Jamaican Standard

Jamaica Energy Conservation Code

BUREAU OF STANDARDS JAMAICA

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JS 309: 2023

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Jamaican Standard

Jamaica Energy Conservation Code

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Jamaican Standards establish requirements in relation to commodities, processes and practices, but do not purport to include all the necessary provisions of a contract.

The attention of those using this standard is called to the necessity of complying with any relevant legislation.

Amendments

No.	Date of issue	Remarks	Entered by and date

Preface

This standard is a revision of and supersedes JS 309: 2019 Jamaican Standard Jamaica Application Document for the International Energy Conservation Code.

Jamaica imports nearly all its energy and at considerable cost, for example, in 2008 Jamaica spent approximately US $2.4 billion importing crude and finished petroleum products. The country imports approximately 97% of its energy needs; therefore the economy is susceptible to the repercussions of rapid and fairly frequent petroleum price increases. Added to this is the fact that consumption of petroleum products carries with it the emanation of greenhouse gases that increase global warming and its concomitant by-products of more intense and frequent floods, droughts and hurricanes. The high cost of petroleum has resulted in an increase in the cost of electricity and transportation therefore making it extremely difficult for Jamaican industries to be cost competitive within our traditional markets. High energy cost as well as inefficient use of energy therefore has the effect of forcing industries, jobs and wealth out of Jamaica. The efficient use of energy and energy diversification are the most immediate solutions to the energy crisis facing Jamaica. An Energy Efficiency Building Code (EEBC) is extremely important to achieving the most immediate solutions but this code must be mandatory requirement for all building types (hotels, apartment complexes, offices, other commercial properties and residences) in Jamaica since buildings consume as much as 55% of the total electrical energy generated.

Recognizing the importance of energy efficient buildings to Jamaica, an effort was made in 1987 / 1988 to develop a comprehensive EEBC. This project, sponsored by the Canadian International Development Agency (CIDA) through the World Bank Energy Sector Management Assistance Program (ESMAP), saw to the development of an energy efficiency code that covered the building envelope; lighting (use of natural and energy efficient artificial lighting); electrical power distribution; air-conditioning, heating and ventilation; operation and maintenance for commercial buildings and high rise conditioned residential buildings. With this code, building envelops and services were targeted for energy saving and while the minimum targeted saving was 30% on the then conventional construction techniques used, the building owner was encouraged to look beyond the minimum saving where construction budget could afford an energy increment greater than the 5% increase that it took to deliver the 30% energy saving.

The 2003 version of the International Energy Conservation Code (IECC) has concentrated its energy saving possibilities on the building envelope of all building types including those of the low rise residential sector. The 2003 IECC therefore complements the existing Jamaica EEBC that targets only the commercial sector and conditioned residential buildings above four stories.

The 2019 Application Document combined the IECC and EEBC as well as updating where necessary EEBC requirements that was over 10 years old. The approach taken was to specify the minimum energy saving requirement while supporting greater energy saving possibilities where it can be accommodated. That Application Document covered energy saving in the Low Rise Residential Sector for the first time in Jamaica and provided the following three approaches for designing energy efficient buildings in this Sector:

a. A Systems Analysis Method utilizing renewable energy sources
b. A Component Performance Method
c. A Prescriptive Method that simply specifies practical measures to achieve major energy saving.

Perhaps the most radical difference between that Application Document and the IECC is that the Application Document required unconditioned buildings to practice energy conservation for the building envelope, lighting, appliances and equipment including hot water heaters. That difference arises from the fact that in Jamaica most residential and small commercial buildings are initially constructed as unconditioned buildings that need heat alleviating measures especially in the summer months.

This Jamaica Energy Conservation Code incorporates the 2018 CARICOM Regional Energy Efficiency Building Code (CREEBC): which is itself substantially based on the 2018 version of the IECC. Differences with the EEBC described above

no longer exist. IECC now incorporates the prescriptive, component performance, and system analysis methods: which is referred to in the 2018 CREEBC. And the CREEBC makes no provision for unconditioned buildings, although most residential and small commercial buildings in the CARICOM region initially are also constructed as unconditioned buildings.

This standard is voluntary.

Applicable Version of the IECC

This document is based on the 2018 version of the International Energy Conservation Code (IECC). However, the user will not have to reference that document unless specifically instructed to do.

Subsequent versions of the IECC may require subsequent versions of this document.

Use and Structure

Users wishing to apply the IECC in Jamaica must first consult this Application Document in order to get guidance on what applies, additional data and information that applies only to Jamaica.

The structure of this application document runs parallel to that of the IECC at the Chapters' level. This means that all chapter titles from the IECC are covered and included in the application document. The numbering system of the chapters is also maintained as far as is practicable.

Section and sub-section titles and numbering system are maintained according to the following rules:

1. Where there are national requirements, the section and/or sub-section number and title along with the appropriate clause are included in this Application Document. The number and title of sections and sub-sections follow the numbering sequence of the IECC;
2. For ease of use and to minimize any ambiguity in the reading or interpretation of this Application Document, there are instances when number and title of a section or sub-section are retained; this rule applies mainly to scope and application or when the information may be helpful to establish sequence or context.

Development

A Steering or Managing Committee comprising stakeholders from the Jamaica Institution of Engineers (JIE), Jamaica Institution of Architects (JIA), Incorporated Master-builders Association of Jamaica (IMAJ), University of Technology, Jamaica (UTECH), Ministry of Local Government & Community Development (MLGCD), Ministry of Land and Development (MLD), Bureau of Standards Jamaica (BSJ), Housing Developers & Mortgagers / Financiers, National Environmental Protection Agency (NEPA) and Practicing Architects and Engineers was first put in place to manage the code development process. This Committee started monthly meetings in September 2003 to plan the adoption process, develop implementation strategy and put in place the organizational structure to accomplish the adoption process.

Adoption

The International Code Council (ICC) has made the IFGC available for adoption and use by jurisdictions internationally through the Ordinance process. In view of this, a Sample Ordinance is included at the front of the IFGC showing the information that a jurisdiction needs to fill in for the adoption process to be legally complete and binding. In Jamaica adoption by Ordinance is not practiced as Ordinance is considered subsidiary legislation; adoption can only be by Act of Parliament and Regulations. This Jamaica Application Document for the IECC and the associated International Code is legally binding through the enactment of the Building Laws of Jamaica.

Maintenance

Application Documents will require updating and changes over time. Jamaica will participate in the ICC Standards Development and Maintenance programme. CREEBC is intended to be updated within 6 years from the completion of the document. CROSQ will participate in the ICC Standards Development and Maintenance programme.

Letter Designations in Front of Section Numbers

JIE /BSJ do not plan annual reviews of the Application Documents and to indicate by way of vertical or other positional marks areas that have been revised. Letter designation scheme will not be required for the Application Documents.

Committee Representation

The preparation of this Jamaica Application Document for the Standards Council, established under the Standards Act of 1969, was carried out under the supervision of the National Building Code Technical Committee which at the time comprised the following members:

National Building Code Technical Committee

Mr. Paul Hay (Consultant)	- PHC Facilities Development
Mr. Oneil Josephs	- University of Technology, Jamaica
Mr. Roosevelt DaCosta	- Endacosta Ltd.
Mr. Karl Kaiser	- Brandschutz Kaiser

Mr. Stanley Smellie	- University of the West Indies, Mona
Ms. Winsome Grant	- Jamaica Fire Brigade
Ms. Alciann Samuels- Bennett	- Ministry of Health & Wellness
Mr. Alfrico Adams	- SMADA Consultants Ltd.
Mr. Noel Dacosta	- Endacosta Ltd.
Mr. Gregory Bennett	- National Environment and Planning Agency
Mr. Derval McKenzie	- Jamaica Fire Brigade
Ms. Erica Boswell Munroe	- Endacosta Ltd.
Mr. Richard Lawrence	- Bureau of Standards Jamaica
Mr. Wilfred Francis	- Bureau of Standards Jamaica
Mr. Shane Slater (Facilitator)	- Bureau of Standards Jamaica

ACKNOWLEDGEMENTS

CREEBC COMMITTEE REPRESENTATION

The development of the CARICOM Regional Energy Efficiency Building Code [CREEBC] was facilitated by a Regional Project Team (hosted by the CARICOM Member State, Jamaica), which at the time comprised the following members:

Members	Representing
Mr. Zepherinus Churchill Norbert (Chairman)	Project Coordinator/Consultant Department of Environment Ministry of Health, Wellness and the Environment Antigua and Barbuda
Mr. Mali Barnes	Energy Officer Ministry of Public Utilities, Civil Aviation, Transport and Energy Antigua and Barbuda
Mr. Craig Delancy	Building Control Officer Ministry of Works and Urban Development Bahamas
Mr. Fabian Scott	Chief Technical Officer Barbados National Standards Institution (BNSI) Barbados
Mr. Jonathan Platt	Technical Officer Barbados National Standards Institution (BNSI) Barbados
Mr. Ryan Cobb	Director of Energy Ministry of Energy Belize
Mr. Fred Esprit	Managing Director Esprit Ultimate Design, Inc. Member Dominica Society of Architects Dominica

Mr. Dwayne Cenac	Planning and Engineering Manager Grenlec Secretary, Grenada Institute of Professional Engineers Grenada
Mr. Whyme Cox	Planning and Development Manager NAWASA President Grenada Institute of Professional Engineers Grenada
Mr. Brian A. Constantine	Energy Engineer Guyana Energy Agency Guyana
Mr. Hemraj Sanichara	Technical Officer Guyana National Bureau of Standards Guyana

Members	**Representing**
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Mr. Joseph A. Junior Jean-Gilles	Standards Officer Bureau Haiti de Normalization Haiti
Mr. Stanley G. Smellie	Campus Energy Manager/Engineer University of the West Indies, Mona Jamaica
Mr. Shane Slater (Technical Secretary)	Standards Officer Bureau of Standards Jamaica Jamaica
Mr. Alvin Ryan	Senior Electrical Inspector Ministry of Trade, Lands, Housings and Environment Montserrat
Mr. Bertille Brown	Director, Energy Unit Ministry of Public Infrastructure, Post, Urban Development and Transport St. Kitts and Nevis

Mr Rhon Boddie	Director Ministry of Public Infrastructure, Post, Urban Development and Transport St. Kitts and Nevis
Mr. Verne Emmanuel (Vice Chairman)	Chairman Mechanical Products Technical Committee Saint Lucia Bureau of Standards President Saint Lucia Association of Professional Engineers Saint Lucia
Mr. David Hird	MEP Consultant Member – Mechanical Products Technical Committee Saint Lucia Bureau of Standards Saint Lucia
Mr. Ellsworth Dacon	Director of Energy St. Vincent and the Grenadines
Mr. Ricardo Adams	Chairman National Mirror Committee St. Vincent and the Grenadines Bureau of Standards St. Vincent and the Grenadines
Mr. Devanand Ragbir	Chairman National Mirror Committee Engineer Member Trinidad and Tobago Green Building Council Trinidad and Tobago

Members	**Representing**
Nadita Ramachala	Standards Officer Trinidad and Tobago Bureau of Standards Trinidad and Tobago
Andia Persad-Maharaj	Standards Officer Trinidad and Tobago Bureau of Standards Trinidad and Tobago

Technical Advisory Group

Members	**Representing**

Mr. Christopher Lou	Architect The Jamaican Institute of Architect (JIA)
Mr. Douet Stennett	Director, Regulatory Affairs Ministry of Science, Energy and Technology (MSET) Jamaica

Acknowledgements

Members	Representing
Mr. Miguel Quinones	Sustainability Consultant SYRQUL
Dr. Devon Gardner	Programme Manager CARICOM Secretariat Energy Unit
Ms. Nadia Mohammed	Project Officer CARICOM Energy Unit
Mr. Glynn Morris	Programme Leader Renewable Energy Energy Efficiency Technical Assistance Programme (REEETA)
Ms. Amanda Harris-Logie	Energy Efficiency Officer Renewable Energy Energy Efficiency Technical Assistance Programme (REEETA)
Mr. Nigel Duncan	Project Officer, Administration Renewable Energy Energy Efficiency Technical Assistance Programme (REEETA)
Mr. Deryck Omar	Chief Executive Officer CARICOM Regional Organisation for Standards and Quality (CROSQ)
Ms. Euleen Alleyne	Administrative Assistant CARICOM Regional Organisation for Standards and Quality (CROSQ)

Mr. Fulgence St. Prix	Technical Officer – Standards CARICOM Regional Organisation for Standards and Quality (CROSQ)

The Bureau of Standards Jamaica (BSJ) also wishes to acknowledge the kind cooperation and assistance of the International Code Council (ICC) in allowing the use of its IBC Document in the production of the CREEBC.

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IECC—COMMERCIAL PROVISIONS

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CHAPTER 1 [CE]

SCOPE AND ADMINISTRATION

User note:

About this chapter: *Chapter 1 establishes the limits of applicability of the code and describes how the code is to be applied and enforced. Chapter 1 is in two parts: Part 1—Scope and Application and Part 2—Administration and Enforcement. Section 101 identifies what buildings, systems, appliances and equipment fall under its purview and references other I-Codes as applicable. Standards and codes are scoped to the extent referenced.*

The code is intended to be adopted as a legally enforceable document and it cannot be effective without adequate provisions for its administration and enforcement. The provisions of Chapter 1 establish the authority and duties of the code official appointed by the authority having jurisdiction and also establish the rights and privileges of the design professional, contractor and property owner.

PART 1—SCOPE AND APPLICATION

SECTION C101
SCOPE AND GENERAL REQUIREMENTS

C101.1 Title. This code shall be known as the 2023 *JS309 International Energy Conservation Building Code* 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 associated systems and equipment.

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.

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 residential and commercial buildings. Where a building includes both *residential building* and *commercial building* portions, each portion shall be separately considered and meet the applicable provisions of IECC—Commercial Provisions or IECC—Residential Provisions.

C101.5 Compliance. *Residential buildings* shall meet the provisions of IECC—Residential Provisions. *Commercial buildings* shall meet the provisions of IECC—Commercial Provisions.

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

SECTION C102
ALTERNATE MATERIALS METHOD OF CONSTRUCTION, DESIGN OR INSULATING SYSTEMS

C102.1 General. The requirements of this code shall apply.

C102.1.1 Above code programs. The requirements of this code shall apply.

PART 2—ADMINISTRATION AND ENFORCEMENT

SECTION C103
CONSTRUCTION DOCUMENTS

C103.1 General. Construction documents, technical reports and other supporting data shall be submitted in one or more sets with each application for a permit. The construction documents and technical reports shall be prepared by a registered design professional as prescribed by the local jurisdiction or national regulatory authority.

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

C103.2 Information on construction documents. Construction documents shall be drawn to scale on suitable material. Electronic media documents are permitted to be submitted where *approved* by the *code official*. 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. Mechanical system design criteria.
5. Mechanical and service water heating systems and equipment types, sizes and efficiencies.
6. Economizer description.
7. Equipment and system controls.
8. Fan motor power and controls.
9. Duct sealing, duct and pipe insulation and location.
10. Lighting fixture schedule with wattage and control narrative.
11. Location of *daylight* zones on floor plans.
12. Air sealing details.

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* 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* 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* 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*. 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 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* 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* 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 and closeout submittal 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.

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 2 of Section C401.2, the documentation shall include:

1. The envelope insulation compliance path.
2. All compliance calculations including those required by Sections C402.1.5, C403.8.1, C405.3 and C405.4.

For projects complying with Section C407, the documentation shall include that required by Sections C407.4.1 and C407.4.2.

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
FEES

C104.1 Fees. A permit shall not be issued until the fees prescribed in Section C104.2 have been paid, nor shall an amendment to a permit be released until the additional fee, if any, has been paid.

C104.2 Schedule of permit fees. A fee for each permit shall be paid as required, in accordance with the schedule as established by the applicable governing authority.

C104.3 Work commencing before permit issuance. Any person who commences any work before obtaining the necessary permits shall be subject to an additional fee established by the *code official* that shall be in addition to the required permit fees.

C104.4 Related fees. The payment of the fee for the construction, *alteration*, removal or demolition of work done in connection to or concurrently with the work or activity authorized by a permit shall not relieve the applicant or holder of the permit from the payment of other fees that are prescribed by law.

C104.5 Refunds. The *code official* is authorized to establish a refund policy.

SECTION C105
INSPECTIONS

C105.1 General. Construction or work for which a permit is required shall be subject to inspection by the code official, 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 nor the

jurisdiction shall be liable for expense entailed in the removal or replacement of any material, product, system or building component required to allow inspection to validate compliance with this code.

C105.2 Required inspections. The *code official,* his or her designated agent or an approved agency, upon notification, shall make the inspections set forth in Sections C105.2.1 through C105.2.6.

C105.2.1 Footing and foundation insulation. Inspections shall verify the footing and foundation insulation *R*-value, location, thickness, depth of burial and protection of insulation as required by the code, *approved* plans and specifications.

C105.2.2 Thermal envelope. Inspections shall verify the correct type of insulation, *R*-values, location of insulation, fenestration, *U*-factor, SHGC and VT, and that air leakage controls are properly installed, as required by the code, *approved* plans and specifications.

C105.2.3 Plumbing system. Inspections shall verify the type of insulation, *R*-values, protection required, controls and heat traps as required by the code, *approved* plans and specifications.

C105.2.4 Mechanical system. Inspections shall verify the installed HVAC equipment for the correct type and size, controls, insulation, R-values, system and damper air leakage, minimum fan efficiency, energy recovery and economizer as required by the code, *approved* plans and specifications.

C105.2.5 Electrical system. Inspections shall verify lighting system controls, components, and meters as required by the code, *approved* plans and specifications.

C105.2.6 Final inspection. 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 in accordance with Section C408.

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

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

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

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

C105.7 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*.

C105.7.1 Revocation. The *code official* 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 C106
VALIDITY

C106.1 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 C107
REFERENCED STANDARDS

C107.1 Referenced codes and standards. The codes and standards referenced in this code shall be those listed in Chapter 6, and such codes and standards shall be considered as part of the requirements of this code to the prescribed extent of each such reference and as further regulated in Sections C107.1.1 and C107.1.2.

C107.1.1 Conflicts. Where conflicts occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.

C107.1.2 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.

C107.2 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.

C107.3 Other laws. The requirements of this code shall not be deemed to nullify any requirements of local, state or national law. If local codes or requirements exceed the requirements set forth in this code, the most current requirements shall apply.

SECTION C108
STOP WORK ORDER

C108.1 Authority. Where the *code official* finds any work regulated by this code being performed in a manner either contrary to the provisions of this code or dangerous or unsafe, the *code official* is authorized to issue a stop work order.

C108.2 Issuance. The stop work order shall be in writing and shall be given to the owner of the property involved, the owner's authorized agent, or to the person doing the work. Upon issuance of a stop work order, the cited work shall immediately cease. The stop work order shall state the reason for the order and the conditions under which the cited work will be permitted to resume.

C108.3 Emergencies. Where an emergency exists, the *code official* shall not be required to give a written notice prior to stopping the work.

C108.4 Failure to comply. Any person who shall continue any work after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be liable to a fine as set by the applicable governing authority.

SECTION C109
BOARD OF APPEALS
DELETED

CHAPTER 2 [CE]

DEFINITIONS

User note:

About this chapter: *Codes, by their very nature, are technical documents. Every word, term and punctuation mark can add to or change the meaning of a technical requirement. It is necessary to maintain a consensus on the specific meaning of each term contained in the code. Chapter 2 performs this function by stating clearly what specific terms mean for the purposes of the code.*

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. 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* shall have the meanings ascribed to them in those codes.

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 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. Acceptable to the code official.

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*.

AUTHORITY HAVING JURISDICTION. An organization, office, or individual responsible for enforcing the requirements of a code or standard, appointing code officials, or for approving equipment, materials, an installation, or a procedure.

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 W/(m^2 • K) (Btu/h • ft^2 • °F).

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.

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.

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.

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

COEFFICIENT OF PERFORMANCE (COP) – HEATING. The ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system, including the compressor and, if applicable, auxiliary heat, under designated operating conditions.

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

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 0.092 m^2 (20 watts per f^2) 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. 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.

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 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.

ENERGY USE INTENSITY (EUI). An expression of building energy use per year in terms of net energy divided by gross floor.

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 POWER . The power delivered to the fan's shaft. Brake horsepower does not include the mechanical drive losses such as that from belts and gears.

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

FAN SYSTEM Watt. The sum of the fan brake power of all fans that are required to operate at fan system design conditions to supply air from the heating or cooling source to the *conditioned spaces* and 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 W. The sum of the motor nameplate power 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 [W/(m • K)] (Btu/h • ft • °F].

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

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.

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

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

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

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

HIGH SPEED DOOR. A nonswinging door used primarily to facilitate vehicular access or material transportation, with a minimum opening rate of 813 mm (32 in) per second, a minimum closing rate of 610 mm (24 in) 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 50 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 50 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.

INTEGRATED COEFFICIENT OF PERFORMANCE ($ICOP_C$). A single-number figure of merit expressing cooling part-load COP efficiency for commercial unitary air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment (analogous to IEER, but for SI or other consistent units).

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.

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* 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 50 hertz.

LUMINAIRE-LEVEL LIGHTING CONTROLS. A lighting system consisting of one or more luminaires with em-bedded 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").

NAMEPLATE POWER. 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 12.35.2 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 12.35.2 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 12.35.2 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.

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.

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 0 °C (32 °F) and at or below 24 °C (75 °F), that can be walked into and has a total chilled storage area of not less than 279 m^2 (3,000 ft^2).

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

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

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

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

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 buildings three stories or less in height above grade plane.

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

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

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

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

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

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

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

SEASONAL COEFFICIENT OF PERFORMANCE—COOLING ($SCOP_C$). The total cooling output of an air conditioner during its normal annual usage period for cooling divided by the total electric energy input during the same period in consistent units (analogous to SEER but in SI or other consistent units).

SEASONAL COEFFICIENT OF PERFORMANCE—HEATING ($SCOP_H$). The total heating output of a heat pump during its normal annual usage period for heating divided by the total electric energy input during the same period in consistent units (analogous to HSPF but in SI or other consistent units).

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 [W/(m^2 • K)] (Btu/h • ft^2 • °F).

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 0 °C (32 °F) and less than 12.8 °C (55 °F) that can be walked into, has a ceiling height of not less than 2 m (79 in) and has a total chilled storage area of less than 279 m^2 (3,000 ft^2).

WALK-IN FREEZER. An enclosed storage space capable of being refrigerated to temperatures at or below 0 °C (32 °F) that can be walked into, has a ceiling height of not less than 2 m (79 in) and has a total chilled storage area of less than 279 m^2 (3,000 ft^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 [CE]

GENERAL REQUIREMENTS

User note:

About this chapter: *Chapter 3 addresses broadly applicable requirements that would not be at home in other chapters having more specific coverage of subject matter. This chapter establishes thermal climate zones for CARICOM Countries and also contains product rating, marking and installation requirements for materials such as insulation, windows, doors and siding.*

SECTION C301
CLIMATE ZONES

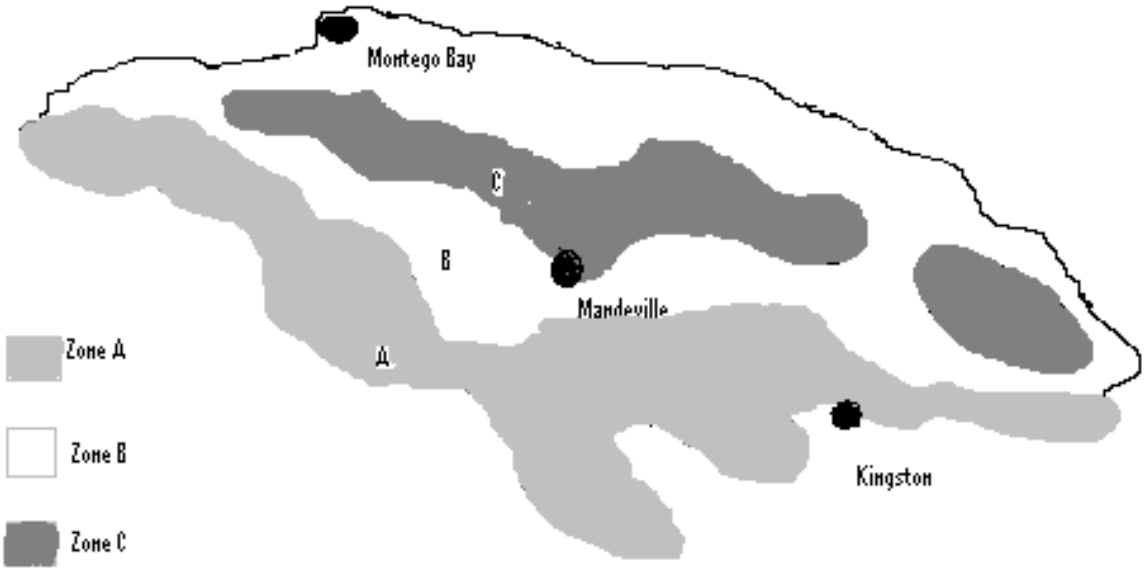
C301.1 General. Climate zone 1A shall be used as an acceptable approximation for all locations throughout Jamaica in determining the applicable requirements from Chapters 4 [CE]. This was arrived at by using the climate zone classification for Puerto Rico and Hawaii that are tropical islands with similar latitude to Jamaica. The actual climate zone for a specific location anywhere in Jamaica shall be assigned according to Sub-section C301.3 below.

C301.2 Warm humid locations. Warm humid locations are identified in Table C301.1.

C301.3 International climate zones. The climate zone for a specific location within Jamaica shall be determined by applying Table C301.3(1) and then Table C301.3(2). Further details on the micro *climate zones* of Jamaica may be obtained from the Jamaica climate zone map of Figure C301.3 below and Table C302.1.

FIGURE C301.3.

CLIMATE ZONES OF JAMAICA



NOTES

1. The map shown in Figure 301.3 defines the climate zones of Jamaica for which the data in Table 302.2 is provided.

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 22 °C (72 °F) for heating and minimum of 24 °C (75 °F) for cooling.

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 305 mm (12 in) 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 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 thick-ness shall be *listed* on the certification. For insulated siding, the *R*-value shall be labelled 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 labelled as required by the material standards specified in Table 1508.2 of the *International Building Code*.

C303.1.1.1 Blown or sprayed roof/ceiling insulation. The thickness of blown-in or sprayed roof/ceiling insulation (fiberglass or cellulose) shall be written in mm (in) on markers that are installed at least one for every 28 m^2 (300 ft^2) 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 25 mm (1 in) 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 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).

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 • ft^2 • °F/Btu at a mean temperature of 24 °C (75 °F).

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.

TABLE C303.1.3(1)
DEFAULT OPAQUE DOOR *U*-FACTORS

FRAME TYPE	SINGLE PANE	DOUBLE PANE	SKYLIGHT	
			Single	Double
Metal	6.81 W/m^2 • K	4.54 W/m^2 • K	11.36 W/m^2 • K	7.38 W/m^2 • K
	(1.20 Btu/h • ft^2 • °F)	(0.80 Btu/h • ft^2 • °F)	(2.00 Btu/h • ft^2 • °F)	(1.30 Btu/h • ft^2 • °F)
Metal with Thermal Break	6.25 W/m^2 • K	3.69 W/m^2 • K	10.79 W/m^2 • K	6.25 W/m^2 • K
	(1.10 Btu/h • ft^2 • °F)	(0.65 Btu/h • ft^2 • °F)	(1.90 Btu/h • ft^2 • °F)	(1.10 Btu/h • ft^2 • °F)
Nonmetal or Metal Clad	5.39 W/m^2 • K	3.12 W/m^2 • K	9.94 W/m^2 • K	5.96 W/m^2 • K
	(0.95 Btu/h • ft^2 • °F)	(0.55 Btu/h • ft^2 • °F)	(1.75 Btu/h • ft^2·°F)	(1.05 Btu/h • ft^2 • °F)
Glazed Block	3.41 W/m^2 • K			
	(0.60 Btu/h • ft^2 • °F)			

TABLE C301.1
CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID DESIGNATIONS BY COUNTY AND TERRITORY

Key: A – Moist, B – Dry, C – Marine. Absence of moisture designation indicates moisture regime is irrelevant.

COUNTRY	LOCATION	WMO#	CZ	SI				I-P			
				Elev (m)	CDD10	HDD18	Precip (mm)	Elev (ft)	CDD50	HDD65	Precip (in)
Anguilla (AIA)[a]	WALLBLAKE AIRPORT	–	0A	10[c]	6691	0[c]	617[c]	33[c]	10450[c]	0[c]	24[c]
Antigua and Barbuda (ATG)[b]	V.C. BIRD INTL AIRPORT	788620	0A	10	6249	0	883	33	11248	0	35
Bahamas (BHS)[b]	LYNDEN PINDLING INTL AIRPORT	780730	1A	7	5643	9	1334	23	10157	16	53
	SETTLEMENT POINT	994390	1A	3	5322	19	1281	10	9580	34	50
Barbados (BRB)[b]	GRANTLEY ADAMS INTL AIRPORT	789540	0A	56	6308	0	1155	184	11354	0	45
Belize (BLZ)[b]	BELIZE/PHILLIP GOLDSON INTL AIRPORT	785830	0A	5	6145	0	1944	16	11061	0	77
Bermuda (BMU)[b]	BERMUDA INTL AIRPORT	780160	2A	6	4596	88	1456	20	8273	158	57
British Virgin Islands (VGB)[a]	TERRANCE B. LETTSOME INTL AIRPORT		0A	10[c]	6453	0[c]	841[c]	33[c]	10445[c]	0[c]	33[c]
Cayman Islands (CYM)[a]	OWEN ROBERTS INTL AIRPORT	–	0A	10[c]	6620	0[c]	1037[c]	33[c]	10889[c]	0[c]	41[c]
Dominica (DMA)[a]	DOUGLAS-CHARLES AIRPORT	–	0A	10[c]	6288	0[c]	878[c]	33[c]	10631[c]	0[c]	35[c]
Grenada (GRD)[b]	MAURICE BISHOP INTL AIRPORT	789580	0A	7	6378	0	1197	23	11480	0[c]	47
Guyana (GUY)[b]	CHEDDI JAGAN INTL AIRPORT	810020	0A	29	6136	0	2234	95	11045	0	88
Haiti (HTI)[a]	PORT-AU-PRINCE AEROPORT INTL		0A	10[c]	6848	0[c]	1404[c]	33[c]	10278[c]	0[c]	55[c]
Jamaica (JAM)[b]	KINGSTON NORMAN MANLEY INTL AIRPORT	783970	1A	14	6608	0	730	46	11894	0	29
	MONTEGO BAY/SANGSTE INTL AIRPORT	783880	1B	8	6336	0	1184	26	11405	0	47
Montserrat (MSR)[a]	JOHN A. OSBORNE AIRPORT	–	1A	10[c]	5946	0[c]	702[c]	33[c]	10615[c]	0[c]	28[c]
Saint Lucia (LCA)[b]	HEWANORRA INTL AIRPORT	789480	0A	10	6429	0	1128	33	11572	0	44
St. Kitts and Nevis (KNA)[a]	ROBERT L. BRADSHAW INTL AIRPORT	–	0A	10[c]	6388	0[c]	696[c]	33[c]	10516[c]	0[c]	27[c]
St. Vincent and the Grenadines (VCT)[a]	ARGYLE INTL AIRPORT	–	0A	10[c]	6647	0[c]	582[c]	33[c]	10729[c]	0[c]	23[c]

Suriname (SUR)	JOHAN A. PENGEL INTL AIRPORT at Zanderij	812250	0A	9	6264	0	2249	30	11275	0	89
	Paramaribo [a]	–	–	10[c]	6361	0[c]	2293[c]	33[c]	10688[c]	0[c]	90[c]
Trinidad and Tobago (TTO)[b]	ARTHUR NAPOLEON RAYMOND ROBINSON INTL AIRPORT	789620	0A	6	6307	0	1452	20	11353	0	57
	PIARCO INTL AIRPORT	789700	0A	15	6274	0	1781	49	11293	0	70
Turks and Caicos Islands (TCA)[a]	PROVIDENCIALES INTL AIRPORT	–	0A	10[c]	6439	0[c]	673[c]	33[c]	10331[c]	0[c]	27[c]

a. Calculated CARICOM Member State or Associate.
b. CARICOM Member State or Associate.
c, RETScreen Expert Data

TABLE C301.3(2)
UNSTATED THERMAL CLIMATE ZONE DEFINITIONS [SOURCE: ASHRAE STANDARD 169—2013]

THERMAL ZONE	NAME	SI UNITS	IP UNITS
0	Tropical[1]	6000 < CDD10 °C	10,800 < CDD50 °F
1	Very Hot	5000 < CDD10 °C ≤ 6000	9000 < CDD50 °F ≤ 10,800
2	Hot	3500 < CDD10 °C ≤ 5000	6300 < CDD50 °F ≤ 9000
3	Warm	CDD10 °C ≤ 3500 AND HDD18 °C ≤ 2000	CDD50 °F ≤ 6300 AND HDD65 °F ≤ 3600

1. ASHRAE Standard 169—2013 uses the term “Extremely hot”

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

DOOR TYPE	*U*-FACTOR
Uninsulated Metal	6.81 W/m^2 • K
	(1.20 Btu/h • ft^2 • °F)
Insulated Metal (Rolling)	5.11 W/m^2 • K
	(0.90 Btu/h • ft^2 • °F)
Insulated Metal (Other)	3.41 W/m^2 • K
	(0.60 Btu/h • ft^2 • °F)
Wood	2.84 W/m^2 • K
	(0.50 Btu/h • ft^2 • °F)
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	1.99 W/m^2 • K
	(0.35 Btu/h • ft^2 • °F)

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

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

TABLE C301.3(1)
UNSTATED CLIMATE ZONE DEFINITIONS

MAJOR CLIMATE TYPE DEFINITIONS
Marine (C) Definition—Locations meeting all four criteria: 1. Mean temperature of coldest month between -3 °C (27 °F) and 18 °C (65 °F). 2. Warmest month mean < 22 °C (72 °F). 3. At least four months with mean temperatures over 10 °C (50 °F). 4. Dry season in summer. The month with the heaviest precipitation in the cold season has at least three times as much precipitation as the month with the least precipitation in the rest of the year. The cold season is October through March in the Northern Hemisphere and April through September in the Southern Hemisphere.

Dry (B) Definition—Locations meeting the following criteria:

1. Not Marine (C)
2. If 70% or more of the precipitation, P, occurs during the high sun period, then the dry/humid threshold is $P_{mm} < 20.0 \times (T + 14)$ (SI) [$P_{in} < 0.44 \times (T - 7)$ (I-P)]
3. If between 30% and 70% of the precipitation, *P*, occurs during the high sun period, then the dry/humid threshold is $P_{mm} < 20.0 \times (T + 7)$ (SI) [$P_{in} < 0.44 \times (T - 19.5)$ (I-P)]
4. If 30% or less of the precipitation, P, occurs during the high sun period, then the dry/humid threshold is $P_{mm} < 20 \times T$ (SI) [$P_{in} < 0.44 \times (T - 32)$ (I-P)] where:

P = Annual precipitation, in. (mm)

T = Annual mean temperature, °F (°C)

Summer or high sun = April through September in the Northern Hemisphere and October through March period in the Southern Hemisphere

Winter or cold season = October through March in the Northern Hemisphere and April through September in the Southern Hemisphere

Humid (A) Definition—Locations that are not marine and not dry.

Warm-humid Definition—Humid (A) locations where either of the following wet-bulb temperature conditions shall occur during the warmest six consecutive months of the year:

1. 19.4 °C (67 °F) or higher for 3,000 or more hours; or
2. 22.8 °C (73 °F) or higher for 1,500 or more hours.

For IP:°F = [(°F - 32)] × 5/9], 1 mm = 0.03937 in.

CHAPTER 4 [CE]

COMMERCIAL ENERGY EFFICIENCY

User note:

About this chapter: *Chapter 4 presents the paths and options for compliance with the energy efficiency provisions. Chapter 4 contains energy efficiency provisions for the building envelope, fenestration, mechanical systems, appliances, freezers and coolers, kitchen exhaust, interior and exterior lighting, water heating systems, transformers and motors.*

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 ANSI/ASHRAE/IESNA 90.1.
2. The requirements of Sections C402 through C405 and C408. In addition, commercial buildings shall comply with Section C406 and tenant spaces shall comply with Section C406.1.1.

C401.2.1 Application to replacement fenestration products. Where some or all of an existing *fenestration* unit is replaced with a new *fenestration* product, including sash and glazing, the replacement *fenestration* unit shall meet the applicable requirements for *U*-factor and *SHGC* in Table C402.4.

Exception: An area-weighted average of the *U*-factor of replacement fenestration products being installed in the building for each fenestration product category listed in Table C402.4 shall be permitted to satisfy the *U*-factor requirements for each fenestration product category listed in Table C402.4. Individual fenestration products from different product categories listed in Table C402.4 shall not be combined in calculating the area-weighted average *U*-factor.

~~All capacities~~ SECTION C402
BUILDING ENVELOPE REQUIREMENTS

C402.1 General (Prescriptive). 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 2 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 C402.1.3; the *U*-, *C*- and *F*-factor-based method of Section C402.1.4; or the component performance alternative of Section C402.1.5.
2. Roof solar reflectance and thermal emittance shall comply with Section C402.3.
3. Fenestration in building envelope assemblies shall comply with Section C402.4.
4. Air leakage of building envelope assemblies shall comply with Section C402.5.

Alternatively, where buildings have a vertical fenestration area or skylight area exceeding that allowed in Section C402.4, the building and building thermal envelope shall comply with Section C401.2, Item 1 or Section C401.2, Item 3.

Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.10.1 or C403.10.2.

C402.1.1 Low energy use intensity buildings. The following low-energy buildings, or portions thereof separated from the remainder of the building by *building thermal envelope* assemblies complying with this section, shall be exempt from the *building thermal envelope* provisions of Section C402.

1. Those with a peak design rate of energy usage less than 10.7 W/m^2 (3.4 Btu/h • ft^2) or 10.7 W/m^2 (1.0 w/ft^2) of floor area for space conditioning purposes.
2. Unconditioned space that does not contain habitable space.
3. Greenhouses.

C402.1.2 Equipment buildings. Buildings that comply with the following shall be exempt from the *building thermal envelope* provisions of this code:

1. Are separate buildings with floor area not more than 46.5 m^2 (500 ft^2).
2. Are intended to house electronic equipment with installed equipment power totalling not less than 75 W/m^2 (7 watts/ft^2) and not intended for human occupancy.
3. Have a heating system capacity not greater than 5 kW (17,000 Btu/hr) and a heating thermostat set point that is restricted to not more than 10 °C (50 °F).
4. Have an average wall and roof *U*-factor less than 1.14 W/m^2 • K (U-0.200 Btu/h • ft^2 • °F) in *Climate Zones* 0 through 5 and less than 0.68 W/m^2 • K (U-0.120 Btu/h • ft^2 • °F) in *Climate Zones* 6 through 8.
5. Comply with the roof solar reflectance and thermal emittance provisions for *Climate Zones* 0 and 1.

C402.1.3 Insulation component *R*-value-based method. *Building thermal envelope* opaque assemblies shall comply with the requirements of Sections C402.2 and C402.4 based on the *climate zone* specified in Chapter 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 Table C402.1.3. Commercial buildings or portions of commercial buildings enclosing *Group R* occupancies shall use the *R*-values from the "*Group R*" column of Table C402.1.3. Commercial buildings or portions of commercial buildings enclosing occupancies other than *Group R* shall use the *R*-values from the "All other" column of Table C402.1.3.

TABLE C402.1.3
BUILDING ENVELOPE REQUIREMENTS FOR THE TROPICAL CLIMATE ZONES[a]

	ALL OTHER		GROUP R	
OPAQUE ELEMENTS	**Assembly Maximum**	**Insulation Min. *R-Value***	**Assembly Maximum**	**Insulation Min. *R-Value***
Roofs				
Insulation entirely above deck	U-0.220 W/m^2 • K (U-0.039 Btu/h • ft^2 • °F)	R-4.4 c.i. m^2 • K/W (R-25 c.i. h • ft^2 • °F/Btu)	U-0.184 W/m^2 • K (U-0.032 Btu/h • ft^2 • °F)	R-4.4 c.i. m^2 • K/W (R-25 c.i. h • ft^2 • °F/Btu)
Metal building[b]	U-0.233 W/m^2 • K (U-0.041 Btu/h • ft^2 • °F)	R-1.8 + R-3.3 FC m^2 • K/W (R-10 + R-19 FC h • ft^2 • °F/Btu)	U-0.233 W/m^2 • K (U-0.041 Btu/h • ft^2 • °F)	R-1.8 + R-3.3 FC m^2 • K/W (R-10 + R-19 FC h • ft^2 • °F/Btu)
Attic and other	U-0.153 W/m^2 • K (U-0.027 Btu/h • ft^2 • °F)	R-6.7 m^2 • K/W (R-38 c.i. h • ft^2 • °F/Btu)	U-0.153 W/m^2 • K (U-0.027 Btu/h • ft^2 • °F)	R-6.7 m^2 • K/W (R-38 c.i. h • ft^2 • °F/Btu)
Walls, above grade				
Mass	U-3.293 W/m^2 • K (U-0.151 Btu/h • ft^2 • °F)	NR	U-0.857 W/m^2 • K (U-0.151 Btu/h • ft^2 • °F)	R-1.0 c.i. m^2 • K/W (R-5.7 c.i. h • ft^2 • °F/Btu)
Metal building	U-0.533 W/m^2 • K (U-0.094 Btu/h • ft^2 • °F)	R-0 + R-1.7 c.i. m^2 • K/W (R-0 + R-9.8 c.i. h • ft^2 • °F/Btu)	U-0.533 W/m^2 • K (U-0.094 Btu/h • ft^2 • °F)	R-0 + R-1.7 c.i. m^2 • K/W (R-0 + R-9.8 c.i. h • ft^2 • °F/Btu)
Steel-framed	U-0.705 W/m^2 • K (U-0.124 Btu/h • ft^2 • °F)	R-2.3 m^2 • K/W (R-13 c.i. h • ft^2 • °F/Btu)	U-0.705 W/m^2 • K (U-0.124 Btu/h • ft^2 • °F)	R-2.3 m^2 • K/W (R-13 c.i. h • ft^2 • °F/Btu)
Wood-framed and other	U-0.504 W/m^2 • K (U-0.089 Btu/h • ft^2 • °F)	R-2.3 m^2 • K/W (R-13 c.i. h • ft^2 • °F/Btu)	U-0.504 W/m^2 • K (U-0.089 Btu/h • ft^2 • °F)	R-2.3 m^2 • K/W (R-13 c.i. h • ft^2 • °F/Btu)
Walls, below grade				

Below-grade wall	C-6.473 W/m^2 • K (C-1.140 Btu/h • ft^2 • °F)	NR	C-6.473 W/m^2 • K (C-1.140 Btu/h • ft^2 • °F)	NR
Floors				
Mass	U-1.825 W/m^2 • K (U-0.322 Btu/h • ft^2 • °F)	NR	U-1.825 W/m^2 • K (U-0.322 Btu/h • ft^2 • °F)	NR
Steel joist	U-1.986 W/m^2 • K (U-0.350 Btu/h • ft^2 • °F)	NR	U-1.986 W/m^2 • K (U-0.350 Btu/h • ft^2 • °F)	NR
Wood-framed and other	U-1.599 W/m^2 • K (U-0.282 Btu/h • ft^2 • °F)	NR	U-1.599 W/m^2 • K (U-0.282 Btu/h • ft^2 • °F)	NR
Slab-on-grade-Floors				
Unheated	F-1.264 W/m^2 • K (F-0.730 Btu/h • ft^2 • °F)	NR	F-1.264 W/m^2 • K (F-0.730 Btu/h • ft^2 • °F)	NR
Heated	F-1.766 W/m^2 • K (F-1.020 Btu/h • ft^2 • °F)	R-1.3 m^2 • K/W (R-7.5 h • ft^2 • °F/Btu) for 300 mm (12in.)	F-1.766 W/m^2 • K (F-1.020 Btu/h • ft^2 • °F)	R-1.3 m^2 • K/W (R-7.5 h • ft^2 • °F/Btu) for 300 mm (12 in)
Opaque doors				
Swinging	U-2.101 W/m^2 • K (U-0.370 Btu/h • ft^2 • °F)		U-2.101 W/m^2 • K (U-0.370 Btu/h • ft^2 • °F)	
Nonswinging	U-1.760 W/m^2 • K (U-0.310 Btu/h • ft^2 • °F)		U-1.760 W/m^2 • K (U-0.310 Btu/h • ft^2 • °F)	

(continued)

TABLE C402.1.3—continued
BUILDING ENVELOPE REQUIREMENTS FOR THE TROPICAL CLIMATE ZONES[a]

	ALL OTHER			GROUP R		
Fenestration	**Assembly Max. U**	**Assembly Max. *SHGC***	**Assembly Min. VT/*SHGC***	**Assembly Max. U**	**ASSEMBLY Max. *SHGC***	**ASSEMBLY Min. VT/*SHGC***
Vertical Fenestration, 0% to 40% of Wall		(for all frame types)			(for all frame types)	
Nonmetal framing, all	U-1.82 W/m^2 • K	0.22	1.1	U-1.82 W/m^2 • K	0.22	1.1
Metal framing, fixed	U-2.84 W/m^2 • K			U-2.84 W/m^2 • K		
Metal framing, operable	U-3.69 W/m^2 • K			U-3.69 W/m^2 • K		
Metal framing, entrance door	U-4.71 W/m^2 • K			U-4.71 W/m^2 • K		
Skylight, 0% to 3% of Roof						
All types	U-4.26 W/m^2 • K	0.35	NR	U-4.26 W/m^2 • K	0.35	NR

a. The following definitions apply:
c.i. = 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.
FC = The first rated *R*-value of insulation represents faced or unfaced insulation installed between the purlins. The second rated *R*-value of insulation represents unfaced insulation installed above the first layer, perpendicular to the purlins and compressed when the metal roof panels are attached. A supporting structure retains the bottom of the first layer at the prescribed depth required for the full thickness of insulation. A minimum R-0.9 m^2 • K/W (R-5.1 h·ft^2 • °F/Btu) thermal spacer block between the purlins and the metal roof panels is required unless compliance is shown by the overall assembly *U*-factor.
NR = no (insulation) requirement.

b. The two *R*-values are for the separate layers of insulation which must be installed. When using the *R*-value compliance method for metal building roofs, a thermal spacer block is required.

C402.1.4 Assembly *U*-factor, *C*-factor or *F*-factor-based method. Building thermal envelope opaque assemblies shall meet the requirements of Sections C402.2 and C402.4 based on the climate zone specified in Chapter 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 Table C402.1.3. 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 C402.1.3. Commercial buildings or portions of commercial buildings enclosing occupancies other than *Group R* shall use the *U*-, *C*- or *F*-factor.

C402.1.4.1 Thermal resistance of cold-formed steel walls. *U*-factors of walls with cold-formed steel studs shall be permitted to be determined in accordance with Equation 4-1:

$U = 1/[R_s + (ER)]$ **(Equation 4-1)**

where:

R_s = The cumulative *R*-value of the wall components along the path of heat transfer, excluding the *cavity insulation* and steel studs.

ER = The effective *R*-value of the *cavity insulation* with steel studs as specified in Table C402.1.4.1.

TABLE C402.1.4.1
EFFECTIVE *R*-VALUES FOR STEEL STUD WALL ASSEMBLIES

SPACING OF FRAMING		NOMINAL STUD DEPTH		CAVITY R-VALUE (insulation)		CORRECTION FACTOR (Fc)	EFFECTIVE R-VALUE (ER) (Cavity *R*-Value x Fc)	
mm	inches	mm	inches	$m^2 \bullet K/W$	$h \bullet ft^2 \bullet °F/Btu$		$m^2 \bullet K/W$	$h \bullet ft^2 \bullet °F/Btu$
406	16	89	3.5	2.3	13	0.46	4.98	5.98
				2.6	15	0.43	1.14	6.45
		152	6	3.3	19	0.37	1.24	7.03
				3.7	21	0.35	1.29	7.35
		203	8	4.4	25	0.31	1.36	7.75
610	24	89	3.5	2.3	13	0.55	1.26	7.15
				2.6	15	0.52	1.37	7.80
		152	6	3.3	19	0.45	1.51	8.55
				3.7	21	0.43	1.59	9.03
		203	8	4.4	25	0.38	1.67	9.50

C402.1.5 Component performance alternative. Building envelope values and fenestration areas determined in accordance with Equation 4-2 shall be an alternative to compliance with the *U*-, *F*- and *C*-factors in Tables C402.1.4 and C402.4 and the maximum allowable fenestration areas in Section C402.4.1. *Fenestration* shall meet the applicable SHGC requirements of Section C402.4.3.

$A + B + C + D + E \leq Zero$ **(Equation 4-2)**

where:

A = Sum of the (UA Dif) values for each distinct assembly type of the building thermal envelope, other than slabs on grade and below-grade walls.

UA Dif = UA Proposed - UA Table.

UA Proposed = Proposed *U*-value × Area.

UA Table = (*U*-factor from Table C402.1.3, C402.1.4 or C402.4 × Area.

B = Sum of the (FL Dif) values for each distinct slab-on-grade perimeter condition of the building thermal envelope.

FL Dif = FL Proposed - FL Table.

FL Proposed = Proposed *F*-value × Perimeter length.

FL Table = (*F*-factor specified in Table C402.1.4) × Perimeter length.

C = Sum of the (CA Dif) values for each distinct below-grade wall assembly type of the building thermal envelope.

CA Dif = CA Proposed - CA Table.

CA Proposed = Proposed *C*-value × Area.

CA Table = (Maximum allowable *C*-factor specified in Table C402.1.4) × Area.

Where the proposed vertical glazing area is less than or equal to the maximum vertical glazing area allowed by Section C402.4.1, the value of D (Excess Vertical Glazing Value) shall be zero. Otherwise:

D = (DA × UV) - (DA × U Wall), but not less than zero.

DA = (Proposed Vertical Glazing Area) - (Vertical Glazing Area allowed by Section C402.4.1).

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 C402.4.1, the value of E (Excess Skylight Value) shall be zero. Otherwise:

E = (EA × US) - (EA × U Roof), but not less than zero.

EA = (Proposed Skylight Area) - (Allowable Skylight Area as specified in Section C402.4.1).

U Roof = Area-weighted average *U*-value of all roof assemblies.

UAS = Sum of the (UA Proposed) values for each skylight assembly.

US = UAS/total skylight area.

C402.2 Specific building thermal envelope insulation requirements (Prescriptive). Insulation in building thermal envelope opaque assemblies shall comply with Sections C402.2.1 through C402.2.7 and Table C402.1.3.

C402.2.1 Roof assembly. The minimum thermal resistance (*R*-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table C402.1.3, based on construction materials used in the roof assembly. Insulation installed on a suspended ceiling having removable ceiling tiles shall not be considered as part of the minimum thermal resistance of the roof insulation. Continuous insulation board shall be installed in not less than 2 layers and the edge joints between each layer of insulation shall be staggered.

Exceptions:

1. Continuously insulated roof assemblies where the thickness of insulation varies 25 mm or less and where the area-weighted *U*-factor is equivalent to the same assembly with the *R*-value specified in Table C402.1.3.
2. Where tapered insulation is used with insulation entirely above deck, the *R*-value where the insulation thickness varies 25 mm (1 in) or less from the minimum thickness of tapered insulation shall comply with the *R*-value specified in Table C402.1.3.
3. Two layers of insulation are not required where insulation tapers to the roof deck, 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-0.88 (m^2 • K)/W (R-5 ft^2 • h • °F/Btu), whichever is less.

Exception: Unit skylight curbs included as a component of a skylight listed and labelled 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 C402.1.3, 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 C402.1.3 except as otherwise noted in the table. In determining compliance with Table C402.1.4 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 171 kg/m^2 (35 lbs/ft^2) of wall surface area.
2. Weigh not less than 122 kg/m^2 (25 lbs/ft^2) of wall surface area where the material weight is not more than 1900 kg/m^3 (120 pcf).
3. Have a heat capacity exceeding 144 kJ/m^2 • K (7 Btu/ft^2 • °F).
4. Have a heat capacity exceeding 103 kJ/m^2 • K (5 Btu/ft^2 • °F), where the material weight is not more than 1900 kg/m^3 (120 pcf).

C402.2.3 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 C402.1.3 or C402.1.4 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.

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

1. 171 kg/m^2 (35 lbs/ft^2) of floor surface area.
2. 122 kg/m^2 (25 lbs/ft^2) of floor surface area where the material weight is not more than 1923 kg/m^3 (120 lbs per cu ft).

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 C402.1.3 for "Metal framed" or "Wood framed and other" values for "Walls, Above Grade" and extends from the bottom to the top of all perimeter floor framing or floor assembly members.
2. Insulation applied to the underside of concrete floor slabs shall be permitted an airspace of not more than 25 mm (1 in) where it turns up and is in contact with the underside of the floor under walls associated with the *building thermal envelope.*

C402.2.4 Slabs-on-grade perimeter insulation. Where the slab on grade is in contact with the ground, 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 C402.1.3. The perimeter insulation shall be placed on the outside of the foundation or on the inside of the foundation wall. The perimeter insulation shall extend downward from the top of the slab for the minimum distance shown in the table or to the top of the footing, whichever is less, or downward to not less than the bottom of the slab and then horizontally to the interior or exterior for the total distance shown in the table. Insulation extending away from the building shall be protected by pavement or by not less than 254 mm (10 in) of soil.

Exception: Where the slab-on-grade floor is greater than 610 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 C402.1.3. The *R*-value of the insulating material installed continuously within or on the below-grade exterior walls of the building envelope shall be in accordance with Table C402.1.3. The *C*-factor or *R*-value required shall extend to a depth of not less than 3048 mm (10 ft) 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 with a minimum of R-0.62 m^2/K • W (R-3.5 h • ft^2 • °F/Btu) 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 C402.1.4.

Exception: Heated slabs on grade insulated in accordance with Section C402.2.4.

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 Roof solar reflectance and thermal emittance. Low-sloped roofs directly above cooled conditioned spaces shall comply with one or more of the options in Table C402.3.

Exception: The following roofs and portions of roofs are exempt from the requirements of Table C402.3:

1. Portions of the roof that include or are covered by the following:
   1.1. Photovoltaic systems or components.
   1.2. Solar air or water-heating systems or components.
   1.3. Roof gardens or landscaped roofs.
   1.4. Above-roof decks or walkways.
   1.5. Skylights.
   1.6. HVAC systems and components, and other opaque objects mounted above the roof.
2. Portions of the roof shaded during the peak sun angle on the summer solstice by permanent features of the building or by permanent features of adjacent buildings.
3. Portions of roofs that are ballasted with a minimum stone ballast of 74 kg/m^2 (17 lb/ft^2) or 117 kg/m^2 (23 lb/ft^2) pavers.
4. Roofs where not less than 75 percent of the roof area complies with one or more of the exceptions to this section.

TABLE C402.3
MINIMUM ROOF REFLECTANCE AND EMITTANCE OPTIONS[a]

Three-year-aged solar reflectance index[b] of 55 and 3-year aged thermal emittance[c] of 0.75
Three-year-aged solar reflectance index[d] of 64

a. The use of area-weighted averages to comply with these requirements shall be permitted. Materials lacking 3-year-aged tested values for either solar reflectance or thermal emittance shall be assigned both a 3-year-aged solar reflectance in accordance with Section C402.3.1 and a 3-year-aged thermal emittance of 0.90.
b. Aged solar reflectance tested in accordance with ASTM C1549, ASTM E903 or ASTM E1918 or CRRC-S100.
c. Aged thermal emittance tested in accordance with ASTM C1371 or ASTM E408 or CRRC-S100.
d. Solar reflectance index (SRI) shall be determined in accordance with ASTM E1980 using a convection coefficient of 2.1 Btu/h • ft^2 • °F (12W/m^2 • K). Calculation of aged SRI shall be based on aged tested values of solar reflectance and thermal emittance.

C402.3.1 Aged roof solar reflectance. Where an aged solar reflectance required by Section C402.3 is not available, it shall be determined in accordance with Equation 4-3.

$$R_{aged} = [0.2 + 0.7(R_{initial} - 0.2)] \qquad \textbf{(Equation 4-3)}$$

where:

R_{aged} = The aged solar reflectance.

$R_{initial}$ = The initial solar reflectance determined in accordance with CRRC-S100.

C402.4 Fenestration (Prescriptive). Fenestration shall comply with Sections C402.4.1 through C402.4.5 and Table C402.4. Daylight responsive controls shall comply with this section and Section C405.2.3.1.

TABLE C402.4
BUILDING ENVELOPE FENESTRATION MAXIMUM *U*-FACTOR AND SHGC REQUIREMENTS

Vertical fenestration		
***U*-factor**		
Fixed fenestration	2.84 W/m^2 • K	
Operable fenestration	3.69 W/m^2 • K	
Entrance doors	6.25 W/m^2 • K	
SHGC		
Orientation[a]	SEW	
PF < 0.2	0.25	
0.2 ≤ PF ≤ 0.5	0.30	
0.5 ≤ PF	0.40	
Skylights		
U-factor	4.26 W/m^2 • K	
SHGC	0.35	

NR = No requirement, PF = Projection factor.

Commented [PH1]: In table 402.4, column under "N" has been deleted because Jamaica is less than 23.5 degree latitude

C402.4.1 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.

C402.4.1.1 Increased vertical fenestration area with daylight responsive controls. Not more than 40 percent of the gross above-grade wall area shall be permitted to be vertical fenestration, provided 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.

C402.4.1.2 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*.

C402.4.2 Minimum skylight fenestration area. In an enclosed space greater than 232 m^2 (2500 ft^2) in floor area, directly under a roof with not less than 75 percent of the ceiling area with a ceiling height greater than 4572 mm (15 ft), and used as an office, lobby, atrium, concourse, corridor, storage space, gymnasium/exercise centre, convention centre, automotive service area, space where manufacturing occurs, nonrefrigerated warehouse, retail store, distribution/sorting area, transportation depot or workshop, the *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 *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 4-4.

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

(Equation 4-4)

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 610 mm (2 ft), or 0.7 if light well depth is 610 mm (2 ft) 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 5.4 W/m^2 (0.5 W/ft^2).
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 1500 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 *daylight zones* adjacent to vertical fenestration is less than 232 m^2 (2500 sq ft), and where the lighting is controlled according to Section C405.2.5.

C402.4.2.1 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*.

C402.4.2.2 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.

C402.4.3 Maximum *U*-factor and SHGC. The maximum *U*-factor and solar heat gain coefficient (SHGC) for fenestration shall be as specified in Table C402.4.

The window projection factor shall be determined in accordance with Equation 4-5.

$$PF = A/B$$ **(Equation 4-5)**

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.

C402.4.3.1 Increased skylight SHGC. Skylights shall be permitted a maximum SHGC of 0.60 where located above *daylight zones* provided with *daylight responsive controls*.

C402.4.3.2 Increased skylight *U*-factor. Where skylights are installed above *daylight zones* provided with daylight responsive controls, a maximum *U*-factor of 0.9 shall be permitted. .

C402.4.3.3 Dynamic glazing. Where dynamic glazing is intended to satisfy the SHGC and VT requirements of Table C402.4, 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 C402.4.

C402.4.3.4 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 C402.4. Individual fenestration products from different fenestration product categories listed in Table C402.4 shall not be combined in calculating area-weighted average *U*-factor.

C402.4.4 Daylight zones. Daylight zones referenced in Sections C402.4.1.1 through C402.4.3.2 shall comply with Sections C405.2.3.2 and C405.2.3.3, as applicable. Daylight zones shall include *toplit zones* and sidelit zones.

C402.4.5 Doors. Opaque swinging doors shall comply with Table C402.1.4. Opaque nonswinging doors shall comply with Table C402.1.3. Opaque doors shall be considered as part of the gross area of above-grade walls that are part of the building *thermal envelope*. Other doors shall comply with the provisions of Section C402.4.3 for vertical fenestration.

C402.5 Air leakage—thermal envelope (Mandatory). The *thermal envelope* of buildings shall comply with Sections C402.5.1 through C402.5.8, or the building *thermal envelope* shall be tested in accordance with ASTM E779 at a pressure differential of 75 Pa (0.3 in water gauge) or an equivalent method approved by the code official 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 2.0 L/s • m^2 (0.40 cfm/ft^2). Where compliance is based on such testing, the building shall also comply with Sections C402.5.5, C402.5.6 and C402.5.7.

C402.5.1 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 comply with Sections C402.5.1.1 and C402.5.1.2.

Exception: Air barriers are not required in buildings located in *Climate Zone* 2B.

C402.5.1.1 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 C402.5.8. Where similar objects are installed that penetrate the air barrier, provisions shall be made to maintain the integrity of the air barrier.

C402.5.1.2 Air barrier compliance options. A continuous air barrier for the opaque building envelope shall comply with Section C402.5.1.2.1 or C402.5.1.2.2.

C402.5.1.2.1 Materials. Materials with an air permeability not greater than 0.02 L/s • m^2 (0.004 cfm/ft^2) under a pressure differential of 75 Pa (0.3 in water gauge) 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 10 mm ($^3/_8$ in).
2. Oriented strand board having a thickness of not less than 10 mm ($^3/_8$ in).
3. Extruded polystyrene insulation board having a thickness of not less than 12.7 mm ($^1/_2$ in).
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 12.7 mm ($^1/_2$ in).
5. Closed-cell spray foam a minimum density of 2.4 kg/m^3 (1.5 lb/ft^2) having a thickness of not less than 38 mm ($1^1/_2$ in).
6. Open-cell spray foam with a density between 0.6 and 2.4 kg/m^3 (0.4 and 1.5 lb/ft^2) and having a thickness of not less than 113 mm (4.5 in).
7. Exterior or interior gypsum board having a thickness of not less than 12.7 mm ($^1/_2$ in).
8. Cement board having a thickness of not less than 12.7 mm ($^1/_2$ in).
9. Built-up roofing membrane.
10. Modified bituminous roof membrane.
11. Fully adhered single-ply roof membrane.
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than 15.9 mm ($^5/_8$ in).
13. Cast-in-place and precast concrete.
14. Fully grouted concrete block masonry.
15. Sheet steel or aluminium.
16. Solid or hollow masonry constructed of clay or shale masonry units.

C402.5.1.2.2 Assemblies. Assemblies of materials and components with an average air leakage not greater than 0.2 L/s • m^2 (0.04 cfm/ft^2) under a pressure differential of 75 Pa [0.3 in of water gauge (w.g.)] 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 joints are sealed and the requirements of Section C402.5.1.1 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 102 mm (4 in) or more.
3. A Portland cement/sand parge, stucco or plaster not less than 12.7 mm ($^1/_2$ in) in thickness.

C402.5.2 Air leakage of fenestration. The air leakage of fenestration assemblies shall meet the provisions of Table C402.5.2. Testing shall be in accordance with the applicable reference test standard in Table C402.5.2 by an accredited, independent testing laboratory and *labeled* by the manufacturer.

Exceptions:

1. Field-fabricated fenestration assemblies that are sealed in accordance with Section C402.5.1.
2. Fenestration in buildings that comply with the testing alternative of Section C402.5 are not required to meet the air leakage requirements in Table C402.5.2.

TABLE C402.5.2
MAXIMUM AIR LEAKAGE RATE
FOR FENESTRATION ASSEMBLIES

FENESTRATION ASSEMBLY	MAXIMUM RATE[a]		TEST PROCEDURE
	L/s	(CFM/FT²)	

Windows	0.09[a]	0.20[a]	AAMA/WDMA/ CSA101/I.S.2/A440 or NFRC 400
Sliding doors	0.09[a]	0.20 [a]	
Swinging doors	0.09[a]	0.20 [a]	
Skylights – with condensation weepage openings	0.14	0.30	
Skylights – all other	0.09[a]	0.20 [a]	
Curtain walls	0.03	0.06	NFRC 400 or ASTM E283 at 75 Pa (1.57 psf)
Storefront glazing	0.03	0.06	
Commercial glazed swinging entrance doors	0.47	1.00	
Power-operated sliding doors and power-operated folding doors	0.47	1.00	
Revolving doors	0.47	1.00	
Garage doors	0.19	0.40	ANSI/DASMA 105, NFRC 400 or ASTM E283 at 75 Pa (1.57 psf)
Rolling doors	0.47	1.00	
High-speed doors	0.61	1.3	

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

a. The maximum rate for windows, sliding and swinging doors, and skylights is permitted to be 0.14 L/s (0.3 cfm) per 0.093 m^2 ($1ft^2$) of fenestration or door area when tested in accordance with AAMA/WDMA/CSA101/I.S.2/A440 at 300 Pa (6.24 psf).

Commented [PH2]: Jamaica is in climate zone 1

C402.5.4 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 C402.5.2 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.*

C402.5.5 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.

C402.5.6 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 doorway.

C402.5.7 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.

Exception: Vestibules are not required for the following:

2. Doors not intended to be used by the public, such as doors to mechanical or electrical equipment rooms, or intended solely for employee use.

5. Revolving doors.

6. Doors that have an air curtain with a velocity of not less than 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 C408.2.3.

C402.5.8 Recessed lighting. Recessed luminaires installed in the *building thermal envelope* shall be all of the following:

1. IC-rated.

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

SECTION C403
BUILDING MECHANICAL SYSTEMS

C403.1 General

Mechanical Systems and Equipment serving the building heat, cooling, ventilatiling and refrigerating needs shall comply with this section**C403.1.1.1 Design loads.** Design loads shall be attached to the code compliance form submitted to the building department when the building is permitted, or in the event the mechanical permit is obtained at a later time, the sizing calculation shall be submitted with the application for the mechanical permit.

C403.2 System design (Mandatory). Mechanical systems shall be designed to comply with Sections C403.2.1 and C403.2.2. 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 2323 m^2 in floor area or that span more than one floor and are design 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 outside air to and exhaust air from the isolation area. Each isolation area shall be controlled independently by a device meeting the requirements of section 403.4.2.2. 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 2360 L/s (5000 cfm).

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

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

C403.2.2 Ventilation (Mandatory). Ventilation, either natural or mechanical, shall be provided in accordance with Chapter 4 of the *International Mechanical Code*. Where mechanical ventilation is provided, the system shall provide the capability to reduce the outdoor air supply to the minimum required by Chapter 4 of the *International Mechanical Code*.

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.

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.
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.

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

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air conditioners, air cooled	< 19 kW[b]	All	Split system	3.81 $SCOP_C$	AHRI 210/240
			Single package	4.10 $SCOP_C$	
Through the wall, air cooled	≤ 9 kW[b]	All	Split system	3.51 $SCOP_C$	AHRI 210/240
			Single package	3.51 $SCOP_C$	
Small duct, high velocity, air cooled	≤ 19 kW[b]	All	Split system	2.93 $SCOP_C$	AHRI 210/240
Air conditioners, air cooled	≥ 19 kW and < 40 kW	Electric resistance (or none)	Split system and single package	3.28 COP_C 3.78 $ICOP_C$	AHRI 340/360
		All other		3.22 COP_C 3.76 $ICOP_C$	
	≥ 40 kW and < 70 kW	Electric resistance (or none)		3.22 COP_C 3.75 $ICOP_C$	
		All other		3.16 COP_C 3.72 $ICOP_C$	
	≥ 70 kW and < 223 kW	Electric resistance (or none)		2.93 COP_C 3.40 $ICOP_C$	
		All other		2.87 COP_C 3.34 $ICOP_C$	
	≥ 223 kW	Electric resistance (or none)		2.84 COP_C 3.28 $ICOP_C$	
		All other		2.78 COP_C 3.22 $ICOP_C$	
Air conditioners, water cooled	< 19 kW	All	Split system and single package	3.54 COP_C 3.60 $ICOP_C$	AHRI 210/240
	≥ 19 kW and < 40 kW	Electric resistance (or none)		3.54 COP_C 4.07 $ICOP_C$	AHRI 340/360
		All other		3.48 COP_C 4.02 $ICOP_C$	

	≥ 40 kW and < 70 kW	Electric resistance (or none)		3.66 COP_C 4.07 $ICOP_C$	
		All other		3.60 COP_C 4.02 $ICOP_C$	
	≥ 70 kW and < 223 kW	Electric resistance (or none)		3.63 COP_C 3.99 $ICOP_C$	
		All other		3.57 COP_C 3.93 $ICOP_C$	
	≥ 223 kW	Electric resistance (or none)		3.57 COP_C 3.96 $ICOP_C$	
		All other		3.51 COP_C 3.90 $ICOP_C$	

(continued)

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

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air conditioners, evaporatively cooled	< 19 kW[b]	All	Split System and Single Package	3.54 COP_C	AHRI 210/240
				3.60 $ICOP_C$	
	≥ 19 kW and <40 kW	Electric Resistance (or None)	Split System and Single Package	3.54 COP_C	AHRI 340/360
				3.60 $ICOP_C$	
		All other	Split System and Single Package	3.48 COP_C	
				3.54 $ICOP_C$	
	≥ 40 kW and < 70 kW	Electric Resistance (or None)	Split System and Single Package	3.51 COP_C	
				3.57 $ICOP_C$	
		All other	Split System and Single Package	3.46 COP_C	
				3.51 $ICOP_C$	
	≥ 70 kW and < 223 kW	Electric Resistance (or None)	Split System and Single Package	3.48 COP_C	
				3.54 $ICOP_C$	
		All other	Split System and Single Package	3.43 COP_C	
				3.48 $ICOP_C$	
	≥ 223 kW	Electric Resistance (or None)	Split System and Single Package	3.43 COP_C	
				3.48 $ICOP_C$	
		All other	Split System and Single Package	3.37 COP_C	
				3.43 $ICOP_C$	
Condensing units, air cooled	≥ 40 kW	—	—	3.07 COP_C	AHRI 365
				3.46 $ICOP_C$	
Condensing units, water cooled	≥ 40 kW	—	—	3.95 COP_C	
				4.10 $ICOP_C$	
Condensing units, evaporatively cooled	≥ 40 kW	—	—	3.95 COP_C	
				4.10 $ICOP_C$	

For IP: 1 kW = 3,412 Btu/h.
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 19 kW (65,000 Btu/h) are regulated by NAECA. SEER values are those set by NAECA.

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

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (cooling mode)	< 19 kW[b]	All	Split system	4.10 $SCOP_C$	AHRI 210/240
			Single package	4.10 $SCOP_C$	
Through the wall, air cooled	≤ 9 kW[b]	All	Split system	3.52 $SCOP_C$	
			Single package	3.52 $SCOP_C$	
Small duct, high velocity, air cooled	≤ 19 kW[b]	All	Split System	2.93 $SCOP_C$	
Air cooled (cooling mode)	≥ 19 kW and < 40 kW	Electric Resistance (or None)	Split System and Single Package	3.22 COP_C	AHRI 340/360
				3.57 $ICOP_C$	
		All other	Split System and Single Package	3.17 COP_C	
				3.52 $ICOP_C$	
	≥ 40 kW and < 70 kW	Electric Resistance (or None)	Split System and Single Package	3.11 COP_C	
				3.40 $ICOP_C$	
		All other	Split System and Single Package	3.05 COP_C	
				3.34 $ICOP_C$	
	≥ 70 kW	Electric Resistance (or None)	Split System and Single Package	2.78 COP_C	
				3.11 $ICOP_C$	
		All other	Split System and Single Package	2.72 COP_C	
				3.05 $ICOP_C$	
Water to air, water loop (cooling mode)	< 5 kW	All	30 °C entering water	3.57 COP_C	ISO 13256-1
	≥ 5 kW and < 19 kW	All	30 °C entering water	3.81 COP_C	
	≥ 19 kW and < 40 kW	All	30 °C entering water	3.81 COP_C	
Water to air, groundwater (cooling mode)	< 40 kW	All	15 °C entering water	5.27 COP_C	
Brine to air, ground loop (cooling mode)	< 40 kW	All	25 °C entering water	4.13 COP_C	
Water to water, water loop (cooling mode)	< 40 kW	All	30 °C entering water	3.10 COP_C	ISO 13256-2
Water to water, groundwater (cooling mode)	< 40 kW	All	15 °C entering water	4.77 COP_C	
Brine to water, ground loop (cooling mode)	< 40 kW	All	25 °C entering water	3.55 COP_C	

(continued)

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

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (heating mode)	< 19 kW[b]	—	Split system	2.26 $SCOP_H$	AHRI 210/240
		—	Single package	2.40 $SCOP_H$	
Through-the-wall, (air cooled, heating mode)	≤ 9 kW[b]	—	Split system	3.34 $SCOP_H$	
		—	Single package	2.17 $SCOP_H$	
Small-duct high velocity (air cooled, heating mode)	< 19 kW[b]	—	Split system	2.17 $SCOP_H$	
Air cooled (heating mode)	≤ 40 kW and < 70 kW	—	8.3 °C db/6.1 °C wb outdoor air	3.3 COP_H	AHRI 340/360
		—	–8.3 °C db/–9.4 °C wb outdoor air	2.25 COP_H	
	≤ 70 kW	—	8.3 °C db/6.1 °C wb outdoor air	3.2 COP_H	
		—	8.3 °C db/–9.4 °C wb outdoor air	2.05 COP_H	
Water to Air: Water Loop (heating mode)	< 40 kW	—	20 °C entering water	4.3 COP_H	ISO 13256-1
Water to Air: Ground Water (heating mode)	< 40 kW	—	10 °C entering water	3.7 COP_H	
Brine to Air: Ground Loop (heating mode)	< 40 kW	—	0 °C entering fluid	3.2 COP_H	
Water to Water: Water Loop (heating mode)	< 40 kW	—	20 °C entering water	3.7 COP_H	ISO 13256-2
Water to Water: Ground Water (heating mode)	< 40 kW	—	10 °C entering water	3.1 COP_H	
Brine to Water: Ground Loop (heating mode)	< 40 kW	—	0 °C entering fluid	2.5 COP_H	

For IP: 1 kW = 3,412 Btu/hr.
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 19 kW (65,000 Btu/h) are regulated by NAECA. SEER values are those set by NAECA.

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	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
PTAC (cooling mode) new construction	All capacities	35.0 °C db outdoor air	4.10 – (0.300 × Cap/1000) COP_C	AHRI 310/380
PTAC (cooling mode) replacements[b]	All capacities	35.0 °C db outdoor air	3.19 – (0.213 × Cap/1000) COP_C	
PTHP (cooling mode) new construction	All capacities	35.0 °C db outdoor air	4.10 – (0.300 × Cap/1000) COP_C	

PTHP (cooling mode) replacements[b]	All capacities	35.0 °C db outdoor air	3.16 – (0.213 × Cap/1000) COP_C	
PTHP (heating mode) new construction	All capacities	—	3.7 – (0.052 × Cap/1000) COP_H	
PTHP (heating mode) replacements[b]	All capacities	—	2.9 – (0.026 × Cap/1000) COP_H	
SPVAC (cooling mode)	< 19 kW	35.0 °C db/23.9 °C wb outdoor air	2.64 COP_C	AHRI 390
	≥ 40 kW and < 70 kW	35.0 °C db/23.9 °C wb outdoor air	2.61 COP_C	
	≥ 70 kW	35.0 °C db/23.9 °C wb outdoor air	2.52 COP_C	
SPVHP (cooling mode)	< 19 kW	35.0 °C db/23.9 °C wb outdoor air	2.64 COP_C	
	≥ 40 kW and < 70 kW	35.0 °C db/23.9 °C wb outdoor air	2.61 COP_C	
	≥ 70 kW	35.0 °C db/23.9 °C wb outdoor air	2.52 COP_C	
SPVHP (heating mode)	< 19 kW	8.3 °C db/6.1 °C wb outdoor air	3.0 COP_H	
	≥ 40 kW and < 70 kW	8.3 °C db/6.1 °C wb outdoor air	3.0 COP_H	
	≥ 70 kW	8.3 °C db/6.1 °C wb outdoor air	2.9 COP_H	
Room air conditioners, with louvered sides	< 1.8 kW	—	2.84 COP_C	ANSI/ AHAM RAC-1
	≥ 1.8 kW and <2.3 kW	—	2.84 COP_C	
	≥ 2.3 kW and < 4.1 kW	—	2.87 COP_C	
	≥ 4.1 kW and < 5.9 kW	—	2.84 COP_C	
	≥ 5.9 kW	—	2.49 COP_C	
Room air conditioners, without louvered sides	< 2.3 kW	—	2.64 COP_C	
	≥ 2.3 kW and < 5.9 kW	—	2.49 COP_C	
	≥ 5.9 kW	—	2.49 COP_C	
Room air conditioners, with louvered sides	< 5.9 kW	—	2.64 COP_C	
	≥ 5.9 kW	—	2.49 COP_C	
Room air conditioners, without louvered sides	< 5.9 kW	—	2.49 COP_C	
	≥ 5.9 kW	—	2.34 COP_C	

(continued)

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	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
PTAC (cooling mode) new construction	All capacities	35.0 °C db outdoor air	4.10 – (0.300 × Cap/1000) COP_C	AHRI 310/380

PTAC (cooling mode) replacements[b]	All capacities	35.0 °C db outdoor air	3.19 – (0.213 × Cap/1000) COP_C	
PTHP (cooling mode) new construction	All capacities	35.0 °C db outdoor air	4.10 – (0.300 × Cap/1000) COP_C	
PTHP (cooling mode) replacements[b]	All capacities	35.0 °C db outdoor air	3.16 – (0.213 × Cap/1000) COP_C	
PTHP (heating mode) new construction	All capacities	—	3.7 – (0.052 × Cap/1000) COP_H	
PTHP (heating mode) replacements[b]	All capacities	—	2.9 – (0.026 × Cap/1000) COP_H	
SPVAC (cooling mode)	< 19 kW	35.0 °C db/23.9 °C wb outdoor air	2.64 COP_C	AHRI 390
	≥ 40 kW and < 70 kW	35.0 °C db/23.9 °C wb outdoor air	2.61 COP_C	
	≥ 70 kW	35.0 °C db/23.9 °C wb outdoor air	2.52 COP_C	
SPVHP (cooling mode)	< 19 kW	35.0 °C db/23.9 °C wb outdoor air	2.64 COP_C	
	≥ 40 kW and < 70 kW	35.0 °C db/23.9 °C wb outdoor air	2.61 COP_C	
	≥ 70 kW	35.0 °C db/23.9 °C wb outdoor air	2.52 COP_C	
SPVHP (heating mode)	< 19 kW	8.3 °C db/6.1 °C wb outdoor air	3.0 COP_H	
	≥ 40 kW and < 70 kW	8.3 °C db/6.1 °C wb outdoor air	3.0 COP_H	
	≥ 70 kW	8.3 °C db/6.1 °C wb outdoor air	2.9 COP_H	
Room air conditioners, with louvered sides	< 1.8 kW	—	2.84 COP_C	ANSI/ AHAM RAC-1
	≥ 1.8 kW and <2.3 kW	—	2.84 COP_C	
	≥ 2.3 kW and < 4.1 kW	—	2.87 COP_C	
	≥ 4.1 kW and < 5.9 kW	—	2.84 COP_C	
	≥ 5.9 kW	—	2.49 COP_C	
Room air conditioners, without louvered sides	< 2.3 kW	—	2.64 COP_C	
	≥ 2.3 kW and < 5.9 kW	—	2.49 COP_C	
	≥ 5.9 kW	—	2.49 COP_C	
Room air conditioners, with louvered sides	< 5.9 kW	—	2.64 COP_C	
	≥ 5.9 kW	—	2.49 COP_C	
Room air conditioners, without louvered sides	< 5.9 kW	—	2.49 COP_C	
	≥ 5.9 kW	—	2.34 COP_C	

For IP: °F = 1.8 •°C + 32, kW = (Btu/h) • 3,412, EER [Btu/W] = COP [W/W] • 3.412

"Cap" = The rated cooling capacity of the project in Btu/h. Where the unit's capacity is less than 2 kW (7000 Btu/h), use 2 kW (7000 Btu/h) in the calculation. Where the unit's capacity is greater than 4 kW (15,000 Btu/h), use 4 kW (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 406 mm (16 inches) in height and less than 1067 mm (42 inches) 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

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[d, e]	TEST PROCEDURE[a]
Warm-air furnaces, gas fired	< 66 kW	—	78% AFUE or 80%Et_c	DOE 10 CFR Part 430 or ANSI Z21.47
	≥ 66 kW	Maximum capacity[c]	80%Et_f	ANSI Z21.47
Warm-air furnaces, oil fired	< 66 kW	—	78% AFUE or 80%	DOE 10 CFR Part 430 or 83%
	≥ 66 kW	Maximum capacity[b]	81%E_t[g]	UL 727
Warm-air duct furnaces, gas fired	All capacities	Maximum capacity[b]	80%E_c	ANSI Z83.8
Warm-air unit heaters, gas fired	All capacities	Maximum capacity[b]	80%E_c	ANSI Z83.8
Warm-air unit heaters, oil fired	All capacities	Maximum capacity[b]	80%E_c	UL 731

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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 19 kW) shall comply with either rating.
d. E_t = Thermal efficiency. See test procedure for detailed discussion.
e. E_c = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.
f. E_c = Combustion efficiency. Units shall also include an IID, have jackets not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
g. E_t = Thermal efficiency. Units shall also include an IID, have jacket losses not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

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

EQUIPMENT TYPE[a]	SUBCATEGORY OR RATING CONDITION	SIZE CATEGORY (INPUT)	MINIMUM EFFICIENCY[d, e]	TEST PROCEDURE
Boilers, hot water	Gas-fired	< 87 kW	80% AFUE	10 CFR Part 430
		≥ 87 kW and ≤ 733 kW[b]	80% E_t	10 CFR Part 431
		> 733 kW[a]	82% E_c	
	Oil-fired[c]	< 87 kW	80% AFUE	10 CFR Part 430
		≥ 87 kW and ≤ 733 kW[b]	82% E_t	10 CFR Part 431
		> 733 kW[a]	84% E_c	
Boilers, steam	Gas-fired	< 87 kW	75% AFUE	10 CFR Part 430
	Gas-fired- all, except natural draft	≥ 87 kW and ≤ 733 kW[b]	79% E_t	10 CFR Part 431
		> 733 kW[a]	79% E_t	

	Gas-fired, natural draft	≥ 87 kW and ≤ 733 kW[b]	77% E_t	
		> 733 kW[a]	77% E_t	
	Oil-fired[c]	< 87 kW	80% AFUE	10 CFR Part 430
		≥ 87 kW and ≤ 733 kW[b]	81% E_t	10 CFR Part 431
		> 733 kW[a]	81% E_t	

For IP: 1 kW = 3,412 Btu/h.

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 19 kW (65,000 Btu/h)] shall comply with either rating.

d. E_t = Thermal efficiency. See test procedure for detailed discussion.

e. E_c = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.

f. E_c = Combustion efficiency. Units shall also include an IID, have jackets not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

g. E_t = Thermal efficiency. Units shall also include an IID, have jacket losses not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

TABLE C403.3.2(6)
MINIMUM EFFICIENCY REQUIREMENTS:
CONDENSING UNITS, ELECTRICALLY OPERATED

EQUIPMENT TYPE	SIZE CATEGORY	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
Condensing units, air cooled	≥ 40 kW	10.1 EER 11.2 IPLV	AHRI 365
Condensing units, water or evaporatively cooled	≥ 40 kW	13.1 EER 13.1 IPLV	

For IP: 1 kW = 3,412 Btu/h.

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

b. IPLVs are only applicable to equipment with capacity modulation.

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

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	BEFORE 1/1/2015		TEST PROCEDURE[c]
			Path A	Path B	
Air-cooled chillers	< 528 KW	COP (W/W)	≥ 2.985 FL	≥ 2.866 FL	AHRI 551/591
			≥ 4.048 IPLV.SI	≥ 4.669 IPLV.SI	
	≥ 528 KW		≥ 2.985 FL	≥ 2.866 FL	
			≥ 4.137 IPLV.SI	≥ 4.758 IPLV.SI	
Air cooled without condenser, electrically operated	All capacities	COP (W/W)	Air-cooled chillers without condenser shall be rated with matching condensers and complying with air-cooled chiller efficiency requirements.		
Water cooled, electrically operated positive displacement	< 264 kW	COP (W/W)	≥ 4.694 FL	≥ 4.513 FL	
			≥ 5.867 IPLV.SI	≥ 7.041 IPLV.SI	

	≥ 264 kW and < 528 kW		≥ 4.889 FL	≥ 4.694 FL	
			≥ 6.286 IPLV.SI	≥ 7.184 IPLV.SI	
	≥ 528 kW and < 1055 kW		≥ 5.334 FL	≥ 5.177 FL	
			≥ 6.519 IPLV.SI	≥ 8.001 IPLV.SI	
	≥ 1055 kW and < 2110 kW		≥ 5.771 FL	≥ 5.633 FL	
			≥ 6.770 IPLV.SI	≥ 8.586 IPLV.SI	
	≥ 2110 kW		≥ 6.286 FL	≥ 6.018 FL	
			≥ 7.041 IPLV.SI	≥ 9.264 IPLV.SI	
Water cooled, electrically operated centrifugal	≥ 528 KW and < 1055 kW	COP (W/W)	≥ 5.771 FL	≥ 5.065 FL	
			≥ 6.401 IPLV.SI	≥ 8.001 IPLV.SI	
	≥ 528 KW and < 1055 kW		≥ 5.771 FL	≥ 5.544 FL	
			≥ 6.401 IPLV.SI	≥ 8.001 IPLV.SI	
	≥ 528 KW and < 1055 kW		≥ 6.286 FL	≥ 6.018 FL	
			≥ 6.770 IPLV.SI	≥ 8.586 IPLV.SI	
	≥ 528 KW and < 1055 kW		≥ 6.286 FL	≥ 6.081 FL	
			≥ 7.041IPLV.SI	≥ 9.264 IPLV.SI	
	≥ 528 KW and < 1055 kW		≥ 6.286 FL	≥ 6.018 FL	
			≥ 7.041 IPLV.SI	≥ 9.264 IPLV.SI	
Air cooled, absorption, single effect	All capacities	COP	≥ 0.600 FL	NA[c]	AHRI 560
Water cooled absorption, single effect	All capacities	COP	≥ 0.700 FL	NA[c]	
Absorption, double effect, indirect fired	All capacities	COP	≥ 1.000 FL	NA[c]	
			≥ 1.050 IPLV.SI		
Absorption double effect direct fired	All capacities	COP	≥ 1.000 FL	NA[c]	
			≥ 1.000 IPLV.SI		

For IP: °F = 1.8 • °C + 32, kW/ton = 12/(COP • 3.412), Ton = 3.517 • kW, EER (Btu/W) = COP (W/W) / 3.412.

a. The requirements for centrifugal chiller shall be adjusted for nonstandard rating conditions in accordance with Section C403.2.3.1 and are only applicable for the range of conditions listed in Section C403.2.3.1. 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(8)
MINIMUM EFFICIENCY REQUIREMENTS: HEAT REJECTION EQUIPMENT

EQUIPMENT TYPE[a]	TOTAL SYSTEM HEAT REJECTION CAPACITY AT RATED CONDITIONS	SUBCATEGORY OR RATING CONDITION[i]	PERFORMANCE REQUIRED[b, c, d, g, h]	TEST PROCEDURE[e, f]
Propeller or axial fan open-circuit cooling towers	All	35.0 °C entering water 29.4 °C leaving water 23.9 °C entering wb	≥ 3.40 L/s • kW	CTI ATC-105 and CTI STD-201 RS
Centrifugal fan open-circuit cooling towers	All	35.0 °C entering water 29.4 °C leaving water 23.9 °C entering wb	≥ 1.7 L/s • kW	CTI ATC-105 and CTI STD-201 RS
Propeller or axial fan closed-circuit cooling towers	All	38.9 °C entering water 32.2 °C leaving water 23.9 °C entering wb	≥ 1.36 L/s • kW	CTI ATC-105S and CTI STD-201 RS
Centrifugal fan closed- circuit cooling towers	All	38.9 °C entering water 32.2 °C leaving water 23.9 °C entering wb	≥ 0.59 L/s • kW	CTI ATC-105S and CTI STD-201 RS
Propeller or axial fan evaporative condensers	All	Ammonia Test Fluid 60 °C entering gas temperature 35.7 °C condensing temperature 23.9 °C entering wb	≥ 52.6 COP_c	CTI ATC-106
Centrifugal fan evaporative condensers	All	Ammonia Test Fluid 60 °C entering gas temperature 35.7 °C condensing temperature 23.9 °C entering wb	≥ 61.6 COP_c	CTI ATC-106
Propeller or axial fan evaporative condensers	All	R-507A Test Fluid 73.9 °C entering gas temperature 40.6 °C condensing temperature 23.9 °C entering wb	≥ 43.2 COP_c	CTI ATC-106
Centrifugal fan evaporative condensers	All	R-507A Test Fluid 73.9 °C entering gas temperature 40.6 °C condensing temperature 23.9 °C entering wb	≥ 53.0 COP_c	CTI ATC-106
Air-cooled condensers	All	52 °C Condensing Temperature 88 °C Entering Gas Temperature 8 °C subcooling 35 °C entering db	≥ 69 COP_c	AHRI 460

For IP: °F = 1.8 •°C + 32, gpm/hp = [L/(s • kW)] • (11.83), Btu/(h • hp) = COP • 2550.7, db = dry bulb temperature, °C, wb = wet bulb temperature, °C.

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 403.3.2(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 403.3.2(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 C403.3.2(9)
MINIMUM EFFICIENCY AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS

EQUIPMENT TYPE	NET SENSIBLE COOLING CAPACITY[a]	MINIMUM SCOP-127[b] EFFICIENCY DOWNFLOW UNITS / UPFLOW UNITS	TEST PROCEDURE
Air conditioners, air cooled	< 19 Kw	2.20 / 2.09	ANSI/ASHRAE 127
	≥ 19 kW and < 70 kW	2.10 / 1.99	
	≥ 70 kW	1.90 / 1.79	
Air conditioners, water cooled	< 19 kW	2.60 / 2.49	
	≥ 19 kW and < 70 kW	2.50 / 2.39	
	≥ 70 kW	2.40 /2.29	
Air conditioners, water cooled with fluid economizer	< 19 kW	2.55 /2.44	
	≥ 19 kW and < 70 kW	2.45 / 2.34	
	≥ 70 kW	2.35 / 2.24	
Air conditioners, glycol cooled (rated at 40% propylene glycol)	< 19 kW	2.50 / 2.39	
	≥ 19 kW and < 70 kW	2.15 / 2.04	
	≥ 70 kW	2.10 / 1.99	
Air conditioners, glycol cooled (rated at 40% propylene glycol) with fluid economizer	< 19 kW	2.45 / 2.34	
	≥ 19 kW and < 70 kW	2.10 / 1.99	
	≥ 70 kW	2.05 / 1.94	

For IP: 1 kW = 3,412 Btu/h

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)
HEAT TRANSFER EQUIPMENT

EQUIPMENT TYPE	SUBCATEGORY	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Liquid-to-liquid heat exchangers	Plate type	NR	AHRI 400

NR = No Requirement.

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

TABLE C403.3.2(11)
MINIMUM EFFICIENCY REQUIREMENTS: VARIABLE REFRIGERANT FLOW MULTI-SPLIT AIR CONDITIONERS AND HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING TYPE	MINIMUM EFFICIENCY	TEST PROCEDURE
VRF Multi-Split Air Conditioners (Air-cooled)	≤ 19 kW	All	3.81 SCOPc	AHRI 1230
	≥ 19 kW and < 40 kW	Electric Resistance (or none)	4.54 ICOP	

		All other	4.37 ICOP	
	≥ 40 kW and < 70 kW	Electric Resistance (or none)	4.37 ICOP	
		All other	4.07 ICOP	
	≥ 70 kW and < 223 kW	Electric Resistance (or none)	4.07 ICOP	
		All other	3.52 ICOP	
VRF Multi-Split Heat Pumps (Air-cooled)	≤ 19 kW	All	3.81 ICOP	
	≥ 19 kW and < 40 kW	Electric Resistance (or none)	4.37 ICOP	
		All other	4.22 ICOP	
	≥ 40 kW and < 70 kW	Electric Resistance (or none)	4.07 ICOP	
		All other	4.01 ICOP	
	≥ 70 kW and < 223 kW	Electric Resistance (or none)	3.72 ICOP	
		All other	3.52 ICOP	
VRF Multi-Split Air Conditioners (Water-Source)	< 5 kW	Without heat recovery	4.69 ICOP	
		With heat recovery	4.63 ICOP	
	≥ 5 kW and < 19 kW	All	4.69 ICOP	
	≥ 19 kW and < 40 kW	All	4.69 ICOP	
	≥ 40 kW and < 223 kW	Without heat recovery	4.07ICOP	
		With heat recovery	3.46 ICOP	

For IP: 1 kW = 3,412 Btu/h, IEER = ICOP • 3.412, SEER = $SCOP_c$ • 3.412.

C403.3.2.1 Water-cooled centrifugal chilling packages (Mandatory). Equipment not designed for operation at AHRI Standard 550/590 test conditions of 7 °C (44 °F) leaving chilled-water temperature and 0.04 mL/J (2.4 gpm/ton) evaporator fluid flow and 29 °C (85 °F) entering condenser water temperature with 0.054 L/s • kW (3 gpm/ton) condenser water flow shall have maximum full-load kW/ton (FL) and part-load ratings requirements adjusted using Equations 4-6 and 4-7.

$FL_{adj} = FL/K_{adj}$ **(Equation 4-6)**

$PLV_{adj} = IPLV/K_{adj}$ **(Equation 4-7)**

where:

K_{adj} = A × B

FL = Full-load kW/ton value as specified in Table C403.3.2(7).

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

$IPLV$ = Value as specified in Table C403.3.2(7).

PLV_{adj} = Maximum $NPLV$ rating, adjusted for nonstandard conditions.

A = $0.00000014592 \times (LIFT)^4 - 0.0000346496 \times (LIFT)^3 + 0.00314196 \times (LIFT)^2 - 0.147199 \times (LIFT) + 3.9302$

B = $0.0015 \times L_{vg}E_{vap} + 0.934$

$LIFT$ = $L_{vg}Cond - L_{vg}E_{vap}$

$L_{vg}Cond$ = Full-load condenser leaving fluid temperature (°F).

$L_{vg}E_{vap}$ = Full-load evaporator leaving temperature (°F).

The FL_{adj} and PLV_{adj} values are only applicable for centrifugal chillers meeting all of the following full-load design ranges:

1. Minimum evaporator leaving temperature: 2 °C (36° F).
2. Maximum condenser leaving temperature: 46 °C (115 °F).
3. -7 °C (20 °F) ≤ LIFT ≤ 27 °C (80 °F).

C403.3.2.2 Positive displacement (air- and water-cooled) chilling packages (Mandatory). Equipment with a leaving fluid temperature higher than 0 °C (32 °F) and water-cooled positive displacement chilling packages with a condenser leaving fluid temperature below 46 °C (115 °F) shall meet the requirements of Table C403.3.2(7) when tested or certified with water at standard rating conditions, in accordance with the referenced test procedure.

C403.3.3 Hot gas bypass limitation. Cooling systems shall not use hot gas bypass or other evaporator pressure control systems unless the system is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot gas bypass shall be limited as indicated in Table C403.3.3, as limited by Section C403.5.1.

TABLE C403.3.3
MAXIMUM HOT GAS BYPASS CAPACITY

RATED CAPACITY kW (Btu/h)	MAXIMUM HOT GAS BYPASS CAPACITY (% of total capacity)
≤ 70kW (240,000 Btu/h)	50
> 70kW (240,000 Btu/h)	25

C403.3.4 Boiler turndown. Boiler systems with design input of greater than 293 kW (1000000 Btu/h) 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
BOILER TURNDOWN

BOILER SYSTEM DESIGN INPUT kW (Btu/h)	MINIMUM TURNDOWN RATIO
≤ 293 kW (1,000,000 Btu/h) and less than or equal to 1,465 kW	3 to 1
> 1,465 kW (5,000,000 Btu/h) and less than or equal to 2931 kW	4 to 1
> 2,931 kW(10,000,000 Btu/h)	5 to 1

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, at least 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:

1. The perimeter system includes at least one thermostatic control zone for each building exposure having exterior walls facing only one orientation (within +/-45 degrees) (0.8 rad) for more than 15 m (50 contiguous feet); and
2. The perimeter system heating and cooling supply is controlled by thermostats located within the zones served by the system.

C403.4.1.1 Heat pump supplementary heat (Mandatory). Heat pumps having supplementary electric resistance heat shall have controls that, except during defrost, prevent supplementary heat operation where the heat pump can provide the heating load.

C403.4.1.2 Deadband. 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 2.8 °C (5 °F) 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 Cooled vestibules (Mandatory). Vestibule cooling systems shall be controlled by a thermostat located in the vestibule configured to limit cooling to a temperature not less than 29 °C (85 °F).

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 an outdoor setback control that lowers the boiler water temperature based on the outdoor temperature.

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 2 kW (6,800 Btu/h) and having a readily accessible manual shutoff switch.

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 up to 29 °C (85 °F).

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 146.5 kW (500,000 Btu/h) 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 8.3 °C (15 °F) 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 16.7 °C (30 °F) 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 11 °C (20 °F) 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 11 °C (20 °F) shall be permitted.

C403.4.3.3.2 Heat rejection. The following shall apply to hydronic water loop heat pump systems in *Climate Zones* 3 and 4:

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.

C403.4.3.3.3 Two-position valve. Each hydronic heat pump on the hydronic system having a total pump system power exceeding 7.5 kW (10 hp) shall have a two-position valve.

C403.4.4 Part-load controls. Hydronic systems greater than or equal to 146.5 kW (300,000 Btu/h) 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 sup-ply-to-return water temperature difference.
2. Automatically vary fluid flow for hydronic systems with a combined pump motor capacity of 1.5 kW (2 hp) 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 1.49 kW (2 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 motors having the same or greater nominal output power indicated in Table C403.4.4 based on the climate zone and system served.
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 con-trolled to maintain one control valve nearly wide open or to satisfy the minimum differential pressure.

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. Variable speed drives are not required on heating water pumps where more than 50 percent of annual heat is generated by an electric boiler.

TABLE C403.4.4
VARIABLE SPEED DRIVE (VSD) REQUIREMENTS FOR DEMAND-CONTROLLED PUMPS

CHILLED WATER AND HEAT REJECTION LOOP PUMPS IN THESE CLIMATE ZONES	HEATING WATER PUMPS IN THESE CLIMATE ZONES	VSD REQUIRED FOR MOTORS WITH RATED OUTPUT OF:
0A, 1A, 1B,	—	≥ 1.5 kW
—	1B	≥ 74.6 kW
—	0A, 1A	≥ 149.1 kW

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(1).
2. Individual fan systems with cooling capacity greater than or equal to 15.8 kW (54,000 Btu/h) in buildings having other than a *Group R* occupancy.

   The total supply capacity of all fan cooling units not provided with economizers shall not exceed 20 percent of the total supply capacity of all fan cooling units in the building or 88 kW (300,000 Btu/h), whichever is greater.
3. Individual fan systems with cooling capacity greater than or equal to 79.1 kW (270,000 Btu/h) in buildings having a *Group R* occupancy.

The total supply capacity of all fan cooling units not provided with economizers shall not exceed 20 percent of the total supply capacity of all fan cooling units in the building or 440 kW (1,500,000 Btu/h), whichever is greater.

Exception: Economizers are not required for the following systems.

1. Individual fan systems not served by chilled water for buildings located in *Climate Zones* 0A, 1A and 1B.
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 1.7 °C (35 °F) dew-point temperature to satisfy process needs.
3. Systems expected to operate less than 20 hours per week.
4. Systems serving supermarket areas with open refrigerated casework.
6. Systems that include a heat recovery system in accordance with Section C403.9.5.

TABLE C403.5(1)
MINIMUM CHILLED-WATER SYSTEM COOLING CAPACITY FOR DETERMINING ECONOMIZER COOLING REQUIREMENTS

CLIMATE ZONES (COOLING)	TOTAL CHILLED-WATER SYSTEM CAPACITY LESS CAPACITY OF COOLING UNITS WITH AIR ECONOMIZERS	
	Local Water-cooled Chilled-water Systems	Air-cooled Chilled-water Systems or District Chilled-Water Systems
0A, 1A	No economizer requirement	No economizer requirement
1B	281 kW	366 kW

For IP: 1 kW = 3,412 Btu/h.

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, such as hot gas bypass, 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 7 °C .
2. Direct expansion (DX) units that control 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 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 C403.5.1.

TABLE C403.5.1
DX COOLING STAGE REQUIREMENTS FOR MODULATING AIRFLOW UNITS

RATING CAPACITY	MINIMUM NUMBER OF MECHANICAL COOLING STAGES	MINIMUM COMPRESSOR DISPLACEMENT[a]
≥ 19,000W and < 70,300W	3 stages	≤ 35% of full load
≥70,300W	4 stages	≤ 25% full load

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

a. For mechanical cooling stage control that does not use variable compressor displacement, the percent displacement shall be equivalent to the mechanical cooling capacity reduction evaluated at the full load rating conditions for the compressor.

C403.5.2 Economizer heating system impact. HVAC system design and economizer controls shall be such that economizer operation does not increase building heating energy use during normal operation.

Exception: Economizers on variable air volume (VAV) systems that cause zone level heating to increase because of a reduction in supply air temperature.

C403.5.3 Air economizers. Where economizers are required by Section C403.5, air economizers shall comply with Sections C403.5.3.1 through C403.5.3.5.

C403.5.3.1 Design capacity. Air economizer systems shall be configured to modulate *outdoor air* and return air dampers to provide up to 100 percent of the design supply air quantity as *outdoor air* for cooling.

C403.5.3.2 Control signal. Economizer controls and dampers shall be configured to sequence the dampers with the mechanical cooling equipment and shall not be controlled by only mixed-air temperature.

Exception: The use of mixed-air temperature limit control shall be permitted for systems controlled from space temperature (such as single-*zone* systems).

C403.5.3.3 High-limit shutoff. Air economizers shall be configured to automatically reduce *outdoor air* intake to the design minimum *outdoor air* quantity when *outdoor air* intake will not reduce cooling energy usage. High-limit shutoff control types for specific climates shall be chosen from Table C403.5.3.3. High-limit shutoff control settings for these control types shall be those specified in Table C403.5.3.3.

TABLE C403.5.3.3
HIGH-LIMIT SHUTOFF CONTROL SETTING FOR AIR ECONOMIZERS[b]

DEVICE TYPE	CLIMATE ZONE	REQUIRED HIGH LIMIT (ECONOMIZER OFF WHEN):	
		Equation	Description
Fixed dry bulb	1B,	T_{OA} > 23.9 °C	Outdoor air temperature exceeds 23.9 °C
	1A	T_{OA} > 18.3 °C	Outdoor air temperature exceeds 18.3 °C
Differential dry bulb	1B,	T_{OA} > T_{RA}	Outdoor air temperature exceeds return air temperature
Fixed enthalpy with fixed dry-bulb temperatures	All	h_{OA} > 65.24KJ/Kg[a] or T_{OA} > 23.9 °C	Outdoor air enthalpy exceeds 65.24KJ/Kg of dry air[a] or Outdoor air temperature exceeds 23.9 °C
Differential enthalpy with fixed dry-bulb temperature	All	h_{OA} > h_{RA} or T_{OA} > 23.9 °C	Outdoor air enthalpy exceeds return air enthalpy or Outdoor air temperature exceeds 23.9 °C

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 23.9 °C and 50-percent relative humidity. As an example, at approximately 1828.8 meters elevation, the fixed enthalpy limit is approximately 71.5 kJ/kg.

b. Devices with selectable setpoints shall be capable of being set to within -16.67 °C and 4.66 KJ/Kg 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 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 10 °C (50 °F) dry bulb/7 °C (45 °F) wet bulb.

Exceptions:

1. Systems primarily serving computer rooms in which 100 percent of the expected system cooling load at 4 °C (40 °F) dry bulb/1.7 °C (35 °F) 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 1.7 °C (35 °F) dry bulb.
3. Systems where dehumidification requirements cannot be met using outdoor air temperatures of 10 °C (50 °F) dry bulb/ 7 °C (45 °F) wet bulb and where 100 percent of the expected system cooling load at 7 °C (45 °F) dry bulb/ 4 °C (40 °F) 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 waterside pressure drop of less than 45 kPa (15 ft) 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 variable refrigerant flow (VRF) units listed in Tables C403.3.2(11) that are equipped with an economizer in accordance with Sections C403.5 through C403.5.4 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 ±1.1 °C (±2 °F) over the range of 4 °C to 26.7 °C (40 °F to 80 °F).
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 diagnostics 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.

C403.6 Requirements for complex 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 Chapter 4 of the *International Mechanical Code*.
4. Any higher rate that can be demonstrated to reduce overall system annual energy use by offsetting re-heat/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.

Exception: The following individual zones or entire air distribution systems are exempted from the requirement for VAV control:

1. *Zones* or supply air systems where not less than 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered, including condenser heat, or site-solar energy source.
2. Systems that prevent reheating, recooling, mixing or simultaneous supply of air that has been previously cooled, either mechanically or through the use of economizer systems, and air that has been previously mechanically heated.

C403.6.2 Single-duct VAV systems, terminal devices. Single-duct VAV systems shall use terminal devices capable of and configured to reduce the supply of primary supply air before reheating or recooling takes place.

C403.6.3 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 configured to reduce the flow from one duct to a minimum before mixing of air from the other duct takes place.

C403.6.4 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 26.4 kW shall not be equipped with air economizers.

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 142 L/s (300 cfm) 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) as defined by the *International Mechanical Code*.

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 299 Pa (1.2 in w.c.). 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.

C403.7 Ventilation and exhaust systems (Mandatory). In addition to other requirements of Section C403 applicable to the provision of ventilation air or the exhaust of air, ventilation and exhaust systems shall be in accordance with Sections C403.7.1 through C403.7.7.

C403.7.1 Demand control ventilation (Mandatory). Demand control ventilation (DCV) shall be provided for spaces larger than 46.5 m^2 (500 ft^2) and with an average occupant load of 25 people or greater per 93 m^2 (1,000 ft^2) of floor area, as established in Table 403.3.1.1 of the *International Mechanical Code*, 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 1416 L/s (3,000 cfm).

   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. Systems with a design outdoor airflow less than 566 L/s (1,200 cfm).
   4. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 566 L/s (1,200 cfm).
   5. Ventilation provided only for process loads.

C403.7.2 Enclosed parking garage ventilation controls. 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 to 50 percent or less of design capacity, or intermittently operate fans less

than 20 percent of the occupied time or as required to maintain acceptable contaminant levels in accordance with *International Mechanical Code* provisions. Failure of contamination sensing devices shall cause the exhaust fans to operate continuously at design airflow.

Exceptions:

1. Garages with a total exhaust capacity less than 10,620 L/s (22,500 cfm) with ventilation systems that do not utilize heating or mechanical cooling.
2. Garages that have a garage area to ventilation system motor nameplate power ratio that exceeds 710 L/(s·kW) (1125 cfm/hp) and do not utilize heating or mechanical cooling.

C403.7.3 Ventilation air heating control (Mandatory). Units that provide ventilation air to multiple zones and operate in conjunction with zone heating and cooling systems shall not use heating or heat recovery to warm supply air to a temperature greater than 16 °C (60 °F) when representative building loads or outdoor air temperatures indicate that the majority of zones require cooling.

C403.7.4 Energy recovery ventilation systems (Mandatory). Where the supply airflow rate of a fan system exceeds the values specified in Tables C403.7.4(1) and C403.7.4(2), 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 ventilation system shall not be required in any of the following conditions:

1. Where energy recovery systems are prohibited by the International Mechanical Code or standards approved by the Authority having Jurisdiction.
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 1.1 °C (2 °F) above room setpoint, cooled to not cooler than 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 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. Heating energy recovery .
6. . NR
7. Systems requiring dehumidification that employ energy recovery in series with the cooling coil.
8. 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.
9. Systems expected to operate less than 20 hours per week at the *outdoor air* percentage covered by Table C403.7.4(1).
10. Systems exhausting toxic, flammable, paint or corrosive fumes or dust.
11. Commercial kitchen hoods used for collecting and removing grease vapours and smoke.

TABLE C403.7.4(1)
ENERGY RECOVERY REQUIREMENT
(Ventilation systems operating less than 8,000 hours per year)

CLIMATE ZONE	PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE							
	≥ 10% and < 20%	≥ 20% and < 30%	≥ 30% and < 40%	≥ 40% and < 50%	≥ 50% and < 60%	≥ 60% and < 70%	≥ 70% and < 80%	≥ 80%
	DESIGN SUPPLY FAN AIRFLOW RATE (cfm)							

1B,	NR	NR	NR	NR	≥ 26,000	≥ 12,000	≥ 5,000	≥ 4,000
1A,	≥ 26,000	≥ 16,000	≥ 5,500	≥ 4,500	≥ 3,500	≥ 2,000	≥ 1,000	> 120

NR = Not Required.

TABLE C403.7.4(2)
ENERGY RECOVERY REQUIREMENT
(Ventilation systems operating not less than 8,000 hours per year)

CLIMATE ZONE	PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE							
	≥ 10% and < 20%	≥ 20% and < 30%	≥ 30% and < 40%	≥ 40% and < 50%	≥ 50% and < 60%	≥ 60% and < 70%	≥ 70% and < 80%	≥ 80%
	Design Supply Fan Airflow Rate (cfm)							
1B,	NR	≥ 19,500	≥ 9,000	≥ 5,000	≥ 4,000	≥ 3,000	≥ 1,500	≥ 120
1A,	≥ 2,500	≥ 2,000	≥ 1,000	≥ 500	≥ 140	≥ 120	≥ 100	≥ 80

For SI: 1 cfm = 0.4719 L/s.
NR = Not Required.

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 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 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 controls necessary to modulate airflow in response to appliance operation and to maintain full capture and containment of smoke, effluent and combustion products during cooking and idle.
3. Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40 percent on not less than 50 percent of the total exhaust airflow.

Where a single hood, or hood section, is installed over appliances with different duty ratings, the maximum allowable flow rate for the hood or hood section shall be based on the requirements for the highest appliance duty rating under the hood or hood section.

Exception: Where not less than 75 percent of all the replacement air is transfer air that would otherwise be exhausted.

TABLE C403.7.5
MAXIMUM NET EXHAUST FLOW RATE,
CFM PER LINEAR FOOT OF HOOD LENGTH

TYPE OF HOOD	LIGHT-DUTY EQUIPMENT		MEDIUM-DUTY EQUIPMENT		HEAVY-DUTY EQUIPMENT		EXTRA-HEAVY-DUTY EQUIPMENT	
	L/s	(CFM)	L/s	(CFM)	L/s	(CFM)	L/s	(CFM)
Wall-mounted canopy	66	(140)	99	(210)	132	(280)	182	(385)
Single island	132	(280)	165	(350)	198	(420)	231	(490)
Double island (per side)	83	(175)	99	(210)	132	(280)	182	(385)
Eyebrow	83	(175)	83	(175)	NA	(NA)	NA	(NA)
Backshelf/Pass-over	99	(210)	99	(210)	132	(280)	NA	(NA)

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 2 °C (4 °F) from the occupant setpoint within 5 minutes after the occupants have left the guestroom and/or have left an exterior door open. The controls shall be capable of and configured to automatically raise the cooling setpoint to not lower than 32 °C (90 °F) and lower the heating setpoint to not higher than 16 °C (60 °F) 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 n*etworked guestroom control system* that is configured to return 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 configured to limit the 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 20.3 L/s • m^2 (4 cfm/ft^2) of damper surface area at 249 Pa (1.0-inch water gauge) 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*, standards approved by the Authority having Jurisdiction, 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) dampers shall be permitted to be used as follows:

1. In buildings less than three stories in height above grade plane.
2. In buildings of any height.
3. Where the design exhaust capacity is not greater than 142 L/s (300 cfm).

Gravity (non-motorized) dampers shall have an air leakage rate not greater than 101.6 L/s • m^2 (20 cfm/ft^2) where not less than 610 mm (24 inches) in either dimension and 203.2 L/s • m^2 (40 cfm/ft^2) where less than 610 mm (24 inches) in either dimension. The rate of air leakage shall be determined at 249 Pa (1.0-inch water gauge) when tested in accordance with AMCA 500D for such purpose. The dampers shall be labelled 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 3.7 kW (5 hp) at fan system design conditions shall not exceed the allowable *fan system motor nameplate* kW (hp) [Option 1] or *fan system* kW (bhp) [Option 2] as 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 0.746 kW (1 hp) or less are exempt from the allowable fan horsepower requirement.

TABLE C403.8.1(1)
FAN POWER LIMITATION

	LIMIT	CONSTANT VOLUME	VARIABLE VOLUME
Option 1: Fan system motor nameplate kW	Allowable nameplate motor kW	$kW \leq L/S_s \times 0.0017$	$kW \leq L/S_s \times 0.0024$
Option 2: Fan system kW	Allowable fan system kW	$kW \leq L/S_s \times 0.0015 + A$	$kW \leq L/S_s \times 0.0032$

For IP: 1kW = 1.34 bhp, 1 kW = 1.36 hp, 1 L/s = 2.12 cfm.
where:
L/SS=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.
kW=The maximum combined motor nameplate horsepower.
kWi=The maximum combined fan brake horsepower.
A = Sum of [PD × L L/SS / 65,0000]
where:
PD = Each applicable pressure drop adjustment from Table C403.8.1(2) in Pa.
L/SD = The design airflow through each applicable device from Table C403.8.1(2) in litres per second.

TABLE C403.8.1(2)
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT

DEVICE	ADJUSTMENT
Credits	
Fully ducted return and/or exhaust air systems	125 Pa (535 Pa for laboratory and vivarium systems)
Return and/or exhaust airflow control devices	125 Pa
Exhaust filters, scrubbers or other exhaust treatment	The pressure drop of device calculated at fan system design

Particulate filtration credit: MERV 9 thru 12	125 Pa
Particulate filtration credit: MERV 13 thru 15	125 Pa
Particulate filtration credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2× clean filter pressure drop at fan system design condition.
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition.
Biosafety cabinet	Pressure drop of device at fan system design condition.
Energy recovery device, other than coil runaround loop	(2.2 × energy recovery effectiveness) – 125 Pa for each airstream.
Coil runaround loop	150 Pa
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design conditions.
Sound attenuation section (fans serving spaces with design background noise goals below NC35)	38 Pa
Exhaust system serving fume hoods	85 Pa
Laboratory and vivarium exhaust systems in high-rise	60 Pa/100 feet of vertical duct exceeding 25 m.
Deductions	
Systems without central cooling device	150 Pa
Systems without central heating device	75 Pa
Systems with central electric resistance heat	50 Pa

For IP: 1 Pa = 1 inch w.c./249 Pa, 1 mm = 0.039 inch.
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 4.4 kW (6 bhp), 1.5 times the fan brake horsepower.
2. For fans 4.4 kW (6 bhp) and larger, 1.3 times the fan brake horsepower.
3. Systems complying with Section C403.8.1 *fan system motor nameplate* kW (hp) [Option 1].

Exception: Fans with motor nameplate horsepower less than 746 W (1 hp) are exempt from this section.

C403.8.3 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 labelled 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 3.7 kW(5 hp) or less as follows:
    1.1. Individual fans with a motor nameplate horsepower of 3.7 kW (5 hp) or less, unless Exception 1.2 applies.
    1.2. Multiple fans in series or parallel that have a combined motor nameplate horsepower of 3.7 kW (5 hp) 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. Motors for fans that are not less than 0.062 kW ($^1/_{12}$ hp) and less than 0.746 kW (1 hp) 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.

Exception: 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 C403.3.2 or Sections C403.8.1 through C403.8.3.
3. 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 airside economizer in accordance with Section C403.5 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 0.746 kW (1 hp) 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 the *International Mechanical Code* 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

COOLING SYSTEM TYPE	FAN MOTOR SIZE	MECHANICAL COOLING CAPACITY
DX cooling	Any	≥ 19 kW (65,000 Btu/h)
Chilled water and evaporative	> 3,728 W (5 hp)	Any
	≥ 186 W ($^1/_4$ hp)	Any

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 3.7 kW (5 hp) or more shall have controls and devices configured to automatically modulate the fan speed to control the leaving fluid temperature or condensing temperature and pressure of the heat rejection device. Fan motor power input shall be not more than 30 percent of design wattage at 50 percent of the design airflow.

Exceptions:

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

C403.9.2 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 4164 L/m (1,100 gpm) or greater at 35 °C (95 °F) condenser water return, 29 °C (85 °F) condenser water supply, and 24 °C (75 °F) 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 twenty-four hours a day, the total installed heat capacity of water-cooled systems exceeds 1758 kW (6000000 Btu/h) of heat rejection and the design service water heating load exceeds 293 kW (1000000 Btu/h).

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 29 °C (85 °F).

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.

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(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.

C403.10.1 Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers (Mandatory). 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 25 mm (1 in) of full closure.

   Exception: Automatic closers are not required for doors more than 1143 mm (45 in) in width or more than 2134 mm (7 ft) in height.

2. Doorways shall have strip doors, curtains, spring-hinged doors or other methods 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-4 m^2 • K/W (R-25 h • ft^2·°F/Btu) and *walk-in freezers* and refrigerated insulation of not less than R-5 m^2 • K/W (R-28 h • ft^2 • °F/Btu).

   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-5 m^2 • K/W (R-28 h • ft^2 • °F/Btu).
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* shall be of double-pane or triple-pane, inert gas-filled, heat-reflective treated glass.
7. Evaporator fan motors that are less than 0.746 kW (1 hp) 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 0.746 kW (1 hp) 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 76 W/m^2 (7.1 W/ft^2) of door opening for *walk-in freezers* and 32 W/m^2 (3.0 W/ft^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.

TABLE C403.10.1(1)
MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATION

EQUIPMENT TYPE	APPLICATION	ENERGY USE LIMITS (kWh per day)[a]	TEST PROCEDURE
Refrigerator with solid doors	Holding Temperature	0.10 × V + 2.04	AHRI 1200
Refrigerator with transparent doors		0.12 × V + 3.34	
Freezers with solid doors		0.40 × V + 1.38	
Freezers with transparent doors		0.75 × V + 4.10	
Refrigerators/freezers with solid doors		the greater of 0.12 × V + 3.34 or 0.70	
Commercial refrigerators	Pulldown	0.126 × V + 3.51	

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

TABLE C403.10.1(2)
MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS

EQUIPMENT TYPE				ENERGY USE LIMITS (kWh/day)[a, b]	TEST PROCEDURE
Equipment Class[c]	Family Code	Operating Mode	Rating Temperature		
VOP.RC.M	Vertical open	Remote condensing	Medium	0.82 × TDA + 4.07	AHRI 1200

SVO.RC.M	Semivertical open	Remote condensing	Medium	0.83 × TDA + 3.18	
HZO.RC.M	Horizontal open	Remote condensing	Medium	0.35 × TDA + 2.88	
VOP.RC.L	Vertical open	Remote condensing	Low	2.27 × TDA + 6.85	
HZO.RC.L	Horizontal open	Remote condensing	Low	0.57 × TDA + 6.88	
VCT.RC.M	Vertical transparent door	Remote condensing	Medium	0.22 × TDA + 1.95	
VCT.RC.L	Vertical transparent door	Remote condensing	Low	0.56 × TDA + 2.61	
SOC.RC.M	Service over counter	Remote condensing	Medium	0.51 × TDA + 0.11	
VOP.SC.M	Vertical open	Self-contained	Medium	1.74 × TDA + 4.71	
SVO.SC.M	Semivertical open	Self-contained	Medium	1.73 × TDA + 4.59	
HZO.SC.M	Horizontal open	Self-contained	Medium	0.77 × TDA + 5.55	
HZO.SC.L	Horizontal open	Self-contained	Low	1.92 × TDA + 7.08	
VCT.SC.I	Vertical transparent door	Self-contained	Ice cream	0.67 × TDA + 3.29	
VCS.SC.I	Vertical solid door	Self-contained	Ice cream	0.38 × V + 0.88	
HCT.SC.I	Horizontal transparent door	Self-contained	Ice cream	0.56 × TDA + 0.43	
SVO.RC.L	Semivertical open	Remote condensing	Low	2.27 × TDA + 6.85	
VOP.RC.I	Vertical open	Remote condensing	Ice cream	2.89 × TDA + 8.7	
SVO.RC.I	Semivertical open	Remote condensing	Ice cream	2.89 × TDA + 8.7	
HZO.RC.I	Horizontal open	Remote condensing	Ice cream	0.72 × TDA + 8.74	
VCT.RC.I	Vertical transparent door	Remote condensing	Ice cream	0.66 × TDA + 3.05	
HCT.RC.M	Horizontal transparent door	Remote condensing	Medium	0.16 × TDA + 0.13	

(continued)

TABLE C403.10.1(2)—continued
MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS

EQUIPMENT TYPE				ENERGY USE LIMITS (kWh/day)[a, b]	TEST PROCEDURE
Equipment Class[c]	Family Code	Operating Mode	Rating Temperature		
HCT.RC.L	Horizontal transparent door	Remote condensing	Low	0.34 × TDA + 0.26	AHRI 1200
HCT.RC.I	Horizontal transparent door	Remote condensing	Ice cream	0.4 × TDA + 0.31	

VCS.RC.M	Vertical solid door	Remote condensing	Medium	0.11 × V + 0.26	
VCS.RC.L	Vertical solid door	Remote condensing	Low	0.23 × V + 0.54	
VCS.RC.I	Vertical solid door	Remote condensing	Ice cream	0.27 × V + 0.63	
HCS.RC.M	Horizontal solid door	Remote condensing	Medium	0.11 × V + 0.26	
HCS.RC.L	Horizontal solid door	Remote condensing	Low	0.23 × V + 0.54	
HCS.RC.I	Horizontal solid door	Remote condensing	Ice cream	0.27 × V + 0.63	
HCS.RC.I	Horizontal solid door	Remote condensing	Ice cream	0.27 × V + 0.63	
SOC.RC.L	Service over counter	Remote condensing	Low	1.08 × TDA + 0.22	
SOC.RC.I	Service over counter	Remote condensing	Ice cream	1.26 × TDA + 0.26	
VOP.SC.L	Vertical open	Self-contained	Low	4.37 × TDA + 11.82	
VOP.SC.I	Vertical open	Self-contained	Ice cream	5.55 × TDA + 15.02	
SVO.SC.L	Semivertical open	Self-contained	Low	4.34 × TDA + 11.51	
SVO.SC.I	Semivertical open	Self-contained	Ice cream	5.52 × TDA + 14.63	
HZO.SC.I	Horizontal open	Self-contained	Ice cream	2.44 × TDA + 9.0	
SOC.SC.I	Service over counter	Self-contained	Ice cream	1.76 × TDA + 0.36	
HCS.SC.I	Horizontal solid door	Self-contained	Ice cream	0.38 × V + 0.88	

a. V = Volume of the case, as measured in accordance with Appendix C of AHRI 1200.
b. TDA = Total display area of the case, as measured in accordance with Appendix D of AHRI 1200.
c. Equipment class designations consist of a combination [in sequential order separated by periods (AAA).(BB).(C)] of:
(AAA) An equipment family code where:
VOP = vertical open
SVO = semivertical open
HZO = horizontal open
HCT = horizontal transparent doors
HCS = horizontal solid doors
SOC = service over counter
(BB) An operating mode code:
RC = remote condensing
SC = self-contained
(C) A rating temperature code:
M = medium temperature (3.3 °C)
L = low temperature (-17.8 °C)
I = ice-cream temperature (-9.4 °C)
For example, “VOP.RC.M” refers to the “vertical-open, remote-condensing, medium-temperature” equipment class.

C403.10.2 Walk-in coolers and walk-in freezers (Mandatory). 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 25 mm of full closure.

Exception: Closers are not required for doors more than 1143 mm (45 in) in width or more than 2134 mm (7 ft) 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-4 $m^2 \cdot K/W$ (R-25 $h \cdot ft^2 \cdot °F/Btu$), ceilings shall be provided with insulation having a thermal resistance of not less than R-4 $m^2 \cdot K/W$ (R-25 $h \cdot ft^2 \cdot °F/Btu$) and doors of *walk-in coolers* and *walk-in freezers* shall be provided with insulation having a thermal resistance of not less than R-6 $m^2 \cdot K/W$ (R-32 $\cdot ft^2 \cdot °F/Btu$).

   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-5 $m^2 \cdot K/W$ (R-28 $h \cdot ft^2 \cdot °F/Btu$).
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 0.746 kW (1 hp) and less than 460 volts shall be electronically commutated motors or 3-phase motors.
8. Condenser fan motors that are less than 0.746 kW (1 hp) 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 279 m^2 (3000 ft^2) 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 76 W/m^2 (7.1 W/ft^2) of door opening for *walk-in freezers* and not greater than 32 W/m^2 (3.0 W/ft^2) of door opening for *walk-in coolers*.
10. Antisweat heater controls shall be configured to 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. 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.

C403.10.2.1 Performance standards (Mandatory). *Walk-in coolers* and *walk-in freezers* shall meet the requirements of Tables C403.10.2.1(1), C403.10.2.1(2) and C403.2.10.2.1(3).

TABLE C403.10.2.1(1)
WALK-IN COOLER AND FREEZER DISPLAY DOOR EFFICIENCY REQUIREMENTS[a]

CLASS DESCRIPTOR	CLASS	MAXIMUM ENERGY CONSUMPTION (kWh/day)[a]
Display door, medium temperature	DD, M	$0.04 \times A_{dd} + 0.41$
Display door, low temperature	DD, L	$0.15 \times A_{dd} + 0.29$

a. A_{dd} is the surface area of the display door.

TABLE C403.10.2.1(2)
WALK-IN COOLER AND FREEZER NONDISPLAY DOOR EFFICIENCY REQUIREMENTS[a]

CLASS DESCRIPTOR	CLASS	MAXIMUM ENERGY CONSUMPTION (kWh/day)[a]
Passage door, medium temperature	PD, M	$0.05 \times A_{nd} + 1.7$
Passage door, low temperature	PD, L	$0.14 \times A_{nd} + 4.8$

Freight door, medium temperature	FD, M	$0.04 \times A_{nd} + 1.9$
Freight door, low temperature	FD, L	$0.12 \times A_{nd} + 5.6$

a. A_{nd} is the surface area of the nondisplay door.

TABLE C403. 10.2.1(3)
WALK-IN COOLER AND FREEZER REFRIGERATION SYSTEM EFFICIENCY REQUIREMENTS

CLASS DESCRIPTOR	CLASS	MINIMUM ANNUAL WALK-IN ENERGY FACTOR (AWEF)	
		W	(Btu/W • h)
Dedicated condensing, medium temperature, indoor system	DC.M.I	1.64	(5.61)
Dedicated condensing, medium temperature, indoor system, > 2.6 kW (9,000 Btu/h) capacity	DC.M.I, > 2.6 kW	1.64	(5.61)
Dedicated condensing, medium temperature, outdoor system	DC.M.I	2.23	(7.6)
Dedicated condensing, medium temperature, outdoor system, >2.6 kW (9,000 Btu/h) capacity	DC.M.I, > 2.6 kW	2.23	(7.6)

C403.10.3 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.

C403.10.4 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 C403.10.4.1 and C403.10.4.2.

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.

C403.10.4.1 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 5.6 °C (10 °F) for low-*temperature refrigeration systems* and the design dry-bulb temperature plus 8 °C (15 °F) 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 0.75 kW (1 hp) 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 21 °C (70 °F).

C403.10.4.2 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 -1.1 °C (30 °F) 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 29.3 kW (100000 Btu/h) with a design-saturated suction temperature of -23 °C (-10 °F) or lower. The sub-cooled liquid temperature shall be controlled at a maximum temperature setpoint of 10 °C (50 °F) 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 -7.8 °C (18 °F) or higher.

    2.1. Insulation for liquid lines with a fluid operating temperature less than 15.6 °C (60 °F) 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 (Mandatory). Ducts, plenums, piping and other elements that are part of an HVAC system shall be constructed and insulated in accordance with Sections C403.11.1 through C403.11.3.1.

C403.11.1 Duct and plenum insulation and sealing (Mandatory). Supply and return air ducts and plenums shall be insulated with not less than R-1.1 (m^2 • K)/W (R-6 ft^2 • h •°F/Btu) insulation where located in unconditioned spaces and where located outside the building with not less than R-1.4 (m^2 • K)/W (R-8 ft^2 • h •°F/Btu) 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-1.4 (m^2 • K)/W (R-8 ft^2 • h •°F/Btu) insulation . Insulation shall be protected from damage, including that due to sunlight, moisture, equipment maintenance and wind, but not limited to the following:

1. Insulation exposed to weather shall be suitable for outdoor service, e.g., protected by aluminium, sheet metal, painted canvas or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.

2. Insulation covering cooling ducts located outside the conditioned space shall include a vapor retardant located outside the insulation (unless the insulation is inherently vapor retardant), all penetrations and joints of which shall be sealed.

    Exception: Where located within equipment. Ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with Section 603.9 of the *International Mechanical Code* or standards approved by the Authority having Jurisdiction.

C403.11.2 Duct construction (Mandatory). Ductwork shall be constructed and erected in accordance with the *International Mechanical Code*.

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 °C (35 °F) 498 Pa [2 in water gauge (w.g.)] shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or

tapes installed in accordance with the manufacturer's instructions. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *International Mechanical Code*.

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. Ducts and plenums designed to operate at a static pressure greater than 498 Pa [2 in water gauge (w.g.)] but less than 747 Pa [3 in water gauge (w.g)] 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 *International Mechanical Code*.

C403.11.2.3 High-pressure duct systems (Mandatory). Ducts and plenums designed to operate at static pressures greater than 747 Pa [3 in water gauge (w.g)] 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 4-8.

$$CL = F/p^{0.65} \qquad \textbf{(Equation 4-8)}$$

where:

F = The measured leakage rate in cubic meter/minute per 9.3 m^2 (cfm per 100 ft^2) of duct surface.

P = The static pressure of the test.

Documentation shall be furnished by the designer demonstrating that representative sections totalling at least 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 and when piping and equipment operate at temperatures lower than the ambient air, the pipe system insulation shall include a vapor retardant located outside the insulation (unless the insulation is inherently vapor retardant) and all penetrations and joints of which shall be sealed.

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 15 °C (60 °F) and 41 °C (105 °F).
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 25 mm (1 in) or less in diameter.
6. Direct buried piping that conveys fluids at or below 15 °C (60 °F).

TABLE C403.11.3
MINIMUM PIPE INSULATION THICKNESS [in mm (in)][a]

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°C)	INSULATION CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE (inches)				
	Conductivity W/(m • k)[b]	Mean Rating Temperature, °C	< 25 (1)	25 to < 40	40 to < 100	100 to < 200	≤ 200
> 177	0.046 – 0.049	121	115	125	125	125	125
122 – 177	0.042 – 0.046	93	80	100	115	115	115
94 – 121	0.039 – 0.043	66	65	65	80	80	80
61 – 93	0.036 – 0.042	52	40	50	50	50	50
41 – 60	0.032 – 0.040	38	25	25	40	40	40

4 – 16	0.030 – 0.039	24	13	13	25	25	25
< 4	0.029 – 0.037	10	0.5	13	25	25	38

For IP: 1 mm = 0.04 in, °F = (°C) - 1.8 + 32.

a. For piping smaller than 38 mm ($1^1/_2$ in) and located in partitions within conditioned spaces, reduction of these thicknesses by 25.4 mm (1 in) shall be permitted (before thickness adjustment required in Note b) but not to a thickness less than 25.4 mm (1 in).

b. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

$T = r [(1 + t/r)K/k – 1]$

where:

T = minimum insulation thickness,
r = actual outside radius of pipe,
t = insulation thickness listed in the table for applicable fluid temperature and pipe size,
K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature W/(m • K), and
k = the upper value of the conductivity range listed in the table for the applicable fluid,

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.

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. Deleted.

C403.12.2 Snow- and ice-melt system controls. Deleted.

C403.12.3 Freeze protection system controls. Deleted.

SECTION C404
SERVICE WATER HEATING (MANDATORY)

C404.1 General. This section covers the minimum efficiency of, and controls for, service water-heating equipment and insulation of service hot water piping.

C404.2 Service water-heating equipment performance efficiency. Water-heating equipment and hot water storage tanks shall meet the requirements of Table C404.2. The efficiency shall be verified through data furnished by the manufacturer of the equipment or through certification under an *approved* certification program. Water-heating equipment intended to be used to provide space heating shall meet the applicable provisions of Table C404.2.

TABLE C404.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a, b, g]	TEST PROCEDURE
Water heaters, electric	≤ 12 kW[d]	Tabletop[e], ≥ 76 L and ≤ 454 L	0.93 - 0.00035V, EF	DOE 10 CFR Part 430
		Resistance	0.960 - 0.0008V, EF	
		Grid-enabled[f] > 284 and ≤ 454 L	1.061 - 0.00044V, EF	
	> 12 kW	Resistance	(0.3 + 27/V_m), %/h	ANSI Z21.10.3
Storage water heaters, gas	≤ 24 amps and ≤ 250 volts	Heat pump > 208 L and ≤ 454 L	2.057 - 0.0003V, EF	DOE 10 CFR Part 430
	≥ 58.62 kW	≥ 75 L and ≤ 208 L	0.675 - 0.0004V, EF	DOE 10 CFR Part 430
		> 208 L and ≤ 379 L	0.8012 - 0.00021V, EF	ANSI Z21.10.3
	> 23kW and ≤ 45 kW	< 310 W/L	80% E_t (Q/800 + 110$\sqrt{V}$)SL, kW	
	> 45 kW	< 310 W/L	80% E_t (Q/800 + 110$\sqrt{V}$)SL, kW	
Instantaneous water heaters, gas	> 14.66 kW and < 58.62 kW[c]	≥ 310 W/L and < 7.6 L	0.82 - 0.0005V, EF	DOE 10 CFR Part 430
	≥ 58.62 kW	≥ 310 W/L and < 38 L	80% E_t	ANSI Z21.10.3
	≥ 58.62 kW	≥ 310 W/L and ≥ 38 L	80% E_t (Q/800 + 110$\sqrt{V}$)SL, kW	
Storage water heaters, oil	≤ 30.78 kW	≥ 76 L	0.68 - 0.0005V, EF	DOE 10 CFR Part 430
	> 30.78 kW	< 310 W/L	80% E_t (Q/800 + 110$\sqrt{V}$)SL, kW	ANSI Z21.10.3
Instantaneous water heaters, oil	≤ 61.55 kW	≥ 310 W/L and < 7.6 L	0.59 - 0.0005V, EF	DOE 10 CFR Part 430
	> 61.55 kW	≥ 310 W/L and < 38 L	80% E_t	ANSI Z21.10.3
	> 61.55 kW	≥ 310 W/L and ≥ 38 L	78% E_t (Q/800 + 110$\sqrt{V}$)SL, kW	
Hot water supply boilers, gas and oil	≥ 58.62 kW and < 3664 kW	≥ 310 W/L and < 38 L	80% E_t	ANSI Z21.10.3
Hot water supply boilers, gas	≥ 58.62 kW and < 3664 kW	≥ 310 W/L and ≥ 38 L	80% E_t (Q/800 + 110$\sqrt{V}$)SL, kW	

Hot water supply boilers, oil	≥ 58.62 kW and < 3664 kW	≥ 310 W/L and ≥ 38 L	78% E_t $(Q/800 + 110\sqrt{V})SL$, kW	
Pool heaters, gas and oil	All	—	82% E_t	ASHRAE 146

(continued)

TABLE C404.2—continued
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a, b, g]	TEST PROCEDURE
Heat pump pool heaters	All	—	4.0 COP	AHRI 1160
Solar water heaters, with electric backup	All	—	SEF ≥ 1.8	
Solar water heaters, with gas backup	All	—	SEF ≥ 1.2	
Unfired storage tanks	All	—	Minimum insulation requirement R-2.2 W/(m • K)[R-12.5(h • ft^2 • °F)/Btu]	(none)

For IP: °F = [°C •1.8] + 32, 1 kW = 3,412 Btu/h, 1 L = 0.2642 gal, 1 W/L = 5,076 Btu/gal.

a. Energy factor (EF) and thermal efficiency (E_t) are minimum requirements. In the EF equation, V is the rated volume in litres.

b. Standby loss (SL) is the maximum Btu/h based on a nominal 21 °C (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 litres and Vm is the measured volume in litres. In the SL equation for oil and gas water heaters and boilers, V is the rated volume in litres.

c. Instantaneous water heaters with input rates below 59 kW (200,000 Btu/h) shall comply with these requirements where the water heater is designed to heat water to temperatures 82 °C (180 °F) or higher.

d. Electric water heaters with an input rating of 12 kW (40,950 Btu/hr) or less that are designed to heat water to temperatures of 82 °C (180 °F) or greater shall comply with the requirements for electric water heaters that have an input rating greater than 12 kW (40,950 Btu/h).

e. A tabletop water heater is a water heater that is enclosed in a rectangular cabinet with a flat top surface not more than 914 mm (3 ft) in height.

f. 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 284 L (75 gal).
   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."

g. Solar Energy Factor (SEF): The energy delivered by the total system divided by the electrical or gas energy put into the system.

C404.2.1 High input service water-heating systems. Gas-fired water-heating equipment installed in new buildings shall be in compliance with this section. Where a singular piece of water-heating equipment serves the entire building and the input rating of the equipment is 293 kW (1,000,000 Btu/h) or greater, such equipment shall have a thermal efficiency, E_t, of not less than 90 percent. Where multiple pieces of water-heating equipment serve the building and the combined input rating of the water-heating equipment is 293 kW (1,000,000 Btu/h) 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 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 29.3 kW (100000 Btu/h) 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. Storage tank-type water heaters and hot water storage tanks that have vertical water pipes connecting to the inlet and outlet of the tank shall be provided with integral heat traps at those inlets and outlets or shall have pipe-configured heat traps in the piping connected to those inlets and outlets. Tank inlets and outlets associated with solar water heating system circulation loops shall not be required to have heat traps.

C404.4 Insulation of piping. Piping from a water heater to the termination of the heated water fixture supply pipe shall be insulated in accordance with Table C403.11.3 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 2438 mm (8 ft) 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 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 25 mm (1 in) 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-0.5 m^2 • K/W (R-3 h • ft^2 •°F/Btu.

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 6.4 mm ($^1/_4$ in) piping shall be not greater than 1.9 L/m (0.5 gpm). The flow rate through 7.9 mm ($^5/_{16}$ in) piping shall be not greater than 3.8 L/m (1 gpm). The flow rate through 9.5 mm ($^3/_8$ in) piping shall be not greater than 5.7 L/m (1.5 gpm).

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 C404.5.1
PIPING VOLUME AND MAXIMUM PIPING LENGTHS

NOMINAL PIPE SIZE		VOLUME		MAXIMUM PIPING LENGTH			
mm	(inches)	litres per metre length	(liquid ounces per foot length)	Public lavatory faucets		Other fixtures and appliances	
				m	(ft)	m	(ft)
6.35	($^1/_4$)	0.03	(0.33)	6	(1.83)	50	(15.24)
7.94	($^5/_{16}$)	0.05	(0.50)	4	(1.22)	50	(15.24)
9.53	($^3/_8$)	0.07	(0.75)	3	(0.91)	50	(15.24)
12.7	($^1/_2$)	0.15	(1.50)	2	(0.61)	43	(13.11)
15.9	($^5/_8$)	0.19	(2.00)	1	(0.30)	32	(9.75)
19.1	($^3/_4$)	0.29	(3.00)	0.5	(0.15)	21	(6.40)
22.2	($^7/_8$)	0.39	(4.00)	0.5	(0.15)	16	(4.88)
25.4	(1)	0.49	(5.00)	0.5	(0.15)	13	(3.96)
31.8	($1^1/_4$)	0.78	(8.00)	0.5	(0.15)	8	(2.44)
38.1	($1^1/_2$)	1.07	(11.00)	0.5	(0.15)	6	(1.83)

50.8	(2) or larger	1.75	(18.00)	0.5	(0.15)	4	(1.22)

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 0.06 L (2 oz).
2. For other plumbing fixtures or plumbing appliances; not more than 1.89 L (0.5 gal).

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 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. Controls for circulating hot water system pumps shall start the pump based on the identification of a demand for hot water within the occupancy. The controls shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is not a demand for hot water.

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 control 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 40 °C (104 °F).

C404.8 Drain water heat recovery units. Drain water heat recovery units shall comply with CSA B55.2. Potable waterside pressure loss shall be less than 69 kPa (10 psi) 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 C404.9.5.

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 914 mm (3 ft) 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.

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.

C404.9.4 Pump motors. Pump motors with a pool pump motor capacity of 0.75 kW (1 hp) or greater, shall have the capability of operating at two or more speeds with a low speed having a rotation rate that is no more than one-half of the motor's maximum rotation rate. The pump motor must be operated with a pump control that complies with Section C404.9.5.

C404.9.5 Pump controls. Pool pump motor controls shall have the capability of operating the pool pump at least at two speeds. The control's default circulation speed setting shall be no more than one-half of the motor's maximum rotation rate. Any high-speed override capability shall be for a temporary period not to exceed one 24h cycle without resetting to default settings.

C404.10 Energy consumption of portable spas (Mandatory). The energy consumption of electric-powered portable spas shall be controlled by the requirements of APSP 14.

SECTION C405
ELECTRICAL POWER AND LIGHTING SYSTEMS

C405.1 General (Mandatory). This section covers lighting system controls, the maximum lighting power for interior and exterior applications and electrical energy consumption.

Dwelling units within multifamily buildings shall comply with Section R404.1. All other *dwelling units* shall comply with Section R404.1, or with Sections C405.2.4 and C405.3. *Sleeping units* shall comply with Section C405.2.4, and with Section R404.1 or C405.3. 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 or C403.10.2.

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.

Exception: 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.

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 28 m^2 (300 ft^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 28 m^2 (300 ft^2) in area shall comply with Section C405.2.1.1. Occupant sensor controls in all other open plan office spaces shall comply with all of the following:

1. The controls shall be configured so that general lighting can be controlled separately in control zones with floor areas not greater than 55 m^2 (600 ft^2) 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.

C405.2.2 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 also 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 at least 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 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 465 m^2 (5000 ft^2).

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 465 m^2 (5000 ft^2) provided that such area is less than 1860 m^2 (20,000 ft^2).
2. Where provided with manual control, the following areas are not required to have light reduction control:
   2.1. Spaces that have only one luminaire with a rated power of less than 100 W.
   2.2. Spaces that use less than 6.5 W/m^2 (0.6W/ft^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 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.

Exception: Light reduction controls are not required in *daylight zones* with *daylight responsive controls* complying with Section C405.2.3.

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 gen*eral 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.

Exception: 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.
4. New buildings where the total connected lighting power calculated in accordance with Section C405.3.1 is not greater than the adjusted interior lighting power allowance (LPA_{adj}) calculated in accordance with Equation 4-9:

$$LPA_{adj} = [LPA_{norm} \times (1.0 - 0.4 \times UDZFA / TBFA)]$$

(Equation 4-9)

where:

LPA_{adj} = Adjusted building interior lighting power allowance in watts.

LPA_{norm} = Normal building lighting power allowance in watts calculated in accordance with Section C405.3.2 and reduced in accordance with Section C406.3 where Option 2 of Section C406.1 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* 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. *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 *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 configured to completely shut off all controlled lights.
6. Lights in *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.

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 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 610 mm (2 ft), whichever is less, as indicated in Figure C405.2.3.2.
2. The area of the fenestration is not less than 2.23 m^2 (24 ft^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.

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.

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.

C405.3.1 Total connected interior lighting power. The total connected interior lighting power shall be deter-mined in accordance with Equation 4-10.

$$TCLP = [LVL + BLL + LED + TRK + \text{Other}]$$

(Equation 4-10)

where:

TCLP = Total connected lighting power (W).

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 25 W/lin m (8 W/lin ft).
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.

1. Television broadcast lighting for playing areas in sports arenas.
2. Emergency lighting automatically off during normal building operation.
3. Lighting in spaces specifically designed for use by occupants with special lighting needs, including those with visual impairment and other medical and age-related issues.
4. Casino gaming areas.
5. Mirror lighting in dressing rooms.
6. Task lighting for medical and dental purposes that is in addition to general lighting and controlled by an independent control device.
7. Display lighting for exhibits in galleries, museums and monuments that is in addition to general lighting and controlled by an independent control device.
8. Lighting for theatrical purposes, including performance, stage, film production and video production.

9. Lighting for photographic processes.
10. Lighting integral to equipment or instrumentation and installed by the manufacturer.
11. Task lighting for plant growth or maintenance.
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

BUILDING AREA TYPE	LPD	
	W/m²	(W/ft²)
Automotive facility	7.60	(0.71)
Convention center	8.20	(0.76)
Courthouse	9.70	(0.90)
Dining: bar lounge/leisure	9.70	(0.90)
Dining: cafeteria/fast food	8.50	(0.79)
Dining: family	8.40	(0.78)
Dormitory[a, b]	6.60	(0.61)
Exercise center	7.00	(0.65)
Fire station[a]	5.70	(0.53)
Gymnasium	7.30	(0.68)
Health care clinic	8.80	(0.82)
Hospital[a]	11.30	(1.05)
Hotel/Motel[a, b]	8.10	(0.75)
Library	8.40	(0.78)
Manufacturing facility	9.70	(0.90)
Motion picture theater	8.90	(0.83)
Multifamily[c]	7.30	(0.68)
Museum	11.40	(1.06)
Office	8.50	(0.79)
Parking garage	1.60	(0.15)
Penitentiary	8.10	(0.75)
Performing arts theater	12.70	(1.18)
Police station	8.60	(0.80)

Post office	7.20	(0.67)
Religious building	10.10	(0.94)
Retail	11.40	(1.06)
School/university	8.70	(0.81)
Sports arena	9.40	(0.87)
Town hall	8.60	(0.80)
Transportation	6.60	(0.61)
Warehouse	5.20	(0.48)
Workshop	9.70	(0.90)

a. Where sleeping units are excluded from lighting power calculations by application of Section R405.1, neither the area of the sleeping units nor the wattage of lighting in the sleeping units is counted.
b. Where dwelling units are excluded from lighting power calculations by application of Section R405.1, neither the area of the dwelling units nor the wattage of lighting in the dwelling units is counted.
c. Dwelling 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

COMMON SPACE TYPES[a]	LPD	
	W/m²	
Less than 12.2 m (40 ft) in height	0.10 per metre total height	
Greater than 12.2 m (40 ft) in height	0.40 + 0.07 per metre total height	
Audience seating area		
In an auditorium	6.8	
In a convention center	8.9	
In a gymnasium	7.1	
In a motion picture theater	12.3	
In a penitentiary	3.1	
In a performing arts theater	21.8	
In a religious building	16.5	
In a sports arena	4.7	
Otherwise	4.7	
Banking activity area	9.26	
Breakroom (See Lounge/Breakroom)		
Classroom/lecture hall/training room		
In a penitentiary	14.5	
Otherwise	10.3	

Computer Room	14.3	
Conference/meeting/multipurpose room	10.3	
Copy/print room	6	
Corridor		
In a facility for the visually impaired (and not used primarily by the staff)[b]	9.9	
In a hospital	9.9	
In a manufacturing facility	3.1	
Otherwise	7.1	
Courtroom	18.51	
Dining area		
In a penitentiary	10.3	
In a facility for the visually impaired (and not used primarily by the staff)[b]	21.5	
In bar/lounge or leisure dining	10	
In cafeteria or fast food dining	6.8	
In family dining	7.6	
Otherwise	6.8	
Electrical/mechanical room	4.6	
Emergency vehicle garage	4.4	

(continued)

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

COMMON SPACE TYPES[a]	LPD	
	W/m²	
Food preparation area	11.40	
Guestroom[c, d]	8.30	
Laboratory		
In or as a classroom	12.90	
Otherwise	15.60	
Laundry/washing area	4.60	
Loading dock, interior	6.20	
Lobby		
In a facility for the visually impaired (and not used primarily by the staff)[b]	21.80	
For an elevator	7.30	
In a hotel	11.50	
In a motion picture theater	4.80	

In a performing arts theater	18.30	
Otherwise	10.80	
Locker room	5.20	
Lounge/breakroom		
In a healthcare facility	8.40	
Otherwise	6.70	
Office		
Enclosed	10.00	
Open plan	10.00	
Parking area, interior	1.50	
Pharmacy area	14.40	
Restroom		
In a facility for the visually impaired (and not used primarily by the staff)[b]	10.30	
Otherwise	9.10	
Sales area	13.10	
Seating area, general	15.30	
Stairway (See Space containing stairway)		
Stairwell	6.20	
Storage room	4.90	
Vehicular maintenance area	6.00	
Workshop	12.30	
BUILDING TYPE SPECIFIC SPACE TYPES[a]	**W/m²**	**(W/ft²)**
Automotive (See Vehicular Maintenance Area above)		
Convention Center—exhibit space	9.50	
Dormitory—living quarters[c, d]	5.80	
Facility for the visually impaired[b]		
In a chapel (and not used primarily by the staff)	11.40	
In a recreation room (and not used primarily by the staff)	19.40	
Fire Station—sleeping quarters[c]	2.20	
Gymnasium/fitness center		
In an exercise area	5.40	
In a playing area	8.80	

(continued)

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

BUILDING TYPE SPECIFIC SPACE TYPES[a]	**LPD**	
	W/m²	

Healthcare facility		
In an exam/treatment room	18.1	
In an imaging room	11.4	
In a medical supply room	5.8	
In a nursery	10.8	
In a nurse's station	8.7	
In an operating room	23.4	
In a patient room	6.7	
In a physical therapy room	9	
In a recovery room	11.1	
Library		
In a reading area	8.8	
In the stacks	12.9	
Manufacturing facility		
In a detailed manufacturing area	10	
In an equipment room	7	
In an extra high bay area (greater than 15.2 m [50 ft] floor-to-ceiling height)	11.3	
In a high bay area (7.6 to 15.2 m [25–50 ft] floor-to-ceiling height)	8.1	
In a low bay area (less than 7.6 m [25 ft] floor-to-ceiling height)	10.3	
Museum		
In a general exhibition area	11.3	
In a restoration room	9.2	
Performing arts theater—dressing room	3.9	
Post Office—sorting area	7.3	
Religious buildings		
In a fellowship hall	5.9	
In a worship/pulpit/choir area	16.5	
Retail facilities		
In a dressing/fitting room	5.4	
In a mall concourse	9.7	
Sports arena—playing area		
For a Class I facility[e]	26.6	
For a Class II facility[f]	21.1	
For a Class III facility[g]	18.3	
For a Class IV facility[h]	12.2	
Transportation facility		
In a baggage/carousel area	4.8	
In an airport concourse	3.3	

At a terminal ticket counter	6.7	

(continued)

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

BUILDING TYPE SPECIFIC SPACE TYPES[a]	LPD	
	W/m²	(W/ft²)
Warehouse—storage area		
For medium to bulky, palletized items	3.8	(0.35)
For smaller, hand-carried items	7.4	(0.69)

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 by application of Section R405.1, neither the area of the sleeping units nor the wattage of lighting in the sleeping units is counted.
d. Where dwelling units are excluded from lighting power calculations by application of Section R405.1, neither the area of the dwelling units nor the wattage of lighting in the dwelling units is counted.
e. Class I facilities consist of professional facilities; and semiprofessional, collegiate, or club facilities with seating for 5,000 or more spectators.
f. Class II facilities consist of collegiate and semiprofessional facilities with seating for fewer than 5,000 spectators; club facilities with seating for between 2,000 and 5,000 spectators; and amateur league and high-school facilities with seating for more than 2,000 spectators.
g. Class III facilities consist of club, amateur league and high-school facilities with seating for 2,000 or fewer spectators.
h. Class IV facilities consist of primary 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 4-11.

   Additional interior lighting power allowance = 1000 W + (Retail Area 1 × 4.8 W/m^2) + (Retail Area 2 × 4.84 W/m^2) + (Retail Area 3 × 11 W/m^2) + (Retail Area 4 × 20 W/m^2)

   For IP units:

   Additional interior lighting power allowance = 1000 W + (Retail Area 1 × 0.45 W/ft^2) + (Retail Area 2 × 0.45 W/ft^2) + (Retail Area 3 × 1.05 W/ft^2) + (Retail Area 4 × 1.87 W/ft^2)

   (Equation 4-11)

where:

Retail Area 1 = The floor area for all products not listed in Retail Area 2, 3 or 4.

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

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

Retail Area 4 = The floor area used for the sale of jewelry, crystal and china.

Exception: Other merchandise categories are permitted to be included in Retail Areas 2 through 4, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is approved by the code official.

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 9.7 W/m^2 (0.9 W/ft^2) in lobbies and not more than 8.1 W/m^2 (0.75 W/ft^2) in other spaces.

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.

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.
9. Temporary lighting.
10. Industrial production, material handling, transportation sites and associated storage areas.
11. Theme elements in theme/amusement parks.
12. Used to highlight features of art, public monuments, and the national flag.
13. Lighting for water features and swimming pools.
14. Lighting controlled from within dwelling units, where the lighting complies with Section R404.1.

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

LIGHTING ZONE	DESCRIPTION
1	Developed areas of national parks, state parks, forest land, and rural areas

2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed-use areas
3	All other areas not classified as lighting zone 1, 2 or 4
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

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

	LIGHTING ZONES			
	Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance	350 W	400 W	500 W	900 W
Uncovered Parking Areas				
Parking areas and drives	0.32 W/m^2	0.43 W/m^2	0.65 W/m^2	0.86 W/m^2
Building Grounds				
Walkways and ramps less than 3048 mm wide	1.6 W/linear metre	1.6 W/linear metre	2.0 W/linear metre	2.3 W/linear metre
Walkways 3048 mm wide or greater, plaza areas, special feature areas	1.1 W/m^2	1.1 W/m^2	1.2 W/m^2	1.5 W/m^2
Dining areas	7.00 W/m^2	7.00 W/m^2	8.07 W/m^2	10.23 W/m^2
Stairways	6.46 W/m^2	7.53 W/m^2	7.53 W/m^2	7.53 W/m^2
Pedestrian tunnels	1.29 W/m^2	1.29 W/m^2	1.51 W/m^2	2.26 W/m^2
Landscaping	0.32 W/m^2	0.43 W/m^2	0.43 W/m^2	0.43 W/m^2
Building Entrances and Exits				
Main entries	46 W/linear metre of door width	46 W/linear metre of door width	69 W/linear metre of door width	69 W/linear metre of door width
Entry canopies	0.22 W/m^2	2.69 W/m^2	4.31 W/m^2	4.31 W/m^2
Loading docks	3.77 W/m^2	3.77 W/m^2	3.77 W/m^2	3.77 W/m^2
Sales Canopies				
Free-standing and attached	0.43 W/m^2	0.43 W/m^2	6.46 W/m^2	7.53 W/m^2
Outdoor Sales				
Open areas (including vehicle sales lots)	0.07 W/m^2	0.07 W/m^2	1.15 W/m^2	0.16 W/m^2
Street frontage for vehicle sales lots in addition to “open area” allowance	No allowance	23 W/linear metre	23 W/linear metre	69 W/linear metre

For IP:1 m = 3.28 ft, 1 W/m^2 = 10.76 W/ft^2, 1 W/lin m = 3.28 W/lin ft, W = watts.

TABLE C405.4.2(3)
INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

LIGHTING ZONES				
	Zone 1	Zone 2	Zone 3	Zone 4
Building facades	No allowance	0.81 W/m^2 of gross above-grade wall area	1.22 W/m^2 of gross above-grade wall area	1.61 W/m^2 of gross above-grade wall area
Automated teller machines (ATM) and night depositories	135 W per location plus 45 W per additional ATM per location			
Uncovered entrances and gatehouse inspection stations at guarded facilities	1.6 W/m^2 of area			
Uncovered loading areas for law enforcement, fire, ambulance and other emergency service vehicles	3.77 W/m^2 of area			
Drive-up windows/doors	200 W per drive-through			
Parking near 24-hour retail entrances.	400 W per main entry			

For IP:1 m = 3.28 ft, 1 W/m^2 = 10.76 W/ft^2, 1 W/lin m = 3.28 W/lin ft, W = watts.

C405.4.2.1 Additional exterior lighting power. Any increase in the exterior lighting power allowance is limited to the specific lighting applications indicated in Table C405.4.2(3). The additional power shall be used only for the luminaires that are serving these applications and shall not be used for any other purpose.

C405.4.3 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 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 or another equivalent test procedure. The efficiency shall be verified through certification under an approved certification program or, where a certification program does not exist, the equipment efficiency ratings shall be supported by data furnished by the transformer manufacturer.

Exception: The following transformers are exempt:

1. Transformers that meet the *Energy Policy Act of 2005* exclusions based on the DOE 10 CFR 431 definition of special purpose applications.
2. Transformers that meet the *Energy Policy Act of 2005* exclusions that are not to be used in general purpose applications based on information provided in DOE 10 CFR 431.
3. Transformers that meet the *Energy Policy Act of 2005* exclusions with multiple voltage taps where the highest tap is not less than 20 percent more than the lowest tap.
4. Drive transformers.
5. Rectifier transformers.
6. Auto-transformers.
7. Uninterruptible power system transformers.
8. Impendance transformers.
9. Regulating transformers.
10. Sealed and nonventilating transformers.

11. Machine tool transformers.
12. Welding transformers.
13. Grounding transformers.
14. Testing transformers.

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

kVA[a]	Efficiency (%)[b]	kVA[a]	Efficiency (%)[b]
15	97.70	15	97.89
25	98.00	30	98.23
37.5	98.20	45	98.40
50	98.30	75	98.60
75	98.50	112.5	98.74
100	98.60	150	98.83
167	98.70	225	98.94
250	98.80	300	99.02
333	98.90	500	99.14
—	—	750	99.23
—	—	1000	99.28

a. kiloVolt-Amp rating.
b. Nominal efficiencies shall be established in accordance with the DOE 10 CFR 431 test procedure for low-voltage dry-type transformers.

C405.7 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]

MOTOR HORSEPOWER (STANDARD KILOWATT EQUIVALENT)	NOMINAL FULL-LOAD EFFICIENCY (%) AS OF JUNE 1, 2016			
	2 Pole	4 Pole	6 Pole	8 Pole

	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1 (0.75)	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5 (1.1)	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2 (1.5)	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3 (2.2)	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5 (3.7)	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5 (5.5)	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10 (7.5)	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15 (11)	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20 (15)	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25 (18.5)	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30 (22)	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40 (30)	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50 (37)	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60 (45)	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75 (55)	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100 (75)	94.1	93.6	95.4	95.4	95.0	95.0	93.6	94.1
125 (90)	95.0	94.1	95.4	95.4	95.0	95.0	94.1	94.1
150 (110)	95.0	94.1	95.8	95.8	95.8	95.4	94.1	94.1
200 (150)	95.4	95.0	96.2	95.8	95.8	95.4	94.5	94.1
250 (186)	95.8	95.0	96.2	95.8	95.8	95.8	95.0	95.0
300 (224)	95.8	95.4	96.2	95.8	95.8	95.8		
350 (261)	95.8	95.4	96.2	95.8	95.8	95.8		
400 (298)	95.8	95.8	96.2	95.8				
450 (336)	95.8	96.2	96.2	96.2				
500 (373)	95.8	96.2	96.2	96.2				

a. Nominal efficiencies shall be established in accordance with DOE 10 CFR 431.

b. For purposes of determining the required minimum nominal full-load efficiency of an electric motor that has a kilowatt rating between two kilowatt ratings listed in this table, each such motor shall be deemed to have a listed kilowatt rating, determined as follows:

1. A kilowatt rating at or above the midpoint between the two consecutive kilowatt ratings shall be rounded up to the higher of the two kilowatt ratings.
2. A kilowatt rating below the midpoint between the two consecutive kilowatt ratings shall be rounded down to the lower of the two kilowatt ratings.

TABLE C405.7(2)
MINIMUM NOMINAL FULL-LOAD EFFICIENCY FOR NEMA DESIGN C AND IEC DESIGN H MOTORS AT 60 HZ[a, b]

MOTOR HORSEPOWER (STANDARD KILOWATT EQUIVALENT)	NOMINAL FULL-LOAD EFFICIENCY (%) AS OF JUNE 1, 2016		
	4 Pole	6 Pole	8 Pole

	Enclosed	Open	Enclosed	Open	Enclosed	Open
0.75 (1)	85.5	85.5	82.5	82.5	75.5	75.5
1.1 (1.5)	86.5	86.5	87.5	86.5	78.5	77.0
1.5 (2)	86.5	86.5	88.5	87.5	84.0	86.5
2.2 (3)	89.5	89.5	89.5	88.5	85.5	87.5
3.7 (5)	89.5	89.5	89.5	89.5	86.5	88.5
5.5 (7.5)	91.7	91.0	91.0	90.2	86.5	89.5
7.5 (10)	91.7	91.7	91.0	91.7	89.5	90.2
11 (15)	92.4	93.0	91.7	91.7	89.5	90.2
15 (20)	93.0	93.0	91.7	92.4	90.2	91.0
18.5 (25)	93.6	93.6	93.0	93.0	90.2	91.0
22 (30)	93.6	94.1	93.0	93.6	91.7	91.7
30 (40)	94.1	94.1	94.1	94.1	91.7	91.7
37 (50)	94.5	94.5	94.1	94.1	92.4	92.4
45 (60)	95.0	95.0	94.5	94.5	92.4	93.0
55 (75)	95.4	95.0	94.5	94.5	93.6	94.1
75 (100)	95.4	95.4	95.0	95.0	93.6	94.1
90 (125)	95.4	95.4	95.0	95.0	94.1	94.1
110 (150)	95.8	95.8	95.8	95.4	94.1	94.1
150 (200)	96.2	95.8	95.8	95.4	94.5	94.1

a. Nominal efficiencies shall be established in accordance with DOE 10 CFR 431.
b. For purposes of determining the required minimum nominal full-load efficiency of an electric motor that has a kilowatt rating between two kilowatt ratings listed in this table, each such motor shall be deemed to have a listed kilowatt rating, determined as follows:
   1. A kW at or above the midpoint between the two consecutive kW shall be rounded up to the higher of the two kW.
   2. A kW below the midpoint between the two consecutive kW shall be rounded down to the lower of the two kW.

TABLE C405.7(3)
MINIMUM AVERAGE FULL-LOAD EFFICIENCY POLYPHASE SMALL ELECTRIC MOTORS[a]

MOTOR HORSEPOWER kW (hp)	OPEN MOTORS			
	Number of Poles	2	4	6
	Synchronous Speed (RPM)	3600	1800	1200
0.19 (0.25)		65.6	69.5	67.5
0.25 (0.33)		69.5	73.4	71.4
0.37 (0.50)		73.4	78.2	75.3
0.56 (0.75)		76.8	81.1	81.7
0.75 (1)		77.0	83.5	82.5
1.1 (1.5)		84.0	86.5	83.8

1.5 (2)		85.5	86.5	N/A
2.2 (3)		85.5	86.9	N/A

a. Average full load efficiencies shall be established in accordance with 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[a]

MOTOR HORSEPOWER	OPEN MOTORS			
	Number of Poles	2	4	6
	Synchronous Speed (RPM)	3600	1800	1200
0.19 (0.25)		66.6	68.5	62.2
0.25 (0.33)		70.5	72.4	66.6
0.37 (0.50)		72.4	76.2	76.2
0.56 (0.75)		76.2	81.8	80.2
0.75 (1)		80.4	82.6	81.1
1.1 (1.5)		81.5	83.8	N/A
1.5 (2)		82.9	84.5	N/A
2.2 (3)		84.1	N/A	N/A

a. Average full load efficiencies shall be established in accordance with 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 35 lumens per watt. Ventilation fans in elevators that do not have their own air-conditioning system shall not consume more than 0.70 W s/L (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, un-occupied 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 340 kg (750 lbs).

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 Sub-metering (Mandatory). In new buildings with tenants, metering shall be provided for the entire building and individually for each tenant occupying 93 m^2 (1000 ft^2) (total enclosed and unenclosed) or more. Tenants shall have access to data collected for their space. A tenant is defined as "one who rents or leases from a landlord."

SECTION C406
ADDITIONAL EFFICIENCY PACKAGES

C406.1 Requirements. Buildings shall comply with one or more of the following:

1. More efficient HVAC performance in accordance with Section C406.2.
2. Reduced lighting power in accordance with Section C406.3.
3. Enhanced lighting controls in accordance with Section C406.4.
4. On-site supply of renewable energy in accordance with Section C406.5.
5. Provision of a dedicated outdoor air system for certain HVAC equipment in accordance with Section C406.6.
6. High-efficiency service water heating in accordance with Section C406.7.
7. Enhanced envelope performance in accordance with Section C406.8.
8. Reduced air infiltration in accordance with Section C406.9

C406.1.1 Tenant spaces. Tenant spaces shall comply with Section C406.2, C406.3, C406.4, C406.6 or C406.7. Alternatively, tenant spaces shall comply with Section C406.5 where the entire building is in compliance.

Exception: Previously occupied tenant spaces that comply with this code in accordance with Section C501.

C406.2 More efficient HVAC equipment performance. Equipment shall exceed the minimum efficiency requirements listed in Tables C403.3.2(1) through C403.3.2(7) 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/IESNA 90.1 by 10 percent. Equipment not listed in Tables C403.3.2(1) through C403.3.2(7) shall be limited to 10 percent of the total building system capacity.

C406.3 Reduced lighting power. The total connected interior lighting power calculated in accordance with Section C405.3.1 shall be less than 90 percent of the total lighting power allowance calculated in accordance with Sections C405.2.1 through C405.2.3.

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.

1. Luminaires shall be configured for continuous dimming.
2. Luminaires shall be addressed individually. Where individual addressability is not available for the luminaire class type, a controlled group of not more than four luminaries shall be allowed.
3. Not more than eight luminaires shall be controlled together in a *daylight zone.*
4. Fixtures shall be controlled through a digital control system that includes the following function:
    4.1. Control reconfiguration based on digital addressability.
    4.2. Load shedding.
    4.3. Individual user control of overhead general illumination in open offices.
    4.4. Occupancy sensors shall be 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.
6. Functional testing of lighting controls shall comply with Section C408.

C406.5 On-site renewable energy. The total minimum ratings of on-site renewable energy systems shall be one of the following:

1. Not less than 5.4 W/m^2 (1.71 Btu/h/ft^2 or 0.50 W/ft^2) of conditioned floor area.
2. Not less than 3 percent of the energy used within the building for building mechanical and service water heating equipment and lighting regulated in Chapter 4.

C406.6 Dedicated outdoor air system. 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 *International Mechanical Code.* 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 be of the following types to use this compliance method:

1. *Group R*-1: Boarding houses, hotels or motels.
2. Group I-2: Hospitals, psychiatric hospitals and nursing homes.
3. Group A-2: Restaurants and banquet halls or buildings containing food preparation areas.
4. Group F: Laundries.
5. *Group R*-2.
6. Group A-3: Health clubs and spas.
7. Buildings showing a service hot water load of 10 percent or more of total building energy loads, as shown with an energy analysis as described in Section C407.

C406.7.1 Load fraction. The building service water-heating system shall have one or more of the following that are sized to provide not less than 60 percent of the building's annual hot water requirements or sized to provide 100 percent of the building's annual hot water requirements if the building shall otherwise comply with Section C403.9.5:

1. Waste heat recovery from service hot water, heat- recovery chillers, building equipment, or process equipment.
2. *On-site renewable energy* water-heating systems.

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 in accordance with Section C402.1.5.

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 2.0 L/s • m^2 (0.25 cfm/ft^2) under a pressure differential of 75 Pa (0.3 in water column), 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 25 000 m^2 (250,000 ft^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.

SECTION C407
TOTAL BUILDING PERFORMANCE

C407.1 Scope. This section establishes criteria for compliance using total building performance. The following systems and loads shall be included in determining the total building performance: heating systems, cooling systems, service water heating, fan systems, lighting power, receptacle loads and process loads.

Exception: Energy used to recharge or refuel vehicles that are used for on-road and off-site transportation purposes.

C407.2 Mandatory requirements. Compliance with this section requires compliance with Sections C402.5, C403.2, C403.3 through C403.3.2, C403.4 through C403.4.2.3, C403.5.5, C403.7, C403.8.1 through C403.8.4, C403.10.1 through C403.10.3, C403.11, C403.12, C404 and C405.

C407.3 Performance-based compliance. Compliance based on total building performance requires that a proposed building (*proposed design*) be shown to have an annual energy cost that is less than or equal to the annual energy cost of the *standard*

reference design. Energy prices shall be taken from a source *approved* by the *code official*, such as the Department of Energy, Energy Information Administration's *State Energy Price and Expenditure Report. Code officials* shall be permitted to require time-of-use pricing in energy cost calculations. The reduction in energy cost of the proposed design associated with *on-site renewable energy* shall be not more than 5 percent of the total energy cost. The amount of renewable energy purchased from off-site sources shall be the same in the *standard reference design* and the *proposed design*.

Exception: Jurisdictions that require site energy (1 kWh = 3413 Btu) rather than energy cost as the metric of comparison.

C407.4 Documentation. Documentation verifying that the methods and accuracy of compliance software tools conform to the provisions of this section shall be provided to the *code official.*

C407.4.1 Compliance report. Permit submittals shall include a report documenting that the proposed design has annual energy costs less than or equal to the annual energy costs of the standard reference design. The compliance documentation shall include the following information:

1. Address of the building.
2. An inspection checklist documenting the building component characteristics of the *proposed design* as specified in Table C407.5.1(1). The inspection checklist shall show the estimated annual energy cost for both the *standard reference design* and the *proposed design*.
3. Name of individual completing the compliance report.
4. Name and version of the compliance software tool.

C407.4.2 Additional documentation. The *code official* shall be permitted to require the following documents:

1. Documentation of the building component characteristics of the *standard reference design*.
2. Thermal zoning diagrams consisting of floor plans showing the thermal zoning scheme for *standard reference design* and *proposed design*.
3. Input and output reports from the energy analysis simulation program containing the complete input and output files, as applicable. The output file shall include energy use totals and energy use by energy source and end-use served, total hours that space conditioning loads are not met and any errors or warning messages generated by the simulation tool as applicable.
4. An explanation of any error or warning messages appearing in the simulation tool output.
5. A certification signed by the builder providing the building component characteristics of the *proposed design* as given in Table C407.5.1(1).
6. Documentation of the reduction in energy use associated with *on-site renewable energy*.

C407.5 Calculation procedure. Except as specified by this section, the *standard reference design* and *proposed design* shall be configured and analyzed using identical methods and techniques.

C407.5.1 Building specifications. The *standard reference design* and *proposed design* shall be configured and analyzed as specified by Table C407.5.1(1). Table C407.5.1(1) shall include by reference all notes contained in Table C402.1.4.

TABLE C407.5.1(1)
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT CHARACTERISTICS	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Space use classification	Same as proposed	The space use classification shall be chosen in accordance with Table C405.5.2 for all areas of the building covered by this permit. Where the space use classification for a building is not known, the building shall be categorized as an office building.
Roofs	Type: Insulation entirely above deck	As proposed
	Gross area: same as proposed	As proposed
	U-factor: as specified in Table C402.1.3	As proposed

	Solar absorptance: 0.75	As proposed
	Emittance: 0.90	As proposed
Walls, above-grade	Type: Mass wall where proposed wall is mass; otherwise steel-framed wall	As proposed
	Gross area: same as proposed	As proposed
	U-factor: as specified in Table C402.1.3	As proposed
	Solar absorptance: 0.75	As proposed
	Emittance: 0.90	As proposed
Walls, below-grade	Type: Mass wall	As proposed
	Gross area: same as proposed	As proposed
	U-Factor: as specified in Table C402.1.3 with insulation layer on interior side of walls	As proposed
Floors, above-grade	Type: joist/framed floor	As proposed
	Gross area: same as proposed	As proposed
	U-factor: as specified in Table C402.1.3	As proposed
Floors, slab-on-grade	Type: Unheated	As proposed
	F-factor: as specified in Table C402.1.3	As proposed
Opaque doors	Type: Swinging	As proposed
	Area: Same as proposed	As proposed
	U-factor: as specified in Table C402.1.3	As proposed
Vertical fenestration other than opaque doors	Area 1. The proposed glazing; where the proposed glazing area is less than 40 percent of above-grade wall area. 2. 40 percent of above-grade wall area; where the proposed glazing area is 40 percent or more of the above-grade wall area.	As proposed
	U-factor: as specified in Table C402.1.3	As proposed
	SHGC: as specified in Table C402.1.3 except that for climates with no requirement (NR) SHGC = 0.40 shall be used	As proposed
	External shading and PF: None	As proposed
Skylights	Area 1. The proposed skylight area; where the proposed skylight area is less than that permitted by Section C402.1. 2. The area permitted by Section C402.1; where the proposed skylight area exceeds that permitted by Section C402.1	As proposed
	U-factor: as specified in Table C402.4	As proposed
	SHGC: as specified in Table C402.4, except that for climates with no requirement (NR) SHGC = 0.40 shall be used.	As proposed
Lighting, interior	The interior lighting power shall be determined in accordance with Section C405.3.2. Where the occupancy of the building is not known, the lighting power density shall be 10.7 W/m^2 (1.0 Watt/ft^2) based on the categorization of buildings with unknown	As proposed

	space classification as offices.	
Lighting, exterior	The lighting power shall be determined in accordance with Table C405.4.2(2) and C405.4.2(3). Areas and dimensions of surfaces shall be the same as proposed.	As proposed

(continued)

TABLE C407.5.1(1)—continued
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT CHARACTERISTICS	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Internal gains	Same as proposed	Receptacle, motor and process loads shall be modeled and estimated based on the space use classification. End-use load components within and associated with the building shall be modeled to include, but not be limited to, the following: exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators, escalators, refrigeration equipment and cooking equipment.
Schedules	Same as proposed **Exception:** Thermostat settings and schedules for HVAC systems that utilize radiant heating, radiant cooling and elevated air speed, provided that equivalent levels of occupant thermal comfort are demonstrated by means of equal Standard Effective Temperature as calculated in Normative Appendix B of ASHRAE Standard 55.	Operating schedules shall include hourly profiles for daily operation and shall account for variations between weekdays, weekends, holidays and any seasonal operation. Schedules shall model the time-dependent variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads. The schedules shall be typical of the proposed building type as determined by the designer and approved by the jurisdiction.
Mechanical ventilation	Same as proposed	As proposed, in accordance with Section C403.2.2.
Heating systems	Fuel type: same as proposed design	As proposed
	Equipment type[a]: as specified in Tables C407.5.1(2) and C407.5.1(3)	As proposed
	Efficiency: as specified in Tables C403.3.2(4) and C403.3.2(5)	As proposed
	Capacity[b]: sized proportionally to the capacities in the proposed design based on sizing runs, and shall be established such that no smaller number of unmet heating load hours and no larger heating capacity safety factors are provided than in the proposed design.	As proposed
Cooling systems	Fuel type: same as proposed design	As proposed
	Equipment type[c]: as specified in Tables C407.5.1(2) and C407.5.1(3)	As proposed
	Efficiency: as specified in Tables C403.3.2(1), C403.3.2(2) and C403.3.2(3)	As proposed
	Capacity[b]: sized proportionally to the capacities in the proposed design based on sizing runs, and shall be established such that no smaller number of unmet cooling load hours and no larger cooling capacity safety factors are provided than in the proposed design.	As proposed
	Economizer[d]: same as proposed, in accordance with Section C403.5.	As proposed
Service water heating[e]	Fuel type: same as proposed	As proposed

	Efficiency: as specified in Table C404.2	For *Group R*, as proposed multiplied by SWHF. For other than *Group R*, as proposed multiplied by efficiency as provided by the manufacturer of the DWHR unit.
	Capacity: same as proposed	As proposed
	Where no service water hot water system exists or is specified in the proposed design, no service hot water heating shall be modeled.	

SWHF = Service water heat recovery factor, DWHR = Drain water heat recovery.

a. Where no heating system exists or has been specified, the heating system shall be modeled as fossil fuel. The system characteristics shall be identical in both the standard reference design and proposed design.

b. The ratio between the capacities used in the annual simulations and the capacities determined by sizing runs shall be the same for both the standard reference design and proposed design.

c. Where no cooling system exists or no cooling system has been specified, the cooling system shall be modeled as an air-cooled single-zone system, one unit per thermal zone. The system characteristics shall be identical in both the standard reference design and proposed design.

d. If an economizer is required in accordance with Table C403.5(1) and where no economizer exists or is specified in the proposed design, then a supply-air economizer shall be provided in the standard reference design in accordance with Section C403.5.

e. The SWHF shall be applied as follows:

1. Where potable water from the DWHR unit supplies not less than one shower and not greater than two showers, of which the drain water from the same showers flows through the DWHR unit then SWHF = [1 – (DWHR unit efficiency • 0.36)].
2. Where potable water from the DWHR unit supplies not less than three showers and not greater than four showers, of which the drain water from the same showers flows through the DWHR unit then SWHF = [1 – (DWHR unit efficiency • 0.33)].
3. Where potable water from the DWHR unit supplies not less than five showers and not greater than six showers, of which the drain water from the same showers flows through the DWHR unit, then SWHF = [1 – (DWHR unit efficiency • 0.26)].
4. Where Items 1 through 3 are not met, SWHF = 1.0.

TABLE C407.5.1(2)
HVAC SYSTEMS MAP

CONDENSER COOLING SOURCE[a]	HEATING SYSTEM CLASSIFICATION[b]	STANDARD REFERENCE DESIGN HVC SYSTEM TYPE[c]		
		Single-zone Residential System	Single-zone Nonresidential System	All Other
Water/ground	Electric resistance	System 5	System 5	System 1
	Heat pump	System 6	System 6	System 6
	Fossil fuel	System 7	System 7	System 2
Air/none	Electric resistance	System 8	System 9	System 3
	Heat pump	System 8	System 9	System 3
	Fossil fuel	System 10	System 11	System 4

a. Select “water/ground” where the proposed design system condenser is water or evaporatively cooled; select “air/none” where the condenser is air cooled. Closed-circuit dry coolers shall be considered to be air cooled. Systems utilizing district cooling shall be treated as if the condenser water type were “water.” Where mechanical cooling is not specified or the mechanical cooling system in the proposed design does not require heat rejection, the system shall be treated as if the condenser water type were “Air.” For proposed designs with ground-source or groundwater-source heat pumps, the standard reference design HVAC system shall be water-source heat pump (System 6).

b. Select the path that corresponds to the proposed design heat source: electric resistance, heat pump (including air source and water source), or fuel fired. Systems utilizing district heating (steam or hot water) and systems without heating capability shall be treated as if the heating system type were “fossil fuel.” For systems with mixed fuel heating sources, the system or systems that use the secondary heating source type (the one with the smallest total installed output capacity for the spaces served by the system) shall be modeled identically in the standard reference design and the primary heating source type shall be used to determine standard reference design HVAC system type.

c. Select the standard reference design HVAC system category: The system under “single-zone residential system” shall be selected where the HVAC system in the proposed design is a single-zone system and serves a Group R occupancy. The system under “single-zone nonresidential system” shall be selected where the HVAC system in the proposed design is a single-zone system and serves other than Group R occupancy. The system under “all other” shall be selected for all other cases.

TABLE C407.5.1(3)
SPECIFICATIONS FOR THE STANDARD REFERENCE DESIGN HVAC SYSTEM DESCRIPTIONS

SYSTEM NO.	SYSTEM TYPE	FAN CONTROL	COOLING TYPE	HEATING TYPE
1	Variable air volume with parallel fan-powered boxes[a]	VAV[d]	Chilled water[e]	Electric resistance
2	Variable air volume with reheat[b]	VAV[d]	Chilled water[e]	Hot water fossil fuel boiler[f]
3	Packaged variable air volume with parallel fan-powered boxes[a]	VAV[d]	Direct expansion[c]	Electric resistance
4	Packaged variable air volume with reheat[b]	VAV[d]	Direct expansion[c]	Hot water fossil fuel boiler[f]
5	Two-pipe fan coil	Constant volume[i]	Chilled water[e]	Electric resistance
6	Water-source heat pump	Constant volume[i]	Direct expansion[c]	Electric heat pump and boiler[g]
7	Four-pipe fan coil	Constant volume[i]	Chilled water[e]	Hot water fossil fuel boiler[f]
8	Packaged terminal heat pump	Constant volume[i]	Direct expansion[c]	Electric heat pump[h]
9	Packaged rooftop heat pump	Constant volume[i]	Direct expansion[c]	Electric heat pump[h]
10	Packaged terminal air conditioner	Constant volume[i]	Direct expansion	Hot water fossil fuel boiler[f]
11	Packaged rooftop air conditioner	Constant volume[i]	Direct expansion	Fossil fuel furnace

For IP:1 m = 3.28 ft, 1 L/s = 2.13 cfm/ft^2, 1 W = 3,412 Btu/h, °C = [(°F) - 32/1.8].

a. **VAV with parallel boxes:** Fans in parallel VAV fan-powered boxes shall be sized for 50 percent of the peak design flow rate and shall be modeled with 0.35 W/cfm fan power. Minimum volume setpoints for fan-powered boxes shall be equal to the minimum rate for the space required for ventilation consistent with Section C403.6.1, Item 3. Supply air temperature setpoint shall be constant at the design condition.

b. **VAV with reheat:** Minimum volume setpoints for VAV reheat boxes shall be 0.19 L/s (0.4 cfm/ft^2) of floor area. Supply air temperature shall be reset based on zone demand from the design temperature difference to a -12 °C (10 °F) temperature difference under minimum load conditions. Design airflow rates shall be sized for the reset supply air temperature, i.e., a -12 °C (10 °F) temperature difference.

c. **Direct expansion:** The fuel type for the cooling system shall match that of the cooling system in the proposed design.

d. **VAV:** Where the proposed design system has a supply, return or relief fan motor 18.6 kW (25 hp) or larger, the corresponding fan in the VAV system of the standard reference design shall be modeled assuming a variable-speed drive. For smaller fans, a forward-curved centrifugal fan with inlet vanes shall be modeled. Where the proposed design's system has a direct digital control system at the zone level, static pressure setpoint reset based on zone requirements in accordance with Section C403.8.5 shall be modeled.

e. **Chilled water:** For systems using purchased chilled water, the chillers are not explicitly modeled and chilled water costs shall be based as determined in Sections C407.3 and C407.5.2. Otherwise, the standard reference design's chiller plant shall be modeled with chillers having the number as indicated in Table C407.5.1(4) as a function of standard reference building chiller plant load and type as indicated in Table C407.5.1(5) as a function of individual chiller load. Where chiller fuel source is mixed, the system in the standard reference design shall have chillers with the same fuel types and with capacities having the same proportional capacity as the proposed design's chillers for each fuel type. Chilled water supply temperature shall be modeled at 7 °C (44 °F) design supply temperature and 13 °C (56 °F) return temperature. Piping losses shall not be modeled in either building model. Chilled water supply water temperature shall be reset in accordance with Section C403.9.3. Pump system power for each pumping system shall be the same as the proposed design; where the proposed design has no chilled water pumps, the standard reference design pump power shall be 1.4 Ws/L (22 W/gpm) (equal to a pump operating against a 22.9 m (75 ft) head, 65 percent combined impeller and motor efficiency). The chilled water system shall be modeled as primary-only variable flow with flow maintained at the design rate through each chiller using a bypass. Chilled water pumps shall be modeled as riding the pump curve or with variable-speed drives where required in Section C403.9.3. The heat rejection device shall be an axial fan cooling tower with two-speed fans where required in Section C403.9. Condenser water design supply temperature shall be 29 °C (85 °F) or -12 °C (10 °F) approach to design wet-bulb temperature, whichever is lower, with a design temperature rise of -12 °C (10 °F). The tower shall be controlled to maintain a 21 °C (70 °F) leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. Pump system power for each pumping system shall be the same as the proposed design; where the proposed design has no condenser water pumps, the standard reference design pump power shall be 1.2 s/L (19 W/gpm) (equal to a pump operating against a 18.3 m (60 ft) head, 60 percent combined impeller and motor efficiency). Each chiller shall be modeled with separate condenser water and chilled water pumps interlocked to operate with the associated chiller.

f. **Fossil fuel boiler:** For systems using purchased hot water or steam, the boilers are not explicitly modeled and hot water or steam costs shall be based on actual utility rates. Otherwise, the boiler plant shall use the same fuel as the proposed design and shall be natural draft. The standard reference design boiler plant shall be modeled with a single boiler where the standard reference design plant load is 176 kW (600,000 Btu/h) and less and with two equally sized boilers for plant capacities exceeding 176 kW (600,000 Btu/h). Boilers shall be staged as required by the load. Hot water supply temperature shall be modeled at 82 °C (180 °F) design supply temperature and 54 °C (130 °F) return temperature. Piping losses shall not be modeled in either building model. Hot water supply water temperature shall be reset in accordance with Section C403.9.3. Pump system power for each pumping system shall be the same as the proposed design; where the proposed design has no hot water pumps, the standard reference design pump power shall be 1.2 s/L (19 W/gpm) (equal to a pump operating against a 18.3 m (60 ft) head, 60 percent combined impeller and motor efficiency). The hot water system shall be modeled as primary only with continuous variable flow. Hot water pumps shall be modeled as riding the pump curve or with variable speed drives where required by Section C403.9.3.

g. **Electric heat pump and boiler:** Water-source heat pumps shall be connected to a common heat pump water loop controlled to maintain temperatures between 16 °C (60 °F) and 32 °C (90 °F). Heat rejection from the loop shall be provided by an axial fan closed-circuit evaporative fluid cooler with two-speed fans where required in Section C403.8.5. Heat addition to the loop shall be provided by a boiler that uses the same fuel as the proposed design

and shall be natural draft. Where no boilers exist in the proposed design, the standard reference building boilers shall be fossil fuel. The standard reference design boiler plant shall be modeled with a single boiler where the standard reference design plant load is 176 kW (600,000 Btu/h) or less and with two equally sized boilers for plant capacities exceeding 176 kW (600,000 Btu/h). Boilers shall be staged as required by the load. Piping losses shall not be modeled in either building model. Pump system power shall be the same as the proposed design; where the proposed design has no pumps, the standard reference design pump power shall be 1.4 W·s/L (22 W/gpm), which is equal to a pump operating against a 22.9 m (75 ft) head, with a 65 percent combined impeller and motor efficiency. Loop flow shall be variable with flow shutoff at each heat pump when its compressor cycles off as required by Section C403.9.3. Loop pumps shall be modeled as riding the pump curve or with variable speed drives where required by Section C403.9.3.

h. **Electric heat pump:** Electric air-source heat pumps shall be modeled with electric auxiliary heat. The system shall be controlled with a multistage space thermostat and an outdoor air thermostat wired to energize auxiliary heat only on the last thermostat stage and when outdoor air temperature is less than 4 °C (40 °F).

i. **Constant volume:** Fans shall be controlled in the same manner as in the proposed design; i.e., fan operation whenever the space is occupied or fan operation cycled on calls for heating and cooling. Where the fan is modeled as cycling and the fan energy is included in the energy efficiency rating of the equipment, fan energy shall not be modeled explicitly.

TABLE C407.5.1(4)
NUMBER OF CHILLERS

TOTAL CHILLER PLANT CAPACITY	NUMBER OF CHILLERS
≤ 300 tons	1
> 300 tons, < 600 tons	2, sized equally
≥ 600 tons	2 minimum, with chillers added so that all are sized equally and none is larger than 800 tons

For SI:1 ton = 3517 W.

TABLE C407.5.1(5)
WATER CHILLER TYPES

INDIVIDUAL CHILLER PLANT CAPACITY	ELECTRIC CHILLER TYPE	FOSSIL FUEL CHILLER TYPE
≤ 100 tons	Reciprocating	Single-effect absorption, direct fired
> 100 tons, < 300 tons	Screw	Double-effect absorption, direct fired
≥ 300 tons	Centrifugal	Double-effect absorption, direct fired

For SI:1 ton = 3517 W.

C407.5.2 Thermal blocks. The *standard reference design* and *proposed design* shall be analyzed using identical thermal blocks as specified in Section C407.5.2.1, C407.5.2.2 or C407.5.2.3.

C407.5.2.1 HVAC zones designed. Where HVAC *zones* are defined on HVAC design drawings, each HVAC *zone* shall be modeled as a separate thermal block.

Exception: Different HVAC *zones* shall be allowed to be combined to create a single thermal block or identical thermal blocks to which multipliers are applied, provided that:

1. The space use classification is the same throughout the thermal block.
2. All HVAC *zones* in the thermal block that are adjacent to glazed exterior walls face the same orientation or their orientations are within 45 degrees (0.79 rad) of each other.
3. All of the *zones* are served by the same HVAC system or by the same kind of HVAC system.

C407.5.2.2 HVAC zones not designed. Where HVAC zones have not yet been designed, thermal blocks shall be defined based on similar internal load densities, occupancy, lighting, thermal and temperature schedules, and in combination with the following guidelines:

1. Separate thermal blocks shall be assumed for interior and perimeter spaces. Interior spaces shall be those located more than 4.6 m from an exterior wall. Perimeter spaces shall be those located closer than 4.6 m from an *exterior wall*.

2. Separate thermal blocks shall be assumed for spaces adjacent to glazed exterior walls: a separate zone shall be provided for each orientation, except orientations that differ by not more than 45 degrees (0.79 rad) shall be permitted to be considered to be the same orientation. Each *zone* shall include floor area that is 4.6 m or less from a glazed perimeter wall, except that floor area within 4.6 m of glazed perimeter walls having more than one orientation shall be divided proportionately between *zones*.
3. Separate thermal blocks shall be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from *zones* that do not share these features.
4. Separate thermal blocks shall be assumed for spaces having exterior ceiling or roof assemblies from *zones* that do not share these features.

C407.5.2.3 *Group R*-2 occupancy buildings. *Group R*-2 occupancy spaces shall be modeled using one thermal block per space except that those facing the same orientations are permitted to be combined into one thermal block. Corner units and units with roof or floor loads shall only be combined with units sharing these features.

C407.5.2.4 Enthalpy Recovery Ventilation systems (ERVs). An annual energy cost reduction may be claimed in the whole building performance method calculations for Enthalpy Recovery Ventilation systems used in the proposed building. This annual energy cost reduction is applicable for buildings in which every HVAC system has a design supply airflow of less than 2.36 m^3/s (5,000 cfm). The annual energy cost reduction shall also be applicable to buildings where one or more HVAC systems in the building have a design supply flow equal to 2.36 m^3/s (5,000 cfm) or greater but shall have minimum outdoor air supply less than 70 percent of the design supply airflow for that HVAC system. The annual energy cost shall be reduced by 6 percent of total HVAC annual energy use

C407.6 Calculation software tools. Calculation procedures used to comply with this section shall be software tools capable of calculating the annual energy consumption of all building elements that differ between the *standard reference design* and the *proposed design* and shall include the following capabilities.

1. Building operation for a full calendar year (8,760 hours).
2. Climate data for a full calendar year (8,760 hours) and shall reflect *approved* coincident hourly data for temperature, solar radiation, humidity and wind speed for the building location.
3. Ten or more thermal zones.
4. Thermal mass effects.
5. Hourly variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads.
6. Part-load performance curves for mechanical equipment.
7. Capacity and efficiency correction curves for mechanical heating and cooling equipment.
8. Printed *code official* inspection checklist listing each of the *proposed design* component characteristics from Table C407.5.1(1) determined by the analysis to provide compliance, along with their respective performance ratings including, but not limited to, *R*-value, *U*-factor, SHGC, HSPF, AFUE, SEER, EF.

C407.6.1 Specific approval. Performance analysis tools complying with the applicable subsections of Section C407 and tested according to ASHRAE Standard 140 shall be permitted to be *approved.* Tools are permitted to be *approved* based on meeting a specified threshold for a jurisdiction. The *code official* shall be permitted to approve tools for a specified application or limited scope.

C407.6.2 Input values. Where calculations require input values not specified by Sections C402, C403, C404 and C405, those input values shall be taken from an *approved* source.

C407.6.3 Exceptional calculation methods. Where the simulation program does not model a design, material or device of the *proposed design*, an exceptional calculation method shall be used where approved by the *code official.* Where there are multiple designs, materials or devices that the simulation program does not model, each shall be calculated separately and exceptional savings determined for each. The total exceptional savings shall not constitute more than half of the difference between the baseline building performance and the proposed building performance. Applications for approval of an exceptional method shall include all of the following:

1. Step-by-step documentation of the exceptional calculation method performed, detailed enough to reproduce the results.

2. Copies of all spreadsheets used to perform the calculations.
3. A sensitivity analysis of energy consumption where each of the input parameters is varied from half to double the value assumed.
4. The calculations shall be performed on a time step basis consistent with the simulation program used.
5. The performance rating calculated with and without the exceptional calculation method.

SECTION C408
MAINTENANCE INFORMATION AND SYSTEM COMMISSIONING

C408.1 General. This section covers the provision of maintenance information and the commissioning of, and the functional testing requirements for, building systems.

C408.1.1 Building operations and maintenance information. The building operations and maintenance docu-ments shall be provided to the owner and shall consist of manufacturers' information, specifications and recom-mendations; 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.

C408.2 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* upon request in accordance with Sections C408.2.4 and C408.2.5.

Exception: The following systems are exempt:

1. Mechanical systems and service water heater systems in buildings where the total mechanical equipment capacity is less than 141 kW (480,000 Btu/h) cooling capacity and 176 kW (600,000 Btu/h) combined service water-heating and space-heating capacity.
2. Systems included in Section C403.5 that serve individual *dwelling units* and *sleeping units*.

C408.2.1 Commissioning plan. A *commissioning plan* shall be developed by a *registered design professiona*l 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.

C408.2.2 Air distribution system testing, adjusting and balancing. Construction documents shall require that a written balance report be provided to the owner or the designated representative of the building owner for HVAC systems serving zones with a total conditioned area exceeding 465 m^2 (5000 ft^2). Air distribution systems shall be tested, adjusted and balanced by a licensed engineer or an individual who holds a current certification from a recognized testing and balancing agency organization in accordance with generally accepted engineering standards.

Exceptions:

1. Buildings with cooling or heating system capacities of 53 kW (15 tons) or less per system may be tested and balanced by a mechanical contractor licensed to design and install such system(s).

2. Buildings with cooling or heating system capacities of 19 kW (65,000 Btu/h) or less per system are exempt from the requirements of this section.

C408.2.2.1 Air systems balancing. Air system balancing shall be accomplished in a manner to first minimize throttling losses; then for fans with fan system power greater than 0.75 kW (1 hp), fan speeds shall be adjusted to meet design flow conditions. Balancing procedures shall be in accordance with the National Environmental Balancing Bureau (NEBB) Procedural Standards, the Associated Air Balance Council (AABC) National Standards, or equivalent procedures.

Exception: Damper throttling may be used for air system balancing with fan motors of 0.75 kW (1 hp) or less, or if throttling results in no greater than 0.25 kW ($^1/_3$ hp) fan horsepower draw above that required if the fan speed were adjusted.

Notes:

1. Building envelope pressurization should be either neutral or positive to prevent infiltration of excess latent load.
2. Commercial kitchen hood exhaust L/s (cfm) shall be sized to prevent depressurization.
3. Discharge dampers are prohibited on constant volume fans and variable volume fans with motors 7.5 kW (10 hp) and larger.

C408.2.2.2 Hydronic systems balancing. Individual hydronic heating and cooling coils shall be equipped with means for balancing and measuring flow. Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses, then the pump impeller shall be trimmed or 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.

Exception: The following equipment is not required to be equipped with a means for balancing or measuring flow:

1. Pumps with pump motors of 3.7 kW (5 hp) or less.
2. Where throttling results in no greater than 5 percent of the nameplate horsepower draw above that required if the impeller were trimmed.

C408.2.3 Functional performance testing. Functional performance testing specified in Sections C408.2.3.1 through C408.2.3.3 shall be conducted.

C408.2.3.1 Equipment. Equipment functional performance testing shall demonstrate the installation and operation of components, systems, and system-to-system interfacing relationships in accordance with approved plans and specifications such that operation, function, and maintenance serviceability for each of the commissioned systems is confirmed. Testing shall include all modes and *sequence of operation*, including under full-load, part-load and the following emergency conditions:

1. All modes as described in the *sequence* of *operation*.
2. Redundant or *automatic* back-up mode.
3. Performance of alarms.
4. Mode of operation upon a loss of power and restoration of power.

Exception: Unitary or packaged HVAC equipment listed in Tables C403.3.2(1) through C403.3.2(3) that do not require supply air economizers.

C408.2.3.2 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.

C408.2.3.3 Economizers. Air economizers shall undergo a functional test to determine that they operate in accordance with manufacturer's specifications.

C408.2.4 Preliminary commissioning report. A preliminary report of *commissioning* test procedures and results shall be completed and certified by the r*egistered 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 C408.2.4, 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.

C408.2.4.1 Acceptance of report. Buildings, or portions thereof, shall not be considered as acceptable for a final inspection pursuant to Section C105.2.6 until the *code official* has received the Preliminary Commissioning Report from the building owner or owner's authorized agent.

C408.2.4.2 Copy of report. The *code official* shall be permitted to require that a copy of the Preliminary Commissioning Report be made available for review by the *code official*.

C408.2.5 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*.

C408.2.5.1 System balancing report. A written report describing the activities and measurements completed in accordance with Section C408.2.2.

C408.2.5.2 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.

C408.3 Functional testing of lighting controls. Automatic lighting controls required by this code shall comply with this section.

C408.3.1 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 C408.3.1.1 through C408.3.1.3 for the applicable control type.

C408.3.1.1 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.

C408.3.1.2 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.*

C408.3.1.3 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.

C408.3.2 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*.

C408.3.2.1 Drawings. Construction documents shall include the location and catalogue number of each piece of equipment.

C408.3.2.2 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.

C408.3.2.3 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.

FIGURE C408.2.4
COMMISSIONING COMPLIANCE CHECKLIST

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_____

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. *Alterations, repairs, additions* and changes of occupancy to, or relocation of, existing *buildings* and structures shall comply with the provisions for *alterations, repairs, additions* and changes of occupancy or relocation, respectively, in this code and in the *International Building Code, International Existing Building Code, International Fire Code, International Fuel Gas Code, International Mechanical Code, International Plumbing Code, International Property Maintenance Code, International Private Sewage Disposal Code*, NFPA 70 and standards approved by the Authority having Jurisdiction.

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 report has been submitted to the *code official* and signed by 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*.

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 C402.4.1 shall comply with Section C402.1.5, C402.4.3 or C407. *Additions* with *vertical fenestration* that result in a total building *fenestration* area greater than Section C402.4.1 or *additions* that exceed the fenestration area greater than Section C402.4.1 shall comply with Section C402.4.1.1 for the *addition* only. *Additions* that result in a

total building vertical fenestration area exceeding that specified in Section C402.4.1.1 shall comply with Section C402.1.5 or C407.

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 C402.4.1 shall comply with Section C402.1.5 or C407. *Additions* with *skylight* area that result in a total building *skylight* area greater than C402.4.1 or additions that exceed the *skylight* area shall comply with Section C402.4.1.2 for the *addition* only. *Additions* that result in a total building *skylight* area exceeding that specified in Section C402.4.1.2 shall comply with Section C402.1.5 or C407.

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. *Roof recover*.
6. *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 non-conditioned or low-energy-intensity space that is altered to become conditioned space shall be required to be brought into full compliance with this code.

C503.3 Building envelope. New building envelope assemblies that are part of the *alteration* shall comply with Sections C402.1 through C402.5.

Exception: Where the existing building exceeds the fenestration area limitations of Section C402.4.1 prior to alteration, the building is exempt from Section C402.4.1 provided that there is not an increase in fenestration area.

C503.3.1 Roof replacement. *Roof replacements* shall comply with Section C402.1.3, C402.1.4, C402.1.5 or C407 where the existing roof assembly is part of the *building thermal envelope*.

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 C402.4.1 shall comply with Section C402.1.5, C402.4.3 or C407. The addition of *vertical fenestration* that results in a total building *fenestration* area greater than Section C402.4.1 shall comply with Section C402.4.1.1 for the space adjacent to the new fenestration only. *Alterations* that result in a total building *vertical fenestration* area exceeding that specified in Section C402.4.1.1 shall comply with Section C402.1.5 or C407. Provided that the vertical fenestration area is not changed, using the same vertical fenestration area in the *standard reference design* as the building prior to alteration shall be an alternative to using the vertical fenestration area specified in Table C407.5.1(1).

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 C402.1.5, C402.4 or C407. The addition of *skylight* area that results in a total building skylight area greater than Section C402.4.1 shall comply with Section C402.4.1.2 for the space adjacent to the new skylights. *Alterations* that result in a total building skylight area exceeding that specified in Section C402.4.1.2 shall comply with Section C402.1.5 or C407. Provided that the skylight area is not changed, using the same skylight area in the *standard reference design* as the building prior to alteration shall be an alternative to using the skylight area specified in Table C407.5.1(1).

C503.4 Heating and cooling systems. New heating, cooling and duct systems that are part of the *alteration* shall comply with Sections 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 C402.4.1, the space is exempt from Section C402.4.1 provided that there is not an increase in fenestration area.

Exceptions:

1. Where the component performance alternative in Section C402.1.5 is used to comply with this section, the proposed UA shall be not greater than 110 percent of the target UA.
2. Where the total building performance option in Section C407 is used to comply with this section, the annual energy cost of the proposed design shall be not greater than 110 percent of the annual energy cost otherwise permitted by Section C407.3.

CHAPTER 6 [CE]

REFERENCED STANDARDS

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

AAMA/WDMA/CSA 101/I.S.2/A 440—17

North American Fenestration Standard/Specifications for Windows, Doors and Unit Skylights
Table C402.5.2

AHAM

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

ANSI/AHAM RAC-1—2008

Room Air Conditioners
Table C403.3.2(3)

AHAM HRF-1—2016

Energy, Performance and Capacity of Household Refrigerators, Refrigerator-Freezers and Freezers
Table C403.10.1

AHRI

Air-Conditioning, Heating, & Refrigeration Institute
2111 Wilson Blvd, Suite 500
Arlington, VA 22201

ISO/AHRI/ASHRAE 13256-1 (1998 RA2014)

Water-to-Air and Brine-to-Air Heat Pumps—Testing and Rating for Performance
Table C403.3.2(2)

ISO/AHRI/ASHRAE 13256-2 (1998 RA2014)

Water-to-Water and Brine-to-Water Heat Pumps —Testing and Rating for Performance
Table C403.3.2(2)

210/240—2016

Performance Rating of Unitary Air-conditioning and Air-source Heat Pump Equipment
Table C403.3.2(1), Table C403.3.2(2)

310/380—2014 (CSA-C744-04)

Standard for Packaged Terminal Air Conditioners and Heat Pumps
Table C403.3.2(3)

340/360—2015

Performance Rating of Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment
Table C403.3.2(1), Table C403.3.2(2)

365(I-P)—2009

Commercial and Industrial Unitary Air-conditioning Condensing Units
Table C403.3.2(1), Table C403.3.2(6)

390 (I-P)—2015

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)

AHRI—continued

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)

AMCA

Air Movement and Control Association International
30 West University Drive
Arlington Heights, IL 60004-1806

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

American National Standards Institute
25 West 43rd Street, 4th Floor
New York, NY 10036

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

The Association of Pool & Spa Professionals
2111 Eisenhower Avenue, Suite 580
Alexandria, VA 22314

14—2014

American National Standard for Portable Electric Spa Energy Efficiency
C404.8

ASHRAE

ASHRAE
1791 Tullie Circle NE
Atlanta, GA 30329

ASHRAE 127—2007

Method of Testing for Rating Computer
Table C403.3.2(9)

ANSI/ASHRAE/ACCA Standard 183—2007 (RA2014)

Peak Cooling and Heating Load Calculations in Buildings, Except Low-rise Residential Buildings
C403.1.1

ASHRAE—2016

ASHRAE HVAC Systems and Equipment Handbook
C403.1.1

ISO/AHRI/ASHRAE
13256-1 (1998 RA2014)

Water-to-Air and Brine-to-Air Heat Pumps—Testing and Rating for Performance
Table C403.3.2(2)

ASHRAE—continued

ISO/AHRI/ASHRAE 13256-2 (1998 RA2014)

Water-to-Water and Brine-to-Water Heat Pumps—Testing and Rating for Performance
Table C403.3.2(2)

55—2013

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

ASME

American Society of Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990

ASME A17.1—2016/CSA B44—16

Safety Code for Elevators and Escalators
C405.8.2

ASTM

ASTM International
100 Barr Harbor Drive, P.O. Box C700
West Conshohocken, PA 19428-2959

C90—14

Specification for Load-bearing Concrete Masonry Units
Table C401.3

C1363—11

Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus
C303.1.4.1, Table C402.1.4, 402.2.7

C1371—15

Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers
Table C402.3

C1549—09(2014)

Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer
Table C402.3

D1003—13

Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics
C402.4.2.2

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
Table C402.3

E779—10

Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
C402.5

E903—12

Standard Test Method Solar Absorptance, Reflectance and Transmittance of Materials Using Integrating Spheres (Withdrawn 2005)
Table C402.3

E1677—11

Specification for Air Barrier (AB) Material or Systems for Low-rise Framed Building Walls
C402.5.1.2.2

E1827—11

Standard Test Methods for Determining Airtightness of Building Using an Orifice Blower Door
C402.5, C406.9, C606.4

E1918—06(2015)

Standard Test Method for Measuring Solar Reflectance of Horizontal or Low-sloped Surfaces in the Field
Table C402.3

E1980—11

Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-sloped Opaque Surfaces
Table C402.3, C402.3.2

E2178—13

Standard Test Method for Air Permanence of Building Materials
C402.5.1.2.1

ASTM—continued

E2357—11

Standard Test Method for Determining Air Leakage of Air Barriers Assemblies
C402.5.1.2.2

CRRC

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

ANSI/CRRC-S100—2016

Standard Test Methods for Determining Radiative Properties of Materials
Table C402.3, C402.3.1

CSA

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

AAMA/WDMA/CSA 101/I.S.2/A440—17

North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights
Table C402.5.2

CSA B55.1—2015

Test Method for Measuring Efficiency and Pressure Loss of Drain Water Heat Recovery Units

C404.8

CSA B55.2—2015

Drain Water Heat Recovery Units
C404.8

CTI

Cooling Technology Institute
P. O. Box 681807
Houston, TX 77268

ATC 105 (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)

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)

DASMA

Door & Access Systems Manufacturers Association, International
1300 Sumner Avenue
Cleveland, OH 44115-2851

105—2016

Test Method for Thermal Transmittance and Air Infiltration of Garage Doors and Rolling Doors
C303.1.3, Table C402.5.2

DOE

U.S. Department of Energy
c/o Superintendent of Documents
1000 Independence Avenue SW
Washington, DC 20585

10 CFR, Part 430—2015

Energy Conservation Program for Consumer Products: Test Procedures and Certification and Enforcement Requirement for Plumbing Products; and Certification and Enforcement Requirements for Residential Appliances; Final Rule
Table C403.3.2(4), Table C403.3.2(5), Table C404.2

DOE—continued

10 CFR, Part 430, Subpart B, Appendix N—(2015)

Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers
C202

10 CFR, Part 431—2015

Energy Efficiency Program for Certain Commercial and Industrial Equipment: Test Procedures and Efficiency Standards; Final Rules
Table C403.3.2(5), C405.6, Table C405.6, C405.7

10 CFR 431 Subpart B App B

Uniform Test Method for Measuring Nominal Full Load Efficiency of Electric Motors
C403.8.4, Table C405.7(1), Table C405.7(2), Table C405.7(3), C405.7(4)

NAECA 87—(88)

National Appliance Energy Conservation Act 1987 [Public Law 100-12 (with Amendments of 1988-P.L. 100-357)]
Table C403.3.2(1), Table C403.3.2(2), Table C403.3.2(4)

ICC

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

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

IMC—18

International Mechanical Code®
C403.7.7, C403.2.2, C403.7.1, C403.7.2, C403.7.4, C403.7.5, C403.11.1, C403.11.2.1, C403.11.2.2, C403.6, C403.6.6, C406.6, 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

IEEE 515.1—2012

IEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Commercial Applications

C404.6.2

IES

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

ANSI/ASHRAE/IESNA
90.1—2016

Energy Standard for Buildings, Except Low-rise Residential Buildings
C401.2, Table C402.1.3, Table C402.1.4, C406.2, C502.1, C503.1, C504.1

ISO

International Organization for Standardization
Chemin de Blandonnet 8, CP 401, 1214 Vernier
Geneva, Switzerland

ISO/AHRI/ASHRAE 13256-1(1998 RA2014)

Water-to-Air and Brine-to-Air Heat Pumps -Testing and Rating for Performance
Table C403.3.2(2)

ISO/AHRI/ASHRAE 13256-2(1998 RA2014)

Water-to-Water and Brine-to-Water Heat Pumps -Testing and Rating for Performance
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

National Fenestration Rating Council, Inc.
6305 Ivy Lane, Suite 140
Greenbelt, MD 20770

100—2017

Procedure for Determining Fenestration Products *U-factors*
C303.1.3, C402.2.1.1

200—2017

Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence
C303.1.3, C402.4.1.1

400—2017

Procedure for Determining Fenestration Product Air Leakage
Table C402.5.2

SMACNA

Sheet Metal and Air Conditioning Contractors' National Association, Inc.
4021 Lafayette Center Drive
Chantilly, VA 20151-1219

SMACNA—2012

HVAC Air Duct Leakage Test Manual Second Edition
C403.2.11.2.3

UL

UL LLC
333 Pfingsten Road
Northbrook, IL 60062-2096

710—12

Exhaust Hoods for Commercial Cooking Equipment—with Revisions through November 2013
C403.7.5

727—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
Table C403.3.2(4)

1784—01

Air Leakage Tests of Door Assemblies—with Revisions through February 2015
C402.5.3

US-FTC

United States-Federal Trade Commission
600 Pennsylvania Avenue NW
Washington, DC 20580

CFR Title 16 (2015)

***R*-value Rule**
C303.1.4

WDMA

Window and Door Manufacturers Association
2025 M Street NW, Suite 800
Washington, DC 20036-3309

AAMA/WDMA/CSA 101/I.S.2/A440—17

North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights
Table C402.5.2

APPENDIX CA

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.

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.
5. Section of building's roof designated for use of fire escape/s

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 subzone shall be not less than 1524 mm (5 feet) 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 24.41 kg/m^2 (5 psf) 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.

IECC—RESIDENTIAL PROVISIONS

TABLE OF CONTENTS

CHAPTER 1 [RE]

SCOPE AND ADMINISTRATION

User note:

About this chapter: *Chapter 1 establishes the limits of applicability of this code and describes how the code is to be applied and enforced. Chapter 1 is in two parts: Part 1—Scope and Application (Sections 101–102) and Part 2—Administration and Enforcement (Sections 103–109). Section 101 identifies which buildings and structures come under its purview and references other I-Codes as applicable. Standards and codes are scoped to the extent referenced (see Section 107.1).*

This code is intended to be adopted as a legally enforceable document, and it cannot be effective without adequate provisions for its administration and enforcement. The provisions of Chapter 1 establish the authority and duties of the code official appointed by the authority having jurisdiction and also establish the rights and privileges of the design professional, contractor and property owner.

PART 1—SCOPE AND APPLICATION

SECTION R101
SCOPE AND GENERAL REQUIREMENTS

R101.1 Title. This code shall be known as the 2023 *Jamaica Energy Conservation Building Code* and shall be cited as such. It is referred to herein as "this code."

R101.2 Scope. This code applies to *residential buildings* and the *building* sites and associated systems and equipment.

R101.3 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.

R101.4 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.

R101.4.1 Mixed residential and commercial buildings. Where a *building* includes both *residential* building and *commercial building* portions, each portion shall be separately considered and meet the applicable provisions of the IECC—Commercial Provisions or IECC—Residential Provisions.

R101.5 Compliance. *Residential buildings* shall meet the provisions of IECC—Residential Provisions. *Commercial buildings* shall meet the provisions of IECC—Commercial Provisions.

R101.5.1 Compliance materials. The *code official* shall be permitted to approve specific computer software, worksheets, compliance manuals and other similar materials that meet the intent of this code.

SECTION R102
ALTERNATIVE MATERIALS, DESIGN AND METHODS OF CONSTRUCTION AND EQUIPMENT

R102.1 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. The *code official* shall have the authority to approve an alternative material, design or method of construction upon application of the owner or the owner's authorized agent. The code official shall first find that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code for strength, effectiveness, fire resistance, durability and safety. Where the alternative material, design or method of construction is not *approved*, the *code official* shall respond to the applicant, in writing, stating the reasons why the alternative was not *approved*.

R102.1.1 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 R103
CONSTRUCTION DOCUMENTS

R103.1 General. Construction documents, technical reports and other supporting data shall be submitted in one or more sets with each application for a permit. The construction documents and technical reports shall be prepared by a registered design professional as prescribed by the local jurisdiction or national regulatory authority.

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

R103.2 Information on construction documents. Construction documents shall be drawn to scale on suitable material. Electronic media documents are permitted to be submitted where *approved* by the *code official*. 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 the following as applicable:

1. Insulation materials and their *R*-values.
2. Fenestration *U*-factors and *solar heat gain coefficients* (SHGC).
3. Area-weighted *U*-factor and *solar heat gain coefficients* (SHGC) calculations.
4. Mechanical system design criteria.
5. Mechanical and service water-heating systems and equipment types, sizes and efficiencies.
6. Equipment and system controls.
7. Duct sealing, duct and pipe insulation and location.
8. Air sealing details.

R103.2.1 Building thermal envelope depiction. The *building thermal envelope* shall be represented on the construction documents.

R103.3 Examination of documents. The *code official* 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* 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.

R103.3.1 Approval of construction documents. When the *code official* 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*. 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 a duly authorized representative.

R103.3.2 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.

R103.3.3 Phased approval. The *code official* 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 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.

R103.4 Amended construction documents. Work shall be installed in accordance with the *approved* construction documents, and any changes made during construction that are not in compliance with the *approved* construction documents shall be re-submitted for approval as an amended set of construction documents.

R103.5 Retention of construction documents. One set of *approved* construction documents shall be retained by the *code official* 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.

SECTION R104
FEES

R104.1 Fees. A permit shall not be issued until the fees prescribed in Section R104.2 have been paid, nor shall an amendment to a permit be released until the additional fee, if any, has been paid.

R104.2 Schedule of permit fees. A fee for each permit shall be paid as required, in accordance with the schedule as established by the applicable governing authority.

R104.3 Work commencing before permit issuance. Any person who commences any work before obtaining the necessary permits shall be subject to an additional fee established by the *code official* that shall be in addition to the required permit fees.

R104.4 Related fees. The payment of the fee for the construction, *alteration*, removal or demolition of work done in connection to or concurrently with the work or activity authorized by a permit shall not relieve the applicant or holder of the permit from the payment of other fees that are prescribed by law.

R104.5 Refunds. The *code official* is authorized to establish a refund policy.

SECTION R105
INSPECTIONS

R105.1 General. Construction or work for which a permit is required shall be subject to inspection by the *code official* or his or her designated agent, and such construction or work shall remain visible and able to be accessed for inspection purposes until *approved*. 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* 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.

R105.2 Required inspections. The *code official* or his or her designated agent, upon notification, shall make the inspections set forth in Sections R105.2.1 through R105.2.5.

R105.2.1 Footing and foundation inspection. Inspections associated with footings and foundations shall verify compliance with the code as to *R-value*, location, thickness, depth of burial and protection of insulation as required by the code and *approved* plans and specifications.

R105.2.2 Framing and rough-in inspection. Inspections at framing and rough-in shall be made before application of interior finish and shall verify compliance with the code as to: types of insulation and corresponding *R-values* and their correct location and proper installation; fenestration properties such as *U*-factor and SHGC and proper installation; and air leakage controls as required by the code; and approved plans and specifications.

R105.2.3 Plumbing rough-in inspection. Inspections at plumbing rough-in shall verify compliance as required by the code and *approved* plans and specifications as to types of insulation and corresponding *R*-values and protection, and required controls.

R105.2.4 Mechanical rough-in inspection. Inspections at mechanical rough-in shall verify compliance as required by the code and *approved* plans and specifications as to installed HVAC equipment type and size, required controls, system insulation and corresponding *R*-value, system air leakage control, programmable thermostats, dampers, whole-house ventilation, and minimum fan efficiency.

Exception: Systems serving multiple dwelling units shall be inspected in accordance with Section C105.2.4.

R105.2.5 Final inspection. The *building* shall have a final inspection and shall not be occupied until *approved*. The final inspection shall include verification of the installation of all required *building* systems, equipment and controls and their proper operation and the required number of high-efficacy lamps and fixtures.

R105.3 Reinspection. A *building* shall be reinspected where determined necessary by the *code official*.

R105.4 Approved inspection agencies. The *code official* 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.

R105.5 Inspection requests. It shall be the duty of the holder of the permit or their duly authorized agent to notify the *code official* 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.

R105.6 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* for inspection and testing.

R105.7 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*.

R105.7.1 Revocation. The *code official* is authorized to, in writing, suspend or revoke 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 R106
VALIDITY

R106.1 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 R107
REFERENCED STANDARDS

R107.1 Referenced codes and standards. The codes and standards referenced in this code shall be those indicated in Chapter 5, 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 R107.1.1 and R107.1.2.

R107.1.1 Conflicts. Where conflicts occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.

R107.1.2 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.

R107.2 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.

R107.3 Other laws. The provisions of this code shall not be deemed to nullify any provisions of local, state or national law. If local codes or requirements exceed the requirements set forth in this code, the most current provisions shall apply.

SECTION R108
STOP WORK ORDER

R108.1 Authority. Where the *code official* finds any work regulated by this code being performed in a manner either contrary to the provisions of this code or dangerous or unsafe, the *code official* is authorized to issue a stop work order.

R108.2 Issuance. The stop work order shall be in writing and shall be given to the owner of the property involved, to the owner's authorized agent, or to the person doing the work. Upon issuance of a stop work order, the cited work shall immediately cease. The stop work order shall state the reason for the order and the conditions under which the cited work will be permitted to resume.

R108.3 Emergencies. Where an emergency exists, the *code official* shall not be required to give a written notice prior to stopping the work.

R108.4 Failure to comply. Any person who shall continue any work after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be subject to a fine as set by the applicable governing authority.

SECTION R109
BOARD OF APPEALS

R109.1 General. In order to hear and decide appeals of orders, decisions or determinations made by the *code official* relative to the application and interpretation of this code, there shall be and is hereby created a board of appeals. The *code official* shall be an ex officio member of said board but shall not have a vote on any matter before the board. The board of appeals shall be appointed by the governing body and shall hold office at its pleasure. The board shall adopt rules of procedure for conducting its business, and shall render all decisions and findings in writing to the appellant with a duplicate copy to the *code official*.

R109.2 Limitations on authority. An application for appeal shall be based on a claim that the true intent of this code or the rules legally adopted thereunder have been incorrectly interpreted, the provisions of this code do not fully apply or an equally good or better form of construction is proposed. The board shall not have authority to waive requirements of this code.

R109.3 Qualifications. The board of appeals shall consist of members who are qualified by experience and training and are not employees of the jurisdiction.

CHAPTER 2 [RE]

DEFINITIONS

User note:

About this chapter: *Codes, by their very nature, are technical documents. Every word, term and punctuation mark can add to or change the meaning of a technical requirement. It is necessary to maintain a consensus on the specific meaning of each term contained in the code. Chapter 2 performs this function by stating clearly what specific terms mean for the purpose of the code.*

SECTION R201
GENERAL

R201.1 Scope. Unless stated otherwise, the following words and terms in this code shall have the meanings indicated in this chapter.

R201.2 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.

R201.3 Terms defined in other codes. 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* shall have the meanings ascribed to them in those codes.

R201.4 Terms not defined. Terms not defined by this chapter shall have ordinarily accepted meanings such as the context implies.

SECTION R202
GENERAL DEFINITIONS

ABOVE-GRADE WALL. A wall more than 50 percent above grade and enclosing *conditioned space*. This includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and *skylight* shafts.

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

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-IMPERMEABLE INSULATION. An insulation that functions as an air barrier material.

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. Acceptable to the *code official*.

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

AUTHORITY HAVING JURISDICTION. An organization, office, or individual responsible for enforcing the requirements of a code or standard, appointing *code officials,* or for approving equipment, materials, an installation, or a procedure.

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").

BASEMENT WALL. A wall 50 percent or more below grade and enclosing *conditioned space*.

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

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

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 fixtures and back to the water-heating equipment.

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.

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

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 that is directly or indirectly heated or cooled. 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.

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 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.

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

ENERGY USE INTENSITY (EUI). An expression of building energy use per year in terms of net energy divided by gross floor.

ERI REFERENCE DESIGN. A version of the *rated design* that meets the minimum requirements of the 2006 *International Energy Conservation Code.*

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

FENESTRATION. Products classified as either *vertical fenestration* or *skylights*.

Skylights. Glass or other transparent or translucent glazing material installed at a slope of less than 60 degrees (1.05 rad) from horizontal.

Vertical fenestration. Windows that are fixed or operable, opaque doors, glazed doors, glazed block and combination opaque/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, 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.

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. 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 the following:

1. 60 lumens per watt for lamps over 40 watts.
2. 50 lumens per watt for lamps over 15 watts to 40 watts.
3. 40 lumens per watt for lamps 15 watts or less.

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.

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.

INSULATED SIDING. A type of continuous insulation with manufacturer-installed insulating material as an integral part of the cladding product having an *R*-value of not less than R-2.

INSULATING SHEATHING. An insulating board with a core material having an *R*-value of not less than R-2.

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 such 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.

LISTED. Equipment, materials, products or services included in a list published by an organization acceptable to the *code official* 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-VOLTAGE LIGHTING. Lighting equipment powered through a transformer such as a cable conductor, a rail conductor and track lighting.

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

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

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

RATED DESIGN. A description of the proposed *building* used to determine the energy rating index.

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*").

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 townhouses as well as *Group R*-2, R-3 and R-4 buildings three stories or less in height above grade plane.

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 and roof deck, and can also include a thermal barrier, an ignition barrier, insulation or a vapor retarder.

ROOF RE-COVER. The process of installing an additional roof covering over a prepared existing roof covering without removing the existing roof covering.

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

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

***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 [$(m^2 \cdot K)/W$].

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

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.

SUNROOM. A one-story structure attached to a dwelling with a glazing area in excess of 40 percent of the gross area of the structure's *exterior walls* and roof.

THERMAL ISOLATION. Physical and space conditioning separation from *conditioned spaces*. The *conditioned spaces* shall be controlled as separate zones for heating and cooling or conditioned by separate equipment.

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

***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) [$W/(m^2 \cdot K)$].

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.

WHOLE HOUSE MECHANICAL VENTILATION SYSTEM. An exhaust system, supply system, or combination thereof that is designed to mechanically exchange indoor air with outdoor air when operating continuously or through a programmed intermittent schedule to satisfy the whole house ventilation rates.

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 [RE]

GENERAL REQUIREMENTS

User note:

About this chapter: *Chapter 3 covers general regulations for energy conservation features of buildings. The climate zone for a building is established by geographic location tables and figures in this chapter.*

SECTION R301
CLIMATE ZONES

R301.1 General. Climate zone 1A shall be used as an acceptable approximation for all locations throughout Jamaica in determining the applicable requirements from Chapters 4 [RE]. This was arrived at by using the climate zone classification for Puerto Rico and Hawaii that are tropical islands with similar latitude to Jamaica. The actual climate zone for a specific location anywhere in Jamaica shall be assigned according to Sub-section R301.3 below.

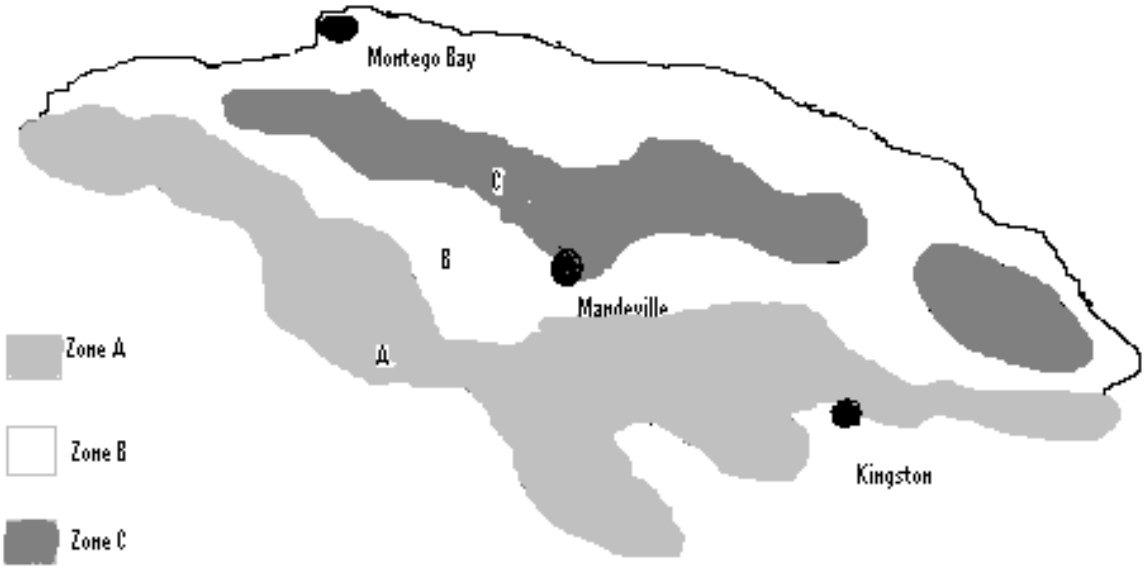
FIGURE R301.1 CLIMATE ZONES. Deleted.

R301.2 Warm humid locations. Warm humid locations are identified in Table R301.1.

R301.3 International climate zones. The climate zone for a specific location within Jamaica shall be determined by applying Table R301.3(1) and then Table R301.3(2). Further details on the micro *climate zones* of Jamaica may be obtained from the Jamaica climate zone map of Figure R301.3 below and Table R302.1.

FIGURE R301.3.

CLIMATE ZONES OF JAMAICA



NOTES

1. The map shown in Figure 301.3 defines the climate zones of Jamaica for which the data in Table 302.2 is provided.

SECTION R302
DESIGN CONDITIONS

R302.1 Interior design conditions. The interior design temperatures used for heating and cooling load calculations shall be a maximum of 22 °C (72 °F) for heating and minimum of 24 °C (75 °F) for cooling.

SECTION R303
MATERIALS, SYSTEMS AND EQUIPMENT

R303.1 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.

R303.1.1 Building thermal envelope insulation. An *R*- value identification mark shall be applied by the manufacturer to each piece of *building thermal envelope* insulation 305 mm (12 in) 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 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 thick- ness of the areas covered and *R*-value of installed thick- ness shall be listed on the certification. For insulated siding, the *R*-value shall be labelled on the product's pack- age 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.

R303.1.1.1 Blown or sprayed roof/ceiling insulation. The thickness of blown-in or sprayed roof/ceiling insulation (fiberglass or cellulose) shall be written in mm (in) on markers that are installed at least one for every 28 m^2 (300 ft^2) 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 25 mm (1 in) 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.

R303.1.2 Insulation mark installation. Insulating materials shall be installed such that the manufacturer's *R*-value mark is readily observable at inspection.

R303.1.3 Fenestration product rating. *U*-factors of fenestration products such as windows, doors and *skylights* shall be determined in accordance with NFRC 100.

Exception: Where required, garage door *U*-factors 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 R303.1.3(1) or R303.1.3(2). The *solar heat gain coefficient* (SHGC) and *visible transmittance* (VT) of glazed fenestration products such as 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 R303.1.3(3).

R303.1.4 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 $m^2 \cdot K/W$ ($h \cdot ft^2 \cdot °F/Btu$) at a mean temperature of 24 °C (75 °F).

R303.1.4.1 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.

R303.2 Installation. Materials, systems and equipment shall be installed in accordance with the manufacturer's instructions and the *International Building Code* or the *International Residential Code*, as applicable.

R303.2.1 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 153 mm (6 in) below grade.

R303.3 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.

TABLE R301.3(1)
UNSTATED CLIMATE ZONE DEFINITIONS

MAJOR CLIMATE-TYPE DEFINITIONS
Marine (C) Definition—Locations meeting all four criteria: Mean temperature of coldest month between -3 °C (27 °F) and 18 °C (65 °F). Warmest month mean < 22 °C (72 °F). At least four months with mean temperatures over 10 °C (50 °F). Dry season in summer. The month with the heaviest precipitation in the cold season has at least three times as much precipitation as the month with the least precipitation in the rest of the year. The cold season is October through March in the Northern Hemisphere and April through September in the Southern Hemisphere.
Dry (B) Definition—Locations meeting the following criteria: 1. Not Marine (C) 2. If 70 percent or more of the precipitation, *P*, occurs during the high sun period, then the dry/humid threshold is: $P_{in} < 0.44 \times (T - 7)$ (I-P) [$P_{mm} < 20.0 \times (T + 14)$ (SI)] 3. If between 30 percent and 70 percent of the precipitation, *P*, occurs during the high sun period, then the dry/humid threshold is: $P_{in} < 0.44 \times (T - 19.5)$ (I-P) [$P_{mm} < 20.0 \times (T + 7)$ (SI)] 4. If 30 percent or less of the precipitation, *P*, occurs during the high sun period, then the dry/humid threshold is: $P_{in} < 0.44 \times (T - 32)$ (I-P) [$P_{mm} < 20 \times T$ (SI)] where: P = annual precipitation, mm (in) T = annual mean temperature, °C (°F) Summer or high sun = April through September in the Northern Hemisphere and October through March period in the Southern Hemisphere Winter or cold season = October through March in the Northern Hemisphere and April through September in the Southern Hemisphere
Humid (A) Definition—Locations that are not marine and not dry.
Warm-humid Definition—Humid (A) locations where either of the following wet-bulb temperature conditions shall occur during the warmest six consecutive months of the year: 1. 19.4 °C (67 °F) or higher for 3000 or more hours. 2. 22.8 °C (73 °F) or higher for 1500 or more hours.

For SI:°C = [(°F) - 32]/1.8, 1 inch = 2.54 cm.

TABLE R301.3(2)
UNSTATED CLIMATE ZONE DEFINITIONS [ASHRAE STANDARD 169—2013]

CLIMATE ZONE	NAME	SI Units	IP Units
0	Tropical[a]	6000 < CDD10 °C	10,800 < CDD50 °F
1	Very Hot	5000 < CDD10 °C ≤ 6000	9000 < CDD50 °F ≤ 10,800
2	Hot	3500 < CDD10 °C ≤ 5000	6300 < CDD50 °F ≤ 9000
3	Warm	CDD10 °C ≤ 3500 AND HDD18 °C ≤ 2000	CDD50 °F ≤ 6300 AND HDD65 °F ≤ 3600

a. ASHRAE Standard 169—2013 uses the term “Extremely hot.”

TABLE R303.1.3(1)
DEFAULT GLAZED FENESTRATION U-FACTORS

FRAME TYPE	SINGLE PANE	DOUBLE PANE	SKYLIGHT	
			Single	Double
Metal	6.81 $W/m^2 \cdot K$	4.54 $W/m^2 \cdot K$	11.36 $W/m^2 \cdot K$	7.38 $W/m^2 \cdot K$
	(1.20 Btu/h • ft^2 • °F)	(0.80 Btu/h • ft^2 • °F)	(2.00 Btu/h • ft^2 • °F)	(1.30 Btu/h • ft^2 • °F)
Metal with Thermal Break	6.25 $W/m^2 \cdot K$	3.69 $W/m^2 \cdot K$	10.79 $W/m^2 \cdot K$	6.25 $W/m^2 \cdot K$
	(1.10 Btu/h • ft^2 • °F)	(0.65 Btu/h • ft^2 • °F)	(1.90 Btu/h • ft^2 • °F)	(1.10 Btu/h • ft^2 • °F)
Nonmetal or Metal Clad	5.39 $W/m^2 \cdot K$	3.12 $W/m^2 \cdot K$	9.94 $W/m^2 \cdot K$	5.96 $W/m^2 \cdot K$
	(0.95 Btu/h • ft^2 • °F)	(0.55 Btu/h • ft^2 • °F)	(1.75 Btu/h • ft^2 • °F)	(1.05 Btu/h • ft^2 • °F)
Glazed Block	3.41 $W/m^2 \cdot K$			
	(0.60 Btu/h • ft^2 • °F)			

TABLE R301.1
CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID DESIGNATIONS BY STATE, COUNTY AND TERRITORY

Key: A – Moist, B – Dry, C – Marine. Absence of moisture designation indicates moisture regime is irrelevant. Asterisk (*) indicates a warm-humid location.

				SI				I-P			
COUNTRY	LOCATION	WMO#	CZ	Elev (m)	CDD10	HDD18	Precip (mm)	Elev (ft)	CDD50	HDD65	Precip (in)
Anguilla (AIA)[a]	WALLBLAKE AIRPORT	–	0A	10[c]	6691	0[c]	617[c]	33[c]	10450[c]	0[c]	24[c]
Antigua and Barbuda (ATG)[b]	V.C. BIRD INTL AIRPORT	788620	0A	10	6249	0	883	33	11248	0	35
Bahamas (BHS)[b]	LYNDEN PINDLING INTL AIRPORT	780730	1A	7	5643	9	1334	23	10157	16	53
	SETTLEMENT POINT	994390	1A	3	5322	19	1281	10	9580	34	50
Barbados (BRB)[b]	GRANTLEY ADAMS INTL AIRPORT	789540	0A	56	6308	0	1155	184	11354	0	45
Belize (BLZ)[b]	BELIZE/PHILLIP GOLDSON INTL AIRPORT	785830	0A	5	6145	0	1944	16	11061	0	77
Bermuda (BMU)[b]	BERMUDA INTL AIRPORT	780160	2A	6	4596	88	1456	20	8273	158	57
British Virgin Islands (VGB)[a]	TERRANCE B. LETTSOME INTL AIRPORT		0A	10[c]	6453	0[c]	841[c]	33[c]	10445[c]	0[c]	33[c]
Cayman Islands (CYM)[a]	OWEN ROBERTS INTL AIRPORT	–	0A	10[c]	6620	0[c]	1037[c]	33[c]	10889[c]	0[c]	41[c]
Dominica (DMA)[a]	DOUGLAS-CHARLES AIRPORT	–	0A	10[c]	6288	0[c]	878[c]	33[c]	10631[c]	0[c]	35[c]
Grenada (GRD)[b]	MAURICE BISHOP INTL AIRPORT	789580	0A	7	6378	0	1197	23	11480	0[c]	47
Guyana (GUY)[b]	CHEDDI JAGAN INTL AIRPORT	810020	0A	29	6136	0	2234	95	11045	0	88
Haiti (HTI)[a]	PORT-AU-PRINCE AEROPORT INTL		0A	10[c]	6848	0[c]	1404[c]	33[c]	10278[c]	0[c]	55[c]
Jamaica (JAM)[b]	KINGSTON NORMAN MANLEY INTL AIRPORT	783970	0A	14	6608	0	730	46	11894	0	29
	MONTEGO BAY/SANGSTE INTL AIRPORT	783880	0A	8	6336	0	1184	26	11405	0	47
Montserrat (MSR)[a]	JOHN A. OSBORNE AIRPORT	–	1A	10[c]	5946	0[c]	702[c]	33[c]	10615[c]	0[c]	28[c]
Saint Lucia (LCA)[b]	HEWANORRA INTL AIRPORT	789480	0A	10	6429	0	1128	33	11572	0	44
St. Kitts and Nevis (KNA)[a]	ROBERT L. BRADSHAW INTL AIRPORT	–	0A	10[c]	6388	0[c]	696[c]	33[c]	10516[c]	0[c]	27[c]
St. Vincent and the Grenadines (VCT)[a]	ARGYLE INTL AIRPORT	–	0A	10[c]	6647	0[c]	582[c]	33[c]	10729[c]	0[c]	23[c]

Suriname (SUR)	JOHAN A. PENGEL INTL AIRPORT at Zanderij	812250	0A	9	6264	0	2249	30	11275	0	89
	Paramaribo [a]	–	–	10[c]	6361	0[c]	2293[c]	33[c]	10688[c]	0[c]	90[c]
Trinidad and Tobago (TTO)[b]	ARTHUR NAPOLEON RAYMOND ROBINSON INTL AIRPORT	789620	0A	6	6307	0	1452	20	11353	0	57
	PIARCO INTL AIRPORT	789700	0A	15	6274	0	1781	49	11293	0	70
Turks and Caicos Islands (TCA)[a]	PROVIDENCIALES INTL AIRPORT	–	0A	10[c]	6439	0[c]	673[c]	33[c]	10331[c]	0[c]	27[c]

a. Calculated CARICOM Member State or Associate.
b. CARICOM Member State or Associate.
c, RETScreen Expert Data

TABLE R303.1.3(2)
DEFAULT DOOR *U*-FACTORS

DOOR TYPE	*U*-FACTOR
Uninsulated Metal	6.81 $W/m^2 \cdot K$
Insulated Metal	3.41 $W/m^2 \cdot K$
Wood	2.84 $W/m^2 \cdot K$
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	1.99 $W/m^2 \cdot K$

TABLE R303.1.3(3)
DEFAULT GLAZED FENESTRATION SHGC AND VT

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

CHAPTER 4 [RE]

RESIDENTIAL ENERGY EFFICIENCY

User note:

About this chapter: *Chapter 4 provides requirements for the thermal envelope of a building, including minimum insulation values for walls, ceiling and floors; maximum fenestration U-factors; minimum fenestration solar heat gain coefficients; and methods for determining building assembly and a total building U-factor. A performance alternative and an energy rating alternative are also provided to allow for energy code compliance other than by the prescriptive method.*

SECTION R401
GENERAL

R401.1 Scope. This chapter applies to *residential buildings*.

R401.2 Compliance. Projects shall comply with one of the following:

1. Sections R401 through R404.
2. Section R405 and the provisions of Sections R401 through R404 labelled "Mandatory."
3. An energy rating index (ERI) approach in Section R406.
4. The Tropical zone requirements in Section R401.2.1.

R401.2.1 Tropical zone. Residential buildings in the tropical zone at elevations below 7315 meters (2400 ft) above sea level shall be deemed to comply with this chapter where the following conditions are met:

1. Not more than one-half of the occupied space is air conditioned.
2. The occupied space is not heated.
3. Solar, wind or other renewable energy source supplies not less than 90 percent of the energy for service water heating.
4. Glazing in dwelling units shall have a maximum solar heat gain coefficient (SHGC) as specified in Table R401.2.1.
5. Permanently installed lighting is in accordance with Section R404.
6. The roof/ceiling complies with one of the following options:
   a. Comply with one of the roof surface options in Table C402.3 and install R-2.3 (m^2 • K)/W (R-13 h • ft^2/Btu) insulation or greater.
   b. Install R-3.3 (m^2 • K)/W (R-19 h • ft^2/Btu) insulation or greater.

   If present, attics above the insulation are vented and attics below the insulation are unvented.

   Exception: The roof/ceiling assembly is permitted to comply with Section R407.
7. Roof surfaces have a minimum slope of 21-percent slope. The finished roof does not have water accumulation areas.
8. Operable fenestration provides ventilation area equal to not less than 14 percent of the floor area in each room. Alternatively, equivalent ventilation is provided by a ventilation fan.
9. Bedrooms with exterior walls facing two different directions have operable fenestration on exterior walls facing different directions.
10. Interior doors to bedrooms are capable of being secured in the open position.
11. A ceiling fan or ceiling fan rough-in is provided for bedrooms and the largest space that is not used as bedroom.
12. Skylights in dwelling units shall have a maximum *U*-factor as specified in Table R401.2.1.
13. Jalousie windows shall have an air infiltration rate of no more than 6.1 L/s • m^2 (1.2 cfm/ft^2).
14. Walls, floors and ceilings separating air-conditioned spaces from non-air-conditioned spaces shall be constructed to limit air leakage in accordance with the requirements in Table R402.4.1.1.

TABLE R401.2.1
BUILDING ENVELOPE FENESTRATION MAXIMUM U-FACTOR AND SHGC REQUIREMENTS

Vertical fenestration		
U-factor		
Fixed fenestration	2.84 W/m^2 • K	
Operable fenestration	3.69 W/m^2 • K	
Entrance doors	6.25 W/m^2 • K	
SHGC		
Orientation[a]	SEW	
PF < 0.2	0.25	
0.2 ≤ PF ≤ 0.5	0.30	
0.5 ≤ PF	0.40	
Skylights		
U-factor	4.26 W/m^2 • K	
SHGC	0.35	

PF = Projection factor.

R401.3 Certificate (Mandatory). A permanent certificate shall be completed by the builder or other *approved* party and posted on a wall in the space where the furnace is located, a utility room or an *approved* location inside the *building*.

Where located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. The certificate shall indicate the predominant *R*-values of insulation installed in or on ceilings, roofs, walls, foundation components such as slabs, *basement walls*, crawl space walls and floors and ducts outside *conditioned spaces*; *U*-factors of fenestration and the *solar heat gain coefficient* (SHGC) of fenestration, and the results from any required duct system and *building* envelope air leakage testing performed on the *building*. Where there is more than one value for each component, the certificate shall indicate the value covering the largest area. The certificate shall indicate the types and efficiencies of heating, cooling and service water heating equipment. Where a gas-fired unvented room heater, electric furnace or baseboard electric heater is installed in the residence, the certificate shall indicate "gas-fired unvented room heater," "electric furnace" or "baseboard electric heater," as appropriate. An efficiency shall not be indicated for gas-fired unvented room heaters, electric furnaces and electric baseboard heaters.

SECTION R402
BUILDING THERMAL ENVELOPE

R402.1 General (Prescriptive). The *building thermal envelope* shall meet the requirements of Sections R402.1.1 through R402.1.5.

Exception: The following low energy use intensity buildings, or portions thereof, separated from the remainder of the building by building thermal envelope assemblies complying with this section shall be exempt from the building thermal envelope provisions of Section R402.

1. Those with a peak design rate of energy usage less than 10.7 W/m^2 (3.4 Btu/h-ft^2) or 10.7 W/m^2 (1.0 W/ft^2) of floor area for space-conditioning purposes.
2. Unconditioned space that does not contain habitable space.
3. Greenhouses.

R402.1.1 Vapor retarder. Wall assemblies in the *building thermal envelope* shall comply with the vapor retarder requirements of Section R702.7 of the *International Residential Code* or Section 1404.3 of the *International Building Code,* as applicable.

R402.1.2 Insulation and fenestration criteria. The *building thermal envelope* shall meet the requirements of Table R402.1.2, based on the *climate zone* specified in Chapter 3.

Commented [PH1]: In table R401.2.1, column under "N" has been deleted because Jamaica is at less than 23.5 degrees latitude

R402.1.3 *R*-value computation. Insulation material used in layers, such as framing *cavity insulation* or continuous insulation, shall be summed to compute the corresponding component *R*-value. The manufacturer's settled *R*-value shall be used for blown-in insulation. Computed *R*-values shall not include an *R*-value for other building materials or air films. Where insulated siding is used for the purpose of complying with the continuous insulation requirements of Table R402.1.2, the manufacturer's labeled *R*-value for the insulated siding shall be reduced by R-0.6.

R402.1.4 *U*-factor alternative. An assembly with a *U*-factor equal to or less than that specified in Table R402.1.4 shall be permitted as an alternative to the *R*-value in Table R402.1.2.

R402.1.5 Total UA alternative. If the total building thermal envelope UA (sum of *U*-factor times assembly area) is less than or equal to the total UA resulting from using the *U*-factors in Table R402.1.4 (multiplied by the same assembly area as in the proposed building), the building shall be considered in compliance with Table R402.1.2. The UA calculation shall be done using a method consistent with the ASHRAE *Handbook of Fundamentals* and shall include the thermal bridging effects of framing materials. The SHGC requirements shall be met in addition to UA compliance.

R402.2 Specific insulation requirements (Prescriptive). In addition to the requirements of Section R402.1, insulation shall meet the specific requirements of Sections R402.2.1 through R402.2.13.

Exception: Above-grade walls and ceilings shall be permitted to comply with Section R407.

R402.2.1 Ceilings with attic spaces. Where Section R402.1.2 would require R-6.7 (m^2 • K)/W insulation in the ceiling, installing R-5.3 (m^2 • K)/W over 100 percent of the ceiling area requiring insulation shall be deemed to satisfy the requirement for R-6.7 (m^2 • K)/W wherever the full height of uncompressed R-5.3 (m^2 • K)/W insulation extends over the wall top plate at the eaves. This reduction shall not apply to the *U*-factor alternative approach in Section R402.1.4 and the total UA alternative in Section R402.1.5.

R402.2.2 Ceilings without attic spaces. Where Section R402.1.2 would require insulation levels above R-5.3 (m^2 • K)/W and the design of the roof/ceiling assembly does not allow sufficient space for the required insulation, the minimum required insulation for such roof/ceiling assemblies shall be R-5.3 (m^2 • K)/W . This reduction of insulation from the requirements of Section R402.1.2 shall be limited to 46 m^2 or 20 percent of the total insulated ceiling area, whichever is less. This reduction shall not apply to the *U*-factor alternative approach in Section R402.1.4 and the total UA alternative in Section R402.1.5.

R402.2.3 Eave baffle. For air-permeable insulations in vented attics, a baffle shall be installed adjacent to soffit and eave vents. Baffles shall maintain an opening equal or greater than the size of the vent. The baffle shall extend over the top of the attic insulation. The baffle shall be permitted to be any solid material.

R402.2.4 Access hatches and doors. Access doors from *conditioned spaces* to *unconditioned spaces* such as attics and crawl spaces shall be weatherstripped and insulated to a level equivalent to the insulation on the surrounding surfaces. Access that prevents damaging or compressing the insulation shall be provided to all equipment. Where loose-fill insulation is installed, a wood-framed or equivalent baffle or retainer shall be installed to prevent the loose-fill insulation from spilling into the living space when the attic access is opened. The baffle or retainer shall provide a permanent means of maintaining the installed *R*-value of the loose-fill insulation.

Exception: Vertical doors providing access from *conditioned spaces* to *unconditioned spaces* that comply with the fenestration requirements of Table R402.1.2 based on the applicable *climate zone* specified in Chapter 3.

R402.2.5 Mass walls. Mass walls where used as a component of the building thermal envelope shall be one of the following:

1. Above-ground walls of concrete block, concrete, insulated concrete form, masonry cavity, brick but not brick veneer, adobe, compressed earth block, rammed earth, solid timber or solid logs.
2. Any wall having a heat capacity greater than or equal to 123 kJ/m^2 • K .

R402.2.6 (N1102.2.6) Steel-frame ceilings, walls and floors. Steel-frame ceilings, walls, and floors shall comply with the insulation requirements of Table R402.2.6 or the *U*-factor requirements of Table R402.2.6. The calculation of the *U*-factor for a steel-frame envelope assembly shall use a series-parallel path calculation method.

R402.2.7 Walls with partial structural sheathing. Where Section R402.1.2 would require continuous insulation on *exterior walls* and structural sheathing covers 40 percent or less of the gross area of all *exterior walls*, the continuous insulation *R*-value shall be permitted to be reduced by an amount necessary to result in a consistent total sheathing thickness, but not more than R-0.5 (m^2 • K)/W (R-3 h • ft^2/Btu), on areas of the walls covered by structural sheathing. This reduction shall not apply to the *U*-factor alternative approach in Section R402.1.4 and the total UA alternative in Section R402.1.5.

R402.2.8 Floors. Floor framing-*cavity insulation* shall be installed to maintain permanent contact with the underside of the subfloor decking.

Exception: As an alternative, the floor framing-*cavity insulation* shall be in contact with the topside of sheathing or continuous insulation installed on the bottom side of floor framing where combined with insulation that meets or exceeds the minimum wood frame wall *R*-value in Table R402.1.2 and that extends from the bottom to the top of all perimeter floor framing members.

R402.2.9 Basement walls. Walls associated with conditioned basements shall be insulated from the top of the *basement wall* down to 10 feet (3048 mm) below grade or to the basement floor, whichever is less. Walls associated with unconditioned basements shall comply with this requirement except where the floor overhead is insulated in accordance with Sections R402.1.2 and R402.2.8.

R402.2.10 Slab-on-grade floors. Slab-on-grade floors with a floor surface less than 305 mm (12 in) below grade shall be insulated in accordance with Table R402.1.2. The insulation shall extend downward from the top of the slab on the outside or inside of the foundation wall. Insulation located below grade shall be extended the distance provided in Table R402.1.2 by any combination of vertical insulation, insulation extending under the slab or insulation extending out from the *building*. Insulation extending away from the *building* shall be protected by pavement or by not less than 254 mm (10 in) of soil. The top edge of the insulation installed between the *exterior wall* and the edge of the interior slab shall be permitted to be cut at a 45-degree (0.79 rad) angle away from the *exterior wall*. Slab-edge insulation is not required in jurisdictions designated by the *code official* as having a very heavy termite infestation.

R402.2.11 Crawl space walls. As an alternative to insulating floors over crawl spaces, crawl space walls shall be permitted to be insulated when the crawl space is not vented to the outside. Crawl space wall insulation shall be permanently fastened to the wall and extend downward from the floor to the finished grade level and then vertically and/or horizontally for at least an additional 610 mm (24 in). Exposed earth in unvented crawl space foundations shall be covered with a continuous Class I vapor retarder in accordance with the *International Building Code* or *International Residential Code*, as applicable. All joints of the vapor retarder shall overlap by 153 mm (6 in) and be sealed or taped. The edges of the vapor retarder shall extend not less than 153 mm (6 in) up the stem wall and shall be attached to the stem walls.

R402.2.12 Masonry veneer. Insulation shall not be required on the horizontal portion of a foundation that supports a masonry veneer.

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. **R402.3 Fenestration (Prescriptive).** In addition to the requirements of Section R402, fenestration shall comply with Sections R402.3.1 through R402.3.5.

R402.3.1 *U*-factor. An area-weighted average of fenestration products shall be permitted to satisfy the *U*-factor requirements.

R402.3.2 Glazed fenestration SHGC. Fenestration shall have a maximum solar heat gain coefficient as specified in Table R402.1.2. An area-weighted average of fenestration products more than 50 percent glazed shall be permitted to satisfy the SHGC requirements.

Dynamic glazing shall be permitted to satisfy the SHGC requirements of Table R402.1.2 provided the ratio of the higher to lower labelled SHGC is greater than or equal to 2.4 and the dynamic glazing is 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 when both the lower and higher labelled SHGC already comply with the requirements of Table R402.1.2.

R402.3.3 Glazed fenestration exemption. Up to 1.4 m^2 (15 ft^2) of glazed fenestration per dwelling unit shall be permitted to be exempt from *U*-factor and SHGC requirements in Section R402.1.2. This exemption shall not apply to the *U*-factor alternative approach in Section R402.1.4 and the Total UA alternative in Section R402.1.5.

R402.3.4 Opaque door exemption. One side-hinged opaque door assembly up to 2.22 m^2 (24 ft^2) in area is exempted from the *U*-factor requirement in Section R402.1.4. This exemption shall not apply to the *U*-factor alternative approach in Section R402.1.4 and the Total UA alternative in Section R402.1.5.

R402.3.5 Sunroom fenestration. *Sunrooms* enclosing *conditioned space* shall meet the fenestration requirements of this code.

New fenestration separating the sunroom with thermal isolation from conditioned space shall meet the building thermal envelope requirements of this code.

R402.4 Air leakage (Mandatory). The *building thermal envelope* shall be constructed to limit air leakage in accordance with the requirements of Sections R402.4.1 through R402.4.5.

R402.4.1 Building thermal envelope. The *building thermal envelope* shall comply with Sections R402.4.1.1 and R402.4.1.2. The sealing methods between dissimilar materials shall allow for differential expansion and contraction.

R402.4.1.1 Installation. The components of the *building thermal envelope* as indicated in Table R402.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1, as applicable to the method of construction. Where required by the *code official*, an *approved* third party shall inspect all components and verify compliance.

R402.4.1.2 (N1102.4.1.2) Testing. The *building* or dwelling unit shall be tested and verified as having an air leakage rate not exceeding five air changes per hour. Testing shall be conducted in accordance with RESNET/ICC 380 and reported at a pressure of 50 Pa (0.2 in w.g.). Where required by the *code official*, testing shall be conducted by an *approved* third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the *code official*. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope.

During testing:

1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed, beyond the intended weather-stripping or other infiltration control measures.
2. Dampers including exhaust, intake, makeup air, backdraft and flue dampers shall be closed, but not sealed beyond intended infiltration control measures.
3. Interior doors, where installed at the time of the test, shall be open.
4. Exterior or interior terminations for continuous ventilation systems shall be sealed.
5. Heating and cooling systems, where installed at the time of the test, shall be turned off.
6. Supply and return registers, where installed at the time of the test, shall be fully open.

R402.4.2 Fireplaces. New wood-burning fireplaces shall have tight-fitting flue dampers or doors, and outdoor combustion air. Where using tight-fitting doors on factory-built fireplaces *listed* and *labeled* in accordance with UL 127, the doors shall be tested and *listed* for the fireplace.

R402.4.3 Fenestration air leakage. Windows, *skylights* and sliding glass doors shall have an air infiltration rate of no more than 1.5 L/s • m^2 (0.3 cfm/ft^2) and swinging doors no more than 2.6 L/s • m^2 (0.5 cfm/ft^2), when tested according to NFRC 400 or AAMA/WDMA/CSA 101/I.S.2/A440 by an accredited, independent laboratory and listed and labelled by the manufacturer.

Exception: Site-built windows, *skylights* and doors.

R402.4.4 Rooms containing fuel-burning appliances. In *Climate Zones* 3 and 4, where open combustion air ducts provide combustion air to open combustion fuel burning appliances, the appliances and combustion air opening shall be located outside the *building thermal envelope* or enclosed in a room, isolated from inside the thermal envelope. Such rooms shall be sealed and insulated in accordance with the envelope requirements of Table R402.1.2, where the walls, floors and ceilings shall meet not less than the *basement wall R*-value requirement. The door into the room shall be fully gasketed and any water lines and ducts in the room insulated in accordance with Section R403. The combustion air duct shall be insulated where it passes through *conditioned space* to a minimum of R-1.4 (m^2 • K)/W.

Exceptions:

1. Direct vent appliances with both intake and exhaust pipes installed continuous to the outside.
2. Fireplaces and stoves complying with Section R402.4.2 and Section R1006 of the *International Residential Code.*

R402.4.5 Recessed lighting. Recessed luminaires installed in the *building thermal envelope* shall be sealed to limit air leakage between conditioned and *unconditioned spaces.* All recessed luminaires shall be IC-rated and *labelled* as having an air leakage rate not more than 0.944 L/s when tested in accordance with ASTM E283 at a 75 Pa pressure differential. All recessed luminaires shall be sealed with a gasket or caulk between the housing and the interior wall or ceiling covering.

R402.5 Maximum fenestration *U*-factor and SHGC (Mandatory). The area-weighted average maximum fenestration SHGC permitted using tradeoffs from Section R405 shall be 0.50.

SECTION R403
SYSTEMS

R403.1 Controls (Mandatory). Not less than one thermostat shall be provided for each separate heating and cooling system.

R403.1.1 Programmable thermostat. The thermostat controlling the primary heating or cooling system of the dwelling unit shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature setpoints at different times of the day. This thermostat shall include the capability to set back or temporarily operate the system to maintain *zone* temperatures down to 13 °C (55 °F) or up to 29 °C (85 °F). The thermostat shall initially be programmed by the manufacturer with a heating temperature setpoint no higher than 21 °C (70 °F) and a cooling temperature setpoint no lower than 26 °C (78 °F).

R403.1.2 Heat pump supplementary heat (Mandatory). Heat pumps having supplementary electric-resistance heat shall have controls that, except during defrost, prevent supplemental heat operation when the heat pump compressor can meet the heating load.

R403.2 Hot water boiler outdoor temperature setback. Hot water boilers that supply heat to the *building* through one- or two-pipe heating systems shall have an outdoor setback control that decreases the boiler water temperature based on the outdoor temperature.

R403.3 Ducts. Ducts and air handlers shall be installed in accordance with Sections R403.3.1 through R403.3.7.

R403.3.1 Insulation (Prescriptive). Supply and return ducts in attics shall be insulated to a minimum of R-1.4 ($m^2 \bullet K$)/W (R-8 $h \bullet ft^2 \bullet °F$/Btu) where 76 mm (3 in) in diameter and greater and R-1.1 ($m^2 \bullet K$)/W (R-6 $h \bullet ft^2 \bullet °F$/Btu) where less than 76 mm (3 in) in diameter. Supply and return ducts in other portions of the *building* shall be insulated to a minimum of R-1.1 ($m^2 \bullet K$)/W (R-6 $h \bullet ft^2 \bullet °F$/Btu) where 76 mm (3 in) in diameter or greater and R-0.7 ($m^2 \bullet K$)/W (R-4.2 $h \bullet ft^2 \bullet °F$/Btu) where less than 76 mm (3 in) in diameter.

Exception: Ducts or portions thereof located completely inside the *building thermal envelope*.

R403.3.2 Sealing (Mandatory). Ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with either the *International Mechanical Code* or *International Residential Code*, as applicable.

Exceptions:

1. Air-impermeable spray foam products shall be permitted to be applied without additional joint seals.
2. For ducts having a static pressure classification of less than 500 Pa (2 in of w.c.), additional closure systems shall not be required for continuously welded joints and seams and locking-type joints and seams of other than the snap-lock and button-lock types.

R403.3.2.1 Sealed air handler. Air handlers shall have a manufacturer's designation for an air leakage of not greater than 2 percent of the design airflow rate when tested in accordance with ASHRAE 193.

R403.3.3 Duct testing (Mandatory). Ducts shall be pressure tested to determine air leakage by one of the following methods:

1. Rough-in test: Total leakage shall be measured with a pressure differential of 25 Pa (0.1 in w.g.) across the system, including the manufacturer's air handler enclosure if installed at the time of the test. All registers shall be taped or otherwise sealed during the test.
2. Postconstruction test: Total leakage shall be measured with a pressure differential of 25 Pa across the entire system, including the manufacturer's air handler enclosure. Registers shall be taped or otherwise sealed during the test.

Exceptions:

1. A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the *building thermal envelope*.
2. A duct air leaking test shall not be required for ducts serving heat or energy recovery ventilators that are not integrated with ducts serving heating or cooling systems.

A written report of the results of the test shall be signed by the party conducting the test and provided to the *code official.*

R403.3.4 Duct leakage (Prescriptive). The total leakage of the ducts, where measured in accordance with Section R403.3.3, shall be as follows:

1. Rough-in test: The total leakage shall be less than or equal to 113.3 L/min (4 ft^3/min) per 9.29 m^2 (100 ft^2) of conditioned floor area where the air handler is installed at the time of the test. Where the air handler is not installed at the time of the test, the total leakage shall be less than or equal to 85 L/min (3 ft^3/min) per 9.29 m^2 (100 ft^2) of conditioned floor area.

2. Postconstruction test: Total leakage shall be less than or equal to 113.3 L/min (4 ft^3/min) per 9.29 m^2 (100 ft^2) of conditioned floor area.

R403.3.5 Building cavities (Mandatory). *Building* framing cavities shall not be used as ducts or plenums.

R403.3.6 Ducts buried within ceiling insulation. Supply and return ducts shall be permitted to be installed partially, or fully buried within ceiling insulation provided the ducts comply with all of the following:

1. Supply and return ducts shall be insulated with an *R*-value of not less than R-1.4 ($m^2 \bullet K$)/W.
2. At all points along the duct, the sum of the ceiling insulation *R*-values above the top of the duct and below the bottom of the duct shall be not less than 3.3 ($m^2 \bullet K$)/W excluding the duct *R*-value.
3. In *Climate Zones* 0A, 1A, 2A, 3A, where supply ducts are completely covered with ceiling insulation, the supply ducts shall be insulated to an R-value of not less than R-18 and the ducts shall be in accordance with the vapor retarder requirements in Section 604.11 of the *International Mechanical Code*, Section M1601.4.6 of the *International Residential Code,* or standards approved by the Authority having Jurisdiction as applicable.

Exception: Sections of supply ducts less than 914 mm (3 ft) from the supply outlet.

R403.3.6.1 Effective *R*-value of deeply buried ducts. Where using a simulated energy performance analysis, sections of ducts that are: installed in accordance with Section R403.3.6; located directly on, or within 140 mm (5.5 in) of the ceiling; surrounded with blown-in attic insulation having an *R*-value of R-5.3 ($m^2 \bullet K$)/W (R-30 $h \bullet ft^2 \bullet °F$/Btu) or greater and located such that the top of the duct is not less than 89 mm (3.5 in) below the top of the insulation, shall be considered as having an effective duct insulation *R*-value of R-4.4 ($m^2 \bullet K$)/W (R-25 $h \bullet ft^2 \bullet °F$/Btu).

R403.3.7 Ducts located in conditioned space. For ducts to be considered as inside a conditioned space, such ducts shall comply with either of the following:

1. The duct system shall be located completely within the continuous air barrier and within the building thermal envelope.
2. The ducts shall be buried within ceiling insulation in accordance with Section R403.3.6 and all of the following conditions shall exist:

2.1. The air handler is located completely within the *continuous air barrier* and within the building thermal envelope.

2.2. The duct leakage, as measured either by a rough-in test of the ducts or a post-construction total system leakage test to outside the building thermal envelope in accordance with Section R403.3.4, is less than or equal to 42.5 L/min (1.5 ft^3/min) per 9.29 m^2 (100 ft^2) of conditioned floor area served by the duct system.

2.3. The ceiling insulation *R*-value installed against and above the insulated duct is greater than or equal to the proposed ceiling insulation *R*-value, less the *R*-value of the insulation on the duct.

R403.4 Mechanical system piping insulation (Mandatory). Mechanical system piping capable of carrying fluids above 41 °C (105 °F) or below 13 °C (55 °F) shall be insulated to a minimum of R-0.5 ($m^2 \bullet K$)/W (R-3 $h \bullet ft^2 \bullet °F$/Btu.

R403.4.1 Protection of piping insulation. Piping insulation exposed to weather shall be protected from damage, including that caused by sunlight, moisture, equipment maintenance and wind. The protection shall provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall be prohibited.

R403.5 Service hot water systems. Energy conservation measures for service hot water systems shall be in accordance with Sections R403.5.1 through R403.5.4.

R403.5.1 Heated water circulation and temperature maintenance systems (Mandatory). Heated water circulation systems shall be in accordance with Section R403.5.1.1. Heat trace temperature maintenance systems shall be in accordance with Section R403.5.1.2. Automatic controls, temperature sensors and pumps shall be *accessible*. Manual controls shall be readily *accessible*.

R403.5.1.1 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 water system pumps shall start the pump based on the identification of a demand for hot water within the occupancy. The controls shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is no demand for hot water.

R403.5.1.2 Heat trace systems. Electric heat trace systems shall comply with IEEE 515.1 or UL 515. Controls for such systems shall 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.

R403.5.2 Demand recirculation water systems. 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 shall be a *demand recirculation water system*. Pumps shall have controls that comply with both of the following:

1. The control 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 control shall limit the temperature of the water entering the cold-water piping to 40 °C (104 °F).

R403.5.3 Hot water pipe insulation (Prescriptive). Insulation for hot water pipe with a minimum thermal resistance (*R*-value) of 0.5 ($m^2 \bullet K$)/W (R-3 $h \bullet ft^2 \bullet °F$/Btu) shall be applied to the following:

1. Piping 19.1 mm ($^3/_4$ in) and larger in nominal.
2. Piping serving more than one dwelling unit.
3. Piping located outside the *conditioned space*.
4. Piping from the water heater to a distribution manifold.
5. Piping located under a floor slab.
6. Buried piping.
7. Supply and return piping in recirculation systems other than demand recirculation systems.

R403.5.4 Drain water heat recovery units. Drain water heat recovery units shall comply with CSA B55.2 Drain water heat recovery units shall be tested in accordance with CSA B55.1. Potable water-side pressure loss of drain water heat recovery units shall be less than 20.7 kPa (3 psi) for individual units connected to one or two showers. Potable water-side pressure loss of drain water heat recovery units shall be less than 13.8 kPa (2 psi) for individual units connected to three or more showers.

R403.5.5 Heat traps (Mandatory). Storage water heaters not equipped with integral heat traps and having vertical pipe risers shall have heat traps installed on both the inlets and outlets. External heat traps shall consist of either a commercially available heat trap or a downward and upward bend of at least 89 mm ($3^1/_2$ in) in the hot water distribution line and cold-water line located as close as possible to the storage tank.

R403.5.6 Water heater efficiencies (Mandatory).

R403.5.6.1 Storage water heater temperature controls.

R403.5.6.1.1 Automatic controls. Service water-heating systems shall be equipped with automatic temperature controls capable of adjustment from the lowest to the highest acceptable temperature settings for the intended use. The minimum temperature setting range shall be from 38 °C to 60 °C (100 °F to 140 °F).

R403.5.6.1.2 Shut down. A separate switch or a clearly marked circuit breaker shall be provided to permit the power supplied to electric service systems to be turned off. A separate valve shall be provided to permit the energy supplied to the main burner(s) of combustion types of service water-heating systems to be turned off.

R403.5.6.2 Water-heating equipment. Water-heating equipment installed in residential units shall meet the minimum efficiencies of Table C404.2 in Chapter 4 of the Commercial Provisions, for the type of equipment installed. Equipment used to provide heating functions as part of a combination system shall satisfy all stated requirements for the appropriate water-heating category. Solar water heaters shall meet the criteria of Section R403.5.6.2.1.

R403.5.6.2.1 Solar water-heating systems. Solar water heating systems for domestic hot water production shall comply with ICC 900/SRCC 300 Solar Thermal System Standard and be rated by the annual solar energy factor of the system for the location where the system is to be installed. The solar energy factor of a system shall be determined from the ICC-SRCC OG-300 Solar Thermal System Certification Program or standards approved by the Authority having Jurisdiction.

Solar collectors shall comply with ICC 901/SRCC 100 Solar Thermal Collector Standard. Collectors in installed solar water-heating systems shall be installed with a tilt angle between 10 degrees and 40 degrees.

R403.6 Mechanical ventilation (Mandatory). The *building* shall be provided with ventilation that complies with the requirements of the *International Residential Code* or *International Mechanical Code*, as applicable, or with other *approved* means of

ventilation. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.

R403.6.1 Whole-house mechanical ventilation system fan efficacy. Fans used to provide whole-house mechanical ventilation shall meet the efficacy requirements of Table R403.6.1.

Exception: Where an air handler that is integral to tested and *listed* HVAC equipment is used to provide whole-house mechanical ventilation, the air handler shall be powered by an electronically commutated motor.

R403.7 Cooling and heating equipment (Mandatory).

R403.7.1 Equipment sizing and efficiency rating. Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies, based on building loads for the directional orientation of the building. The manufacturer and model number of the outdoor and indoor units (if split system) shall be submitted along with the sensible and total cooling capacities at the design conditions described in Section R302.1. This code does not allow designer safety factors, provisions for future expansion or other factors that affect equipment sizing. System sizing calculations shall not include loads created by local intermittent mechanical ventilation such as standard kitchen and bathroom exhaust systems. New or replacement heating and cooling equipment shall have an efficiency rating equal to or greater than the minimum required by applicable laws of CARICOM countries for the geographic location where the equipment is installed.

R403.7.1.1 Cooling equipment capacity. Cooling only equipment shall be selected so that its total capacity is not less than the calculated total load but not more than 1.15 times greater than the total load calculated according to the procedure selected in Section R403.7, or the closest available size provided by the manufacturer's product lines. The corresponding latent capacity of the equipment shall not be less than the calculated latent load.

The published value for AHRI total capacity is a nominal, rating-test value and shall not be used for equipment sizing. Manufacturer's expanded performance data shall be used to select cooling-only equipment. This selection shall be based on the outdoor design dry-bulb temperature for the load calculation (or entering water temperature for water-source equipment), the blower CFM (m^3/s) provided by the expanded performance data, the design value for entering wet-bulb temperature and the design value for entering dry-bulb temperature.

Design values for entering wet-bulb and dry-bulb temperatures shall be for the indoor dry bulb and relative humidity used for the load calculation and shall be adjusted for return side gains if the return duct(s) is installed in an unconditioned space.

Exceptions:

1. Attached single- and multiple-family residential equipment sizing may be selected so that its cooling capacity is less than the calculated total sensible load but not less than 80 percent of that load.
2. When signed and sealed by a registered engineer, in attached single- and multiple-family units, the capacity of equipment may be sized in accordance with good design practice.

R403.8 Systems serving multiple dwelling units (Mandatory). Systems serving multiple dwelling units shall comply with Sections C403 and C404 of the *International Energy Conservation Code*—Commercial Provisions instead of Section R403.

R403.9 Snow melt and ice system controls (Mandatory). Deleted.

R403.10 Pools and permanent spa energy consumption (Mandatory). The energy consumption of pools and permanent spas shall be in accordance with Sections R403.10.1 through R403.10.5.

R403.10.1 Heaters. The electric power to 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 914 mm (3 ft) of the heater. 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.

R403.10.2 Time switches. Time switches or other control methods that can automatically turn off and on 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.

R403.10.3 Covers. Outdoor heated pools and outdoor permanent spas shall be provided with a vapor-retardant cover or other *approved* vapor-retardant means.

Exception: Where more than 75 percent of the energy for heating, computed over an operation season of not less than three calendar months, is from a heat pump or an on-site renewable energy system, covers or other vapor-retardant means shall not be required.

R403.10.4 Pump motors. Pump motors with a pool pump motor capacity of 0.75kw (1 hp) or greater, shall have the capability of operating at two or more speeds with a low speed having a rotation rate that is no more than one-half of the motor's maximum rotation rate. The pump motor must be operated with a pump control that complies with Section R403.10.5.

R403.10.5 Pump controls. Pool pump motor controls shall have the capability of operating the pool pump at least at two speeds. The control's default circulation speed setting shall be no more than one-half of the motor's maximum rotation rate. Any high speed override capability shall be for a temporary period not to exceed one 24-hour cycle without resetting to default settings.

R403.10.6 Solar water heating systems. Solar water heating systems utilized for pools and spas shall comply with ICC 902/APSP 902/SRCC 400. This provision is consistant with the language slated for inclusion in the 2021 *International Swimming Pool and Spa Code*. Standard 400 also references Standard 100 for collectors used in solar pool heaters.

R403.11 Portable spas (Mandatory). The energy consumption of electric-powered portable spas shall be controlled by the requirements of APSP 14.

R403.12 Residential pools and permanent residential spas. Residential swimming pools and permanent residential spas that are accessory to detached one- and two-family dwellings and townhouses three stories or less in height above grade plane and that are available only to the household and its guests shall be in accordance with APSP 15.

SECTION R404
ELECTRICAL POWER AND LIGHTING SYSTEMS

R404.1 Lighting equipment (Mandatory). Not less than 90 percent of the permanently installed lighting fixtures shall contain only high-efficacy lamps.

R404.1.1 Lighting equipment (Mandatory). Fuel gas lighting systems shall not have continuously burning pilot lights.

R404.2 Ceiling fans (mandatory). A ceiling fan or ceiling fan rough-in is provided for bedrooms and the largest space that is not used as a bedroom.

SECTION R405
SIMULATED PERFORMANCE ALTERNATIVE (PERFORMANCE)

R405.1 Scope. This section establishes criteria for compliance using simulated energy performance analysis. Such analysis shall include heating, cooling, mechanical ventilation and service water heating energy only.

R405.2 Mandatory requirements. Compliance with this section requires that the mandatory provisions identified in Section R401.2 be met. Supply and return ducts not completely inside the *building thermal envelope* shall be insulated to an *R*-value of not less than 1.1 ($m^2 \bullet K$)/W (R-6 $h \bullet ft^2 \bullet °F$/Btu).

R405.3 Performance-based compliance. Compliance based on simulated energy performance requires that a proposed residence (*proposed design)* be shown to have an annual energy cost that is less than or equal to the annual energy cost of the *standard reference design.* Energy prices shall be taken from a source *approved* by the *code official,* such as the Department of Energy, Energy Information Administration's State Energy Data System Prices and Expenditures reports. *Code officials* shall be permitted to require time-of-use pricing in energy cost calculations.

Exception: The energy use based on source energy expressed in Btu or Btu per square foot of *conditioned floor area* shall be permitted to be substituted for the energy cost. The source energy multiplier for electricity shall be 3.16. The source energy multiplier for fuels other than electricity shall be 1.1.

R405.4 Documentation. Documentation of the software used for the performance design and the parameters for the *building* shall be in accordance with Sections R405.4.1 through R405.4.3.

R405.4.1 Compliance software tools. Documentation verifying that the methods and accuracy of the compliance software tools conform to the provisions of this section shall be provided to the *code official.*

R405.4.2 Compliance report. Compliance software tools shall generate a report that documents that the *proposed design* complies with Section R405.3. A compliance report on the *proposed design* shall be submitted with the application for the *building* permit. Upon completion of the *building*, a compliance report based on the as-built condition of the *building* shall be submitted to the *code official* before a certificate of occupancy is issued. Batch sampling of *buildings* to determine energy code compliance shall only be allowed for stacked multiple-family units.

Compliance reports shall include information in accordance with Sections R405.4.2.1 and R405.4.2.2. Where the *proposed design* of a *building* could be built on different sites where the cardinal orientation of the building on each site is different, compliance of the *proposed design* for the purposes of the application for the building permit shall be based on the worst-case orientation, worst-case configuration, worst-case *building* air leakage and worst- case duct leakage. Such worst-case parameters shall be used as inputs to the compliance software for energy analysis.

R405.4.2.1 Compliance report for permit application. A compliance report submitted with the application for building permit shall include the following:

1. Building street address, or other building site identification.
2. A statement indicating that the *proposed design* complies with Section R405.3.
3. An inspection checklist documenting the building component characteristics of the *proposed design* as indicated in Table R405.5.2(1). The inspection checklist shall show results for both the *standard reference design* and the *proposed design* with user inputs to the compliance software to generate the results.
4. A site-specific energy analysis report that is in compliance with Section R405.3.
5. The name of the individual performing the analysis and generating the report.
6. The name and version of the compliance software tool.

R405.4.2.2 Compliance report for certificate of occupancy. A compliance report submitted for obtaining the certificate of occupancy shall include the following:

1. Building street address, or other building site identification.
2. A statement indicating that the as-built building complies with Section R405.3.
3. A certificate indicating that the building passes the performance matrix for code compliance and indicating the energy saving features of the buildings.
4. A site-specific energy analysis report that is in compliance with Section R405.3.
5. The name of the individual performing the analysis and generating the report.
6. The name and version of the compliance software tool.

R405.4.3 Additional documentation. The *code official* shall be permitted to require the following documents:

1. Documentation of the building component characteristics of the *standard reference design.*
2. A certification signed by the builder providing the building component characteristics of the *proposed design* as given in Table R405.5.2(1).
3. Documentation of the actual values used in the software calculations for the *proposed design.*

R405.5 Calculation procedure. Calculations of the performance design shall be in accordance with Sections R405.5.1 and R405.5.2.

R405.5.1 General. Except as specified by this section, the *standard reference design* and *proposed design* shall be configured and analyzed using identical methods and techniques.

R405.5.2 Residence specifications. The *standard reference design* and *proposed design* shall be configured and analyzed as specified by Table R405.5.2(1). Table R405.5.2(1) shall include, by reference, all notes contained in Table R402.1.2.

R405.6 Calculation software tools. Calculation software, where used, shall be in accordance with Sections R405.6.1 through R405.6.3.

R405.6.1 Minimum capabilities. Calculation procedures used to comply with this section shall be software tools capable of calculating the annual energy consumption of all building elements that differ between the *standard reference design* and the *proposed design* and shall include the following capabilities:

1. Computer generation of the *standard reference design* using only the input for the *proposed design.* The calculation procedure shall not allow the user to directly modify the building component characteristics of the *standard reference design.*
2. Calculation of whole-building (as a single *zone*) sizing for the heating and cooling equipment in the *standard reference design* residence in accordance with Section R403.6.
3. Calculations that account for the effects of indoor and outdoor temperatures and part-load ratios on the performance of heating, ventilating and air-conditioning equipment based on climate and equipment sizing.
4. Printed *code official* inspection checklist listing each of the *proposed design* component characteristics from Table R405.5.2(1) determined by the analysis to provide compliance, along with their respective performance ratings such as *R*-value, *U*-factor, SHGC, HSPF, AFUE, SEER and EF.

R405.6.2 Specific approval. Performance analysis tools meeting the applicable provisions of Section R405 shall be permitted to be *approved.* Tools are permitted to be *approved* based on meeting a specified threshold for a jurisdiction. The *code official* shall be permitted to approve such tools for a specified application or limited scope.

R405.6.3 Input values. When calculations require input values not specified by Sections R402, R403, R404 and R405, those input values shall be taken from an *approved* source.

SECTION R406
ENERGY RATING INDEX
COMPLIANCE ALTERNATIVE

R406.1 Scope. This section establishes criteria for compliance using an Energy Rating Index (ERI) analysis.

R406.2 Mandatory requirements. Compliance with this section requires that the provisions identified in Sections R401 through R404 indicated as "Mandatory" and Section R403.5.3 be met. The *building thermal envelope* shall be greater than or equal to levels of efficiency and *Solar Heat Gain Coefficients* in Table 402.1.1 or 402.1.3 of the 2009 *International Energy Conservation Code*.

Exception: Supply and return ducts not completely inside the *building thermal envelope* shall be insulated to an *R*-value of not less than 1.1 ($m^2 \bullet K$)/W.

R406.3 Energy Rating Index. The Energy Rating Index (ERI) shall be determined in accordance with RESNET/ICC 301 except for buildings covered by the *International Residential Code*, the ERI Reference Design Ventilation rate shall be in accordance with Equation 4-1.

Ventilation rate, L/s = (0.01 × total m^2 area of house) +
[7.5 × (number of bedrooms + 1)]

(Equation 4-1)

Energy used to recharge or refuel a vehicle used for transportation on roads that are not on the building site shall not be included in the *ERI reference design* or the *rated design*.

R406.4 ERI-based compliance. Compliance based on an ERI analysis requires that the *rated design* be shown to have an ERI less than or equal to the appropriate value indicated in Table R406.4 when compared to the *ERI reference design*.

TABLE R406.4
MAXIMUM ENERGY RATING INDEX

CLIMATE ZONE	ENERGY RATING INDEX[a]
1	57

a. Where on-site renewable energy is included for compliance using the ERI analysis of Section R406.4, the building shall meet the mandatory requirements of Section R406.2, and the building thermal envelope shall be greater than or equal to the levels of efficiency and SHGC in Table R402.1.2 or Table R402.1.4 of the 2015 *International Energy Conservation Code*.

R406.5 Verification by approved agency. Verification of compliance with Section R406 shall be completed by an *approved* third party.

R406.6 Documentation. Documentation of the software used to determine the ERI and the parameters for the *residential building* shall be in accordance with Sections R406.6.1 through R406.6.3.

R406.6.1 Compliance software tools. Software tools used for determining ERI shall be Approved Software Rating Tools in accordance with RESNET/ICC 301.

R406.6.2 Compliance report. Compliance software tools shall generate a report that documents that the ERI of the *rated design* complies with Sections R406.3 and R406.4. The compliance documentation shall include the following information:

1. Address or other identification of the residential building.
2. An inspection checklist documenting the building component characteristics of the *rated design*. The inspection checklist shall show results for both the *ERI reference design* and the *rated design*, and shall document all inputs entered by the user necessary to reproduce the results.
3. Name of individual completing the compliance report.
4. Name and version of the compliance software tool.

Exception: Where an otherwise identical building model is offered in multiple orientations, compliance for any orientation shall be permitted by documenting that the building meets the performance requirements in each of the four (north, east, south and west) cardinal orientations.

R406.6.3 Additional documentation. The *code official* shall be permitted to require the following documents:

1. Documentation of the building component characteristics of the *ERI reference design*.
2. A certification signed by the builder providing the building component characteristics of the *rated design.*
3. Documentation of the actual values used in the software calculations for the *rated design*.

R406.6.4 Specific approval. Performance analysis tools meeting the applicable sections of Section R406 shall be *approved*. Documentation demonstrating the approval of performance analysis tools in accordance with Section R406.6.1 shall be provided.

R406.6.5 Input values. Where calculations require input values not specified by Sections R402, R403, R404 and R405, those input values shall be taken from RESNET/ICC 301.

TABLE R402.1.4
EQUIVALENT *U*-FACTORS[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR	SKYLIGHT *U*-FACTOR	CEILING *U*-FACTOR	FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR[b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR	CRAWL SPACE WALL *U*-FACTOR
1	0.50	0.75	0.035	0.084	0.197	0.064	0.360	0.477

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.
b. Mass walls shall be in accordance with Section R402.2.5. Where more than half the insulation is on the interior, the mass wall *U*-factors shall not exceed 0.17 in
c. In warm-humid locations as defined by Figure R301.1 and Table R301.1, the basement wall *U*-factor shall not exceed 0.360.

TABLE R402.1.2
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

Opaque Elements	Assembly Maximum *U*-Factor	Insulation Minimum *R-Value*	
Ceiling	U-0.184 W/m^2 • K (U-0.032 Btu/h • ft^2 • °F)	R-5.3 c.i. m^2 • K/W (R-30 c.i h • ft^2 • °F/Btu)	
Walls, above Grade			
Mass	U-0.857 W/m^2 • K (U-0.151 Btu/h • ft^2 • °F)	R-1.0 m^2 • K/W (R-5.7 c.i. h • ft^2 • °F/Btu)	
Wall, below Grade			
Below-grade wall	U-6.473 W/m^2 • K (U-1.140 Btu/h • ft^2 • °F)	NR	
Floors			
Mass	U-1.825 W/m^2 • K (U-0.322 Btu/h • ft^2 • °F)	NR	
Wood-framed and other	U-1.599 W/m^2 • K (U-0.282 Btu/h • ft^2 • °F)	NR	
Crawl Space	U-1.264 W/m^2 • K (U-0.730 Btu/h • ft^2 • °F)	NR	
Slab-on-Grade Floors	U-1.599 W/m^2 • K (U-0.282 Btu/h • ft^2 • °F)	NR	
Fenestration	**Assembly Maximum *U*-Factor**	**Assembly Maximum SHGC**	**Assembly Minimum VT/SHGC**
Fenestration	U-1.84 W/m^2 • K (Btu/h • ft^2 • °F)		
Glazed Fenestration	U-2.84 W/m^2 • K (Btu/h • ft^2 • °F)	0.25	1.10
Skylights	U-4.26 W/m^2 • K (Btu/h • ft^2 • °F)	0.35	NR

NR = No Requirement

TABLE R402.4.1.1
AIR BARRIER AND INSULATION INSTALLATION[a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
General requirements	A continuous air barrier shall be installed in the building envelope. The exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed.	Air-permeable insulation shall not be used as a sealing material.
Ceiling/attic	The air barrier in any dropped ceiling/soffit shall be aligned with the insulation and any gaps in the air barrier shall be sealed. Access openings, drop down stairs or knee wall doors to unconditioned attic spaces shall be sealed.	The insulation in any dropped ceiling/soffit shall be aligned with the air barrier.

Walls	The junction of the foundation and sill plate shall be sealed. The junction of the top plate and the top of exterior walls shall be sealed. Knee walls shall be sealed.	Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance of R-0.5 (m^2 • K)/W (R-3 h • ft^2 • °F/Btu) per 25.4 mm (1 in) minimum. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.
Windows, skylights and doors	The space between window/ door jambs and framing, and skylights, and framing shall be sealed.	—
Rim joists	Rim joists shall include the air barrier.	Rim joists shall be insulated.
Floors, including above garage and cantilevered floors	The air barrier shall be installed at any exposed edge of insulation.	Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of subfloor decking, or floor framing cavity insulation shall be in contact with the top side of sheathing, or continuous insulation installed on the underside of floor framing and extends from the bottom to the top of all perimeter floor framing members.
Crawl space walls	Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.	Where provided instead of floor insulation, insulation shall be permanently attached to the crawlspace walls.
Shafts, penetrations	Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed.	—
Narrow cavities	—	Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled with insulation that on installation readily conforms to the available cavity space.
Garage separation	Air sealing shall be provided between the garage and conditioned spaces.	—
Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be sealed to the drywall.	Recessed light fixtures installed in the building thermal envelope shall be air tight and IC rated.
Plumbing and wiring	—	Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation, that on installation readily conforms to available space shall extend behind piping and wiring.
Shower/tub on exterior wall	The air barrier installed at exterior walls adjacent to showers and tubs shall separate them from the showers and tubs.	Exterior walls adjacent to showers and tubs shall be insulated.
Electrical/phone box on exterior walls	The air barrier shall be installed behind electrical or communication boxes or air-sealed boxes shall be installed.	—
HVAC register boots	HVAC register boots that penetrate building thermal envelope shall be sealed to the subfloor or drywall.	—
Concealed sprinklers	When required to be sealed, concealed fire sprinklers shall only be sealed 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.	—

a. In addition, inspection of log walls shall be in accordance with the provisions of ICC 400.

TABLE R403.6.1
WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM FAN EFFICACY[a]

FAN LOCATION	AIR FLOW RATE MINIMUM L/s	MINIMUM EFFICACY L/W • s	L/s
HRV or ERV	Any	0.57 L/W • s	Any
Range hoods	Any	1.32 L/W • s	Any
In-line fan	Any		Any
Bathroom, utility room	4.7	0.66 L/W • s	< 42.5
Bathroom, utility room	42.5	1.32 L/W • s	Any

a. When tested in accordance with HVI Standard 916.

TABLE R405.5.2(1)
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Above-grade walls	Type: mass, where the proposed wall is a mass wall; otherwise, wood frame.	As proposed
	Gross area: same as proposed.	As proposed
	U-factor: as specified in Table R402.12.	As proposed
	Solar absorptance = 0.75.	As proposed
	Emittance = 0.90.	As proposed
Basement and crawl space walls	Type: same as proposed.	As proposed
	Gross area: same as proposed.	As proposed
	U-factor: as specified in Table R402.1.2, with the insulation layer on the interior side of the walls.	As proposed
Above-grade floors	Type: wood frame.	As proposed
	Gross area: same as proposed.	As proposed
	U-factor: as specified in Table R402.1.2.	As proposed
Ceilings	Type: wood frame.	As proposed
	Gross area: same as proposed.	As proposed
	U-factor: as specified in Table R402.1.2.	As proposed
Roofs	Type: composition shingle on wood sheathing.	As proposed
	Gross area: same as proposed.	As proposed
	Solar absorptance = 0.75.	As proposed
	Emittance = 0.90.	As proposed
Attics	Type: vented with an aperture of 0.09 m^2 per 27.9 m^2 of ceiling area.	As proposed
Foundations	Type: same as proposed.	As proposed
	Foundation wall area above and below grade and soil characteristics: same as proposed.	As proposed

	Area: 3.7 m^2 .	As proposed
Opaque doors	Orientation: North.	As proposed
	U-factor: same as fenestration as specified Table R402.1.2.	As proposed
Vertical fenestration other than opaque doors	Total area[h] = (a) The proposed glazing area, where the proposed glazing area is less than 15% of the conditioned floor area (b) 15% of the conditioned floor area, where the proposed glazing area is 15% or more of the conditioned floor area.	As proposed
	Orientation: equally distributed to four cardinal compass orientations (N, E, S & W).	As proposed
	U-factor: as specified in Table R402.1.2.	As proposed
	SHGC: as specified in Table R402.1.2 except for climate zones without an SHGC requirement, the SHGC shall be equal to 0.40.	As proposed
	Interior shade fraction: 0.92-(0.21 × SHGC for the standard reference design).	Interior shade fraction: 0.92-(0.21 × SHGC as proposed)
	External shading: none.	As proposed
Skylights	None.	As proposed
Thermally isolated sunrooms	None.	As proposed
Air exchange rate	The air leakage rate at a pressure of 50 Pa (0.2 inch w.g.) shall be 2: 5 air changes per h. The mechanical ventilation rate shall be in addition to the air leakage rate and shall be the same as in the proposed design, but not greater than $0.01 \times CFA + 7.5 \times (N_{br} + 1)$ where: CFA = conditioned floor area, m^2 . N_{br} = number of bedrooms. Energy recovery shall not be assumed for mechanical ventilation.	The measured air exchange rate.[a] The mechanical ventilation rate[b] shall be in addition to the air leakage rate and shall be as proposed.

(continued)

TABLE R405.5.2(1)—continued
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Mechanical ventilation	Where mechanical ventilation is not specified in the proposed design: None Where mechanical ventilation is specified in the proposed design, the annual vent fan energy use, in units of kWh/yr, shall equal: $(1/e_f) \times [0.0876 \times CFA + 65.7 \times (N_{br} + 1)]$ where: e_f = the minimum exhaust fan efficacy, as specified in Table R403.6.1, corresponding to a flow rate of $0.01 \times CFA + 7.5 \times (N_{br}+1)$ CFA = conditioned floor area, m^2 (ft^2). N_{br} = number of bedrooms.	As proposed

Internal gains	IGain, in units of kW/day per dwelling unit, shall equal: $(17{,}900 + 23.8 \times CFA + 4{,}104 \times N_{br})/3412$ where: CFA = conditioned floor area, m^2 (ft^2). N_{br} = number of bedrooms.	Same as standard reference design.
Internal mass	Internal mass for furniture and contents: 383 Pa (8 lbs/ft^2) of floor area.	Same as standard reference design, plus any additional mass specifically designed as a thermal storage element[c] but not integral to the building envelope or structure.
Structural mass	For masonry floor slabs: 80% of floor area covered by R-2 carpet and pad, and 20% of floor directly exposed to room air.	As proposed
	For masonry basement walls: as proposed, but with insulation as specified in Table R402.1.2, located on the interior side of the walls.	As proposed
	For other walls, ceilings, floors, and interior walls: wood frame construction.	As proposed
Heating systems[d, e]	For other than electric heating without a heat pump: as proposed. Where the proposed design utilizes electric heating without a heat pump, the standard reference design shall be an air source heat pump meeting the requirements of Section C403 of the IECC—Commercial Provisions. Capacity: sized in accordance with Section R403.7.	As proposed
Cooling systems[d, f]	As proposed. Capacity: sized in accordance with Section R403.7.	As proposed
Service water heating[d, e, f, g]	As proposed. Use: same as proposed design.	As proposed Use, in units of L/day = $(30 + (10 \times N_{br}))/3.8$ where: N_{br} = number of bedrooms.
Thermal distribution systems	Duct insulation: in accordance with Section R403.3.1. A thermal distribution system efficiency (DSE) of 0.88 shall be applied to both the heating and cooling system efficiencies for all systems other than tested duct systems. **Exception:** For nonducted heating and cooling systems that do not have a fan, the standard reference design thermal distribution system efficiency (DSE) shall be 1. For tested duct systems, the leakage rate shall be 113.3 L/min (4 cfm) per 9.29 m^2 (100 ft^2) of *conditioned floor area* at a pressure of differential of 25 Pa (0.1 inch w.g.).	Duct insulation: as proposed. As tested or, where not tested, as specified in Table R405.5.2(2)
Thermostat	Type: Manual, cooling temperature setpoint = 24 °C (75 °F); Heating temperature setpoint = 22 °C (72 °F).	Same as standard reference design.

(continued)

TABLE R405.5.2(1)—continued
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

For IP: 1 m² = 10.8 square feet, 1 J = 0.0009 Btu, 1 kg/m² = 0.20 pound per square foot, 1 L = 0.26 gallon (US),°F = (°F • 1.8) + 32. 1 rad = 57.2 degrees.

a. Where required by the code official, testing shall be conducted by an approved party. Hourly calculations as specified in the ASHRAE *Handbook of Fundamentals*, or the equivalent shall be used to determine the energy loads resulting from infiltration.

b. The combined air exchange rate for infiltration and mechanical ventilation shall be determined in accordance with Equation 43 of 2001 ASHRAE *Handbook of Fundamentals*, page 26.24 and the "Whole-house Ventilation" provisions of 2001 ASHRAE *Handbook of Fundamentals*, page 26.19 for intermittent mechanical ventilation.

c. Thermal storage element shall mean a component that is not part of the floors, walls or ceilings that is part of a passive solar system, and that provides thermal storage such as enclosed water columns, rock beds, or phase-change containers. A thermal storage element shall be in the same room as fenestration that faces within 0.26 rad (15 degrees) of true south, or shall be connected to such a room with pipes or ducts that allow the element to be actively charged.

d. For a proposed design with multiple heating, cooling or water heating systems using different fuel types, the applicable standard reference design system capacities and fuel types shall be weighted in accordance with their respective loads as calculated by accepted engineering practice for each equipment and fuel type present.

e. For a proposed design without a proposed heating system, a heating system having the prevailing federal minimum efficiency shall be assumed for both the standard reference design and proposed design.

f. For a proposed design home without a proposed cooling system, an electric air conditioner having the prevailing federal minimum efficiency shall be assumed for both the standard reference design and the proposed design.

g. For a proposed design with a nonstorage-type water heater, a 151 L (40-gallon) storage-type water heater having the prevailing federal minimum energy factor for the same fuel as the predominant heating fuel type shall be assumed. For a proposed design without a proposed water heater, a 151 L (40-gallon) storage-type water heater having the prevailing federal minimum efficiency for the same fuel as the predominant heating fuel type shall be assumed for both the proposed design and standard reference design.

h. For residences with conditioned basements, R-2 and R-4 residences, and townhouses, the following formula shall be used to determine glazing area:

$AF = A_s \times FA \times F$

where:

AF = Total glazing area.

A_s = Standard reference design total glazing area.

FA = (Above-grade thermal boundary gross wall area)/(above-grade boundary wall area + 0.5 × below-grade boundary wall area).

F = (above-grade thermal boundary wall area)/(above-grade thermal boundary wall area + common wall area) or 0.56, whichever is greater, and where:

Thermal boundary wall is any wall that separates conditioned space from unconditioned space or ambient conditions.

Above-grade thermal boundary wall is any thermal boundary wall component not in contact with soil.

Below-grade boundary wall is any thermal boundary wall in soil contact.

Common wall area is the area of walls shared with an adjoining dwelling unit. L and CFA are in the same units.

TABLE R405.5.2(2)
DEFAULT DISTRIBUTION SYSTEM EFFICIENCIES FOR PROPOSED DESIGNS[a]

DISTRIBUTION SYSTEM CONFIGURATION AND CONDITION	FORCED AIR SYSTEMS	HYDRONIC SYSTEMS[b]
Distribution system components located in unconditioned space	—	0.95
Untested distribution systems entirely located in conditioned space[c]	0.88	1
"Ductless" systems[d]	1	—

For IP: 1 L/s = 2.12 cubic foot per minute, 1 m² = 10,76 square foot, 1 Pa = 0.00045 psi, 1 Pa = 0.004 inch water gauge.

a. Default values in this table are for untested distribution systems, which must still meet minimum requirements for duct system insulation.

b. Hydronic systems shall mean those systems that distribute heating and cooling energy directly to individual spaces using liquids pumped through closed-loop piping and that do not depend on ducted, forced airflow to maintain space temperatures.

c. Entire system in conditioned space shall mean that no component of the distribution system, including the air-handler unit, is located outside of the conditioned space.

d. Ductless systems shall be allowed to have forced airflow across a coil but shall not have any ducted airflow external to the manufacturer's air-handler enclosure.

TABLE R402.2.6
STEEL-FRAME CEILING, WALL AND FLOOR INSULATION (*R*-VALUE)

WOOD FRAME *R*-VALUE REQUIREMENT		COLD-FORMED STEEL EQUIVALENT *R*-VALUE[a]	
(m² • K)/W	(h • ft² • °F/Btu)	(m² • K)/W	(h • ft² • °F/Btu)
Steel Truss Ceilings[b]			
R-5.3	R-30	R-6.7 or R-5.3 + 0.5 or R-4.6 + 0.9	R-38 or R-30 + 3 or R-26 + 5

R-6.7	R-38	R-8.6 or R-6.7 + 0.5	R-49 or R-38 + 3
R-8.6	R-49	R-6.7 + 0.9	R-38 + 5
Steel Joist Ceilings[b]			
R-5.3	R-30	R-6.7 in 51 × 102 or 51 × 152 or 51 × 203 R-8.6	R-38 in 2 × 4 or 2 × 6 or 2 × 8 R-49
		in any framing	in any framing
R-6.7	R-38	R-8.6 in 51 × 102 or 51 × 152 or 51 × 203 or 51 × 254	R-49 in 2 × 4 or 2 × 6 or 2 × 8 or 2 × 10
Steel-Framed Wall, 406 mm (16") on center			
R-2.3	R-13	R-2.3 + 0.7 or R-3.3 + 0.4 or R-3.7 + 0.5 or R-0 + 1.6 or R-2.6 + 0.7 or R-3.7 + 0.5	R-13 + 4.2 or R-19 + 2.1 or R-21 + 2.8 or R-0 + 9.3 or R-15 + 3.8 or R-21 + 3.1
R-2.3 + 0.5	R-13 + 3	R-0 + 2.0 or R-2.3 + 1.1 or R-2.6 + 1.0 or R-3.3 + 0.9 or R-3.7 + 0.8	R-0 + 11.2 or R-13 + 6.1 or R-15 + 5.7 or R-19 + 5.0 or R-21 + 4.7
R-3.5	R-20	R-0 + 2.5 or R-2.3 + 1.6 or R-2.6 + 1.5 or R-3.3 + 1.4 or R-3.3 + 1.1 or R-3.7 + 1.3	R-0 + 14.0 or R-13 + 8.9 or R-15 + 8.5 or R-19 + 7.8 or R-19 + 6.2 or R-21 + 7.5
R-3.5 + 0.9	R-20 + 5	R-2.3 + 2.2 or R-2.6 + 2.2 or R-3.3 + 2.0 or R-3.7 + 2.0 or R-4.4 + 1.9	R-13 + 12.7 or R-15 + 12.3 or R-19 + 11.6 or R-21 + 11.3 or R-25 + 10.9
R-3.7	R-21	R-0 + 2.6 or R-2.3 + 1.7 or R-2.6 + 1.6 or R-3.3 + 1.5 or R-3.7 + 1.4 or R-4.4 + 1.4	R-0 + 14.6 or R-13 + 9.5 or R-15 + 9.1 or R-19 + 8.4 or R-21 + 8.1 or R-25 + 7.7
Steel Framed Wall, 601 mm (24") on center			
R-2.3	R-13	R-0 + 1.6 or R-2.3 + 0.5 or R-2.6 + 0.4	R-0 + 9.3 or R-13 + 3.0 or R-15 + 2.4
R-2.3 + 0.5	R-13 + 3	R-0 + 2.0 or R-2.3 + 0.9 or R-2.6 + 0.8 or R-3.3 + 0.6 or R-3.7 + 0.5	R-0 + 11.2 or R-13 + 4.9 or R-15 + 4.3 or R-19 + 3.5 or R-21 + 3.1
R-3.5	R-20	R-0 + 2.5 or R-2.3 + 1.4 or R-2.6 + 1.3 or R-3.3 + 1.1 or R-3.7 + 1.1	R-0 + 14.0 or R-13 + 7.7 or R-15 + 7.1 or R-19 + 6.3 or R-21 + 5.9
R-3.5 + 0.9	R-20 + 5	R-2.3 + 2.0 or R-2.6 + 1.9 or R-3.3 + 1.8 or R-3.7 + 1.7 or R-4.4 + 1.6	R-13 + 11.5 or R-15 + 10.9 or R-19 + 10.1 or R-21 + 9.7 or R-25 + 9.1
R-3.7	R-21	R-0 + 2.6 or R-2.3 + 2.6 or R-2.6 + 1.4 or R-3.3 + 1.2 or R-3.7 + 1.1 or R-4.4 + 1.0	R-0 + 14.6 or R-13 + 8.3 or R-15 + 7.7 or R-19 + 6.9 or R-21 + 6.5 or R-25 + 5.9
Steel Joist Floor			
R-2.3	R-13	R-3.3 in 51 × 152, or R-3.3 + 1 in 51 × 203 or 51 × 254	R-19 in 2 × 6, or R-19 + 6 in 2 × 8 or 2 × 10
R-3.3	R-19	R-3.3 + 1.1 in 51 × 152, or R-3.3 + 2.1 in 51 × 203 or 51 × 254	R-19 + 6 in 2 × 6, or R-19 + 12 in 2 × 8 or 2 × 10

a. Cavity insulation R-value is listed first, followed by continuous insulation R-value.
b. Insulation exceeding the height of the framing shall cover the framing.

CHAPTER 5 [RE]

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 R501
GENERAL

R501.1 Scope. The provisions of this chapter shall control the *alteration*, *repair*, *addition* and change of occupancy of existing *buildings* and structures.

R501.1.1 Additions, alterations, or repairs: General. *Additions*, *alterations*, or *repairs* to an existing *building*, *building* system or portion thereof shall comply with Section R502, R503 or R504. Unaltered portions of the existing *building* or *building* supply system shall not be required to comply with this code.

R501.2 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.

R501.3 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 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.

R501.4 Compliance. *Alterations*, *repairs*, *additions* and changes of occupancy to, or relocation of, existing *buildings* and structures shall comply with the provisions for *alterations*, *repairs*, *additions* and changes of occupancy or relocation, respectively, in this code and the *International Residential Code*, *International Building Code*, *International Existing Building Code*, *International Fire Code*, *International Fuel Gas Code*, *International Mechanical Code*, *International Plumbing Code*, *International Property Maintenance Code*, *International Private Sewage Disposal Code* and NFPA 70.

R501.5 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 their use in *buildings* of similar occupancy, purpose and location.

R501.6 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 report has been submitted to the *code official* and signed by the owner, 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*.

SECTION R502
ADDITIONS

R502.1 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 where the *addition* alone complies, where the existing *building* and *addition* comply with this code as a single *building*, or where the *building* with the *addition* does not use more energy than the existing *building*. *Additions* shall be in accordance with Section R502.1.1 or R502.1.2.

R502.1.1 Prescriptive compliance. *Additions* shall comply with Sections R502.1.1.1 through R502.1.1.4.

R502.1.1.1 Building envelope. New *building* envelope assemblies that are part of the *addition* shall comply with Sections R402.1, R402.2, R402.3.1 through R402.3.5, and R402.4.

Exception: Where *unconditioned space* is changed to *conditioned space*, the *building* envelope of the addition shall comply where the Total UA, as determined in Section R402.1.5, of the existing *building* and the *addition*, and any *alterations* that are part of the project, is less than or equal to the Total UA generated for the existing *building*.

R502.1.1.2 Heating and cooling systems. New heating, cooling and duct systems that are part of the *addition* shall comply with Section R403.

Exception: Where ducts from an existing heating and cooling system are extended to an *addition*, duct systems with less than 12.19 linear m (40 ft) in unconditioned spaces shall not be required to be tested in accordance with Section R403.3.3.

R502.1.1.3 Service hot water systems. New service hot water systems that are part of the *addition* shall comply with Section R403.5.

R502.1.1.4 Lighting. New lighting systems that are part of the *addition* shall comply with Section R404.1.

R502.1.2 Existing plus addition compliance (Simulated Performance Alternative). Where *unconditioned space* is changed to *conditioned space*, the *addition* shall comply where the annual energy cost or energy use of the *addition* and the existing *building*, and any *alterations* that are part of the project, is less than or equal to the annual energy cost of the existing *building* when modeled in accordance with Section R405. The *addition* and any *alterations* that are part of the project shall comply with Section R405 in its entirety.

SECTION R503
ALTERATIONS

R503.1 General. *Alterations* to any *building* or structure shall comply with the requirements of 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 they 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* shall be such that the existing *building* or structure does not use more energy than the existing *building* or structure prior to the *alteration*. *Alterations* to existing *buildings* shall comply with Sections R503.1.1 through R503.2.

R503.1.1 Building envelope. *Building* envelope assemblies that are part of the *alteration* shall comply with Section R402.1.2 or R402.1.4, Sections R402.2.1 through R402.2.13, R402.3.1, R402.3.2, R402.4.3 and R402.4.5.

Exception: The following *alterations* shall not be required to 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. Existing ceiling, wall or floor cavities exposed during construction provided that these cavities are filled with insulation.
3. Construction where the existing roof, wall or floor cavity is not exposed.
4. Roof re-cover.
5. Roofs without insulation in the cavity and where the sheathing or insulation is exposed during reroofing shall be insulated either above or below the sheathing.
6. Surface-applied window film installed on existing single pane fenestration assemblies to reduce solar heat gain provided that the code does not require the glazing or fenestration assembly to be replaced.

R503.1.1.1 Replacement fenestration. 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 as specified Table R402.1.2. Where more than one replacement *fenestration* unit is to be installed, an area-weighted average of the *U*-factor, SHGC or both of all replacement *fenestration* units shall be an alternative that can be used to show compliance.

R503.1.2 Heating and cooling systems. New heating, cooling and duct systems that are part of the *alteration* shall comply with Section R403.

Exception: Where ducts from an existing heating and cooling system are extended, duct systems with less than 12.19 lin m (40 ft) in *unconditioned spaces* shall not be required to be tested in accordance with Section R403.3.3.

R503.1.3 Service hot water systems. New service hot water systems that are part of the *alteration* shall comply with Section R403.5.

R503.1.4 Lighting. New lighting systems that are part of the *alteration* shall comply with Section R404.1.

Exception: *Alterations* that replace less than 50 percent of the luminaires in a space, provided that such *alterations* do not increase the installed interior lighting power.

R503.2 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 simulated performance option in Section R405 is used to comply with this section, the annual energy cost of the *proposed design* is permitted to be 110 percent of the annual energy cost otherwise allowed by Section R405.3.

SECTION R504
REPAIRS

R504.1 General. *Buildings*, structures and parts thereof shall be repaired in compliance with Section R501.3 and this section. Work on nondamaged components 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 R501.3, 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.

R504.2 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. *Repairs* where only the bulb, 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 R505
CHANGE OF OCCUPANCY OR USE

R505.1 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.

R505.2 General. Any space that is converted to a dwelling unit or portion thereof from another use or occupancy shall comply with this code.

Exception: Where the simulated performance option in Section R405 is used to comply with this section, the annual energy cost of the *proposed design* is permitted to be 110 percent of the annual energy cost allowed by Section R405.3.

CHAPTER 6 [RE]

REFERENCED STANDARDS

User note:

***About this chapter**: This code contains numerous references to standards promulgated by other organizations that are used to provide requirements for materials and methods of construction. Chapter 6 contains a comprehensive list of all standards that are referenced in this code. These standards, in essence, are part of this code to the extent of the reference to the standard.*

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 R107.

AAMA

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

AAMA/WDMA/CSA 101/I.S.2/A C440—17

North American Fenestration Standard/Specifications for Windows, Doors and Unit Skylights
R402.4.3

ACCA

Air Conditioning Contractors of America
2800 Shirlington Road, Suite 300
Arlington, VA 22206

Manual J—16

Residential Load Calculation Eighth Edition
R403.7

Manual S—14

Residential Equipment Selection
R403.7

APSP

The Association of Pool & Spa Professionals
2111 Eisenhower Avenue, Suite 500
Alexandria, VA 22314

ANSI/APSP/ICC 14—2014

American National Standard for Portable Electric Spa Energy Efficiency
R403.11

ANSI/APSP/ICC 15a—2011

American National Standard for Residential Swimming Pool and Spa Energy Efficiency—includes Addenda A Approved January 9, 2013
R403.12

ASHRAE

ASHRAE
1791 Tullie Circle NE
Atlanta, GA 30329

ASHRAE—2017

ASHRAE Handbook of Fundamentals
R402.1.5

ASHRAE—2001

2001 ASHRAE Handbook of Fundamentals
Table R405.5.2(1)

ASHRAE 169—2013

Climate Data for Building Design Standards
Table R301.3.2

ASHRAE 193—2010(RA 2014)

Method of Test for Determining the Airtightness of HVAC Equipment
R403.3.2.1

ASTM

ASTM International
100 Barr Harbor Drive, P.O. Box C700
West Conshohocken, PA 19428-2959

C1363—11

Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus
R303.1.4.1

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
R402.4.5

E779—10

Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
R402.4.1.2

E1827—11

Standard Test Methods for Determining Airtightness of Building Using an Orifice Blower Door
R402.4.1.2

CSA

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

AAMA/WDMA/CSA 101/I.S.2/A440—17

North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights
R402.4.3

CSA B55.1—2015

Test Method for Measuring Efficiency and Pressure Loss of Drain Water Heat Recovery Units
R403.5.4

CSA B55.2—2015

Drain Water Heat Recovery Units
R403.5.4

DASMA

Door & Access Systems Manufacturers Association
1300 Sumner Avenue
Cleveland, OH 44115-2851

105—2016

Test Method for Thermal Transmittance and Air Infiltration of Garage Doors and Rolling Doors
R303.1.3

HVI

Home Ventilating Institute
1000 North Rand Road, Suite 214
Wauconda, IL 60084

916—09

Airflow Test Procedure
Table R403.6.1

ICC

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

ANSI/APSP/ICC 14—2014

American National Standard for Portable Electric Spa Energy Efficiency
R403.11

ANSI/APSP/ICC 15a—2011

American National Standard for Residential Swimming Pool and Spa Energy Efficiency—includes Addenda A Approved January 9, 2013
R403.12

IBC—18

International Building Code®
R201.3, R303.1.1, R303.2, R402.1.1, R501.4

ICC 400—17

Standard on the Design and Construction of Log Structures
R402.1, Table R402.5.1.1

ICC—continued

ICC 900/SRCC 300—2015

Solar Thermal System Standard
R403.5.6.2.1

ICC 901/SRCC 100—2015

Solar Thermal Collector Standard
R403.5.6.2.1

ICC 902/APSP 902/SRCC 400—2017

Solar Pool and Spa Heating System Standard
R403.10.6

ICC-SRCC OG 300—2017

Solar Thermal System Certification Program
R403.5.6.2.1

IEBC—18

International Existing Building Code®
R501.4

IECC—18

International Energy Conservation Code®
R101.4.1, R403.8

IECC—15

2015 International Energy Conservation Code®
Table R406.4

IECC—09

2009 International Energy Conservation Code®
R406.2

IECC—06

2006 International Energy Conservation Code®
R202

IFC—18

International Fire Code®
R201.3, R501.4

IFGC—18

International Fuel Gas Code®
R201.3, R501.4

IMC—18

International Mechanical Code®
R201.3, R403.3.2, R403.3.6, R403.6, R501.4

IPC—18

International Plumbing Code®
R201.3, R501.4

IPSDC—18

International Private Sewage Disposal Code®
R501.4

IPMC—18

International Property Maintenance Code®
R501.4

IRC—18

International Residential Code®
R201.3, R303.1.1, R303.2, R402.1.1, R402.2.11, R403.3.2, R403.3.6, R403.6, R501.4

ANSI/RESNET/ICC 301—2014

Standard for the Calculation and Labeling of the Energy Performance of Low-rise Residential Buildings using an Energy Rating Index First Published March 7, 2014—Republished January 2016
R406.3

ANSI/RESNET/ICC 380—2016

Standard for Testing Airtightness for Building Enclosures, Airtightness of Heating and Cooling Air Distribution Systems and Airflow of Mechanical Ventilation Systems—Republished January 2016
R402.4.1.2

IEEE

Institute of Electrical and Electronic Engineers, Inc.
3 Park Avenue, 17th Floor
New York, NY 10016-5997

515.1—2012

IEEE Standard for the Testing, Design, Installation and Maintenance of Electrical Resistance Trace Heating for Commercial Applications
R403.5.1.2

NFPA

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

70—17

National Electrical Code
R501.4

NFRC

National Fenestration Rating Council, Inc.
6305 Ivy Lane, Suite 140
Greenbelt, MD 20770

100—2017

Procedure for Determining Fenestration Products *U*-factors
R303.1.3

200—2017

Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence
R303.1.3

400—2017

Procedure for Determining Fenestration Product Air Leakage
R402.4.3

RESNET

Residential Energy Services Network, Inc.
P.O. Box 4561
Oceanside, CA 92052-4561

ANSI/RESNET/ICC 301—2014

Standard for the Calculation and Labeling of the Energy Performance of Low-rise Residential Buildings using an Energy Rating Index First Published March 7, 2014—Republished January 2016
R406.3, R406.6.1, R406.6.5

ANSI/RESNET/ICC 380—2016

Standard for Testing Airtightness for Building Enclosures, Airtightness of Heating and Cooling Air Distribution Systems, and Airflow of Mechanical Ventilation Systems—Republished January 2016

R402.4.1.2

UL

UL LLC
333 Pfingsten Road
Northbrook, IL 60062

127—11

Standard for Factory Built Fireplaces—with Revisions through May 2015
R402.4.2

515—11

Electrical Resistance Heat Tracing for Commercial and Industrial Applications Including Revisions through July 2015
R403.5.1.2

US-FTC

United States-Federal Trade Commission
600 Pennsylvania Avenue NW
Washington, DC 20580

CFR Title 16 (2015)

R-value Rule
R303.1.4

WDMA

Window and Door Manufacturers Association
2025 M Street NW, Suite 800
Washington, DC 20036-3309

AAMA/WDMA/CSA 101/I.S.2/A440—17

North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights
R402.4.3

APPENDIX RA

SOLAR-READY PROVISIONS—DETACHED ONE- AND TWO-FAMILY DWELLINGS AND TOWNHOUSES

The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.

User note:

About this appendix: *Harnessing the heat or radiation from the sun's rays is a method to reduce the energy consumption of a building. Although Appendix RA does not require solar systems to be installed for a building, it does require the space(s) for installing such systems, providing pathways for connections and requiring adequate structural capacity of roof systems to support the systems.*

SECTION RA101
SCOPE

RA101.1 General. These provisions shall be applicable for new construction.

SECTION RA102
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 RA103
SOLAR-READY ZONE

RA103.1 General. New detached one- and two-family dwellings, and townhouses with not less than 55.74 m^2 (600 ft^2) of roof area oriented between 110 degrees and 270 degrees of true north shall comply with Sections RA103.2 through RA103.8.

Exceptions:

1. New residential buildings 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. Section of building's roof designated for use of fire escape/s

RA103.2 Construction document requirements for solar- ready zone. Construction documents shall indicate the solar-ready zone.

RA103.3 Solar-ready zone area. The total solar-ready zone area shall be not less than 27.87 m^2 (300 ft^2) exclusive of mandatory access or set back areas as required by the *International Fire Code*. New townhouses three stories or less in height above grade plane and with a total floor area less than or equal to 185.8 m^2 (2000 ft^2) per dwelling shall have a solar-ready zone area of not less than 13.94 m^2 (150 ft^2). The solar-ready zone shall be composed of areas not less than 1524 mm (5 ft) in width and not less than 7.44 m^2 (80 ft^2) exclusive of access or set back areas as required by the *International Fire Code*.

RA103.4 Obstructions. Solar-ready zones shall be free from obstructions, including but not limited to vents, chimneys, and roof-mounted equipment.

RA103.5 Roof load documentation. The structural design loads for roof dead load and roof live load shall be clearly indicated on the construction documents.

RA103.6 Interconnection pathway. Construction documents shall indicate pathways for routing of conduit or plumbing from the solar-ready zone to the electrical service panel or service hot water system.

RA103.7 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 opposite (load) end from the input feeder location or main circuit location.

RA103.8 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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