.

SECTION C406
ADDITIONAL EFFICIENCY PACKAGE OPTIONS

C406.1 Requirements.
Buildings shall comply with at least one of the following:

1. More efficient HVAC performance in accordance with Section C406.2.
2. Reduced lighting power density system 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.

C406.1 Additional Energy Efficiency Credit Requirements. New buildings shall comply with sufficient packages from Table C406.1 to achieve a minimum number of 6 credits. Buildings with more than one commercial building occupancy type shall use the “All Other Groups” column in Table 406.1, unless 65% 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

<table>
<thead>
<tr>
<th>Code Section</th>
<th>Commercial Building Occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group R-1</td>
</tr>
<tr>
<td>Additional Efficiency Credits</td>
<td></td>
</tr>
<tr>
<td>1. More efficient HVAC performance in accordance with Section C406.2.</td>
<td>2</td>
</tr>
<tr>
<td>2.1 Reduced lighting power: Option 1 in accordance with Section C406.3.1.</td>
<td>1</td>
</tr>
<tr>
<td>2.2 Reduced lighting power: Option 2 in accordance with Section C406.3.2.</td>
<td>2</td>
</tr>
<tr>
<td>3. Enhanced lighting controls in accordance with C406.4.</td>
<td>N/A</td>
</tr>
<tr>
<td>4. On-site supply of renewable energy in accordance with</td>
<td>3</td>
</tr>
</tbody>
</table>
C406.1 Tenant spaces.
Tenant spaces shall comply with Section C406 sufficient packages from Table C406.1 to achieve a minimum number of 3 credits from Sections C406.2, C406.3, C406.4, C406.6 or C406.7. Alternatively, where applicable. Where an entire building complies with Section C406.5, C406.8 or C406.9, tenant spaces within the building shall be deemed to comply with Section C406.5 where the entire building is in compliance with this section.

**Exception:** Previously occupied tenant spaces that comply with this code in accordance with Section C501.

C406.2 More efficient HVAC equipment and fan performance.
Equipment shall exceed comply with Sections C406.2.1 through C406.2.3.

C406.2.1 HVAC system selection. No less than 90 percent of the minimum efficiency requirements of total HVAC capacity serving the building shall be provided by equipment that is listed in Tables C403.3.2.3(1) through C403.3.2.3(7(12).

**Exception:** Air-to-water heat pumps or heat recovery chillers are also permitted to be utilized for Option 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 10 percent, in addition to the requirements of Section C403. Where multiple performance requirements are provided, the equipment shall exceed all requirements by 10 percent. **Variable refrigerant flow systems shall exceed the energy efficiency provisions of ANSI/ASHRAE/IES 90.1-2013 by 10 percent.** Equipment not listed in Tables C403.2.3(1) through C403.2.3(7) shall be limited to 10 percent of the total building system capacity.
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 density.

- Buildings shall comply with Sections C406.3.1 or C406.3.2. Dwelling units and sleeping units within the building shall comply with C406.3.3.

C406.3.1 Reduced lighting power option 1. The total connected interior lighting power (watts) of the building calculated in accordance with Section C405.3.1 shall be determined by using 90 percent or less of the total interior lighting power values specified calculated in Table C405.4.3.2.1 times the floor area for the building types, or by using 90 percent of the total interior lighting power allowance calculated by the Space-by-Space Method in accordance with Section C405.4.3.2.

C406.3.2 Reduced lighting power option 2. 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.

C406.3.3 Lamp fraction. 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 in the building shall have the following enhanced lighting controls that shall be located, scheduled and operated in accordance with Section C405.2.2 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 capable of being configured for continuous dimming.

2. Luminaires shall be capable of being addressed individually. Where individual addressability is not available for the luminaire class type, a controlled group of not more than four luminaires mounted on no more than 12 linear feet of a single lighting track and addressed as a single luminaire.

3. Not more than eight luminaires shall be controlled together 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 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. Individual user control in open and enclosed offices, the illumination level of overhead general illumination in open offices luminaire are configured to be individually adjusted by occupants.

4.4. Occupancy sensors shall be and daylight responsive controls are capable of being reconfigured through the digital control system.

5. Construction documents shall include submittal of a Sequence of Operations, including a specification outlining each of the functions in Item 4 of required by this section.

6. Functional testing of lighting controls shall comply with Section C408.

C406.5 On-site renewable energy.

Total minimum ratings of: Buildings shall be provided with on-site renewable energy systems shall comply with one of the following:

1. Provide not less than 0.50 watt a total system rating per square foot (5.4 W/m²) of conditioned floor area.

2. Provide of the building of not less than 3 percent of the energy used within the building for building mechanical and service water heating equipment and lighting regulated value specified in Chapter 4 Table C406.5.

<table>
<thead>
<tr>
<th>TABLE C406.5 ON-SITE RENEWABLE ENERGY SYSTEM RATING (PER SQUARE FOOT) Building Area Type</th>
<th>kBTU per year</th>
<th>kWh per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>1.8</td>
<td>0.53</td>
</tr>
<tr>
<td>Dining</td>
<td>10.7</td>
<td>3.14</td>
</tr>
<tr>
<td>Hospital</td>
<td>3.6</td>
<td>1.06</td>
</tr>
<tr>
<td>Hotel/Motel</td>
<td>2.0</td>
<td>0.59</td>
</tr>
<tr>
<td>Multi-family residential Office</td>
<td>0.50</td>
<td>0.15</td>
</tr>
<tr>
<td>Other</td>
<td>0.82</td>
<td>0.24</td>
</tr>
<tr>
<td>Retail</td>
<td>2.02</td>
<td>0.59</td>
</tr>
<tr>
<td>School/University</td>
<td>1.17</td>
<td>0.34</td>
</tr>
<tr>
<td>Supermarket</td>
<td>5.0</td>
<td>1.47</td>
</tr>
<tr>
<td>Warehouse</td>
<td>0.43</td>
<td>0.13</td>
</tr>
</tbody>
</table>

C406.6 Dedicated outdoor air system.

Not less than 90% of the building conditioned floor area, excluding floor area of unoccupied spaces that do not require ventilation per 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, C403.8.5, C403.8.5.1, C403.9.1, C403.9.2, C403.9.3 or C403.9.4 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 the ASHRAE Standard 62.1-2013. 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 at least 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 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, not less than 90 percent of the building conditioned floor area shall be of the following types to use this compliance method:

- 1. Group R-1: Boarding houses, hotels or motels.
- 3. Group A-2: Restaurants and banquet halls or buildings containing food preparation areas.

7. Buildings showing a service—

C406.7.2 Load fraction.
Not less than 60 percent of the annual building service hot water load of 10 percent or more of total building energy loads.

C406.7.1 Load fraction.
The use, or not less than 100 percent of the annual building service hot water heating system shall have energy use in buildings subject to the requirements of Section C403.9.5, shall be provided by one or more of the following that are sized to provide not less than 60 percent of hot water requirements, or sized to provide 100 percent of hot water requirements if the building shall otherwise comply with Section C403.4.7:

- 1. Waste heat recovery from service hot water, heat—recovery chillers, building equipment, process equipment, or a combined heat and powerother approved system.
- 2. SolarOn-site renewable energy water-heating systems.

C406.7.3 High Performance Water Heating Equipment. The combined input-capacity-weighted-average equipment rating of all water heating equipment in the building shall be not less than 95% Et or 0.95 EF.

C406.7.4 Heat pump water heater. All Service hot water system delivering 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/ft² (2.0 L/s × m²) 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 m²) 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 Efficient Kitchen Appliances.
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 (0.30 m) 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 m²) and not to exceed one full floor. The device shall be capable of being overridden for periods of up to two 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 m²). Override switches for controlled receptacles are permitted to control the lighting within the same area.

**Exception:**

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 (0.30 m) of a controlled receptacle.

2. Within a single modular office workstation, non-controlled 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.**

*New buildings* This section covers the provision of 50,000 gross square feet maintenance information and the commissioning of conditioned space or greater shall meet the provisions of Sections C407.2 through C407.4.

**C407.21.1 Qualifications.**

The scope required by Section C408.3 shall be completed by the project commissioning authority. The commissioning authority shall:

1. Have experience as a commissioning authority on at least (3) previous projects each at least 20,000 square feet or greater, and

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 registered design professional or approved 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 other authority having jurisdiction, upon request in accordance with Sections C407.2.4 and C407.2.5.

Exceptions: 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 registered design professional or approved 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. Equipment. 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 verification testing.

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 (18.6 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 verification testing shall demonstrate the correct installation and operation of power consumption of systems in accordance with the energy performance criteria noted in Section C407.3.1. 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:

**C407.3.1 Equipment requiring performance verification.**

1. Economizers (Section C403.3).
2. Variable Air Volume (VAV) fan control (Section C403.4.1).
3. Part Load Hydronic Controls (Section C403.4.2.4).
4. Lighting control systems (Section C405.2).

**C407.3.2 Mechanical system.**
1. All modes as described in the sequence of operation.
2. Redundant or automatic back-up mode.
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) 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 registered design professional or approved 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 verification requirements.

The scope of the deferred tests.

4. Results of functional performance verification testing shall test and record the following tests.

A. Economizers (Section C403.3).
   1. Method of economizer control.
   2. Economizer setpoints.
   3. Economizer operates in full 100% outside air mode when enabled.
   4. Economizer operates with additional mechanical cooling when 100% outside air mode is active.
   5. When economizer is disabled, outside air dampers revert to minimum outside air mode that provides for the minimum amount of outside air necessary.

B. Variable Air Volume (VAV) fan control (Section C403.4.1) and Part Load Hydronic Controls (Section C403.4.2.4).
   1. Power input (watts or kW) when system operates in full load mode.
   2. Power input (watts or kW) when system operates at 50% of design air or water flow.
      2.1. Verify that power input at 50% of design air or water flow is no greater than 30 percent of the full load power input.
      2.2. The 50% of design flow test in B.2.2.1 shall be conducted with actual reduced flow and flow measured by:
         2.2.1. Hydronic flow measurement devices such as balance valves, venturi metering devices equipped with test ports or permanent or temporary calibrated electronic flow measurement devices.
         2.2.2. Airflow measurement devices such as portable direct air flow measurement (pitot tubes) or permanent calibrated electronic flow measurement station devices or summation of terminal unit air flow measurement or by fan curve extrapolation based on measured fan speed and pressures.
         2.2.3. Reducing the fan or pump speed or pressure control setpoint using only manual overrides for purposes of conducting the 50% flow performance verification is prohibited.
         2.2.4. Visually inspect and verify the pressure control device is installed in a location in accordance with Sections C403.4.1 and C403.4.3.
         2.2.5. Where air systems utilizing a duct static pressure control device, verify the static pressure control setpoint is reset in accordance with Section C403.4.1.
2.2.6. Power input units shall only be kW or watt engineering units. Amperage alone is not an acceptable unit.

2.2.7. Power input shall be permitted to be determined using kW display readout where variable speed drives are utilized.

C407.3.3 Lighting system 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 C408.2.1)
- Commissioning Plan was used during construction and includes all items required by Section C408.2.1
- 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 C408.2.4

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 2018 IECC.

Signature of Building Owner or Owner’s Representative __________________________ Date ____________

FIGURE C407.2.4 COMMISSIONING COMPLIANCE CHECKLIST
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 C408.2.2.

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.
   Controls, 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 automatic repeatability.

Exception: Deferred tests that cannot be performed at the time of report preparation due to climatic conditions.

C407.3 Functional testing of lighting systems controls.
Automatic lighting controls required by this code shall comply with this section.

C407.3.3.1 Functional testing.
Prior to passing final inspection, the commissioning authority registered design professional 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 C407.3.3.1.1 and through C407.3.3.1.23 for the applicable control type.

C407.3.3.1.1 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—but and in no case less than one, of each combination shall be tested unless the code official or other authority having jurisdiction 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.

C407.3.3.1.2 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.

C407.3.3.1.3 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 set-points in response to available daylight.

3. The locations of calibration adjustment equipment are readily accessible only to authorized personnel.

C407.3.4 Acceptance and documentation.
The commissioning authority shall submit completed, dated and signed performance verification test documents certifying the performance verification process has been successfully completed and the applicable system performance conforms to this energy code, prior to occupancy.
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.
**CHAPTER 5**  
**[CE-]**  
**EXISTING BUILDINGS**

**User note:**

*About this chapter:* Many buildings are renovated or altered in numerous ways that could affect the energy use of the building as a whole. Chapter 5 requires the application of certain parts of Chapter 4 in order to maintain, if not improve, the conservation of energy by the renovated or altered building.

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**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.

C501.2 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.

C501.3 Maintenance.
*Buildings* and structures, and parts thereof, shall be maintained in a safe and sanitary condition. Devices and systems *that are* 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.

C501.5 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 *permit* use of these materials in buildings of similar occupancy, purpose and location.
C501.6 Historic buildings.  

No 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 either the owner, an owner's agent, a registered design professional, or 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 other 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 need not comply with C406. Additions complying with ANSI/ASHRAE/IESNA 90.1-2013 need not comply with Sections C402, C403, C404 and C405.

C502.2 Prescriptive compliance.  
Additions shall comply with Sections C502.2.1 through C502.2.6.2.

C502.2.1 Vertical fenestration.  
New vertical fenestration area 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. Additions with vertical fenestration that result in a total building fenestration area greater than Section C402.3.1 or additions that exceed the fenestration area greater than Section C402.3.1 shall comply with Section C402.3.1.1 for the addition only. Additions 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.

C502.2.2 Skylight area.  
New skylight area 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. Additions with skylight area that result in a total building skylight area greater than C402.3.1 or additions that exceed the skylight area shall comply with Section C402.3.1.2 for the addition only. Additions that result in a total building skylight area exceeding that specified in Section C402.3.1.2 shall comply with Section C402.1.3.

C502.2.3 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.

C502.2.4 Service water-heating systems.  
New service water-heating equipment, controls and service water heating piping shall comply with Section C404.
C502.2.5 Pools and inground permanently installed spas.
New pools and inground permanently installed spas shall comply with Section C404.9-10.

C502.2.6 Lighting power and systems.
New lighting systems that are installed as part of the addition shall comply with Section C405.

C502.2.6.1 Interior lighting power.
The total interior lighting power for the addition shall comply with Section C405.43.2 for the addition alone, or the existing building and the addition shall comply as a single building.

C502.2.6.2 Exterior lighting power.
The total exterior lighting power for the addition shall comply with Section C405.5.44.2 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 need not comply with C406. Alterations complying with ANSI/ASHRAE/IESNA 90.1-2013, 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 already 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.

C503.3 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.

C503.3.1 Roof replacement.
Roof replacements shall comply with Table 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.

C503.3.2 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 glass fenestration area exceeding that specified in Section C402.3.1.1 shall comply with Section C407-C402.1.3.

C503.3.3 Skylight area.
The addition of new skylight area that results in a total building skylight area less than or equal to that specified in Section C402.3.4.1 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 C407-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 Section C403.

C503.4.1 Economizers.
New cooling systems that are part of alteration shall comply with Section C403.3.5.

C503.5 Service hot water systems.
New service hot water systems that are part of the alteration shall comply with Section C404.

C503.6 Lighting systems.
New lighting systems that are part of the alteration shall comply with Section C405.

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.

Repairs need not comply with C406. Where a building was constructed to comply with ANSI/ASHRAE/IESNA 90.1-2013, 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 C405.43.2(1) or C405.43.2(2) to another use in Table C405.43.2(1) or C405.43.2(2), the installed lighting wattage shall comply with Section C405.43. 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

These Referenced standards shall be updated through the copy-editing process.

This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the section or sections of this document that reference the standard. The application of the referenced standards shall be as specified in Section 106.

<table>
<thead>
<tr>
<th>Standard reference number</th>
<th>Title</th>
<th>User note:</th>
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American Architectural Manufacturers Association 1827 Walden Office Square Suite 550 Schaumburg, IL 60173-4268

Association of Home Appliance Manufacturers 1111 19th Street, NW, Suite 402 Washington, DC 20036

2015 Vermont Commercial Building Energy Standards

2019 VERMONT COMMERCIAL BUILDING ENERGY STANDARDS
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<tr>
<th>Standard Reference Number</th>
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<tr>
<td>ANSI/AHAM RAC-1—2008</td>
<td><strong>ANSI/AHAM RAC-1—2008</strong>: Room Air Conditioners.</td>
<td>Table C403.3.2(3)</td>
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<td>AHAM HRF-1—2007</td>
<td><strong>AHAM HRF-1—2016</strong>: Energy, Performance and Capacity of Household Refrigerators, Refrigerator-Freezers and Freezers</td>
<td>Table C403.10.1</td>
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<td>ISO/AHRI/ASHRAE 13256-1 (2011)</td>
<td><strong>ISO/AHRI/ASHRAE 13256-1 (2017):</strong> Water-to-Air and Brine-to-Air Heat Pumps—Testing and Rating for Performance</td>
<td>Table C403.3.2(2)</td>
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<tr>
<td>210/240—08 with 210/240—2016: Performance Rating of Unitary Air-conditioning and Air-source Heat Pump Equipment Addenda 1 and 2</td>
<td>Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment</td>
<td>Table C403.2.3(1), Table C403.3.2(2)</td>
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<td>310/380—04 (CSA-C744-04)</td>
<td><strong>310/380—2014 (CSA-C744-04):</strong> Standard for Packaged Terminal Air Conditioners and Heat Pumps</td>
<td>Table C403.2.3(1), Table C403.2.3(2)</td>
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340/360—2007 with Addendum 2

Table C403.3.2(3)


Table C403.3.2(1), Table C403.3.2(2)

365(I-P)—09

365(I-P)—2009: Commercial and Industrial Unitary Air-Conditioning Condensing Units.
### Table C403.3.2(1), Table C403.3.2(6)

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<td>390-03</td>
<td><strong>390 (I-P)—2015</strong>: Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps</td>
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### Table C403.3.2(3)

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<td>440—2008: Performance Rating of Room Fan Coils—with Addendum 1</td>
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<td>550/590—2011</td>
<td><strong>550/590 (I-P)—2015</strong>: Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle</td>
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<td>Table C403.3.2(7)</td>
<td>560-00: Absorption Water Chilling and Water Heating Packages</td>
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<th>1200 (I-P)—2013: Performance Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets</th>
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<td>205—12</td>
<td><strong>205—12: Energy Efficiency Classification for Fans</strong></td>
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C403.8.3

220—08 (R2012)  

**220—08 (R2012): Laboratory Methods of Testing Air Curtain Units for Aerodynamic Performance Rating**

C402.5.6

500D—12  

**500D—12: Laboratory Methods for Testing Dampers for Rating**

ANSI

American National Standards Institute  
25 West 43rd Street  
Fourth Floor  
New York, NY 10036

Z21.10.3/CSA 4.3—11  

**Z21.10.3/CSA 4.3—11: 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  

**Z21.47/CSA 2.3—12: Gas-fired Central Furnaces**

Table C404.2
Table C403.3.2(4)

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The Association of Pool & Spa Professionals
2111 Eisenhower Avenue
Alexandria, VA 22314
62.1—2013

Ventilation for Acceptable Indoor Air-Quality Table C403.3.2(9)
ASHRAE 127-2007


C403.1.1
ISO/AHRI/ASHRAE
13256-1 (2011)

Table C403.3.2(2)

ISO/AHRI/ASHRAE 13256-2 (2011)

Table C403.3.2(2)

55—2013: Thermal Environmental Conditions for Human Occupancy
Table C407.5.1

90.1—2016: Energy Standard for Buildings Except Low-rise Residential Buildings
90.1—2013

2015 Vermont Commercial Building Energy Standards
140—2014: Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs

146—2011: Testing and Rating Pool Heaters

Table C404.2

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<td>C402.3.1.4.1, Table C402.1.4, 402.2.7</td>
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<td>C1363-11</td>
<td>Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus</td>
<td>C303.1.4.1, Table C402.1.4, 402.2.7</td>
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<td>C1371-15</td>
<td>Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers</td>
<td>C402.3.1.4.1, Table C402.1.4, 402.2.7</td>
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<td>D1003-14</td>
<td>Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics</td>
<td>C402.4.2.2</td>
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E283—04: 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: Standard Test Method for Determining Air Leakage Rate by Fan Pressurization

Table C402.3


Table C402.3

E1677—11: Specification for an Air-retarder (AR) Barrier (AB) Material or Systems for Low-rise Framed Building Walls
C402.5, C406.9, C606.4

Table C402.3

Table C402.3, C402.3.2


CSA Group
8501 East Pleasant Valley
Cleveland, OH 44131-5516

2015 Vermont Commercial Building Energy Standards
AAMA/WDMA
A/CSA
101/I.S.2/A4
40—11
North American Fenestration Standard/Specification for
Windows, Doors and Unit Skylights Table C402.3, C402.3.1

CSA
B55.1—2012
Test Method for Measuring Efficiency and Pressure Loss of Drain Water Heat Recovery Units

CSA
B55.2—2012
Drain Water Heat Recovery Units

Doors and Unit Skylights
Table C402.5.2

CSA Group
8501 East Pleasant Valley Road
Cleveland, OH 44131-5516
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10 CFR 431 Subpart B App B: Uniform Test Method for Measuring Nominal Full Load Efficiency of Electric Motors
10 CFR 431 Subpart B App B
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Table C403.2(1), Table C403.2(2), Table C403.2(4)

International Code Council, Inc.
500 New Jersey Avenue, NW
6th Floor
Washington, DC 20001

Standard reference number

IBC—18: International Building Code®
2015 Vermont Commercial Building Energy Standards

2019 VERMONT COMMERCIAL BUILDING ENERGY STANDARDS

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C501.4 International Residential Code

IEEE—The Institute of Electrical and Electronic Engineers Inc.
3 Park Avenue
New York, NY 10016

Institute of Electrical and Electronic Engineers
3 Park Avenue, 17th Floor
New York, NY 10016

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<td>1300 North 17th Street, Suite 1752 Rosslyn, VA 22209</td>
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APPENDIX CA
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 CA101
SCOPE

CA101.1 General.
These provisions shall be applicable for new construction where solar-ready provisions are required.

SECTION CA102
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 CA103
SOLAR-READY ZONE

CA103.1 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.

CA103.2 Construction document requirements for a solar-ready zone.
Construction documents shall indicate the solar-ready zone.
CA103.3 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.

CA103.4 Obstructions.
Solar ready zones shall be free from obstructions, including pipes, vents, ducts, HVAC equipment, skylights and roof-mounted equipment.

CA103.5 Roof loads and documentation.
A collateral dead load of not less than 5 pounds per square foot (5 psf) (24.41 kg/m²) 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.

CA103.6 Interconnection pathway.
Construction documents shall indicate pathways for routing of conduit or piping from the solar-ready zone to the electrical service panel or service hot water system.

CA103.7 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 shall be labeled “For Future Solar Electric.” The reserved space shall be positioned at the end of the panel that is opposite from the panel supply conductor connection.

CA103.8 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 or registered design professional.
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