

**CITY OF BOULDER  
PLANNING BOARD AGENDA ITEM**

**MEETING DATE: December 15, 2016**

**AGENDA TITLE:** Recommendation to City Council on a proposed ordinance amending Section 9-9-12, "Landscaping and Screening Standards," and Chapters 10-5.5, 10-6, 10-7, 10-7.5, 10-10 of Title 10, "Structures," B.R.C. 1981, to revise the energy conservation and green building requirements for construction projects, repealing the International Energy Conservation Code and adopting by reference the "2017 City of Boulder Energy Conservation Code," and setting forth related details.

**REQUESTING DEPARTMENT:**

Planning, Housing + Sustainability and Public Works  
Maureen Rait, Executive Director of Public Works  
David Driskell, Executive Director of Planning, Housing + Sustainability  
Hella Pannewig, Assistant City Attorney  
Dave Thacker, Building Services Manager/Chief Building Official  
Kendra Tupper, Energy Services Manager  
Elizabeth Vasatka, Business Sustainability Coordinator

**OBJECTIVE:**

Define the steps for Planning Board consideration of this request:

1. Hear staff presentation
2. Public Hearing
3. Planning Board discussion
4. Planning Board recommendation to council

**SUMMARY**

This memo outlines the long-term strategy for Boulder's energy codes and proposed updates for the next building and energy code update. Staff has provided an outline of the long-term strategy ([Attachment A](#)) for context and is seeking a recommendation to council from the Planning Board on the proposed changes to the city's energy conservation and green building requirements for new buildings and additions and alterations to existing buildings, including updates to the landscaping and screening standards of Section 9-9-12, B.R.C. 1981.

**Proposed Updates**

Staff has developed proposed updates to the building and energy codes, which is scheduled for City Council consideration and adoption in Q1 2017. The proposed effective date of these changes is scheduled for Q2 2017.

Proposed building and energy code updates include:

1. Adoption of the 2017 City of Boulder Energy Conservation Code (CBECC), which is based on the current adopted code, International Energy Conservation Code (IECC) 2012, but is significantly amended.
2. Restructuring and updating the existing residential energy code, Green Building and Green Points ([link to the current Green Building and Green Points program](#)), within the new CBECC.
3. Revisions to Title 9, incorporating single family residential landscaping requirements.
4. Revised prescriptive energy code requirements and new requirements for alterations for commercial buildings.
5. Requirements for new commercial and residential buildings to have electric vehicle charging infrastructure and be solar-ready for the installation of future photovoltaic systems.
6. Other miscellaneous updates include: adding new radon mitigation requirements, revising how multi-family buildings are addressed and allowing off-site renewable energy for residential energy code compliance.

### **Summary of Long-Term Strategy ([Attachment A](#))**

The City of Boulder has set an aggressive goal of reaching net zero energy (NZE) construction through building and energy codes by 2031, and has developed a strategy and pathway to achieve that target. These proposed updates represent a key step along this pathway.

Staff recognizes that in order to support the city's [Climate Commitment](#) and sustainability goals, energy codes must begin to address sustainability beyond just energy use, such as transportation, water, indoor environmental quality and waste. In fact, when staff projected emissions reductions out to 2050, savings from the implementation of progressively more stringent energy codes was the largest of any building efficiency program, including [EnergySmart](#), [SmartRegs](#) and the [Building Performance Program](#).

Proposed elements of the long-term strategy for energy codes include:

1. A phased schedule for NZE deadlines
2. Early adopter incentives
3. Allowance of off-site renewables
4. Future adoption of outcome-based codes
5. The encouragement of all-electric buildings
6. A six-year national code adoption cycle for major updates with a three-year cycle for local evaluation and key amendments.
7. The prioritization and phase-in schedule of non-energy sustainability requirements for commercial energy codes aligned with the International Green Construction Code (IgCC)

## **BACKGROUND**

Please refer to **Attachment B** for an overview of energy and green codes. This attachment provides background information on national energy and green codes, definitions of key terms that are used throughout this memo, and brief history of Boulder's energy codes.

### **Goals and Objectives of the City's Energy Codes**

The overall long-term goal for the city's energy code<sup>1</sup> is to build high performance, NZE residential and commercial buildings. The objectives below are designed to support this overarching goal:

#### Supporting the City's Climate Commitment

- To achieve and sustain significant greenhouse gas (GHG) reductions
- To design and adopt NZE codes for all building types by 2031
- To support technologies and practices that will move the community towards local, distributed and renewable energy systems (for both buildings and transportation) that support the goal of 100 percent renewable electricity, economic vitality and community resilience

#### Promoting High Performance Buildings

- To promote sustainable building practices throughout the lifecycle of the building process (e.g., waste management, water management, transportation impacts, etc.)
- To promote the development and ongoing maintenance of safe, comfortable and high-performing buildings
- To support energy resilience (the ability to maintain operations during grid failure)

#### Creating Effective and Viable Codes

- To adopt codes that are feasible (e.g., updated regularly, implementable and enforceable)
- To provide building owners and design professionals with viable and economically feasible paths to comply with energy codes that are straightforward and easy to understand

### **What is Net Zero Energy (NZE)?**

While NZE can be defined several ways, in this context, NZE means:

*The amount of renewable energy produced on site, plus the amount purchased from approved community energy systems, is equal to or greater than the annual energy consumption of the site.*

This definition makes it possible for all buildings to become NZE even with poor solar access or other site constraints.

Current conversations among experts and advocates at the national level have introduced alternative terminology, including terms such as "net zero carbon" codes and "net zero emissions" codes. Staff is engaged in these conversations and may propose updated terminology in future updates.

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<sup>1</sup> While the majority of this is addressed within the energy code itself, some key components such as waste, water, and transportation impacts are covered in applicable sections of the International Building Code (IBC) or International Residential Code (IRC).

## **ANALYSIS**

As the city evaluates and updates its energy codes every three years, staff has gathered stakeholder feedback on some of the challenges related to compliance with current energy codes. Staff has drafted updates based on the feedback received and will present them to council for adoption in early 2017, with a mid-2017 effective date. Specifically, staff proposes the following building and energy code amendments and updates, explained in more detail below:

- 1) New Energy Code Format
- 2) Residential Energy and Building Code Updates
- 3) Commercial Energy and Building Code Updates

Please see [Attachment C](#) for an analysis of the potential cost impacts for these planned amendments.

In addition, staff plans to improve the energy code compliance process by streamlining processes and providing more consistent and detailed guidance. Please see the [July 19, 2016 Information Packet Memo](#) (Attachment G) for a summary of the scope and intended outcomes of this compliance improvement effort. Staff also plans to make a few administrative updates to clarify common points of confusion, such as how to measure square footage.

### **Proposed New Energy Code Format**

Currently, Boulder has adopted the IECC 2012 as its energy code and has amended the requirements in the Boulder Revised Code (BRC). This requires users of the energy code to first reference the IECC 2012 and then cross-reference the BRC amendments to identify differences. Feedback from customers and staff indicates that this cross-referencing creates confusion. A unified code, with all the information in one place, would increase usability and decrease error.

Because of the large number of amendments being proposed for this round, staff recommends that the city adopt a stand-alone City of Boulder Energy Conservation Code (CBECC) that is based on IECC 2012, but that incorporates the needed changes. The city will work with the International Code Council (ICC) to create this custom code and to license the use of the IECC 2012 as the basis for this code. Under this scenario, the BRC would simply reference and link to the CBECC, which could be downloaded or printed as a standalone document.

### **Proposed Residential Energy and Building Code Updates**

- 1) Eliminate the point structure in the Green Building and Green Points program, and prioritize and update key sustainability measures as mandatory (see Table 1).

**Table 1: Proposed Changes to the Current Green Building and Green Points Program**

<b>Requirements</b>	<b>Current Requirements</b>	<b>Proposed Requirements</b>	<b>Location of Requirements</b>
<b>Energy Performance<sup>1</sup></b>	ERI/HERs	ERI/HERs	City of Boulder ECC
<b>Waste Management</b>	Mandatory	Mandatory	IRC

<b>Landscaping:</b> Require shading from existing and new trees; water conservation and Xeriscape landscape practices; and stormwater management <sup>3</sup>	Optional point	Mandatory <sup>2</sup>	Title 9-9-12
<b>Solar Photovoltaic “Ready:”</b> Pre-wire for solar PV and a space allocation roof plan	Optional point	Mandatory	IRC
<b>Electric Vehicle Charging Infrastructure:</b> Require the installation of both 120-Volt and 240-Volt charging outlets in any dedicated off-street parking space for single family homes and townhomes. For multi-family units, require charging infrastructure (120 and 240 V outlets) for 10 percent of the parking spaces, and require Level 2 dual port charging stations for at least one space. <sup>3</sup>	NA	Mandatory (NEW)	IRC
<b>Water Efficiency:</b> High efficiency kitchen and bathroom fixtures	Optional point	Mandatory <sup>4</sup>	IRC
<b>Sustainable Products:</b> Require the use of re-used, recycled, bio-based, environmentally certified or locally sources materials	Optional point	Not required	NA
<b>Solar Thermal “Ready”:</b> Require solar thermal systems <sup>2</sup> to heat hot water (water heating, space heating and/or pools and spas)	Optional point	Not required	NA
<b>Material Efficient Framing:</b> Require efficient use of lumber and methods to frame a house and design the structure	Optional point	Not required	NA
<b>Indoor Air Quality:</b> Require means of detecting, reducing and mitigating indoor air pollutants	Optional point		
<b>Design Process and Education:</b> Require green building design professionals and an owner manual for efficient operation	Optional point		
<sup>1</sup> Updated for both new construction (Figure 1) and additions. <sup>2</sup> A landscape plan is required for new construction and specific valuation thresholds for additions and/or remodels must be submittal with a building permit. <sup>3</sup> This requirement is only triggered when there are at least 25 parking spaces. <sup>4</sup> Staff will increase the current requirements in the International Residential Code (IRC) to match the current national EPA’s <a href="#">WaterSense Standards</a>			

The justification for not making the following optional points mandatory is as follows:

- **Sustainable Products:** The city’s efforts to transform the market, including voluntary encouragement and the incorporation of this into the Green Points requirements have led to the use of these products being standard practice for building professionals to use these materials and products in residential construction in Boulder.
- **Solar Thermal “Ready”:** Instead of encouraging solar thermal systems, the city would like to encourage all electric homes with highly efficient electric water heaters powered by solar electric (photovoltaic) systems. This system setup (solar PV with electric water heaters) has been proven

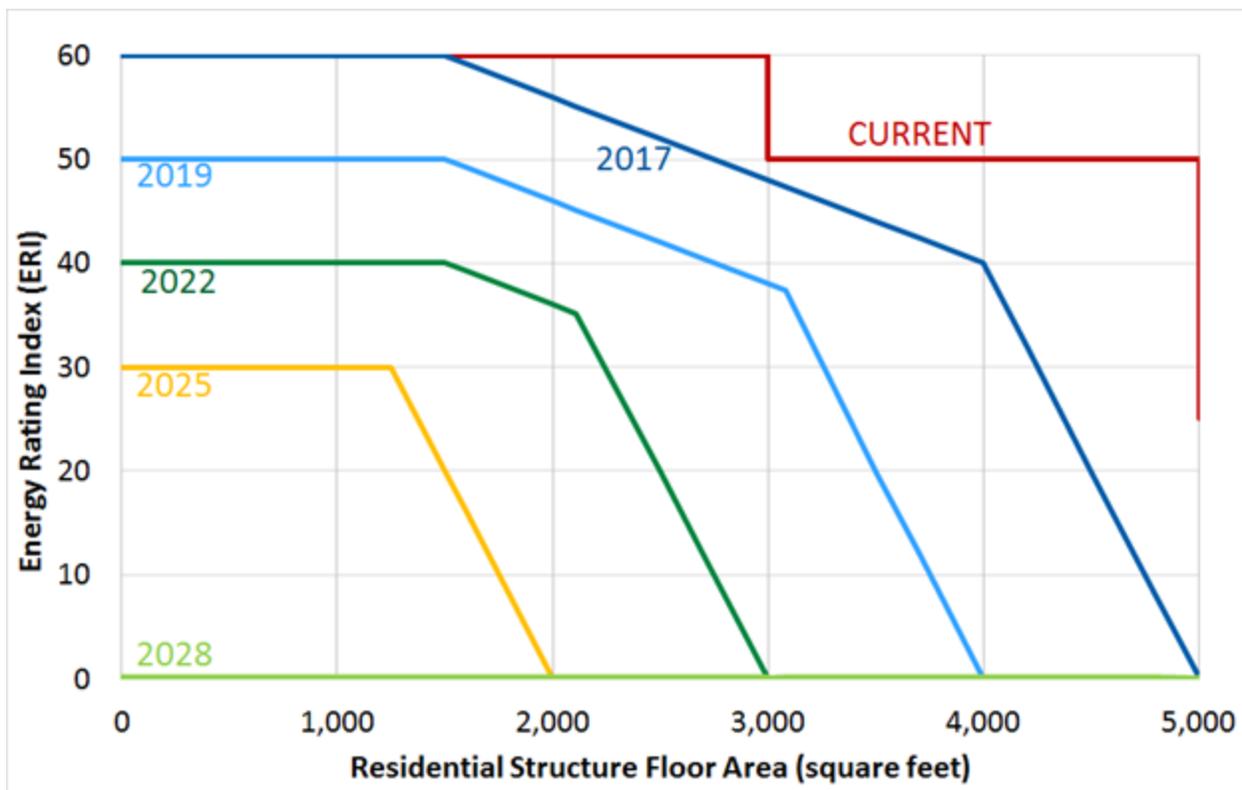
<sup>2</sup> Rooftop solar collectors that directly heat water which is stored in a thermal storage tank. These systems usually have a backup heating source which can either be a natural gas or electric water heater.

to have less maintenance issues than solar thermal systems and can have a better rate of return when solar PV incentives are considered.

- Material Efficient Framing, Indoor Air Quality, and Design Process and Evaluation: An updated HERS rating software will be released in the near future, which will incorporate these sustainability attributes. The design manual will remain a requirement.

2) Implement a sliding Energy Rating Index (ERI, same as the existing HERS<sup>3</sup> rating) scale based on floor area which will require new residential buildings larger than 5,000 square feet (sf) to be NZE. The table below illustrates how subsequent code updates will increase the NZE requirement (to 4,000 sf homes in 2019, and 3,000 sf homes in 2022, etc.) until all new residential structures will be NZE by 2028. This accelerated timeline of 2028 is partially based on the expectation that the electricity grid will have a much higher percentage of renewables by then, and that rooftop solar will have become even more affordable.

**Table 2: Proposed Changes to Efficiency Requirements for New Homes<sup>4</sup>**



It should be noted that Boulder County already requires new homes larger than 5,000 sf to be net zero energy. Further, Santa Monica, CA recently became the first city to require all new homes to be net zero. The long-term plan for California’s state energy code, Title 24, is to require net zero for all new residential construction, including low-rise multi-family, by 2020.

<sup>3</sup> Home Energy Rating System (HERS), the RESNET rating scale of energy efficiency, which is equivalent to the International Energy Conservation Code (IECC) nonproprietary rating scale of Energy Rating Index (ERI).

<sup>4</sup> The potential evolution of these requirements in future years is shown for illustrative purposes only. Staff is only proposing the 2017 line in this set of code updates.

- 3) Revise the ERI requirements for additions to impose more efficient requirements for larger homes and the additions being proposed. ERI requirements for additions will only apply if the addition is 1,000 sf or larger. Additions smaller than 1,000 sf will be required to meet the prescriptive requirements of the 2012 International Energy Conservation Code (IECC). The table below summarizes the ERI requirements for additions, but is illustrative only as it does not show the applicable ERI for all possible scenarios.<sup>5</sup>

**Table 3: Summary Tables of Proposed ERI Requirements for Existing Homes to Which an Addition is Added (Illustrative Only)**

		Percent of Increase in Square Footage																			
		5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
<b>Total Proposed Square Footage</b>	1000	95	91	87	83	79	79	78	78	77	77	76	76	75	75	74	73	73	72	71	70
	1250	91	87	83	79	75	75	74	74	73	73	72	72	71	71	70	69	69	68	67	66
	1500	87	83	79	75	71	71	70	70	69	69	68	68	67	67	66	65	65	64	63	62
	1750	83	79	75	71	67	67	66	66	65	65	64	64	63	63	62	61	61	60	59	58
	2000	79	75	71	67	63	63	62	62	61	61	60	60	59	59	58	57	57	56	55	54
	2250	77	73	69	65	61	61	60	60	59	59	58	58	57	57	56	56	55	54	53	53
	2500	76	72	68	64	60	59	59	58	58	57	57	56	56	55	55	54	53	52	52	51
	2750	74	70	66	62	58	57	57	56	56	55	55	54	54	53	53	52	51	51	50	49
	3000	72	68	64	60	56	56	55	55	54	54	53	53	52	52	51	50	50	49	48	47
	3250	70	66	62	58	54	54	53	53	52	52	51	51	50	50	49	49	48	47	46	46
	3500	69	65	61	57	53	52	52	51	51	50	50	49	49	48	48	47	46	45	45	44
	3750	67	63	59	55	51	50	50	49	49	48	48	47	47	46	46	45	44	44	43	42
	4000	65	61	57	53	49	48	48	47	47	46	46	45	45	44	44	43	42	42	41	40
	4250	60	56	52	48	44	44	43	43	42	42	41	41	40	40	39	38	38	37	36	35
	4500	55	51	47	43	39	39	38	38	37	37	36	36	35	35	34	34	33	32	31	31
	4750	51	47	43	39	35	34	34	33	33	32	32	31	31	30	30	29	28	27	27	26
5000	46	42	38	34	30	29	29	28	28	27	27	26	26	25	25	24	23	23	22	21	

<sup>5</sup>The exact ERI requirements may be calculated using the new City of Boulder ERI Worksheet for Additions by entering the existing square footage and the square footage of the proposed addition. The City of Boulder ERI Worksheet for Additions will be available on the City of Boulder website when the code updates are adopted.

- 4) Revise alterations requirements as follows:
  - a) Eliminate the Green Building and Green Points program “point” options and the 500 sf threshold components of the residential code program. This will provide clarity and streamline the building permit process.
  - b) Change the metric for how alteration requirements are determined, from measured floor area to the percentage of the construction valuation<sup>6</sup> compared to the appraised value of the existing structure (see Table 4).
  - c) Require mandatory efficiency measures for all alterations, including energy advising, energy audits and new construction regulations (see Table 4).

**Table 4: Proposed Residential Energy Efficiency Requirements for Alterations and Repairs to Existing Buildings**

Thresholds for requirements	Construction valuation is $\leq 25\%$ of assessed value <sup>1</sup> of existing building	Construction valuation is 26-50% of assessed value <sup>1</sup> of existing building	Construction valuation is $\geq 51\%$ of assessed value <sup>1</sup> of existing building
<b>Requirements</b>	All energy and building code requirements (for the scope of the alteration)		
	Energy advising <sup>2</sup>	Energy assessment <sup>3</sup> and advising	Triggers new construction requirements
		Air sealing and insulation in ceiling and walls <sup>4</sup>	
		Crawl space insulation, vapor barrier, and ventilation <sup>4</sup>	
<p><sup>1</sup> Assessed value is obtained from Boulder County’s Tax Assessor Database.</p> <p><sup>2</sup> Homeowner must contact a qualified energy advisor, as defined by the city manager, and discuss the construction project to learn how efficiency opportunities can be maximized.</p> <p><sup>3</sup> Homeowner must obtain an energy assessment for the building from a qualified energy assessor, as defined by the city manager, before building permit application is submitted.</p> <p><sup>4</sup> When applicable shall meet the requirements in this code.</p>			

- 5) New Radon Mitigation requirements are intended to provide a passive means of resisting radon gas entry and prepare the dwelling for post-construction radon mitigation if necessary. This requirement will be for new construction only.
- 6) Due to shading and roof space constraints, off-site renewable energy will be required for some homes to meet the new, lower ERIs (especially for the larger homes required to have an ERI of 0). Off-site renewable options will only be allowed if all on-site renewable options have been exhausted. Participation in a verified community solar program<sup>7</sup>, but not Renewable Energy Certificates (RECs), will be allowed to meet required overall energy performance for new buildings and major alterations.

<sup>6</sup> Construction valuation will be based on the valuation table in the Boulder Revised Code (BRC 4-20-4(d)).

<sup>7</sup> Current Community Solar programs in Colorado offer two options: (a) a subscription based plan that can be cancelled at any time or (b) an option where you purchase a certain amount of solar panels. Only option (b) will be allowed for code compliance.

- 7) Revise the definition of residential buildings to only include single family homes, townhomes, duplexes, and R-3 and R-4 occupancy buildings (includes boarding and care facilities). Any mixed use or multifamily apartment or condo buildings, will be regulated under the commercial code.

**Proposed Commercial Energy and Building Code Updates**

- 1) The scope of the requirements for alterations will be based on the percent of the project cost to the assessed value of the building (see Table 5).

**Table 5: Requirements for Commercial Building Alterations**

Thresholds for requirements	Construction valuation is ≤25% of assessed value <sup>1</sup> of existing building	Construction valuation is 26-50% of assessed value <sup>1</sup> of existing building	Construction valuation is ≥51% of assessed value <sup>1</sup> of existing building
<b>Requirements</b>	All mandatory and prescriptive energy and building code requirements (for the scope of the alteration)	Shall have annual energy operating costs for the proposed design that are equal to or less than the standard reference design of Appendix G of ASHRAE 90.1-2010. <sup>2</sup>	Triggers new construction requirements <sup>2,3</sup>
<p><sup>1</sup> Assessed value is obtained from Boulder County’s Tax Assessor Database.</p> <p><sup>2</sup> These projects must demonstrate compliance through performance modeling which complies with all requirements of ASHRAE 90.1-2010 Appendix G, performed by a registered design professional.</p> <p><sup>3</sup> Shall have annual energy operating costs for the proposed design that are at least 30% less than the standard reference design of Appendix G of ASHRAE 90.1-2010.</p>			

The prescriptive pathway is better suited for smaller scope alterations. For larger scope alterations, performance modeling should be required and the stringency should increase with the scope of the alteration.

- 2) New prescriptive energy code requirements<sup>8</sup>

Revisions to the prescriptive path of Boulder’s commercial energy code are being proposed with the primary goal of improving usability and compliance while maintaining or increasing energy efficiency. While the performance pathway for new construction and major alterations must have an energy performance which is 30 percent better than IECC 2012, the prescriptive path is limited by market availability and construction and cost feasibility per individual requirement.

<sup>8</sup> A prescriptive code requires that each component is built to a certain standard, e.g., Wall R-value at least 20. A performance code requires that the whole building performs to a certain standard, shown through energy modeling.

The changes, and the related rationale, are described below.

**Table 6: Proposed Changes to Commercial Prescriptive Energy Requirements**

Proposed Change	Rationale
<p><b>When the Prescriptive Approach is Allowed:</b></p> <p>For new buildings and additions with a project cost less than \$500,000<sup>9</sup>, compliance using the prescriptive requirements will be allowed. Alterations which have a construction value of less than 25 percent of the assessed value of the building will be allowed to comply with the prescriptive requirements.</p>	<p>Performance approach compliance (whole building energy modeling) is designed for new construction and major alterations that must achieve the city’s energy requirement of 30 percent better than ASHRAE 90.1-2010. This requirement is so efficient that it requires the whole building tradeoffs allowed via the performance pathway.</p> <p>For smaller scope alterations, the prescriptive pathway is much better suited.</p>
<p><b>Revision of Prescriptive Requirements:</b></p> <p>The custom prescriptive pathway is being replaced with amendments to the IECC 2012 prescriptive path. These amendments will increase the stringency of IECC 2012 requirements up to what is allowed by federal regulations, or what is being proposed for the 2018 version of the International Green Conservation Code (IgCC). These changes address insulation levels, fenestration performance, lighting power, and equipment efficiency.</p>	<p>Current prescriptive requirements in the commercial energy code are extremely stringent, without the tradeoffs allowed through the modeling-based performance path. Overwhelming stakeholder feedback indicates that the requirements are confusing and extremely difficult, if not impossible, to achieve. Due to federal efficiency standards on equipment which limit how much efficiency can be required by local codes, no single improvement or upgrade can increase efficiency by 30 percent. These new prescriptive requirements will replace a complicated set of custom requirements. Simplification of prescriptive requirements that are based on nationally developed standards will improve compliance and simplify enforcement.</p>

- 3) Amendments to the energy code and International Building Code (IBC) to address requirements such as heating and cooling system shut off, electric vehicle charging infrastructure, and solar- ready buildings (see Table 7).

<sup>9</sup> A threshold of a project cost of \$500,000 was chosen as the limit for allowing the prescriptive path for new construction and additions based on the typical costs of energy modeling require for the performance and outcome based paths. This limit should keep the modeling costs to below 2.5 percent of the total project cost.

**Table 7: Proposed Changes Amendments to Energy Code and IBC**

Proposed Change	Rationale
<p><b>Operable Window/Door Shut Off:</b></p> <p>New mandatory requirement for operable windows and doors to have switches which will control heating and cooling equipment to shut off when doors or windows are left open.</p>	<p>This change prevents wasted operation of heating and cooling equipment when doors or windows remain opened. These requirements are based on requirements already present in other energy codes.</p>
<p><b>Solar “Ready” Requirements<sup>10</sup>:</b></p> <p>Mandatory requirement that buildings identify roof locations for installation of future solar systems, and keep these areas clear of obstructions. Locations for conduit and other electrical equipment that would be required for the solar system must also be identified. This equipment need not be installed.</p>	<p>Identification and reservation of space for future solar systems will greatly facilitate future installation of solar systems where solar systems are not currently required or where larger systems may be required in the future.</p>
<p><b>Requirements for Electric Vehicle (EV) Charging Infrastructure:</b></p> <p>The following will be required for offices, industrial buildings, and multi-family buildings<sup>11</sup>:</p> <ul style="list-style-type: none"> <li>• 10 percent of parking spaces must have (1) 240-V and (1) 120-V charging outlet</li> <li>• At least one parking space must have a Level 2, dual port charging station installed</li> </ul> <p>Lodging facilities will be required to install charging stations (Level 2, dual port) for 1 percent of parking spots (a minimum of 1).</p> <p>This requirement will reside in the National Electric Code.</p>	<p>Workplace EV charging provides employees that live in multi-family units without EV charging the opportunity to drive an EV. There is also a need for EV charging facilities at lodging facilities, as more and more rental car agencies are beginning to offer EV options. However, there has been very little usage in general public charging stations provided at commercial buildings for transient visitors.</p>

**PUBLIC NOTIFICATION / COMMENTS**

City staff informed relevant city boards and industry stakeholders about potential residential and commercial energy code amendments and gathered feedback. Table 8 summarizes these engagement activities, and more details about community feedback on this topic can found in the [July 19, 2016 Information Packet Memo](#) to council.

<sup>10</sup> For new homes that are not already installing PV systems at the time of construction

<sup>11</sup> There must be at least 25 parking spaces to trigger these requirements.

**Table 8: Outreach Activities to Solicit Feedback**

<b>Date in 2016</b>	<b>Outreach Activity</b>	<b>Number of Respondents</b>	<b>Description</b>
<b>March 2016</b>	Interviews with staff working for jurisdictions that adopted IgCC	Five respondents	Questions focused on how and when the code was adopted, the general impact of adoption, any training that occurred, and budget and staffing impacts.
<b>April 27</b>	Open House Board Meeting	Six city boards 19 respondents	City staff presented an overview of the history of Boulder energy code, the current energy codes in place, and introduced a list of green code topics to be considered for potential adoption as part of the energy code updates this year. Attendees were asked to prioritize the green code topics for both commercial and residential construction.
<b>April 25 to May 6</b>	Stakeholder Survey	240 (127 complete) (113 partial)	City staff mailed a survey to the licensed building professionals to solicit feedback from the stakeholder community about the same energy/green code topics introduced during the open house.
<b>May 24</b>	Residential Energy Code Key Stakeholder Meeting	Four	City staff organized a meeting to invite long-term, prominent residential building stakeholders to discuss and give direct feedback on the existing Green Building and Green Points program.
<b>May 27</b>	Commercial Energy Code Key Stakeholder Meeting	Six	City staff organized a meeting to invite long-term, prominent commercial building stakeholders to discuss and provide direct feedback on commercial energy code adoption, amendments and sustainability measures.
<b>Sept. 7</b>	Environmental Advisory Board	Five	City staff reviewed and discussed new elements of the energy code and revised requirements for electric vehicle charging that would apply to multi-family and commercial buildings, based on board feedback.
<b>Oct. 5</b>	Landmarks Board	Six	City staff reviewed changes with the focus on historic exemptions to the energy code. Following the meeting, staff worked to amend and further define clarity to the code.

**STAFF FINDINGS AND RECOMMENDATION**

Staff recommends Planning Board recommend to City Council adoption of the proposed ordinance amending Section 9-9-12, “Landscaping and Screening Standards,” and Chapters 10-5.5, 10-6, 10-7, 10-7.5, 10-10 of Title 10, “Structures,” B.R.C. 1981, to revise the energy conservation and green building requirements for construction projects, repealing the International Energy Conservation Code and adopting by reference the “2017 City of Boulder Energy Conservation Code,” and setting forth related details.

- **Attachment D:** Proposed 2017 City of Boulder Energy Conservation Code
  - This attachment shows the redlines to the currently adopted IECC 2012, which would become the new standalone energy code.
- **Attachment E:** Ordinance showing amendments to other portions of the code

## **NEXT STEPS**

In terms of the next code updates, there are several more steps scheduled for the coming months:

- Q1 2017: Staff presents energy code amendments to City Council for adoption.
- Q2 2017: Amendments to energy code become effective (following 60-day grace period after adoption).
- Q1-Q2 2017: Noresco, the city's code consultant, will conduct staff and public training and develop supporting documentation and resources on the city's website to help explain the energy codes.
- Q3 2017: Staff will implement changes to improve energy code compliance.

Once the 2018 version of the national codes are released, the city will work to adopt the 2018 versions of the codes, with local amendments.

- Q1 2018: Staff will review the newly released 2018 codes, including IECC 2018 and IgCC 2018.
- Q3 2018: Staff will review the next building code update with the relevant boards, including moving from IECC 2012 to IECC 2018 and beginning to adopt portions of IgCC 2018.
- Q4 2018: Propose adoption of full set of ICC 2018 building codes, with amendments to City Council.
- Q1 2019: New building codes (based on ICC 2018 codes) become effective.

Approved By:



David Driskell, Executive Director  
Department of Community Planning and Sustainability

**ATTACHMENTS:**

A: Long-Term Strategy

B: Overview of Energy and Green Codes

C: Analysis of Potential Cost Impacts

D: Proposed 2017 City of Boulder Energy Conservation Code

E: Ordinance showing Amendments to Other Portions of the Code

## ATTACHMENT A: LONG-TERM STRATEGY

Proposed elements of the long-term strategy for energy codes include:

1. The long-term pathway for achieving high performance, NZE codes including:
  - a. The allowance of off-site renewables to meet energy code requirements.
  - b. The adoption of an outcome-based pathway for commercial energy codes.
  - c. A schedule for when new buildings would need to meet a NZE code.
  - d. Early adopter incentives for designing NZE buildings before the requirements ARE phased in.
  - e. The encouragement of all-electric buildings.
2. A six-year cycle for major updates linked to the national code adoption schedule, with local evaluation and updates every three years (see the [July 19, 2016 Information Packet Memo](#) for more information).
3. Prioritization and a proposed phasing schedule of adopting IgCC's non-energy sustainability requirements for commercial codes, and subsequently amending other portions of the city's codes that may currently address these issues (see the [July 19, 2016 Information Packet Memo](#) for more information).

The City of Boulder has set an aggressive goal of having NZE codes in effect by 2031, and this recent work effort represents staff's first attempt at charting a clear strategy and pathway to achieve that target. The table below provides more details on the key components of the long-term strategy and illustrate when each is suggested to go into effect.

**Table 1: Long-Term Strategy Key Components (Post 2016/2017 Updates)**

Key Component of Long-Term Strategy	Description	Scope	Phasing
<b>Off-Site Renewables</b>	<p>Due to shading, roof space constraints, and high energy intensity buildings (such as a data center or lab), off-site renewable energy will be required for many buildings to achieve NZE. Off-site renewable options will only be allowed if all on-site renewable options have been exhausted.</p> <p>Community solar gardens, but not Renewable Energy Credits (RECS), will be allowed to meet required overall zEPI scores for new buildings and major renovations.</p>	Commercial and Residential	2017 for Residential, 2019 for Commercial

Key Component of Long-Term Strategy	Description	Scope	Phasing
<b>Require a Base Level of Efficiency Prior to Renewables</b>	<p>The following method will ensure that building efficiency is prioritized before the use of renewables:</p> <ul style="list-style-type: none"> <li>• A maximum energy use intensity (EUI) (commercial) or ERI (residential) is required for overall compliance.</li> <li>• A maximum EUI (depending on the type of commercial building) or an ERI of 50 must be achieved through efficiency alone; renewables can then be used to achieve the code specified energy target.</li> </ul>	Commercial and Residential	2019
<b>Outcome-Based Codes for Commercial Buildings</b>	<p>Staff plans to pilot a voluntary outcome based energy code for new commercial buildings, which will be based on the actual, measured energy consumption of the building post-occupancy.</p> <ul style="list-style-type: none"> <li>• Outcome-based codes bring energy behavior of occupants, maintenance and operating practices under the purview of the codes. These factors can account for 50 percent of a building’s energy use.</li> <li>• This is a new approach to energy codes; compliance and enforcement approaches are still under development nationally.</li> <li>• Data collected from the <a href="#">Building Performance Program</a> will aid this process.</li> </ul>	Commercial	Voluntary pilot 2019; possibly mandatory in 2022 (depending on pilot outcome)
<b>Schedule for NZE Compliance</b>	<p>Staff is planning a slightly accelerated schedule for NZE for new residential and commercial buildings. Those with low energy use intensity and high roof to floor area ratios, can reasonably be required to be NZE sooner than 2031. This allows NZE requirements to be phased in over time to minimize enforcement issues, and accelerates achievement of the city’s Climate Commitment goals.</p>	Commercial and Residential	2017 to 2031
<b>Early Adopter Incentives</b>	<ul style="list-style-type: none"> <li>• Providing incentives for buildings to be NZE before it is required by code encourages owners and design teams to develop advanced designs and share feasible examples for other buildings.</li> <li>• These incentives might include reduced city fees, expedited plans approvals and/or positive publicity.</li> </ul>	Commercial and Residential	2020

Key Component of Long-Term Strategy	Description	Scope	Phasing
<p><b>Encouragement of All-Electric Buildings</b></p>	<p>To support long-term goals, local code amendments should begin encouraging all-electric buildings within the next five years.</p> <ul style="list-style-type: none"> <li>• Many of the city's long-term goals will eventually require that the use of natural gas in buildings be minimized or eliminated: the goals of having all new buildings be NZE; moving the city towards local, distributed and fossil-fuel-free energy systems; and achieving and sustaining significant greenhouse gas reductions.</li> <li>• Buildings that use natural gas be made net zero with onsite or building-owned resources. They must have a market to allow excess renewable energy to be sold to other buildings to offset the gas consumption.</li> <li>• Minimizing the use of natural gas in new buildings facilitates the long-term achievement of a sizeable population of net zero buildings.</li> </ul>	<p>Commercial and Residential</p>	<p>2022</p>

## ATTACHMENT B: OVERVIEW OF ENERGY AND GREEN CODES

Many components of the long term strategy, as well as the short term updates, rely on the national suite of building and energy codes. This section provides background information on those codes, definitions of key terms that are used throughout this memo, and brief history of Boulder’s energy codes.

The International Code Council (ICC) publishes an extensive series of model codes every three years. In Colorado, these codes can then be adopted by local jurisdictions along with modifications or exclusions, as desired. The International Energy Conservation Code (IECC) and the International Green Construction Code (IgCC) are two such codes, and both are based on standards developed by the America Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

**Table 2: Summary of National Energy and Green Codes**

National Code	International Energy Conservation Code (IECC)	International Green Construction Code (IgCC)
<b>Scope</b>	Building energy performance – applies to both commercial and residential buildings	“Green Code” addressing many aspects of sustainability beyond energy; applies only to commercial and high-rise (>3 stories) residential buildings
<b>Use in Boulder Code</b>	<u>Residential</u> : IECC 2012 with local amendments (Green Building and Green Points) <u>Commercial</u> : 30 percent more stringent than IECC 2012	Not currently adopted
<b>Alternate compliance via ASHRAE</b>	Commercial: 30% more stringent than ASHRAE 90.1-2010	ASHRAE 189.1 (2014 is equivalent to IgCC 2015)
<b>Important Notes</b>	IECC 2015 is only slightly more stringent than the 2012 version <sup>1</sup> , and still far less stringent than Boulder’s current codes. IECC 2018 is expected to have more significant updates and changes when released.	IgCC 2018 <sup>2</sup> will be merged with the ASHRAE Standard 189.1-2017, reducing confusion and pulling the best aspects from both codes.

While the IgCC is now available to provide green code language for commercial buildings, there is still no suitable national model code<sup>3</sup> for low-rise residential buildings. There are also many voluntary residential green building programs, but most of them have third-party evaluators, cost money to participate and verify,

<sup>1</sup> IECC 2015 compared to IECC 2012: 8.7% more stringent for commercial buildings and 0.73% more stringent for residential buildings (according to Department of Energy)

<sup>2</sup> Planned for release in late 2017

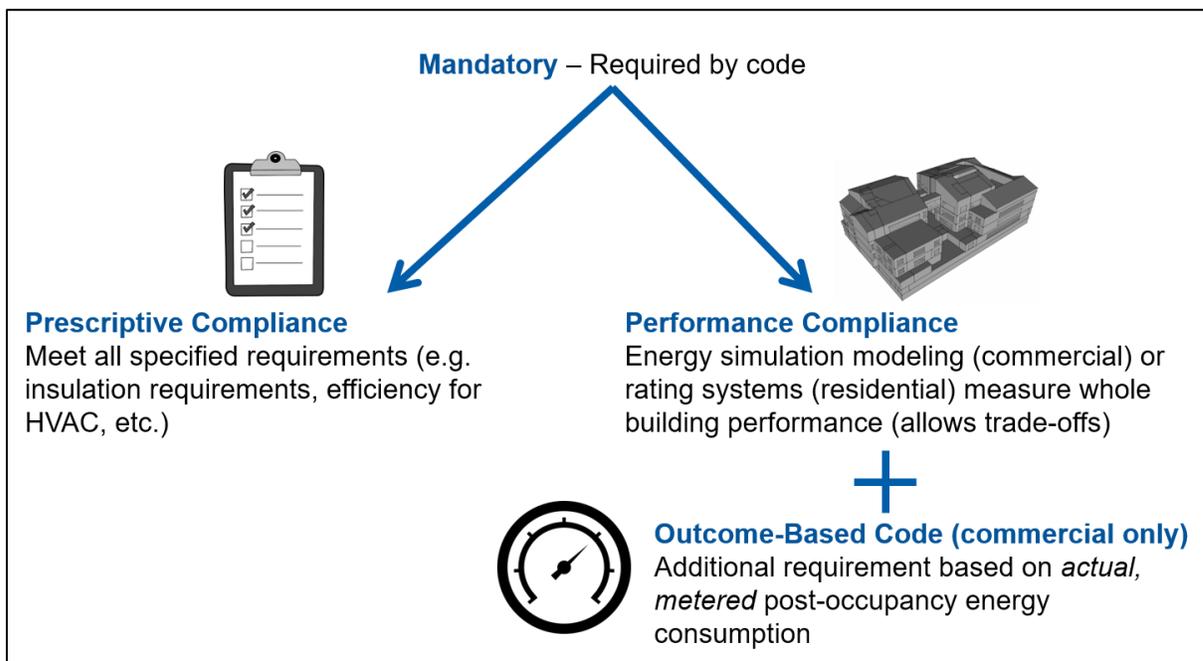
<sup>3</sup> National Green Building Standard (NGBS) is the only known option, but is not recommended because the energy chapter is not set up to guide builders to reach NZE and because it requires that certification is achieved through the Home Innovations Research Lab, a subsidiary of the National Association of Home Builders.

have their own compliance guidelines and were not designed to be “codified” (e.g., LEED for Homes, etc.) As a result, Boulder will continue to update and evolve its residential green building code, the Green Building and Green Points program.

### Pathways for Compliance

Energy codes have traditionally included at least two paths to compliance, prescriptive and performance (see figure below). More recently, an additional option of outcome-based energy codes has emerged. Mandatory requirements must be met regardless of which path is chosen.

**Figure 1: Energy Code Pathways for Compliance**



One limitation to both prescriptive and performance pathways is that they only address efficiency characteristics of building design. Studies have shown that these design aspects only account for 50 percent or less of the total energy consumption of the building. Characteristics that are just as important include good building maintenance, efficient process and plug loads, and operating practices by occupants and building staff.

To account for the energy performance of the entire building as used after occupancy, the addition of *outcome-based* compliance is being explored for commercial buildings. This is an approach that uses performance modeling to establish an energy consumption target during the design stage, but final compliance is shown by monitoring of a building’s energy consumption over a period of time (typically one year) following full occupancy. A building that exceeds the target energy consumption established at the design stage must then take corrective actions to reduce consumption. This type of code is currently being evaluated for inclusion in IgCC, IECC, and in several jurisdictions. It is also being piloted in Seattle as an optional compliance path with a lower energy target than the performance path alone ([link to 2014 ACEEE paper on Seattle’s program](#)). Outcome-based codes verify and guarantee that new buildings are actually performing to the efficiency levels to which they were designed, but they also feature more complicated

compliance verification and contract structures, as compliance responsibility is spread over multiple parties, including building occupants.

### Metrics for Energy Code Stringency and Compliance

As the energy codes become more stringent, new methods of showing compliance or describing stringency are evolving. As a result, several metrics have been established to compare energy code stringency. These metrics will be referred to later in this memo.

**Table 3: Metrics and Energy Rating Scales**

<p><b>EUI (Energy Use Intensity):</b> the total annual energy used per square foot of gross floor area. It is expressed in unit of kBtus (thousand British thermal units) per square foot per year (kBtu/ft<sup>2</sup>-yr).</p>	<div style="text-align: center;"> <h4>ERI and zEPI Scale</h4> </div>
<p><b>HERS (Home Energy Rating System):</b> A nationally recognized index created by RESNET and used as the industry standard to measure the energy efficiency of a house. It is a scale where 0 is a NZE house and 100 is the energy consumption of a typical new construction house that meets the IECC 2006 for energy efficiency.</p>	
<p><b>ERI (Energy Rating Index)<sup>4</sup>:</b> The ERI is essentially a non-trademarked equivalent of the HERS index. It is used as the scale for establishing the performance path target by the current version of the IECC for low-rise residential buildings. Current Boulder residential energy code requires a HERS score/ERI ranging from 25 to 60, depending on house size.</p>	
<p><b>zEPI (Zero Energy Performance Index):</b> This is a scale for commercial buildings that is similar to the ERI for residential buildings. This scale also uses 0 for NZE buildings, but a score of 100 is representative of the EUI of typical existing building (opposed to new construction) from the 2003 CBECs<sup>5</sup> data. The current Boulder energy code is equivalent to a zEPI score of 38.</p>	

<sup>4</sup> Because ERI is the metric used in national energy codes, the city will use this term in place of HERS.

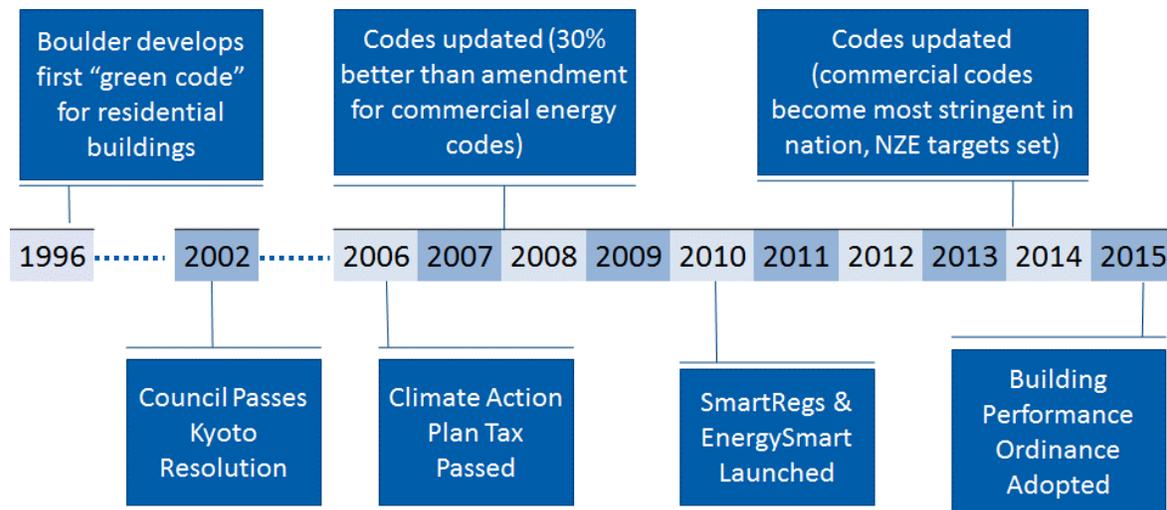
<sup>5</sup> Commercial Building Energy Consumption Survey – The Energy Information Administration (EIA) conducts a survey of existing building energy use by building type and climate zone to form this dataset.

The metrics described the figure above can help establish more stringent energy code requirements by specifying a lower EUI or zEPI or HERS/ERI requirement, thereby moving toward NZE. By using these metrics, the comparison with energy code requirements throughout the country is possible, regardless of which model code is adopted. However, compliance with the commercial energy code requires modeling the energy usage of the reference building. This can vary by building type, floor area and other factors. In the future, there is an opportunity to simplify the commercial energy codes greatly by stating energy targets by building usage in terms of Energy Use Intensity (EUI), which then eliminates the need for modeling a fictitious reference building.

### Brief History of the City’s Energy Codes

The city has a long history of “green” (also referred to as “above” or “sustainability”) code programs, and more recently, it has acquired a reputation of boldly adopting aggressive energy code requirements. Below is a summary and brief timeline of code and policy adoption that has put the city at the forefront in progressive and stringent building and energy code requirements, with supporting programs such as [Energy Smart](#), [SmartRegs](#), and the [Building Performance Program](#).

**Table 4: Overview of Boulder Energy Code History**



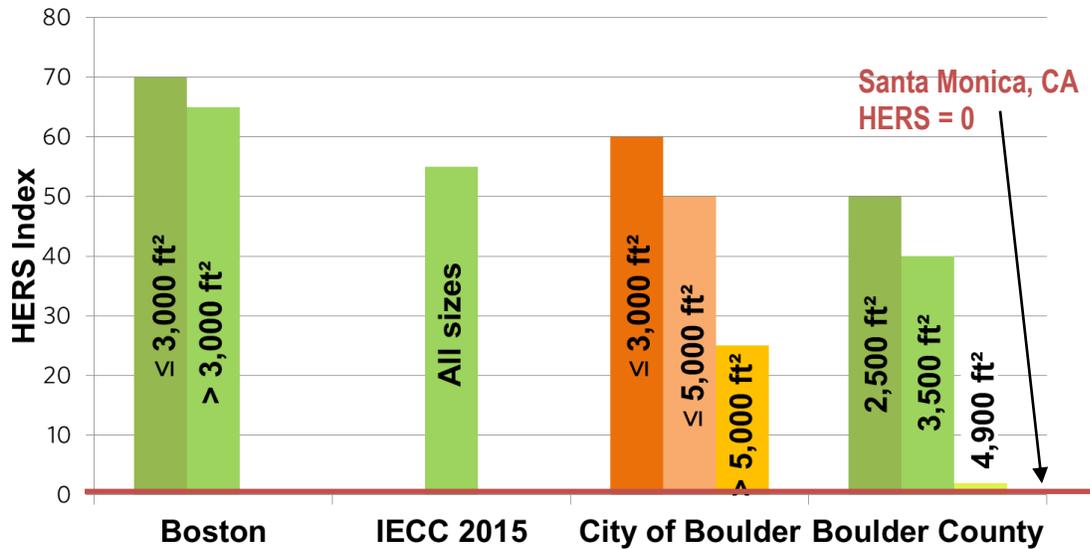
Currently, the city evaluates and amends the latest national codes on a three-year cycle, and usually adopts the newest suite of national/international code every six years. Because the city has not yet adopted a national green building code, such as the IgCC for commercial buildings, other portions of the city’s codes and Design Standards currently address many non-energy sustainability issues (such as transportation and water). Please refer to Attachment A in the [July 19, 2016 Information Packet Memo](#) for a more complete history of the city’s residential and commercial energy codes, including a comparison of their stringency to other energy codes.

### Energy Performance of the City’s Energy Codes

In terms of stringency, Boulder’s current residential energy code is more stringent than most cities in the country, with the exception of Boulder County’s BuildSmart program, and Santa Monica, CA which recently became the first city to require all new homes to be net zero. Figure 2 shows a comparison of the

stringency of the current version of IECC, as well as the few other municipalities that adopt energy requirements that differ from some version of IECC.

**Figure 2: Comparison of Stringency of Residential Energy Codes**

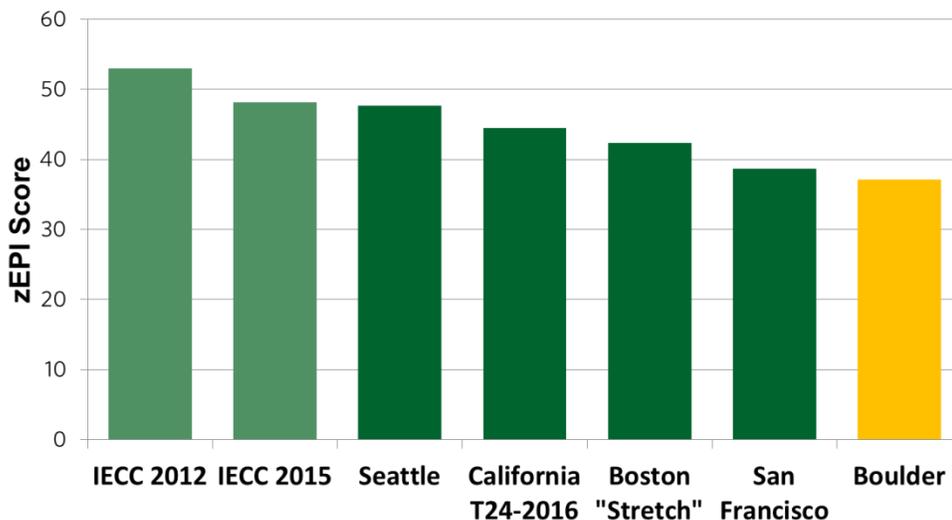


The long term plan for California’s state energy code, Title 24, is to require net zero for all new residential construction by 2020.

Commercial Energy Code

As shown in Figure 3, Boulder’s current commercial energy code is the most stringent commercial energy code in the country. The long term plan for California’s state energy code, Title 24, is to require net zero for all new commercial construction by 2030.

**Figure 3: Boulder Commercial Energy Code Comparison to Other Jurisdictions**



## ATTACHMENT C: ANALYSIS OF POTENTIAL COST IMPACTS

Higher performing buildings increase property values, command higher lease prices, cost less to operate and improve occupant comfort in addition to reducing greenhouse gases. However, initial costs to construct these buildings are higher. While staff is not proposing to significantly increase the stringency of the energy performance requirements of the codes in the update coming later this year, some of the new requirements do present unique challenges to the traditional cost-benefit analysis. In this traditional approach, measures that have been shown to be cost effective, usually over the life of the building, have been added to the codes. This approach has worked well over the last 30 years, with the goal being simply to increase the efficiency of buildings.

However, with the evolution of energy and sustainability goals, such cost-benefit analyses become problematic. Many non-energy sustainability requirements have benefits that are difficult or impossible to quantify in cost terms. Requiring that the building provide bicycle storage, for example, requires the use of numerous assumptions about occupant response to establish a cost benefit. Similarly, while improved daylighting and indoor air quality have been repeatedly linked to improved worker productivity or increased sales, there is no direct way to quantify these benefits. Most other non-energy requirements face similar difficulties.

Additionally, when the goals of the energy code change from “make the building efficient” to “make the building net zero,” cost-benefit analysis needs to become more holistic as opposed to evaluating measures in isolation. Also, financial incentives and predictions of future energy costs need to be considered as well. With this in mind, staff plans to acknowledge and describe these non-quantifiable benefits and holistic costs in future assessments of code updates, and use this to supplement the traditional cost-benefit analysis.

For the proposed code updates, staff has attempted to quantify the potential cost impacts for those updates that can be quantified.

**Table 5: Potential Cost Impacts of Proposed Code Updates**

Proposed Code Update	Potential Cost Impact
Energy Rating Index (ERI) more stringent (~10) for homes 2,000 – 4,000 square feet (sf)	~\$3.00/sf ~\$9000 for a 3,000 sf home (~1-2% of const. costs)
Net Zero Energy for homes larger than 5,000 sf	For a 5,000 sf home: ~\$28,000 in solar PV (Payback of ~ 15 years) (~1 - 2.5% of const. costs)
Streamline Green Points system	Should be a net cost savings by removing many of less impactful measures
Revise Commercial Prescriptive Path	Should be a neutral impact because most requirements are being streamlined and simplified, but solar ready buildings are required

<p>Electric Vehicle Charging Infrastructure</p>	<ol style="list-style-type: none"> <li>1. Dwellings with dedicated off-street parking <ol style="list-style-type: none"> <li>a. Require a 240 V and 120 V outlet</li> <li>b. ~\$350-500 per unit</li> </ol> </li> <li>2. Multi-family with shared parking <ol style="list-style-type: none"> <li>a. Require a 240 V and 120 V outlet for 10% of spaces (~\$850 per space)</li> <li>b. Have at least 1 charging station installed (~\$4,000-6,000)</li> </ol> </li> <li>3. Certain Commercial Building types <ol style="list-style-type: none"> <li>a. Require EV Ready (Level 2 station) for 10% of parking spaces (~\$850 per space)</li> <li>b. Require Level 2 charging stations (~\$4,000-6,000) for at least one parking space</li> </ol> </li> </ol>
<p>Radon Mitigation Requirements (for new homes only)</p>	<p>Per the US Environmental Protection Agency (EPA), on average, installing radon-resistant features during construction costs as little as \$100 and potentially up to \$500.</p>

## CHAPTER 1 [CE] SCOPE AND ADMINISTRATION

### PART 1—SCOPE AND APPLICATION

#### SECTION C101 SCOPE AND GENERAL REQUIREMENTS

##### C101.1 Title.

This code shall be known as the ~~International Energy Conservation Code of [NAME OF JURISDICTION]~~ 2017 City of Boulder Energy Conservation 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 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.

##### C101.4.2 Historic buildings.

Any building or structure that is listed in the State or National Register of Historic Places; locally designated as a ~~historic property under local or state designation law or survey~~ an individual

landmark; certified as a contributing resource with a National Register listed or locally designated historic district; or with an opinion or certification that the property is eligible to be listed on the National or State Registers of Historic Places either individually or as a contributing building or structure to a historic district by the State Historic Preservation Officer or the Keeper of the National Register of Historic Places; or has been found, through a historic building inventory, to be eligible for local designation as a landmark or to be listed as a contributing building or structure to a local historic district, are exempt from this code shall comply with the requirements of this code. The code official may approve an alteration or modification to the requirements of this code where the requirement would have a detrimental impact on the special character or special historical, architectural, aesthetic interest or value of the building or structure individually or of the historic district to which the building or structure is contributing or, if the alteration would require a landmark alteration certificate under Chapter 9-11, "Historic Preservation," B.R.C. 1981, but would not meet the applicable standards of Section 9-11-18, "Standards for Landmark Alteration Certificate Applications," B.R.C. 1981.

**C101.4.3 Additions, alterations, ~~renovations~~ or repairs.**

Additions, alterations, ~~renovations~~ or repairs 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 portion(s) of the existing building or building system to comply with this code. Additions, alterations, ~~renovations~~ or repairs 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.

**Exception:** The following need not comply provided the energy use of the building is not increased:

1. Storm windows installed over existing fenestration.
2. Glass only replacements in an existing sash and frame.
- ~~3. Existing ceiling, wall or floor cavities exposed during construction provided that these cavities are filled with insulation.~~
34. Construction where the existing roof, wall or floor cavity is not exposed.

45. Reroofing for roofs where neither the sheathing nor the insulation is exposed. 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.

56. Replacement of existing doors that separate *conditioned space* from the exterior shall not require the installation of a vestibule or revolving door, provided, however, that an existing vestibule that separates a conditioned space from the exterior shall not be removed,

67. 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.

78. Alterations that replace only the bulb and ballast within the existing luminaires in a space provided that the *alteration* does not increase the installed interior lighting power.

**C101.4.4 Change in occupancy or use.**

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 C405.5.2(1) or (2) to another use in Table C405.5.2(1) or (2), the installed lighting wattage shall comply with Section C405.5.

**C101.4.5 Change in space conditioning.**

Any nonconditioned space that is altered to become *conditioned space* shall be required to be brought into full compliance with this code.

**C101.4.6 Mixed occupancy.**

Where a building includes both *residential and commercial* occupancies, ~~each occupancy shall be separately considered and meet the applicable provisions of IECC—the building shall meet the requirements of this code for commercial buildings~~Commercial Provisions or IECC—Residential Provisions.

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**C101.5 Compliance.**

*Residential buildings* shall meet the ~~provisions of IECC—Residential Provisions~~ of this code, Sections R101 through R404. *Commercial buildings* shall meet the ~~provisions of IECC—Commercial Provisions~~ of this code, Sections C101 through C407.

**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.

**C101.5.2 Low energy buildings.**

The following buildings, or portions thereof, separated from the remainder of the building by *building thermal envelope* assemblies complying with this code shall be exempt from the *building thermal envelope* provisions of this code:

1. Those with a peak design rate of energy usage less than 3.4 Btu/h • ft² (10.7 W/m²) or 1.0 watt/ft² (10.7 W/m²) of floor area for space conditioning purposes.
2. Those that do not contain *conditioned space*.

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

**C102.1 General.**

This code is not intended to prevent the use of any material, method of construction, design or insulating system not specifically prescribed herein, provided that such construction, design or insulating system has been *approved* by the *code official* as meeting the intent of this code.

**C102.1.1 Above code programs.**

The *code official* or other authority having jurisdiction shall be permitted to deem a national, state or local energy efficiency program to exceed the energy efficiency required by this code. Buildings *approved* in writing by such an energy efficiency program shall be considered in compliance with this code. The requirements identified as “mandatory” in Chapter 4 shall be met.

**PART 2—ADMINISTRATION AND ENFORCEMENT**

**SECTION C103  
CONSTRUCTION DOCUMENTS**

**C103.1 General.**

Construction documents and other supporting data shall be submitted in one or more sets with each application for a permit. The construction documents and designs submitted under the provisions of this code shall be prepared by and bear the stamp of a Colorado licensed professional engineer or architect. ~~The construction documents shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.~~ Where special conditions exist, the *code official* is authorized to require necessary additional construction documents to be prepared by a registered design professional ~~Colorado licensed professional engineer or architect.~~

Exception: The code official may waive the submission of construction documents and other supporting data if the official finds that the nature of the work does not require review of the documents or data to obtain compliance. This waiver authority does not apply to documents required to be prepared by a Colorado licensed architect or engineer. 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 upon suitable material. Electronic media documents are permitted to be submitted when *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, as applicable, insulation materials and their R-values; fenestration U-factors and SHGCs; area-weighted U-factor and SHGC calculations; mechanical system design criteria; mechanical and service water heating system and equipment types, sizes and efficiencies; economizer description; equipment and systems controls; fan motor horsepower (hp) and controls; duct sealing, duct and pipe insulation and location; lighting fixture schedule with wattage and control narrative; and air sealing details; and any details related to energy savings modeled in the performance modeling described in Section C401.2.

### **~~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.~~

#### **~~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 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.

**SECTION C104  
INSPECTIONS**

**C104.1 General.**

Construction or work for which a permit is required shall be subject to inspection by the code official.

**C104.2 Required approvals.**

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

**C104.3 Final inspection.**

The building shall have a final inspection and not be occupied until *approved*. The applicant must provide at time of final inspection of a commercial building written verification which bears the stamp of a licensed architect or engineer or special inspector as described in Section 107.3.4 of the Building Code of the City of Boulder that the structure conforms with the provisions of Chapter 4.

**C104.4 Reinspection.**

A building shall be reinspected when determined necessary by the *code official*.

**~~C104.5 Approved inspection agencies.~~**

~~The code official is authorized to accept reports of approved inspection agencies, provided such agencies satisfy the requirements as to qualifications and reliability.~~

**~~C104.6 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.~~

**~~C104.7 Reinspection and testing.~~**

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

**~~C104.8 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.~~

**~~C104.8.1 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 C105  
VALIDITY**

**C105.1 General.**

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

**SECTION C106**  
**REFERENCED STANDARDS**

**C106.1 Referenced codes and standards.**

The codes and standards referenced in this code shall be those listed in Chapter 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 C106.1.1 and C106.1.2.

**C106.1.1 Conflicts.**

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

**C106.1.2 Provisions in referenced codes and standards.**

Where the extent of the reference to a referenced code or standard includes subject matter that is within the scope of this code, the provisions of this code, as applicable, shall take precedence over the provisions in the referenced code or standard.

**C106.2 Conflicting requirements.**

Where the provisions of this code and the referenced standards conflict, the provisions of this code shall take precedence.

**C106.3 Application of references.**

References to chapter or section numbers, or to provisions not specifically identified by number, shall be construed to refer to such chapter, section or provision of this code.

**C106.4 Other laws.**

The provisions of this code shall not be deemed to nullify any provisions of local, state or federal law. This code is intended to comply with and be interpreted and enforced so as to comply with 42 U.S.C. Section 6297(f)(3) and any other federal requirements to avoid preemption. For purposes of 42 U.S.C. Section 6297(f)(3), "new construction" shall be interpreted to include all work that triggers the requirements established in this code.

SECTION C107  
ADMINISTRATION FEES

**C107.1 Fees Administration.**

This code shall be administered in accordance with and as part of Chapter 10-5, "Building Code," B.R.C. 1981. A permit shall not be issued until the fees prescribed in Section C107.2 have been paid, nor shall an amendment to a permit be released until the additional fee, if any, has been paid.

**C107.2 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.

**C107.3 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, which shall be in addition to the required permit fees.

**C107.4 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.

**C107.5 Refunds.**

The code official is authorized to establish a refund policy.

SECTION C108  
STOP WORK ORDER

**C108.1 Authority.**

Whenever 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, or to the owner's 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 of not less than [AMOUNT] dollars or more than [AMOUNT] dollars.

~~SECTION C109~~  
~~BOARD OF APPEALS~~

**~~C109.1 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 have no 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.~~

**~~C109.2 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 have no authority to waive requirements of this code.~~

**~~C109.3 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 [CE] DEFINITIONS

### SECTION C201 GENERAL

#### C201.1 Scope.

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

#### C201.2 Interchangeability.

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

#### C201.3 Terms defined in other codes.

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

**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 or height of a building or structure.

**AIR BARRIER.** Material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or a combination of materials.

**ALTERATION.** Any construction or renovation to an existing structure other than repair or addition that requires a permit. Also, a change in a mechanical system that involves an extension, addition or change to the arrangement, type or purpose of the original installation that requires a permit.

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

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

**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").

**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, floor, roof, and any other building elements that enclose *conditioned space* or provides a boundary between *conditioned space* and exempt or unconditioned space.

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

**CODE OFFICIAL.** The code official is the city manager, officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative.

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

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

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

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

**CONDITIONED SPACE.** An area or room within a building being heated or cooled, containing uninsulated ducts, or with a fixed opening directly into an adjacent *conditioned space*.

**CONSTRUCTION VALUATION.** The total value of work covered by the permit, to be determined consistent with the standards of Subsection 4-20-4(d), B.R.C. 1981. The higher of the two valuations considered under Subsection 4-20-4(d), B.R.C. 1981, shall be the total value of work.

**CONTINUOUS AIR BARRIER.** A combination of materials and assemblies that restrict or prevent the passage of air through the building thermal 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 ZONE.**

1. **Under skylights.** The area under skylights whose horizontal dimension, in each direction, is equal to the skylight dimension in that direction plus either the floor-to-ceiling height or the dimension to a ceiling height opaque partition, or one-half the distance to adjacent skylights or vertical fenestration, whichever is least.

2. **Adjacent to vertical fenestration.** The area adjacent to vertical fenestration which receives daylight through the fenestration. For purposes of this definition and unless more detailed analysis is provided, the daylight *zone* depth is assumed to extend into the space a distance of 15 feet (4572 mm) or to the nearest ceiling height opaque partition, whichever is less. The daylight zone width is assumed to be the width of the window plus 2 feet (610 mm) on each side, or the window width plus the distance to an opaque partition, or the window

width plus one-half the distance to adjacent skylight or vertical fenestration, whichever is least.

**DEMAND CONTROL VENTILATION (DCV).** A ventilation system capability that provides for the automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy.

**DEMAND RECIRCULATION WATER SYSTEM.** A water distribution system where pump(s) prime the service hot water piping with heated water upon demand for hot water.

**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.

**[B] 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*, SHGC, or 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.

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

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

**ENTRANCE DOOR.** Fenestration products used for ingress, egress and access in nonresidential buildings, including, but not limited to, exterior entrances that utilize latching hardware and automatic closers and contain over 50-percent glass specifically designed to withstand heavy use and possibly abuse.

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

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

**FAN BRAKE HORSEPOWER (BHP).** The horsepower delivered to the fan's shaft. Brake horsepower does not include the mechanical drive losses (belts, gears, etc.).

**FAN SYSTEM BHP.** The sum of the fan brake horsepower of all fans that are required to operate at fan system design conditions to supply air from the heating or cooling source to the *conditioned space(s)* 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.

**FAN SYSTEM MOTOR NAMEPLATE HP.** The sum of the motor nameplate horsepower of all fans that are required to operate at design conditions to supply air from the heating or cooling source to the *conditioned space(s)* and return it to the source or exhaust it to the outdoors.

**FENESTRATION.** Skylights, roof windows, vertical windows (fixed or moveable), opaque doors, glazed doors, glazed block and combination opaque/glazed doors. Fenestration includes products with glass and nonglass glazing materials.

**FENESTRATION PRODUCT, FIELD-FABRICATED.** A fenestration product whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut,

or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door. Field fabricated does not include site-built fenestration.

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

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

**FLOOR AREA.** The total square footage of all levels as measured from the inside finished surface of the walls, but excluding courts, unconditioned garages, and uninhabitable crawl spaces and attics.

**FURNACE ELECTRICITY RATIO.** The ratio of furnace electricity use to total furnace energy computed as ratio =  $(3.412 \times E_{AE}) / 1000 \times E_F + 3.412 \times E_{AE}$  where  $E_{AE}$  (average annual auxiliary electrical consumption) and  $E_F$  (average annual fuel energy consumption) are defined in Appendix N to Subpart B of Part 430 of Title 10 of the Code of Federal Regulations and  $E_F$  is expressed in millions of Btu's per year.

**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.

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

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

**HIGH-EFFICACY LAMPS.** Compact fluorescent lamps, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy of:

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

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

**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.

**INSULATING SHEATHING.** An insulating board with a core material having a minimum *R-value* of R-2.

**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.

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

**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 SLOPE – Low slopes are defined as slopes up to and including 2:12 (rise:run)**

**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").

**MECHANICAL HEATING – Mechanical heating is raising the temperature within a space using electric resistance heaters, fossil fuel burners, heat pumps, or other systems that require energy to directly condition the space.**

**MECHANICAL COOLING – Mechanical Cooling is lowering the temperature within a space using refrigerant compressors or absorbers, desiccant dehumidifiers, or other systems that require energy to directly condition the space. In nonresidential, high-rise residential, and hotel/motel buildings, cooling of a space by direct or indirect evaporation of water alone is not considered mechanical cooling.**

**NAMEPLATE HORSEPOWER.** The nominal motor horsepower rating stamped on the motor nameplate.

**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 ARI standard rating conditions.

**ON-SITE RENEWABLE ENERGY.** Energy derived from solar radiation, wind, waves, tides, landfill gas, biomass, or the internal heat of the earth. The energy system providing on-site renewable energy shall be located on the project site.

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

**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.

**RESIDENTIAL BUILDING.** For this code, includes detached one- and two-family dwellings and multiple single-family dwellings (townhouses and duplexes) with a separate means of egress and their accessory structures, 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, roof deck, insulation, vapor retarder and interior finish.

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

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

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

**SHADING** - Shading is the protection from heat gains because of direct solar radiation by permanently attached exterior devices or building elements, interior shading devices, glazing material, or adherent materials.

**SKYLIGHT.** Glass or other transparent or translucent glazing material installed at a slope of less than 60 degrees (1.05 rad) from horizontal. Glazing material in skylights, including unit skylights, solariums, sunrooms, roofs and sloped walls is included in this definition.

**SKYLIGHT AREA** - Skylight area is the area of the rough opening for the skylight.

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

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

**SOLAR ZONE** – A solar zone is a section of the roof designated and reserved for the future installation of a solar electric or solar thermal system.

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

**STANDARD TEST CONDITIONS.** A fixed set of conditions for which PV module performance is rate. These conditions are 1000 W/m<sup>2</sup> incident solar radiation, 25 °C cell temperature, 0.0 wind speed, and air mass 1.5 spectrum.

**STEEP SLOPE** – Steep slopes are defined as slopes greater than 2:12 (rise:run).

**STOREFRONT.** A nonresidential system of doors and windows mullied 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 mullied windows and doors.

**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 space(s)*. The *conditioned space(s)* 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 set point.

**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<sup>2</sup> • °F) [W/(m<sup>2</sup> • K)].

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

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

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

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

## CHAPTER 3 [CE] GENERAL REQUIREMENTS

### SECTION C301- CLIMATE ZONES

#### ~~C301.1 General.~~

~~Climate zones from Figure C301.1 or Table C301.1 shall be used in determining the applicable requirements from Chapter 4. Locations not in Table C301.1 (outside the United States) shall be assigned a climate zone based on Section C301.3.~~

#### ~~C301.2 Warm humid counties.~~

~~Warm humid counties are identified in Table C301.1 by an asterisk.~~

#### ~~C301.3 International climate zones.~~

~~The climate zone for any location outside the United States shall be determined by applying Table C301.3(1) and then Table C301.3(2).~~

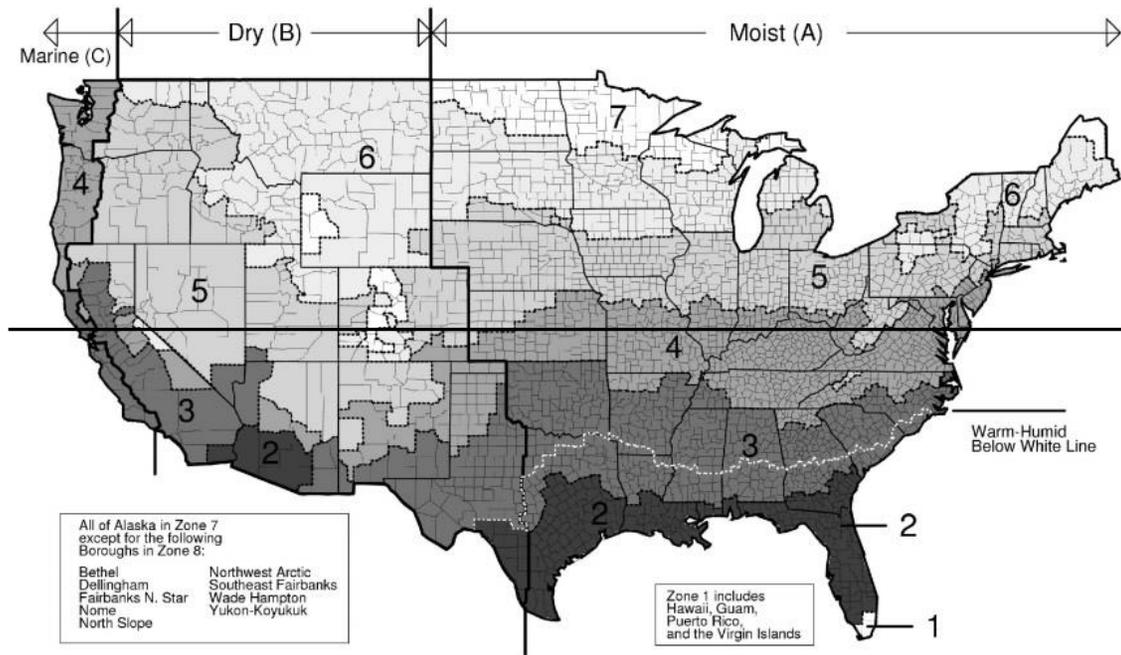


FIGURE C301.1-  
CLIMATE ZONES

TABLE C301.1-  
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.**

<b>ALABAMA</b>		<b>US STATES</b>		
	3A-Lee	7-Kodiak Island	3A-Calhoun	3A-Monroe
3A-Autauga*	3A-Limestone	7-Lake and Peninsula	4A-Carroll	3A-Montgomery
2A-Baldwin*	3A-Lowndes*	7-Matanuska-Susitna	3A-Chicot	3A-Nevada
3A-Barbour*	3A-Macon*	8-Nome	3A-Clark	4A-Newton
3A-Bibb	3A-Madison	8-North Slope	3A-Clay	3A-Ouachita
3A-Blount	3A-Marengo*	8-Northwest Arctic	3A-Cleburne	3A-Perry
3A-Bullock*	3A-Marion	7-Prince of Wales	3A-Cleveland	3A-Phillips
3A-Butler*	3A-Marshall	Outer Ketchikan	3A-Columbia*	3A-Pike
3A-Calhoun	2A-Mobile*	7-Sitka	3A-Conway	3A-Poinsett
3A-Chambers	3A-Monroe*	7-Skagway-Hoonah-	3A-Craighead	3A-Polk
3A-Cherokee	3A-Montgomery*	Angeon	3A-Crawford	3A-Pope
3A-Chilton	3A-Morgan	8-Southeast Fairbanke	3A-Crittenden	3A-Prairie
3A-Choctaw*	3A-Perry*	7-Valdez-Cordova	3A-Cross	3A-Pulaski
3A-Clarke*	3A-Pickens	8-Wade-Hampton	3A-Dallas	3A-Randolph
3A-Clay	3A-Pike*	7-Wrangell-Petersburg	3A-Desha	3A-Saline
3A-Cleburne	3A-Randolph	7-Yakutat	3A-Drew	3A-Scott
3A-Coffee*	3A-Russell*	8-Yukon-Koyukuk	3A-Faulkner	4A-Scarey
3A-Colbert	3A-Shelby		3A-Franklin	3A-Sebastian
3A-Conecuh*	3A-St. Clair	<b>ARIZONA</b>	4A-Fulton	3A-Sevier*
3A-Coosa	3A-Sumter	5B-Apache	3A-Garland	3A-Sharp
3A-Covington*	3A-Talladega	3B-Cochise	3A-Grant	3A-St. Francis
3A-Crenshaw*	3A-Tallapoosa	5B-Cocconino	3A-Greene	4A-Stone
3A-Cullman	3A-Tuscaloosa	4B-Gila	3A-Hempstead*	3A-Union*
3A-Dale*	3A-Walker	3B-Graham	3A-Hot Spring	3A-Van Buren
3A-Dallas*	3A-Washington*	3B-Greenlee	3A-Howard	4A-Washington
3A-DeKalb	3A-Wilcox*	2B-La Paz	3A-Independence	3A-White

3A Elmore\*  
 3A Escambia\*  
 3A Etowah  
 3A Fayette  
 3A Franklin  
 3A Geneva\*  
 3A Greene  
 3A Hale  
 3A Henry\*  
 3A Houston\*  
 3A Jackson  
 3A Jefferson  
 3A Lamar  
 3A Lauderdale  
 3A Lawrence

3A Winston

**ALASKA**

7 Aleutians East  
 7 Aleutians West  
 7 Anchorage  
 8 Bethel  
 7 Bristol Bay  
 7 Denali  
 8 Dillingham  
 8 Fairbanks North Star  
 7 Haines  
 7 Juneau  
 7 Kenai Peninsula  
 7 Ketchikan Gateway

2B Maricopa  
 3B Mohave  
 5B Navajo  
 2B Pima  
 2B Pinal  
 3B Santa Cruz  
 4B Yavapai  
 2B Yuma

**ARKANSAS**

3A Arkansas  
 3A Ashley  
 4A Baxter  
 4A Benton  
 4A Boone  
 3A Bradley

*(continued)*

4A Izard  
 3A Jackson  
 3A Jefferson  
 3A Johnson  
 3A Lafayette\*  
 3A Lawrence  
 3A Lee  
 3A Lincoln  
 3A Little River\*  
 3A Logan  
 3A Lonoke  
 4A Madison  
 4A Marion  
 3A Miller\*  
 3A Mississippi

3A Woodruff  
 3A Yell

**CALIFORNIA**

3C Alameda  
 6B Alpine  
 4B Amador  
 3B Butte  
 4B Calaveras  
 3B Colusa  
 3B Contra Costa  
 4C Del Norte  
 4B El Dorado  
 3B Fresno  
 3B Glenn

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

4C Humboldt  
 2B Imperial  
 4B Inyo  
 3B Kern  
 3B Kings  
 4B Lake  
 5B Lassen  
 3B Los Angeles

3B Yuba  
**COLORADO**  
 5B Adams  
 6B Alamosa  
 5B Arapahoe  
 6B Archuleta  
 4B Baca

5B Morgan  
 4B Otero  
 6B Ouray  
 7 Park  
 5B Phillips  
 7 Pitkin  
 5B Prowers  
 5B Pueblo

2A Escambia\*  
 2A Flagler\*  
 2A Franklin\*  
 2A Gadsden\*  
 2A Gilchrist\*  
 2A Glades\*  
 2A Gulf\*  
 2A Hamilton\*

2A Taylor\*  
 2A Union\*  
 2A Volusia\*  
 2A Wakulla\*  
 2A Walton\*  
 2A Washington\*  
**GEORGIA**

3B Madera  
3C Marin  
4B Mariposa  
3C Mendocino  
3B Merced  
5B Modoc  
6B Mono  
3C Monterey  
3C Napa  
5B Nevada  
3B Orange  
3B Placer  
5B Plumas  
3B Riverside  
3B Sacramento  
3C San Benito  
3B San Bernardino  
3B San Diego  
3C San Francisco  
3B San Joaquin  
3C San Luis Obispo  
3C San Mateo  
3C Santa Barbara  
3C Santa Clara  
3C Santa Cruz  
3B Shasta  
5B Sierra  
5B Siskiyou  
3B Solano  
3C Sonoma  
3B Stanislaus

5B Bent  
5B Boulder  
6B Chaffee  
5B Cheyenne  
7 Clear-Creek  
6B Conejos  
6B Costilla  
5B Crowley  
6B Custer  
5B Delta  
5B Denver  
6B Dolores  
5B Douglas  
6B Eagle  
5B Elbert  
5B El Paso  
5B Fremont  
5B Garfield  
5B Gilpin  
7 Grand  
7 Gunnison  
7 Hinsdale  
5B Huerfano  
7 Jackson  
5B Jefferson  
5B Kiowa  
5B Kit Carson  
7 Lake  
5B La Plata  
5B Larimer  
4B Las Animas

6B Rio Blanco  
7 Rio-Grande  
7 Routt  
6B Saguache  
7 San Juan  
6B San Miguel  
5B Sedgwick  
7 Summit  
5B Teller  
5B Washington  
5B Weld  
5B Yuma

**CONNECTICUT**

5A (all)

**DELAWARE**

4A (all)

**DISTRICT OF COLUMBIA**

4A (all)

**FLORIDA**

2A Alachua\*  
2A Baker\*  
2A Bay\*  
2A Bradford\*  
2A Brevard\*  
1A Broward\*  
2A Calhoun\*  
2A Charlotte\*

2A Hardee\*  
2A Hendry\*  
2A Hernando\*  
2A Highlands\*  
2A Hillsborough\*  
2A Holmes\*  
2A Indian River\*  
2A Jackson\*  
2A Jefferson\*  
2A Lafayette\*  
2A Lake\*  
2A Lee\*  
2A Leon\*  
2A Levy\*  
2A Liberty\*  
2A Madison\*  
2A Manatee\*  
2A Marion\*  
2A Martin\*  
1A Miami Dade\*  
1A Monroe\*  
2A Nassau\*  
2A Okaloosa\*  
2A Okeechobee\*  
2A Orange\*  
2A Osceola\*  
2A Palm Beach\*  
2A Pasco\*  
2A Pinellas\*  
2A Polk\*  
2A Putnam\*

2A Appling\*  
2A Atkinson\*  
2A Bacon\*  
2A Baker\*  
3A Baldwin  
4A Banks  
3A Barrow  
3A Bartow  
3A Ben Hill\*  
2A Berrien\*  
3A Bibb  
3A Blockley\*  
2A Brantley\*  
2A Brooks\*  
2A Bryan\*  
3A Bulloch\*  
3A Burke  
3A Butts  
3A Calhoun\*  
2A Camden\*  
3A Candler\*  
3A Carroll  
4A Gateosa  
2A Charlton\*  
2A Chatham\*  
3A Chattahoochee\*  
4A Chattooga  
3A Cherokee  
3A Clarke  
3A Clay\*  
3A Clayton

3B Sutter	5B Lincoln	2A Citrus*	2A Santa Rosa*	2A Clinch*
3B Tehama	5B Logan	2A Clay*	2A Sarasota*	3A Cobb
4B Trinity	5B Mesa	2A Collier*	2A Seminole*	3A Coffee*
3B Tulare	7 Mineral	2A Columbia*	2A St. Johns*	2A Colquitt*
4B Tuolumne	6B Moffat	2A DeSoto*	2A St. Lucie*	3A Columbia
3C Ventura	5B Montezuma	2A Dixie*	2A Sumter*	2A Cook*
3B Yolo	5B Montrose	2A Duval*	2A Suwannee*	3A Coweta

(continued)

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

3A Crawford	2A Lanier*	3A Taylor*	5B Cassia	4A Crawford
3A Crisp*	3A Laurens*	3A Telfair*	6B Clark	5A Cumberland
4A Dade	3A Lee*	3A Terrell*	5B Clearwater	5A DeKalb
4A Dawson	2A Liberty*	2A Thomas*	6B Custer	5A De Witt
2A Decatur*	3A Lincoln	3A Tift*	5B Elmore	5A Douglas
3A DeKalb	2A Long*	2A Toombs*	6B Franklin	5A DuPage
3A Dodge*	2A Lowndes*	4A Towns	6B Fremont	5A Edgar
3A Dooly*	4A Lumpkin	3A Treutlen*	5B Gem	4A Edwards
3A Dougherty*	3A Macon*	3A Troup	5B Gooding	4A Effingham
3A Douglas	3A Madison	3A Turner*	5B Idaho	4A Fayette
3A Early*	3A Marion*	3A Twiggs*	6B Jefferson	5A Ford
2A Echols*	3A McDuffie	4A Union	5B Jerome	4A Franklin
2A Effingham*	2A McIntosh*	3A Upson	5B Kootenai	5A Fulton
3A Elbert	3A Meriwether	4A Walker	5B Latah	4A Gallatin
3A Emanuel*	2A Miller*	3A Walton	6B Lemhi	5A Greene
2A Evans*	2A Mitchell*	2A Ware*	5B Lewis	5A Grundy
4A Fannin	3A Monroe	3A Warren	5B Lincoln	4A Hamilton

3A Fayette  
4A Floyd  
3A Forsyth  
4A Franklin  
3A Fulton  
4A Gilmer  
3A Glascock  
2A Glynn\*  
4A Gordon  
2A Grady\*  
3A Greene  
3A Gwinnett  
4A Habersham  
4A Hall  
3A Hancock  
3A Haralson  
3A Harris  
3A Hart  
3A Heard  
3A Henry  
3A Houston\*  
3A Irwin\*  
3A Jackson  
3A Jasper  
2A Jeff Davis\*  
3A Jefferson  
3A Jenkins\*  
3A Johnson\*  
3A Jones  
3A Lamar

3A Montgomery\*  
3A Morgan  
4A Murray  
3A Muscogee  
3A Newton  
3A Oconee  
3A Oglethorpe  
3A Paulding  
3A Peach\*  
4A Pickens  
2A Pierce\*  
3A Pike  
3A Polk  
3A Pulaski\*  
3A Putnam  
3A Quitman\*  
4A Rabun  
3A Randolph\*  
3A Richmond  
3A Rockdale  
3A Schley\*  
3A Screven\*  
2A Seminole\*  
3A Spalding  
4A Stephens  
3A Stewart\*  
3A Sumter\*  
3A Talbot  
3A Taliaferro  
2A Tattnell\*

3A Washington  
2A Wayne\*  
3A Webster\*  
3A Wheeler\*  
4A White  
4A Whitfield  
3A Wilcox\*  
3A Wilkes  
3A Wilkinson  
3A Worth\*

#### **HAWAII**

4A (all)\*

#### **IDAHO**

5B Ada  
6B Adams  
6B Bannock  
6B Bear Lake  
5B Benewah  
6B Bingham  
6B Blaine  
6B Boise  
6B Bonner  
6B Bonneville  
6B Boundary  
6B Butte  
6B Camas  
5B Canyon  
6B Caribou

6B Madison  
5B Minidoka  
5B Nez Perce  
6B Oneida  
5B Owyhee  
5B Payette  
5B Power  
5B Shoshone  
6B Teton  
5B Twin Falls  
6B Valley  
5B Washington

#### **ILLINOIS**

5A Adams  
4A Alexander  
4A Bond  
5A Boone  
5A Brown  
5A Bureau  
5A Calhoun  
5A Carroll  
5A Cass  
5A Champaign  
4A Christian  
5A Clark  
4A Clay  
4A Clinton  
5A Coles  
5A Cook

5A Hancock  
4A Hardin  
5A Henderson  
5A Henry  
5A Iroquois  
4A Jackson  
4A Jasper  
4A Jefferson  
5A Jersey  
5A Jo Daviess  
4A Johnson  
5A Kane  
5A Kankakee  
5A Kendall  
5A Knox  
5A Lake  
5A La Salle  
4A Lawrence  
5A Lee  
5A Livingston  
5A Logan  
5A Macon  
4A Macoupin  
4A Madison  
4A Marion  
5A Marshall  
5A Mason  
4A Massac  
5A McDonough  
5A McHenry

(continued)

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

5A McLean	5A Boone	5A Miami	5A Appanoose	5A Jasper
5A Menard	4A Brown	4A Monroe	5A Audubon	5A Jefferson
5A Mercer	5A Carroll	5A Montgomery	5A Benton	5A Johnson
4A Monroe	5A Cass	5A Morgan	6A Black Hawk	5A Jones
4A Montgomery	4A Clark	5A Newton	5A Boone	5A Keokuk
5A Morgan	5A Clay	5A Noble	6A Bremer	6A Kossuth
5A Moultrie	5A Clinton	4A Ohio	6A Buchanan	5A Lee
5A Ogle	4A Crawford	4A Orange	6A Buena Vista	5A Linn
5A Peoria	4A Daviess	5A Owen	6A Butler	5A Louisa
4A Perry	4A Dearborn	5A Parke	6A Calhoun	5A Lucas
5A Piatt	5A Decatur	4A Perry	5A Carroll	6A Lyon
5A Pike	5A De Kalb	4A Pike	5A Cass	5A Madison
4A Pope	5A Delaware	5A Porter	5A Cedar	5A Mahaska
4A Pulaski	4A Dubois	4A Posey	6A Cerro Gordo	5A Marion
5A Putnam	5A Elkhart	5A Pulaski	6A Cherokee	5A Marshall
4A Randolph	5A Fayette	5A Putnam	6A Chickasaw	5A Mills
4A Richland	4A Floyd	5A Randolph	5A Clarke	6A Mitchell
5A Rock Island	5A Fountain	4A Ripley	6A Clay	5A Monona
4A Saline	5A Franklin	5A Rush	6A Clayton	5A Monroe
5A Sangamon	5A Fulton	4A Scott	5A Clinton	5A Montgomery
5A Schuyler	4A Gibson	5A Shelby	5A Crawford	5A Muscatine
5A Scott	5A Grant	4A Spencer	5A Dallas	6A O'Brien
4A Shelby	4A Greene	5A Starke	5A Davis	6A Osceola
5A Stark	5A Hamilton	5A Steuben	5A Decatur	5A Page

4A St. Clair	5A Hancock	5A St. Joseph	6A Delaware	6A Palo Alto
5A Stephenson	4A Harrison	4A Sullivan	5A Des Moines	6A Plymouth
5A Tazewell	5A Hendricks	4A Switzerland	6A Dickinson	6A Pocahontas
4A Union	5A Henry	5A Tippecanoe	5A Dubuque	5A Polk
5A Vermillion	5A Howard	5A Tipton	6A Emmet	5A Pottawattamie
4A Wabash	5A Huntington	5A Union	6A Fayette	5A Poweshiek
5A Warren	4A Jackson	4A Vanderburgh	6A Floyd	5A Ringgold
4A Washington	5A Jasper	5A Vermillion	6A Franklin	6A Sac
4A Wayne	5A Jay	5A Vigo	5A Fremont	5A Scott
4A White	4A Jefferson	5A Wabash	5A Greene	5A Shelby
5A Whiteside	4A Jennings	5A Warren	6A Grundy	6A Sioux
5A Will	5A Johnson	4A Warrick	5A Guthrie	5A Story
4A Williamson	4A Knox	4A Washington	6A Hamilton	5A Tama
5A Winnebago	5A Kosciusko	5A Wayne	6A Hancock	5A Taylor
5A Woodford	5A Lagrange	5A Wells	6A Hardin	5A Union
<b>INDIANA</b>	5A Lake	5A White	5A Harrison	5A Van Buren
5A Adams	5A La Porte	5A Whitley	5A Henry	5A Wapelle
5A Allen	4A Lawrence	<b>IOWA</b>	6A Howard	5A Warren
5A Bartholomew	5A Madison	5A Adair	6A Humboldt	5A Washington
5A Benton	5A Marion	5A Adams	6A Ida	5A Wayne
5A Blackford	5A Marshall	6A Allamakee	5A Iowa	6A Webster
	4A Martin		5A Jackson	6A Winnebago

(continued)

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

6A Winnechick	4A Haskell	4A Sedgwick	2A Iberville*	6A Cumberland
5A Woodbury	4A Hodgeman	4A Seward	3A Jackson*	6A Franklin

6A Worth  
6A Wright

**KANSAS**

4A Allen  
4A Anderson  
4A Atchison  
4A Barber  
4A Barton  
4A Bourbon  
4A Brown  
4A Butler  
4A Chase  
4A Chautauqua  
4A Cherokee  
5A Cheyenne  
4A Clark  
4A Clay  
5A Cloud  
4A Coffey  
4A Comanche  
4A Cowley  
4A Crawford  
5A Decatur  
4A Dickinson  
4A Doniphan  
4A Douglas  
4A Edwards  
4A Elk  
5A Ellis  
4A Ellsworth

4A Jackson  
4A Jefferson  
5A Jewell  
4A Johnson  
4A Kearny  
4A Kingman  
4A Kiowa  
4A Labette  
5A Lane  
4A Leavenworth  
4A Lincoln  
4A Linn  
5A Logan  
4A Lyon  
4A Marion  
4A Marshall  
4A McPherson  
4A Meade  
4A Miami  
5A Mitchell  
4A Montgomery  
4A Morris  
4A Morton  
4A Nemaha  
4A Neosho  
5A Ness  
5A Norton  
4A Osage  
5A Osborne  
4A Ottawa  
4A Pawnee

4A Shawnee  
5A Sheridan  
5A Sherman  
5A Smith  
4A Stafford  
4A Stanton  
4A Stevens  
4A Sumner  
5A Thomas  
5A Trego  
4A Wabaunsee  
5A Wallace  
4A Washington  
5A Wichita  
4A Wilson  
4A Woodson  
4A Wyandotte

**KENTUCKY**

4A (all)

**LOUISIANA**

2A Acadia\*  
2A Allen\*  
2A Ascension\*  
2A Assumption\*  
2A Avoyelles\*  
2A Beauregard\*  
3A Bienville\*  
3A Bossier\*  
3A Cade\*

2A Jefferson\*  
2A Jefferson Davis\*  
2A Lafayette\*  
2A Lafourche\*  
3A La Salle\*  
3A Lincoln\*  
2A Livingston\*  
3A Madison\*  
3A Morehouse  
3A Natchitoches\*  
2A Orleans\*  
3A Ouachita\*  
2A Plaquemines\*  
2A Pointe Coupee\*  
2A Rapides\*  
3A Red River\*  
3A Richland\*  
3A Sabine\*  
2A St. Bernard\*  
2A St. Charles\*  
2A St. Helena\*  
2A St. James\*  
2A St. John  
the Baptist\*  
2A St. Landry\*  
2A St. Martin\*  
2A St. Mary\*  
2A St. Tammany\*  
2A Tangipahoa\*  
3A Tensas\*  
2A Terrebonne\*

6A Hancock  
6A Kennebec  
6A Knox  
6A Lincoln  
6A Oxford  
6A Penobscot  
6A Piscataquis  
6A Sagadahoc  
6A Somerset  
6A Waldo  
6A Washington  
6A York

**MARYLAND**

4A Allegany  
4A Anne Arundel  
4A Baltimore  
4A Baltimore (city)  
4A Calvert  
4A Caroline  
4A Carroll  
4A Cecil  
4A Charles  
4A Dorchester  
4A Frederick  
5A Garrett  
4A Harford  
4A Howard  
4A Kent  
4A Montgomery  
4A Prince George's

4A Finney  
 4A Ford  
 4A Franklin  
 4A Geary  
 5A Gove  
 5A Graham  
 4A Grant  
 4A Gray  
 5A Greeley  
 4A Greenwood  
 5A Hamilton  
 4A Harper  
 4A Harvey

5A Phillips  
 4A Pottawatomie  
 4A Pratt  
 5A Rawlins  
 4A Rene  
 5A Republic  
 4A Rice  
 4A Riley  
 5A Rooks  
 4A Rush  
 4A Russell  
 4A Saline  
 5A Scott

2A Calcasieu\*  
 3A Caldwell\*  
 2A Cameron\*  
 3A Catahoula\*  
 3A Claiborne\*  
 3A Concordia\*  
 3A De Soto\*  
 2A East Baton Rouge\*  
 3A East Carroll  
 2A East Feliciana\*  
 2A Evangeline\*  
 3A Franklin\*  
 3A Grant\*  
 2A Iberia\*

3A Union\*  
 2A Vermilion\*  
 3A Vernon\*  
 2A Washington\*  
 3A Webster\*  
 2A West Baton  
 Rouge\*  
 3A West Carroll  
 2A West Feliciana\*  
 3A Winn\*

4A Queen Anne's  
 4A Somerset  
 4A St. Mary's  
 4A Talbot  
 4A Washington  
 4A Wicomico  
 4A Worcester

**MASSACHUSETTS**

5A (all)

**MICHIGAN**

**MAINE**

6A Androscoggin  
 7A Arden

6A Alcona  
 6A Alger

(continued)

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

5A Allegan  
 6A Alpena  
 6A Antrim  
 6A Arenac  
 7 Baraga  
 5A Barry  
 5A Bay  
 6A Benzie  
 5A Berrien  
 5A Branch

7 Mackinac  
 5A Macomb  
 6A Manistee  
 6A Marquette  
 6A Mason  
 6A Mecosta  
 6A Menominee  
 5A Midland  
 6A Missaukee  
 5A Monroe

6A Carver  
 7 Cass  
 6A Chippewa  
 6A Chisago  
 7 Clay  
 7 Clearwater  
 7 Cook  
 6A Cottonwood  
 7 Crow Wing  
 6A Dakota

7 Otter Tail  
 7 Pennington  
 7 Pine  
 6A Pipestone  
 7 Polk  
 6A Pope  
 6A Ramsey  
 7 Red Lake  
 6A Redwood  
 6A Renville

3A Clarke  
 3A Clay  
 3A Coahoma  
 3A Copiah\*  
 3A Covington\*  
 3A DeSoto  
 3A Forrest\*  
 3A Franklin\*  
 3A George\*  
 3A Greene\*



5A Lapeer	6A Benton	6A Murray	3A Calhoun	3A Oktibbeha
6A Leelanau	6A Big Stone	6A Nicolle	3A Carroll	3A Panola
5A Lenawee	6A Blue Earth	6A Nobles	3A Chickasaw	2A Pearl River*
5A Livingston	6A Brown	7 Norman	3A Choctaw	3A Perry*
7 Luce	7 Carlton	6A Olmsted	3A Claiborne*	3A Pike*

(continued)

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

3A Pontotoc	5A Chariton	4A Mississippi	4A Webster	4A Cumberland
3A Prentiss	4A Christian	4A Moniteau	5A Worth	4A Essex
3A Quitman	5A Clark	4A Monroe	4A Wright	4A Gloucester
3A Rankin*	4A Clay	4A Montgomery	<b>MONTANA</b>	4A Hudson
3A Scott	5A Clinton	4A Morgan	6B (all)	5A Hunterdon
3A Sharkey	4A Cole	4A New Madrid	<b>NEBRASKA</b>	5A Mercer
3A Simpson*	4A Cooper	4A Newton	5A (all)	4A Middlesex
3A Smith*	4A Crawford	5A Nodaway	<b>NEVADA</b>	4A Monmouth
2A Stone*	4A Dade	4A Oregon	5B Carson City (city)	5A Morris
3A Sunflower	4A Dallas	4A Osage	5B Churchill	4A Ocean
3A Tallahatchie	5A Daviess	4A Ozark	3B Clark	5A Passaic
3A Tate	5A DeKalb	4A Pemiscot	5B Douglas	4A Salem
3A Tippah	4A Dent	4A Perry	5B Elko	5A Somerset
3A Tishomingo	4A Douglas	4A Pettis	5B Esmeralda	5A Sussex
3A Tunica	4A Dunklin	4A Phelps	5B Eureka	4A Union
3A Union	4A Franklin	5A Pike	5B Humboldt	5A Warren
3A Walthall*	4A Gasconade	4A Platte		<b>NEW MEXICO</b>
3A Warren*	5A Gentry	4A Polk		4B Bernalillo
3A Washington	4A Greene	4A Pulaski		

3A Wayne\*  
3A Webster  
3A Wilkinson\*  
3A Winston  
3A Yalobusha  
3A Yazoo

**MISSOURI**

5A Adair  
5A Andrew  
5A Atchison  
4A Audrain  
4A Barry  
4A Barton  
4A Bates  
4A Benton  
4A Bollinger  
4A Boone  
5A Buchanan  
4A Butler  
5A Caldwell  
4A Callaway  
4A Camden  
4A Cape Girardeau  
4A Carroll  
4A Carter  
4A Cass  
4A Cedar

5A Grundy  
5A Harrison  
4A Henry  
4A Hickory  
5A Holt  
4A Howard  
4A Howell  
4A Iron  
4A Jackson  
4A Jasper  
4A Jefferson  
4A Johnson  
5A Knox  
4A Laclede  
4A Lafayette  
4A Lawrence  
5A Lewis  
4A Lincoln  
5A Linn  
5A Livingston  
5A Macon  
4A Madison  
4A Maries  
5A Marion  
4A McDonald  
5A Mercer  
4A Miller

5A Putnam  
5A Ralls  
4A Randolph  
4A Ray  
4A Reynolds  
4A Ripley  
4A Saline  
5A Schuyler  
5A Scotland  
4A Scott  
4A Shannon  
5A Shelby  
4A St. Charles  
4A St. Clair  
4A Ste. Genevieve  
4A St. Francois  
4A St. Louis  
4A St. Louis (city)  
4A Stoddard  
4A Stone  
5A Sullivan  
4A Taney  
4A Texas  
4A Vernon  
4A Warren  
4A Washington  
4A Wayne

*(continued)*

5B Lander  
5B Lincoln  
5B Lyon  
5B Mineral  
5B Nye  
5B Pershing  
5B Storey  
5B Washoe  
5B White Pine

**NEW HAMPSHIRE**

6A Belknap  
6A Carroll  
5A Cheshire  
6A Coos  
6A Grafton  
5A Hillsborough  
6A Merrimack  
5A Rockingham  
5A Strafford  
6A Sullivan

**NEW JERSEY**

4A Atlantic  
5A Bergen  
4A Burlington  
4A Camden  
4A Cape May

5B Catron  
3B Chaves  
4B Cibola  
5B Colfax  
4B Curry  
4B DeBaca  
3B Dona Ana  
3B Eddy  
4B Grant  
4B Guadalupe  
5B Harding  
3B Hidalgo  
3B Lea  
4B Lincoln  
5B Los Alamos  
3B Luna  
5B McKinley  
5B Mora  
3B Otero  
4B Quay  
5B Rio Arriba  
4B Roosevelt  
5B Sandoval  
5B San Juan  
5B San Miguel  
5B Santa Fe  
4B Sierra  
4B Socorro

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

5B-Taos	4A-Queens	4A-Clay	4A-Orange	7-Divide
5B-Torrance	5A-Rensselaer	4A-Cleveland	3A-Pamlico	6A-Dunn
4B-Union	4A-Richmond	3A-Columbus*	3A-Pasquotank	7-Eddy
4B-Valencia	5A-Rockland	3A-Craven	3A-Pender*	6A-Emmons
<b>NEW YORK</b>	5A-Saratoga	3A-Cumberland	3A-Perquimans	7-Foster
5A-Albany	5A-Schenectady	3A-Currituck	4A-Person	6A-Golden Valley
6A-Allegany	6A-Schoharie	3A-Dare	3A-Pitt	7-Grand Forks
4A-Bronx	6A-Schuyler	3A-Davidson	4A-Polk	6A-Grant
6A-Broome	5A-Seneca	4A-Davie	3A-Randolph	7-Griggs
6A-Cattaraugus	6A-Steuben	3A-Duplin	3A-Richmond	6A-Hettinger
5A-Cayuga	6A-St. Lawrence	4A-Durham	3A-Robeson	7-Kidder
5A-Chautauqua	4A-Suffolk	3A-Edgecombe	4A-Rockingham	6A-LaMoire
5A-Chemung	6A-Sullivan	4A-Forsyth	3A-Rowan	6A-Logan
6A-Chenango	5A-Tioga	4A-Franklin	4A-Rutherford	7-McHenry
6A-Clinton	6A-Tompkins	3A-Gaston	3A-Sampson	6A-McIntosh
5A-Columbia	6A-Ulster	4A-Gates	3A-Scotland	6A-McKenzie
5A-Cortland	6A-Warren	4A-Graham	3A-Stanly	7-McLean
6A-Delaware	5A-Washington	4A-Granville	4A-Stokes	6A-Mercer
5A-Dutchess	5A-Wayne	3A-Greene	4A-Surry	6A-Morton
5A-Erie	4A-Westchester	4A-Guilford	4A-Swain	7-Mountrail
6A-Essex	6A-Wyoming	4A-Halifax	4A-Tennessee	7-Nelson
6A-Franklin	5A-Yates	4A-Harnett	3A-Tyrrell	6A-Oliver
6A-Fulton	<b>NORTH</b>	4A-Haywood	3A-Union	7-Pembina
5A-Genesee	<b>CAROLINA</b>	4A-Henderson	4A-Vance	7-Pierce
5A-Greene	4A-Alamance	4A-Hertford	4A-Wake	7-Ramsey
		3A-Hoke	4A-Warren	6A-Ransom

6A Hamilton	4A Alexander	3A Hyde	3A Washington	7 Renville
6A Herkimer	5A Alleghany	4A Iredell	5A Watauga	6A Richland
6A Jefferson	3A Anson	4A Jackson	3A Wayne	7 Relette
4A Kings	5A Ashe	3A Johnston	4A Wilkes	6A Sargent
6A Lewis	5A Avery	3A Jones	3A Wilson	7 Sheridan
5A Livingston	3A Beaufort	4A Lee	4A Yadkin	6A Sioux
6A Madison	4A Bertie	3A Lenoir	5A Yancey	6A Slope
5A Monroe	3A Bladen	4A Lincoln		6A Stark
6A Montgomery	3A Brunswick*	4A Macon	<b>NORTH DAKOTA</b>	7 Steele
4A Nassau	4A Buncombe	4A Madison	6A Adams	7 Stutsman
4A New York	4A Burke	3A Martin	7 Barnes	7 Towner
5A Niagara	3A Cabarrus	4A McDowell	7 Benson	7 Traill
6A Oneida	4A Caldwell	3A Mecklenburg	6A Billings	7 Walsh
5A Onondaga	3A Camden	5A Mitchell	7 Bottineau	7 Ward
5A Ontario	3A Carteret*	3A Montgomery	6A Bowman	7 Wells
5A Orange	4A Caswell	3A Moore	7 Burke	7 Williams
5A Orleans	4A Catawba	4A Nash	6A Burleigh	
5A Oswego	4A Chatham	3A New Hanover*	7 Cass	<b>OHIO</b>
6A Otsege	4A Cherokee	4A Northampton	7 Cavalier	4A Adams
5A Putnam	3A Chowan	3A Onslow*	6A Dickey	5A Allen

(continued)

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

5A Ashland	5A Mahoning	3A Bryan	3A Okfuskee	4C Linn
5A Ashtabula	5A Marion	3A Cadde	3A Oklahoma	5B Malheur
5A Athens	5A Medina	3A Canadian	3A Okmulgee	4C Marion
5A Auglaize	5A Meigs	3A Carter	3A Osage	5B Morrow

5A Belmont  
4A Brown  
5A Butler  
5A Carroll  
5A Champaign  
5A Clark  
4A Clermont  
5A Clinton  
5A Columbiana  
5A Coshocton  
5A Crawford  
5A Cuyahoga  
5A Darke  
5A Defiance  
5A Delaware  
5A Erie  
5A Fairfield  
5A Fayette  
5A Franklin  
5A Fulton  
4A Gallia  
5A Geauga  
5A Greene  
5A Guernsey  
4A Hamilton  
5A Hancock  
5A Hardin  
5A Harrison  
5A Henry  
5A Highland  
5A Hecking

5A Mercer  
5A Miami  
5A Monroe  
5A Montgomery  
5A Morgan  
5A Morrow  
5A Muskingum  
5A Noble  
5A Ottawa  
5A Paulding  
5A Perry  
5A Pickaway  
4A Pike  
5A Portage  
5A Preble  
5A Putnam  
5A Richland  
5A Ross  
5A Sandusky  
4A Scioto  
5A Seneca  
5A Shelby  
5A Stark  
5A Summit  
5A Trumbull  
5A Tuscarawas  
5A Union  
5A Van Wert  
5A Vinton  
5A Warren  
4A Washington

3A Cherokee  
3A Choctaw  
4B Cimarron  
3A Cleveland  
3A Coal  
3A Comanche  
3A Cotton  
3A Craig  
3A Creek  
3A Custer  
3A Delaware  
3A Dewey  
3A Ellis  
3A Garfield  
3A Garvin  
3A Grady  
3A Grant  
3A Greer  
3A Harmon  
3A Harper  
3A Haskell  
3A Hughes  
3A Jackson  
3A Jefferson  
3A Johnston  
3A Kay  
3A Kingfisher  
3A Kiowa  
3A Latimer  
3A Le Flore  
3A Lincoln

3A Ottawa  
3A Pawnee  
3A Payne  
3A Pittsburg  
3A Pontotoc  
3A Pottawatomie  
3A Pushmataha  
3A Roger Mills  
3A Rogers  
3A Seminole  
3A Sequoyah  
3A Stephens  
4B Texas  
3A Tillman  
3A Tulsa  
3A Wagoner  
3A Washington  
3A Washita  
3A Woods  
3A Woodward  
  
**OREGON**  
5B Baker  
4C Benton  
4C Clackamas  
4C Clatsop  
4C Columbia  
4C Coos  
5B Crook  
4C Curry  
5B Deschutes

4C Multnomah  
4C Polk  
5B Sherman  
4C Tillamook  
5B Umatilla  
5B Union  
5B Wallowa  
5B Wasco  
4C Washington  
5B Wheeler  
4C Yamhill

**PENNSYLVANIA**

5A Adams  
5A Allegheny  
5A Armstrong  
5A Beaver  
5A Bedford  
5A Berks  
5A Blair  
5A Bradford  
4A Bucks  
5A Butler  
5A Cambria  
6A Cameron  
5A Carbon  
5A Centre  
4A Chester  
5A Clarion  
6A Clearfield  
5A Clinton

5A Holmes	5A Wayne	3A Logan	4C Douglas	5A Columbia
5A Huron	5A Williams	3A Love	5B Gilliam	5A Crawford
5A Jackson	5A Wood	3A Major	5B Grant	5A Cumberland
5A Jefferson	5A Wyandot	3A Marshall	5B Harney	5A Dauphin
5A Knox	<b>OKLAHOMA</b>	3A Mayes	5B Hood River	4A Delaware
5A Lake		3A McClain	4C Jackson	6A Elk
4A Lawrence	3A Adair	3A McCurtain	5B Jefferson	5A Erie
5A Licking	3A Alfalfa	3A McIntosh	4C Josephine	5A Fayette
5A Logan	3A Atoka	3A Murray	5B Klamath	5A Forest
5A Lorain	4B Beaver	3A Muskogee	5B Lake	5A Franklin
5A Lucas	3A Beckham	3A Noble	4C Lane	5A Fulton
5A Madison	3A Blaine	3A Nowata	4C Lincoln	5A Greene

(continued)

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

5A Huntingdon	3A Bamberg*	5A Bennett	6A Minnehaha	4A Gibson
5A Indiana	3A Barnwell*	5A Bon Homme	6A Moody	4A Giles
5A Jefferson	3A Beaufort*	6A Brookings	6A Pennington	4A Grainger
5A Juniata	3A Berkeley*	6A Brown	6A Perkins	4A Greene
5A Lackawanna	3A Calhoun	6A Brule	6A Potter	4A Grundy
5A Lancaster	3A Charleston*	6A Buffalo	6A Roberts	4A Hamblen
5A Lawrence	3A Cherokee	6A Butte	6A Sanborn	4A Hamilton
5A Lebanon	3A Chester	6A Campbell	6A Shannon	4A Hancock
5A Lehigh	3A Chesterfield	5A Charles Mix	6A Spink	3A Hardeman
5A Luzerne	3A Clarendon	6A Clark	6A Stanley	3A Hardin
5A Lycoming	3A Colleton*	5A Clay	6A Sully	4A Hawkins
6A McKean	3A Darlington	6A Codrington	5A Todd	3A Haywood

5A Mercer  
5A Mifflin  
5A Monroe  
4A Montgomery  
5A Montour  
5A Northampton  
5A Northumberland  
5A Perry  
4A Philadelphia  
5A Pike  
6A Potter  
5A Schuylkill  
5A Snyder  
5A Somerset  
5A Sullivan  
6A Susquehanna  
6A Tioga  
5A Union  
5A Venange  
5A Warren  
5A Washington  
6A Wayne  
5A Westmoreland  
5A Wyoming  
4A York

**RHODE ISLAND**

5A (all)

**SOUTH CAROLINA**

3A Abbeville

3A Dillon  
3A Dorchester\*  
3A Edgefield  
3A Fairfield  
3A Florence  
3A Georgetown\*  
3A Greenville  
3A Greenwood  
3A Hampton\*  
3A Horry\*  
3A Jasper\*  
3A Kershaw  
3A Lancaster  
3A Laurens  
3A Lee  
3A Lexington  
3A Marion  
3A Marlboro  
3A McCormick  
3A Newberry  
3A Oconee  
3A Orangeburg  
3A Pickens  
3A Richland  
3A Saluda  
3A Spartanburg  
3A Sumter  
3A Union  
3A Williamsburg  
3A York

**SOUTH DAKOTA**

6A Corson  
6A Custer  
6A Davison  
6A Day  
6A Deuel  
6A Dewey  
5A Douglas  
6A Edmunds  
6A Fall River  
6A Faulk  
6A Grant  
5A Gregory  
6A Haakon  
6A Hamlin  
6A Hand  
6A Hanson  
6A Harding  
6A Hughes  
5A Hutchinson  
6A Hyde  
5A Jackson  
6A Jerauld  
6A Jones  
6A Kingsbury  
6A Lake  
6A Lawrence  
6A Lincoln  
6A Lyman  
6A Marshall  
6A McCook  
6A McPherson

5A Tripp  
6A Turner  
5A Union  
6A Walworth  
5A Yankton  
6A Ziebach

**TENNESSEE**

4A Anderson  
4A Bedford  
4A Benton  
4A Bledsoe  
4A Blount  
4A Bradley  
4A Campbell  
4A Cannon  
4A Carroll  
4A Carter  
4A Cheatham  
3A Chester  
4A Claiborne  
4A Clay  
4A Coker  
4A Coffee  
3A Crockett  
4A Cumberland  
4A Davidson  
4A Decatur  
4A DeKalb  
4A Dickson  
3A Dyer

3A Henderson  
4A Henry  
4A Hickman  
4A Houston  
4A Humphreys  
4A Jackson  
4A Jefferson  
4A Johnson  
4A Knox  
3A Lake  
3A Lauderdale  
4A Lawrence  
4A Lewis  
4A Lincoln  
4A Loudon  
4A Macon  
3A Madison  
4A Marion  
4A Marshall  
4A Maury  
4A McMinn  
3A McNairy  
4A Meigs  
4A Monroe  
4A Montgomery  
4A Moore  
4A Morgan  
4A Obion  
4A Overton  
4A Perry  
4A Pickett

3A Aiken		6A Meade	3A Fayette	4A Polk
3A Allendale*	6A Aurora	5A Mollette	4A Fentress	4A Putnam
3A Anderson	6A Beadle	6A Miner	4A Franklin	4A Rhea

(continued)

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

4A Roane	3B Brewster	3B Ector	3B Howard	3B McCulloch
4A Robertson	4B Briscoe	2B Edwards*	3B Hudspeth	2A McLennan*
4A Rutherford	2A Brooks*	3A Ellis*	3A Hunt*	2A McMullen*
4A Scott	3A Brown*	3B El Paso	4B Hutchinson	2B Medina*
4A Sequatchie	2A Burleson*	3A Erath*	3B Irion	3B Menard
4A Sevier	3A Burnet*	2A Falls*	3A Jack	3B Midland
3A Shelby	2A Caldwell*	3A Fannin	2A Jackson*	2A Milam*
4A Smith	2A Calhoun*	2A Fayette*	2A Jasper*	3A Mills*
4A Stewart	3B Callahan	3B Fisher	3B Jeff Davis	3B Mitchell
4A Sullivan	2A Cameron*	4B Floyd	2A Jefferson*	3A Montague
4A Sumner	3A Camp*	3B Foard	2A Jim Hogg*	2A Montgomery*
3A Tipton	4B Carson	2A Fort Bend*	2A Jim Wells*	4B Moore
4A Trousdale	3A Case*	3A Franklin*	3A Johnson*	3A Morris*
4A Unicoi	4B Castro	2A Freestone*	3B Jones	3B Motley
4A Union	2A Chambers*	2B Frio*	2A Karnes*	3A Nacogdoches*
4A Van Buren	2A Cherokee*	3B Gaines	3A Kaufman*	3A Navarro*
4A Warren	3B Childress	2A Galveston*	3A Kendall*	2A Newton*
4A Washington	3A Clay	3B Garza	2A Kenedy*	3B Nolan
4A Wayne	4B Cochran	3A Gillespie*	3B Kent	2A Nueces*
4A Weakley	3B Coke	3B Glasscock	3B Kerr	4B Ochiltree
4A White	3B Coleman	2A Goliad*	3B Kimble	4B Oldham

4A Williamson  
4A Wilson

**TEXAS**

2A Anderson\*  
3B Andrews  
2A Angelina\*  
2A Aransas\*  
3A Archer  
4B Armstrong  
2A Atascosa\*  
2A Austin\*  
4B Bailey  
2B Bandera\*  
2A Bastrop\*  
3B Baylor  
2A Bee\*  
2A Bell\*  
2A Bexar\*  
3A Blanco\*  
3B Borden  
2A Bosque\*  
3A Bowie\*  
2A Brazoria\*  
2A Brazos\*

3A Collin\*  
3B Collingsworth  
2A Colorado\*  
2A Comal\*  
3A Comanche\*  
3B Concho  
3A Cooke  
2A Coryell\*  
3B Cottle  
3B Crane  
3B Crockett  
3B Crosby  
3B Culberson  
4B Dallam  
3A Dallas\*  
3B Dawson  
4B Deaf Smith  
3A Delta  
3A Denton\*  
2A DeWitt\*  
3B Dickens  
2B Dimmit\*  
4B Donley  
2A Duval\*  
3A Eastland

2A Gonzales\*  
4B Gray  
3A Grayson  
3A Gregg\*  
2A Grimes\*  
2A Guadalupe\*  
4B Hale  
3B Hall  
3A Hamilton\*  
4B Hansford  
3B Hardeman  
2A Hardin\*  
2A Harris\*  
3A Harrison\*  
4B Hartley  
3B Haskell  
2A Hays\*  
3B Hemphill  
3A Henderson\*  
2A Hidalgo\*  
2A Hill\*  
4B Hockley  
3A Hood\*  
3A Hopkins\*  
2A Houston\*

*(continued)*

3B King  
2B Kinney\*  
2A Kleberg\*  
3B Knox  
3A Lamar\*  
4B Lamb  
3A Lampasas\*  
2B La Salle\*  
2A Lavaca\*  
2A Lee\*  
2A Leon\*  
2A Liberty\*  
2A Limestone\*  
4B Lipscomb  
2A Live Oak\*  
3A Llano\*  
3B Loving  
3B Lubbock  
3B Lynn  
2A Madison\*  
3A Marion\*  
3B Martin  
3B Mason  
2A Matagorda\*  
2B Maverick\*

2A Orange\*  
3A Palo Pinto\*  
3A Panola\*  
3A Parker\*  
4B Parmer  
3B Pecos  
2A Polk\*  
4B Potter  
3B Presidio  
3A Rains\*  
4B Randall  
3B Reagan  
2B Real\*  
3A Red River\*  
3B Reeves  
2A Refugio\*  
4B Roberts  
2A Robertson\*  
3A Rockwall\*  
3B Runnels  
3A Rusk\*  
3A Sabine\*  
3A San Augustine\*  
2A San Jacinto\*  
2A San Patricio\*

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

3A San Saba*	3A Young	4C Clark	4A Gilmer	<b>WISCONSIN</b>
3B Schleicher	2B Zapata*	5B Columbia	5A Grant	6A Adams
3B Scurry	2B Zavala*	4C Cowlitz	5A Greenbrier	7 Ashland
3B Shackelford		5B Douglas	5A Hampshire	6A Barron
3A Shelby*	<b>UTAH</b>	6B Ferry	5A Hancock	7 Bayfield
4B Sherman	5B Beaver	5B Franklin	5A Hardy	6A Brown
3A Smith*	6B Box Elder	5B Garfield	5A Harrison	6A Buffalo
3A Somervell*	6B Cache	5B Grant	4A Jackson	7 Burnett
2A Starr*	6B Carbon	4C Grays Harbor	4A Jefferson	6A Calumet
3A Stephens	6B Daggett	4C Island	4A Kanawha	6A Chippewa
3B Sterling	5B Davis	4C Jefferson	5A Lewis	6A Clark
3B Stonewall	6B Duchesne	4C King	4A Lincoln	6A Columbia
3B Sutton	5B Emery	4C Kitsap	4A Logan	6A Crawford
4B Swisher	5B Garfield	5B Kittitas	5A Marion	6A Dane
3A Tarrant*	5B Grand	5B Klickitat	5A Marshall	6A Dodge
3B Taylor	5B Iron	4C Lewis	4A Mason	6A Door
3B Terrell	5B Juab	5B Lincoln	4A McDowell	7 Douglas
3B Terry	5B Kane	4C Mason	4A Mercer	6A Dunn
3B Throckmorton	5B Millard	6B Okanogan	5A Mineral	6A Eau Claire
3A Titus*	6B Morgan	4C Pacific	4A Minge	7 Florence
3B Tom Green	5B Piute	6B Pend Oreille	5A Monongalia	6A Fond du Lac
2A Travis*	6B Rich	4C Pierce	4A Monroe	7 Forest
2A Trinity*	5B Salt Lake	4C San Juan	4A Morgan	6A Grant
2A Tyler*	5B San Juan	4C Skagit	5A Nicholas	6A Green
3A Upshur*	5B Sanpete	5B Skamania	5A Ohio	6A Green Lake
3B Upton	5B Sevier	4C Snohomish	5A Pendleton	6A Iowa

2B Uvalde*	6B Summit	5B Spokane	4A Pleasants	7 Iron
2B Val Verde*	5B Toccoe	6B Stevens	5A Pocahontas	6A Jackson
3A Van Zandt*	6B Uintah	4C Thurston	5A Preston	6A Jefferson
2A Victoria*	5B Utah	4C Wahkiakum	4A Putnam	6A Juneau
2A Walker*	6B Wasatch	5B Walla Walla	5A Raleigh	6A Kenosha
2A Waller*	3B Washington	4C Whatcom	5A Randolph	6A Kewaunee
3B Ward	5B Wayne	5B Whitman	4A Ritchie	6A La Crosse
2A Washington*	5B Weber	5B Yakima	4A Roane	6A Lafayette
2B Webb*	<b>VERMONT</b>	<b>WEST VIRGINIA</b>	5A Summers	7 Langlade
2A Wharton*	6A (all)	5A Barbour	5A Taylor	7 Lincoln
3B Wheeler	<b>VIRGINIA</b>	4A Berkeley	5A Tucker	6A Manitowoc
3A Wichita	4A (all)	4A Boone	4A Tyler	6A Marathon
3B Wilbarger	<b>WASHINGTON</b>	4A Braxton	5A Upshur	6A Marinette
2A Willacy*	5B Adams	4A Brooke	4A Wayne	6A Marquette
2A Williamson*	5B Asotin	4A Cabell	5A Webster	6A Menominee
2A Wilson*	5B Benton	4A Calhoun	5A Wetzel	6A Milwaukee
3B Winkler	5B Chelan	4A Clay	4A Wirt	6A Monroe
3A Wise	4C Clallam	5A Deddridge	4A Wood	6A Oconto
3A Wood*		5A Fayette	4A Wyoming	7 Oneida
4B Yeakum				6A Outagamie

(continued)

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

6A Ozaukee	7 Taylor	6B Big Horn	6B Sheridan	<b>NORTHERN MARIANA ISLANDS</b>
6A Pepin	6A Trempealeau	6B Campbell	7 Sublette	

6A Pierce	6A Vernon	6B Carbon	6B Sweetwater	1A (all)*
6A Polk	7 Vilas	6B Converse	7 Teton	<b>PUERTO RICO</b>
6A Portage	6A Walworth	6B Crook	6B Uinta	1A (all)*
7 Price	7 Washburn	6B Fremont	6B Washakie	<b>VIRGIN ISLANDS</b>
6A Racine	6A Washington	5B Goshen	6B Weston	1A (all)*
6A Richland	6A Waukesha	6B Hot Springs	<b>US TERRITORIES</b>	
6A Rock	6A Waupaca	6B Johnson	<b>AMERICAN</b>	
6A Rusk	6A Waushara	6B Laramie	<b>SAMOA</b>	
6A Sauk	6A Winnebago	7 Lincoln	1A (all)*	
7 Sawyer	6A Wood	6B Natrona	<b>GUAM</b>	
6A Shawano	<b>WYOMING</b>	6B Niobrara		
6A Sheboygan		6B Park		
6A St. Croix	6B Albany	5B Platte	1A (all)*	

TABLE C301.3(1)  
INTERNATIONAL 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:	
Not marine and $P_{in} < 0.44 \times (TF - 19.5)$ [ $P_{in} < 2.0 \times (TC + 7)$ in SI units]	
where:	
$P_{in}$ = Annual precipitation in inches (cm)	
T = Annual mean temperature in °F (°C)	
Moist (A) Definition—Locations that are not marine and not dry.	

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

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

2. 73°F (22.8°C) or higher for 1,500 or more hours.

For SI: °C = [(°F) - 32]/1.8, 1 inch = 2.54 cm.

TABLE C301.3(2)  
INTERNATIONAL CLIMATE ZONE DEFINITIONS

ZONE NUMBER	THERMAL CRITERIA	
	IP Units	SI Units
1	9000 < CDD50°F	5000 < CDD10°C
2	6300 < CDD50°F ≤ 9000	3500 < CDD10°C ≤ 5000
3A and 3B	4500 < CDD50°F ≤ 6300 AND HDD65°F ≤ 5400	2500 < CDD10°C ≤ 3500 AND HDD18°C ≤ 3000
4A and 4B	CDD50°F ≤ 4500 AND HDD65°F ≤ 5400	CDD10°C ≤ 2500 AND HDD18°C ≤ 3000
3C	HDD65°F ≤ 3600	HDD18°C ≤ 2000
4C	3600 < HDD65°F ≤ 5400	2000 < HDD18°C ≤ 3000
5	5400 < HDD65°F ≤ 7200	3000 < HDD18°C ≤ 4000
6	7200 < HDD65°F ≤ 9000	4000 < HDD18°C ≤ 5000
7	9000 < HDD65°F ≤ 12600	5000 < HDD18°C ≤ 7000
8	12600 < HDD65°F	7000 < HDD18°C

For SI: °C  
= (°F)  
32/1.8.

## SECTION C3012 DESIGN CONDITIONS

### C3012.1 Interior design conditions.

The interior design temperatures used for heating and cooling load calculations shall be a maximum of 70~~2~~°F (21~~2~~°C) for heating and minimum of 75°F (24°C) for cooling.

## SECTION C3023 MATERIALS, SYSTEMS AND EQUIPMENT

### C3023.1 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.

#### C3023.1.1 Building thermal envelope insulation.

An *R*-value identification mark shall be applied by the manufacturer to each piece of *building thermal envelope* insulation 12 inches (305 mm) or greater in width. Alternately, 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 thickness shall be *listed* on the certification. The insulation installer shall sign, date and post the certification in a conspicuous location on the job site.

##### C3023.1.1.1 Blown or sprayed roof/ceiling insulation.

The thickness of blown-in or sprayed roof/ceiling insulation (fiberglass or cellulose) shall be written in inches (mm) on markers that are installed at least one for every 300 square feet (28 m<sup>2</sup>) throughout the attic space. The markers shall be affixed to the trusses or

joists and marked with the minimum initial installed thickness with numbers a minimum of 1 inch (25 mm) in height. Each marker shall face the attic access opening. Spray polyurethane foam thickness and installed *R-value* shall be *listed* on certification provided by the insulation installer.

**C3023.1.2 Insulation mark installation.**

Insulating materials shall be installed such that the manufacturer's *R-value* mark is readily observable upon inspection.

**C3023.1.3 Fenestration product rating.**

*U*-factors of fenestration products (windows, doors and skylights) shall be determined in accordance with NFRC 100 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 C3023.1.3(1) or C3023.1.3(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 C3023.1.3(3).

TABLE C3023.1.3(1)  
DEFAULT GLAZED FENESTRATION *U*-FACTOR

FRAME TYPE	SINGLE PANE	DOUBLE PANE	SKYLIGHT	
			Single	Double
Metal	1.20	0.80	2.00	1.30
Metal with Thermal Break	1.10	0.65	1.90	1.10
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05
Glazed Block	0.60			

TABLE C3023.1.3(2)  
DEFAULT DOOR *U*-FACTORS

DOOR TYPE	U-FACTOR
Uninsulated Metal	1.20
Insulated Metal	0.60
Wood	0.50
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	0.35

TABLE C3023.1.3(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

**C3023.1.4 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<sup>2</sup> × °F/Btu at a mean temperature of 75°F (24°C).

**C3023.2 Installation.**

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

**C3023.2.1 Protection of exposed foundation insulation.**

Insulation applied to the exterior of basement walls, crawlspace 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 a minimum of 6 inches (153 mm) below grade.

**C3023.3 Maintenance information.**

Maintenance instructions shall be furnished for equipment and systems that require preventive maintenance. Required regular maintenance

actions shall be clearly stated and incorporated on a *readily accessible* label. The label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product.

## CHAPTER 4 [CE] COMMERCIAL ENERGY EFFICIENCY

### SECTION C401 GENERAL

#### C401.1 Scope.

The requirements contained in this chapter are applicable to commercial buildings, or portions of commercial buildings.

#### C401.2 Application.

Commercial buildings shall comply with ~~one of~~ the following:

##### C401.2.1 Application to new buildings and additions.

New buildings and additions to existing buildings shall comply with the following:

~~1. The requirements of ANSI/ASHRAE/IESNA 90.1-2010 Energy Standard for Buildings except for Low-Rise Residential Buildings. Compliance shall be demonstrated through performance modeling which complies with all requirements of ASHRAE 90.1-2010 Appendix G, performed by a registered design professional. In addition, new buildings and additions shall comply with all mandatory requirements of this chapter.~~

~~2. The requirements of Sections C402, C403, C404 and C405. In addition, commercial buildings shall comply with either Section C406.2, C406.3 or C406.4.~~

~~3. The requirements of Section C407, C402.4, C403.2, C404, C405.2, C405.3, C405.4, C405.6 and C405.7. The building energy cost shall be equal to or less than 85 percent of the standard reference design building.~~

~~C401.2.1 Application to existing buildings.~~

~~Additions, alterations and repairs to existing buildings shall comply with one of the following:~~

~~1. Sections C402, C403, C404 and C405; or~~

~~2. ANSI/ASHRAE/IESNA 90.1-2010 Energy Standard for Buildings except for Low-Rise Residential Buildings. Compliance shall be demonstrated through performance modeling which complies with all requirements of ASHRAE 90.1-2010 Appendix G, performed by a registered design professional. In addition, new buildings and additions shall comply with all mandatory requirements of this chapter.~~

1. New buildings and additions with a construction valuation of \$500,000 or more shall have annual energy operating costs for the proposed design that are at least 30 percent less than the standard reference design of Appendix G of ASHRAE/IESNA Standard 90.1-2010 Energy Standard for Building except for Low-Rise Residential Buildings. Compliance shall be demonstrated through performance modeling which complies with all requirements of ASHRAE 90.1-2010 Appendix G, performed by a registered design professional. In addition, new buildings and additions shall comply with all mandatory requirements of this chapter.

1.1 Commercial core and shell buildings may take credit for energy efficiency that is part of the future interior tenant finish design provided the efficiency measures are shown on the final tenant build-out drawings. The code official will issue a temporary certificate

of occupancy until the final tenant drawings are submitted showing the efficiency measures. If all efficiency measures are shown on the final tenant drawings, a permanent certificate of occupancy will be issued.

2. New buildings and additions with a construction valuation less than \$500,000 shall comply with Sections C402, C403, C404, C405, C406, and C407.

Exception: If the work is limited to mechanical equipment replacement, the replacement equipment shall meet the requirements of sections C403 and C404.

C401.2.2 Application to alterations and repairs. Alterations and repairs to existing buildings shall comply with all mandatory requirements of this chapter and the requirements specified in Table C401.2.2. The applicable requirements in Table C401.2.2 are determined by construction valuation.

**TABLE C401.2.2**

**ALTERATION AND REPAIR GENERAL ENERGY EFFICIENCY REQUIREMENTS**

<u>Thresholds for requirements</u>	<u>Construction valuation is <math>\leq 25\%</math> of assessed value<sup>1</sup> of existing building</u>	<u>Construction valuation is <math>26-50\%</math> of assessed value<sup>1</sup> of existing building</u>	<u>Construction valuation is <math>\geq 51\%</math> of assessed value<sup>1</sup> of existing building</u>
<u>Requirements</u>	<u>All energy and building code requirements (for the scope of the alteration)</u>	<u>Shall have annual energy operating costs for the proposed design that are equal to or less than the standard reference design of Appendix G of ASHRAE/IESNA Standard 90.1-2010 Energy Standard for Building except for Low-Rise Residential Buildings.<sup>2</sup></u>	<u>Triggers new construction requirements (C401.2.1)</u>

**Commented [PH1]:** ICC: Please format these new tables and table headings to match the others

<sup>1</sup> Assessed value is obtained from Boulder County's Tax Assessor Database.

<sup>2</sup> These projects must demonstrate compliance through performance modeling which complies with all requirements of ASHRAE 90.1-2010 Appendix G, performed by a registered design professional.

**SECTION C402  
BUILDING ENVELOPE REQUIREMENTS**

**C402.1 General (Prescriptive).**

The building thermal envelope shall comply with Section [C402.1.1](#). Section [C402.1.2](#) shall be permitted as an alternative to the *R-values* specified in Section [C402.1.1](#).

**C402.1.1 Insulation and fenestration criteria.**

The *building thermal envelope* shall meet the requirements of Tables [C402.2](#) and [C402.3](#) based on the climate zone specified in ~~Chapter 3~~. Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the *R-values* from the "Group R" column of Table [C402.2](#). 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 [C402.2](#). ~~Buildings with a vertical fenestration area or skylight area that exceeds that allowed in Table [C402.3](#) shall comply with the building envelope provisions of ANSI/ASHRAE/IESNA 90.1.~~

**C402.1.2 U-factor alternative.**

An assembly with a *U-factor*, *C-factor*, or *F-factor* equal or less than that specified in Table [C402.1.2](#) shall be permitted as an alternative to the *R-value* in Table [C402.2](#). Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the *U-factor*, *C-factor*, or *F-factor* from the "Group R" column of Table [C402.1.2](#). Commercial buildings or portions of commercial buildings enclosing occupancies other than Group R shall use the *U-factor*, *C-factor* or *F-factor* from the "All other" column of Table [C402.1.2](#).

TABLE C402.1.2  
OPAQUE THERMAL ENVELOPE ASSEMBLY REQUIREMENTS

**Commented [TK2]:** For ICC: Please remove all references to CZs and just remake this table with the requirements for CZ5

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
<b>Roofs</b>																
Insulation entirely above deck	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.039	U-0.039	U-0.039 U-0.030	U-0.039	U-0.032	U-0.032	U-0.028	U-0.028	U-0.028	U-0.028

Metal buildings	U-0.044	U-0.035	U-0.031	U-0.031	U-0.029	U-0.029	U-0.029	U-0.029								
Attic and other	U-0.027	<del>U-0.027</del> U-0.020	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021								
<b>Walls, Above Grade</b>																
Mass	U-0.142	U-0.142	U-0.142	U-0.123	U-0.110	U-0.104	U-0.104	U-0.090	U-0.078	U-0.078	U-0.078	U-0.071	U-0.061	U-0.061	U-0.061	U-0.061
Metal building	U-0.079	U-0.079	U-0.079	U-0.079	U-0.079	U-0.052	U-0.052	U-0.052	U-0.052	<del>U-0.052</del> U-0.048	U-0.052	U-0.052	U-0.052	U-0.039	U-0.052	U-0.039
Metal framed	U-0.077	U-0.077	U-0.077	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	<del>U-0.064</del> U-0.052	U-0.064	U-0.064	U-0.057	U-0.064	U-0.052	U-0.045
Wood framed and other	U-0.064	<del>U-0.064</del> U-0.048	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.036								
<b>Walls, Below Grade</b>																
Below-grade wall <sup>b</sup>	C-1.140	C-1.140	C-1.140	C-1.140	C-1.140	C-1.140	C-0.119	C-0.119	C-0.119	<del>C-0.119</del> C-0.113	C-0.119	C-0.119	C-0.119	C-0.092	C-0.092	C-0.092
<b>Floors</b>																
Mass	U-0.322	U-0.322	U-0.107	U-0.087	U-0.076	U-0.076	U-0.076	U-0.076	U-0.074	<del>U-0.074</del> U-0.054	U-0.064	U-0.064	U-0.057	U-0.055	U-0.051	U-0.055

Joist/framing	U-0.066	U-0.066	U-0.033													
<b>Slab-on-Grade Floors</b>																
Unheated slabs	F-0.73	F-0.73	F-0.73	F-0.73	F-0.73	F-0.73	F-0.54	F-0.54	F-0.54	F-0.54	F-0.52	F-0.40	F-0.40	F-0.40	F-0.40	F-0.40
Heated slabs	F-0.70	F-0.70	F-0.70	F-0.70	F-0.70	F-0.70	F-0.65	F-0.65	F-0.58	F-0.58	F-0.58	F-0.55	F-0.55	F-0.55	F-0.55	F-0.55

a. Use of opaque assembly *U* factors, *C* factors, and *F* factors from ANSI/ASHRAE/IESNA 90.1 Appendix A shall be permitted, provided the construction complies with the applicable construction details from ANSI/ASHRAE/IESNA 90.1 Appendix A.

ab. Where heated slabs are below grade, below-grade walls shall comply with the *F*-factor requirements for heated slabs.

**C402.2 Specific insulation requirements (Prescriptive).**

Opaque assemblies shall comply with Table C402.2. 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. If the continuous insulation board manufacturer's installation instructions do not address installation of two or more layers, the edge joints between each layer of continuous insulation boards shall be staggered.

TABLE C402.2  
OPAQUE THERMAL ENVELOPE REQUIREMENTS

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
<b>Roofs</b>																
Insulation entirely above deck	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci

**Commented [TK3]:** For ICC: Please remove all references to CZs and just remake this table with the requirements for CZ5

Metal buildings (with R-5 thermal blocks) <sup>a</sup>	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS											
Attic and other	R-38	<del>R-38</del> R-50.1	R-49													
<b>Walls, Above Grade</b>																
Mass <sup>c</sup>	R-5.7ci <sup>c</sup>	R-5.7ci <sup>c</sup>	R-5.7ci <sup>c</sup>	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	<del>R-11.4ci</del> R-12.8ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal building	R-13+ R-6.5ci	R-13+ R-6.5ci	R-13+ R-6.5ci	R-13+ R-13ci	R-13+ R-6.5ci	R-13+ R-13ci	R-13+ R-13ci	R-13+ R-13ci	R-13+ R-13ci	R-13+ R-13ci	R-13+ R-13ci	R-13+ R-13ci	R-13+ R-13ci	R-13+ R-19.5ci	R-13+ R-13ci	R-13+ R-19.5ci
Metal framed	R-13+ R-5ci	R-13+ R-5ci	R-13+ R-5ci	R-13+ R-7.5ci	<del>R-7.5ci</del> R-8.1ci	R-13+ R-7.5ci	R-13+ R-7.5ci	R-13+ R-7.5ci	R-13+ R-7.5ci	R-13+ R-15.6ci	R-13+ R-7.5ci	R-13+ R-17.5ci				
Wood framed and other	R-13+ R-3.8ci or R-20	<del>R-13+ R-3.8ci</del> R-6.1ci or R-20	R-13+ R-7.5ci or R-20 + R-3.8ci	R-13+ R-15.6ci or R-20 + R-10ci	R-13+ R-15.6ci or R-20 + R-10ci											
<b>Walls, Below Grade</b>																
Below-grade wall <sup>d</sup>	NR	NR	NR	NR	NR	NR	R-7.5ci	R-7.5ci	<del>R-7.5ci</del> R-8.8ci	R-7.5ci	R-7.5ci	R-7.5ci	R-10ci	R-10ci	R-10ci	R-12.5ci
<b>Floors</b>																

Mass	NR	NR	R-6.3ci	R-8.3ci	R-10ci	R-10ci	R-10ci	R-10.4ci	<del>R-10ci</del> R-18.5ci	R-12.5ci	R-12.5ci	R-12.5ci	R-15ci	R-16.7ci	R-15ci	R-16.7ci
Joist/framing	NR	NR	R-30	R-30	R-30	R-30	R-30	R-30	<del>R-30</del> R-31.9	R-30	R-30	R-30°	R-30°	R-30°	R-30°	R-30°
<b>Slab-on-Grade Floors</b>																
Unheated slabs	NR	NR	NR	NR	NR	NR	R-10 for 24" below	R-10 for 24" below	<del>R-10</del> R-15 for 24" below	R-10 for 24" below	R-10 for 24" below	R-15 for 24" below	R-20 for 24" below			
Heated slabs <sup>d</sup>	R-7.5 for 12" below	R-10 for 24" below	R-10 for 24" below	R-15 for 24" below	R-15 for 24" below	R-15 for 36" below	R-15 for 36" below	R-15 for 36" below	R-20 for 48" below	R-20 for 24" below	R-20 for 48" below	R-20 for 48" below	R-20 for 48" below			
<b>Opaque Doors</b>																
Swinging	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37
Roll-up or sliding	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75

For SI: 1 inch = 25.4 mm. ci = Continuous insulation. NR = No requirement.

LS = Liner System—A continuous membrane installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins.

a. Assembly descriptions can be found in ANSI/ASHRAE/IESNA Appendix A.

b. Where using R-value compliance method, a thermal spacer block shall be provided, otherwise use the *U-factor* compliance method in Table [C402.1.2](#).

c. R-5.7ci is allowed to be substituted with concrete block walls complying with [ASTM C 90](#), ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-ft<sup>2</sup> °F.

- d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.
- e. Steel floor joist systems shall be insulated to R-38.

**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 [C402.2](#), based on construction materials used in the roof assembly. Skylight curbs shall be insulated to the level of roofs with insulation entirely above deck or R-5, whichever is less.

**Exceptions:**

- 1. Continuously insulated roof assemblies where the thickness of insulation varies 1 inch (25 mm) or less and where the area-weighted *U-factor* is equivalent to the same assembly with the R-value specified in Table [C402.2](#).
- 2. Unit skylight curbs included as a component of an [NFRC](#) 100 rated assembly shall not be required to be insulated.

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

~~**C402.2.1.1 Roof solar reflectance and thermal emittance.**~~

~~Low-sloped roofs, with a slope less than 2 units vertical in 12 horizontal, directly above cooled conditioned spaces in Climate Zones 1, 2, and 3 shall comply with one or more of the options in Table [C402.2.1.1](#).~~

~~**Exceptions:** The following roofs and portions of roofs are exempt from the requirements in Table [C402.2.1.1](#):~~

- ~~1. Portions of roofs that include or are covered by:
  - ~~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, components, and other opaque objects mounted above the roof.~~~~
- ~~2. Portions of roofs 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 17 pounds per square foot (psf) (74 kg/m<sup>2</sup>) or 23 psf (117 kg/m<sup>2</sup>) pavers.
- 4. Roofs where a minimum of 75 percent of the roof area meets a minimum of one of the exceptions above.

TABLE C402.2.1.1  
MINIMUM ROOF REFLECTANCE AND EMITTANCE OPTIONS\*

Three-year aged solar reflectance <sup>a</sup> of 0.55 and three-year aged thermal emittance <sup>a</sup> of 0.75
Initial solar reflectance <sup>a</sup> of 0.70 and initial thermal emittance <sup>a</sup> of 0.75
Three-year aged solar reflectance index <sup>a</sup> of 64
Initial solar reflectance index <sup>a</sup> of 82

- a. The use of area-weighted averages to meet these requirements shall be permitted. Materials lacking initial tested values for either solar reflectance or thermal emittance, shall be assigned both an initial solar reflectance of 0.10 and an initial thermal emittance of 0.90. Materials lacking three-year aged tested values for either solar reflectance or thermal emittance shall be assigned both a three-year aged solar reflectance of 0.10 and a three-year aged thermal emittance of 0.90.
- b. Solar reflectance tested in accordance with ASTM C 1549, ASTM E 903 or ASTM E 1918.
- c. Thermal emittance tested in accordance with ASTM C 1371 or ASTM E 408.
- d. Solar reflectance index (SRI) shall be determined in accordance with ASTM E 1980 using a convection coefficient of 2.1 Btu/h x ft<sup>2</sup>x°F (12W/m<sup>2</sup> x K). Calculation of aged SRI shall be based on aged tested values of solar reflectance and thermal emittance. Calculation of initial SRI shall be based on initial tested values of solar reflectance and thermal emittance.

**C402.2.2 Classification of walls.**

Walls associated with the building envelope shall be classified in accordance with Section C402.2.2.1 or C402.2.2.2.

**C402.2.2.1 Above-grade walls.**

Above-grade walls are those walls covered by Section C402.2.3 on the exterior of the building and completely above grade or walls that are more than 15 percent above grade.

**C402.2.2.2 Below-grade walls.**

Below-grade walls covered by Section C402.2.4 are basement or first-story walls associated with the exterior of the building that are at least 85 percent below grade.

### **C402.2.3 Thermal resistance of above-grade walls.**

The minimum thermal resistance (*R-value*) of the insulating materials installed in the wall cavity between the framing members and continuously on the walls shall be as specified in Table [C402.2](#), based on framing type and construction materials used in the wall assembly. The *R-value* of integral insulation installed in concrete masonry units (CMU) shall not be used in determining compliance with Table [C402.2](#).

"Mass walls" shall include walls weighing not less than:

1. 35 psf (170 kg/m<sup>2</sup>) of wall surface area; or
2. 25 psf (120 kg/m<sup>2</sup>) of wall surface area if the material weight is not more than 120 pounds per cubic foot (pcf) (1900 kg/m<sup>3</sup>).

### **C402.2.4 Thermal resistance of below-grade walls.**

The minimum thermal resistance (*R-value*) of the insulating material installed in, or continuously on, the below-grade walls shall be as specified in Table [C402.2](#), and shall extend to a depth of 10 feet (3048 mm) below the outside finished ground level, or to the level of the floor, whichever is less.

### **C402.2.5 Floors over outdoor air or unconditioned space.**

The minimum thermal resistance (*R-value*) of the insulating material installed either between the floor framing or continuously on the floor assembly shall be as specified in Table [C402.2](#), based on construction materials used in the floor assembly.

"Mass floors" shall include floors weighing not less than:

1. 35 psf (170 kg/m<sup>2</sup>) of floor surface area; or
2. 25 psf (120 kg/m<sup>2</sup>) of floor surface area if the material weight is not more than 120 pcf (1,900 kg/m<sup>3</sup>).

### **C402.2.6 Slabs on grade.**

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 shall be as specified in Table [C402.2](#). The insulation shall be placed on the outside of the foundation or on the inside of the foundation wall. The insulation shall extend downward from the top of the slab for a minimum distance as shown in the table or to the top of the footing, whichever is less, or downward to at least the bottom of the slab and then horizontally to the interior or exterior for the total distance shown in the table. Insulation extending away from the building shall be protected by pavement or by a minimum of 10 inches (254 mm) of soil.

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

**C402.2.7 Opaque doors.**

Opaque doors (doors having less than 50 percent glass area) shall meet the applicable requirements for doors as specified in Table C402.2 and be considered as part of the gross area of above-grade walls that are part of the building envelope.

**C402.2.8 Insulation of radiant heating systems.**

Radiant panels, and associated U-bends and headers, designed for sensible heating of an indoor space through heat transfer from the thermally effective panel surfaces to the occupants or indoor space by thermal radiation and natural convection and the bottom surfaces of floor structures incorporating radiant heating shall be insulated with a minimum of R-3.5 (0.62 m<sup>2</sup>/K × W).

**C402.3 Fenestration (Prescriptive).**

Fenestration shall comply with Table C402.3. Automatic daylighting controls specified by this section shall comply with Section C405.2.2.3.2.

TABLE C402.3  
BUILDING ENVELOPE REQUIREMENTS: FENESTRATION

CLIMATE ZONE	1	2	3	4 EXCEPT MARINE	5 AND MARINE 4	6	7	8
<b>Vertical fenestration</b>								
<b>U-factor</b>								
Fixed fenestration	0.50	0.50	0.46	0.38	0.38	0.36	0.29	0.29
Operable fenestration	0.65	0.65	0.60	0.45	0.45	0.43	0.37	0.37
Entrance doors	1.10	0.83	0.77	0.77	<del>0.77</del> <u>0.773</u>	0.77	0.77	0.77
<b>SHGC</b>								
SHGC	0.25	0.25	0.25	0.40	<del>0.40</del> <u>0.4038</u>	0.40	0.45	0.45
<b>Skylights</b>								
<b>U-factor</b>	0.75	0.65	0.55	0.50	<del>0.50</del> <u>0.50475</u>	0.50	0.50	0.50
<b>SHGC</b>	0.35	0.35	0.35	0.40	<del>0.40</del> <u>0.4038</u>	0.40	NR	NR

**Commented [TK4]:** For ICC: Please remove all references to CZs and just remake this table with the requirements for CZ5

NR = No requirement.

**C402.3.1 Maximum area.**

The vertical fenestration area (not including opaque doors and opaque spandrel panels) shall not exceed 30 percent of the gross above-grade wall area. The skylight area shall not exceed 3 percent of the gross roof area.

**C402.3.1.1 Increased vertical fenestration area with daylighting controls.**

In Climate Zones 1 through 6, a maximum of 40 percent of the gross above-grade wall area shall be permitted to be vertical fenestration, provided:

1. No less than 50 percent of the conditioned floor area is within a daylight zone;
2. Automatic daylighting controls are installed in daylight zones; and
3. Visible transmittance (VT) of vertical fenestration is greater than or equal to 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 3.

**C402.3.1.2 Increased skylight area with daylighting controls.**

The skylight area shall be permitted to be a maximum of 5 percent of the roof area provided automatic daylighting controls are installed in daylight zones under skylights.

**C402.3.2 Minimum skylight fenestration area.**

In an *enclosed space* greater than 10,000 square feet (929 m<sup>2</sup>), directly under a roof with ceiling heights greater than 15 feet (4572 mm), and used as an office, lobby, atrium, concourse, corridor, storage, gymnasium/exercise center, convention center, automotive service, manufacturing, non-refrigerated warehouse, retail store, distribution/sorting area, transportation, or workshop, the total daylight zone under skylights shall be not less than half the floor area and shall provide a minimum skylight area to daylight zone under skylights of either:

1. Not less than 3 percent with a skylight VT of at least 0.40; or
2. Provide a minimum skylight effective aperture of at least 1 percent determined in accordance with Equation [C4-1](#).

$$\text{Skylight Effective Aperture} = \frac{0.85 \times \text{Skylight Area} \times \text{Skylight VT} \times \text{WF}}{\text{Daylight zone under skylight}} \text{ (Equation C4-1)}$$

where:

Skylight area = Total fenestration area of skylights.

Skylight VT = Area weighted average *visible transmittance* of skylights.

WF = Area weighted average well factor, where well factor is 0.9 if light well depth is less than 2 feet (610 mm), or 0.7 if light well depth is 2 feet (610 mm) or greater.

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

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

~~1. Buildings in climate zones 6 through 8.~~

12. Spaces where the designed *general lighting* power densities are less than 0.5 W/ft<sup>2</sup> (5.4 W/m<sup>2</sup>).

23. Areas where it is documented that existing structures or natural objects block direct beam sunlight on at least half of the roof over the enclosed area for more than 1,500 daytime hours per year between 8 am and 4 pm.

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

#### **C402.3.2.1 Lighting controls in daylight zones under skylights.**

All lighting in the daylight zone shall be controlled by multilevel lighting controls that comply with Section [C405.2.2.3.3](#).

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

~~1. Buildings in Climate Zones 6 through 8.~~

12. Spaces where the designed *general lighting* power densities are less than 0.5 W/ft<sup>2</sup> (5.4 W/m<sup>2</sup>).

23. Areas where it is documented that existing structures or natural objects block direct beam sunlight on at least half of the roof over the enclosed area for more than 1,500 daytime hours per year between 8 am and 4 pm.

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

#### **C402.3.2.2 Haze factor.**

Skylights in office, storage, automotive service, manufacturing, nonrefrigerated warehouse, retail store, and distribution/sorting area spaces shall have a glazing material or diffuser with a measured haze factor greater than 90 percent when tested in accordance with [ASTM D 1003](#).

**Exception:** Skylights designed to exclude direct sunlight entering the occupied space by the use of fixed or automated baffles, or the geometry of skylight and light well need not comply with Section [C402.3.2.2](#).

#### **C402.3.3 Maximum *U-factor* and *SHGC*.**

For vertical fenestration, the maximum *U-factor* and *solar heat gain coefficient* (SHGC) shall be as specified in Table [C402.3](#), based on the window projection factor. For skylights, the maximum *U-factor* and *solar heat gain coefficient* (SHGC) shall be as specified in Table [C402.3](#).

The window projection factor shall be determined in accordance with Equation [C4-2](#).

$$PF = A/B \text{ (Equation C4-2)}$$

where:

$PF$  = Projection factor (decimal).

$A$  = Distance measured horizontally from the furthest continuous extremity of any overhang, eave, or permanently attached shading device to the vertical surface of the glazing.

$B$  = Distance measured vertically from the bottom of the glazing to the underside of the overhang, eave, or permanently attached shading device.

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

**C402.3.3.1 SHGC adjustment.**

Where the fenestration projection factor for a specific vertical fenestration product is greater than or equal to 0.2, the required maximum SHGC from Table [C402.3](#) shall be adjusted by multiplying the required maximum SHGC by the multiplier specified in Table [C402.3.3.1](#) corresponding with the orientation of the fenestration product and the projection factor.

TABLE C402.3.3.1  
SHGC ADJUSTMENT MULTIPLIERS

PROJECTION FACTOR	ORIENTED WITHIN 45 DEGREES OF TRUE NORTH	ALL OTHER ORIENTATION
$0.2 \leq PF < 0.5$	1.1	1.2
$PF \geq 0.5$	1.2	1.6

~~**C402.3.3.2 Increased vertical fenestration SHGC.**~~

~~In Climate Zones 1, 2 and 3, vertical fenestration entirely located not less than 6 feet (1729 mm) above the finished floor shall be permitted a maximum SHGC of 0.40.~~

~~**C402.3.3.23 Increased skylight SHGC.**~~

~~In Climate Zones 1 through 6, Skylights shall be permitted a maximum SHGC of 0.60 where located above daylight zones provided with automated daylighting controls.~~

**C402.3.3.34 Increased skylight U-factor.**

Where skylights are installed above daylight zones provided with automatic daylighting controls, ~~a maximum U-factor of 0.9 shall be permitted in Climate Zones 1 through 3, and~~ a maximum U-factor of 0.75 shall be permitted in Climate Zones 4 through 8.

**C402.3.3.45 Dynamic glazing.**

For compliance with Section [C402.3.3](#), the SHGC for dynamic glazing shall be determined using the manufacturer's lowest-rated SHGC, and the VT/SHGC ratio shall be determined using the maximum VT and maximum SHGC. 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.

**C402.3.4 Area-weighted U-factor.**

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

**C402.4 Air leakage (Mandatory).**

The thermal envelope of buildings shall comply with Sections [C402.4.1](#) through [C402.4.8](#).

**C402.4.1 Air barriers.**

A *continuous air barrier* shall be provided throughout the building thermal envelope. The air barriers shall be permitted to be located on the inside or outside of the building envelope, located within the assemblies composing the envelope, or any combination thereof. The air barrier shall comply with Sections [C402.4.1.1](#) and [C402.4.1.2](#).

~~**Exception:** Air barriers are not required in buildings located in Climate Zones 1, 2 and 3.~~

**C402.4.1.1 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. Air barrier penetrations shall be sealed in accordance with Section [C402.4.2](#). 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. Recessed lighting fixtures shall comply with Section [C402.4.8](#). Where similar objects are installed which penetrate the air barrier, provisions shall be made to maintain the integrity of the air barrier.

**Exception:** Buildings that comply with Section [C402.4.1.2.13](#) are not required to comply with Items 1 and 3.

**C402.4.1.2 Air barrier compliance options.**

A continuous air barrier for the opaque building envelope shall comply with Section [C402.4.1.2.1](#), ~~C402.4.1.2.2~~, or ~~C402.4.1.2.3~~. In addition, all dwelling units must comply with C402.4.1.2.2.

**~~C402.4.1.2.1 Materials.~~**

~~Materials with an air permeability no greater than 0.004 cfm/ft<sup>2</sup> (0.02 L/s • m<sup>2</sup>) under a pressure differential of 0.3 inches water gauge (w.g.) (75 Pa) when tested in accordance with ASTM E 2178 shall comply with this section. Materials in Items 1 through 15 shall be deemed to comply with this section provided joints are sealed and materials are installed as air barriers in accordance with the manufacturer's instructions.~~

- ~~1. Plywood with a thickness of not less than  $\frac{3}{8}$  inch (10 mm).~~
- ~~2. Oriented strand board having a thickness of not less than  $\frac{3}{8}$  inch (10 mm).~~
- ~~3. Extruded polystyrene insulation board having a thickness of not less than  $\frac{1}{2}$  inch (12 mm).~~
- ~~4. Foil-back polyisocyanurate insulation board having a thickness of not less than  $\frac{1}{2}$  inch (12 mm).~~
- ~~5. Closed cell spray foam a minimum density of 1.5 pcf (2.4 kg/m<sup>3</sup>) having a thickness of not less than 1  $\frac{1}{2}$  inches (36 mm).~~
- ~~6. Open cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m<sup>3</sup>) and having a thickness of not less than 4.5 inches (113 mm).~~
- ~~7. Exterior or interior gypsum board having a thickness of not less than  $\frac{1}{2}$  inch (12 mm).~~
- ~~8. Cement board having a thickness of not less than  $\frac{1}{2}$  inch (12 mm).~~
- ~~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  $\frac{1}{8}$  inch (16 mm).~~
- ~~13. Cast-in-place and precast concrete.~~
- ~~14. Fully grouted concrete block masonry.~~

15. Sheet steel or aluminum.

**C402.4.1.2.2 Assemblies.**

Assemblies of materials and components with an average air leakage not to exceed 0.04 cfm/ft<sup>2</sup> (0.2 L/s • m<sup>2</sup>) under a pressure differential of 0.3 inches of water gauge (w.g.) (75 Pa) when tested in accordance with ASTM E 2357, ASTM E 1677 or ASTM E 283 shall comply with this section. Assemblies listed in Items 1 and 2 shall be deemed to comply provided joints are sealed and requirements of Section C402.4.1.1 are met.

1. Concrete masonry walls coated with one application either of block filler and two applications of a paint or sealer coating;
2. A Portland cement/sand parge, stucco or plaster minimum 1/2 inch (12 mm) in thickness.

**C402.4.1.2.13 Commercial Building Test.**

The completed building shall be tested and the air leakage rate of the *building envelope* shall not exceed 0.40 cfm/ft<sup>2</sup> at a pressure differential of 0.3 inches water gauge (2.0 L/s • m<sup>2</sup> at 75 Pa) in accordance with ASTM E 779 or an equivalent method approved by the code official.

Testing and inspection shall be conducted by a third party registered design professional. A written report of the test results shall be signed by the party conducting the test and provided to the code official. Testing shall be performed at any time after completion of all penetrations of the building thermal envelope.

**C402.4.1.2.2 Dwelling Unit Air Infiltration**

A sampling of dwelling units shall be tested and the air leakage rate of each tested dwelling unit's enclosure surface area shall not exceed 0.25 cfm/ft<sup>2</sup>. For purposes of this section, enclosure surface area of a unit means the total surface area of all walls, floors, and ceiling. Testing shall be conducted with a blower door at a pressure of 0.2 inches water gauge (50 Pascals).

Testing and inspection shall be conducted by a third party registered design professional. A written report of the test results shall be signed by the party conducting the test and provided to the code official. Testing shall be performed at any time after completion of all penetrations of the building thermal envelope.

The sampling of dwelling units tested shall include at least 20 percent of the dwelling units in each building, including at least one of each unit type (a unit type is distinct if it has a different floorplan or a different exterior exposure) and approximately an equal number of units on each floor level. Each of these units must be tested and pass without a failure. If a failure occurs, items causing the failure must be diagnosed, corrected, and the unit re-tested until it passes. A minimum of at least two additional units of this type in the same building must also be tested and pass.

During testing:

1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed beyond the intended weatherstripping 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, if installed at the time of the test, shall be open;
4. Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;
5. Heating and cooling systems, if installed at the time of the test, shall be turned off; and
6. Supply and return registers, if installed at the time of the test, shall be fully open.

**C402.4.2 Air barrier penetrations.**

Penetrations of the air barrier and paths of air leakage shall be caulked, gasketed or otherwise sealed in a manner compatible with the construction materials and location. Joints and seals shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials shall be appropriate to the construction materials being sealed. 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.

**C402.4.3 Air leakage of fenestration.**

The air leakage of fenestration assemblies shall meet the provisions of Table [C402.4.3](#). Testing shall be in accordance with the applicable reference test standard in Table [C402.4.3](#) by an accredited, independent testing laboratory and *labeled* by the manufacturer.

**Exceptions:**

1. Field-fabricated fenestration assemblies that are sealed in accordance with Section [C402.4.1](#).
2. Fenestration in buildings that comply with Section [C402.4.1.2.13](#) are not required to meet the air leakage requirements in Table [C402.4.3](#).

TABLE C402.4.3  
MAXIMUM AIR INFILTRATION RATE  
FOR FENESTRATION ASSEMBLIES

FENESTRATION ASSEMBLY	MAXIMUM RATE (CFM/FT <sup>2</sup> )	TEST PROCEDURE
Windows	0.20 <sup>a</sup>	<a href="#">AAMA/WDMA/CSA 101/I.S.2/A440</a> or <a href="#">NFRC 400</a>
Sliding doors	0.20 <sup>a</sup>	
Swinging doors	0.20 <sup>a</sup>	
Skylights – with condensation weepage openings	0.30	
Skylights – all other	0.20 <sup>a</sup>	
Curtain walls	0.06	<a href="#">NFRC 400</a> or <a href="#">ASTM E 283</a> at 1.57 psf (75 Pa)
Storefront glazing	0.06	
Commercial glazed swinging entrance doors	1.00	
Revolving doors	1.00	
Garage doors	0.40	ANSI/DASMA 105, <a href="#">NFRC 400</a> , or <a href="#">ASTM E 283</a> at 1.57 psf (75 Pa)
Rolling doors	1.00	

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

a. The maximum rate for windows, sliding and swinging doors, and skylights is permitted to be 0.3 cfm per square foot of fenestration or door area when tested in accordance with [AAMA/WDMA/CSA 101/I.S.2/A440](#) at 6.24 psf (300 Pa).

**C402.4.4 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 shall either meet the requirements of Section [C402.4.3](#) or shall be gasketed, weatherstripped or sealed.

**Exception:** Door openings required to comply with Section [716](#) or [716.4](#) of the *International Building Code*; or doors and door openings required by the *International Building Code* to comply with [UL 1784](#) shall not be required to comply with Section [C402.4.4](#).

**C402.4.5 Air intakes, exhaust openings, stairways and shafts.**

Stairway enclosures and elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be provided with dampers in accordance with Sections [C402.4.5.1](#) and [C402.4.5.2](#).

**C402.4.5.1 Stairway and shaft vents.**

Stairway and shaft vents shall be provided with Class I motorized dampers with a maximum leakage rate of 4 cfm/ft<sup>2</sup> (20.3 L/s • m<sup>2</sup>) at 1.0 inch water gauge (w.g.) (249 Pa) when tested in accordance with [AMCA 500D](#).

Stairway and shaft vent dampers shall be installed with controls so that they are capable of automatically opening upon:

1. The activation of any fire alarm initiating device of the building's fire alarm system; or
2. The interruption of power to the damper.

**C402.4.5.2 Outdoor air intakes and exhausts.**

*Outdoor air* supply and exhaust openings shall be provided with Class IA motorized dampers with a maximum leakage rate of 4 cfm/ft<sup>2</sup> (20.3 L/s • m<sup>2</sup>) at 1.0 inch water gauge (w.g.) (249 Pa) when tested in accordance with [AMCA 500D](#).

**Exceptions:**

1. Gravity (nonmotorized) dampers having a maximum leakage rate of 20 cfm/ft<sup>2</sup> (101.6 L/s • m<sup>2</sup>) at 1.0 inch water gauge (w.g.) (249 Pa) when tested in accordance with [AMCA 500D](#) are permitted to be used as follows:

- 1.1. In buildings for exhaust and relief dampers.
- 1.2. In buildings less than three stories in height above grade.

~~1.3. For ventilation air intakes and exhaust and relief dampers in buildings of any height located in Climate Zones 1, 2 and 3.~~

1.3.4. Where the design *outdoor air* intake or exhaust capacity does not exceed 300 cfm (141 L/s).

1.4. Gravity (nonmotorized) dampers for ventilation air intakes shall be protected from direct exposure to wind.

2. Dampers smaller than 24 inches (610 mm) in either dimension shall be permitted to have a leakage of 40 cfm/ft<sup>2</sup> (203.2 L/s • m<sup>2</sup>) at 1.0 inch water gauge (w.g.) (249 Pa) when tested in accordance with [AMCA 500D](#).

**C402.4.6 Loading dock weatherseals.**

Cargo doors and loading dock doors shall be equipped with weatherseals to restrict infiltration when vehicles are parked in the doorway.

**C402.4.7 Vestibules.**

All 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.

**Exceptions:**

~~1. Buildings in Climate Zones 1 and 2.~~

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

23. Doors opening directly from a *sleeping unit* or dwelling unit.

34. Doors that open directly from a space less than 3,000 square feet (298 m<sup>2</sup>) in area.

45. Revolving doors.

56. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

**C402.4.8 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 *labeled* as having an air leakage rate of not more than 2.0 cfm (0.944 L/s) when tested in accordance with [ASTME 283](#) at a 1.57 psf (75 Pa) pressure differential. All recessed luminaires shall be 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 heating, cooling or ventilating needs shall comply with Section [C403.2](#) (referred to as the mandatory provisions) and either:

1. Section [C403.3](#) (Simple systems); or
2. Section [C403.4](#) (Complex systems).

**C403.2 Provisions applicable to all mechanical systems (Mandatory).**

Mechanical systems and equipment serving the building heating, cooling or ventilating needs shall comply with Sections [C403.2.1](#) through [C403.2.11](#).

**C403.2.1 Calculation of heating and cooling loads.**

Design loads shall be determined in accordance with the procedures described in ANSI/ASHRAE/ACCA Standard 183. The design loads shall account for the building envelope, lighting, ventilation and occupancy loads based on the project design. Heating and cooling loads shall be adjusted to account for load reductions that are achieved where energy recovery systems are utilized in the HVAC system in accordance with the [ASHRAE HVAC Systems and Equipment Handbook](#). Alternatively, design loads shall be determined by an approved equivalent computation procedure, using the design parameters specified in Chapter [3](#).

**C403.2.2 Equipment and system sizing.**

The output capacity of heating and cooling equipment and systems shall not exceed the loads calculated in accordance with Section [C403.2.1](#). A single piece of equipment providing both heating and cooling shall satisfy this provision for one function with the capacity for the other function as small as possible, within available equipment options.

**Exceptions:**

1. Required standby equipment and systems provided with controls and devices that allow such systems or equipment to operate automatically only when the primary equipment is not operating.
2. Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that have the capability to sequence the operation of each unit based on load.

**C403.2.3 HVAC equipment performance requirements.**

Equipment shall meet the minimum efficiency requirements of

Tables [C403.2.3\(1\)](#), [C403.2.3\(2\)](#), [C403.2.3\(3\)](#), [C403.2.3\(4\)](#), [C403.2.3\(5\)](#), [C403.2.3\(6\)](#), [C403.2.3\(7\)](#) and [C403.2.3\(8\)](#) when tested and

rated in accordance with the applicable test procedure. Plate-type liquid-to-liquid heat exchangers shall meet the minimum requirements of Table [C403.2.3\(9\)](#). The efficiency shall be verified through certification under an *approved* certification program or, if no certification program exists, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements. Where components, such as indoor or outdoor coils, from different manufacturers are used, calculations and supporting data shall be furnished by the designer that demonstrates that the combined efficiency of the specified components meets the requirements herein.

TABLE C403.2.3(1)  
 MINIMUM EFFICIENCY REQUIREMENTS:  
 ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE <sup>a</sup>
				<del>Before 6/1/2014</del>	<b>As of 6/1/2014 Prescriptive Renovation and Alteration</b>	
Air conditioners, air cooled	< 65,000 Btu/h <sup>b</sup>	All	Split System	<del>13.0</del> SEER	13.0 SEER	AHRI 210/240
			Single Package	<del>13.0</del> SEER	<del>13.0</del> 14.0 SEER	
Through-the-wall (air cooled)	≤ 30,000 Btu/h <sup>b</sup>	All	Split system	<del>12.0</del> SEER	12.0 SEER	
			Single Package	<del>12.0</del> SEER	12.0 SEER	
Small-duct high-velocity (air cooled)	< 65,000 Btu/h <sup>b</sup>	All	Split System	<del>10.0</del> SEER	<del>10.0</del> 11.0 SEER	
Air conditioners, air cooled	≥65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	<del>11.2</del> EER <del>11.4</del> IEER	11.2 EER <del>11.4</del> 12.9 IEER	
		All other	Split System and Single Package	<del>11.0</del> EER <del>11.2</del> IEER	11.0 EER <del>11.2</del> 12.7 IEER	
	Electric Resistance (or None)	Split System and Single Package	<del>11.0</del> EER	11.0 EER <del>11.2</del> 12.4 IEER		

	≥135,000 Btu/h and < 240,000 Btu/h			<del>11.2</del> <del>IEER</del>		
		All other	Split System and Single Package	<del>10.8</del> <del>EER</del> <del>11.0</del> <del>IEER</del>	10.8 EER <del>11.0</del> 12.2 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	<del>10.0</del> <del>EER</del> <del>10.4</del> <del>IEER</del>	10.0 EER <del>10.4</del> 11.6 IEER	
		All other	Split System and Single Package	<del>9.8</del> <del>EER</del> <del>9.9</del> <del>IEER</del>	9.8 EER <del>9.9</del> 11.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	<del>9.7</del> <del>EER</del> <del>9.8</del> <del>IEER</del>	9.7 EER <del>9.8</del> 11.2 IEER	
		All other	Split System and Single Package	<del>9.5</del> <del>EER</del> <del>9.6</del> <del>IEER</del>	9.5 EER <del>9.6</del> 11.0 IEER	
Air conditioners, water cooled	< 65,000 Btu/h <sup>b</sup>	All	Split System and Single Package	<del>12.1</del> <del>EER</del> <del>12.3</del> <del>IEER</del>	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	<del>11.5</del> <del>EER</del> <del>11.7</del> <del>IEER</del>	12.1 EER <del>12.3</del> 13.9 IEER	AHRI 340/360
		All other	Split System and Single Package	<del>11.3</del> <del>EER</del> <del>11.5</del> <del>IEER</del>	11.9 EER <del>12.4</del> 13.7 IEER	

	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	<del>11.0 EER 11.2 IEER</del>	12.5 EER <del>12.7</del> 13.9 IEER
		All other	Split System and Single Package	<del>10.8 EER 11.0 IEER</del>	12.3 EER <del>12.5</del> 13.7 IEER
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	<del>11.0 EER 11.1 IEER</del>	12.4 EER <del>12.6</del> 13.6 IEER
		All other	Split System and Single Package	<del>10.8 EER 10.9 IEER</del>	12.2 EER <del>12.4</del> 13.4 IEER
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	<del>11.0 EER 11.1 IEER</del>	12.0 EER <del>12.4</del> 13.5 IEER
		All other	Split System and Single Package	<del>10.8 EER 10.9 IEER</del>	12.0 EER <del>12.2</del> 13.3 IEER

(continued)

TABLE C403.2.3(1)—continued  
MINIMUM EFFICIENCY REQUIREMENTS:  
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE <sup>a</sup>
				<del>Before 6/1/2011</del>	<del>As of 6/1/2011</del>	

Air conditioners, evaporatively cooled	< 65,000 Btu/h <sup>b</sup>	All	Split System and Single Package	<del>12.1 EER</del> <del>12.3 IEER</del>	12.1 EER 12.3 IEER	AHRI 210/240		
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	<del>11.5 EER</del> <del>11.7 IEER</del>	12.1 EER 12.3 IEER		AHRI 340/360	
		All other	Split System and Single Package	<del>11.3 EER</del> <del>11.5 IEER</del>	11.9 EER 12.1 IEER			
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	<del>11.0 EER</del> <del>11.2 IEER</del>	12.0 EER 12.2 IEER			
		All other	Split System and Single Package	<del>10.8 EER</del> <del>11.0 IEER</del>	11.8 EER 12.0 IEER			
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	<del>11.0 EER</del> <del>11.1 EER</del>	11.9 EER 12.1 EER			
		All other	Split System and Single Package	<del>10.8 EER</del> <del>10.9 EER</del>	12.2 EER 11.9 EER			
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	<del>11.0 EER</del> <del>11.1 EER</del>	11.7 EER 11.9 EER			
		All other	Split System and Single Package	<del>10.8 EER</del> <del>10.9 EER</del>	11.5 EER 11.7 EER			
	Condensing units, air cooled	≥ 135,000 Btu/h			<del>10.1 EER</del> <del>11.4 IEER</del>	10.5 EER 14.0 IEER		AHRI 365
	Condensing units, water cooled	≥ 135,000 Btu/h			<del>13.1 EER</del> <del>13.6 IEER</del>	13.5 EER 14.0 IEER		
	Condensing units, evaporatively cooled	≥ 135,000 Btu/h			<del>13.1 EER</del> <del>13.6 IEER</del>	13.5 EER 14.0 IEER		

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

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

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

TABLE C403.2.3(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 <sup>a</sup>
Air cooled (cooling mode)	< 65,000 Btu/h <sup>b</sup>	All	Split System	<del>13.0</del> 14.0 SEER	AHRI 210/240
			Single Packaged	<del>13.0</del> 14.0 SEER	
Through-the-wall, air cooled	≤ 30,000 Btu/h <sup>b</sup>	All	Split System	13.0 SEER	
			Single Packaged	13.0 SEER	
Single-duct high-velocity air cooled	< 65,000 Btu/h <sup>b</sup>	All	Split System	<del>10.0</del> 11.0 SEER	
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER <del>11.2</del> 12.2 IEER	
		All other	Split System and Single Package	10.8 EER <del>11.0</del> 12.0 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.6 EER <del>10.7</del> 11.6 IEER	
		All other	Split System and Single Package	10.4 EER <del>10.5</del> 11.4 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER <del>9.6</del> 10.6 IEER	
		All other	Split System and Single Package	9.3 EER <del>9.4</del> 10.4 IEER	
Water source (cooling mode)	< 17,000 Btu/h	All	86°F entering water	<del>11.2</del> 12.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h	All	86°F entering water	<del>12.0</del> 13.0 EER	

	≥ 65,000 Btu/h and < 135,000 Btu/h	All	86°F entering water	<del>42.0</del> 13.0 EER	
Ground water source (cooling mode)	< 135,000 Btu/h	All	59°F entering water	<del>16.2</del> 18.0 EER	
		All	77°F entering water	<del>13.4</del> 14.1 EER	
Water-source water to water (cooling mode)	< 135,000 Btu/h	All	86°F entering water	10.6 EER	ISO 13256-2
			59°F entering water	16.3 EER	
Ground water source Brine to water (cooling mode)	< 135,000 Btu/h	All	77°F entering fluid	12.1 EER	
Air cooled (heating mode)	< 65,000 Btu/h <sup>b</sup>	—	Split System	<del>7.7</del> 8.2 HSPF	
		—	Single Package	<del>7.7</del> 8.0 HSPF	
Through-the-wall, (air cooled, heating mode)	≤ 30,000 Btu/h <sup>b</sup> (cooling capacity)	—	Split System	7.4 HSPF	
		—	Single Package	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h <sup>b</sup>	—	Split System	6.8 HSPF	

(continued)

**TABLE C403.2.3(2)**—continued  
 MINIMUM EFFICIENCY REQUIREMENTS:  
 ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE <sup>a</sup>
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb Outdoor Air	3.3 COP	AHRI 340/360
			17°F db/15°F wb Outdoor Air	2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb Outdoor Air	3.2 COP	

			17°F db/15°F wb Outdoor Air	2.05 COP	
Water source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	<del>4.2</del> 4.3 COP	ISO 13256-1
Ground water source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	<del>3.6</del> 3.7 COP	
Ground source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	<del>3.4</del> 3.2 COP	
Water-source water to water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	3.7 COP	ISO 13256-2
		—	50°F entering water	3.1 COP	
Ground source brine to water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	2.5 COP	

TABLE C403.2.3(3)  
 MINIMUM EFFICIENCY REQUIREMENTS:  
 ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS,  
 PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGE VERTICAL AIR CONDITIONERS,  
 SINGLE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONER HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE <sup>a</sup>
			Before 10/08/2012	As of 10/08/2012	
PTAC (cooling mode) new construction	All Capacities	95°F db outdoor air	<del>12.5 - (0.213 × Cap/1000)</del> EER	13.8 - (0.300 × Cap/1000) EER	AHRI 310/380

PTAC (cooling mode) replacements <sup>b</sup>	All Capacities	95°F db outdoor air	<del>10.9 - (0.213 × Cap/1000)</del> EER	10.9 - (0.213 × Cap/1000) EER	
PTHP (cooling mode) new construction	All Capacities	95°F db outdoor air	<del>12.3 - (0.213 × Cap/1000)</del> EER	14.0 - (0.300 × Cap/1000) EER	
PTHP (cooling mode) replacements <sup>b</sup>	All Capacities	95°F db outdoor air	<del>10.8 - (0.213 × Cap/1000)</del> EER	10.8 - (0.213 × Cap/1000) EER	
PTHP (heating mode) new construction	All Capacities	—	<del>3.2 - (0.026 × Cap/1000)</del> COP	3.2 - (0.026 × Cap/1000) COP	
PTHP (heating mode) replacements <sup>b</sup>	All Capacities	—	<del>2.9 - (0.026 × Cap/1000)</del> COP	2.9 - (0.026 × Cap/1000) COP	
SPVAC (cooling mode)	< 65,000 Btu/h	95°F db/ 75°F wb outdoor air	<del>9.0 EER</del>	9.0 EER	<a href="#">AHRI 390</a>
	≥65,000 Btu/h and < 135,000 Btu/h	95°F db/ 75°F wb outdoor air	<del>8.9 EER</del>	8.9 EER	
	≥135,000 Btu/h and < 240,000 Btu/h	95°F db/ 75°F wb outdoor air	<del>8.6 EER</del>	8.6 EER	
SPVHP (cooling mode)	< 65,000 Btu/h	95°F db/ 75°F wb outdoor air	<del>9.0 EER</del>	9.0 EER	
	≥65,000 Btu/h and < 135,000 Btu/h	95°F db/ 75°F wb outdoor air	<del>8.9 EER</del>	8.9 EER	
	≥135,000 Btu/h and < 240,000 Btu/h	95°F db/ 75°F wb outdoor air	<del>8.6 EER</del>	8.6 EER	
SPVHP (heating mode)	< 65,000 Btu/h	47°F db/ 43°F wb outdoor air	<del>3.0 COP</del>	3.0 COP	<a href="#">AHRI 390</a>

	≥65,000 Btu/h and < 135,000 Btu/h	47°F db/ 43°F wb outdoor air	<del>3.0 COP</del>	3.0 COP	
	≥ 135,000 Btu/h and < 240,000 Btu/h	47°F db/ 75°F wb outdoor air	<del>2.9 COP</del>	2.9 COP	

(continued)

TABLE C403.2.3(3)—continued  
 MINIMUM EFFICIENCY REQUIREMENTS:  
 ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS,  
 PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGE VERTICAL AIR CONDITIONERS,  
 SINGLE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONER HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE <sup>a</sup>
			Before 10/08/2012	As of 10/08/2012	
Room air conditioners, with louvered slides	< 6,000 Btu/h	—	<del>9.7 SEER</del>	9.7 SEER	ANSI/AHAM RAC-1
	≥ 6,000 Btu/h and < 8,000 Btu/h	—	<del>9.7 EER</del>	9.7 EER	
	≥ 8,000 Btu/h and < 14,000 Btu/h	—	<del>9.8 EER</del>	9.8 EER	
	≥14,000 Btu/h and < 20,000 Btu/h	—	<del>9.7 SEER</del>	9.7 SEER	
	≥ 20,000 Btu/h	—	<del>8.5 EER</del>	8.5 EER	
Room air conditioners, without louvered slides	< 8,000 Btu/h	—	<del>9.0 EER</del>	9.0 EER	
	≥ 8,000 Btu/h and < 20,000 Btu/h	—	<del>8.5 EER</del>	8.5 EER	
	≥ 20,000 Btu/h	—	<del>8.5 EER</del>	8.5 EER	
Room air-conditioner heat pumps with louvered sides	< 20,000 Btu/h	—	<del>9.0 EER</del>	9.0 EER	
	≥ 20,000 Btu/h	—	<del>8.5 EER</del>	8.5 EER	
	< 14,000 Btu/h	—	<del>8.5 EER</del>	8.5 EER	

Room air-conditioner heat pumps without louvered sides	≥ 14,000 Btu/h	—	<del>8.0 EER</del>	8.0 EER	
Room air conditioner casement only	All capacities	—	<del>8.7 EER</del>	8.7 EER	
Room air conditioner casement-slider	All capacities	—	<del>9.5 EER</del>	9.5 EER	

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

“Cap” = The rated cooling capacity of the project in Btu/h. If the unit’s capacity is less than 7000 Btu/h, use 7000 Btu/h in the calculation. If the unit’s capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculations.

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

b. Replacement unit shall be factory labeled as follows: “MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY: NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS.” Replacement efficiencies apply only to units with existing sleeves less than 16 inches (406 mm) in height and less than 42 inches (1067 mm) in width.

TABLE 403.2.3(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 <sup>a,b</sup>	TEST PROCEDURE <sup>a</sup>
Warm air furnaces, gas fired	< 225,000 Btu/h	—	78% AFUE or 80% $E_f$	<a href="#">DOE</a> 10 CFR Part 430 or <a href="#">ANSI</a> Z21.47
	≥ 225,000 Btu/h	Maximum capacity <sup>c</sup>	80% $E_t$	<a href="#">ANSI</a> Z21.47
Warm air furnaces, oil fired	< 225,000 Btu/h	—	78% AFUE or 80% $E_f$	<a href="#">DOE</a> 10 CFR Part 430 or <a href="#">UL</a> 727
	≥ 225,000 Btu/h	Maximum capacity <sup>b</sup>	81% $E_p$	<a href="#">UL</a> 727
Warm air duct furnaces, gas fired	All capacities	Maximum capacity <sup>b</sup>	80% $E_c$	<a href="#">ANSI</a> Z83.8

Warm air unit heaters, gas fired	All capacities	Maximum capacity <sup>b</sup>	80% $E_c$	<a href="#">ANSI Z83.8</a>
Warm air unit heaters, oil fired	All capacities	Maximum capacity <sup>b</sup>	80% $E_c$	<a href="#">UL 731</a>

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

- a. Chapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
- b. Minimum and maximum ratings as provided for and allowed by the unit's controls.
- c. Combination units not covered by the National Appliance Energy Conservation Act of 1987 (NAECA) (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h [19 kW]) shall comply with either rating.
- d.  $E_t$  = Thermal efficiency. See test procedure for detailed discussion.
- e.  $E_c$  = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.
- f.  $E_c$  = Combustion efficiency. Units must 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 must 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 C403.2.3(5)  
MINIMUM EFFICIENCY REQUIREMENTS: GAS- AND OIL-FIRED BOILERS

EQUIPMENT TYPE <sup>a</sup>	SUBCATEGORY OR RATING CONDITION	SIZE CATEGORY (INPUT)	MINIMUM EFFICIENCY	TEST PROCEDURE
Boilers, hot water	Gas-fired	< 300,000 Btu/h	<del>80</del> 82% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h <sup>b</sup>	80% $E_t$	10 CFR Part 431
		> 2,500,000 Btu/h <sup>c</sup>	82% $E_c$	
	Oil-fired <sup>d</sup>	< 300,000 Btu/h	<del>80</del> 84% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h <sup>b</sup>	82% $E_t$	10 CFR Part 431
		> 2,500,000 Btu/h <sup>c</sup>	84% $E_c$	

Boilers, steam	Gas-fired	< 300,000 Btu/h	<del>75</del> 80% AFUE	10 CFR Part 430
	Gas-fired- all, except natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h <sup>b</sup>	79% $E_t$	10CFR Part 431
		> 2,500,000 Btu/h <sup>a</sup>	79% $E_t$	
	Gas-fired-natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h <sup>b</sup>	77% $E_t$	
		> 2,500,000 Btu/h <sup>a</sup>	77% $E_t$	
	Oil-fired <sup>c</sup>	< 300,000 Btu/h	<del>80</del> 82% AFUE	10 CFR Part 430
≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h <sup>b</sup>		81% $E_t$	10CFR Part 431	
> 2,500,000 Btu/h <sup>a</sup>		81% $E_t$		

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

$E_c$  = Combustion efficiency (100 percent less flue losses).  $E_t$  = Thermal efficiency. See referenced standard document for detailed information.

- a. These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.
- b. Maximum capacity – minimum and maximum ratings as provided for and allowed by the unit's controls.
- c. Includes oil-fired (residual).

TABLE C403.2.3(6)  
MINIMUM EFFICIENCY REQUIREMENTS:  
CONDENSING UNITS, ELECTRICALLY OPERATED

EQUIPMENT TYPE	SIZE CATEGORY	MINIMUM EFFICIENCY <sup>b</sup>	TEST PROCEDURE <sup>a</sup>
Condensing units, air cooled	≥ 135,000 Btu/h	10.1 EER 11.2 IPLV	AHRI 365
Condensing units, water or evaporatively cooled	≥ 135,000 Btu/h	13.1 EER 13.1 IPLV	

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

- a. Chapter 6 of the referenced standard 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 C403.2.3(7)  
MINIMUM EFFICIENCY REQUIREMENTS:  
WATER CHILLING PACKAGES<sup>a</sup>

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	BEFORE 1/1/2010		AS OF 1/1/2010 <sup>b</sup>				TEST PROCEDURE <sup>c</sup>
			FULL LOAD	IPLV	PATH A		PATH B		
					FULL LOAD	IPLV	FULL LOAD	IPLV	
Air-cooled chillers	< 150 tons	EER	≥9.562	≥10.416	≥ 9.562	≥ 12.500	NA	NA	<a href="#">AHRI</a> 550/590
	≥150 tons	EER			≥ 9.562	≥ 12.750	NA	NA	
Air cooled without condenser, electrical operated	All capacities	EER	≥10.586	≥ 11.782	Air-cooled chillers without condensers shall be rated with matching condensers and comply with the air-cooled chiller efficiency requirements				
Water cooled, electrically operated, reciprocating	All capacities	kW/ton	≤ 0.837	≤0.696	Reciprocating units shall comply with water cooled positive displacement efficiency requirements				
Water cooled, electrically operated, positive displacement	< 75 tons	kW/ton	≤ 0.790	≤ 0.676	≤ 0.780	≤ 0.630	≤ 0.800	≤ 0.600	
	≥ 75 tons and < 150 tons	kW/ton			≤ 0.775	≤ 0.615	≤ 0.790	≤ 0.586	
	≥ 150 tons and < 300 tons	kW/ton	≤0.717	≤ 0.627	≤ 0.680	≤ 0.580	≤ 0.718	≤ 0.540	
	≥ 300 tons	kW/ton	≤ 0.639	≤ 0.571	≤0.620	≤ 0.540	≤0.639	≤ 0.490	
Water cooled, electrically operated, centrifugal	< 150 tons	kW/ton	≤ 0.703	≤ 0.669	≤ 0.634	≤ 0.596	≤ 0.639	≤0.450	
	≥150 tons and < 300 tons	kW/ton	≤0.634	≤ 0.596					

	≥300 tons and < 600 tons	kW/ton	≤ 0.576	≤0.549	≤ 0.576	≤ 0.549	≤ 0.600	≤ 0.400	
	≥600 tons	kW/ton	≤0.576	≤ 0.549	≤ 0.570	≤ 0.539	≤ 0.590	≤ 0.400	
Air cooled, absorption single effect	All capacities	COP	≥0.600	NR	≥0.600	NR	NA	NA	<a href="#">AHRI 560</a>
Water cooled, absorption single effect	All capacities	COP	≥0.700	NR	≥ 0.700	NR	NA	NA	
Absorption double effect, indirect fired	All capacities	COP	≥1.000	≥ 1.050	≥ 1.000	≥1.050	NA	NA	
Absorption double effect, direct fired	All capacities	COP	≥1.000	≥ 1.000	≥ 1.000	≥1.000	NA	NA	

For SI: 1 ton = 3517 W, 1 British thermal unit per hour = 0.2931 W, °C = [(°F) - 32]/1.8.

NA = Not applicable, not to be used for compliance; NR = No requirement.

a. The centrifugal chiller equipment requirements, after adjustment in accordance with Section [C403.2.3.1](#) or Section [C403.2.3.2](#), do not apply to chillers used in low-temperature applications where the design leaving fluid temperature is less than 36°F. The requirements do not apply to positive displacement chillers with leaving fluid temperatures less than or equal to 32°F. The requirements do not apply to absorption chillers with design leaving fluid temperatures less than 40°F.

b. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or B. However, both the full load and IPLV shall be met to fulfill the requirements of Path A or B.

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

TABLE C403.2.3(8)  
MINIMUM EFFICIENCY REQUIREMENTS:  
HEAT REJECTION EQUIPMENT

EQUIPMENT TYPE <sup>a</sup>	TOTAL SYSTEM HEAT REJECTION	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED <sup>b, c, d</sup>	TEST PROCEDURE <sup>e, f</sup>
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	CAPACITY AT RATED CONDITIONS			
Propeller or axial fan open circuit cooling towers	All	95°F Entering Water 85°F Leaving Water 75°F Entering wb	≥ <del>38.2</del> 40.2 gpm/hp	<a href="#">CTI</a> ATC-105 and <a href="#">CTI</a> STD-201
Centrifugal fan open circuit cooling towers	All	95°F Entering Water 85°F Leaving Water 75°F Entering wb	≥ 20.0 gpm/hp	<a href="#">CTI</a> ATC-105 and <a href="#">CTI</a> STD-201
Propeller or axial fan closed circuit cooling towers	All	102°F Entering Water 90°F Leaving Water 75°F Entering wb	≥ <del>14.0</del> 16.1 gpm/hp	<a href="#">CTI</a> ATC-105S and <a href="#">CTI</a> STD-201
Centrifugal closed circuit cooling towers	All	102°F Entering Water 90°F Leaving Water 75°F Entering wb	≥ 7.0 gpm/hp	<a href="#">CTI</a> ATC-105S and <a href="#">CTI</a> STD-201
Air-cooled condensers	All	125°F Condensing Temperature R-22 Test Fluid 190°F Entering Gas Temperature 15°F Subcooling 95°F Entering db	≥ 176,000 Btu/h•hp	ARI 460

For SI: °C = [(°F)-32]/1.8, L/s • kW = (gpm/hp)/(11.83), COP = (Btu/h • hp)/(2550.7).

db = dry bulb temperature, °F, wb = wet bulb temperature, °F

- a. The efficiencies and test procedures for both open and closed circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of wet and dry heat exchange sections.
- b. For purposes of this table, open circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table [403.2.3\(8\)](#) divided by the fan nameplate rated motor power.
- c. For purposes of this table, closed circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table [403.2.3\(8\)](#) divided by the sum of the fan nameplate rated motor power and the spray pump nameplate rated motor power.

- d. For purposes of this table, air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan nameplate rated motor power.
- e. Chapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
- f. If 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, if 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.

TABLE C403.2.3(9)  
HEAT TRANSFER EQUIPMENT

EQUIPMENT TYPE	SUBCATEGORY	MINIMUM EFFICIENCY	TEST PROCEDURE <sup>a</sup>
Liquid-to-liquid heat exchangers	Plate type	NR	<a href="#">AHRI</a> 400

NR = No Requirement

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

**C403.2.3.1 Water-cooled centrifugal chilling packages.**

Equipment not designed for operation at [AHRI](#) Standard 550/590 test conditions of 44°F (7°C) leaving chilled-water temperature and 85°F (29°C) entering condenser water temperature with 3 gpm/ton (0.054 l/s • kW) condenser water flow shall have maximum full-load kW/ton and *NPLV* ratings adjusted using Equations [C4-3](#) and [C4-4](#).

Adjusted minimum full-load COP ratings =  
(Full-load COP from Table 6.8.1C of [AHRI](#) (Equation C4-3)  
Standard 550/590) ×  $K_{adj}$

Adjusted minimum *NPLV* rating =  
(*IPLV* from Table 6.8.1C of [AHRI](#) Standard (Equation C4-4)  
550/590) ×  $K_{adj}$

where:

$$K_{adj} = A \times B$$

$$A = 0.0000015318 \times (\text{LIFT})^4 - 0.000202076 \times (\text{LIFT})^3 + 0.0101800 \times (\text{LIFT})^2 - 0.264958 \times \text{LIFT} + 3.930196$$

$$B = 0.0027 \times L_{vg}^{Evap} (\text{°C}) + 0.982$$

$$\text{LIFT} = L_{vg}^{Cond} - L_{vg}^{Evap}$$

$L_{vg}^{Cond}$  = Full-load condenser leaving water temperature (°C)

$L_{vg}^{Evap}$  = Full-load leaving evaporator temperature (°C)

SI units shall be used in the  $K_{adj}$  equation.

The adjusted full-load and NPLV values shall only be applicable for centrifugal chillers meeting all of the following full-load design ranges:

1. The leaving evaporator fluid temperature is not less than 36°F (2.2°C).
2. The leaving condenser fluid temperature is not greater than 115°F (46.1°C).
3. LIFT is not less than 20°F (11.1 °C) and not greater than 80°F (44.4°C).

**Exception:** Centrifugal chillers designed to operate outside of these ranges need not comply with this code.

#### **C403.2.3.2 Positive displacement (air- and water-cooled) chilling packages.**

Equipment with a leaving fluid temperature higher than 32°F (0°C), shall meet the requirements of Table [C403.2.3\(7\)](#) when tested or certified with water at standard rating conditions, in accordance with the referenced test procedure.

#### **C403.2.4 HVAC system controls.**

Each heating and cooling system shall be provided with thermostatic controls as specified in Section [C403.2.4.1](#), [C403.2.4.2](#), [C403.2.4.3](#), [C](#), [C403.4.1](#), [C403.4.2](#), [C403.4.3](#) or [C403.4.4](#).

##### **C403.2.4.1 Thermostatic controls.**

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 or 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 50 contiguous feet (15 240 mm); and
2. The perimeter system heating and cooling supply is controlled by a thermostats located within the *zones* served by the system.

**C403.2.4.1.1 Heat pump supplementary heat.**

Heat pumps having supplementary electric resistance heat shall have controls that, except during defrost, prevent supplementary heat operation where the heat pump can meet the heating load.

**C403.2.4.2 Set point overlap restriction.**

Where used to control both heating and cooling, *zone* thermostatic controls shall provide a temperature range or deadband of at least 5°F (2.8°C) within which the supply of heating and cooling energy to the *zone* is capable of being shut off or reduced to a minimum.

**Exception:** Thermostats requiring manual changeover between heating and cooling modes.

**C403.2.4.3 Off-hour controls.**

Each *zone* shall be provided with thermostatic setback controls that are controlled by either an automatic time clock or programmable control system.

**Exceptions:**

1. *Zones* that will be operated continuously.
2. *Zones* with a full HVAC load demand not exceeding 6,800 Btu/h (2 kW) and having a readily accessible manual shutoff switch.

**C403.2.4.3.1 Thermostatic setback capabilities.**

Thermostatic setback controls shall have the capability to set back or temporarily operate the system to maintain *zone* temperatures down to 55°F (13°C) or up to 85°F (29°C).

**C403.2.4.3.2 Automatic setback and shutdown capabilities.**

Automatic time clock or programmable controls shall be capable of starting and stopping the system for seven different daily schedules per week and retaining their programming and time setting during a loss of power for at least 10 hours.

Additionally, the controls shall have a manual override that allows temporary operation of the system for up to 2 hours; a manually operated timer capable of being adjusted to operate the system for up to 2 hours; or an occupancy sensor.

#### **C403.2.4.3.3 Automatic start capabilities.**

Automatic start controls shall be provided for each HVAC system. The controls shall be capable of automatically adjusting the daily start time of the HVAC system in order to bring each space to the desired occupied temperature immediately prior to scheduled occupancy.

#### **C403.2.4.4 Shutoff damper controls.**

Both outdoor air supply and exhaust ducts shall be equipped with motorized dampers that will automatically shut when the systems or spaces served are not in use.

##### **Exceptions:**

1. Gravity dampers shall be permitted in buildings less than three stories in height.
- ~~2. Gravity dampers shall be permitted for buildings of any height located in Climate Zones 1, 2 and 3.~~
- ~~23.~~ Gravity dampers shall be permitted for outside air intake or exhaust airflows of 300 cfm (0.14 m<sup>3</sup>/s) or less.

#### **C403.2.4.5 Mechanical System Shut Off**

##### **C403.2.4.5.1 Operable Wall or Roof Openings**

Any directly conditioned space with operable wall or roof openings to the outdoors shall be equipped with interlock controls that disable or reset the temperature setpoint for mechanical heating and cooling. The reset setpoint for mechanical heating shall be 55°F and for mechanical cooling shall be 90°F. The system shutoff or setpoint temperature reset shall activate within 5 minutes of any such operable wall or roof opening being opened.

**Exception:** Interlock controls are not required for systems and spaces as follows:

1. On doors with automatic closing devices.
2. For vestibules or revolving doors.
3. Any space without a thermostatic control (thermostat or a space temperature sensor used to control heating or cooling to the space).

##### **C403.2.4.5.2 Overhead door HVAC shut-off devices.**

Overhead doors, cargo doors, sliding doors, folding and accordion style wall systems, and other loading dock style doors that open to the outdoors shall be equipped with interlock controls that disable the heating, cooling and humidity control equipment that serves the area or zone adjacent to the door. The shut off shall activate prior to the door being 25 percent open. A shutoff override, designed to be used when vehicles are parked in the doorway, may be included on doors equipped with weatherseals. The override must automatically deactivate when the vehicle is removed.

**Exceptions:**

1. Interlock controls are not required in areas where HVAC equipment must remain on for safety, sanitation or other health related reasons.
2. Interlock controls are not required in areas heated by a radiant heating systems.
3. The shutoff override shall activate within 5 minutes in groups U, SI, and B Motor vehicle showroom occupancies.

**C403.2.4.65 Snow melt system controls.**

Snow- and ice-melting systems, supplied through energy service to the building, shall include automatic controls capable of shutting off the system when the pavement temperature is above 50°F (10°C) and no precipitation is falling and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F (4°C) so that the potential for snow or ice accumulation is negligible.

**C403.2.5 Ventilation.**

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*.

**C403.2.5.1 Demand controlled ventilation.**

Demand control ventilation (DCV) shall be provided for conditioned spaces larger than 500 square feet (50 m<sup>2</sup>) and with an average occupant load of 25 people per 1000 square feet (93 m<sup>2</sup>) of conditioned floor area (as established in Table 403.3 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; or
3. A design outdoor airflow greater than 3,000 cfm (1400 L/s).

**Exception:** Demand control ventilation is not required for systems and spaces as follows:

1. Systems with energy recovery complying with Section C403.2.6.
2. Multiple-*zone* systems without direct digital control of individual *zones* communicating with a central control panel.
3. System with a design outdoor airflow less than 1,200 cfm (600 L/s).
4. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1,200 cfm (600 L/s).

5. Ventilation provided for process loads only.

**C403.2.6 Heating Energy recovery ventilation systems.**

Where the supply airflow rate of a fan system exceeds the values specified in Table [C403.2.6](#), the system shall include an heating energy recovery system. The heating energy recovery system shall have the capability to provide a change in the enthalpy of the outdoor air supply of not less than 50 percent of the difference between the outdoor air and return air enthalpies, at design conditions. Where an air economizer is required, the heating energy recovery system shall include a bypass or controls which permit operation of the economizer as required by Section [C403.4](#)

**Exception:** An heating 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*.
2. Laboratory fume hood systems that include at least one of the following features:
  - 2.1. Variable-air-volume hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to 50 percent or less of design values.
  - 2.2. Direct makeup (auxiliary) air supply equal to at least 75 percent of the exhaust rate, heated no warmer than 2°F (1.1°C) above room setpoint, cooled to no cooler than 3°F (1.7°C) below room setpoint, no humidification added, and no simultaneous heating and cooling used for dehumidification control.
3. Systems serving spaces that are heated to less than 60°F (15.5°C) and are not cooled.
4. Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site solar energy.
- ~~5. Heating energy recovery in Climate Zones 1 and 2.~~
- ~~6. Cooling energy recovery in Climate Zones 3C, 4C, 5B, 5C, 6B, 7 and 8.~~
- ~~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 [C403.2.6](#)~~

TABLE C403.2.6  
ENERGY RECOVERY REQUIREMENT

**Commented [TK5]:** For ICC: Please remove all references to CZs and just remake this table with the requirements for CZ5B

CLIMATE ZONE	PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE					
	≥ 30% and < 40%	≥ 40% and < 50%	≥ 50% and < 60%	≥ 60% and < 70%	≥ 70% and < 80%	≥ 80%
	DESIGN SUPPLY FAN AIRFLOW RATE (cfm)					
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	≥ 5000	≥ 5000
1B, 2B, 5C	NR	NR	≥ 26000	≥ 12000	≥ 5000	≥ 4000
6B	≥ 11000	≥ 5500	≥ 4500	≥ 3500	≥ 2500	≥ 1500
1A, 2A, 3A, 4A, 5A, 6A	≥ 5500	≥ 4500	≥ 3500	≥ 2000	≥ 1000	> 0
7, 8	≥ 2500	≥ 1000	> 0	> 0	> 0	> 0

NR = not required

**C403.2.7 Duct and plenum insulation and sealing.**

All supply and return air ducts and plenums shall be insulated with a minimum of R-6 insulation where located in unconditioned spaces and a minimum of R-8 insulation where located outside the building. Where located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by a minimum of R-8 insulation.

**Exceptions:**

1. Where located within equipment.
2. Where the design temperature difference between the interior and exterior of the duct or plenum does not exceed 15°F (8°C).

All ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with Section [603.9](#) of the *International Mechanical Code*.

**C403.2.7.1 Duct construction.**

Ductwork shall be constructed and erected in accordance with the *International Mechanical Code*.

**C403.2.7.1.1 Low-pressure duct systems.**

All longitudinal and transverse joints, seams and connections of supply and return ducts operating at a static pressure less than or equal to 2 inches water gauge (w.g.) (500 Pa) shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes installed in accordance with the manufacturer’s installation instructions. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *International Mechanical Code*.

**Exception:** Continuously welded and locking-type longitudinal joints and seams on ducts operating at static pressures less than 2 inches water gauge (w.g.) (500 Pa) pressure classification.

**C403.2.7.1.2 Medium-pressure duct systems.**

All ducts and plenums designed to operate at a static pressure greater than 2 inches water gauge (w.g.) (500 Pa) but less than 3 inches w.g. (750 Pa) shall be insulated and sealed in accordance with Section [C403.2.7](#). Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *International Mechanical Code*.

**C403.2.7.1.3 High-pressure duct systems.**

Ducts designed to operate at static pressures in excess of 3 inches water gauge (w.g.) (750 Pa) shall be insulated and sealed in accordance with Section [C403.2.7](#). In addition, ducts and plenums shall be leak-tested in accordance with the [SMACNA HVAC Air Duct Leakage Test Manual](#) with the rate of air leakage (CL) less than or equal to 6.0 as determined in accordance with Equation [C4-5](#).

$$CL = F/P^{0.65} \text{ (Equation C4-5)}$$

where:

$F$  = The measured leakage rate in cfm per 100 square feet of duct surface.

$P$  = The static pressure of the test.

Documentation shall be furnished by the designer demonstrating that representative sections totaling at least 25 percent of the duct area have been tested and that all tested sections meet the requirements of this section.

**C403.2.8 Piping insulation.**

All piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table [C403.2.8](#).

**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 840, respectively.
3. Piping that conveys fluids that have a design operating temperature range between 60°F (15°C) and 105°F (41°C).

4. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power.
5. Strainers, control valves, and balancing valves associated with piping 1 inch (25 mm) or less in diameter.
6. Direct buried piping that conveys fluids at or below 60°F (15°C)

TABLE C403.2.8  
MINIMUM PIPE INSULATION THICKNESS (thickness in inches)<sup>a</sup>

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	INSULATION CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE (inches)				
	Conductivity Btu • in./ (h • ft <sup>2</sup> • °F) <sup>b</sup>	Mean Rating Temperature, °F	< 1	1 to < 1 1/2	1 1/2 to < 4	4 to < 8	≤ 8
> 350	0.32 – 0.34	250	4.5	5.0	5.0	5.0	5.0
251 – 350	0.29 – 0.32	200	3.0	4.0	4.5	4.5	4.5
201 – 250	0.27 – 0.30	150	2.5	2.5	2.5	3.0	3.0
141 – 200	0.25 – 0.29	125	1.5	1.5	2.0	2.0	2.0
105 – 140	0.21 – 0.28	100	1.0	1.0	1.5	1.5	1.5
40 – 60	0.21 – 0.27	75	0.5	0.5	1.0	1.0	1.0
< 40	0.20 – 0.26	75	0.5	1.0	1.0	1.0	1.5

- a. For piping smaller than 1 1/2 inch (38 mm) and located in partitions within *conditioned spaces*, reduction of these thicknesses by 1 inch (25 mm) shall be permitted (before thickness adjustment required in footnote b) but not to a thickness less than 1 inch (25 mm).
- b. For insulation outside the stated conductivity range, the minimum thickness (*T*) shall be determined as follows:

$$T = r \{ (1 + t/r)^{k/k} - 1 \}$$

Where:

- T* = minimum insulation thickness,
- r* = actual outside radius of pipe,
- t* = insulation thickness listed in the table for applicable fluid temperature and pipe size,

- $K$  = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu × in/h × ft<sup>2</sup> × °F) and
- $k$  = the upper value of the conductivity range listed in the table for the applicable fluid temperature.

**C403.2.8.1 Protection of piping insulation.**

Piping insulation exposed to weather shall be protected from damage, including that due to sunlight, moisture, equipment maintenance and wind, and shall provide shielding from solar radiation that can cause degradation of the material. Adhesives tape shall not be permitted.

**C403.2.9 Mechanical systems commissioning and completion requirements.**

Mechanical systems shall be commissioned and completed in accordance with Section [C407.2](#).

**C403.2.10 Air system design and control.**

Each HVAC system having a total fan system motor nameplate horsepower (hp) exceeding 5 horsepower (hp) (3.7 kW) shall meet the provisions of Sections [C403.2.10.1](#) through [C403.2.10.2](#).

**C403.2.10.1 Allowable fan motor horsepower.**

Each HVAC system at fan system design conditions shall not exceed the allowable *fan system motor nameplate hp (Option 1)* or *fan system bhp (Option 2)* as shown in Table [C403.2.10.1\(1\)](#). This includes supply 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.

**Exception:** The following fan systems are exempt from allowable fan floor horsepower requirement.

1. Hospital, vivarium and laboratory systems that utilize flow control devices on exhaust and/or return to maintain space pressure relationships necessary for occupant health and safety or environmental control shall be permitted to use variable volume fan power limitation.
2. Individual exhaust fans with motor nameplate horsepower of 1 hp or less.

TABLE C403.2.10.1(1)  
FAN POWER LIMITATION

	LIMIT	CONSTANT VOLUME	VARIABLE VOLUME
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Option 1: Fan system motor nameplate hp	Allowable nameplate motor hp	$hp \leq CFM_s \times 0.0011$	$hp \leq CFM_s \times 0.0015$
Option 2: Fan system bhp	Allowable fan system bhp	$bhp \leq CFM_s \times 0.00094 + A$	$bhp \leq CFM_s \times 0.0013 + A$

where:

$CFM_s$  = The maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute.

hp = The maximum combined motor nameplate horsepower.

Bhp = The maximum combined fan brake horsepower.

A = Sum of  $[PD \times CFM_b / 4131]$

For SI: 1 cfm = 0.471 L/s.

where:

PD = Each applicable pressure drop adjustment from Table [C403.2.10.1\(2\)](#) in. w.c.

$CFM_b$  = The design airflow through each applicable device from Table [C403.2.10.1\(2\)](#) in cubic feet per minute.

For SI: 1 bhp = 735.5 W, 1 hp = 745.5 W.

TABLE C403.2.10.1(2)  
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT

DEVICE	ADJUSTMENT
<b>Credits</b>	
Fully ducted return and/or exhaust air systems	0.5 inch w.c. (2.15 in w.c. for laboratory and vivarium systems)
Return and/or exhaust air flow control devices	0.5 inch w.c.
Exhaust filters, scrubbers, or other exhaust treatment.	The pressure drop of device calculated at fan system design condition
Particulate filtration credit: MERV 9 thru 12	0.5 inch w.c.
Particulate filtration credit: MERV 13 thru 15	0.9 inch. w.c.
Particulate filtration credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2x clean filter pressure drop at fan system design condition.
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition.
Biosafety cabinet	Pressure drop of device at fan system design condition.

Energy recovery device, other than coil runaround loop	(2.2 × energy recovery effectiveness) – 0.5 inch w.c. for each airstream
Coil runaround loop	0.6 inch w.c. for each airstream
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design conditions
Sound attenuation section	0.15 inch w.c.
Exhaust system serving fume hoods	0.35 inch w.c.
Laboratory and vivarium exhaust systems in high-rise buildings	0.25 inch w.c./100 feet of vertical duct exceeding 75 feet

w.c. = water column

For SI: 1 inch w.c. = 249 Pa, 1 inch = 25.4 mm.

**C403.2.10.2 Motor nameplate horsepower.**

For each fan, the selected fan motor shall be no larger than the first available motor size greater than the brake horsepower (bhp). The fan brake horsepower (bhp) shall be indicated on the design documents to allow for compliance verification by the *code official*.

**Exceptions:**

1. For fans less than 6 bhp (4413 W), where the first available motor larger than the brake horsepower has a nameplate rating within 50 percent of the bhp, selection of the next larger nameplate motor size is allowed.
2. For fans 6 bhp (4413 W) and larger, where the first available motor larger than the bhp has a nameplate rating within 30 percent of the bhp, selection of the next larger nameplate motor size is allowed.

**C403.2.11 Heating outside a building.**

Systems installed to provide heat outside a building shall be radiant systems. Such heating systems shall be controlled by an occupancy sensing device or a timer switch, so that the system is automatically deenergized when no occupants are present.

**C403.3 Simple HVAC systems and equipment (Prescriptive).**

This section applies to buildings served by unitary or packaged HVAC equipment listed in Tables [C403.2.3\(1\)](#) through [C403.2.3\(8\)](#), each serving one *zone* and controlled by a single thermostat in the *zone* served. It also applies to two-pipe heating systems serving one or more *zones*, where no cooling system is installed.

**C403.3.1 Economizers.**

Each cooling system that has a fan shall include either an air or water economizer meeting the requirements of Sections [C403.3.1.1](#) through [C403.3.1.1.4](#).

**Exception:** Economizers are not required for the systems listed below.

1. Individual fan-cooling units with a supply capacity less than the minimum listed in Table [C403.3.1\(1\)](#).
2. Where more than 25 percent of the air designed to be supplied by the system is to spaces that are designed to be humidified above 35°F (1.7 °C) dew-point temperature to satisfy process needs.
3. Systems that serve *residential* spaces where the system capacity is less than five times the requirement listed in Table [C403.3.1\(1\)](#).
4. Systems expected to operate less than 20 hours per week.
5. Where the use of *outdoor air* for cooling will affect supermarket open refrigerated casework systems.
6. ~~Where the cooling efficiency meets or exceeds the efficiency requirements in Table [C403.3.1\(2\)](#).~~

TABLE C403.3.1(1)  
ECONOMIZER REQUIREMENTS

CLIMATE ZONES	ECONOMIZER REQUIREMENT
1A, 1B	No requirement
2A, 2B, 3A, 3B, 3C, 4A, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	Economizers on all cooling systems $\geq 33,000$ Btu/h <sup>a</sup>

**Commented [TK6]:** For ICC: Please remove all references to CZs and just remake this table with the requirements for CZ5B

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

a. The total capacity of all systems without economizers shall not exceed 300,000 Btu/h per *building*, or 20 percent of its air economizer capacity, whichever is greater.

~~TABLE C403.3.1(2)-  
EQUIPMENT EFFICIENCY PERFORMANCE-  
EXCEPTION FOR ECONOMIZERS~~

<del>CLIMATE ZONES</del>	<del>COOLING EQUIPMENT PERFORMANCE IMPROVEMENT (EER OR IPLV)</del>
<del>2B</del>	<del>10% Efficiency Improvement</del>
<del>3B</del>	<del>15% Efficiency Improvement</del>

4B	20% Efficiency Improvement
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**C403.3.1.1 Air economizers.**

Air economizers shall comply with Sections [C403.3.1.1.1](#) through [C403.3.1.1.4](#).

**C403.3.1.1.1 Design capacity.**

Air economizer systems shall be capable of modulating *outdoor air* and return air dampers to provide up to 100 percent of the design supply air quantity as *outdoor air* for cooling.

**C403.3.1.1.2 Control signal.**

Economizer dampers shall be capable of being sequenced with the mechanical cooling equipment and shall not be controlled by only mixed air temperature.

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

**C403.3.1.1.3 High-limit shutoff.**

Air economizers shall be capable of automatically reducing *outdoor air* intake to the design minimum *outdoor air* quantity when *outdoor air* intake will no longer reduce cooling energy usage. High-limit shutoff control types for specific climates shall be chosen from Table [C403.3.1.1.3\(1\)](#). High-limit shutoff control settings for these control types shall be those specified in Table [C403.3.1.1.3\(2\)](#).

TABLE C403.3.1.1.3(1)  
HIGH-LIMIT SHUTOFF CONTROL OPTIONS FOR AIR ECONOMIZERS

CLIMATE ZONES	ALLOWED CONTROL TYPES	PROHIBITED CONTROL TYPES
1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	Fixed dry bulb	Fixed enthalpy
	Differential dry bulb	
	Electronic enthalpy <sup>a</sup>	
	Differential enthalpy	
	Dew-point and dry-bulb temperatures	
1A, 2A, 3A, 4A	Fixed dry bulb	Differential dry bulb
	Fixed enthalpy	

**Commented [TK7]:** For ICC: Please remove all references to CZs and just remake this table with the requirements for CZ5B

	Electronic enthalpy <sup>a</sup>	—
	Differential enthalpy	
	Dew-point and dry-bulb temperatures	
All other climates	Fixed dry bulb	
	Differential dry bulb	
	Fixed enthalpy	
	Electronic enthalpy <sup>a</sup>	
	Differential enthalpy	
	Dew-point and dry-bulb temperatures	

a. Electronic enthalpy controllers are devices that use a combination of humidity and dry-bulb temperature in their switching algorithm.

TABLE C403.3.1.1.3(2)  
HIGH-LIMIT SHUTOFF CONTROL SETTING FOR AIR ECONOMIZERS

**Commented [TK8]:** For ICC: Please remove all references to CZs and just remake this table with the requirements for CZ5B

DEVICE TYPE	CLIMATE ZONE	REQUIRED HIGH LIMIT (ECONOMIZER OFF WHEN):	
		EQUATION	DESCRIPTION
Fixed dry bulb	1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	$T_{OA} > 75^{\circ}\text{F}$	Outdoor air temperature exceeds 75°F
	5A, 6A, 7A	$T_{OA} > 70^{\circ}\text{F}$	Outdoor air temperature exceeds 70°F
	All other zones	$T_{OA} > 65^{\circ}\text{F}$	Outdoor air temperature exceeds 65°F
Differential dry bulb	1B, 2B, 3B, 3C, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	$T_{OA} > T_{RA}$	Outdoor air temperature exceeds return air temperature
Fixed enthalpy	All	$h_{OA} > 28 \text{ Btu/lb}^a$	Outdoor air enthalpy exceeds 28 Btu/lb of dry air <sup>a</sup>
Electronic Enthalpy	All	$(T_{OA}, RH_{OA}) > A$	Outdoor air temperature/RH exceeds the "A" setpoint curve <sup>b</sup>
Differential enthalpy	All	$h_{OA} > h_{RA}$	Outdoor air enthalpy exceeds return air enthalpy

Dew-point and dry bulb temperatures	All	$DP_{oa} > 55^{\circ}\text{F}$ or $T_{oa} > 75^{\circ}\text{F}$	Outdoor air dry bulb exceeds 75°F or outside dew point exceeds 55°F (65 gr/lb)
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For SI:  $^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times \frac{5}{9}$ , 1 Btu/lb = 2.33 kJ/kg.

- a. At altitudes substantially different than sea level, the Fixed Enthalpy limit shall be set to the enthalpy value at 75°F and 50-percent relative humidity. As an example, at approximately 6,000 feet elevation the fixed enthalpy limit is approximately 30.7 Btu/lb.
- b. Setpoint "A" corresponds to a curve on the psychrometric chart that goes through a point at approximately 75°F and 40-percent relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.

**C403.3.1.1.4 Relief of excess outdoor air.**

Systems shall be capable of relieving excess *outdoor air* during air economizer operation to prevent over-pressurizing the building. The relief air outlet shall be located to avoid recirculation into the building.

**C403.3.2 Hydronic system controls.**

Hydronic systems of at least 300,000 Btu/h (87 930 W) design output capacity supplying heated and chilled water to comfort conditioning systems shall include controls that meet the requirements of Section [C403.4.3](#).

**C403.4 Complex HVAC systems and equipment. (Prescriptive).**

This section applies to buildings served by HVAC equipment and systems not covered in Section [C403.3](#).

**C403.4.1 Economizers.**

Economizers shall comply with Sections [C403.4.1.1](#) through [C403.4.1.4](#).

**C403.4.1.1 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 50°F dry bulb (10°C dry bulb)/45°F wet bulb (7.2°C wet bulb) and below.

**Exception:** Systems in which a water economizer is used and where dehumidification requirements cannot be met using outdoor air temperatures of 50°F dry bulb (10°C dry bulb)/45°F wet bulb (7.2°C wet bulb) shall satisfy 100 percent of the expected system cooling load at 45°F dry bulb (7.2°C dry bulb)/40°F wet bulb (4.5°C wet bulb).

**C403.4.1.2 Maximum pressure drop.**

Precooling coils and water-to-water heat exchangers used as part of a water economizer system shall either have a water-side pressure drop of less than 15 feet (4572 mm) of water or a secondary loop shall be created so that the coil or heat exchanger pressure drop is not seen by the circulating pumps when the system is in the normal cooling (noneconomizer) mode.

**C403.4.1.3 Integrated economizer control.**

Economizer systems shall be integrated with the mechanical cooling system and be capable of providing partial cooling even where additional mechanical cooling is required to meet the remainder of the cooling load.

**Exceptions:**

1. Direct expansion systems that include controls that reduce the quantity of *outdoor air* required to prevent coil frosting at the lowest step of compressor unloading, provided this lowest step is no greater than 25 percent of the total system capacity.
2. Individual direct expansion units that have a rated cooling capacity less than 54,000 Btu/h (15 827 W) and use nonintegrated economizer controls that preclude simultaneous operation of the economizer and mechanical cooling.

**C403.4.1.4 Economizer heating system impact.**

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

**Exception:** Economizers on VAV systems that cause *zone* level heating to increase due to a reduction in supply air temperature.

**C403.4.2 Variable air volume (VAV) fan control.**

Individual VAV fans with motors of 7.5 horsepower (5.6 kW) or greater shall be:

1. Driven by a mechanical or electrical variable speed drive;
2. Driven by a vane-axial fan with variable-pitch blades; or
3. The fan shall have controls or devices that will result in fan motor demand of no more than 30 percent of their design wattage at 50 percent of design airflow when static pressure set point equals one-third of the total design static pressure, based on manufacturer's certified fan data.

**C403.4.2.1 Static pressure sensor location.**

Static pressure sensors used to control VAV fans shall be placed in a position such that the controller setpoint is no greater than one-third the total design fan static pressure, except for systems with *zone* reset control complying with Section [C403.4.2.2](#). For sensors installed down-stream of major duct splits, at least one sensor shall be located on each major branch to ensure that static pressure can be maintained in each branch.

**C403.4.2.2 Set points for direct digital control.**

For systems with direct digital control of individual *zone* boxes reporting to the central control panel, the static pressure set point

shall be reset based on the *zone* requiring the most pressure, i.e., the set point is reset lower until one *zone* damper is nearly wide open.

#### **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 capable of sequencing operation of the boilers. Hydronic heating systems comprised of a single boiler and greater than 500,000 Btu/h (146 550 W) 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 dead band between changeover from one mode to the other of at least 15°F (8.3°C) outside air temperatures; be designed to and provided with controls that will allow operation in one mode for at least 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 no more than 30°F (16.7°C) apart.

##### **C403.4.3.3 Hydronic (water loop) heat pump systems.**

Hydronic heat pump systems shall comply with Sections [C403.4.3.3.1](#) through [C403.4.3.3.3](#).

###### **C403.4.3.3.1 Temperature dead band.**

Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition shall have controls that are capable of providing a heat pump water supply temperature dead band of at least 20°F (11.1°C) between initiation of heat rejection and heat addition by the central devices.

**Exception:** Where a system loop temperature optimization controller is installed and can determine the most efficient operating temperature based on realtime conditions of demand and capacity, dead bands of less than 20°F (11°C) shall be permitted.

###### **C403.4.3.3.2 Heat rejection.**

Heat rejection equipment shall comply with Sections [C403.4.3.3.2.1](#) and [C403.4.3.3.2.2](#). If an open- or closed-circuit cooling tower is used, a separate heat exchanger shall be provided to isolate the cooling tower from the heat pump loop, and heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop and providing an automatic valve to stop the flow of fluid.

**Exception:** Where it can be demonstrated that a heat pump system will be required to reject heat throughout the year.

**~~C403.4.3.3.2.1 Climate Zones 3 and 4.~~**

~~For Climate Zones 3 and 4:~~

- ~~1. If a closed-circuit cooling tower is used directly in the heat pump loop, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower, or lower leakage positive closure dampers shall be provided.~~
- ~~2. If an open-circuit tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the tower.~~
- ~~3. If an open or closed-circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the cooling tower from the heat pump loop, then heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.~~

**~~C403.4.3.3.2.2 Climate Zones 5 through 8.~~**

~~For Climate Zones 5 through 8, if an open or closed-circuit cooling tower is used, then a separate heat exchanger shall be provided to isolate the cooling tower from the heat pump loop, and heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop and providing an automatic valve to stop the flow of fluid.~~

**C403.4.3.3.3 Two position valve.**

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

**C403.4.3.4 Part load controls.**

Hydronic systems greater than or equal to 300,000 Btu/h (87 930 W) in design output capacity supplying heated or chilled water to comfort conditioning systems shall include controls that have the capability to:

1. Automatically reset the supply-water temperatures using zone-return water temperature, building-return water temperature, or outside air temperature as an indicator of building heating or cooling demand. The temperature shall be capable of being reset by at least 25 percent of the design supply-to-return water temperature difference; or
2. Reduce system pump flow by at least 50 percent of design flow rate utilizing adjustable speed drive(s) on pump(s), or multiple-staged pumps where at least one-half of the total pump horsepower is capable of being automatically turned off or control valves designed to modulate or step down, and close, as a function of load, or other *approved means*.

**C403.4.3.5 Pump isolation.**

Chilled water plants including more than one chiller shall have the capability to reduce flow automatically through the chiller plant

when a chiller is shut down. Chillers piped in series for the purpose of increased temperature differential shall be considered as one chiller.

Boiler plants including more than one boiler shall have the capability to reduce flow automatically through the boiler plant when a boiler is shut down.

#### **C403.4.4 Heat rejection equipment fan speed control.**

Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at two-thirds of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

**Exception:** Factory-installed heat rejection devices within HVAC equipment tested and rated in accordance with Tables [C403.2.3\(6\)](#) and [C403.2.3\(7\)](#).

#### **C403.4.5 Requirements for complex mechanical systems serving multiple zones.**

Sections [C403.4.5.1](#) through [C403.4.5.4](#) shall apply to complex mechanical systems serving multiple zones. Supply air systems serving multiple zones shall be VAV systems which, during periods of occupancy, are designed and capable of being controlled to reduce primary air supply to each *zone* to one of the following before reheating, recooling or mixing takes place:

1. Thirty percent of the maximum supply air to each *zone*.
2. Three hundred cfm (142 L/s) or less where the maximum flow rate is less than 10 percent of the total fan system supply airflow rate.
3. The minimum ventilation requirements of Chapter [4](#) of the *International Mechanical Code*.

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

1. *Zones* where special pressurization relationships or cross-contamination requirements are such that VAV systems are impractical.
2. *Zones* or supply air systems where at least 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.
3. *Zones* where special humidity levels are required to satisfy process needs.
4. *Zones* with a peak supply air quantity of 300 cfm (142 L/s) or less and where the flow rate is less than 10 percent of the total fan system supply airflow rate.

5. *Zones* where the volume of air to be reheated, recooled or mixed is no greater than the volume of outside air required to meet the minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.

6. *Zones* or supply air systems with thermostatic and humidistatic controls capable of operating in sequence the supply of heating and cooling energy to the *zones* and which are capable of preventing reheating, recooling, mixing or simultaneous supply of air that has been previously cooled, either mechanically or through the use of economizer systems, and air that has been previously mechanically heated.

**C403.4.5.1 Single duct variable air volume (VAV) systems, terminal devices.**

Single duct VAV systems shall use terminal devices capable of reducing the supply of primary supply air before reheating or recooling takes place.

**C403.4.5.2 Dual duct and mixing VAV systems, terminal devices.**

Systems that have one warm air duct and one cool air duct shall use terminal devices which are capable of reducing the flow from one duct to a minimum before mixing of air from the other duct takes place.

**C403.4.5.3 Single fan dual duct and mixing VAV systems, economizers.**

Individual dual duct or mixing heating and cooling systems with a single fan and with total capacities greater than 90,000 Btu/h [(26 375 W) 7.5 tons] shall not be equipped with air economizers.

**C403.4.5.4 Supply-air temperature reset controls.**

Multiple *zone* HVAC systems shall include controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperature. The controls shall be capable of resetting the supply air temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

**Exceptions:**

1. Systems that prevent reheating, recooling or mixing of heated and cooled supply air.
2. Seventy five percent of the energy for reheating is from site-recovered or site solar energy sources.
3. Zones with peak supply air quantities of 300 cfm (142 L/s) or less.

**C403.4.6 Heat recovery for service water heating.**

Condenser heat recovery shall be installed for heating or reheating of service hot water provided the facility operates 24 hours a day, the total installed heat capacity of water-cooled systems exceeds 6,000,000 Btu/hr (1 758 600 W) of heat rejection, and the design service water heating load exceeds 1,000,000 Btu/h (293 100 W).

The required heat recovery system shall have the capacity to provide the smaller of:

1. Sixty percent of the peak heat rejection load at design conditions; or
2. The preheating required to raise the peak service hot water draw to 85°F (29°C).

**Exceptions:**

1. Facilities that employ condenser heat recovery for space heating or reheat purposes with a heat recovery design exceeding 30 percent of the peak water-cooled condenser load at design conditions.
2. Facilities that provide 60 percent of their service water heating from site solar or site recovered energy or from other sources.

**C403.4.7 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 C

**Exception:** Unitary packaged systems with cooling capacities not greater than 90,000 Btu/h (26 379 W).

TABLE C403.4.7  
MAXIMUM HOT GAS BYPASS CAPACITY

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

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

**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 (Prescriptive).**

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 or through certification under an *approved* certification program.

TABLE C404.2  
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED <sup>a, b</sup>	TEST PROCEDURE
Water heaters, electric	≤ 12 kW	<del>Resistance</del> <del>≤55 gal</del>	<del>0.97–0.00132V, EF</del> <del>0.960–0.0003V, EF</del>	<a href="#">DOE 10 CFR Part 430</a>
	> 12 kW	Resistance ≥20	<del>1.73V+155 SL, Btu/h</del> <del>0.3+27/V<sub>m</sub>%/h</del>	<a href="#">ANSI Z21.10.3</a>
	≤ 24 amps and ≤ 250 volts	<del>Heat pump</del> >55 gal	<del>0.93–0.00132V, EF</del> <del>2.057–0.00113V, EF</del>	<a href="#">DOE 10 CFR Part 430</a>
Storage water heaters, gas	≤ 75,000 Btu/h	<del>≥20 gallons and ≤55 gal</del>	<del>0.67–0.0019V, EF</del> <del>0.675–0.0015V, EF</del>	<a href="#">DOE 10 CFR Part 430</a>
	<del>≤ 75,000 Btu/h</del>	>55 gallons and ≤100 gallons	0.8012–0.00078 V, EF	<a href="#">DOE 10 CFR Part 430</a>
	> 75,000 Btu/h and ≤155,000 Btu/h	< 4,000 Btu/h/gal	$80\% E_t$ $(Q/800 + 110/\sqrt{V})SL, \text{ Btu/h}$	<a href="#">ANSI Z21.10.3</a>
	> 155,000 Btu/h	< 4,000 Btu/h/gal	$80\% E_t$ $(Q/800 + 110/\sqrt{V})SL, \text{ Btu/h}$	
Instantaneous water heaters, gas	> 50,000 Btu/h and < 200,000 Btu/h <sup>c</sup>	≥ 4,000 (Btu/h)/gal and < 2 gal	<del>0.62–0.0019V, EF</del> <del>0.82–0.0019V, EF</del>	<a href="#">DOE 10 CFR Part 430</a>
	≥200,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E <sub>t</sub>	<a href="#">ANSI Z21.10.3</a>

	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	$80\% E_t$ $(Q/800 + 110./\sqrt{V})SL, \text{ Btu/h}$	
Storage water heaters, oil	≤ 105,000 Btu/h	≥ 20 gal	<del>0.59 - 0.0019V, EF</del> 0.68 - 0.0019V, EF	<a href="#">DOE 10 CFR Part 430</a>
	≥ 105,000 Btu/h	< 4,000 Btu/h/gal	$78\% E_t$ $(Q/800 + 110./\sqrt{V})SL, \text{ Btu/h}$	<a href="#">ANSI Z21.10.3</a>
Instantaneous water heaters, oil	≤ 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 2 gal	0.59 - 0.0019V, EF	<a href="#">DOE 10 CFR Part 430</a>
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% $E_t$	<a href="#">ANSI Z21.10.3</a>
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	$78\% E_t$ $(Q/800 + 110./\sqrt{V})SL, \text{ Btu/h}$	
Hot water supply boilers, gas and oil	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% $E_t$	<a href="#">ANSI Z21.10.3</a>
Hot water supply boilers, gas	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	$80\% E_t$ $(Q/800 + 110./\sqrt{V})SL, \text{ Btu/h}$	
Hot water supply boilers, oil	> 300,000 Btu/h and < 12,500,000 Btu/h	> 4,000 Btu/h/gal and > 10 gal	$78\% E_t$ $(Q/800 + 110./\sqrt{V})SL, \text{ Btu/h}$	
Pool heaters, gas and oil	All	—	<del>78% <math>E_t</math></del> 82% $E_t$	<a href="#">ASHRAE 146</a>
Heat pump pool heaters	All	—	4.0 COP	<a href="#">AHRI 1160</a>
Unfired storage tanks	All	—	Minimum insulation requirement R-12.5 (h • ft <sup>2</sup> • °F)/Btu	(none)

For SI: °C = [(°F) - 32]/1.8, 1 British thermal unit per hour = 0.2931 W, 1 gallon = 3.785 L, 1 British thermal unit per hour per gallon = 0.078 W/L.

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

b. Standby loss (SL) is the maximum Btu/h based on a nominal 70°F temperature difference between stored water and ambient requirements. In the SL equation, Q is the nameplate input rate in Btu/h. In the SL equation for electric water heaters, V is the rated volume in gallons. In the SL equation for oil and gas water heaters and boilers, V is the rated volume in gallons.

c. Instantaneous water heaters with input rates below 200,000 Btu/h must comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.

d.  $V_m$  is the measured volume in the tank.  $V_m\%/h$  is a rating that represents the allowable standby loss in %/h, percent per hour. The percent is the total heat added to the water to bring it up to the storage temperature in the tank.

**C404.3 Temperature controls (Mandatory).**

Service water-heating equipment shall be provided with controls to allow a setpoint of 110°F (43°C) for equipment serving dwelling units and 90°F (32°C) for equipment serving other occupancies. The outlet temperature of lavatories in public facility rest rooms shall be limited to 110°F (43°C).

**C404.4 Heat traps (Mandatory).**

Water-heating equipment not supplied with integral heat traps and serving noncirculating systems shall be provided with heat traps on the supply and discharge piping associated with the equipment.

**C404.5 Pipe insulation (Mandatory).**

For automatic-circulating hot water and heat-traced systems, piping shall be insulated with not less than 1 inch (25 mm) of insulation having a conductivity not exceeding 0.27 Btu per inch/h × ft<sup>2</sup> × °F (1.53 W per 25 mm/m<sup>2</sup> × K). The first 8 feet (2438 mm) of piping in non-hot-water-supply temperature maintenance systems served by equipment without integral heat traps shall be insulated with 0.5 inch (12.7 mm) of material having a conductivity not exceeding 0.27 Btu per inch/h × ft<sup>2</sup> × °F (1.53 W per 25 mm/m<sup>2</sup> × K).

**Exception:** Heat-traced piping systems shall meet the insulation thickness requirements per the manufacturer's installation instructions. Untraced piping within a heat traced system shall be insulated with not less than 1 inch (25 mm) of insulation having a conductivity not exceeding 0.27 Btu per inch/h × ft<sup>2</sup> × °F (1.53 W per 25 mm/m<sup>2</sup> × K).

**C404.6 Hot water system controls (Mandatory).**

Circulating hot water system pumps or heat trace shall be arranged to be turned off either automatically or manually when there is limited hot water demand. Ready access shall be provided to the operating controls.

**C404.7 Pools and inground permanently installed spas (Mandatory).**

Pools and inground permanently installed spas shall comply with Sections [C404.7.1](#) through [C404.7.3](#).

**C404.7.1 Heaters.**

All heaters shall be equipped with a *readily accessible* on-off switch that is mounted outside of the heater to allow shutting off the heater without adjusting the thermostat setting. Gas-fired heaters shall not be equipped with constant burning pilot lights.

**C404.7.2 Time switches.**

Time switches or other control method that can automatically turn off and on heaters and pumps according to a preset schedule shall

be installed on all heaters and pumps. Heaters, pumps and motors that have built in timers shall be deemed in compliance with this requirement.

**Exceptions:**

1. Where public health standards require 24-hour pump operation.
2. Where pumps are required to operate solar- and waste-heat-recovery pool heating systems.

**C404.7.3 Covers.**

Heated pools and inground permanently installed spas shall be provided with a vapor-retardant cover.

**Exception:** A vapor-retardant cover is not required for pools deriving over 70 percent of the energy for heating from site-recovered energy, such as a heat pump or solar energy source computed over an operating season.

**SECTION C405  
ELECTRICAL POWER, AND, LIGHTING SYSTEMS  
(MANDATORY)**

**C405.1 General (Mandatory).**

This section covers lighting system controls, the connection of ballasts, the maximum lighting power for interior applications, electrical energy consumption, and minimum acceptable lighting equipment for exterior applications.

**Exception:** Dwelling units within commercial buildings shall not be required to comply with Sections [C405.2](#) through [C405.5](#) provided that not less than 75 percent of the permanently installed light fixtures, other than low-voltage lighting, shall be fitted for, and contain only, high efficacy lamps.

**C405.2 Lighting controls (Mandatory).**

Lighting systems shall be provided with controls as specified in Sections [C405.2.1](#), [C405.2.2](#), [C405.2.3](#) and [C405.2.4](#).

**C405.2.1 Manual lighting controls.**

All buildings shall include manual lighting controls that meet the requirements of Sections [C405.2.1.1](#) and [C405.2.1.2](#).

**C405.2.1.1 Interior lighting controls.**

Each area enclosed by walls or floor-to-ceiling partitions shall have at least one manual control for the lighting serving that area. The required controls shall be located within the area served by the controls or be a remote switch that identifies the lights served and indicates their status.

**Exceptions:**

1. Areas designated as security or emergency areas that need to be continuously lighted.
2. Lighting in stairways or corridors that are elements of the means of egress.

**C405.2.1.2 Light reduction controls.**

Each area that is required to have a manual control shall also allow the occupant to reduce the connected lighting load in a reasonably uniform illumination pattern by at least 50 percent. Lighting reduction shall be achieved by one of the following or other *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; or

4. Switching each luminaire or each lamp.

**Exception:** Light reduction controls need not be provided in the following areas and spaces:

1. Areas that have only one luminaire, with rated power less than 100 watts.
2. Areas that are controlled by an occupant-sensing device.
3. Corridors, equipment rooms, storerooms, restrooms, public lobbies, electrical or mechanical rooms.
4. *Sleeping unit* (see Section [C405.2.3](#)).
5. Spaces that use less than 0.6 watts per square foot (6.5 W/m<sup>2</sup>).
6. Daylight spaces complying with Section [C405.2.2.3.2](#).

#### **C405.2.2 Additional lighting controls.**

Each area that is required to have a manual control shall also have controls that meet the requirements of Sections [C405.2.2.1](#), [C405.2.2.2](#) and [C405.2.2.3](#).

**Exception:** Additional lighting controls need not be provided in the following spaces:

1. *Sleeping units*.
2. Spaces where patient care is directly provided.
3. Spaces where an automatic shutoff would endanger occupant safety or security.
4. Lighting intended for continuous operation.

#### **C405.2.2.1 Automatic time switch control devices.**

Automatic time switch controls shall be installed to control lighting in all areas of the building.

#### **Exceptions:**

1. Emergency egress lighting does not need to be controlled by an automatic time switch.
2. Lighting in spaces controlled by occupancy sensors does not need to be controlled by automatic time switch controls.

The automatic time switch control device shall include an override switching device that complies with the following:

1. The override switch shall be in a readily accessible location;

2. The override switch shall be located where the lights controlled by the switch are visible; or the switch shall provide a mechanism which announces the area controlled by the switch;
3. The override switch shall permit manual operation;
4. The override switch, when initiated, shall permit the controlled lighting to remain on for a maximum of 2 hours; and
5. Any individual override switch shall control the lighting for a maximum area of 5,000 square feet (465 m<sup>2</sup>).

**Exception:** Within malls, arcades, auditoriums, single tenant retail spaces, industrial facilities and arenas:

1. The time limit shall be permitted to exceed 2 hours provided the override switch is a captive key device; and
2. The area controlled by the override switch is permitted to exceed 5,000 square feet (465 m<sup>2</sup>), but shall not exceed 20,000 square feet (1860 m<sup>2</sup>).

#### **C405.2.2.2 Occupancy sensors.**

Occupancy sensors shall be installed in all classrooms, conference/meeting rooms, employee lunch and break rooms, private offices, restrooms, storage rooms and janitorial closets, and other spaces 300 square feet (28 m<sup>2</sup>) or less enclosed by floor-to-ceiling height partitions. These automatic control devices shall be installed to automatically turn off lights within 30 minutes of all occupants leaving the space, and shall either be manual on or shall be controlled to automatically turn the lighting on to not more than 50 percent power.

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

#### **C405.2.2.3 Daylight zone control.**

Daylight zones shall be designed such that lights in the daylight zone are controlled independently of general area lighting and are controlled in accordance with either Section [C405.2.2.3.1](#) or Section [C405.2.2.3.2](#). Each daylight control zone shall not exceed 2,500 square feet (232 m<sup>2</sup>). Contiguous daylight zones adjacent to vertical fenestration are allowed to be controlled by a single controlling device provided that they do not include zones facing more than two adjacent cardinal orientations (i.e., north, east, south, west). Daylight zones under skylights more than 15 feet (4572 mm) from the perimeter shall be controlled separately from daylight zones adjacent to vertical fenestration.

**Exception:** Daylight zones enclosed by walls or ceiling height partitions and containing two or fewer light fixtures are not required to have a separate switch for general area lighting.

**C405.2.2.3.1 Manual daylighting controls.**

Manual controls shall be installed in daylight zones unless automatic controls are installed in accordance with Section [C405.2.2.3.2](#).

**C405.2.2.3.2 Automatic daylighting controls.**

Set-point and other controls for calibrating the lighting control device shall be readily accessible.

Daylighting controls device shall be capable of automatically reducing the lighting power in response to available daylight by either one of the following methods:

1. Continuous dimming using dimming ballasts and daylight-sensing automatic controls that are capable of reducing the power of general lighting in the daylit zone continuously to less than 35 percent of rated power at maximum light output.
2. Stepped dimming using multi-level switching and daylight-sensing controls that are capable of reducing lighting power automatically. The system shall provide a minimum of two control channels per zone and be installed in a manner such that at least one control step is between 50 percent and 70 percent of design lighting power and another control step is no greater than 35 percent of design power.

**C405.2.2.3.3 Multi-level lighting controls.**

Where multi-level lighting controls are required by this code, the general lighting in the daylight zone shall be separately controlled by at least one multi-level lighting control that reduces the lighting power in response to daylight available in the space. Where the daylit illuminance in the space is greater than the rated illuminance of the general lighting of daylight zones, the general lighting shall be automatically controlled so that its power draw is no greater than 35 percent of its rated power. The multi-level lighting control shall be located so that calibration and set point adjustment controls are readily accessible and separate from the light sensor.

**C405.2.3 Specific application controls.**

Specific application controls shall be provided for the following:

1. Display and accent light shall be controlled by a dedicated control which is independent of the controls for other lighting within the room or space.
2. Lighting in cases used for display case purposes shall be controlled by a dedicated control which is independent of the controls for other lighting within the room or space.
3. Hotel and motel sleeping units and guest suites shall have a master control device at the main room entry that controls all permanently installed luminaires and switched receptacles.

4. Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting, shall have a control device integral to the luminaires or be controlled by a wall-mounted control device provided the control device is readily accessible.
5. Lighting for nonvisual applications, such as plant growth and food warming, shall be controlled by a dedicated control which is independent of the controls for other lighting within the room or space.
6. Lighting equipment that is for sale or for demonstrations in lighting education shall be controlled by a dedicated control which is independent of the controls for other lighting within the room or space.

**C405.2.4 Exterior lighting controls.**

Lighting not designated for dusk-to-dawn operation shall be controlled by either a combination of a photosensor and a time switch, or an astronomical time switch. Lighting designated for dusk-to-dawn operation shall be controlled by an astronomical time switch or photosensor. All time switches shall be capable of retaining programming and the time setting during loss of power for a period of at least 10 hours.

**C405.3 Tandem wiring (Mandatory).**

The following luminaires located within the same area shall be tandem wired:

1. Fluorescent luminaires equipped with one, three or odd-numbered lamp configurations, that are recess-mounted within 10 feet (3048 mm) center-to-center of each other.
2. Fluorescent luminaires equipped with one, three or any odd-numbered lamp configuration, that are pendant- or surface-mounted within 1 foot (305 mm) edge-to-edge of each other.

**Exceptions:**

1. Where electronic high-frequency ballasts are used.
2. Luminaires on emergency circuits.
3. Luminaires with no available pair in the same area.

**C405.4 Exit signs (Mandatory).**

Internally illuminated exit signs shall not exceed 5 watts per side.

**C405.5 Interior lighting power requirements (Prescriptive).**

A building complies with this section if its total connected lighting power calculated under Section [C405.5.1](#) is no greater than the interior lighting power calculated under Section [C405.5.2](#).

**C405.5.1 Total connected interior lighting power.**

The total connected interior lighting power (watts) shall be the sum of the watts of all interior lighting equipment as determined in accordance with Sections [C405.5.1.1](#) through [C405.5.1.4](#).

**Exceptions:**

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
  - 1.1. Professional sports arena playing field lighting.
  - 1.2. *Sleeping unit* lighting in hotels, motels, boarding houses or similar buildings.
  - 1.3. Emergency lighting automatically off during normal building operation.
  - 1.4. Lighting in spaces specifically designed for use by occupants with special lighting needs including the visually impaired visual impairment and other medical and age-related issues.
  - 1.5. Lighting in interior spaces that have been specifically designated as a registered interior historic landmark.
  - 1.6. Casino gaming areas.
2. Lighting equipment used for the following shall be exempt provided that it is in addition to general lighting and is controlled by an independent control device:
  - 2.1. Task lighting for medical and dental purposes.
  - 2.2. Display lighting for exhibits in galleries, museums and monuments.
3. Lighting for theatrical purposes, including performance, stage, film production and video production.
4. Lighting for photographic processes.
5. Lighting integral to equipment or instrumentation and is installed by the manufacturer.
6. Task lighting for plant growth or maintenance.
7. Advertising signage or directional signage.
8. In restaurant buildings and areas, lighting for food warming or integral to food preparation equipment.
9. Lighting equipment that is for sale.

10. Lighting demonstration equipment in lighting education facilities.
11. Lighting *approved* because of safety or emergency considerations, inclusive of exit lights.
12. Lighting integral to both open and glass-enclosed refrigerator and freezer cases.
13. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.
14. Furniture mounted supplemental task lighting that is controlled by automatic shutoff.

**C405.5.1.1 Screw lamp holders.**

The wattage shall be the maximum *labeled* wattage of the luminaire.

**C405.5.1.2 Low-voltage lighting.**

The wattage shall be the specified wattage of the transformer supplying the system.

**C405.5.1.3 Other luminaires.**

The wattage of all other lighting equipment shall be the wattage of the lighting equipment verified through data furnished by the manufacturer or other *approved* sources.

**C405.5.1.4 Line-voltage lighting track and plug-in busway.**

The wattage shall be:

1. The specified wattage of the luminaires included in the system with a minimum of 30 W/lin ft. (98 W/lin. m);
2. The wattage limit of the system's circuit breaker; or
3. The wattage limit of other permanent current limiting device(s) on the system.

**C405.5.2 Interior lighting power.**

The total interior lighting power allowance (watts) is determined according to ~~Table C405.5.2(1) using the Building Area Method, or Table C405.5.2(2) using the Space-by-Space Method, for all areas of the building covered in this permit. For the Building Area Method, the interior lighting power allowance is the floor area for each building area type listed in Table C405.5.2(1) times the value from Table C405.5.2(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 C405.5.2(1). Where this method is used to calculate the total interior lighting power for an entire building, each building area type shall be treated as a separate area.~~ For the 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 C405.5.2(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.

TABLE C405.5.2(1)-  
 INTERIOR LIGHTING POWER ALLOWANCES:-  
 BUILDING AREA METHOD

BUILDING AREA TYPE	LPD (w/ft²)
Automotive facility	0.9
Convention center	1.2
Courthouse	1.2
Dining: bar lounge/leisure	1.3
Dining: cafeteria/fast food	1.4
Dining: family	1.6
Dormitory	1.0
Exercise center	1.0
Fire station	0.8
Gymnasium	1.1
Health care clinic	1.0
Hospital	1.2
Hotel	1.0
Library	1.3

Manufacturing facility	1.3
Motel	1.0
Motion picture theater	1.2
Multifamily	0.7
Museum	1.1
Office	0.9
Parking garage	0.3
Penitentiary	1.0
Performing arts theater	1.6
Police station	1.0
Post office	1.1
Religious building	1.3
Retail	1.4
School/university	1.2
Sports arena	1.1
Town hall	1.1
Transportation	1.0

Warehouse	0.6
Workshop	1.4

TABLE C405.5.2(21)  
 INTERIOR LIGHTING POWER ALLOWANCES:  
 SPACE-BY-SPACE METHOD

COMMON SPACE-BY-SPACE TYPES	LPD (w/ft <sup>2</sup> )
Atrium – First 40 feet in height	0.03 per ft. ht.
Atrium – Above 40 feet in height	0.02 per ft. ht.
Audience/seating area – permanent	
For auditorium	0.9
For performing arts theater	<del>2.6</del> 2.43
For motion picture theater	<del>1.2</del> 1.14
Classroom/lecture/training	<del>1.30</del> 1.05
Conference/meeting/multipurpose	<del>1.2</del> 1.11
Corridor/transition	<del>0.7</del> 0.56
Dining area	
Bar/lounge/leisure dining	<del>1.40</del> 0.963
Family dining area	<del>1.40</del> 0.801
Dressing/fitting room performing arts theater	<del>1.1</del> 0.61
Electrical/mechanical	<del>1.10</del> 0.42
Food preparation	1.20

Laboratory for classrooms	1.3
Laboratory for medical/industrial/research	<del>1.8</del> 1.7
Lobby	<del>1.10</del> 0.90
Lobby for performing arts theater	<del>3.3</del> 2.0
Lobby for motion picture theater	<del>1.0</del> 0.56
Locker room	<del>0.80</del> 0.75
Lounge recreation	<del>0.8</del> 0.62
Office – enclosed	<del>1.1</del> 1.05
Office – open plan	<del>1.0</del> 0.93
Restroom	<del>1.0</del> 0.98
Sales area	<del>1.6</del> 1.37
Stairway	<del>0.70</del> 0.69
Storage	<del>0.8</del> 0.63
Workshop	<del>1.60</del> 1.59
Courthouse/police station/penetentiary	
Courtroom	<del>1.90</del> 1.46
Confinement cells	<del>1.1</del> 0.81
Judge chambers	<del>1.30</del> 1.05
Penitentiary audience seating	<del>0.5</del> 0.28

Penitentiary classroom	1.3
Penitentiary dining	<del>1.1</del> 0.96
<b>BUILDING SPECIFIC SPACE-BY-SPACE TYPES</b>	
Automotive – service/repair	0.70
Bank/office – banking activity area	<del>1.5</del> 1.0
Dormitory living quarters	<del>1.40</del> 0.38
Gymnasium/fitness center	
Fitness area	<del>0.9</del> 0.61
Gymnasium audience/seating	<del>0.40</del> 0.55
Playing area	<del>1.40</del> 1.20

(continued)

TABLE C405.5.2(21)—continued  
 INTERIOR LIGHTING POWER ALLOWANCES:  
 SPACE-BY-SPACE METHOD

<b>COMMON SPACE-BY-SPACE TYPES</b>	<b>LPD (w/ft<sup>2</sup>)</b>
Healthcare clinic/hospital	1.00
Corridors/transition	<del>1.70</del> 1.41
Exam/treatment	2.70
Emergency	<del>0.80</del> 0.78
Public and staff lounge	<del>1.40</del> 0.67
Medical supplies	<del>0.9</del> 0.75
Nursery	<del>1.00</del> 0.64
Nurse station	<del>0.90</del> 0.77
Physical therapy	<del>0.70</del> 0.56
Patient room	1.20

Pharmacy	1.3
Radiology/imaging	2.20
Operating room	<del>1.2</del> 1.15
Recovery	0.8
Lounge/recreation	<del>0.60</del> 0.57
Laundry – washing	
Hotel	
Dining area	<del>1.30</del> 0.59
Guest rooms	<del>1.40</del> 0.91
Hotel lobby	<del>2.40</del> 1.06
Highway lodging dining	<del>1.20</del> 0.59
Highway lodging guest rooms	<del>1.40</del> 0.91
Library	
Stacks	<del>1.70</del> 1.62
Card file and cataloguing	1.10
Reading area	<del>1.20</del> 1.06
Manufacturing	
Corridors/transition	0.40
Detailed manufacturing	<del>1.3</del> 1.29
Equipment room	<del>1.0</del> 0.74
Extra high bay (> 50-foot floor-ceiling height)	<del>1.1</del> 1.05
High bay (25- – 50-foot floor-ceiling height)	<del>1.20</del> 1.05
Low bay (< 25-foot floor-ceiling height)	<del>1.2</del> 1.01
Museum	
General exhibition	<del>1.00</del> 1.05
Restoration	<del>1.70</del> 1.02
Parking garage – garage areas	0.2 0.19

Convention center Exhibit space Audience/seating area	<del>1.50</del> 1.23 <del>0.90</del> 0.82
Fire stations Engine room Sleeping quarters	0.80 <del>0.30</del> 0.22
Post office Sorting area	0.9
Religious building Fellowship hall Audience seating Worship pulpit/choir	0.60 <del>2.40</del> 1.53 <del>2.40</del> 1.53
Retail Dressing/fitting area Mall concourse Sales area	<del>0.9</del> 0.71 <del>1.6</del> 1.44 <del>1.6</del> <sup>a</sup> 1.44 <sup>a</sup>

(continued)

TABLE C405.5.2(21)—continued  
INTERIOR LIGHTING POWER ALLOWANCES:  
SPACE-BY-SPACE METHOD

BUILDING SPECIFIC SPACE-BY-SPACE TYPES	LPD (w/ft <sup>2</sup> )
Sports arena Audience seating	0.4
Court sports area – Class 4	0.7
Court sports area – Class 3	1.2
Court sports area – Class 2	1.9

Court sports area – Class 1	3.0
Ring sports area	2.7
Transportation	
Air/train/bus baggage area	<del>1.00</del> 0.50
Airport concourse	<del>0.60</del> 0.32
Terminal – ticket counter	<del>1.50</del> 0.68
Warehouse	
Fine material storage	<del>1.40</del> 0.95
Medium/bulky material	<del>0.60</del> 0.49

For SI: 1 foot = 304.8 mm, 1 watt per square foot = 11 W/m<sup>2</sup>.

a. Where lighting equipment is specified to be installed to highlight specific merchandise in addition to lighting equipment specified for general lighting and is switched or dimmed on circuits different from the circuits for general lighting, the smaller of the actual wattage of the lighting equipment installed specifically for merchandise, or additional lighting power as determined below shall be added to the interior lighting power determined in accordance with this line item.

Calculate the additional lighting power as follows:

Additional Interior Lighting Power Allowance = 500 watts + (Retail Area 1 × 0.6 W/ft<sup>2</sup>) + (Retail Area 2 × 0.6 W/ft<sup>2</sup>) + (Retail Area 3 × 1.4 W/ft<sup>2</sup>) + (Retail Area 4 × 2.5 W/ft<sup>2</sup>).

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 above, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is *approved by the authority having jurisdiction*.

**C405.6 Exterior lighting (Mandatory).**

Where the power for exterior lighting is supplied through the energy service to the building, all exterior lighting, other than low-voltage landscape lighting, shall comply with Sections [C405.6.1](#) and [C405.6.2](#).

**Exception:** Where *approved* because of historical, safety, signage or emergency considerations.

**C405.6.1 Exterior building grounds lighting.**

All exterior building grounds luminaires that operate at greater than 100 watts shall contain lamps having a minimum efficacy of 60 lumens per watt unless the luminaire is controlled by a motion sensor or qualifies for one of the exceptions under Section [C405.6.2](#).

**C405.6.2 Exterior building lighting power.**

The total exterior lighting power allowance for all exterior building applications is the sum of the base site allowance plus the individual allowances for areas that are to be illuminated and are permitted in Table [C405.6.2\(2\)](#) for the applicable lighting zone. Tradeoffs are allowed only among exterior lighting applications listed in Table [C405.6.2\(2\)](#), Tradable Surfaces section. The lighting zone for the building exterior is determined from Table [C405.6.2\(1\)](#) unless otherwise specified by the local jurisdiction. Exterior lighting for all applications (except those included in the exceptions to Section [C405.6.2](#)) shall comply with the requirements of Section [C405.6.1](#).

**Exception:** Lighting used for the following exterior applications is exempt where equipped with a control device independent of the control of the nonexempt lighting:

1. Specialized signal, directional and marker lighting associated with transportation;
2. Advertising signage or directional signage;
3. Integral to equipment or instrumentation and is installed by its manufacturer;
4. Theatrical purposes, including performance, stage, film production and video production;
5. Athletic playing areas;
6. Temporary lighting;
7. Industrial production, material handling, transportation sites and associated storage areas;
8. Theme elements in theme/amusement parks; and

9. Used to highlight features of public monuments and registered historic landmark structures or buildings.

TABLE C405.6.2(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
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

TABLE C405.6.2(2)  
INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

	LIGHTING ZONES			
	Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance (Base allowance is usable in tradable or nontradable surfaces.)	<del>500</del> 350 W	<del>600</del> 400 W	<del>750</del> 500 W	<del>1300</del> 900 W

Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas are tradable.)	<b>Uncovered Parking Areas</b>				
	Parking areas and drives	<del>0.04</del> 0.03 W/ft <sup>2</sup>	<del>0.06</del> 0.04 W/ft <sup>2</sup>	<del>0.10</del> 0.06 W/ft <sup>2</sup>	<del>0.13</del> 0.08 W/ft <sup>2</sup>
	<b>Building Grounds</b>				
	Walkways less than 10 feet wide	<del>0.7</del> 0.5 W/linear foot	<del>0.7</del> 0.5 W/linear foot	<del>0.8</del> 0.6 W/linear foot	<del>1.0</del> 0.7 W/linear foot
	Walkways 10 feet wide or greater, plaza areas special feature areas	<del>0.14</del> 0.10 W/ft <sup>2</sup>	<del>0.14</del> 0.10 W/ft <sup>2</sup>	<del>0.16</del> 0.11 W/ft <sup>2</sup>	<del>0.2</del> 0.14 W/ft <sup>2</sup>
	Stairways	<del>0.75</del> 0.6 W/ft <sup>2</sup>	<del>1.0</del> 0.7 W/ft <sup>2</sup>	<del>1.0</del> 0.7 W/ft <sup>2</sup>	<del>1.0</del> 0.7 W/ft <sup>2</sup>
	Pedestrian tunnels	<del>0.15</del> 0.12 W/ft <sup>2</sup>	<del>0.15</del> 0.12 W/ft <sup>2</sup>	<del>0.2</del> 0.14 W/ft <sup>2</sup>	<del>0.3</del> 0.21 W/ft <sup>2</sup>
	<b>Building Entrances and Exits</b>				
	<del>Main entries</del> Pedestrian vehicular entrances and exits	<del>20</del> 14 W/linear foot of door width	<del>20</del> 14 W/linear foot of door width	<del>30</del> 21 W/linear foot of door width	<del>30</del> 21 W/linear foot of door width
	<del>Other doors</del>	<del>20 W/linear foot of door width</del>			
	Entry canopies	<del>0.25</del> 0.2 W/ft <sup>2</sup>	0.25 W/ft <sup>2</sup>	0.4 W/ft <sup>2</sup>	0.4 W/ft <sup>2</sup>
	<b>Sales Canopies</b>				
	Free-standing and attached	<del>0.6</del> 0.4 W/ft <sup>2</sup>	<del>0.6</del> 0.4 W/ft <sup>2</sup>	<del>0.8</del> 0.6 W/ft <sup>2</sup>	<del>1.0</del> 0.7 W/ft <sup>2</sup>

Outdoor Sales					
	Open areas (including vehicle sales lots)	<del>0.25</del> 0.2 W/ft <sup>2</sup>	<del>0.25</del> 0.2 W/ft <sup>2</sup>	<del>0.5</del> 0.35 W/ft <sup>2</sup>	<del>0.7</del> 0.5 W/ft <sup>2</sup>
	Street frontage for vehicle sales lots in addition to "open area" allowance	No allowance	10 W/linear foot	<del>40</del> 7 W/linear foot	<del>30</del> 21 W/linear foot
Nontradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	Building facades	No allowance	0.1 W/ft <sup>2</sup> of façade area (1.1 W/m <sup>2</sup> ) or 2.5 W/linear foot (8.2 W/m) of façade length <del>0.1 W/ft<sup>2</sup> for each illuminated wall or surface or 2.5 W/linear foot for each illuminated wall or surface length</del>	0.15 W/ft <sup>2</sup> of façade area (1.6 W/m <sup>2</sup> ) or 3.75 W/linear foot (12.3 W/m) of façade length <del>0.15 W/ft<sup>2</sup> for each illuminated wall or surface or 3.75 W/linear foot for each illuminated wall or surface length</del>	0.2 W/ft <sup>2</sup> of façade area (2.2 W/m <sup>2</sup> ) or 5.0 W/linear foot (16.4 W/m) of façade length <del>0.2 W/ft<sup>2</sup> for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length</del>
	Automated teller machines and night depositories	<del>270</del> 135W per location plus <del>90</del> 45W per additional ATM per location	<del>270</del> 135W per location plus <del>90</del> 45W per additional ATM per location	<del>270</del> 135W per location plus <del>90</del> 45W per additional ATM per location	<del>270</del> 135W per location plus <del>90</del> 45W per additional ATM per location
	Uncovered Entrances and gatehouse	<del>0.75</del> 0.5 W/ft <sup>2</sup> of covered	<del>0.75</del> 0.5 W/ft <sup>2</sup> of covered and uncovered area	<del>0.75</del> 0.5 W/ft <sup>2</sup> of covered and uncovered area	<del>0.75</del> 0.5 W/ft <sup>2</sup> of covered

	inspection stations at guarded facilities	and uncovered area			and uncovered area
	<del>Uncovered</del> Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	<del>0.5</del> 0.35 W/ft <sup>2</sup> of covered and uncovered area	<del>0.5</del> 0.35 W/ft <sup>2</sup> of covered and uncovered area	<del>0.5</del> 0.35 W/ft <sup>2</sup> of covered and uncovered area	<del>0.5</del> 0.35 W/ft <sup>2</sup> of covered and uncovered area
	Drive-up windows/doors	<del>400</del> 200W per drive-through			
	Parking near 24-hour retail entrances	<del>800</del> 400W per main entry			

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m<sup>2</sup>.

**C405.7 Electrical energy consumption (Mandatory).**

In buildings having individual dwelling units, provisions shall be made to determine the electrical energy consumed by each tenant by separately metering individual dwelling units.

**SECTION C406  
ADDITIONAL EFFICIENCY PACKAGE OPTIONS**

**~~C406.1 Requirements.~~**

~~Buildings shall comply with at least one of the following:~~

- ~~1. Efficient HVAC Performance in accordance with Section C406.2.~~
- ~~2. Efficient Lighting System in accordance with Section C406.3.~~
- ~~3. On-Site Supply of Renewable Energy in accordance with Section C406.4.~~

~~Individual tenant spaces shall comply with either Section C406.2 or Section C406.3 unless documentation can be provided that demonstrates compliance with Section C406.4 for the entire building~~

**C406.2 Efficient HVAC performance.**

Equipment shall meet the minimum efficiency requirements of Tables C406.2(1) through C406.2(7) in addition to the requirements in Section C403. This section shall only be used where the equipment efficiencies in Tables C406.2(1) through C406.2(7) are greater than the equipment efficiencies listed in Table C403.2.3(1) through 403.2.3(7) for the equipment type.

**TABLE C406.2(1)  
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY <sup>a</sup>	
			CLIMATE ZONES 1-5	CLIMATE ZONES 6-8
Air conditioners, air cooled	< 65,000 Btu/h	Split system	15.0 SEER- 12.5 EER	14 SEER- 12 EER
		Single package	15.0 SEER- 12.0 EER	14.0 SEER- 11.6 EER
	≥ 65,000 Btu/h and < 240,000 Btu/h	Split system and single package	12.0 EER <sup>b</sup> - 12.54 IEER <sup>b</sup>	11.5 EER <sup>b</sup> - 12.0 IEER <sup>b</sup>
	≥ 240,000 Btu/h and < 760,000 Btu/h	Split system and single package	10.8 EER <sup>b</sup> - 11.3 IEER <sup>b</sup>	10.5 EER <sup>b</sup> - 11.0 IEER <sup>b</sup>
	≥ 760,000 Btu/h	—	10.2 EER <sup>b</sup> - 10.7 IEER <sup>b</sup>	9.7 EER <sup>b</sup> - 10.2 IEER <sup>b</sup>
Air conditioners, water and evaporatively cooled	—	Split system and single package	14.0 EER	14.0 EER

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

a. IEERs are only applicable to equipment with capacity modulation.

b. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

TABLE C406.2(2)  
UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY OPERATED, EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING- CONDITION	MINIMUM EFFICIENCY <sup>a</sup>	
			CLIMATE ZONES- 1-5	CLIMATE ZONES- 6-8
Air-cooled- (Cooling mode)	< 65,000 Btu/h	Split system	15.0 SEER,- 12.5 EER	14.0 SEER,- 12.0 EER
		Single package	15.0 SEER,- 12.0 EER	14.0 SEER- 11.6 EER
	≥65,000 Btu/h and < 240,000 Btu/h	Split system and single package	12.0 SEER,- 12.4 EER	11.5 EER <sup>a</sup> ,- 12.0 IEER <sup>b</sup>
		Split system and single package	12.0 SEER,- 12.4 EER	10.5 EER <sup>a</sup> ,- 10.5 IEER <sup>b</sup>
Water sources- (Cooling mode)	< 135,000 Btu/h	85°F entering water	14.0 EER	14.0 EER
Air-cooled- (Heating mode)	< 65,000 Btu/h- (Cooling capacity)	Split system	9.0 HSPF	8.5 HSPF
		Single package	8.5 HSPF	8.0 HSPF
	≥ 65,000 Btu/h and < 135,000 Btu/h- (Cooling capacity)	47°F db/43°F wb outdoor air	3.4 COP	3.4 COP
		47°F db/45°F wb outdoor air	2.4 COP	2.4 COP

	≥135,000 Btu/h (Cooling capacity)	47°F db/43°F wb outdoor air	3.2 COP	3.2 COP
		77°F db/15°F wb outdoor air	2.1 COP	2.1 COP
Water sources (Heating mode)	< 135,000 Btu/h (Cooling capacity)	70°F entering water	4.6 COP	4.6 COP

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

db = dry-bulb temperature, °F; wb = wet-bulb temperature, °F.

a. IEERs and Part load rating conditions are only applicable to equipment with capacity modulation.

b. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

~~TABLE C406.2(3)  
PACKAGED TERMINAL AIR CONDITIONERS AND PACKAGED TERMINAL HEAT PUMPS~~

<del>EQUIPMENT TYPE</del>	<del>SIZE CATEGORY</del>	<del>MINIMUM EFFICIENCY</del>
<del>Air conditioners and heat pumps (cooling mode)</del>	<del>&lt; 7,000 Btu/h</del>	<del>11.9 EER</del>
	<del>7,000 Btu/h and &lt; 10,000 Btu/h</del>	<del>11.3 EER</del>
	<del>10,000 Btu/h and ≤ 13,000 Btu/h</del>	<del>10.7 EER</del>
	<del>&gt; 13,000 Btu/h</del>	<del>9.5 EER</del>

~~TABLE C406.2(4)  
WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR CONDITIONING UNITS,  
WARM AIR DUCT FURNACES AND UNIT HEATERS, EFFICIENCY REQUIREMENTS~~

EQUIPMENT TYPE	SIZE CATEGORY- (INPUT)	SUBCATEGORY OR- RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE
Warm air furnaces, gas fired <sup>a</sup>	< 225,000 Btu/h	—	For Climate Zones 1 and 2 NR	<u>DOE 10 CFR Part 430-</u> or <u>ANSI Z21.47</u>
			For Climate Zones 3 and 4- 90 AFUE or 90 $E_t$	
			For Climate Zones 4 — 8- 92 AFUE or 92 $E_t$	
	≥ 225,000 Btu/h	Maximum capacity	90% $E_s$	<u>ANSI Z21.47</u>
Warm air furnaces, oil fired <sup>a</sup>	< 225,000 Btu/h	—	For Climate Zones 1 and 2 NR	<u>DOE 10 CFR Part 430-</u> or <u>UL 727</u>
			For Climate Zones 3 — 8- 85 AFUE or 85 $E_t$	
		≥ 225,000 Btu/h	Maximum capacity	85% $E_t$
Warm air duct furnaces, gas fired <sup>a</sup>	All capacities	Maximum capacity	90% $E_s$	<u>ANSI Z83.8</u>
Warm air unit heaters, gas fired	All capacities	Maximum capacity	90% $E_s$	<u>ANSI Z83.8</u>
Warm air unit heaters, oil fired	All capacities	Maximum capacity	90% $E_s$	<u>UL 731</u>

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

$E_t$  = Thermal efficiency.  $E_s$  = Combustion efficiency (100 percent less flue losses).

a. Efficient furnace fan: Fossil fuel furnaces in climate zones 3 to 8 shall have a furnace electricity ratio not greater than 2 percent and shall include a manufacturer's designation of the furnace electricity ratio.

b. Units shall also include an IID (intermittent ignition device), 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.

c. Where there are two ratings for units not covered by NAECA (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h [19 kW]), units shall be permitted to comply with either rating.

TABLE C406.2(5)  
BOILER, EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	FUEL	SIZE CATEGORY	TEST PROCEEDURE	MINIMUM EFFICIENCY
Steam	Gas	< 300,000 Btu/h	DOE 10 CFR Part 430	83% AFUE
		> 300,000 Btu/h and > 2.5 m Btu/h	DOE 10 CFR Part 434	81% $E_i$
		> 2.5 m Btu/h		82% $E_s$
	Oil	< 300,000 Btu/h	DOE 10 CFR Part 430	85% AFUE
		> 300,000 Btu/h and > 2.5 m Btu/h	DOE 10 CFR Part 434	83% $E_i$
		> 2.5 m Btu/h		84% $E_s$
Hot water	Gas	< 300,000 Btu/h	DOE 10 CFR Part 430	97% AFUE
		> 300,000 Btu/h and > 2.5 m Btu/h	DOE 10 CFR Part 434	97% $E_i$
		> 2.5 m Btu/h		94% $E_s$
	Oil	< 300,000 Btu/h	DOE 10 CFR Part 430	90% AFUE

		> 300,000 Btu/h and > 2.5 m Btu/h	DOE 10 CFR Part 431	88% $E_c$
		> 2.5 m Btu/h		87% $E_c$

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

$E_c$  = Thermal efficiency.  $E_s$  = Combustion efficiency (100 percent less flue losses).

TABLE C406.2(6)  
CHILLERS—EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	MINIMUM EFFICIENCY <sup>c</sup> (I-P)				Test Procedure <sup>b</sup>
			Path A		Path B <sup>c</sup>		
			Full Load	IPLV	Full Load	IPLV	
Air-cooled chillers with condenser, electrically operated	< 150 tons	EER	10.000	12.500	NA	NA	AHRI 550/590 <sup>d</sup>
	≥ 150 tons	EER	10.000	12.750	NA	NA	
Air-cooled without condenser, electrical operated	All capacities	EER	Condenserless units shall be rated with matched condensers				AHRI 550/590 <sup>d</sup>
Water-cooled, electrically operated, positive displacement (reciprocating)	All capacities	kw/ton	Reciprocating units required to comply with water-cooled positive displacement requirements				AHRI 550/590 <sup>d</sup>
Water-cooled electrically operated, positive displacement	< 75 tons	kw/ton	0.780	0.630	0.800	0.600	AHRI 550/590 <sup>d</sup>
	≥ 75 tons and < 150 tons	kw/ton	0.775	0.615	0.790	0.586	
	≥ 150 tons and < 300 tons	kw/ton	0.680	0.580	0.718	0.540	

	≥ 300 tons	kw/ton	0.620	0.540	0.639	0.490	
Water-cooled electrically operated, centrifugal <sup>a</sup>	< 150 tons	kw/ton	0.634	0.596	0.639	0.450	AHRI 550/ 590 <sup>c</sup>
	≥150 tons and < 300 tons	kw/ton	0.634	0.596	0.639	0.450	
	≥300 tons and < 600 tons	kw/ton	0.576	0.549	0.600	0.400	
	≥ 600 tons	kw/ton	0.570	0.539	0.590	0.400	
Air-cooled absorption single-effect <sup>a</sup>	All capacities	COP	0.600	NR	NA	NA	AHRI 560
Water-cooled absorption single-effect <sup>a</sup>	All capacities	COP	0.700	NR	NA	NA	
Absorption double-effect indirect-fired	All capacities	COP	1.000	1.050	NA	NA	
Absorption double-effect direct-fired	All capacities	COP	1.000	1.000	NA	NA	

For SI: 1 Ton = 3516 W.

NA = Not applicable and cannot be used for compliance. NR = No minimum requirements.

- a. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or Path B. However both the full load and IPLV shall be met to fulfill the requirements of Path A and Path B.
- b. Chapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
- c. Path B is intended for applications with significant operating time at part load. All Path B machines shall be equipped with demand limiting capable controls.

d. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is greater than 40°F.

e. Only allowed to be used in heat recovery applications.

f. Packages that are not designed for operation at ARI Standard 550/590 test conditions (and, thus, cannot be tested to meet the requirements of Table C-3) of 44°F leaving chilled water temperature and 85°F entering condenser water temperature with 3 gpm/ton condenser water flow shall have maximum full load kW/ton and NPLV ratings adjusted using the following equation:

Adjusted maximum full load kW/ton rating = (full load kW/ton from Table C-3)/ $K_{adj}$

Adjusted maximum NPLV rating = (IPLV from Table C-3)/ $K_{adj}$

where:

$$K_{adj} = 6.174722 - 0.303668(X) + 0.00629466(X)^2 - 0.000045780(X)^3$$

$$X = DT_{std} + LIFT (°F)$$

$$DT_{std} = [(24 + (\text{full load kW/ton from Table C-3}) \times 6.83)] / \text{flow } (°F)$$

$$\text{Flow} = \text{condenser water flow (gpm)} / \text{cooling full load capacity (tons)}$$

$$LIFT = CEWT - CLWT (°F)$$

$$CEWT = \text{full load entering condenser water temperature } (°F)$$

$$CLWT = \text{full load leaving chilled water temperature } (°F)$$

The adjusted full load and NPLV values are only applicable over the following full-load design ranges:

Minimum leaving chilled water temperature: 38°F

Maximum condenser entering water temperature: 102°F

Condenser water flow: 1 to 6 gpm/ton

X ≥ 39°F and ≤ 60°F

TABLE C406.2(7)  
 ABSORPTION CHILLERS—EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	MINIMUM EFFICIENCY—FULL LOAD COP (IPLV)
Air-cooled, single-effect	0.60, allowed only in heat recovery applications
Water-cooled, single-effect	0.70, allowed only in heat recovery applications
Double-effect—direct fired	1.0 (1.05)
Double-effect—indirect fired	1.20

**C406.3 Efficient lighting system.**

Whole building lighting power density (Watts/sf) shall comply with the requirements of Section C406.3.1.

TABLE C406.3  
 REDUCED INTERIOR LIGHTING POWER

BUILDING AREA TYPE*	LPD (w/ft²)
Automotive facility	0.82
Convention center	1.08
Courthouse	1.05
Dining: bar lounge/leisure	0.99

Dining- cafeteria/fast food	0.90
Dining- family	0.89
Dormitory	0.64
Exercise center	0.88
Fire station	0.74
Gymnasium	1.0
Health care clinic	0.87
Hospital	1.10
Library	1.18
Manufacturing facility	1.11
Hotel/motel	0.88
Motion picture theater	0.83
Museum	1.06
Multifamily	0.60
Office	0.90/0.85 <sup>a</sup>
Performing arts theater	1.39
Police station	0.96

Post office	0.87
Religious building	1.05
Retail	1.4/1.3*
School/ university	0.99
Sports arena	0.78
Town hall	0.92
Transportation	0.77
Warehouse*	0.6
Workshop	1.2

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m<sup>2</sup>.

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

b. First LPD value applies if no less than 30 percent of conditioned floor area is in daylight zones. Automatic daylighting controls shall be installed in daylight zones and shall meet the requirements of Section C405.2.2.3. In all other cases, second LPD value applies.

e. No less than 70 percent of the floor area shall be in the daylight zone. Automatic daylighting controls shall be installed in daylight zones and shall meet the requirements of Section C405.2.2.3.

**C406.3.1 Reduced lighting power density.**

The total interior lighting power (watts) of the building shall be determined by using the reduced whole building interior lighting power in Table C406.3 times the floor area for the building types.

**C406.4 On-site renewable energy.**

Total minimum ratings of on-site renewable energy systems shall comply with one of the following:

1. Provide not less than 1.75 Btu (1850 W), or not less than 0.50 watts per square foot (5.4 W/m<sup>2</sup>) of conditioned floor area.
2. Provide not less than 3 percent of the energy used within the building for building mechanical and service water heating equipment and lighting regulated in this chapter.

**SECTION C406**  
**REQUIREMENTS FOR SOLAR READY BUILDINGS**  
**(MANDATORY)**

**C406.1 General (Mandatory)**

All commercial buildings shall comply with the requirements of Sections C406.2 through C406.5.

**C406.2 Solar Zone**

Solar zones shall be clearly indicated on the construction documents.

**C406.2.1 Location and Size of Solar Zone.** The solar zone shall have a minimum total area as described below. The solar zone shall comply with access, pathway, smoke ventilation, and spacing requirements as specified in the Boulder Revised Code. The solar zone total area shall be comprised of one or more rectangular areas that are no less than 80 square feet and no side of any rectangular area shall be less than five feet in length.

The solar zone shall be located:

1. on the roof or overhang of the building.
2. on the roof or overhang of another structure located within 250 feet of the building on the same parcel or lot.
3. on covered parking installed with the building project, or
4. on a façade of the building that is less than 15 degrees greater or less than true south.

The solar zone shall cover a total area of no less than 40 percent of the total roof area, as measured by the area of the roof planes. The following roof areas can be excluded when calculating the total roof area of the building:

1. Roof areas with a permanently installed domestic solar water-heating system.
2. Roof areas where the annual solar access is less than 70 percent. For the purpose of this code, solar access means the ratio of solar insolation including shade to the solar insolation without shade. Shading from obstructions located on the roof or any other part of the building shall not be included in the determination of annual solar access.
3. Roof areas with a permanently installed solar electric system having a nameplate DC power rating, measured under standard test conditions, of no less than one watt per square foot of roof area.

**Exception:** Solar zones are not required in buildings where the roof is designed and approved to be used for vehicular traffic or parking or for a heliport.

**C406.2.2 Orientation**

All sections of the solar zone located on steep slope roofs shall be oriented between 90 degrees and 270 degrees of true north.

### **C406.2.3 Shading**

1. No obstructions, including but not limited to, vents, chimneys, architectural features, and roof mounted equipment, shall be located in the solar zone.
2. Any obstruction located on the roof or any other part of the building that projects above a solar zone shall be located at least twice the distance, measured in the horizontal plane, of the height difference between the highest point of the obstruction and the horizontal projection of the nearest point of the solar zone, measured in the vertical plane.

**Exception:** Any roof obstruction, located on the roof or any other part of the building that is oriented north of all points on the solar zone.

### **C406.2.4 Structural Design Loads on Construction Documents**

For areas of the roof designated as solar zone, the structural design loads for roof dead load and roof live load shall be clearly indicated on the construction documents.

**NOTE:** The inclusion of any collateral loads for future solar energy systems is not required.

### **C406.3 Interconnection Pathways**

The construction documents shall indicate a location for inverters and metering equipment and a pathway for routing of conduit from the solar zone to the point of interconnection with the electrical service.

### **C406.4 Documentation**

A copy of the construction documents or a comparable document indicating the information from sections C406.2 through C406.3 shall be provided to and maintained by the building owner. The building owner shall provide a copy of the construction documents or a comparable document indicating the information from sections C406.2 through C406.3 to any purchasers and subsequent owners of the building or any part thereof.

### **C406.5 Main Electrical Service Panel**

1. The main electrical service panel shall have a minimum busbar rating of no less than 200 amps.
2. The main electrical service panel shall have a reserved space to allow for the installation of double pole circuit breakers for a future solar electric installation. The minimum reserved amperage shall be determined from Table C406.5.
  - A. **Location.** The reserved space shall be positioned at the opposite (load) end from the input feeder location or main circuit location.
  - B. **Marking.** The reserved spaces shall be permanently marked as "For Future Solar Electric."

TABLE C406.5.  
MINIMUM RESERVED AMPERAGE PER SQUARE FOOT OF PLANNED SOLAR AREA

<u>Inverter System Voltage</u>	<u>Amperage Per Square Foot</u>
<u>120</u>	<u>0.125</u>
<u>240</u>	<u>0.063</u>
<u>208</u>	<u>0.042</u>
<u>277</u>	<u>0.054</u>
<u>480</u>	<u>0.018</u>

**SECTION C407**  
**TOTAL BUILDING PERFORMANCE**

[Print from this section](#)

**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.

**C407.2 Mandatory requirements.**

Compliance with this section requires that the criteria of Sections C402.4, C403.2, C404 and C405 be met.

**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. Nondepletable energy collected off site shall be treated and priced the same as purchased energy. Energy from nondepletable energy sources collected on site shall be omitted from the annual energy cost of 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.**

Compliance software tools shall generate a report that documents 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 listed 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; and

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 report(s) 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; and~~
5. ~~A certification signed by the builder providing the building component characteristics of the proposed design as given in Table C407.5.1(1).~~

**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 ~~C402.2~~.

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
	<i>U-factor: from Table C402.1.2</i>	As proposed
	Solar absorptance: 0.75	As proposed
	Emittance: 0.90	As proposed
Walls, above grade	Type: Mass wall if proposed wall is mass; otherwise steel-framed wall	As proposed
	Gross area: same as proposed	As proposed
	<i>U-factor: from Table C402.1.2</i>	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
	<i>U-Factor: from Table C402.1.2 with insulation layer on interior side of walls</i>	As proposed
Floors, above grade	Type: joist/framed floor	As proposed
	Gross area: same as proposed	As proposed

	<i>U-factor: from Table C402.1.2</i>	As proposed
Floors, slab-on-grade	Type: Unheated	As proposed
	<i>F-factor: from Table C402.1.2</i>	As proposed
Doors	Type: Swinging	As proposed
	Area: Same as proposed	As proposed
	<i>U-factor: from Table C402.2</i>	As proposed
Glazing	Area 1. The proposed glazing area; 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
	<i>U-factor: from Table C402.3</i>	As proposed
	SHGC: from Table C402.3 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 3 percent of gross area of roof assembly. 2. 3 percent of gross area of roof assembly; where the proposed skylight area is 3 percent or more of gross area of roof assembly	As proposed
	<i>U-factor: from Table C402.3</i>	As proposed

	SHGC: from Table C402.3 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 C405.5.2. Where the occupancy of the building is not known, the lighting power density shall be 1.0 Watt per square foot (10.73 W/m <sup>2</sup> ) based on the categorization of buildings with unknown space classification as offices.	As proposed
Lighting, exterior	The lighting power shall be determined in accordance with Table C405.6.2(2). Areas and dimensions of tradable and nontradable 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. All 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	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 <u>C403.2.5</u> .
Heating systems	Fuel type: same as proposed design	As proposed
	Equipment type: from Tables <u>C407.5.1(2)</u> and <u>C407.5.1(3)</u>	As proposed
	Efficiency: from Tables <u>C403.2.3(4)</u> and <u>C403.2.3(5)</u>	As proposed
	Capacity: 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: from Tables <u>C407.5.1(2)</u> and <u>C407.5.1(3)</u>	As proposed
	Efficiency: from Tables <u>C403.2.3(1)</u> , <u>C403.2.3(2)</u> and <u>C403.2.3(3)</u>	As proposed
	Capacity: 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: same as proposed, in accordance with Section <u>C-</u>	As proposed
Service water heating	Fuel type: same as proposed	As proposed
	Efficiency: from Table <u>C404.2</u>	As proposed
	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.	

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 C403.3.1(1), and if no economizer exists or is specified in the proposed design, then a supply air economizer shall be provided in accordance with Section C403.4.1.

TABLE C407.5.1(2)  
HVAC SYSTEMS MAP

CONDENSER COOLING SOURCE <sup>a</sup>	HEATING SYSTEM CLASSIFICATION <sup>b</sup>	STANDARD REFERENCE DESIGN HVAC SYSTEM TYPE <sup>c</sup>		
		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" if the proposed design system condenser is water or evaporatively cooled; select "air/none" if the condenser is air cooled. Closed-circuit dry coolers shall be considered air cooled. Systems utilizing district cooling shall be treated as if the condenser water type were "water." If no mechanical cooling is 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 with no 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 if the HVAC system in the proposed design is a single-zone system and serves a residential space. The system under "single-zone nonresidential system" shall be selected if the HVAC system in the proposed design is a single-zone system and serves other than residential spaces. 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
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1	Variable air volume with parallel fan-powered boxes <sup>a</sup>	VAV <sup>d</sup>	Chilled water <sup>e</sup>	Electric resistance
2	Variable air volume with reheat <sup>b</sup>	VAV <sup>d</sup>	Chilled water <sup>e</sup>	Hot water fossil fuel boiler <sup>f</sup>
3	Packaged variable air volume with parallel fan-powered boxes <sup>a</sup>	VAV <sup>d</sup>	Direct expansion <sup>e</sup>	Electric resistance
4	Packaged variable air volume with reheat <sup>b</sup>	VAV <sup>d</sup>	Direct expansion <sup>e</sup>	Hot water fossil fuel boiler <sup>f</sup>
5	Two-pipe fan coil	Constant volume <sup>c</sup>	Chilled water <sup>e</sup>	Electric resistance
6	Water-source heat pump	Constant volume <sup>c</sup>	Direct expansion <sup>e</sup>	Electric heat pump and boiler <sup>g</sup>
7	Four-pipe fan coil	Constant volume <sup>c</sup>	Chilled water <sup>e</sup>	Hot water fossil fuel boiler <sup>f</sup>
8	Packaged terminal heat pump	Constant volume <sup>c</sup>	Direct expansion <sup>e</sup>	Electric heat pump <sup>h</sup>
9	Packaged rooftop heat pump	Constant volume <sup>c</sup>	Direct expansion <sup>e</sup>	Electric heat pump <sup>h</sup>
10	Packaged terminal air conditioner	Constant volume <sup>c</sup>	Direct expansion <sup>e</sup>	Hot water fossil fuel boiler <sup>f</sup>
11	Packaged rooftop air conditioner	Constant volume <sup>c</sup>	Direct expansion <sup>e</sup>	Fossil fuel furnace

For SI: 1 foot = 304.8 mm, 1 cfm/ft<sup>2</sup> = 0.0004719, 1 Btu/h = 0.293W, °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 C403.4.5, Exception 5. Supply air temperature setpoint shall be constant at the design condition.

b. **VAV with reheat:** Minimum volume setpoints for VAV reheat boxes shall be 0.4 cfm/ft<sup>2</sup> of floor area. Supply air temperature shall be reset based on zone demand from the design temperature difference to a 10°F temperature difference under minimum load conditions. Design airflow rates shall be sized for the reset supply air temperature, i.e., a 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:** Constant volume can be modeled if the system qualifies for Exception 1, Section C403.4.5. When the proposed design system has a supply, return or relief fan motor 25 horsepower (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. If 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 C403.4.2 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 44°F design supply temperature and 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 C403.4.3.4. Pump system power for each pumping system shall be the same as the proposed design; if the proposed design has no chilled water pumps, the standard reference design pump power shall be 22 W/gpm (equal to a pump operating against a 75-foot 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 when required in Section C403.4.3.4. The heat rejection device shall be an axial fan cooling tower with two-speed fans if required in Section C403.4.4. Condenser water design supply temperature shall be 85°F or 10°F approach to design wet-bulb temperature, whichever is lower, with a design temperature rise of 10°F. The tower shall be controlled to maintain a 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; if the proposed design has no condenser water pumps, the standard reference design pump power shall be 19 W/gpm (equal to a pump operating against a 60-foot 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 if the standard reference design plant load is 600,000 Btu/h and less and with two equally sized boilers for plant capacities exceeding 600,000 Btu/h. Boilers shall be staged as required by the load. Hot water supply temperature shall be modeled at 180°F design supply temperature and 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 C403.4.3.4. Pump system power for each pumping system shall be the same as the proposed design; if the proposed design has no hot water pumps, the standard reference design pump power shall be 19 W/gpm (equal to a pump operating against a 60-foot 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 when required by Section C403.4.3.4.

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 60°F and 90°F. Heat rejection from the loop shall be provided by an axial fan closed-circuit evaporative fluid cooler with two-speed fans if required in Section C403.4.2. 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. If 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 if the standard reference design plant load is 600,000 Btu/h or less and with two equally sized boilers for plant capacities exceeding 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; if the proposed design has no pumps, the standard reference design pump power shall be 22 W/gpm, which is equal to a pump operating against a 75-foot 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 C403.4.3.3. Loop pumps shall be modeled as riding the pump curve or with variable speed drives when required by Section C403.4.3.4.

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 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. If 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	4
> 300 tons, < 600 tons	2, sized equally
≥ 600 tons	2 minimum, with chillers added so that no chiller is larger than 800 tons, all sized equally

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:

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 15 feet (4572 mm) from an exterior wall. Perimeter spaces shall be those located closer than 15 feet (4572 mm) 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 no 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 15 feet (4572 mm) or less from a glazed perimeter wall, except that floor area within 15 feet (4572 mm) 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 Multifamily residential buildings.**

Residential 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.

#### **C407.6 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. 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. Building operation for a full calendar year (8,760 hours).

3. 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.

4. Ten or more thermal zones.

5. Thermal mass effects.

6. Hourly variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads.

7. Part load performance curves for mechanical equipment.

8. Capacity and efficiency correction curves for mechanical heating and cooling equipment.

9. 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 (e.g., *R*-value, *U* factor, SHGC, HSPF, AFUE, SEER, EF, etc.).

**~~C407.6.1 Specific approval.~~**

~~Performance analysis tools meeting 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*.~~

**SECTION C407~~8~~**  
**SYSTEM COMMISSIONING**  
**(MANDATORY)**

**C407~~8.1~~ General.**

This section covers the *commissioning* of the building mechanical systems in Section C403 and electrical power and lighting systems in Section C405.

**C407~~8.2~~ Mechanical systems commissioning and completion requirements.**

Prior to passing the final mechanical inspection, the *registered design professional* shall provide evidence of mechanical systems *commissioning* and completion in accordance 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 and made available to the *code official* upon request in accordance with Sections C407~~8.2.4~~ and C407~~8.2.5~~.

**Exception:** The following systems are exempt from the *commissioning* requirements:

1. Mechanical systems in buildings where the total mechanical equipment capacity is less than 480,000 Btu/h (140 690 W) cooling capacity and 600,000 Btu/h (175 860 W) heating capacity.

2. Systems included in Section C403.3 that serve dwelling units and sleeping units in hotels, motels, boarding houses or similar units.

**C4078.2.1 Commissioning plan.**

A commissioning plan shall be developed by a *registered design professional* or *approved agency* and shall include the following items:

1. A narrative description of the activities that will be accomplished during each phase of commissioning, including the personnel intended to accomplish each of the activities.
2. A listing of the specific equipment, appliances or systems to be tested and a description of the tests to be performed.
3. Functions to be tested, including, but not limited to calibrations and economizer controls.
4. Conditions under which the test will be performed. At a minimum, testing shall affirm winter and summer design conditions and full outside air conditions.
5. Measurable criteria for performance.

**C4078.2.2 Systems adjusting and balancing.**

HVAC systems shall be balanced in accordance with generally accepted engineering standards. Air and water flow rates shall be measured and adjusted to deliver final flow rates within the tolerances provided in the product specifications. Test and balance activities shall include air system and hydronic system balancing.

**C4078.2.2.1 Air systems balancing.**

Each supply air outlet and *zone* terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the *International Mechanical Code*. Discharge dampers are prohibited on constant volume fans and variable volume fans with motors 10 hp (18.6 kW) and larger. Air systems shall be balanced in a manner to first minimize throttling losses then, for fans with system power of greater than 1 hp (0.74 kW), fan speed shall be adjusted to meet design flow conditions.

**Exception:** Fans with fan motors of 1 hp (0.74 kW) or less.

**C4078.2.2.2 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.

**Exceptions:**

1. Pumps with pump motors of 5 hp (3.7 kW) or less.

2. Where throttling results in no greater than five percent of the nameplate horsepower draw above that required if the impeller were trimmed.

### **C4078.2.3 Functional performance testing.**

Functional performance testing specified in Sections C4078.2.3.1 through C4078.2.3.3 shall be conducted.

#### **C4078.2.3.1 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; and
4. Mode of operation upon a loss of power and restoration of power.

**Exception:** Unitary or packaged HVAC equipment listed in Tables C403.2.3(1) through C403.2.3(3) that do not require supply air economizers.

#### **C4078.2.3.2 Controls.**

HVAC control systems shall be tested to document that control devices, components, equipment, and systems are calibrated, 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.

#### **C4078.2.3.3 Economizers.**

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

### **C4078.2.4 Preliminary commissioning report.**

A preliminary report of commissioning test procedures and results shall be completed and certified by the *registered design professional* or *approved agency* and provided to the building owner. The report shall be identified as "Preliminary Commissioning Report" 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.

**C4078.2.4.1 Acceptance of report.**

*Buildings*, or portions thereof, shall not pass the final mechanical inspection until such time as the *code official* has received a letter of transmittal from the *building owner* acknowledging that the *building owner* has received the Preliminary Commissioning Report.

**C4078.2.4.2 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*.

**C4078.2.5 Documentation requirements.**

The construction documents shall specify that the documents described in this section be provided to the *building owner* within 90 days of the date of receipt of the certificate of occupancy.

**C4078.2.5.1 Drawings.**

Construction documents shall include the location and performance data on each piece of equipment.

**C4078.2.5.2 Manuals.**

An operating and maintenance manual shall be provided and include all of the following:

- ~~1. Submittal data stating equipment size and selected options for each piece of equipment requiring maintenance.~~
  - ~~2. Manufacturer's operation manuals and maintenance manuals for each piece of equipment requiring maintenance, except equipment not furnished as part of the project. Required routine maintenance actions shall be clearly identified.~~
  - ~~3. Name and address of at least one service agency.~~
  - ~~4. HVAC controls system maintenance and calibration information, including wiring diagrams, schematics, and control sequence descriptions. Desired or field-determined setpoints shall be permanently recorded on control drawings at control devices or, for digital control systems, in system programming instructions.~~
1. A complete description of the requirements of the facility, including any owners project requirements or current facility requirements for operation of the building.
  2. Facility, systems and assemblies information including:
    - 2.1. Manufacturer's operation and maintenance data for installed equipment systems and assemblies.
    - 2.2. Warranties and certificate of occupancy.
    - 2.3. Contractor and supplier listing and contact information.

3. A facility operations guide, including an operating plan, building and equipment operating schedules, setpoints and ranges, sequences of operation, system and equipment limitations, and emergency procedures.

45. A narrative of how each system is intended to operate, including recommended setpoints.

At least one copy of the operating and maintenance manual shall be in the possession of the owner or the owner's authorized agent and at least one additional copy shall remain with the building.

**C4078.2.5.3 System balancing report.**

A written report describing the activities and measurements completed in accordance with Section C4078.2.2.

**C4078.2.5.4 Final commissioning report.**

A report of test procedures and results identified as "Final Commissioning Report" shall be delivered to the building owner and shall include:

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 which cannot be performed at the time of report preparation due to climatic conditions.

**C4078.3 Lighting system functional testing.**

Commissioning of controls for automatic lighting systems shall comply with the requirements of this Section 407.3. ~~Controls for automatic lighting systems shall comply with Section C407.3.~~

**C4078.3.1 Functional testing.**

Testing shall ensure that control hardware and software are calibrated, adjusted, programmed and in proper working condition in accordance with the construction documents and manufacturer's installation instructions. The construction documents shall state the party who will conduct the required functional testing. Where required by the code official, an approved party independent from the design or construction of the project shall be responsible for the functional testing and shall provide documentation to the code official certifying that the installed lighting controls meet the provisions of Section C405.

Where occupant sensors, time switches, programmable schedule controls, photosensors or daylighting controls are installed, the following procedures shall be performed:

1. Confirm that the placement, sensitivity and time-out adjustments for occupant sensors yield acceptable performance.

2. Confirm that the time switches and programmable schedule controls are programmed to turn the lights off.
3. Confirm that the placement and sensitivity adjustments for photosensor controls reduce electric light based on the amount of usable daylight in the space as specified.

## CHAPTER 5 [CE] REFERENCED STANDARDS

**Commented [TK9]:** ICC: Can you double check that the code sections referenced here are still accurate when all of the section numbering is finished?

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 C106.

Standard reference number	Title	Referenced in code section number
<div style="display: flex; justify-content: space-between;"> <div style="width: 15%;"> <h3 style="margin: 0;">AAMA</h3> </div> <div style="width: 60%;"> <p>American Architectural Manufacturers Association 1827 Walden Office Square Suite 550 Schaumburg, IL 60173-4268</p> </div> </div>		
<a href="#">AAMA/WDMA/CSA 101/I.S.2/A C440—11</a>	North American Fenestration Standard/ Specifications for Windows, Doors and Unit Skylights	Table <a href="#">C402.4.3</a>
<div style="display: flex; justify-content: space-between;"> <div style="width: 15%;"> <h3 style="margin: 0;">AHAM</h3> </div> <div style="width: 60%;"> <p>Association of Home Appliance Manufacturers 1111 19th Street, NW, Suite 402 Washington, DC 20036</p> </div> </div>		
<a href="#">ANSI/AHAM RAC-1—2008</a>	Room Air Conditioners	Table <a href="#">C403.2.3(3)</a>
<div style="display: flex; justify-content: space-between;"> <div style="width: 15%;"> <h3 style="margin: 0;">AHRI</h3> </div> <div style="width: 60%;"> <p>Air Conditioning, Heating, and Refrigeration Institute 4100 North Fairfax Drive Suite 200 Arlington, VA 22203</p> </div> </div>		

Standard reference number	Title	Referenced in code section number
ISO/AHRI/ASHRAE 13256-1 (2005)	Water-source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-air and Brine-to-air Heat Pumps	Table C403.2.3(2)
ISO/AHRI/ASHRAE 13256-2 (1998)	Water-source Heat Pumps—Testing and Rating for Performance—Part 2: Water-to-water and Brine-to-water Heat Pumps	Table C403.2.3(2)
210/240—08	Unitary Air Conditioning and Air-source Heat Pump Equipment	Table C403.2.3(1), Table C403.2.3(2)
310/380—04	Standard for Packaged Terminal Air Conditioners and Heat Pumps	Table C403.2.3(3)
340/360—2007	Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment	Table C403.2.3(1), Table C403.2.3(2)
365—09	Commercial and Industrial Unitary Air-conditioning Condensing Units	Table C403.2.3(1), Table C403.2.3(6)
390—03	Performance Rating of Single Package Vertical Air Conditioners and Heat Pumps	Table C403.2.3(3)
400—01	Liquid to Liquid Heat Exchangers with Addendum 2	Table C403.2.3(9)
440—08	Room Fan Coil	C403.2.8
460—05	Performance Rating Remote Mechanical Draft Air-cooled Refrigerant Condensers	Table C403.2.3(8)
550/590—03	Water Chilling Packages Using the Vapor Compression Cycle—with Addenda	C403.2.3.1, Table C403.2.3(7), <del>Table C406.2(6)</del>
560—00	Absorption Water Chilling and Water-heating Packages	Table C403.2.3(7)
1160—08	Performance Rating of Heat Pump Pool Heaters	Table C404.2

## AMCA

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

Standard reference number	Title	Referenced in code section number
500D—10	Laboratory Methods for Testing Dampers for Rating	C402.4.5.1, C402.4.5.2

## ANSI

American National Standards Institute  
25 West 43rd Street  
Fourth Floor

New York, NY 10036

Standard reference number	Title	Referenced in code section number
Z21.10.3/CSA 4.3—04	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—06	Gas-fired Central Furnaces	Table C403.2.3(4), Table C406.2.(4)
Z83.8/CSA 2.6—09	Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters and Gas-fired Duct Furnaces	Table C403.2.3(4), Table C406.2.(4)

# ASHRAE

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.  
 1791 Tullie Circle, NE  
 Atlanta, GA 30329-2305

Standard reference number	Title	Referenced in code section number
ANSI/ASHRAE/ACCA Standard 183—2007	Peak Cooling and Heating Load Calculations in Buildings, Except Low-rise Residential Buildings	C403.2.1
ASHRAE—2004	ASHRAE HVAC Systems and Equipment Handbook—2004	C403.2.1
ISO/AHRI/ASHRAE 13256-1 (2005)	Water-source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-air and Brine-to-air Heat Pumps	Table C403.2.3(2)
ISO/AHRI/ASHRAE 13256-2 (1998)	Water-source Heat Pumps—Testing and Rating for Performance—Part 2: Water-to-water and Brine-to-water Heat Pumps	Table C403.2.3(2)
90.1—2010	Energy Standard for Buildings Except Low-rise Residential Buildings	C401.2, C401.2.1, C402.1.1, Table C402.1.2, Table C402.2, Table C407.6.1
119—88 (RA 2004)	Air Leakage Performance for Detached Single-family Residential Buildings	Table C405.5.2(1)
140—2010	Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs	C407.6.1
146—2006	Testing and Rating Pool Heaters	Table C404.2

ASTM International  
 100 Barr Harbor Drive

**Commented [PH10]:** ICC: please fill incorrect table reference. This reference seems to be an error in the IECC?

# ASTM

West Conshohocken, PA 19428-2859

Standard reference number	Title	Referenced in code section number
C 90—08	Specification for Load-bearing Concrete Masonry Units	Table C402.2
C 1371—04	Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emisometers	Table C402.2.1.1
C 1549—04	Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using A Portable Solar Reflectometer	Table C405.2.1.1
D 1003—07e1	Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics	C402.3.2.2
E 283—04	Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen	Table C402.2.1.1, C402.4.1.2.2, Table C402.4.3, C402.4.4, C402.4.8
E 408—71(2002)	Test Methods for Total Normal Emittance of Surfaces Using Inspection-meter Techniques	Table C402.2.1.1
E 779—03	Standard Test Method for Determining Air Leakage Rate by Fan Pressurization	C402.4.1.2.13
E 903—96	Standard Test Method Solar Absorptance, Reflectance and Transmittance of Materials Using Integrating Spheres (Withdrawn 2005)	Table C402.2.1.1
E 1677—05	Standard Specification for an Air-retarder (AR) Material or System for Low-rise Framed Building Walls	C402.4.1.2.2
E 1918—97	Standard Test Method for Measuring Solar Reflectance of Horizontal or Low-sloped Surfaces in the Field	Table C402.2.1.1
E 1980—(2001)	Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-sloped Opaque Surfaces	Table C402.2.1.1
E 2178—03	Standard Test Method for Air Permanence of Building Materials	C402.4.1.2.1
E 2357—05	Standard Test Method for Determining Air Leakage of Air Barriers Assemblies	C404.1.2.2

# CSA

Canadian Standards Association  
5060 Spectrum Way  
Mississauga, Ontario, Canada L4W 5N6

Standard reference number	Title	Referenced in code section number
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<a href="#">AAMA/WDMA/CSA 101/I.S.2/A440—11</a>	North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights	Table <a href="#">C402.4.3</a>
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## CTI

Cooling Technology Institute  
2611 FM 1960 West, Suite A-101  
Houston, TX 77068

Standard reference number	Title	Referenced in code section number
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ATC 105 (00)	Acceptance Test Code for Water Cooling Tower	Table <a href="#">C403.2.3(8)</a>
STD 201—09	Standard for Certification of Water Cooling Towers Thermal Performances	Table <a href="#">C403.2.3(8)</a>

## DASMA

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

Standard reference number	Title	Referenced in code section number
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105—92 (R2004)	Test Method for Thermal Transmittance and Air Infiltration of Garage Doors	Table <a href="#">C402.4.3</a>
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## DOE

U.S. Department of Energy  
c/o Superintendent of Documents  
U.S. Government Printing Office  
Washington, DC 20402-9325

Standard reference number	Title	Referenced in code section number
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10 CFR, Part 430—1998	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 <a href="#">C403.2.3(4)</a> , Table <a href="#">C403.2.3(5)</a> , Table <a href="#">C404.2</a> , Table <a href="#">C406.2(4)</a> , Table <a href="#">C406.2(5)</a>
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10 CFR, Part 430, Subpart B, Appendix N—1998	Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers	C202
10 CFR, Part 431—2004	Energy Efficiency Program for Certain Commercial and Industrial Equipment: Test Procedures and Efficiency Standards; Final Rules	Table C403.2.3(5), Table C406.2(5)
NAECA 87—(88)	National Appliance Energy Conservation Act 1987 [(Public Law 100-12 (with Amendments of 1988-P.L. 100-357)]	Tables C403.2.3(1), (2), (4)

<b>ICC</b>	International Code Council, Inc.	
	500 New Jersey Avenue, NW	
	6th Floor	
	Washington, DC 20001	
	Standard reference number	Referenced in code section number
	IBC—12	International Building Code® C201.3, C303.2, C402.4.4
	IFC—12	International Fire Code® C201.3
IFGC—12	International Fuel Gas Code® C201.3	
IMC—12	International Mechanical Code® C403.2.5, C403.2.5.1, C403.2.6, C403.2.7, C403.2.7.1, C403.2.7.1.1, C403.2.7.1.2, C403.2.7.1.3, C403.4.5, C407.2.2.1	
IPC—12	International Plumbing Code® C201.3	
<b>IESNA</b>	Illuminating Engineering Society of North America	
	120 Wall Street, 17th Floor	
	New York, NY 10005-4001	
Standard reference number	Referenced in code section number	
ANSI/ASHRAE/IESNA 90.1—2010	Energy Standard for Buildings, Except Low-rise Residential Buildings C401.2, C401.2.1, C402.1.1, Table C402.1.2, Table C402.2	
<b>ISO</b>	International Organization for Standardization	
	1, rue de Varembe, Case postale 56, CH-1211	
	Geneva, Switzerland	

Standard reference number	Title	Referenced in code section number
ISO/AHRI/ASHRAE 13256-1 (2005)	Water-source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-air and Brine-to-air Heat Pumps	C403.2.3(2)
ISO/AHRI/ASHRAE 13256-2 (1998)	Water-Source Heat Pumps—Testing and Rating for Performance—Part 2: Water-to-water and Brine-to-water Heat Pumps	C403.2.3(2)
<b>NFRC</b>	National Fenestration Rating Council, Inc.	
	6305 Ivy Lane, Suite 140	
	Greenbelt, MD 20770	
	Standard reference number	Referenced in code section number
100—2010	Title Procedure for Determining Fenestration Products <i>U</i> -factors—Second Edition	C303.1.2, C402.2.1
200—2010	Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence—Second Edition	C303.1.3, C402.3.1.1
400—2010	Procedure for Determining Fenestration Product Air Leakage—Second Edition	Table C402.4.3
<b>SMACNA</b>	Sheet Metal and Air Conditioning Contractors National Association, Inc.	
	4021 Lafayette Center Drive	
	Chantilly, VA 20151-1209	
Standard reference number	Title	Referenced in code section number
SMACNA—85	HVAC Air Duct Leakage Test Manual	C403.2.7.1.3
<b>UL</b>	Underwriters Laboratories	
	333 Pfingsten Road	
	Northbrook, IL 60062-2096	
Standard reference number	Title	Referenced in code section number

727—06	Oil-fired Central Furnaces—with Revisions through April 2010	Table <a href="#">C403.2.3(4)</a> , <a href="#">Table C406.2(4)</a>
731—95	Oil-fired Unit Heaters—with Revisions through April 2010	Table <a href="#">C403.2.3(4)</a> , <a href="#">Table C406.2(4)</a>

**US—FTC**  
 United States - Federal Trade Commission  
 600 Pennsylvania Avenue NW  
 Washington, DC 20580

Standard reference number	Title	Referenced in code section number
CFR Title 16 (May 31, 2005)	R-value Rule	<a href="#">C303.1.4</a>

## WDMA

Window and Door Manufacturers Association  
 1400 East Touhy Avenue, Suite 470  
 Des Plaines, IL 60018

Standard reference number	Title	Referenced in code section number
<a href="#">AAMA/WDMA/CSA</a> 101/I.S.2/A440—11	North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights	Table <a href="#">C402.4.3</a>

## CHAPTER 1 [RE] SCOPE AND ADMINISTRATION

### PART 1—SCOPE AND APPLICATION

#### SECTION R101 SCOPE AND GENERAL REQUIREMENTS

##### R101.1 Title.

This code shall be known as the ~~International Energy Conservation Code of [NAME OF JURISDICTION]~~ 2017 City of Boulder Energy Conservation 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 buildings 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 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.

##### R101.4.2 Historic buildings.

Any building or structure that is listed in the State or National Register of Historic Places; locally designated as an individual landmark ~~historic property under local or state designation law or survey~~; certified as a contributing resource with a National Register listed or locally designated historic district; or with an opinion or certification that the property is eligible to be listed on the National or State Registers of Historic Places either individually or as a contributing building or

structure to a historic district by the State Historic Preservation Officer or the Keeper of the National Register of Historic Places; or has been found, through a historic building inventory, to be eligible for local designation as a landmark or to be listed as a contributing building or structure to a local historic district, are exempt from this code shall comply with the requirements of this code. The code official may approve an alteration or modification to the requirements of this code where the requirement would have a detrimental impact on the special character or special historical, architectural, aesthetic interest or value of the building or structure individually or of the historic district to which the building or structure is contributing or, if the alteration would require a landmark alteration certificate under Chapter 9-11, "Historic Preservation," B.R.C. 1981, but would not meet the applicable standards of Section 9-11-18, "Standards for Landmark Altercation Certificate Applications," B.R.C. 1981.

**R101.4.3 Additions, alterations, ~~renovations~~ or repairs.**

Additions, alterations, ~~renovations~~ or repairs 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 portion(s) of the existing building or building system to comply with this code. Additions, alterations, ~~renovations~~ or repairs 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.

**Exception:** The following need not comply provided the energy use of the building is not increased:

1. Storm windows installed over existing fenestration.
2. Glass only replacements in an existing sash and frame.
- ~~3. Existing ceiling, wall or floor cavities exposed during construction provided that these cavities are filled with insulation.~~
- ~~3~~4. Construction where the existing roof, wall or floor cavity is not exposed.
- ~~4~~5. Reroofing for roofs where neither the sheathing nor the insulation is exposed. 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.

56. Replacement of existing doors that separate *conditioned space* from the exterior shall not require the installation of a vestibule or revolving door, provided, however, that an existing vestibule that separates a *conditioned space* from the exterior shall not be removed,

67. 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.

78. Alterations that replace only the bulb and ballast within the existing luminaires in a space provided that the *alteration* does not increase the installed interior lighting power.

**R101.4.4 Change in occupancy or use.**

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.

**R101.4.5 Change in space conditioning.**

Any nonconditioned space that is altered to become *conditioned space* shall be required to be brought into full compliance with this code.

**R101.4.6 Mixed occupancy.**

Where a building includes both *residential* and *commercial* occupancies, the building shall meet the requirements of this code for commercial buildings~~each occupancy shall be separately considered and meet the applicable provisions of the IECC—Commercial and Residential Provisions.~~

**R101.5 Compliance.**

*Residential buildings* shall meet the ~~provisions of IECC—Residential Provisions~~ of this code, Sections R101 through R404. *Commercial buildings* shall meet the ~~provisions of IECC—Commercial Provisions~~ of this code, Sections C101 through C407.

**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.

**R101.5.2 Low energy buildings.**

The following buildings, or portions thereof, separated from the remainder of the building by *building thermal envelope* assemblies complying with this code shall be exempt from the *building thermal envelope* provisions of this code:

1. Those with a peak design rate of energy usage less than 3.4 Btu/h • ft<sup>2</sup> (10.7 W/m<sup>2</sup>) or 1.0 watt/ft<sup>2</sup> (10.7 W/m<sup>2</sup>) of floor area for space conditioning purposes.
2. Those that do not contain *conditioned space*.

**SECTION R102  
ALTERNATE MATERIALS—METHOD  
OF CONSTRUCTION, DESIGN  
OR INSULATING SYSTEMS**

**R102.1 General.**

This code is not intended to prevent the use of any material, method of construction, design or insulating system not specifically prescribed herein, provided that such construction, design or insulating system has been *approved by the code official as meeting the intent of this code*.

**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 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 and other supporting data shall be submitted in one or more sets with each application for a permit. The construction documents and designs submitted under the provisions of this code shall be prepared by and bear the stamp of a Colorado licensed professional engineer or architect. Documents submitted for the Energy Rating Index shall be submitted by a registered design professional who demonstrates the knowledge and experience to perform such calculations. ~~The construction documents shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the code official is authorized to require necessary construction documents to be prepared by a registered design professional.~~ additional construction documents to be prepared by a Colorado licensed professional engineer or architect.

**Exception:** The code official may waive the submission of construction documents and other supporting data if the official finds that the nature of the work does not require review of the documents or data to obtain compliance. This waiver authority does not apply to documents required to

~~be prepared by a Colorado licensed architect or engineer. 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 upon suitable material. Electronic media documents are permitted to be submitted when *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, as applicable, insulation materials and their *R*-values; fenestration *U*-factors and SHGCs; area-weighted *U*-factor and SHGC calculations; mechanical system design criteria; mechanical and service water heating system and equipment types, sizes and efficiencies; economizer description; equipment and systems controls; fan motor horsepower (hp) and controls; duct sealing, duct and pipe insulation and location; lighting fixture schedule with wattage and control narrative; and air sealing details.

~~**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.~~

~~**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.~~**

~~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.~~

**~~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  
INSPECTIONS**

**R104.1 General.**

Construction or work for which a permit is required shall be subject to inspection by the *code official*.

**R104.2 Required approvals.**

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

**R104.3 Final inspection.**

The building shall have a final inspection and not be occupied until *approved*.

**R104.4 Reinspection.**

A building shall be reinspected when determined necessary by the *code official*.

**~~R104.5 Approved inspection agencies.~~**

~~The code official is authorized to accept reports of approved inspection agencies, provided such agencies satisfy the requirements as to qualifications and reliability.~~

**~~R104.6 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.~~

**~~R104.7 Reinspection and testing.~~**

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

**~~R104.8 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.~~

**~~R104.8.1 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 R105  
VALIDITY**

**R105.1 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 R106  
REFERENCED STANDARDS**

R106.1 Referenced codes and standards.

The codes and standards referenced in this code shall be those listed 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 [R106.1.1](#) and [R106.1.2](#).

R106.1.1 Conflicts.

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

**R106.1.2 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.

**R106.2 Conflicting requirements.**

Where the provisions of this code and the referenced standards conflict, the provisions of this code shall take precedence.

**R106.3 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.

**R106.4 Other laws.**

The provisions of this code shall not be deemed to nullify any provisions of local, state or federal law. This code is intended to comply with and be interpreted and enforced so as to comply with 42 U.S.C. Section 6297(f)(3) and any other federal requirements to avoid preemption. For purposes of 42 U.S.C. Section 6297(f)(3), "new construction" shall be interpreted to include all work that triggers the requirements established in this code.

**SECTION R107  
ADMINISTRATION FEES**

**R107.1 Fees Administration.**

This code shall be administered in accordance with and as part of Chapter 10-5, "Building Code," B.R.C. 1981. A permit shall not be issued until the fees prescribed in Section R107.2 have been paid, nor shall an amendment to a permit be released until the additional fee, if any, has been paid.

**R107.2 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.

**~~R107.3 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, which shall be in addition to the required permit fees.~~

**~~R107.4 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.~~

**~~R107.5 Refunds.~~**

~~The code official is authorized to establish a refund policy.~~

**SECTION R108-  
STOP WORK ORDER**

**~~R108.1 Authority.~~**

~~Whenever 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, or to the owner's 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 liable to a fine of not less than [AMOUNT] dollars or more than [AMOUNT] dollars.~~

**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 have no 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 have no 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

### 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 or height of a building or structure*.

**AIR BARRIER.** Material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or a combination of materials.

**ALTERATION.** Any construction or renovation to an existing structure other than repair or addition that requires a permit. Also, a change in a mechanical system that involves an extension, addition or change to the arrangement, type or purpose of the original installation that requires a permit.

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

**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*.

**BPI.** *Building Performance Institute.*

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**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 PERFORMANCE INSTITUTE.** Building Performance Institute or BPI is a national standards development organization for residential energy efficiency and weatherization retrofit work accredited by the American Standards Institute (ANSI).

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

**BUILDING THERMAL ENVELOPE.** The basement walls, exterior walls, floor, roof, and any other building elements that enclose *conditioned space* or provides a boundary between conditioned space and exempt or unconditioned space.

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

**CODE OFFICIAL.** ~~The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative.~~ The code official is the city manager.

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

**COMMUNITY SOLAR GARDEN.** A solar generation facility where the beneficial use of the electricity generated by the facility belongs to subscribers to the solar generation facility as authorized in §40-2-127, C.R.S.

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

**CONDITIONED SPACE.** An area or room within a building being heated or cooled, containing uninsulated ducts, or with a fixed opening directly into an adjacent *conditioned space*.

**CONSTRUCTION VALUATION.** The total value of work covered by the permit, to be determined consistent with the standards of Subsection 4-20-4(d), B.R.C. 1981. The higher of the two valuations considered under Subsection 4-20-4(d), B.R.C. 1981, shall be the total value of work.

**CONTINUOUS AIR BARRIER.** A combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.

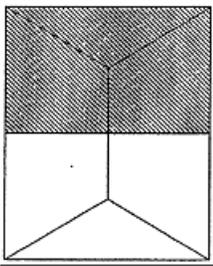
**CRAWL SPACE WALL.** The opaque portion of a wall that encloses a crawl space and is partially or totally below grade.

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

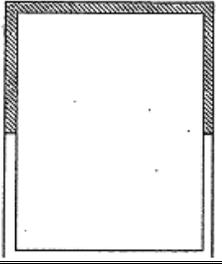
**DEMAND RECIRCULATION WATER SYSTEM.** A water distribution system where pump(s) prime the service hot water piping with heated water upon demand for hot water.

**DEMOLITION OR DEMOLISH.** An act or process which removes one or more of the following. The shaded area illustrates the maximum amount that may be removed without constituting demolition.

(a) Fifty percent or more of the roof area as measured in plain view (see diagram):



(b) Fifty percent or more of the exterior walls of a building as measured contiguously around the "building coverage" as defined in Section 9-16-1, "Definitions," B.R.C., 1981 (see diagram).



A wall shall meet the following minimum standards to be considered a retained exterior wall:

- (1) The wall shall retain studs or other structural elements, the exterior wall finish and the fully framed and sheathed roof above that portion of the remaining building to which such wall is attached.
- (2) The wall shall not be covered or otherwise concealed by a wall that is proposed to be placed in front of the retained wall; and
- (3) Each part of the retained exterior walls shall be connected contiguously and without interruption to every other part of the retained exterior walls

**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 ADVISING.** Guidance provided by a third-party energy professional to educate the property owner about energy efficiency upgrades and/or improvements that will reduce energy use by the building, improve occupant comfort, and reduce utility bills.

**ENERGY ASSESSMENT.** A comprehensive review of a building's thermal envelope, equipment, appliances, lighting, and combustion safety conducted by a BPI or RESENT accredited professional. Blower door testing and infrared imaging measuring infiltration of the existing building shall be included the comprehensive review.

**ENERGY ASSESSOR.** A BPI or RESENT accredited professional who can conduct an energy assessment of a building's thermal envelope, heating and cooling systems, ventilation, and lighting, and recommend energy efficiency improvements to the building to reduce the building's 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 RATING INDEX (ERI).** The ERI value is defined as a numerical score where 100 is equivalent to a home designed to be minimally compliant with 2006 IECC and 0 is equivalent to a net zero energy (NZE) home. An ERI is determined by an energy simulation tool, where each integer value on the scale represents a one percent change in the total energy use of the rated design relative to the total energy use of the ERI reference design. The ERI must be determined in accordance with the ANSI/RESNET/ICC 301-2014 Standard.

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

**ENTRANCE DOOR.** Fenestration products used for ingress, egress and access in nonresidential buildings, including, but not limited to, exterior entrances that utilize latching hardware and automatic closers and contain over 50-percent glass specifically designed to withstand heavy use and possibly abuse.

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

**FENESTRATION.** Skylights, roof windows, vertical windows (fixed or moveable), opaque doors, glazed doors, glazed block and combination opaque/glazed doors. Fenestration includes products with glass and nonglass glazing materials.

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

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

**FLOOR AREA.** The total square footage of all levels as measured from the inside finished surface of the walls, excluding courts, unconditioned garages, and uninhabitable crawl spaces and attics.

**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, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy of:

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

**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.

**INSULATING SHEATHING.** An insulating board with a core material having a minimum *R-value* of *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, inspection agency or other organization concerned with product evaluation that maintains periodic inspection of the production of the above-labeled items and whose labeling indicates either that the equipment, material or product meets identified standards or has been tested and found suitable for a specified purpose.

**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").

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

**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.

**RESIDENTIAL BUILDING.** For this code, includes detached one- and two-family dwellings and multiple single-family dwellings (townhouses and duplexes) with separate means of egress and their accessory structures, as well as Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane.

**RESIDENTIAL ENERGY SERVICES NETWORK.** Residential Energy Services Network or RESNET is a recognized national standards development organization for building energy efficiency rating and certifications systems.

**RESNET.** Residential Energy Services Network.

**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.

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

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

**SKYLIGHT.** Glass or other transparent or translucent glazing material installed at a slope of less than 60 degrees (1.05 rad) from horizontal. Glazing material in skylights, including unit skylights, solariums, sunrooms, roofs and sloped walls is included in this definition.

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

**STANDARD TEST CONDITIONS.** A fixed set of conditions for which PV module performance is rated. These conditions are 1000 W/m<sup>2</sup> incident solar radiation, 25 °C cell temperature, 0.0 wind speed, and air mass 1.5 spectrum.

**~~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 space(s)*. The *conditioned space(s)* 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 set point.

**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<sup>2</sup> • °F) [W/(m<sup>2</sup> • 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

### ~~SECTION R301- CLIMATE ZONES~~

#### ~~R301.1 General-~~

~~Climate zones from Figure R301.1 or Table R301.1 shall be used in determining the applicable requirements from Chapter 4. Locations not in Table R301.1 (outside the United States) shall be assigned a climate zone based on Section R301.3.~~

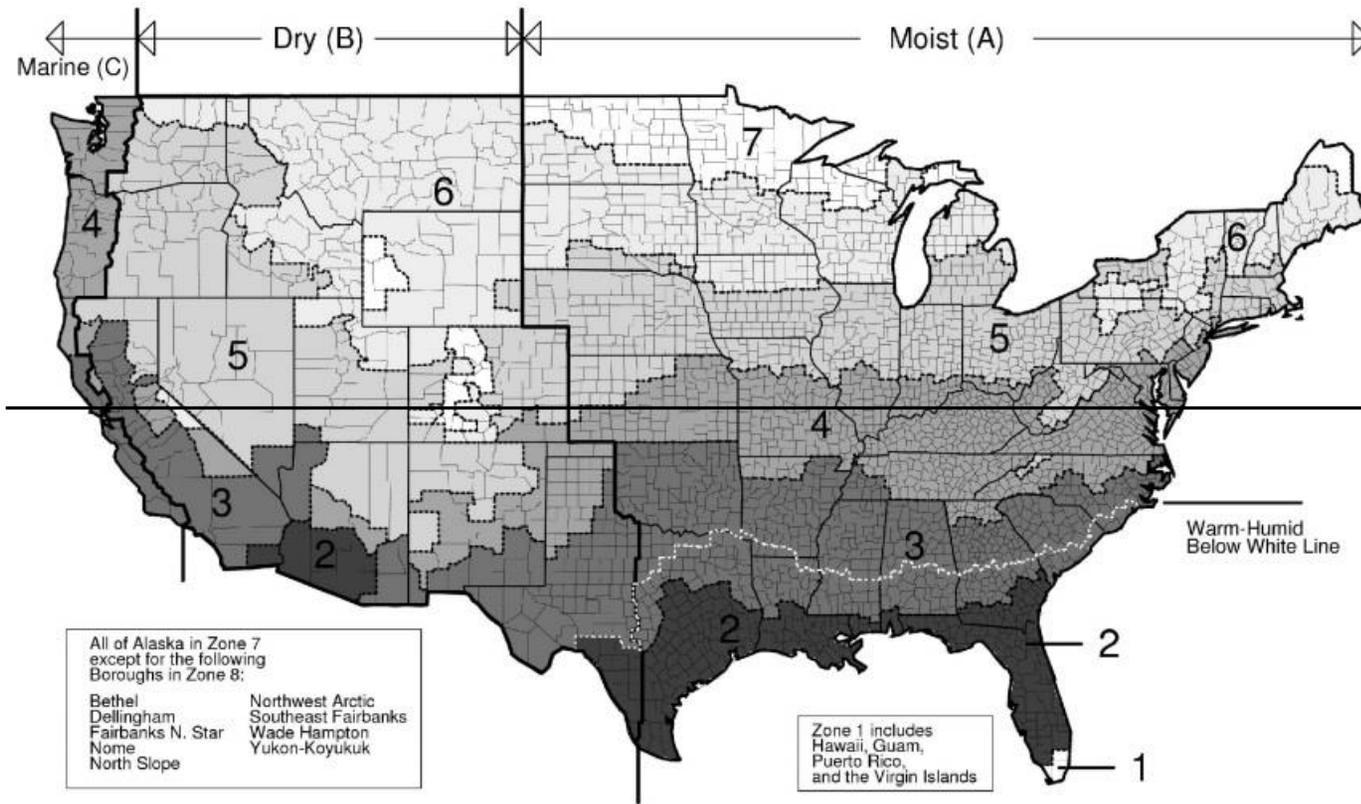


FIGURE R301.1  
CLIMATE ZONES

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.**

**US STATES**

<b>ALABAMA</b>	3A Lee	7 Kodiak Island	3A Calhoun	3A Monroe
3A Autauga*	3A Limestone	7 Lake and Peninsula	4A Carroll	3A Montgomery
2A Baldwin*	3A Lowndes*	7 Matanuska-Susitna	3A Chicot	3A Nevada
3A Barbour*	3A Macon*	8 Nome	3A Clark	4A Newton
3A Bibb	3A Madison	8 North Slope	3A Clay	3A Ouachita
3A Blount	3A Marengo*	8 Northwest Arctic	3A Cleburne	3A Perry
3A Bullock*	3A Marion	7 Prince of Wales- Outer Ketchikan	3A Cleveland	3A Phillips
3A Butler*	3A Marshall	7 Sitka	3A Columbia*	3A Pike
3A Calhoun	2A Mobile*	7 Skagway-Hoonah- Angoon	3A Conway	3A Poinsett
3A Chambers	3A Monroe*	8 Southeast Fairbanks	3A Craighead	3A Polk
3A Cherokee	3A Montgomery*	7 Valdez-Cordova	3A Crawford	3A Pope
3A Chilton	3A Morgan	8 Wade Hampton	3A Crittenden	3A Prairie
3A Choctaw*	3A Perry*	7 Wrangell-Petersburg	3A Cross	3A Pulaski
3A Clarke*	3A Pickens	7 Yakutat	3A Dallas	3A Randolph
3A Clay	3A Pike*	8 Yukon-Koyukuk	3A Desha	3A Saline
3A Cleburne	3A Randolph		3A Drew	3A Scott
3A Coffee*	3A Russell*	<b>ARIZONA</b>	3A Faulkner	4A Searcy
3A Colbert	3A Shelby	5B Apache	3A Franklin	3A Sebastian
3A Conecuh*	3A St. Clair	3B Cochise	4A Fulton	3A Sevier*
3A Coosa	3A Sumter	5B Coconino	3A Garland	3A Sharp
3A Covington*	3A Talladega		3A Grant	3A St. Francis
3A Crenshaw*	3A Tallapoosa		3A Greene	4A Stone

3A-Cullman  
 3A-Dale\*  
 3A-Dallas\*  
 3A-DeKalb  
 3A-Elmore\*  
 3A-Escambia\*  
 3A-Etowah  
 3A-Fayette  
 3A-Franklin  
 3A-Geneva\*  
 3A-Greene  
 3A-Hale  
 3A-Henry\*  
 3A-Houston\*  
 3A-Jackson  
 3A-Jefferson  
 3A-Lamar  
 3A-Lauderdale  
 3A-Lawrence

3A-Tuscaloosa  
 3A-Walker  
 3A-Washington\*  
 3A-Wilcox\*  
 3A-Winston

**ALASKA**

7-Aleutians-East  
 7-Aleutians-West  
 7-Anchorage  
 8-Bethel  
 7-Bristol-Bay  
 7-Denali  
 8-Dillingham  
 8-Fairbanks-North-Star  
 7-Haines  
 7-Juneau  
 7-Kenai-Peninsula  
 7-Ketchikan-Gateway

4B-Gila  
 3B-Graham  
 3B-Greenlee  
 2B-La-Paz  
 2B-Maricopa  
 3B-Mohave  
 5B-Navajo  
 2B-Pima  
 2B-Pinal  
 3B-Santa-Cruz  
 4B-Yavapai  
 2B-Yuma

**ARKANSAS**

3A-Arkansas  
 3A-Ashley  
 4A-Baxter  
 4A-Benton  
 4A-Boone  
 3A-Bradley

*(continued)*

3A-Hempstead\*  
 3A-Hot-Spring  
 3A-Howard  
 3A-Independence  
 4A-Izard  
 3A-Jackson  
 3A-Jefferson  
 3A-Johnson  
 3A-Lafayette\*  
 3A-Lawrence  
 3A-Lee  
 3A-Lincoln  
 3A-Little-River\*  
 3A-Logan  
 3A-Lonoke  
 4A-Madison  
 4A-Marion  
 3A-Miller\*  
 3A-Mississippi

3A-Union\*  
 3A-Van-Buren  
 4A-Washington  
 3A-White  
 3A-Woodruff  
 3A-Yell

**CALIFORNIA**

3C-Alameda  
 6B-Alpine  
 4B-Amador  
 3B-Butte  
 4B-Calaveras  
 3B-Colusa  
 3B-Contra-Costa  
 4C-Del-Norte  
 4B-El-Dorado  
 3B-Fresno  
 3B-Glenn

TABLE R301.1—continued-  
 CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID-  
 DESIGNATIONS BY STATE, COUNTY AND TERRITORY

4C-Humboldt  
 2B-Imperial  
 4B-Inyo  
 3B-Kern

3B-Yuba  
**COLORADO**  
 5B-Adams

5B-Morgan  
 4B-Otero  
 6B-Ouray  
 7-Park

2A-Escambia\*  
 2A-Flagler\*  
 2A-Franklin\*  
 2A-Gadsden\*

2A-Taylor\*  
 2A-Union\*  
 2A-Volusia\*  
 2A-Wakulla\*

3B Kings  
4B Lake  
5B Lassen  
3B Los Angeles  
3B Madera  
3C Marin  
4B Mariposa  
3C Mendocino  
3B Merced  
5B Modoc  
6B Mono  
3C Monterey  
3C Napa  
5B Nevada  
3B Orange  
3B Placer  
5B Plumas  
3B Riverside  
3B Sacramento  
3C San Benito  
3B San Bernardino  
3B San Diego  
3C San Francisco  
3B San Joaquin  
3C San Luis Obispo  
3C San Mateo  
3C Santa Barbara  
3C Santa Clara  
3C Santa Cruz  
3B Shasta  
5B Sierra

6B Alamosa  
5B Arapahoe  
6B Archuleta  
4B Baca  
5B Bent  
5B Boulder  
6B Chaffee  
5B Cheyenn  
7 Clear Creek  
6B Conejos  
6B Costilla  
5B Crowley  
6B Custer  
5B Delta  
5B Denver  
6B Dolores  
5B Douglas  
6B Eagle  
5B Elbert  
5B El Paso  
5B Fremont  
5B Garfield  
5B Gilpin  
7 Grand  
7 Gunnison  
7 Hinsdale  
5B Huerfano  
7 Jackson  
5B Jefferson  
5B Kiowa  
5B Kit Carson

5B Phillips  
7 Pitkin  
5B Prowers  
5B Pueblo  
6B Rio Blanco  
7 Rio Grande  
7 Routt  
6B Saguache  
7 San Juan  
6B San Miguel  
5B Sedgwick  
7 Summit  
5B Teller  
5B Washington  
5B Weld  
5B Yuma

**CONNECTICUT**

5A (all)

**DELAWARE**

4A (all)

**DISTRICT OF COLUMBIA**

4A (all)

**FLORIDA**

2A Alachua\*  
2A Baker\*  
2A Bay\*  
2A Bradford\*

2A Gilchrist\*  
2A Glades\*  
2A Gulf\*  
2A Hamilton\*  
2A Hardee\*  
2A Hendry\*  
2A Hernando\*  
2A Highlands\*  
2A Hillsborough\*  
2A Holmes\*  
2A Indian River\*  
2A Jackson\*  
2A Jefferson\*  
2A Lafayette\*  
2A Lake\*  
2A Lee\*  
2A Leon\*  
2A Levy\*  
2A Liberty\*  
2A Madison\*  
2A Manatee\*  
2A Marion\*  
2A Martin\*  
1A Miami Dade\*  
1A Monroe\*  
2A Nassau\*  
2A Okaloosa\*  
2A Okeechobee\*  
2A Orange\*  
2A Osceola\*  
2A Palm Beach\*

2A Walton\*  
2A Washington\*

**GEORGIA**

2A Appling\*  
2A Atkinson\*  
2A Bacon\*  
2A Baker\*  
3A Baldwin  
4A Banks  
3A Barrow  
3A Bartow  
3A Ben Hill\*  
2A Berrien\*  
3A Bibb  
3A Bleckley\*  
2A Brantley\*  
2A Brooks\*  
2A Bryan\*  
3A Bulloch\*  
3A Burke  
3A Butts  
3A Calhoun\*  
2A Camden\*  
3A Candler\*  
3A Carroll  
4A Catoosa  
2A Charlton\*  
2A Chatham\*  
3A Chattahoochee\*  
4A Chattooga

5B Siskiyou	7 Lake	2A Brevard*	2A Pasco*	3A Cherokee
3B Solano	5B La Plata	1A Broward*	2A Pinellas*	3A Clarke
3C Sonoma	5B Larimer	2A Calhoun*	2A Polk*	3A Clay*
3B Stanislaus	4B Las Animas	2A Charlotte*	2A Putnam*	3A Clayton
3B Sutter	5B Lincoln	2A Citrus*	2A Santa Rosa*	2A Clinch*
3B Tehama	5B Logan	2A Clay*	2A Sarasota*	3A Cobb
4B Trinity	5B Mesa	2A Collier*	2A Seminole*	3A Coffee*
3B Tulare	7 Mineral	2A Columbia*	2A St. Johns*	2A Colquitt*
4B Tuolumne	6B Moffat	2A DeSoto*	2A St. Lucie*	3A Columbia
3C Ventura	5B Montezuma	2A Dixie*	2A Sumter*	2A Cook*
3B Yolo	5B Montrose	2A Duval*	2A Suwannee*	3A Coweta

(continued)

TABLE R301.1—continued  
 CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID-  
 DESIGNATIONS BY STATE, COUNTY AND TERRITORY

3A Crawford	2A Lanier*	3A Taylor*	5B Cassia	4A Crawford
3A Crisp*	3A Laurens*	3A Telfair*	6B Clark	5A Cumberland
4A Dade	3A Lee*	3A Terrell*	5B Clearwater	5A DeKalb
4A Dawson	2A Liberty*	2A Thomas*	6B Custer	5A De Witt
2A Decatur*	3A Lincoln	3A Tift*	5B Elmore	5A Douglas
3A DeKalb	2A Long*	2A Toombs*	6B Franklin	5A DuPage
3A Dodge*	2A Lowndes*	4A Towns	6B Fremont	5A Edgar
3A Dooly*	4A Lumpkin	3A Treutlen*	5B Gem	4A Edwards
3A Dougherty*	3A Macon*	3A Troup	5B Gooding	4A Effingham
3A Douglas	3A Madison	3A Turner*	5B Idaho	4A Fayette
3A Early*	3A Marion*	3A Twiggs*	6B Jefferson	5A Ford
2A Echols*	3A McDuffie	4A Union	5B Jerome	4A Franklin
2A Effingham*	2A McIntosh*	3A Upson	5B Keetenai	5A Fulton

3A Elbert  
3A Emanuel\*  
2A Evans\*  
4A Fannin  
3A Fayette  
4A Floyd  
3A Forsyth  
4A Franklin  
3A Fulton  
4A Gilmer  
3A Glascock  
2A Glynn\*  
4A Gordon  
2A Grady\*  
3A Greene  
3A Gwinnett  
4A Habersham  
4A Hall  
3A Hancock  
3A Haralson  
3A Harris  
3A Hart  
3A Heard  
3A Henry  
3A Houston\*  
3A Irwin\*  
3A Jackson  
3A Jasper  
2A Jeff Davis\*  
3A Jefferson  
3A Jenkins\*

3A Meriwether  
2A Miller\*  
2A Mitchell\*  
3A Monroe  
3A Montgomery\*  
3A Morgan  
4A Murray  
3A Muscogee  
3A Newton  
3A Oconee  
3A Oglethorpe  
3A Paulding  
3A Peach\*  
4A Pickens  
2A Pierce\*  
3A Pike  
3A Polk  
3A Pulaski\*  
3A Putnam  
3A Quitman\*  
4A Rabun  
3A Randolph\*  
3A Richmond  
3A Rockdale  
3A Schley\*  
3A Screven\*  
2A Seminole\*  
3A Spalding  
4A Stephens  
3A Stewart\*  
3A Sumter\*

4A Walker  
3A Walton  
2A Ware\*  
3A Warren  
3A Washington  
2A Wayne\*  
3A Webster\*  
3A Wheeler\*  
4A White  
4A Whitfield  
3A Wilcox\*  
3A Wilkes  
3A Wilkinson  
3A Worth\*

**HAWAII**

1A (all)\*

**IDAHO**

5B Ada  
6B Adams  
6B Bannock  
6B Bear Lake  
5B Benewah  
6B Bingham  
6B Blaine  
6B Boise  
6B Bonner  
6B Bonneville  
6B Boundary  
6B Butte

5B Latah  
6B Lemhi  
5B Lewis  
5B Lincoln  
6B Madison  
5B Minidoka  
5B Nez Perce  
6B Oneida  
5B Owyhee  
5B Payette  
5B Power  
5B Shoshone  
6B Teton  
5B Twin Falls  
6B Valley  
5B Washington

**ILLINOIS**

5A Adams  
4A Alexander  
4A Bond  
5A Boone  
5A Brown  
5A Bureau  
5A Calhoun  
5A Carroll  
5A Cass  
5A Champaign  
4A Christian  
5A Clark  
4A Clay

4A Gallatin  
5A Greene  
5A Grundy  
4A Hamilton  
5A Hancock  
4A Hardin  
5A Henderson  
5A Henry  
5A Iroquois  
4A Jackson  
4A Jasper  
4A Jefferson  
5A Jersey  
5A Jo Daviess  
4A Johnson  
5A Kane  
5A Kankakee  
5A Kendall  
5A Knox  
5A Lake  
5A La Salle  
4A Lawrence  
5A Lee  
5A Livingston  
5A Logan  
5A Macon  
4A Macoupin  
4A Madison  
4A Marion  
5A Marshall  
5A Mason

3A Johnson*	3A Talbot	6B Camas	4A Clinton	4A Massac
3A Jones	3A Taliaferro	5B Canyon	5A Coles	5A McDonough
3A Lamar	2A Tattnall*	6B Caribou	5A Cook	5A McHenry

(continued)

TABLE R301.1—continued  
 CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID-  
 DESIGNATIONS BY STATE, COUNTY AND TERRITORY

5A McLean	5A Boone	5A Miami	5A Appanoose	5A Jasper
5A Menard	4A Brown	4A Monroe	5A Audubon	5A Jefferson
5A Mercer	5A Carroll	5A Montgomery	5A Benton	5A Johnson
4A Monroe	5A Cass	5A Morgan	6A Black Hawk	5A Jones
4A Montgomery	4A Clark	5A Newton	5A Boone	5A Keokuk
5A Morgan	5A Clay	5A Noble	6A Bremer	6A Kossuth
5A Moultrie	5A Clinton	4A Ohio	6A Buchanan	5A Lee
5A Ogle	4A Crawford	4A Orange	6A Buena Vista	5A Linn
5A Peoria	4A Daviess	5A Owen	6A Butler	5A Louisa
4A Perry	4A Dearborn	5A Parke	6A Calhoun	5A Lucas
5A Piatt	5A Decatur	4A Perry	5A Carroll	6A Lyon
5A Pike	5A De Kalb	4A Pike	5A Cass	5A Madison
4A Pope	5A Delaware	5A Porter	5A Cedar	5A Mahaska
4A Pulaski	4A Dubois	4A Posey	6A Cerro Gordo	5A Marion
5A Putnam	5A Elkhart	5A Pulaski	6A Cherokee	5A Marshall
4A Randolph	5A Fayette	5A Putnam	6A Chickasaw	5A Mills
4A Richland	4A Floyd	5A Randolph	5A Clarke	6A Mitchell
5A Rock Island	5A Fountain	4A Ripley	6A Clay	5A Monona
4A Saline	5A Franklin	5A Rush	6A Clayton	5A Monroe
5A Sangamon	5A Fulton	4A Scott	5A Clinton	5A Montgomery
5A Schuyler	4A Gibson	5A Shelby	5A Crawford	5A Muscatine

5A Scott  
4A Shelby  
5A Stark  
4A St. Clair  
5A Stephenson  
5A Tazewell  
4A Union  
5A Vermillion  
4A Wabash  
5A Warren  
4A Washington  
4A Wayne  
4A White  
5A Whiteside  
5A Will  
4A Williamson  
5A Winnebago  
5A Woodford

**INDIANA**

5A Adams  
5A Allen  
5A Bartholomew  
5A Benton  
5A Blackford

5A Grant  
4A Greene  
5A Hamilton  
5A Hancock  
4A Harrison  
5A Hendricks  
5A Henry  
5A Howard  
5A Huntington  
4A Jackson  
5A Jasper  
5A Jay  
4A Jefferson  
4A Jennings  
5A Johnson  
4A Knox  
5A Kosciusko  
5A Lagrange  
5A Lake  
5A La Porte  
4A Lawrence  
5A Madison  
5A Marion  
5A Marshall  
4A Martin

4A Spencer  
5A Starke  
5A Steuben  
5A St. Joseph  
4A Sullivan  
4A Switzerland  
5A Tippecanoe  
5A Tipton  
5A Union  
4A Vanderburgh  
5A Vermillion  
5A Vigo  
5A Wabash  
5A Warren  
4A Warrick  
4A Washington  
5A Wayne  
5A Wells  
5A White  
5A Whitley

**IOWA**

5A Adair  
5A Adams  
6A Allamakee

*(continued)*

5A Dallas  
5A Davis  
5A Decatur  
6A Delaware  
5A Des Moines  
6A Dickinson  
5A Dubuque  
6A Emmet  
6A Fayette  
6A Floyd  
6A Franklin  
5A Fremont  
5A Greene  
6A Grundy  
5A Guthrie  
6A Hamilton  
6A Hancock  
6A Hardin  
5A Harrison  
5A Henry  
6A Howard  
6A Humboldt  
6A Ida  
5A Iowa  
5A Jackson

6A O'Brien  
6A Osceola  
5A Page  
6A Palo Alto  
6A Plymouth  
6A Pocahontas  
5A Polk  
5A Pottawattamie  
5A Poweshiek  
5A Ringgold  
6A Sac  
5A Scott  
5A Shelby  
6A Sioux  
5A Story  
5A Tama  
5A Taylor  
5A Union  
5A Van Buren  
5A Wapello  
5A Warren  
5A Washington  
5A Wayne  
6A Webster  
6A Winnebago

TABLE R301.1—continued  
 CLIMATE ZONES, MOISTURE REGIMES, AND WARM HUMID-  
 DESIGNATIONS BY STATE, COUNTY AND TERRITORY

6A Winnechiek	4A Haskell	4A Sedgwick	2A Iberville*	6A Cumberland
5A Woodbury	4A Hodgeman	4A Seward	3A Jackson*	6A Franklin
6A Worth	4A Jackson	4A Shawnee	2A Jefferson*	6A Hancock
6A Wright	4A Jefferson	5A Sheridan	2A Jefferson-Davis*	6A Kennebec
<b>KANSAS</b>	5A Jewell	5A Sherman	2A Lafayette*	6A Knox
4A Allen	4A Johnson	5A Smith	2A Lafourche*	6A Lincoln
4A Anderson	4A Kearny	4A Stafford	3A La-Salle*	6A Oxford
4A Atchison	4A Kingman	4A Stanton	3A Lincoln*	6A Penobscot
4A Barber	4A Kiowa	4A Stevens	2A Livingston*	6A Piscataquis
4A Barton	4A Labette	4A Sumner	3A Madison*	6A Sagadahoc
4A Bourbon	5A Lane	5A Thomas	3A Morehouse	6A Somerset
4A Brown	4A Leavenworth	5A Trego	3A Natchitoches*	6A Waldo
4A Butler	4A Lincoln	4A Wabaunsee	2A Orleans*	6A Washington
4A Chase	4A Linn	5A Wallace	3A Ouachita*	6A York
4A Chautauqua	5A Logan	4A Washington	2A Plaquemines*	<b>MARYLAND</b>
4A Cherokee	4A Lyon	5A Wichita	2A Pointe-Coupee*	4A Allegany
5A Cheyenne	4A Marion	4A Wilson	2A Rapides*	4A Anne-Arundel
4A Clark	4A Marshall	4A Woodson	3A Red-River*	4A Baltimore
4A Clay	4A McPherson	4A Wyandotte	3A Richland*	4A Baltimore-(city)
5A Cloud	4A Meade	<b>KENTUCKY</b>	3A Sabine*	4A Calvert
4A Coffey	4A Miami	4A -(all)	2A St. Bernard*	4A Carroll
4A Comanche	5A Mitchell	<b>LOUISIANA</b>	2A St. Charles*	4A Cecil
4A Cowley	4A Montgomery	2A Acadia*	2A St. Helena*	4A Charles
4A Crawford	4A Morris	2A Allen*	2A St. James*	4A Dorchester
5A Decatur	4A Morton		2A St. John-the Baptist*	
	4A Nemaha			

4A Dickinson	4A Neosho	2A Ascension*	2A St. Landry*	4A Frederick
4A Doniphan	5A Ness	2A Assumption*	2A St. Martin*	5A Garrett
4A Douglas	5A Norton	2A Avoyelles*	2A St. Mary*	4A Harford
4A Edwards	4A Osage	2A Beauregard*	2A St. Tammany*	4A Howard
4A Elk	5A Osborne	3A Bienville*	2A Tangipahoa*	4A Kent
5A Ellis	4A Ottawa	3A Bossier*	3A Tensas*	4A Montgomery
4A Ellsworth	4A Pawnee	3A Caddo*	2A Terrebonne*	4A Prince-George's
4A Finney	5A Phillips	2A Calcasieu*	3A Union*	4A Queen Anne's
4A Ford	4A Pottawatomie	3A Caldwell*	2A Vermilion*	4A Somerset
4A Franklin	4A Pratt	2A Cameron*	3A Vernon*	4A St. Mary's
4A Geary	5A Rawlins	3A Catahoula*	2A Washington*	4A Talbot
5A Gove	4A Rene	3A Claiborne*	3A Webster*	4A Washington
5A Graham	5A Republic	3A Concordia*	2A West Baton Rouge*	4A Wicomico
4A Grant	4A Rice	3A De Soto*	3A West Carroll	4A Worcester
4A Gray	4A Riley	2A East Baton Rouge*	3A West Feliciana*	
5A Greeley	5A Rooks	3A East Carroll	3A Winn*	<b>MASSACHUSETTS</b>
4A Greenwood	4A Rush	2A East Feliciana*		5A (all)
5A Hamilton	4A Russell	2A Evangeline*	<b>MAINE</b>	<b>MICHIGAN</b>
4A Harper	4A Saline	3A Franklin*	6A Androscoggin	6A Alcona
4A Harvey	5A Scott	3A Grant*	7 Aroostook	6A Alger
		2A Iberia*		

(continued)

TABLE R301.1—continued-  
CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID-  
DESIGNATIONS BY STATE, COUNTY AND TERRITORY

5A Allegan	7 Mackinac	6A Carver	7 Otter Tail	3A Clarke
6A Alpena	5A Macomb	7 Cass	7 Pennington	3A Clay
6A Antrim	6A Manistee	6A Chippewa	7 Pine	3A Coahoma

6A Arenac	6A Marquette	6A Chisago	6A Pipestone	3A Copiah*
7 Baraga	6A Mason	7 Clay	7 Polk	3A Covington*
5A Barry	6A Mecosta	7 Clearwater	6A Pope	3A DeSoto
5A Bay	6A Menominee	7 Cook	6A Ramsey	3A Forrest*
6A Benzie	5A Midland	6A Cottonwood	7 Red Lake	3A Franklin*
5A Berrien	6A Missaukee	7 Crow Wing	6A Redwood	3A George*
5A Branch	5A Monroe	6A Dakota	6A Renville	3A Greene*
5A Calhoun	5A Montcalm	6A Dodge	6A Rice	3A Grenada
5A Cass	6A Montmorency	6A Douglas	6A Rock	2A Hancock*
6A Charlevoix	5A Muskegon	6A Faribault	7 Roseau	2A Harrison*
6A Cheboygan	6A Newaygo	6A Fillmore	6A Scott	3A Hinds*
7 Chippewa	5A Oakland	6A Freeborn	6A Sherburne	3A Holmes
6A Clare	6A Oceana	6A Goodhue	6A Sibley	3A Humphreys
5A Clinton	6A Ogemaw	7 Grant	6A Stearns	3A Issaquena
6A Crawford	7 Ontonagon	6A Hennepin	6A Steele	3A Itawamba
6A Delta	6A Osceola	6A Houston	6A Stevens	2A Jackson*
6A Dickinson	6A Oscoda	7 Hubbard	7 St. Louis	3A Jasper
5A Eaton	6A Otsego	6A Isanti	6A Swift	3A Jefferson*
6A Emmet	5A Ottawa	7 Itasca	6A Todd	3A Jefferson-Davis*
5A Genesee	6A Presque Isle	6A Jackson	6A Traverse	3A Jones*
6A Gladwin	6A Roscommon	7 Kanabec	6A Wabasha	3A Kemper
7 Gogebic	5A Saginaw	6A Kandiyohi	7 Wadena	3A Lafayette
6A Grand Traverse	6A Sanilac	7 Kittson	6A Waseca	3A Lamar*
5A Gratiot	7 Schoolcraft	7 Koochiching	6A Washington	3A Lauderdale
5A Hillsdale	5A Shiawassee	6A Lac qui Parle	6A Watonwan	3A Lawrence*
7 Houghton	5A St. Clair	7 Lake	7 Wilkin	3A Leake
6A Huron	5A St. Joseph	7 Lake of the Woods	6A Winona	3A Lee
5A Ingham	5A Tuscola	6A Le Sueur	6A Wright	3A Leflore
5A Ionia	5A Van Buren	6A Lincoln	6A Yellow	3A Lincoln*
6A Iosco	5A Washtenaw	6A Lyon	Medicine	3A Lowndes
7 Iron	5A Wayne	7 Mahanomen	<b>MISSISSIPPI</b>	3A Madison

6A Isabella	6A Wexford	7 Marshall		3A Marion*
5A Jackson		6A Martin	3A Adams*	3A Marshall
5A Kalamazoo	<b>MINNESOTA</b>	6A McLeod	3A Alcorn	3A Monroe
6A Kalkaska	7 Aitkin	6A Meeker	3A Amite*	3A Montgomery
5A Kent	6A Anoka	7 Mille Lacs	3A Attala	3A Neshoba
7 Keweenaw	7 Becker	6A Morrison	3A Benton	3A Newton
6A Lake	7 Beltrami	6A Mower	3A Bolivar	3A Noxubee
5A Lapeer	6A Benton	6A Murray	3A Calhoun	3A Oktibbeha
6A Leelanau	6A Big Stone	6A Nicollet	3A Carroll	3A Panola
5A Lenawee	6A Blue Earth	6A Nobles	3A Chickasaw	2A Pearl River*
5A Livingston	6A Brown	7 Norman	3A Choctaw	3A Perry*
7 Luce	7 Carlton	6A Olmsted	3A Claiborne*	3A Pike*

(continued)

TABLE R301.1—continued  
 CLIMATE ZONES, MOISTURE REGIMES, AND WARM HUMID-  
 DESIGNATIONS BY STATE, COUNTY AND TERRITORY

3A Pentotoc	5A Chariton	4A Mississippi	4A Webster	4A Cumberland
3A Prentiss	4A Christian	4A Moniteau	5A Worth	4A Essex
3A Quitman	5A Clark	4A Monroe	4A Wright	4A Gloucester
3A Rankin*	4A Clay	4A Montgomery	<b>MONTANA</b>	4A Hudson
3A Scott	5A Clinton	4A Morgan	6B (all)	5A Hunterdon
3A Sharkey	4A Cole	4A New Madrid	<b>NEBRASKA</b>	5A Mercer
3A Simpson*	4A Cooper	4A Newton	5A (all)	4A Middlesex
3A Smith*	4A Crawford	5A Nodaway	<b>NEVADA</b>	4A Monmouth
2A Stone*	4A Dade	4A Oregon	5B Carson City (city)	5A Morris
3A Sunflower	4A Dallas	4A Osage		4A Ocean
3A Tallahatchie	5A Daviess	4A Ozark		5A Passaic
3A Tate	5A DeKalb	4A Pemiscot		4A Salem

3A Tippah  
3A Tishomingo  
3A Tunica  
3A Union  
3A Walthall\*  
3A Warren\*  
3A Washington  
3A Wayne\*  
3A Webster  
3A Wilkinson\*  
3A Winston  
3A Yalobusha  
3A Yazoo

**MISSOURI**

5A Adair  
5A Andrew  
5A Atchison  
4A Audrain  
4A Barry  
4A Barton  
4A Bates  
4A Benton  
4A Bollinger  
4A Boone  
5A Buchanan  
4A Butler  
5A Caldwell  
4A Callaway  
4A Camden  
4A Cape Girardeau

4A Dent  
4A Douglas  
4A Dunklin  
4A Franklin  
4A Gasconade  
5A Gentry  
4A Greene  
5A Grundy  
5A Harrison  
4A Henry  
4A Hickory  
5A Holt  
4A Howard  
4A Howell  
4A Iron  
4A Jackson  
4A Jasper  
4A Jefferson  
4A Johnson  
5A Knox  
4A Laclede  
4A Lafayette  
4A Lawrence  
5A Lewis  
4A Lincoln  
5A Linn  
5A Livingston  
5A Macon  
4A Madison  
4A Maries  
5A Marion

4A Perry  
4A Pettis  
4A Phelps  
5A Pike  
4A Platte  
4A Polk  
4A Pulaski  
5A Putnam  
5A Ralls  
4A Randolph  
4A Ray  
4A Reynolds  
4A Ripley  
4A Saline  
5A Schuyler  
5A Scotland  
4A Scott  
4A Shannon  
5A Shelby  
4A St. Charles  
4A St. Clair  
4A Ste. Genevieve  
4A St. Francois  
4A St. Louis  
4A St. Louis (city)  
4A Stoddard  
4A Stone  
5A Sullivan  
4A Taney  
4A Texas  
4A Vernon

5B Churchill  
3B Clark  
5B Douglas  
5B Elke  
5B Esmeralda  
5B Eureka  
5B Humboldt  
5B Lander  
5B Lincoln  
5B Lyon  
5B Mineral  
5B Nye  
5B Pershing  
5B Storey  
5B Washoe  
5B White Pine

**NEW HAMPSHIRE**

6A Belknap  
6A Carroll  
5A Cheshire  
6A Coos  
6A Grafton  
5A Hillsborough  
6A Merrimack  
5A Rockingham  
5A Strafford  
6A Sullivan

**NEW JERSEY**

4A Atlantic

5A Somerset  
5A Sussex  
4A Union  
5A Warren

**NEW MEXICO**

4B Bernalillo  
5B Catron  
3B Chaves  
4B Cibola  
5B Colfax  
4B Curry  
4B DeBaca  
3B Dona Ana  
3B Eddy  
4B Grant  
4B Guadalupe  
5B Harding  
3B Hidalgo  
3B Lea  
4B Lincoln  
5B Los Alamos  
3B Luna  
5B McKinley  
5B Mora  
3B Otero  
4B Quay  
5B Rio Arriba  
4B Roosevelt  
5B Sandoval  
5B San Juan

4A Carroll	4A McDonald	4A Warren	5A Bergen	5B San Miguel
4A Carter	5A Mercer	4A Washington	4A Burlington	5B Santa Fe
4A Cass	4A Miller	4A Wayne	4A Camden	4B Sierra
4A Cedar			4A Cape May	4B Socorro

(continued)

TABLE R301.1—continued  
 CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID-  
 DESIGNATIONS BY STATE, COUNTY AND TERRITORY

5B Taos	4A Queens	4A Clay	4A Orange	7 Divide
5B Torrance	5A Rensselaer	4A Cleveland	3A Pamlico	6A Dunn
4B Union	4A Richmond	3A Columbus*	3A Pasquotank	7 Eddy
4B Valencia	5A Rockland	3A Craven	3A Pender*	6A Emmons
<b>NEW YORK</b>	5A Saratoga	3A Cumberland	3A Perquimans	7 Foster
	5A Schenectady	3A Currituck	4A Person	6A Golden Valley
5A Albany	6A Schoharie	3A Dare	3A Pitt	7 Grand Forks
6A Allegany	6A Schuyler	3A Davidson	4A Polk	6A Grant
4A Bronx	5A Seneca	4A Davie	3A Randolph	7 Griggs
6A Broome	6A Steuben	3A Duplin	3A Richmond	6A Hettinger
6A Cattaraugus	6A St. Lawrence	4A Durham	3A Robeson	7 Kidder
5A Cayuga	4A Suffolk	3A Edgecombe	4A Rockingham	6A LaMoure
5A Chautauqua	6A Sullivan	4A Forsyth	3A Rowan	6A Logan
5A Chemung	5A Tioga	4A Franklin	4A Rutherford	7 McHenry
6A Chenango	6A Tompkins	3A Gaston	3A Sampson	6A McIntosh
6A Clinton	6A Ulster	4A Gates	3A Scotland	6A McKenzie
5A Columbia	6A Warren	4A Graham	3A Stanly	7 McLean
5A Cortland	5A Washington	4A Granville	4A Stokes	6A Mercer
6A Delaware	5A Wayne	3A Greene	4A Surry	6A Morton
5A Dutchess	4A Westchester	4A Guilford	4A Swain	7 Mountrail

5A Erie  
6A Essex  
6A Franklin  
6A Fulton  
5A Genesee  
5A Greene  
6A Hamilton  
6A Herkimer  
6A Jefferson  
4A Kings  
6A Lewis  
5A Livingston  
6A Madison  
5A Monroe  
6A Montgomery  
4A Nassau  
4A New York  
5A Niagara  
6A Oneida  
5A Onondaga  
5A Ontario  
5A Orange  
5A Orleans  
5A Oswego  
6A Otsego  
5A Putnam

6A Wyoming  
5A Yates

**NORTH  
CAROLINA**

4A Alamance  
4A Alexander  
5A Alleghany  
3A Anson  
5A Ashe  
5A Avery  
3A Beaufort  
4A Bertie  
3A Bladen  
3A Brunswick\*  
4A Buncombe  
4A Burke  
3A Cabarrus  
4A Caldwell  
3A Camden  
3A Carteret\*  
4A Caswell  
4A Catawba  
4A Chatham  
4A Cherokee  
3A Chowan

4A Halifax  
4A Harnett  
4A Haywood  
4A Henderson  
4A Hertford  
3A Hoke  
3A Hyde  
4A Iredell  
4A Jackson  
3A Johnston  
3A Jones  
4A Lee  
3A Lenoir  
4A Lincoln  
4A Macon  
4A Madison  
3A Martin  
4A McDowell  
3A Mecklenburg  
5A Mitchell  
3A Montgomery  
3A Moore  
4A Nash  
3A New Hanover\*  
4A Northampton  
3A Onslow\*

*(continued)*

4A Transylvania  
3A Tyrrell  
3A Union  
4A Vance  
4A Wake  
4A Warren  
3A Washington  
5A Watauga  
3A Wayne  
4A Wilkes  
3A Wilson  
4A Yadkin  
5A Yancey

**NORTH DAKOTA**

6A Adams  
7 Barnes  
7 Benson  
6A Billings  
7 Bottineau  
6A Bowman  
7 Burke  
6A Burleigh  
7 Cass  
7 Cavalier  
6A Dickey

7 Nelson  
6A Oliver  
7 Pembina  
7 Pierce  
7 Ramsey  
6A Ransom  
7 Renville  
6A Richland  
7 Rolette  
6A Sargent  
7 Sheridan  
6A Sioux  
6A Slope  
6A Stark  
7 Steele  
7 Stutsman  
7 Towner  
7 Traill  
7 Walsh  
7 Ward  
7 Wells  
7 Williams

**OHIO**

4A Adams  
5A Allen

TABLE R301.1—continued  
 CLIMATE ZONES, MOISTURE REGIMES, AND WARM HUMID-  
 DESIGNATIONS BY STATE, COUNTY AND TERRITORY

5A Ashland	5A Mahoning	3A Bryan	3A Okfuskee	4C Linn
5A Ashtabula	5A Marion	3A Caddo	3A Oklahoma	5B Malheur
5A Athens	5A Medina	3A Canadian	3A Okmulgee	4C Marion
5A Auglaize	5A Meigs	3A Carter	3A Osage	5B Morrow
5A Belmont	5A Mercer	3A Cherokee	3A Ottawa	4C Multnomah
4A Brown	5A Miami	3A Choctaw	3A Pawnee	4C Polk
5A Butler	5A Monroe	4B Cimarron	3A Payne	5B Sherman
5A Carroll	5A Montgomery	3A Cleveland	3A Pittsburg	4C Tillamook
5A Champaign	5A Morgan	3A Coal	3A Pontotoc	5B Umatilla
5A Clark	5A Morrow	3A Comanche	3A Pottawatomie	5B Union
4A Clermont	5A Muskingum	3A Cotton	3A Pushmataha	5B Wallowa
5A Clinton	5A Noble	3A Craig	3A Roger Mills	5B Wasco
5A Columbiana	5A Ottawa	3A Creek	3A Rogers	4C Washington
5A Coshocton	5A Paulding	3A Custer	3A Seminole	5B Wheeler
5A Crawford	5A Perry	3A Delaware	3A Sequoyah	4C Yamhill
5A Cuyahoga	5A Pickaway	3A Dewey	3A Stephens	
5A Darke	4A Pike	3A Ellis	4B Texas	<b>PENNSYLVANIA</b>
5A Defiance	5A Portage	3A Garfield	3A Tillman	5A Adams
5A Delaware	5A Preble	3A Garvin	3A Tulsa	5A Allegheny
5A Erie	5A Putnam	3A Grady	3A Wagoner	5A Armstrong
5A Fairfield	5A Richland	3A Grant	3A Washington	5A Beaver
5A Fayette	5A Ross	3A Greer	3A Washita	5A Bedford
5A Franklin	5A Sandusky	3A Harmon	3A Woods	5A Berks
5A Fulton	4A Scioto	3A Harper	3A Woodward	5A Blair
4A Gallia	5A Seneca	3A Haskell		5A Bradford
5A Geauga	5A Shelby	3A Hughes	<b>OREGON</b>	4A Bucks

5A-Greene	5A-Stark	3A-Jackson	5B-Baker	5A-Butler
5A-Guernsey	5A-Summit	3A-Jefferson	4C-Benton	5A-Cambria
4A-Hamilton	5A-Trumbull	3A-Johnston	4C-Clackamas	6A-Cameron
5A-Hancock	5A-Tusecarawas	3A-Kay	4C-Clatsop	5A-Carbon
5A-Hardin	5A-Union	3A-Kingfisher	4C-Columbia	5A-Centre
5A-Harrison	5A-Van Wert	3A-Kiowa	4C-Coos	4A-Chester
5A-Henry	5A-Vinton	3A-Latimer	5B-Crook	5A-Clarion
5A-Highland	5A-Warren	3A-Le Flore	4C-Curry	6A-Clearfield
5A-Hocking	4A-Washington	3A-Lincoln	5B-Deschutes	5A-Clinton
5A-Holmes	5A-Wayne	3A-Logan	4C-Douglas	5A-Columbia
5A-Huron	5A-Williams	3A-Love	5B-Gilliam	5A-Crawford
5A-Jackson	5A-Wood	3A-Major	5B-Grant	5A-Cumberland
5A-Jefferson	5A-Wyandot	3A-Marshall	5B-Harney	5A-Dauphin
5A-Knox	<b>OKLAHOMA</b>	3A-Mayes	5B-Hood River	4A-Delaware
5A-Lake		3A-McClain	4C-Jackson	6A-Elk
4A-Lawrence	3A-Adair	3A-McCurtain	5B-Jefferson	5A-Eric
5A-Licking	3A-Alfalfa	3A-McIntosh	4C-Josephine	5A-Fayette
5A-Logan	3A-Atoka	3A-Murray	5B-Klamath	5A-Forest
5A-Lorain	4B-Beaver	3A-Muskogee	5B-Lake	5A-Franklin
5A-Lucas	3A-Beckham	3A-Noble	4C-Lane	5A-Fulton
5A-Madison	3A-Blaine	3A-Nowata	4C-Lincoln	5A-Greene

(continued)

TABLE R301.1—continued-  
 CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID-  
 DESIGNATIONS BY STATE, COUNTY AND TERRITORY

5A-Huntingdon	3A-Bamberg*	5A-Bennett	6A-Minnehaha	4A-Gibson
5A-Indiana	3A-Barnwell*	5A-Bon Homme	6A-Moody	4A-Giles
5A-Jefferson	3A-Beaufort*	6A-Brookings	6A-Pennington	4A-Grainger

5A Juniata  
5A Lackawanna  
5A Lancaster  
5A Lawrence  
5A Lebanon  
5A Lehigh  
5A Luzerne  
5A Lycoming  
6A McKean  
5A Mercer  
5A Mifflin  
5A Monroe  
4A Montgomery  
5A Montour  
5A Northampton  
5A Northumberland  
5A Perry  
4A Philadelphia  
5A Pike  
6A Potter  
5A Schuylkill  
5A Snyder  
5A Somerset  
5A Sullivan  
6A Susquehanna  
6A Tioga  
5A Union  
5A Venango  
5A Warren  
5A Washington  
6A Wayne

3A Berkeley\*  
3A Calhoun  
3A Charleston\*  
3A Cherokee  
3A Chester  
3A Chesterfield  
3A Clarendon  
3A Colleton\*  
3A Darlington  
3A Dillon  
3A Dorchester\*  
3A Edgefield  
3A Fairfield  
3A Florence  
3A Georgetown\*  
3A Greenville  
3A Greenwood  
3A Hampton\*  
3A Horry\*  
3A Jasper\*  
3A Kershaw  
3A Lancaster  
3A Laurens  
3A Lee  
3A Lexington  
3A Marion  
3A Marlboro  
3A McCormick  
3A Newberry  
3A Oconee  
3A Orangeburg

6A Brown  
6A Brule  
6A Buffalo  
6A Butte  
6A Campbell  
5A Charles Mix  
6A Clark  
5A Clay  
6A Codrington  
6A Corson  
6A Custer  
6A Davison  
6A Day  
6A Deuel  
6A Dewey  
5A Douglas  
6A Edmunds  
6A Fall River  
6A Faulk  
6A Grant  
5A Gregory  
6A Haakon  
6A Hamlin  
6A Hand  
6A Hanson  
6A Harding  
6A Hughes  
5A Hutchinson  
6A Hyde  
5A Jackson  
6A Jerauld

6A Perkins  
6A Potter  
6A Roberts  
6A Sanborn  
6A Shannon  
6A Spink  
6A Stanley  
6A Sully  
5A Todd  
5A Tripp  
6A Turner  
5A Union  
6A Walworth  
5A Yankton  
6A Ziebach

**TENNESSEE**

4A Anderson  
4A Bedford  
4A Benton  
4A Bledsoe  
4A Blount  
4A Bradley  
4A Campbell  
4A Cannon  
4A Carroll  
4A Carter  
4A Cheatham  
3A Chester  
4A Claiborne  
4A Clay

4A Greene  
4A Grundy  
4A Hamblen  
4A Hamilton  
4A Hancock  
3A Hardeman  
3A Hardin  
4A Hawkins  
3A Haywood  
3A Henderson  
4A Henry  
4A Hickman  
4A Houston  
4A Humphreys  
4A Jackson  
4A Jefferson  
4A Johnson  
4A Knox  
3A Lake  
3A Lauderdale  
4A Lawrence  
4A Lewis  
4A Lincoln  
4A Loudon  
4A Macon  
3A Madison  
4A Marion  
4A Marshall  
4A Maury  
4A McMinn  
3A McNairy

5A Westmoreland  
 5A Wyoming  
 4A York

**RHODE ISLAND**

5A (all)

**SOUTH CAROLINA**

3A Abbeville  
 3A Aiken  
 3A Allendale\*  
 3A Anderson

3A Pickens  
 3A Richland  
 3A Saluda  
 3A Spartanburg  
 3A Sumter  
 3A Union  
 3A Williamsburg  
 3A York

**SOUTH DAKOTA**

6A Aurora  
 6A Beadle

6A Jones  
 6A Kingsbury  
 6A Lake  
 6A Lawrence  
 6A Lincoln  
 6A Lyman  
 6A Marshall  
 6A McCook  
 6A McPherson  
 6A Meade  
 5A Mollette  
 6A Miner

4A Cocke  
 4A Coffee  
 3A Crockett  
 4A Cumberland  
 4A Davidson  
 4A Decatur  
 4A DeKalb  
 4A Dickson  
 3A Dyer  
 3A Fayette  
 4A Fentress  
 4A Franklin

4A Meigs  
 4A Monroe  
 4A Montgomery  
 4A Moore  
 4A Morgan  
 4A Obion  
 4A Overton  
 4A Perry  
 4A Pickett  
 4A Polk  
 4A Putnam  
 4A Rhea

(continued)

TABLE R301.1—continued  
 CLIMATE ZONES, MOISTURE REGIMES, AND WARM HUMID  
 DESIGNATIONS BY STATE, COUNTY AND TERRITORY

4A Roane  
 4A Robertson  
 4A Rutherford  
 4A Scott  
 4A Sequatchie  
 4A Sevier  
 3A Shelby  
 4A Smith  
 4A Stewart  
 4A Sullivan  
 4A Sumner  
 3A Tipton

3B Brewster  
 4B Briscoe  
 2A Brooks\*  
 3A Brown\*  
 2A Burlison\*  
 3A Burnet\*  
 2A Caldwell\*  
 2A Calhoun\*  
 3B Callahan  
 2A Cameron\*  
 3A Camp\*  
 4B Carson

3B Ector  
 2B Edwards\*  
 3A Ellis\*  
 3B El Paso  
 3A Erath\*  
 2A Falls\*  
 3A Fannin  
 2A Fayette\*  
 3B Fisher  
 4B Floyd  
 3B Foard  
 2A Fort Bend\*

3B Howard  
 3B Hudspeth  
 3A Hunt\*  
 4B Hutchinson  
 3B Irion  
 3A Jack  
 2A Jackson\*  
 2A Jasper\*  
 3B Jeff Davis  
 2A Jefferson\*  
 2A Jim Hogg\*  
 2A Jim Wells\*

3B McCulloch  
 2A McLennan\*  
 2A McMullen\*  
 2B Medina\*  
 3B Menard  
 3B Midland  
 2A Milam\*  
 3A Mills\*  
 3B Mitchell  
 3A Montague  
 2A Montgomery\*  
 4B Moore

4A Trousdale  
4A Unicoi  
4A Union  
4A Van Buren  
4A Warren  
4A Washington  
4A Wayne  
4A Weakley  
4A White  
4A Williamson  
4A Wilson

**TEXAS**

2A Anderson\*  
3B Andrews  
2A Angelina\*  
2A Aransas\*  
3A Archer  
4B Armstrong  
2A Atascosa\*  
2A Austin\*  
4B Bailey  
2B Bandera\*  
2A Bastrop\*  
3B Baylor  
2A Bee\*  
2A Bell\*  
2A Bexar\*  
3A Blanco\*  
3B Borden  
2A Bosque\*

3A Cass\*  
4B Castro  
2A Chambers\*  
2A Cherokee\*  
3B Childress  
3A Clay  
4B Cochran  
3B Coke  
3B Coleman  
3A Collin\*  
3B Collingsworth  
2A Colorado\*  
2A Comal\*  
3A Comanche\*  
3B Concho  
3A Cooke  
2A Coryell\*  
3B Cottle  
3B Crane  
3B Crockett  
3B Crosby  
3B Culberson  
4B Dallam  
3A Dallas\*  
3B Dawson  
4B Deaf Smith  
3A Delta  
3A Denton\*  
2A DeWitt\*  
3B Dickens  
2B Dimmit\*

3A Franklin\*  
2A Freestone\*  
2B Frio\*  
3B Gaines  
2A Galveston\*  
3B Garza  
3A Gillespie\*  
3B Glasscock  
2A Goliad\*  
2A Gonzales\*  
4B Gray  
3A Grayson  
3A Gregg\*  
2A Grimes\*  
2A Guadalupe\*  
4B Hale  
3B Hall  
3A Hamilton\*  
4B Hansford  
3B Hardeman  
2A Hardin\*  
2A Harris\*  
3A Harrison\*  
4B Hartley  
3B Haskell  
2A Hays\*  
3B Hemphill  
3A Henderson\*  
2A Hidalgo\*  
2A Hill\*  
4B Hockley

3A Johnson\*  
3B Jones  
2A Karnes\*  
3A Kaufman\*  
3A Kendall\*  
2A Kenedy\*  
3B Kent  
3B Kerr  
3B Kimble  
3B King  
2B Kinney\*  
2A Kleberg\*  
3B Knox  
3A Lamar\*  
4B Lamb  
3A Lampasas\*  
2B La Salle\*  
2A Lavaca\*  
2A Lee\*  
2A Leon\*  
2A Liberty\*  
2A Limestone\*  
4B Lipscomb  
2A Live Oak\*  
3A Llano\*  
3B Loving  
3B Lubbock  
3B Lynn  
2A Madison\*  
3A Marion\*  
3B Martin

3A Morris\*  
3B Motley  
3A Nacogdoches\*  
3A Navarro\*  
2A Newton\*  
3B Nolan  
2A Nueces\*  
4B Ochiltree  
4B Oldham  
2A Orange\*  
3A Palo Pinto\*  
3A Panola\*  
3A Parker\*  
4B Parmer  
3B Pecos  
2A Polk\*  
4B Potter  
3B Presidio  
3A Rains\*  
4B Randall  
3B Reagan  
2B Real\*  
3A Red River\*  
3B Reeves  
2A Refugio\*  
4B Roberts  
2A Robertson\*  
3A Rockwall\*  
3B Runnels  
3A Rusk\*  
3A Sabine\*

3A Bowie*	4B-Denley	3A Hood*	3B Mason	3A San-Augustine*
2A Brazoria*	2A-Duval*	3A Hopkins*	2A Matagorda*	2A San-Jacinto*
2A Brazos*	3A-Eastland	2A-Houston*	2B-Maverick*	2A San-Patricio*

(continued)

TABLE R301.1—continued  
 CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID-  
 DESIGNATIONS BY STATE, COUNTY AND TERRITORY

3A San-Saba*	3A-Young	4C-Clark	4A-Gilmer	<b>WISCONSIN</b>
3B-Schleicher	2B-Zapata*	5B-Columbia	5A-Grant	6A-Adams
3B-Scurry	2B-Zavala*	4C-Cowlitz	5A-Greenbrier	7-Ashland
3B-Shackelford	<b>UTAH</b>	5B-Douglas	5A-Hampshire	6A-Barron
3A-Shelby*	5B-Beaver	6B-Ferry	5A-Hancock	7-Bayfield
4B-Sherman	6B-Box-Elder	5B-Franklin	5A-Hardy	6A-Brown
3A-Smith*	6B-Cache	5B-Garfield	5A-Harrison	6A-Buffer
3A-Somervell*	6B-Carbon	5B-Grant	4A-Jackson	7-Burnett
2A-Starr*	6B-Daggett	4C-Grays-Harbor	4A-Jefferson	6A-Calumet
3A-Stephens	5B-Davis	4C-Island	4A-Kanawha	6A-Chippewa
3B-Sterling	6B-Duchesne	4C-Jefferson	5A-Lewis	6A-Clark
3B-Stonewall	5B-Emery	4C-King	4A-Lincoln	6A-Columbia
3B-Sutton	5B-Garfield	4C-Kitsap	4A-Logan	6A-Crawford
4B-Swisher	5B-Grand	5B-Kittitas	5A-Marion	6A-Dane
3A-Tarrant*	5B-Iron	5B-Klickitat	5A-Marshall	6A-Dodge
3B-Taylor	5B-Juab	4C-Lewis	4A-Mason	6A-Deer
3B-Terrell	5B-Kane	5B-Lincoln	4A-McDowell	7-Douglas
3B-Terry	5B-Millard	4C-Mason	4A-Mercer	6A-Dunn
3B-Throckmorton	6B-Morgan	6B-Okanogan	5A-Mineral	6A-Eau-Claire
3A-Titus*	5B-Piute	4C-Pacific	4A-Mingo	7-Florence
3B-Tom-Green		6B-Pend-Oreille	5A-Monongalia	

2A Travis\*  
2A Trinity\*  
2A Tyler\*  
3A Upshur\*  
3B Upton  
2B Uvalde\*  
2B Val Verde\*  
3A Van Zandt\*  
2A Victoria\*  
2A Walker\*  
2A Waller\*  
3B Ward  
2A Washington\*  
2B Webb\*  
2A Wharton\*  
3B Wheeler  
3A Wichita  
3B Wilbarger  
2A Willacy\*  
2A Williamson\*  
2A Wilson\*  
3B Winkler  
3A Wise  
3A Wood\*  
4B Yeakum

6B Rich  
5B Salt Lake  
5B San Juan  
5B Sanpete  
5B Sevier  
6B Summit  
5B Tooele  
6B Uintah  
5B Utah  
6B Wasatch  
3B Washington  
5B Wayne  
5B Weber  
**VERMONT**  
6A (all)  
**VIRGINIA**  
4A (all)  
**WASHINGTON**  
5B Adams  
5B Asotin  
5B Benton  
5B Chelan  
4C Clallam

4C Pierce  
4C San Juan  
4C Skagit  
5B Skamania  
4C Snohomish  
5B Spokane  
6B Stevens  
4C Thurston  
4C Wahkiakum  
5B Walla Walla  
4C Whatcom  
5B Whitman  
5B Yakima  
**WEST VIRGINIA**  
5A Barbour  
4A Berkeley  
4A Boone  
4A Braxton  
5A Brooke  
4A Cabell  
4A Calhoun  
4A Clay  
5A Doddridge  
5A Fayette

(continued)

4A Monroe  
4A Morgan  
5A Nicholas  
5A Ohio  
5A Pendleton  
4A Pleasants  
5A Pocahontas  
5A Preston  
4A Putnam  
5A Raleigh  
5A Randolph  
4A Ritchie  
4A Roane  
5A Summers  
5A Taylor  
5A Tucker  
4A Tyler  
5A Upshur  
4A Wayne  
5A Webster  
5A Wetzol  
4A Wirt  
4A Wood  
4A Wyoming

6A Fond du Lac  
7 Forest  
6A Grant  
6A Green  
6A Green Lake  
6A Iowa  
7 Iron  
6A Jackson  
6A Jefferson  
6A Juneau  
6A Kenosha  
6A Kewaunee  
6A La Crosse  
6A Lafayette  
7 Langlade  
7 Lincoln  
6A Manitowee  
6A Marathon  
6A Marinette  
6A Marquette  
6A Menominee  
6A Milwaukee  
6A Monroe  
6A Oconto  
7 Oneida  
6A Outagamie

~~TABLE R301.1—continued~~  
~~CLIMATE ZONES, MOISTURE REGIMES, AND WARM HUMID-~~  
~~DESIGNATIONS BY STATE, COUNTY AND TERRITORY~~

6A Ozaukee	7 Taylor	6B Big Horn	6B Sheridan	<b>NORTHERN-</b>
6A Pepin	6A Trempealeau	6B Campbell	7 Sublette	<b>MARIANA-</b>
6A Pierce	6A Vernon	6B Carbon	6B Sweetwater	<b>ISLANDS</b>
6A Polk	7 Vilas	6B Converse	7 Teton	1A (all)*
6A Portage	6A Walworth	6B Crook	6B Uinta	<b>PUERTO RICO</b>
7 Price	7 Washburn	6B Fremont	6B Washakie	1A (all)*
6A Racine	6A Washington	5B Goshen	6B Weston	<b>VIRGIN ISLANDS</b>
6A Richland	6A Waukesha	6B Hot Springs		
6A Rock	6A Waupaca	6B Johnson	<b>US TERRITORIES</b>	1A (all)*
6A Rusk	6A Waushara	6B Laramie	<b>AMERICAN-</b>	
6A Sauk	6A Winnebago	7 Lincoln	<b>SAMOA</b>	
7 Sawyer	6A Wood	6B Natrona	1A (all)*	
6A Shawano	<b>WYOMING</b>	6B Niobrara	<b>GUAM</b>	
6A Sheboygan		6B Park		
6A St. Croix	6B Albany	5B Platte	1A (all)*	

**R301.2 Warm humid counties—**

Warm humid counties are identified in Table R301.1 by an asterisk.

**R301.3 International climate zones—**

The climate zone for any location outside the United States shall be determined by applying Table R301.3(1) and then Table R301.3(2).

~~TABLE R301.3(1)~~  
~~INTERNATIONAL 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:	
Not marine and $P_{in} < 0.44 \times (TF - 19.5)$ [ $P_{in} < 2.0 \times (TC + 7)$ in SI units]	
where:	
$P_{in}$ = Annual precipitation in inches (cm)	
$T$ = Annual mean temperature in °F (°C)	
Moist (A) Definition—Locations that are not marine and not dry.	
Warm humid Definition—Moist (A) locations where either of the following wet bulb temperature conditions shall occur during the warmest six consecutive months of the year:	
1.	67°F (19.4°C) or higher for 3,000 or more hours; or
2.	73°F (22.8°C) or higher for 1,500 or more hours.
For SI: °C = [(°F) - 32]/1.8, 1 inch = 2.54 cm.	

TABLE R301.3(2)  
INTERNATIONAL CLIMATE ZONE DEFINITIONS

ZONE NUMBER	THERMAL CRITERIA	
	IP Units	SI Units
1	9000 < CDD50°F	5000 < CDD10°C
2	6300 < CDD50°F ≤ 9000	3500 < CDD10°C ≤ 5000
3A and 3B	4500 < CDD50°F ≤ 6300 AND HDD65°F ≤ 5400	2500 < CDD10°C ≤ 3500 AND HDD18°C ≤ 3000
4A and 4B	CDD50°F ≤ 4500 AND HDD65°F ≤ 5400	CDD10°C ≤ 2500 AND HDD18°C ≤ 3000
3C	HDD65°F ≤ 3600	HDD18°C ≤ 2000
4C	3600 < HDD65°F ≤ 5400	2000 < HDD18°C ≤ 3000
5	5400 < HDD65°F ≤ 7200	3000 < HDD18°C ≤ 4000

6	7200 < HDD65°F ≤ 9000	4000 < HDD18°C ≤ 5000
7	9000 < HDD65°F ≤ 12600	5000 < HDD18°C ≤ 7000
8	12600 < HDD65°F	7000 < HDD18°C

For SI: °C = [(°F) - 32] / 1.8.

**SECTION R3012  
DESIGN CONDITIONS**

**R3012.1 Interior design conditions.**

The interior design temperatures used for heating and cooling load calculations shall be a maximum of 70~~2~~<sup>2</sup>°F (21~~2~~<sup>2</sup>°C) for heating and minimum of 75°F (24°C) for cooling.

**SECTION R3023  
MATERIALS, SYSTEMS AND EQUIPMENT**

**R3023.1 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.

**R3023.1.1 Building thermal envelope insulation.**

An *R*-value identification mark shall be applied by the manufacturer to each piece of *building thermal envelope* insulation 12 inches (305 mm) or greater in width. Alternately, 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 thickness shall be *listed* on the certification. The insulation installer shall sign, date and post the certification in a conspicuous location on the job site.

**R3023.1.1.1 Blown or sprayed roof/ceiling insulation.**

The thickness of blown-in or sprayed roof/ceiling insulation (fiberglass or cellulose) shall be written in inches (mm) on markers that

are installed at least one for every 300 square feet (28 m<sup>2</sup>) throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers a minimum of 1 inch (25 mm) in height. Each marker shall face the attic access opening. Spray polyurethane foam thickness and installed *R-value shall be listed on certification provided by the insulation installer.*

**R3023.1.2 Insulation mark installation.**

Insulating materials shall be installed such that the manufacturer's *R-value mark is readily observable upon inspection.*

**R3023.1.3 Fenestration product rating.**

*U*-factors of fenestration products (windows, doors and skylights) shall be determined in accordance with NFRC 100 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 R3023.1.3(1) or R3023.1.3(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 R3023.1.3(3).

TABLE R3023.1.3(1)  
DEFAULT GLAZED FENESTRATION *U*-FACTOR

FRAME TYPE	SINGLE PANE	DOUBLE PANE	SKYLIGHT	
			Single	Double
Metal	1.20	0.80	2.00	1.30
Metal with Thermal Break	1.10	0.65	1.90	1.10
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05
Glazed Block	0.60			

TABLE R3023.1.3(2)  
 DEFAULT DOOR *U*-FACTORS

DOOR TYPE	<i>U</i> -FACTOR
Uninsulated Metal	1.20
Insulated Metal	0.60
Wood	0.50
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	0.35

TABLE R3023.1.3(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

**R3023.1.4 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  $h \times ft^2 \times ^\circ F/Btu$  at a mean temperature of 75°F (24°C).

**R3023.2 Installation.**

All materials, systems and equipment shall be installed in accordance with the manufacturer's installation instructions and the *International Building Code* or *International Residential Code*, as applicable.

**R3023.2.1 Protection of exposed foundation insulation.**

Insulation applied to the exterior of basement walls, crawlspace 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 a minimum of 6 inches (153 mm) below grade.

**R3023.3 Maintenance information.**

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

## CHAPTER 4 [RE] RESIDENTIAL ENERGY EFFICIENCY

### SECTION R401 GENERAL

#### R401.1 Scope.

This chapter applies to residential buildings.

#### R401.2 Compliance. (Mandatory)

##### R401.2.1 New buildings.

New buildings with a floor area of less than 500 square feet shall comply with all mandatory and prescriptive requirements in this chapter. New buildings with a floor area of 500 square feet or larger shall comply with all mandatory requirements of this chapter and are required to achieve the applicable *Energy Rating Index* (ERI) established below in this section and shown in Table R401.2.1. The applicable *energy rating index* shall be determined in accordance with the ANSI/RESNET/ICC 301-2014 Standard and is based on floor area.<sup>1</sup>

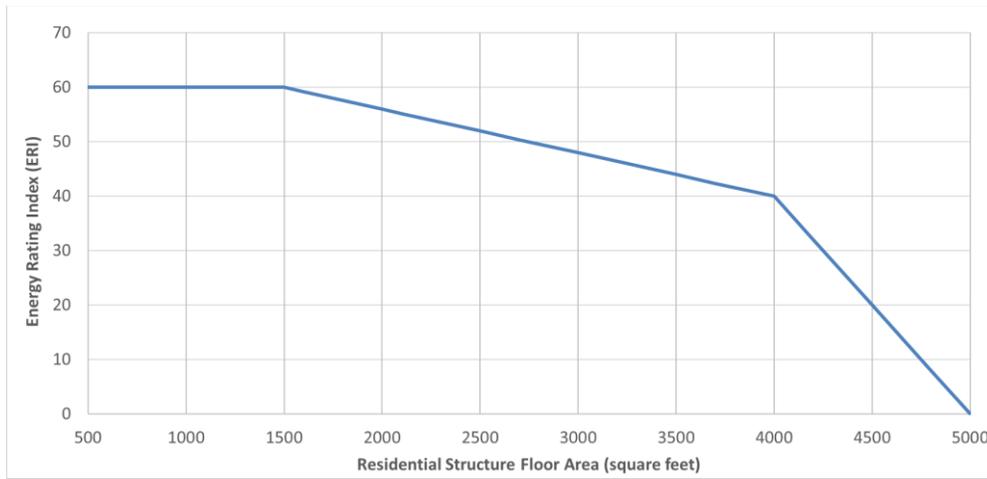
1. Floor area of 500 to 1,499 square feet (SQFT): ERI = 60
2. Floor area of 1,500 to 3,999 square feet: ERI = 60 – (SQFT floor area – 1,500) \* 0.008
3. Floor area of 4,000 to 4,999 square feet: ERI = 40 – (SQFT floor area – 4,000) \* 0.04

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<sup>1</sup> The exact energy rating index requirements may be calculated using the City of Boulder ERI Worksheet for New Buildings by entering the building floor area. The City of Boulder ERI Worksheet for New Buildings can be found on the City of Boulder website. (The total value of work covered by the permit, to be determined consistent with the standards of Subsection 4-20-4(d), B.R.C. 1981. The higher of the two valuations considered under Subsection 4-20-4(d), B.R.C. 1981, shall be the total value of work.

4. Floor area  $\geq$  5,000 square feet: ERI = 0

**TABLE R401.2.1 ENERGY RATING INDEX REQUIREMENTS FOR NEW RESIDENTIAL BUILDINGS**



Where meeting the required ERI on the property of the building is practically infeasible, the code official shall have the authority to approve purchase of a solar garden subscription to achieve the required ERI provided that:

1. The contract for *community solar* garden subscription is at least 20 years in duration.
2. The property of the building shall be identified in the contract as the physical location to which the subscription is attributed.
3. The subscription is of a size that is required to meet the applicable ERI under this code. The submittal document for such request shall include a report and analysis by a registered design professional demonstrating the capacity of on-site solar photovoltaic

panels necessary to achieve the applicable ERI rating. That capacity is the size of the *community solar garden* subscription that must be purchased to meet the requirements of this chapter.

The building shall remain the location to which the community solar garden electricity generation of that subscription is attributed.

Within seven days of request by the city manager, the owner of the property shall provide proof of the continuing subscription to a community solar garden attributed to the property that is required to meet the energy efficiency standards of this chapter. Failure to provide such proof shall constitute a violation under the Boulder Revised Code.

In an administrative enforcement action, evidence of failure of the owner of the property to provide proof to the city manager of a continuing subscription to a community solar garden as required for the building to meet the requirements of this chapter shall constitute prima facie evidence that such owner violated the provisions of this section.

#### **R401.2.2 Additions.**

Additions to an existing structure must comply with all mandatory requirements of this chapter and also the following:

1. **Floor area < 1,000 square feet:** If the floor area is less than 1,000 square feet, the addition shall comply with all mandatory and prescriptive requirements in this chapter.
2. **Floor area ≥ 1,000 square feet:** If the floor area is 1,000 square feet or larger, the entire structure (the addition and the existing structure) shall meet the ERI requirement which shall be calculated consistent with the following<sup>2</sup>:

$$2.1 \text{ ERI} = 115 - (\text{points per SQFT floor area}) - (\text{points per \% increase in floor area})$$

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<sup>2</sup> The exact energy rating index requirements may be calculated using the City of Boulder ERI Worksheet for Additions by entering the existing square footage and the square footage of the proposed addition. The City of Boulder ERI Worksheet for Additions can be found on the City of Boulder website. *(add URL here)*

2.2 The ERI (points per SQFT floor area) shall be established consistent with the requirements of Table R401.2.2.2(1). The point values of Table R401.2.2.2(1) are applied in ranges and only within those ranges. For example, for a home with a total conditioned square footage of 2200 square feet, the first 1999 square feet would have 0.016 ERI points per square foot while the next 200 square feet or would have 0.007 ERI points per square foot.

2.3 The ERI points for each percentage of increase in square footage shall be established consistent with the requirements of Table R401.2.2.2(2). The point values of Table R401.2.2.2(2) are applied in ranges and only within those ranges. For example, an addition which creates a 30 percent increase in square footage will have 24 percent of the increase associated with 80 points and the next 6 percent of increase associated with 10 ERI points per percentage increase.

2.4 The applicable ERI shall be determined in accordance with the ANSI/RESNET/ICC 301-2014 Standard.

2.5 Table R401.2.2.2(3) summarizes the ERI requirements, but is illustrative only as it does not show the applicable ERI for all possible scenarios.

**TABLE R401.2.2.2(1) ERI POINTS PER SQFT FLOOR AREA**

<b><u>Floor Area Range (SQFT)</u></b>	<b><u>ERI Points per SQFT</u></b>
1,000 to 1,999	0.016
2,000 to 3,999	0.007
≥ 4,000	0.019

**TABLE R401.2.2.2(2) ERI POINTS PER ONE PERCENT INCREASE IN SQUARE FEET**

<b><u>% of Addition to Total Finished Floor Area (less than %)</u></b>	<b><u>ERI Points per SQFT</u></b>
25%	80

75%	10
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**TABLE R401.2.2(3) SUMMARY TABLE OF ENERGY RATING INDEX REQUIREMENTS FOR EXISTING STRUCTURES TO WHICH AN ADDITION IS ADDED (ILLUSTRATIVE ONLY)**

		Percent of Increase in Square Feet																			
		5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Total Proposed Square Feet	54	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	500	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	750	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	1000	95	91	87	83	79	79	78	78	77	77	76	76	75	75	74	73	73	72	71	70
	1250	91	87	83	79	75	75	74	74	73	73	72	72	71	71	70	69	69	68	67	66
	1500	87	83	79	75	71	71	70	70	69	69	68	68	67	67	66	65	65	64	63	62
	1750	83	79	75	71	67	67	66	66	65	65	64	64	63	63	62	61	61	60	59	58
	2000	79	75	71	67	63	63	62	62	61	61	60	60	59	59	58	57	57	56	55	54
	2250	77	73	69	65	61	61	60	60	59	59	58	58	57	57	56	56	55	54	53	53
	2500	76	72	68	64	60	59	59	58	58	57	57	56	56	55	55	54	53	52	52	51
	2750	74	70	66	62	58	57	57	56	56	55	55	54	54	53	53	52	51	51	50	49
	3000	72	68	64	60	56	56	55	55	54	54	53	53	52	52	51	50	50	49	48	47
	3250	70	66	62	58	54	54	53	53	52	52	51	51	50	50	49	49	48	47	46	46
	3500	69	65	61	57	53	52	52	51	51	50	50	49	49	48	48	47	46	45	45	44
3750	67	63	59	55	51	50	50	49	49	48	48	47	47	46	46	45	44	44	43	42	
4000	65	61	57	53	49	48	48	47	47	46	46	45	45	44	44	43	42	42	41	40	

<u>4250</u>	<u>60</u>	<u>56</u>	<u>52</u>	<u>48</u>	<u>44</u>	<u>44</u>	<u>43</u>	<u>43</u>	<u>42</u>	<u>42</u>	<u>41</u>	<u>41</u>	<u>40</u>	<u>40</u>	<u>39</u>	<u>38</u>	<u>38</u>	<u>37</u>	<u>36</u>	<u>35</u>
<u>4500</u>	<u>55</u>	<u>51</u>	<u>47</u>	<u>43</u>	<u>39</u>	<u>39</u>	<u>38</u>	<u>38</u>	<u>37</u>	<u>37</u>	<u>36</u>	<u>36</u>	<u>35</u>	<u>35</u>	<u>34</u>	<u>34</u>	<u>33</u>	<u>32</u>	<u>31</u>	<u>31</u>
<u>4750</u>	<u>51</u>	<u>47</u>	<u>43</u>	<u>39</u>	<u>35</u>	<u>34</u>	<u>34</u>	<u>33</u>	<u>33</u>	<u>32</u>	<u>32</u>	<u>31</u>	<u>31</u>	<u>30</u>	<u>30</u>	<u>29</u>	<u>28</u>	<u>27</u>	<u>27</u>	<u>26</u>
<u>5000</u>	<u>46</u>	<u>42</u>	<u>38</u>	<u>34</u>	<u>30</u>	<u>29</u>	<u>29</u>	<u>28</u>	<u>28</u>	<u>27</u>	<u>27</u>	<u>26</u>	<u>26</u>	<u>25</u>	<u>25</u>	<u>24</u>	<u>23</u>	<u>23</u>	<u>22</u>	<u>21</u>

\*NR = Not  
Required

**R401.2.3 Alterations or repairs.**

Alterations and repairs to existing buildings shall comply with all mandatory requirements of this chapter and the prescriptive requirements established in Table R401.2.3, which are determined by construction valuation.

**TABLE R401.2.3 ENERGY EFFICIENCY REQUIREMENTS FOR ALTERATIONS AND REPAIRS TO EXISTING BUILDINGS**

<u>Thresholds for requirements</u>	<u>Construction valuation is ≤25% of assessed value<sup>1</sup> of existing building</u>	<u>Construction valuation is 26-50% of assessed value<sup>1</sup> of existing building</u>	<u>Construction valuation is ≥51% of assessed value<sup>1</sup> of existing building</u>
<b><u>Requirements</u></b>	<u>All energy and building code requirements (for the scope of the alteration)</u>		
	<u>Energy advising<sup>2</sup></u>	<u>Energy assessment<sup>3</sup> and energy advising</u>	<u>Triggers new construction requirements</u>
		<u>Air sealing and insulation in ceiling and walls<sup>4</sup></u>	
		<u>Crawl space insulation, vapor barrier, and ventilation<sup>4</sup></u>	

<sup>1</sup> Assessed value is obtained from Boulder County's Tax Assessor Database.

<sup>2</sup> Homeowner must contact a qualified energy advisor, as defined by the city manager, and discuss the construction project to learn how efficiency opportunities can be maximized.

<sup>3</sup> Homeowner must obtain an energy assessment for the building from a qualified energy assessor, as defined by the city manager, before building permit application.

<sup>4</sup> When applicable shall meet the requirements in this code.

Projects shall comply with Sections identified as "mandatory" and with either sections identified as "prescriptive" or the performance approach in Section R405.

#### **R401.3 Documentation Certificate (Mandatory).**

##### **R401.3.1 Certificate.**

A permanent certificate shall be completed and posted on or in the electrical distribution panel by the builder or registered design professional. The certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. The certificate shall list the predominant *R*-values of insulation installed in or on ceiling/roof, walls, foundation (slab, *basement wall*, crawlspace wall and/or floor) and ducts outside conditioned spaces; *U*-factors for fenestration and the solar heat gain coefficient (SHGC) of fenestration, and the results from any required duct system and building envelope air leakage testing done on the building. Where there is more than one value for each component, the certificate shall list the value covering the largest area. The certificate shall list 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 list "gas-fired unvented room heater," "electric furnace" or "baseboard electric heater," as appropriate. An efficiency shall not be *listed* for gas-fired unvented room heaters, electric furnaces or electric baseboard heaters.

##### **R401.3.2 Homeowner manual.**

The builder or owner's agent shall provide the owner with a binder of all equipment and appliance manufacturers' installation manuals, except for manuals that are required to be affixed to the equipment. This includes the EnergySmart Assessment Report and/or ERI certificate. If the building official approved a community solar garden subscription attributed to the property as a means to meet the

requirements of this chapter, the manual shall include any requirements for a continued subscription to a community solar garden necessary to meet the requirements of this chapter.

**SECTION R402  
BUILDING THERMAL ENVELOPE**

**R402.1 General (Prescriptive).**

The *building thermal envelope* shall meet the requirements of Sections R402.1.1 through R402.1.4.

**R402.1.1 Insulation and fenestration criteria.**

The *building thermal envelope* shall meet the requirements of Table R402.1.1 based on the climate zone specified in Chapter 3.

TABLE R402.1.1  
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT<sup>a</sup>

CLIMATE ZONE	FENESTRATION U-FACTOR <sup>b</sup>	SKYLIGHT <sup>b</sup> U-FACTOR	GLAZED FENESTRATION SHGC <sup>b,c</sup>	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE <sup>e</sup>	FLOOR R-VALUE	BASEMENT <sup>c</sup> WALL R-VALUE	SLAB <sup>b</sup> R-VALUE & DEPTH	CRAWL SPACE <sup>c</sup> WALL R-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.35	0.55	0.25	38	20 or 13+5 <sup>h</sup>	8/13	19	5/13 <sup>i</sup>	0	5/13
4 except Marine	0.35	0.55	0.40	49	20 or 13+5 <sup>h</sup>	8/13	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.30 <sup>2</sup>	0.55	NR	49	20 or 13+5 <sup>h</sup>	13/17	30 <sup>g</sup>	15/19	10, 2 ft	15/19
6	0.32	0.55	NR	49	20+5 or 13+10 <sup>h</sup>	15/20	30 <sup>g</sup>	15/19	10, 4 ft	15/19
7 and 8	>0.32	0.55	NR	49	20+5 or 13+10 <sup>h</sup>	19/21	38 <sup>g</sup>	15/19	10, 4 ft	15/19

**Commented [TK11]:** For ICC: Please remove all references to CZs and just remake this table with the requirements for CZ5B

<sup>a</sup>For SI: 1 foot = 304.8 mm.

- a. *R*-values are minimums. *U*-factors and SHGC are maximums. When insulation is installed in a cavity which is less than the label or design thickness of the insulation, the installed *R*-value of the insulation shall not be less than the *R*-value specified in the table.
- b. The fenestration *U-factor* column excludes skylights. The SHGC column applies to all glazed fenestration. ~~Exception: Skylights may be excluded from glazed fenestration SHGC requirements in Climate Zones 1 through 3 where the SHGC for such skylights does not exceed 0.30.~~
- c. "15/19" means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. "15/19" shall be permitted to be met with R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the home. "10/13" means R-10 continuous insulation on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall.
- d. R-5 shall be added to the required slab edge *R*-values for heated slabs. ~~Insulation depth shall be the depth of the footing or 2 feet, whichever is less in Climate Zones 1 through 3 for heated slabs.~~
- e. There are no SHGC requirements in the Marine Zone.
- f. ~~Basement wall insulation is not required in warm-humid locations as defined by Figure R301.1 and Table R301.1.~~
- g. Or insulation sufficient to fill the framing cavity, R-19 minimum.
- g. First value is cavity insulation, second is continuous insulation or insulated siding, so "13+5" means R-13 cavity insulation plus R-5 continuous insulation or insulated siding. If structural sheathing covers 40 percent or less of the exterior, continuous insulation *R*-value shall be permitted to be reduced by no more than R-3 in the locations where structural sheathing is used – to maintain a consistent total sheathing thickness.
- h. The second *R*-value applies when more than half the insulation is on the interior of the mass wall.

**R402.1.2 *R*-value computation.**

Insulation material used in layers, such as framing cavity insulation and insulating sheathing, shall be summed to compute the component *R*-value. The manufacturer's settled *R*-value shall be used for blown insulation. Computed *R*-values shall not include an *R*-value for other building materials or air films.

**R402.1.3 *U*-factor alternative.**

An assembly with a *U*-factor equal to or less than that specified in Table R402.1.3 shall be permitted as an alternative to the *R*-value in Table R402.1.1.

TABLE R402.1.3  
EQUIVALENT U-FACTORS

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CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	FRAME WALL U-FACTOR	MASS WALL U-FACTOR <sup>a</sup>	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR	CRAWL SPACE WALL U-FACTOR
1	0.50	0.75	0.035	0.082	0.197	0.064	0.360	0.477
2	0.40	0.65	0.030	0.082	0.165	0.064	0.360	0.477
3	0.35	0.55	0.030	0.057	0.098	0.047	0.091 <sup>c</sup>	0.136
4 except Marine	0.35	0.55	0.026	0.057	0.098	0.047	0.059	0.065
5 and Marine 4	0.30 <sup>2</sup>	0.55	0.026	0.057	0.082	0.033	0.050	0.055
6	0.32	0.55	0.026	0.048	0.060	0.033	0.050	0.055
7 and 8	0.32	0.55	0.026	0.048	0.057	0.028	0.050	0.055

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.

b. When more than half the insulation is on the interior, the mass wall *U*-factors shall be a maximum of 0.17 in Climate Zone 1, 0.14 in Climate Zone 2, 0.12 in Climate Zone 3, 0.087 in Climate Zone 4 except Marine, 0.065 in Climate Zone 5 and Marine 4, and 0.057 in Climate Zones 6 through 8.

c. Basement wall *U*-factor of 0.360 in warm-humid locations as defined by Figure R301.1 and Table R301.1.

**R402.1.4 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 R402.1.3 (multiplied by the same assembly area as in the proposed building), the building shall be considered in compliance with Table R402.1.1. 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 R402.2.12.

**R402.2.1 Ceilings with attic spaces.**

When Section R402.1.1 would require R-38 in the ceiling, R-30 shall be deemed to satisfy the requirement for R-38 wherever the full height of uncompressed R-30 insulation extends over the wall top plate at the eaves. Similarly, R-38 shall be deemed to satisfy the

requirement for R-49 wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves. This reduction shall not apply to the *U*-factor alternative approach in Section R402.1.3 and the total UA alternative in Section R402.1.4.

#### **R402.2.2 Ceilings without attic spaces.**

Where Section R402.1.1 would require insulation levels above R-30 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-30. This reduction of insulation from the requirements of Section R402.1.1 shall be limited to 500 square feet (46 m<sup>2</sup>) 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 R402.1.3 and the total UA alternative in Section R402.1.4.

#### **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 (e.g., attics and crawl spaces) shall be weatherstripped and insulated to a level equivalent to the insulation on the surrounding surfaces. Access shall be provided to all equipment that prevents damaging or compressing the insulation. A wood framed or equivalent baffle or retainer is required to be provided when loose fill insulation is installed, the purpose of which is to prevent the loose fill insulation from spilling into the living space when the attic access is opened, and to provide a permanent means of maintaining the installed *R-value of the loose fill insulation*.

#### **R402.2.5 Mass walls.**

Mass walls for the purposes of this chapter shall be considered above-grade walls of concrete block, concrete, insulated concrete form (ICF), masonry cavity, brick (other than brick veneer), earth (adobe, compressed earth block, rammed earth) and solid timber/logs.

**R402.2.6 Steel-frame ceilings, walls, and floors.**

Steel-frame ceilings, walls, and floors shall meet the insulation requirements of Table R402.2.6 or shall meet the *U*-factor requirements of Table R402.1.3. The calculation of the *U*-factor for a steel-frame envelope assembly shall use a series-parallel path calculation method.

TABLE R402.2.6  
STEEL-FRAME CEILING, WALL AND FLOOR INSULATION  
(*R*-VALUE)

<b>WOOD FRAME R-VALUE REQUIREMENT</b>	<b>COLD-FORMED STEEL EQUIVALENT R-VALUE<sup>a</sup></b>
<b>Steel Truss Ceilings<sup>b</sup></b>	
R-30	R-38 or R-30 + 3 or R-26 + 5
R-38	R-49 or R-38 + 3
R-49	R-38 + 5
<b>Steel Joist Ceilings<sup>b</sup></b>	
R-30	R-38 in 2 × 4 or 2 × 6 or 2 × 8 R-49 in any framing
R-38	R-49 in 2 × 4 or 2 × 6 or 2 × 8 or 2 × 10
<b>Steel-Framed Wall 16" O.C.</b>	
R-13	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-13 + 3	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-20	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-20 + 5	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-21	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
<b>Steel Framed Wall, 24" O.C</b>	

R-13	R-0 + 9.3 or R-13 + 3.0 or R-15 + 2.4
R-13 + 3	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-20	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-20 + 5	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-21	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
<b>Steel Joist Floor</b>	
R-13	R-19 in 2 x 6, or R-19 + 6 in 2 x 8 or 2 x 10
R-19	R-19 + 6 in 2 x 6, or R-19 + 12 in 2 x 8 or 2 x 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.

**R402.2.7 Floors.**

Floor insulation shall be installed to maintain permanent contact with the underside of the subfloor decking.

**R402.2.8 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 meet this requirement unless the floor overhead is insulated in accordance with Sections [R402.1.1](#) and [R402.2.7](#).

**R402.2.9 Slab-on-grade floors.**

Slab-on-grade floors with a floor surface less than 12 inches (305 mm) below grade shall be insulated in accordance with Table [R402.1.1](#). 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 [R402.1.1](#) 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 a minimum of 10 inches (254 mm) 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.

**R402.2.10 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 24 inches (610 mm). 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 6 inches (153 mm) and be sealed or taped. The edges of the vapor retarder shall extend at least 6 inches (153 mm) up the stem wall and shall be attached to the stem wall.

**R402.2.11 Masonry veneer.**

Insulation shall not be required on the horizontal portion of the foundation that supports a masonry veneer.

**R402.2.12 Sunroom insulation.**

All sunrooms enclosing conditioned space shall meet the insulation requirements of this code.

**Exception:** For sunrooms with thermal isolation, and enclosing conditioned space, the following exceptions to the insulation requirements of this code shall apply:

1. The minimum ceiling insulation R-values shall be ~~R-19 in Climate Zones 1 through 4 and R-24 in Climate Zones 5 through 8~~; and
2. The minimum wall R-value shall be ~~R-13 in all climate zones~~. Wall(s) separating a sunroom with a thermal isolation from conditioned space shall meet the building thermal envelope requirements of this code.

**R402.3 Fenestration (Prescriptive).**

In addition to the requirements of Section R402 , fenestration shall comply with Sections R402.3.1 through R402.3.6.

**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.**

An area-weighted average of fenestration products more than 50-percent glazed shall be permitted to satisfy the SHGC requirements.

**R402.3.3 Glazed fenestration exemption.**

Up to 15 square feet (1.4 m<sup>2</sup>) of glazed fenestration per dwelling unit shall be permitted to be exempt from U-factor and SHGC requirements in Section R402.1.1. This exemption shall not apply to the U-factor alternative approach in Section R402.1.3 and the Total UA alternative in Section R402.1.4.

**R402.3.4 Opaque door exemption.**

One side-hinged opaque door assembly up to 24 square feet (2.22 m<sup>2</sup>) in area is exempted from the U-factor requirement in Section R402.1.1. This exemption shall not apply to the U-factor alternative approach in Section R402.1.3 and the total UA alternative in Section R402.1.4.

**R402.3.5 Sunroom U-factor.**

All sunrooms enclosing conditioned space shall meet the fenestration requirements of this code.

**Exception:** For sunrooms with thermal isolation and enclosing conditioned space, in Climate Zones 4 through 8, the following exceptions to the fenestration requirements of this code shall apply:

1. The maximum fenestration U-factor shall be 0.45; and
2. The maximum skylight U-factor shall be 0.70. New fenestration separating the sunroom with thermal isolation from conditioned space shall meet the building thermal envelope requirements of this code.

**R402.3.6 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 in Table R402.1.1.

**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 R402.4.4.

**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 listed in Table R402.4.1.1 shall be installed in accordance with the manufacturer’s instructions and the criteria listed 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.

TABLE R402.4.1.1  
AIR BARRIER AND INSULATION INSTALLATION

COMPONENT	CRITERIA <sup>a</sup>
Air barrier and thermal barrier	A continuous air barrier shall be installed in the building envelope. 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 sealed. Access openings, drop down stair or knee wall doors to unconditioned attic spaces shall be sealed.

Walls	<p>Corners and headers shall be insulated and the junction of the foundation and sill plate shall be sealed.</p> <p>The junction of the top plate and top of exterior walls shall be sealed.</p> <p>Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.</p> <p>Knee walls shall be sealed.</p>
Windows, skylights and doors	The space between window/door jambs and framing and skylights and framing shall be sealed.
Rim joists	Rim joists shall be insulated and include the air barrier.
Floors (including above-garage and cantilevered floors)	<p>Insulation shall be installed to maintain permanent contact with underside of subfloor decking.</p> <p>The air barrier shall be installed at any exposed edge of insulation.</p>
Crawl space walls	<p>Where provided in lieu of floor insulation, insulation shall be permanently attached to the crawlspace walls.</p> <p>Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.</p>
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 by 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 air tight, IC rated, and sealed to the drywall.
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	Exterior walls adjacent to showers and tubs shall be insulated and the air barrier installed separating them from the showers and tubs.
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.
Fireplace	An air barrier shall be installed on fireplace walls. Fireplaces shall have gasketed doors.

a. In addition, inspection of log walls shall be in accordance with the provisions of ICC-400.

**R402.4.1.2 Testing.**

The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding ~~5 air changes per hour in Climate Zones 1 and 2, and 3 air changes per hour in Climate Zones 3 through 8.~~ Testing shall be conducted with a blower door at a pressure of 0.2 inches w.g. (50 Pascals). 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-completion 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 weatherstripping 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, if installed at the time of the test, shall be open;
4. Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;
5. Heating and cooling systems, if installed at the time of the test, shall be turned off; and
6. Supply and return registers, if 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 and outdoor combustion air.

**R402.4.3 Fenestration air leakage.**

Windows, skylights and sliding glass doors shall have an air infiltration rate of no more than 0.3 cfm per square foot (1.5 L/s/m<sup>2</sup>), and

swinging doors no more than 0.5 cfm per square foot (2.6 L/s/m<sup>2</sup>), when tested according to [NFRC 400](#) or [AAMA/WDMA/CSA 101/I.S.2/A440](#) by an accredited, independent laboratory and *listed and labeled by the manufacturer*.

**Exception:** Site-built windows, skylights and doors.

#### **R402.4.4 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 *labeled* as having an air leakage rate not more than 2.0 cfm (0.944 L/s) when tested in accordance with [ASTM E 283](#) at a 1.57 psf (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 (*PrescriptiveMandatory*).**

The area-weighted average maximum fenestration *U*-factor permitted using tradeoffs from Section [R402.1.4](#) or [R405](#) shall be 0.48 in ~~Climate Zones 4 and 5 and 0.40 in Climate Zones 6 through 8~~ for vertical fenestration, and 0.75 in ~~Climate Zones 4 through 8~~ for skylights. ~~The area-weighted average maximum fenestration SHGC permitted using tradeoffs from Section R405 in Climate Zones 1 through 3 shall be 0.50.~~

### **SECTION R403 SYSTEMS**

#### **R403.1 Controls (Mandatory).**

At least one thermostat shall be provided for each separate heating and cooling system.

##### **R403.1.1 Programmable thermostat.**

Where the primary heating system is a forced-air furnace, at least one thermostat per dwelling unit shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature set points 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 55°F*

(13°C) or up to 85°F (29°C). The thermostat shall initially be programmed with a heating temperature set point no higher than 70°F (21°C) and a cooling temperature set point no lower than 78°F (26°C).

**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 Ducts (Mandatory).**

Ducts and air handlers shall be in accordance with Sections [R403.2.1](#) through [R403.2.3](#).

**R403.2.1 Insulation ~~(Prescriptive)~~.**

Supply ducts in attics shall be insulated to a minimum of R-8. All other ducts shall be insulated to a minimum of R-6.

**Exception:** Ducts or portions thereof located completely inside the *building thermal envelope*.

**R403.2.2 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. Where a duct connection is made that is partially inaccessible, three screws or rivets shall be equally spaced on the exposed portion of the joint so as to prevent a hinge effect.
3. Continuously welded and locking-type longitudinal joints and seams in ducts operating at static pressures less than 2 inches of water column (500 Pa) pressure classification shall not require additional closure systems.

Duct tightness shall be verified by either of the following:

1. Postconstruction test: Total leakage shall be less than or equal to 4 cfm (113.3 L/min) per 100 square feet (9.29 m<sup>2</sup>) of conditioned floor area when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. All register boots shall be taped or otherwise sealed during the test.

2. Rough-in test: Total leakage shall be less than or equal to 4 cfm (113.3 L/min) per 100 square feet (9.29 m<sup>2</sup>) of conditioned floor area when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the system, including the manufacturer's air handler enclosure. All registers shall be taped or otherwise sealed during the test. If the air handler is not installed at the time of the test, total leakage shall be less than or equal to 3 cfm (85 L/min) per 100 square feet (9.29 m<sup>2</sup>) of conditioned floor area.

**Exception:** The total leakage test is not required for ducts and air handlers located entirely within the building thermal envelope.

**R403.2.2.1 Sealed air handler.**

Air handlers shall have a manufacturer's designation for an air leakage of no more than 2 percent of the design air flow rate when tested in accordance with [ASHRAE 193](#).

**R403.2.3 Building cavities (Mandatory).**

Building framing cavities shall not be used as ducts or plenums.

**R403.3 Mechanical system piping insulation (Mandatory).**

Mechanical system piping capable of carrying fluids above 105°F (41°C) or below 55°F (13°C) shall be insulated to a minimum of R-3.

**R403.3.1 Protection of piping insulation.**

Piping insulation exposed to weather shall be protected from damage, including that caused by sunlight, moisture, equipment maintenance, and wind, and shall provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall not be permitted.

**R403.4 Service hot water systems (Mandatory).**

Energy conservation measures for service hot water systems shall be in accordance with Sections [R403.4.1](#) and [R403.4.2](#).

**R403.4.1 Circulating hot water systems ~~(Mandatory)~~.**

Circulating hot water systems shall be provided with an automatic or readily *accessible manual switch that can turn off the hot-water circulating pump when the system is not in use.*

**R403.4.2 Hot water pipe insulation ~~(Prescriptive)~~.**

Insulation for hot water pipe with a minimum thermal resistance (*R-value*) of R-3 shall be applied to the following:

1. Piping larger than  $\frac{3}{4}$  inch nominal diameter.
2. Piping serving more than one dwelling unit.
3. Piping from the water heater to kitchen outlets.
4. Piping located outside the conditioned space.
5. Piping from the water heater to a distribution manifold.
6. Piping located under a floor slab.
7. Buried piping.
8. Supply and return piping in recirculation systems other than demand recirculation systems.
9. Piping with run lengths greater than the maximum run lengths for the nominal pipe diameter given in Table R403.4.2.

All remaining piping shall be insulated to at least R-3 or meet the run length requirements of Table R403.4.2.

TABLE R403.4.2  
MAXIMUM RUN LENGTH (feet)<sup>a</sup>

Nominal Pipe Diameter of Largest Diameter Pipe in the Run (inch)	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	$> \frac{3}{4}$
Maximum Run Length	30	20	10	5

For SI: 1 inch = 25.4 mm, 1 foot 304.8 mm.

a. Total length of all piping from the distribution manifold or the recirculation loop to a point of use.

**R403.5 Mechanical ventilation (Mandatory).**

The building shall be provided with ventilation that meets 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

**R403.5.1 Whole-house mechanical ventilation system fan efficacy (Prescriptive)**

Mechanical ventilation system fans shall meet the efficacy requirements of Table R403.5.1.

**Exception:** Where mechanical ventilation fans are integral to tested and listed HVAC equipment, they shall be powered by an electronically commutated motor.

TABLE R403.5.1  
MECHANICAL VENTILATION SYSTEM FAN EFFICACY

FAN LOCATION	AIR FLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)	AIR FLOW RATE MAXIMUM (CFM)
Range hoods	Any	2.8 cfm/watt	Any
In-line fan	Any	2.8 cfm/watt	Any
Bathroom, utility room	10	1.4 cfm/watt	< 90
Bathroom, utility room	90	2.8 cfm/watt	Any

For SI: 1 cfm = 28.3 L/min.

**R403.6 Equipment Sizing (Mandatory).**

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.

**~~R403.7 Systems serving multiple dwelling units (Mandatory).~~**

~~Systems serving multiple dwelling units shall comply with Sections C403 and C404 of the IECC—Commercial Provisions in lieu of Section R403.~~

**R403.78 Snow melt system controls (Mandatory).**

Snow- and ice-melting systems, supplied through energy service to the building, shall include automatic controls capable of shutting off the system when the pavement temperature is above 50°F, and no precipitation is falling and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F.

**R403.89 Pools and inground permanently installed spas (Mandatory).**

Pools and inground permanently installed spas shall comply with Sections R403.98.1 through R403.98.3.

**R403.89.1 Heaters.**

All heaters shall be equipped with a readily *accessible* on-off switch that is mounted outside of the heater to allow shutting off the heater without adjusting the thermostat setting. Gas-fired heaters shall not be equipped with constant burning pilot lights.

**R403.89.2 Time switches.**

Time switches or other control method that can automatically turn off and on heaters and pumps according to a preset schedule shall be installed on all heaters and pumps. Heaters, pumps and motors that have built in timers shall be deemed in compliance with this requirement.

**Exceptions:**

1. Where public health standards require 24-hour pump operation.
2. Where pumps are required to operate solar- and waste-heat-recovery pool heating systems.

**R403.8 9.3 Covers.**

Heated pools and inground permanently installed spas shall be provided with a vapor-retardant cover.

~~**Exception:** Pools deriving over 70 percent of the energy for heating from site-recovered energy, such as a heat pump or solar energy source computed over an operating season.~~

**SECTION R404  
ELECTRICAL POWER AND LIGHTING SYSTEMS  
(MANDATORY)**

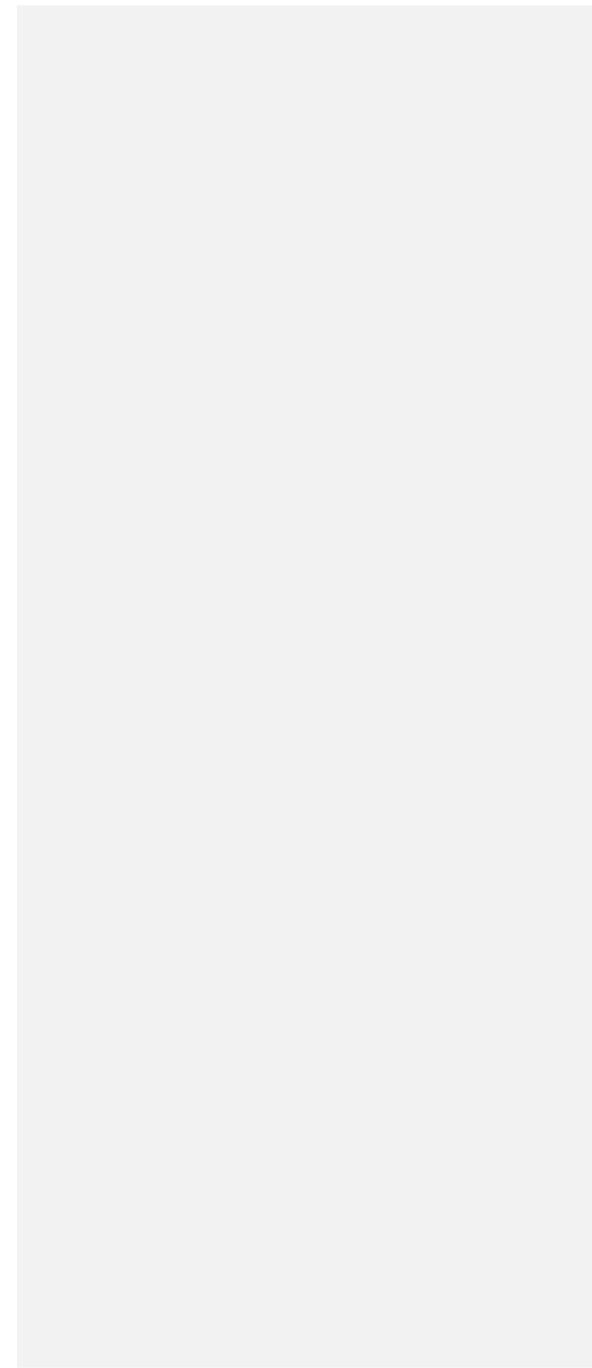
**R404.1 Lighting equipment (Mandatory).**

A minimum of 75 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or a minimum of 75 percent of the permanently installed lighting fixtures shall contain only high efficacy lamps.

**Exception:** Low-voltage lighting shall not be required to utilize high-efficiency lamps.

**R404.1.1 Lighting equipment (Mandatory).**

Fuel gas lighting systems shall not have continuously burning pilot lights.



**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, 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. All supply and return ducts not completely inside the *building thermal envelope* shall be insulated to a minimum of R-6.~~**

**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 Price and Expenditure Report*. *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*. The compliance documentation shall include the following information:~~**

**~~1. Address or other identification of the residence;~~**

**~~2. An inspection checklist documenting the building component characteristics of the *proposed design* as listed in Table R405.5.2(1). The inspection checklist shall show results for both the *standard reference design* and the *proposed design*, and shall document all inputs entered by the user necessary to reproduce the results;~~**

**3. Name of individual completing the compliance report; and**

**4. Name and version of the compliance software tool.**

Exception: ~~Multiple orientations. When 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 cardinal (north, east, south and west) orientations.~~

~~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 R402.1.1.~~

~~TABLE R405.5.2(1)  
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS~~

<del>BUILDING COMPONENT</del>	<del>STANDARD REFERENCE DESIGN</del>	<del>PROPOSED DESIGN</del>
<del>Above-grade walls</del>	<del>Type: mass wall if proposed wall is mass; otherwise wood frame. Gross area: same as proposed U factor: from Table <u>R402.1.3</u></del>	<del>As proposed As proposed As proposed</del>

	Solar absorptance = 0.75 Remittance = 0.90	As proposed As proposed
Basement and crawl space walls	Type: same as proposed Gross area: same as proposed U factor: from Table <u>R402.1.3</u> , with insulation layer on interior side of walls.	As proposed As proposed As proposed
Above grade floors	Type: wood frame Gross area: same as proposed U factor: from Table <u>R402.1.3</u>	As proposed As proposed As proposed
Ceilings	Type: wood frame Gross area: same as proposed U factor: from Table <u>R402.1.3</u>	As proposed As proposed As proposed
Roofs	Type: composition shingle on wood sheathing Gross area: same as proposed Solar absorptance = 0.75 Emittance = 0.90	As proposed As proposed As proposed As proposed
Attics	Type: vented with aperture = 1 ft <sup>2</sup> per 300 ft <sup>2</sup> ceiling area	As proposed
Foundations	Type: same as proposed foundation wall area above and below grade and soil characteristics: same as proposed.	As proposed As proposed
Doors	Area: 40 ft <sup>2</sup> Orientation: North U factor: same as fenestration from Table <u>R402.1.3</u> .	As proposed As proposed As proposed
Glazing	Total area <sup>a</sup> = (a) The proposed glazing area; where proposed glazing area is less than 15% of the conditioned floor	As proposed

	area: (b) 15% of the conditioned floor area; where the proposed glazing area is 15% or more of the conditioned floor area.	
	Orientation: equally distributed to four cardinal compass orientations- (N, E, S & W).	As proposed
	U factor: from Table <u>R402.1.3</u>	As proposed
	SHGC: From Table <u>R402.1.1</u> except that for climates with no requirement (NR) SHGC = 0.40 shall be used. Interior shade fraction: 0.92 (0.21 × SHGC for the standard reference design) External shading: none	As proposed 0.92 (0.21 × SHGC as proposed) As proposed
Skylights	None	As proposed
Thermally isolated sunrooms	None	As proposed

(continued)

TABLE R405.5.2(1) — continued  
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Air exchange rate	Air leakage rate of 5 air changes per hour in Climate Zones 1 and 2, and 3 air changes per hour in Climate Zones 3 through 8 at a pressure of 0.2 inches w.g (50 Pa). The mechanical ventilation rate shall be in addition to the air leakage rate and the same as in the proposed design, but no greater than $0.01 \times CFA + 7.5 \times (N_w + 1)$	For residences that are not tested, the same air leakage rate as the standard reference design. For tested residences, the measured air exchange rate. The mechanical ventilation rate shall be in addition to the air leakage rate and shall be as proposed.

	<p>where:  <i>CFA</i> = conditioned floor area  <i>N<sub>br</sub></i> = number of bedrooms  Energy recovery shall not be assumed for mechanical ventilation.</p>	
Mechanical ventilation	<p>None, except where mechanical ventilation is specified by the proposed design, in which case:  Annual vent fan energy use:  <math>kWh/yr = 0.03942 \times CFA + 29.565 \times (N_{br} + 1)</math>  where:  <i>CFA</i> = conditioned floor area  <i>N<sub>br</sub></i> = number of bedrooms</p>	As proposed
Internal gains	IGain = 17,900 + 23.8 × <i>CFA</i> + 4104 × <i>N<sub>br</sub></i> (Btu/day per dwelling unit)	Same as standard reference design.
Internal mass	An internal mass for furniture and contents of 8 pounds per square foot of floor area.	Same as standard reference design, plus any additional mass specifically designed as a thermal storage element but not integral to the building envelope or structure.
Structural mass	<p>For masonry floor slabs, 80% of floor area covered by R-2 carpet and pad, and 20% of floor directly exposed to room air.  For masonry basement walls, as proposed, but with insulation required by Table R402.1.3 located on the interior side of the walls  For other walls, for ceilings, floors, and interior walls, wood frame construction</p>	<p>As proposed  As proposed  As proposed</p>
Heating systems <sup>5,6</sup>	As proposed for other than electric heating without a heat pump. Where the proposed design utilizes electric heating without a heat pump the standard reference design shall be an air source heat pump meeting the	As proposed

	requirements of Section <u>R403</u> of the IECC—Commercial Provisions. Capacity: sized in accordance with Section <u>R403.6</u>	
Cooling systems <sup>f</sup> <sup>h</sup>	As proposed Capacity: sized in accordance with Section <u>R403.6</u> .	As proposed
Service water- Heating <sup>f, g, h, i</sup>	As proposed Use: same as proposed design	As proposed gal/day = 30 + (10 × N <sub>u</sub> )
Thermal distribution systems		Thermal distribution system efficiency shall be as tested or as specified in Table <u>R405.5.2(2)</u> if not tested. Duct insulation shall be as proposed.
Thermostat	Type: Manual, cooling temperature setpoint = 75°F; Heating temperature setpoint = 72°F	Same as standard reference

For SI: 1 square foot = 0.93 m<sup>2</sup>, 1 British thermal unit = 1055 J, 1 pound per square foot = 4.88 kg/m<sup>2</sup>, 1 gallon (U.S.) = 3.785 L,

°C = (°F - 32)/1.8, 1 degree = 0.79 rad.

a. Glazing shall be defined as sunlight-transmitting fenestration, including the area of sash, curbing or other framing elements, that enclose conditioned space. Glazing includes the area of sunlight-transmitting fenestration assemblies in walls bounding conditioned basements. For doors where the sunlight-transmitting opening is less than 50 percent of the door area, the glazing area is the sunlight-transmitting opening area. For all other doors, the glazing area is the rough frame opening area for the door including the door and the frame.

b. For residences with conditioned basements, R-2 and R-4 residences and townhouses, the following formula shall be used to determine glazing area:

$$i>AF = A_s \times FA \times F</math>$$

where:

AF = Total glazing area.

A<sub>s</sub> = Standard reference design total glazing area.

$FA = (\text{Above-grade thermal boundary gross wall area}) / (\text{above-grade boundary wall area} + 0.5 \times \text{below-grade boundary wall area})$ .

$F = (\text{Above-grade thermal boundary wall area}) / (\text{above-grade thermal boundary wall area} + \text{common wall area})$  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.

c. 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.

d. 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.

e. Thermal storage element shall mean a component 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 must be in the same room as fenestration that faces within 15 degrees (0.26 rad) of true south, or must be connected to such a room with pipes or ducts that allow the element to be actively charged.

f. 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.

g. For a proposed design without a proposed heating system, a heating system with the prevailing federal minimum efficiency shall be assumed for both the standard reference design and proposed design.

h. For a proposed design home without a proposed cooling system, an electric air conditioner with the prevailing federal minimum efficiency shall be assumed for both the standard reference design and the proposed design.

i. For a proposed design with a nonstorage type water heater, a 40-gallon storage type water heater with the prevailing federal minimum energy factor for the same fuel as the predominant heating fuel type shall be assumed. For the case of a proposed design without a proposed water heater, a 40-gallon storage type water heater with 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.

TABLE R405.5.2(2)

DEFAULT DISTRIBUTION SYSTEM EFFICIENCIES FOR PROPOSED DESIGNS<sup>a</sup>

DISTRIBUTION SYSTEM CONFIGURATION AND CONDITION	FORCED AIR SYSTEMS	HYDRONIC SYSTEMS <sup>b</sup>
Distribution system components located in unconditioned space	—	0.95
Untested distribution systems entirely located in conditioned space <sup>c</sup>	0.88	1
"Ductless" systems <sup>d</sup>	1	—

For SI: 1 cubic foot per minute = 0.47 L/s, 1 square foot = 0.093m<sup>2</sup>, 1 pound per square inch = 6895 Pa, 1 inch water gauge = 1250 Pa.

- a. Default values given by 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.

**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 (e.g., *R* value, *U* factor, SHGC, HSPF, AFUE, SEER, EF, etc.).~~

**~~R405.6.2 Specific approval.~~**

~~Performance analysis tools meeting the applicable sections 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 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*.~~

## CHAPTER 5 [RE] REFERENCED STANDARDS

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 [R106](#) .

Standard reference number	Title	Referenced in code section number
<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="width: 15%;"><b><u>AAMA</u></b></div> <div style="width: 60%;">                     American Architectural Manufacturers Association                      1827 Walden Office Square                      Suite 550                      Schaumburg, IL 60173-4268                 </div> <div style="width: 20%;"></div> </div>		
<a href="#">AAMA/WDMA/CSA 101/I.S.2/A C440—11</a>	North American Fenestration Standard/ Specifications for Windows, Doors and Unit Skylights	<a href="#">R402.4.3</a>
<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="width: 15%;"><b><u>ACCA</u></b></div> <div style="width: 60%;">                     Air Conditioning Contractors of America                      2800 Shirlington Road, Suite 300                      Arlington, VA 22206                 </div> <div style="width: 20%;"></div> </div>		
Manual J—11	Residential Load Calculation Eighth Edition	<a href="#">R403.6</a>
Manual S—10	Residential Equipment Selection	<a href="#">R403.6</a>
<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="width: 15%;"><b><u>ASHRAE</u></b></div> <div style="width: 60%;">                     American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.                      1791 Tullie Circle, NE                      Atlanta, <a href="#">GA</a> 30329-2305                 </div> <div style="width: 20%;"></div> </div>		
Standard reference number	Title	Referenced in code section number

**Commented [TK13]:** ICC: Can you double check that the code sections referenced here are still accurate when all of the section numbering is finished?

**Commented [TK14]:** Note to ICC: Please add the ANSI/RESNET/ICC 301-2014 Standard. This is referenced in sections R202  
R401.2.1  
R401.2.2

ASHRAE—2009  
ASHRAE 193—2010

ASHRAE Handbook of Fundamentals  
Method of Test for Determining the Airtightness of HVAC Equipment

R402.1.4,  
Table R405.5.2(1)  
R403.2.2.1

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## ASTM

ASTM International  
100 Barr Harbor Drive  
West Conshohocken, PA 19428-2859

Standard reference number	Title	Referenced in code section number
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<a href="#">E 283—04</a>	Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen	<a href="#">R402.4.4</a>
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## CSA

Canadian Standards Association  
5060 Spectrum Way  
Mississauga, Ontario, Canada L4W 5N6

Standard reference number	Title	Referenced in code section number
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<a href="#">AAMA/WDMA/CSA 101/I.S.2/A440—11</a>	North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights	<a href="#">R402.4.3</a>
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## ICC

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

Standard reference number	Title	Referenced in code section number
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<a href="#">IBC—12</a>	International Building Code®	<a href="#">R201.3</a> , <a href="#">R302.2</a> , <a href="#">R402.2.10</a>
<a href="#">ICC 400—12</a>	<a href="#">Standard on the Design and Construction of Log Structures</a>	Table <a href="#">R402.4.1.1</a>
<a href="#">IFC—12</a>	International Fire Code®	<a href="#">R201.3</a>
<a href="#">IFGC—12</a>	International Fuel Gas Code®	<a href="#">R201.3</a>
<a href="#">IMC—12</a>	International Mechanical Code®	<a href="#">R201.3</a> , <a href="#">R403.2.2</a> , <a href="#">R403.5</a>
<a href="#">IPC—12</a>	International Plumbing Code®	<a href="#">R201.3</a>

[IRC—12](#)

International Residential Code®

[R201.3](#), [R302.2](#), [R402.2.10](#), [R403.2.2](#), [R403.5](#)

**NFRC**

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

Standard reference number	Title	Referenced in code section number
100—2010	Procedure for Determining Fenestration Products <i>U</i> -factors—Second Edition	<a href="#">R302.1.3</a>
200—2010	Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence—Second Edition	<a href="#">R302.1.3</a>
400—2010	Procedure for Determining Fenestration Product Air Leakage—Second Edition	<a href="#">R402.4.3</a>

[US-FTC](#)

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

Standard reference number	Title	Referenced in code section number
CFR Title 16 (May 31, 2005)	R-value Rule	<a href="#">R302.1.4</a>

**WDMA**

Window and Door Manufacturers Association  
1400 East Touhy Avenue, Suite 470  
Des Plaines, IL 60018

Standard reference number	Title	Referenced in code section number
<a href="#">AAMA/WDMA/CSA 101/I.S.2/A440—11</a>	North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights	<a href="#">R402.4.3</a>

ORDINANCE NO. \_\_\_\_\_

AN ORDINANCE AMENDING SECTION 9-9-12, "LANDSCAPING AND SCREENING STANDARDS," AND CHAPTERS 10-5.5, 10-6, 10-7, 10-7.5, 10-10 OF TITLE 10, "STRUCTURES," B.R.C. 1981, TO REVISE THE ENERGY CONSERVATION AND GREEN BUILDING REQUIREMENTS FOR CONSTRUCTION PROJECTS, REPEALING THE INTERNATIONAL ENERGY CONSERVATION CODE AND ADOPTING BY REFERENCE THE "2017 CITY OF BOULDER ENERGY CONSERVATION CODE," AND APPENDIX F, "RADON CONTROL METHOD," OF THE 2015 EDITION OF THE INTERNATIONAL RESIDENTIAL CODE OF THE INTERNATIONAL CODE COUNCIL, AND SETTING FORTH RELATED DETAILS.

BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF BOULDER, COLORADO:

Section 1. Section 9-9-12, B.R.C. 1981, is amended to read:

**9-9-12. - Landscaping and Screening Standards.**

(a) Purpose: The purpose of the landscaping and screening requirements set forth in this chapter is to:

(1) Provide minimum requirements for the landscaping of lots and parcels, street frontages, streetscapes and paved areas;

(2) Provide minimum requirements to ensure the proper installation or cultivation, and maintenance of landscaping materials;

(3) Promote sustainable landscapes and improve the quality of the environment by enhancing air quality, reducing the amount and rate of storm water runoff, improving storm water runoff quality, the spread of noxious weeds, and increasing the capacity for groundwater recharge;

(4) Minimize the amount of water used for landscaping by promoting Xeriscape™ practices and improving irrigation efficiency;

(5) Enhance the appearance of both residential and nonresidential areas, and reduce the visual impacts of large expanses of pavement and rock; and

1 (6) Minimize impacts between uses both on-site and off-site. Landscaping can  
2 improve the compatibility of adjacent land uses and screen undesirable views. The landscaping  
3 standards also enhance the streetscape by separating the pedestrian from motor vehicles, auto  
4 fumes, and dust, providing shade, attenuating noise, and filtering air, buffering wind, and  
5 reducing glare.

6 (b) Scope: This section and Section 9-9-14, "Parking Lot Landscaping Standards,"  
7 B.R.C. 1981, apply to all nonresidential and ~~multi-family~~ residential developments unless  
8 expressly stated otherwise.

9 (1) The standards in this section and Sections 9-9-13, "Streetscape Design  
10 Standards," and 9-9-14, "Parking Lot Landscaping Standards," B.R.C. 1981, shall be met prior to  
11 a final inspection for any building permit for:

12 (A) New development;

13 (B) Redevelopment involving expansion of the total building floor area which  
14 exceeds twenty-five percent of the value of the existing structure for any use except a property  
15 with three or fewer ~~attached~~ dwelling units;

16 (C) Redevelopment involving the expansion of the total floor area for a property that  
17 has three or fewer ~~attached~~ dwelling units, shall meet the landscaping standards as follows:

18 (i) Redevelopment valued at more than twenty-five percent, but less than fifty  
19 percent of the value of the existing structure shall require compliance with the street and alley  
20 tree requirements and the trash and parking screening requirements;

21 (ii) Redevelopment valued at fifty percent or more, but less than seventy-five percent  
22 of the value of the existing structure shall require compliance with the street and alley tree  
23 requirements and the trash and parking screening requirements and the front yard landscape  
24 requirements; and

25 (iii) Redevelopment valued at seventy-five percent or more of the value of the existing  
structure shall require compliance with the landscape regulations.

(D) Redevelopment exceeding one hundred percent of the value of the existing  
structure and not involving expansion of the total building floor area; or

(E) The addition of a dwelling unit.

(F) For purposes of this paragraph (1), the applicant shall demonstrate the value of the  
existing structure by submitting, at the discretion of the applicant, either the actual value assessed  
by the Boulder County Assessor's Office or the fair market value determined by a real estate  
appraiser licensed in Colorado.

(2) When additional parking spaces are provided, or for a change of use where new  
off-street parking spaces are provided, the provisions of Section 9-9-14, "Parking Lot  
Landscaping Standards," B.R.C. 1981, shall be applied as follows:

1 (A) When the number of additional parking spaces that will be provided exceeds  
2 twenty-five percent of the number of existing parking spaces on the site, all standards in Section  
3 9-9-14, "Parking Lot Landscaping Standards," B.R.C. 1981, shall be met for the entire parking  
lot (existing and new portions) prior to the final inspection for a change of use or concurrent with  
the addition of the parking spaces.

4 (B) When the number of additional parking spaces that will be provided is less than  
5 twenty five percent of the number of existing parking spaces on the site, the standards in Section  
6 9-9-14, "Parking Lot Landscaping Standards," B.R.C. 1981, shall be met for the new portions of  
the parking lot prior to the final inspection for a change of use or concurrent with the addition of  
the parking spaces.

7 (c) Modifications to the Landscape Standards: The city manager is authorized to  
8 modify the standards set forth in this section and Sections 9-9-13, "Streetscape Design  
Standards," and 9-9-14, "Parking Lot Landscaping Standards," B.R.C. 1981, upon finding that:

9 (1) The strict application of these standards is not possible due to existing physical  
10 conditions;

11 (2) The modification is consistent with the purpose of the section; and

12 (3) The modification is the minimum modification that would afford relief and would  
be the least modification of the applicable provisions of this chapter.

13 The manager shall require that a person requesting a modification supply the information  
14 necessary to substantiate the reasons for the requested modification. The details of any action  
granting modifications will be recorded and entered in the files of the planning department.

15 (d) General Landscaping and Screening Requirements:

16 (1) Landscaping Plan: A landscaping plan designed in accordance with this section  
17 and Sections 9-9-13, "Streetscape Design Standards," and 9-9-14, "Parking Lot Landscaping  
Standards," B.R.C. 1981, shall be provided for all developments ~~except detached dwelling units~~.  
18 The site plan shall include the following:

19 (A) A site plan with a north arrow showing the major details of the proposed  
20 landscaping and irrigation, prepared on a scale not less than one inch equals thirty feet providing  
21 sufficient detail to evaluate the features of the landscaping and irrigation required by this section  
and Sections 9-9-13, "Streetscape Design Standards," and 9-9-14, "Parking Lot Landscaping  
Standards," B.R.C. 1981;

22 (B) The location of property lines and adjacent streets, the zoning and use of adjacent  
23 properties, the existing and proposed locations of all buildings, sidewalks and curb cuts, bike  
24 paths and pedestrian walkways, drive aisles and curb islands, utilities, and easements, and the  
existing location, size, and type of all trees one and one-half inch caliper or greater;

1 (C) The location of existing and proposed parking lots, including the layout of  
2 parking spaces and interior and perimeter parking lot landscaped areas, and the dimensions and  
total area (in square feet) for each interior parking lot landscaped area;

3 (D) The location, design, and materials of all other landscaped areas, including,  
4 without limitation, planting strips along all streets, earth berms, retaining walls, fences, water  
5 features, benches, trash enclosures, lights, and paved areas. Where fencing is used for required  
screening, a scaled drawing of the fence elevation must be included;

6 (E) The locations of all proposed plant material, drawn at the size the materials will  
be within five years of initial planting;

7 (F) The locations of all proposed planting of all ground surfaces. Grass surfaces must  
8 be identified as sod or seed with the blend or mix specified;

9 (G) The botanical and common names and sizes of all plant material;

10 (H) Location and dimensions of sight distance triangles at all intersections of streets  
and curb cuts;

11 (I) Location and type of irrigation and of plant groupings by water use zone; and

12 (J) A chart comparing the landscaping requirements of Sections 9-9-13, "Streetscape  
13 Design Standards," and 9-9-14, "Parking Lot Landscaping Standards," B.R.C. 1981, to the  
14 proposed materials, including, without limitation, the following information: total lot size (in  
15 square feet), total parking lot size, including all drives and driveways (in square feet), total  
16 number of parking stalls required and the total provided, total interior parking lot landscaped  
area required and the total provided, total perimeter parking lot landscaping required and total  
provided, total number of street trees required and the total provided, and total quantity of plant  
material required and the total provided.

17 (K) The location, size, and species of all existing trees on the property and within the  
18 landscape setbacks of all properties adjacent to the development site.

19 (L) The landscaping plan shall consider and attempt to avoid shading of new trees  
onto a solar zone required under the 2017 City of Boulder Energy Conservation Code.

20 (2) Landscape and Screening Maintenance and Replacement: The property owner  
21 shall maintain the landscaping plan as originally approved, and provide for replacement of plant  
22 materials that have died or have otherwise been damaged or removed, and maintenance of all  
non-live landscaping materials, including, but not limited to, fencing, paving, and retaining walls  
from the issuance of a certificate of occupancy or certificate of completion.

23 (3) Open Space: Required useable open space shall meet the provisions of this section  
24 and Sections 9-7-1, "Schedule of Form and Bulk Standards," and 9-9-11, "Useable Open Space,"  
B.R.C. 1981.

1 (4) Pedestrian Access: In all zones except A, P, RR, RE, RL, and RM, paved  
pedestrian walkways, a minimum of three feet in width, shall be provided as follows:

2 (A) Between at least one building entrance and the sidewalk adjacent to the street;

3 (B) Between the parking lot and the entrance to any buildings larger than 10,000  
4 square feet in size.

5 (5) Screening of Trash Collection and Recycling Areas, Service Areas, and Loading  
6 Areas: In nonresidential and multi-family residential developments, ~~Trash~~ trash collection and  
7 recycling areas, service areas, and loading areas shall be screened on all sides so that no portion  
8 of such areas are visible from public streets and alleys and adjacent properties. Required  
screening may include new and existing plantings, walls, fences, screen panels, doors,  
topographic changes, buildings, horizontal separation, or any combination thereof.

9 (6) Outdoor Service Yards and Storage Areas: Service yards and outdoor storage  
10 areas in commercial and industrial areas shall be screened from public areas, streets, alleys, and  
adjacent areas through the use of one or more of the following: walls, fencing, or plantings.

11 (7) Setbacks: All setbacks adjacent to a street shall be landscaped in accordance with  
12 the standards set forth in Section 9-9-13, "Streetscape Design Standards," B.R.C. 1981,  
including, without limitation, that area between the property line and the edge of the pavement or  
curb of the adjacent street.

13 (8) Minimum Overall Site Landscaping: In all zones except A, P, RR, RE, RL and  
14 RM, one tree and five shrubs are planted for each 1,500 square feet of lot area not covered by a  
building or required parking.

15 (9) Materials: All material required in a landscaped area shall be live plant material,  
16 except as approved by the city manager to provide attractive screening, plazas, or pedestrian  
access. Plant materials shall be planted in sufficient quantity to completely cover within five  
17 years of initial planting, all landscaped areas, including temporary mulched areas, and under  
trees.

18 (10) Mulches:

19 (A) Temporary mulches are required in all shrub, tree, and perennial planting beds  
20 until full plant coverage is achieved. Organic mulches include wood and bark chips, straw, grass  
clippings, and seed hulls. Inorganic or inert mulches include weed-barrier fabrics, gravel, and  
21 rock.

22 (B) Non-living materials such as bark or rocks shall not be used, except as temporary  
23 mulch until full plant coverage is achieved, or as permanent mulch under shrubs.

24 (C) Rocks larger than three inches in diameter shall not be used in the public right of  
25 way or adjacent to sidewalks, and shall be used only upon approval of the city manager as a  
decorative feature. Rock mulches shall not be used in landscaped areas on the south, west, or

1 southwest-facing sides of buildings or in interior parking lot landscaped areas except under the  
2 following conditions:

3 (i) All plants within the rock mulched area are from very low, low, or moderate  
4 water use zones and spaced to fill the beds within three years of initial planting; or

5 (ii) Rock is used as a specific ornamental feature in a limited area or as a pedestrian  
6 path.

7 (11) Minimum Plant Sizes: All materials planted under the provisions of this title shall  
8 meet the following requirements:

9 (A) Deciduous trees are at least two-inch caliper measured six inches above the  
10 ground, except ornamental and flowering trees, including, without limitation, the trees identified  
11 as "small maturing trees" on the approved street tree list in Section 3.03-1, City of Boulder  
12 Design and Construction Standards, that are at least one and one-half inch caliper measured six  
13 inches above the ground;

14 (B) Evergreens are at least five feet tall; and

15 (C) Shrubs are five-gallon container size.

16 (12) Grading Standards for New Earth Berms: Berms adjacent to paved surfaces shall  
17 be graded to capture all irrigation runoff or to convey it to an appropriate water quality design  
18 feature as described in the Urban Storm Drainage Criteria Manual, Vol. 3 (Urban Drainage and  
19 Flood Control District, Denver, Colorado).

20 (13) Soil Preparation and Planting Specifications: Site preparation and all planting  
21 shall be completed, at a minimum, in accordance with the City of Boulder Design and  
22 Construction Standards. Site preparation in any development, ~~including detached dwelling units,~~  
23 shall include tilling the soil to a minimum depth of six inches below the finished grade, together  
24 with soil amendments, including, without limitation, compost, manure, or peat, that are  
25 appropriate to ensure the health and sustainability of the landscaping to be planted.

(14) Water Conservation: Landscaping shall be designed to conserve water through  
application of all Xeriscape™ landscaping principles. Xeriscape™ landscaping principles do not  
include artificial turf or plants, mulched or gravel beds, or areas without landscape plant  
material, bare ground, weed-covered or infested surfaces, paving of areas not required for  
pedestrian access, plazas, or parking lots, or any landscaping that does not comply with the  
standards of this section. Xeriscape™ landscaping principles include:

(A) Planning and design that ensures water-conserving techniques are coordinated and  
implemented in the landscape;

(B) Grouping plants with similar water and cultural requirements (such as sun and  
climate) together in the same water use zones and on the same irrigation zones;

1 (C) Limiting the use of high water use turf grass and plantings to high-use areas with  
high visibility or functional needs;

2 (D) Use of efficient irrigation systems;

3 (E) Use of mulches;

4 (F) Improving soils to allow better water absorption and proper drainage; and

5 (G) Continued maintenance, including weeding, pruning, fertilizing, pest control, and  
6 irrigation maintenance.

7 (15) Xeriscape™ Landscape Standards: The following Xeriscape™ landscape  
standards shall apply to all required landscaped areas:

8 (A) Plants from the same water use zone shall be grouped together on the same  
9 irrigation zones. Water use zones shall be consistent with the Waterwise Plant List as shown in  
10 the City of Boulder, Landscape Requirements for Streetscape, Parking Lots, and All Other  
11 Developments or based on other lists which meet the same criteria for water use and adaptability  
if approved by the city manager;

12 (B) The total amount of high water use zones on a property shall not exceed fifty  
13 percent of the total landscaped area. The total amount of high water use turf grass shall not  
14 exceed twenty-five percent of the total landscaped area. Turf grass areas designated for high use  
or a specific recreational use shall be excluded from the total landscaped area under this  
15 requirement. Trees in tree grates shall also be excluded from the total landscaped area under this  
16 requirement;

17 (C) The use of high-irrigation turf and plantings shall be limited to high-use areas  
18 with high visibility or functional needs;

19 (D) High water use turf grass shall not be used in landscaped areas with any one  
20 dimension less than ten feet in width unless drip, subsurface, or low-volume irrigation is used in  
21 that area;

22 (E) Very low and low water use zone plants and turf grass shall be used to the extent  
23 practicable;

24 (F) Plants or turf grass from a high water use zone shall not be planted on slopes or  
berms at a 4:1 slope or greater.

25 (16) Irrigation: The following standards shall apply to irrigation systems for required  
landscaped areas:

(A) All landscaped areas, including, but not limited to, trees in tree pits, raised  
planters, planting in the public right of way, and all landscaping required in this chapter, shall be  
irrigated with a permanent, automatic irrigation system designed to provide efficient irrigation  
coverage with minimal overspray onto non-landscaped areas.

1 (B) The city manager may approve the use of temporary irrigation systems if all plant  
2 material is from the very low or low water use zones.

3 (C) Low-volume, drip, or subsurface irrigation systems shall be used in the following  
4 conditions:

5 (i) In landscaped areas where any one dimension is less than six feet in width and  
6 surrounded by impervious surfaces;

7 (ii) In all non-turf grass areas.

8 (D) Trees shall be zoned separately from turf grass when located in a low or very low  
9 water use zone.

10 (E) A soil moisture sensing device or other irrigation management system shall be  
11 required for irrigation systems in turf areas.

12 (F) The landscape plan shall indicate the nature, location, and specifications of the  
13 irrigation system which shall be used. Separate irrigation circuits should be specified for  
14 different zones on the landscape plan. The landscape plan shall have sufficient detail to show that  
15 adequate irrigation will be provided to all required landscape areas and plant materials.

16 (G) The irrigation system shall be designed to correlate to the organization of plants  
17 into zones with similar watering requirements.

18 (H) Irrigation systems shall be designed to maximize efficient water use and minimize  
19 the waste of water.

20 (17) Noxious Weeds: All landscape plans must comply with the current state weed and  
21 nursery lists.

22 (18) Tree Protection: All existing trees six inches or more in caliper and located in any  
23 development, ~~including detached dwelling units~~, in the required setback or on the property line  
24 shall be protected from construction impacts, unless the tree is a noxious weed. Trees over six  
25 inches in caliper shall be protected from construction impacts within the drip line of the tree in a  
manner that is consistent with the City of Boulder Design and Construction Standards' tree  
protection for construction site standards.

(19) Final Inspection: Labels that identify the botanical or common name of the plant  
material shall be on all trees at the time of final inspection.

Section 2. Chapter 10-5.5 , B.R.C. 1981, is amended to read:

**Chapter 5.5 - Residential Building Code**

10-5.5-1. - Legislative Intent.

1 The purpose of this chapter is to protect the public health, safety, and general welfare by  
2 regulating the construction, alteration, movement, enlargement, replacement, repair, equipment,  
3 use and occupancy, location, removal, and demolition of detached one- and two-family  
4 dwellings and townhouses, not more than three stories above grade in height with a separate  
5 means of egress, and their accessory structures. The city council hereby adopts the 2012 edition  
6 of the International Residential Code with certain amendments thereto found to be in the best  
7 interests of the city.

8 Ordinance Nos. 7566 (2007); 7925 (2013)

9 10-5.5-2. - Adoption of the International Residential Code With Modifications.

10 (a) The 2012 edition of the International Residential Code of the International Code  
11 Council is hereby adopted by reference as the City of Boulder Residential Building Code and has  
12 the same force and effect as though fully set forth in this chapter, except as specifically amended  
13 by the provisions of this chapter.

14 (b) The Appendix chapters D, E, F, G, H, J, K and P and sections contained therein  
15 are adopted.

16 (c) Section R101.1, "Title," is repealed and reenacted to read:

17 R101.1 Title. These provisions shall be known as the Residential Code of the City of  
18 Boulder or residential code and shall be cited as such and will be referred to herein as "this  
19 code".

20 (d) Sections R102 through R114 are repealed. This code shall be administered in  
21 accordance with chapter 1, "Administration," of the International Building Code as adopted, with  
22 amendments, by Section 10-5-2, "Adoption of International Building Code With Modifications,"  
23 B.R.C. 1981.

24 (e) The following definitions are added to Section R202, "Definitions":

25 COMMUNITY SOLAR GARDEN. A solar generation facility where the beneficial use  
of the electricity generated by the facility belongs to subscribers to the solar generation facility as  
authorized in §40-2-127, C.R.S.

FLOOR AREA. The total square footage of all levels as measured from the inside  
finished surface of the walls, but excluding courts, garages usable exclusively for the storage of  
motor vehicles and uninhabitable areas that are located above the highest inhabitable level or  
below the first floor level.

NEW DWELLING UNIT. A dwelling unit is considered to be a new dwelling unit when  
the entire structure is newly built and when the dwelling unit is built on top of an existing  
foundation, such as caissons, footings, and other foundation systems, that remains from a  
demolished structure.

1        SHADING. Shading is the protection from heat gains because of direct solar radiation by  
2 permanently attached exterior devices or building elements, interior shading devices, glazing  
3 material, or adherent materials.

4        SKYLIGHT AREA. Skylight area is the area of the rough opening for the skylight.

5        SOLAR ZONE. A solar zone is a section of the roof designated and reserved for the  
6 future installation of a solar electric or solar thermal system.

7        STANDARD TEST CONDITIONS. A fixed set of conditions for which PV module  
8 performance is rated. These conditions are 1000 W/m<sup>2</sup> incident solar radiation, 24°C cell  
9 temperature, 0.0 wind speed, and air mass 1.5 spectrum.

10        STORAGE ROOMS OR SPACES. Storage rooms or spaces are rooms or spaces with a  
11 level of finish sufficient only to make the room usable for the intended storage purposes. Rooms  
12 or areas that exceed these minimums will be considered habitable space and will have to meet  
13 the code requirements applicable to habitable space.

14        (f)     A new sentence is added to the end of Section R301.1, "Application," stating:

15        Structural calculations demonstrating how the proposed construction meets the applicable  
16 requirements for load supports must be provided to the building official.

17        (g)     The climatic and geographic design criteria applicable to Table R301.2.1 are:

18        Ground Snow Load = thirty pounds per square foot with a minimum Roof Snow Load of  
19 30 pounds per square foot.

20        Three-second wind gust velocity = 120 mph east of Broadway, 130 mph west of  
21 Broadway

22        Seismic Design Category = B

23        Weathering = severe

24        Frost line depth = 32 inches

25        Termite = slight

      Decay = none to slight

      Winter Design Temp = 2 degrees Fahrenheit

      Ice barrier underlayment required = NO

      Flood Hazards = See Sections 9-3-3 through 9-3-9, B.R.C. 1981

      Air freezing index = 459

1 Mean annual temp = 52.1

2 (h) Section R301.2.4, "Floodplain construction": A new sentence is added to the end  
3 of the section reading "All work on structures in the scope of this code shall also meet the  
4 requirements of Sections 9-3-3 through 9-3-9, B.R.C 1981."

5 (i) The exception listed in Section R302.2, "Townhouses," is repealed and reenacted  
6 to read:

7 Exception: A common 1-hour fire-resistance-rated wall assembly tested in accordance  
8 with ASTM E 119 or UL 263 is permitted for townhouses equipped throughout with an automatic  
9 sprinkler system installed in accordance with the requirements of section P2904 if such walls do  
10 not contain plumbing or mechanical equipment, ducts, or vents in the cavity of the common wall.  
11 The wall shall be rated for fire exposure from both sides and shall extend to and be tight against  
12 exterior walls and the underside of the roof sheathing. Electrical installations shall be installed in  
13 accordance with chapters 34 through 41 and chapter 43. Penetrations of electrical outlet boxes  
14 shall be in accordance with section R302.4. For townhouses not equipped throughout with an  
15 automatic sprinkler system installed in accordance with the requirements of section P2904, a  
16 common 2-hour fire-resistance-rated wall is permitted if such walls do not contain plumbing or  
17 mechanical equipment, ducts or vents in the cavity of the common wall. Electrical installations  
18 shall be installed in accordance with chapters 34 through 41 and chapter 43. Penetrations of  
19 electrical outlet boxes shall be in accordance with section R302.4.

20 (j) The first sentence of the Exception to Item 2 in Section R302.2.2, "Parapets," is  
21 amended by deleting "a minimum class C roof covering" and replacing it with "a minimum Class  
22 B roof covering."

23 (k) Section R302.5.1, "Opening protection," is repealed and reenacted to read:

24 R302.5.1 Opening protection. Openings from a garage directly into a room used for  
25 sleeping purposes shall not be permitted. Other openings between the garage and residence shall  
be equipped with weather-stripped, solid wood doors not less than 1 and 3 / 8 inches (35 mm) in  
thickness, solid or honeycomb-core steel doors not less than 1 and 3 / 8 inches (35 mm) in  
thickness, or 20-minute fire-rated doors, equipped with a self-closing device.

(l) Section R309.5, "Fire sprinklers," is deleted.

(m) Section R311.2, "Egress doors," is repealed and reenacted to read:

R311.2 Egress doors. At least one egress door shall be provided for each dwelling unit .  
The egress door shall be side hinged, and shall provide a minimum clear width of 32 inches (813  
mm) when measured between the face of the door and the stop, with the door open 90 degrees  
(1.57 rad). The minimum clear height of the door opening shall not be less than 78 inches (1981  
mm) in height measured from the top of the threshold to the bottom of the stop.

(n) The following sentences are added to the end of Section R311.7.5.1, "Risers":

1 Where the bottom or top riser adjoins a sloping public way, walkway, or driveway having  
2 an established grade and serving as a landing, the bottom or top riser is permitted to be reduced  
3 along the slope, with the variation in height of the bottom or top riser not to exceed one unit  
4 vertical in 12 units horizontal (8-percent slope) of stairway width. The nosings or leading edges  
5 of treads at such non-uniform height risers shall have a distinctive marking stripe, different from  
any other nosing marking provided on the stair flight. The distinctive marking stripe shall be  
visible in descent of the stair and shall have a slip-resistant surface. Marking stripes shall have a  
width of at least 1 inch (25 mm) but not more than 2 inches (51 mm).

6 (o) A new section R311.9, "Access to exterior balconies, porches, decks, and other  
walking surfaces from the interior of the building," is added, reading as follows:

7 R311.9 Access to exterior balconies, porches, decks, and other walking surfaces from the  
8 interior of the building. Access to exterior balconies, porches, decks, and other walking surfaces  
9 from the interior of the building shall be through a side-hinged or sliding glass door and shall  
10 provide a minimum clear width of 24 inches (610 mm), when measured between the face of the  
11 door and the stop, when the door, other than the sliding glass door, is open 90 degrees (1.57 rad).  
12 The minimum clear height of the door opening shall not be less than 78 inches (1981 mm) in  
height, measured from the top of the threshold to the bottom of the stop. Access to exterior  
balconies, porches, decks, and other walking surfaces from the interior of the building for the  
required egress door shall meet the provisions of section 311.2 for required height and width.

13 (p) Section R313.1, "Townhouse automatic fire sprinkler systems," is repealed and  
reenacted to read:

14 R313.1 Townhouse automatic fire sprinkler systems. Automatic fire sprinkler systems  
15 shall be installed in townhouses in accordance with the requirements of section 903.2.8 of the  
City of Boulder Fire Code.

16 (q) Section R313.2, "One- and two-family dwelling automatic fire sprinkler systems,"  
17 is repealed and reenacted to read:

18 R313.2 One- and two-family dwelling automatic fire sprinkler systems. Automatic  
19 sprinkler systems shall be installed in one- and two-family dwellings in accordance with the  
requirements of section 903.2.8 of the City of Boulder Fire Code.

20 (r) Section R315.1, "Carbon monoxide alarms," is repealed and reenacted to read:

21 R315.1 Carbon monoxide alarms. For new construction, an approved carbon monoxide  
22 alarm shall be installed outside each sleeping area in the immediate vicinity of bedrooms in  
dwelling units within which fuel-fired appliances are installed and in dwelling units and  
23 accessory structures containing habitable space that have attached garages. All carbon monoxide  
alarms shall be installed so as to meet the requirements of Section R315, Carbon monoxide  
24 alarms, and of the applicable provisions of §§ 38-45-101 through 106, C.R.S. Where the  
provisions of this code and the C.R.S. are in conflict, the most restrictive shall govern. Where  
25 there is a conflict between a general requirement and a specific requirement, the specific  
requirement shall be applicable.

1 (s) Section R322, "Flood resistant construction," is repealed and reenacted to read:

2 R322 Flood resistant construction. Buildings and structures constructed in whole or in  
3 part in the floodplain must be designed and constructed in accordance with the floodplain  
4 regulations of Title 9, Land Use Code, B.R.C. 1981.

4 (t) A new Section R324 Construction Waste Management is added to read:

5 SECTION R324 CONSTRUCTION WASTE MANAGEMENT

6 R324.1 Construction Waste Recycling. An applicant for a building permit for a new  
7 dwelling unit or an addition to an existing dwelling unit shall demonstrate all recyclable wood,  
8 metal, and cardboard materials will be donated, reused, or recycled.

8 R324.2 Deconstruction Management. An applicant proposing to demolish more than 50  
9 percent of exterior walls shall demonstrate through a deconstruction plan that 00 percent of  
10 concrete and asphalt and at least 65 percent of other the existing building materials, by weight,  
11 from the deconstruction, excluding concrete and asphalt, will be diverted from the landfill for  
12 reuse or recycling.

11 (u) The first paragraph of Section R401.1, "Application," is repealed and reenacted to  
12 read:

13 R401.1 Application. The provisions of this chapter shall control the design and  
14 construction of the foundation and foundation spaces for all buildings. In addition to the  
15 provisions of this chapter, the design and construction of foundations in a floodplain as  
16 established in Title 9, Land Use Code, B.R.C. 1981, shall meet all applicable provisions of Title  
17 9, Land Use Code, B.R.C. 1981. Where, in any specific case, the provisions of this code and the  
18 B.R.C. are in conflict, the most restrictive shall govern. Where there is a conflict between a  
19 general requirement and a specific requirement, the specific requirement shall be applicable.  
20 Wood foundations shall be designed and installed in accordance with AF&PA PWF.

18 (v) A new Section R401.5, "Placement of backfill," is added to read:

19 R401.5 Placement of backfill. The provisions of section 1804.2 of the Building Code of  
20 the City of Boulder shall apply to the placement of backfill.

20 (w) Section R408.7, "Flood resistance," is repealed and reenacted to read:

21 R408.7 Flood resistance. Buildings located in a floodplain as established in Title 9, Land  
22 Use Code, B.R.C. 1981, shall comply with the applicable provisions in Title 9, Land Use Code,  
23 B.R.C. 1981.

23 (x) Exception 1 in Section R703.2, "Water-resistive barrier," is repealed and  
24 reenacted to read:

25 Exception 1: In detached accessory buildings which are not intended to be conditioned  
and where the interior wall cavities will remain exposed and unfilled.

1           (yx) Exception 3 of Section R806.5, "Unvented attic and unvented enclosed rafter assemblies," is deleted.

2           (zy) Section R902.1, "Roof covering materials," is repealed and reenacted to read:

3           R902.1 Roof covering materials. All roof covering materials shall be listed as Class A as  
4 tested in accordance with UL Standard 790 or ASTM Standard E 108. Roof assemblies with  
5 covering of brick, masonry, slate, clay, or concrete roof tile, exposed concrete roof deck, ferrous  
6 or copper shingles or sheets, and metal sheets and shingles, shall be considered Class A roof  
7 coverings. Unless otherwise specified in this section, roof coverings shall be installed to resist  
8 the component and cladding loads specified in table R301.2(2), adjusted for height and exposure  
9 in accordance with table R301.2(3).

10           (aaz) Section R905.7, "Wood shingles," is repealed and reenacted to read:

11           R905.7 Wood shingles. Wood shakes, wood shingles, and wood roof covering materials  
12 are prohibited except as provided in Section 10-5-5, "Wood Roof Covering Materials  
13 Prohibited," B.R.C. 1981, for certain minimal repairs.

14           (bbaa) Section R905.8, "Wood shakes," is repealed and reenacted to read:

15           R905.8 Wood shakes. Wood shakes, wood shingles, and wood roof covering materials  
16 are prohibited except as provided in Section 10-5-5, "Wood Roof Covering Materials  
17 Prohibited," B.R.C. 1981, for certain minimal repairs.

18           (ccbb) Chapter 11, "Energy Efficiency." Sections N1101 through N1105 are repealed. A  
19 new Section N1101 is added to read:

20           N1101 Scope. Regulations concerning the design and construction of buildings for the  
21 effective use of energy and requirements for green building practices shall be administered in  
22 accordance with the ~~2012 International~~ 2017 City of Boulder Energy Conservation Code as  
23 adopted, ~~with amendments,~~ by Chapter 10-7, "Energy Conservation Code," B.R.C. 1981, ~~and~~  
24 ~~Chapter 10-7.5, "Green Building and Green Points Program," B.R.C. 1981.~~

25           (ddee) Section M1301.1.1, "Flood-resistant installation," is repealed and reenacted to  
read:

          M1301.1.1 Flood-resistant installation. In floodplains, as established in Title 9, Land Use  
Code, B.R.C. 1981, the mechanical appliances, equipment and systems shall be located or  
installed in accordance with the applicable provisions of Title 9, Land Use Code, B.R.C. 1981.

          (eedd) A new Section M1308.3, "Rooftop equipment support and clearances," is added  
to read:

          M1308.3 Rooftop equipment support and clearances.

          (1) Mechanical equipment placed, replaced, or resting over roofing shall be supported  
by curbs or legs which shall be flashed to the roofing and made watertight. Mechanical

1 equipment includes, but is not limited to, heating equipment, cooling and refrigeration  
2 equipment, ventilating fans, blowers, and other similar devices located on the roof.

3 (2) Flat roofs. On roofs having a pitch of less than 2 in 12, mechanical equipment  
4 shall be supported on a solid curb greater in size than the equipment which it serves. Curbs may  
5 be manufactured or built-in-place. If built-in-place, the curb shall be covered with metal of at  
6 least 26 gauge. The metal shall be weather-tight. The curb shall be a minimum of 9 inches above  
7 the finished roof.

8 (A) Ducts less than 4 feet in width shall have at least 12 inches clearance from the  
9 finished roof surface to the bottom of the duct.

10 (B) Ducts between 4 feet and 8 feet in width shall have at least 24 inches clearance  
11 from the finished roof surface to the bottom of the duct.

12 (C) Ducts over 8 feet in width shall have at least 36 inches clearance from the finished  
13 roof surface to the bottom of the duct.

14 (3) Pitched roofs. On roofs having a roof pitch exceeding 2 in 12, mechanical  
15 equipment may be set on legs which provide a minimum of 11 inches clearance between the  
16 finished roof surface and the equipment frame.

17 (~~ffee~~) Section M1401.5, "Flood hazard," is repealed and reenacted to read:

18 M1401.5 Flood hazard. In floodplains, as established in Title 9, Land Use Code, B.R.C.  
19 1981, heating and cooling equipment and appliances shall be located or installed in accordance  
20 with the provisions of Title 9, Land Use Code, B.R.C. 1981.

21 (~~ggff~~) Section M1601.4.9, "Flood hazard areas," is repealed and reenacted to read:

22 M1601.4.9 Flood hazard areas. In floodplains, as established in Title 9, Land Use Code,  
23 B.R.C. 1981, duct systems shall be located or installed in accordance with the provisions of Title  
24 9, Land Use Code, B.R.C. 1981.

25 (~~hhgg~~) A new sentence is added to Section M1602.1, "Return air," to read:

Within individual dwelling units there shall be at least one return air opening on each  
floor.

(~~iihh~~) Section M2001.4, "Flood-resistant installation," is repealed and reenacted to read:

M2001.4 Flood-resistant installation. In floodplains, as established in Title 9, Land Use  
Code, B.R.C. 1981, boilers, water heaters and their control systems shall be located or installed  
in accordance with the provisions of Title 9, Land Use Code, B.R.C. 1981.

(~~jjii~~) Section M2201.6, "Flood-resistant installation," is repealed and reenacted to read:

1 M2201.6 Flood-resistant installation. In floodplains, as established in Title 9, Land Use  
2 Code, B.R.C. 1981, tanks shall be located or installed in accordance with the provisions of Title  
9, Land Use Code, B.R.C. 1981.

3 (kkjj) Chapter 23 is renamed to read “Solar Energy Systems and Solar Ready  
4 Buildings.”

5 (ll) A new Section M2303, "Solar photovoltaic power systems," is added to read:

6 M2303 Solar photovoltaic power systems. Solar photovoltaic power systems shall also  
7 meet the provisions of section E3804, as amended.

8 (mm) A new Section M2304, “Requirements for Solar Ready Buildings,” is added to  
9 read:

10 M2304.1 General. All buildings shall comply with the requirements of this Section  
11 M2304.1.

12 M2304.1.1 Solar Zone. Solar Zones shall be clearly indicated on the construction  
13 documents.

14 M2304.1.1.1 Location and Size of Solar Zones. The solar zone shall have  
15 a minimum total area as described below. The solar zone shall comply  
16 with access, pathway, smoke ventilation, and spacing requirements as  
17 specified in the Boulder Revised Code. The solar zone total area shall be  
18 comprised of one or more rectangular areas that are no less than 80 square  
19 feet and no side of any rectangular area shall be less than five feet in  
20 length.

21 The solar zone shall be located:

- 22 1. On the roof or overhang of the building,
- 23 2. On the roof or overhang of another structure located within 250 feet of  
24 the building on the same parcel or lot,
- 25 3. On covered parking installed with the building project, or
4. On a façade that is less than 15 degrees greater or less than true south.

The solar zone shall have a total area of no less than 40 percent of the total  
roof area, as measured by the area of the roof planes. The following roof  
areas can be excluded when calculating the total roof area of the building:

1 1. Roof areas with a permanently installed domestic solar water-heating  
2 system.

3 2. Roof areas where the annual solar access is less than 70 percent. For  
4 the purpose of this code, solar access means the ratio of solar  
5 insolation including shade to the solar insolation without shade.  
6 Shading from obstructions located on the roof or any other part of the  
7 building shall not be included in the determination of annual solar  
8 access.

9 Exception: Solar zones are not required in:

10 1. Buildings with a permanently installed solar electric system having a  
11 nameplate DC power rating, measured under standard test condition of  
12 no less than one watt per square foot of roof area.

13 2. Buildings where the roof is designed and approved to be used for  
14 vehicular traffic or parking or for a heliport.

15 M2304.1.1.2 Orientation. All sections of the solar zone located on steep  
16 slope roofs shall be oriented between 90 degrees and 270 degrees of true  
17 north.

18 M2304.1.1.3 Shading.

19 1. No obstructions, including but not limited to, vents, chimneys,  
20 architectural features, and roof mounted equipment, shall be located in  
21 the solar zone.

22 2. Any obstruction located on the roof or any other part of the building  
23 that projects above a solar zone shall be located at least twice the  
24 distance, measured in the horizontal plane, of the height difference  
25 between the highest point of the obstruction and the horizontal  
projection of the nearest point of the solar zone, measured in the  
vertical plane.

Exception: Any roof obstruction, located on the roof or any other part  
of the building, that is oriented north of all points on the solar zone.

M2304.1.1.4 Structural Design Loads on Construction Documents. For  
areas of the roof designated as solar zone, the structural design loads for  
roof dead load and roof live load shall be clearly indicated on the  
construction documents.

NOTE: The inclusion of any collateral loads for future solar energy  
systems is not required.

1 M2304.1.2 Interconnection Pathways. The construction documents shall indicate  
2 a location for inverters and metering equipment and a pathway for routing of  
3 conduit for the solar zone to the point of interconnection with the electrical  
4 service.

5 M2304.1.3. Documentation. A copy of the construction documents or a  
6 comparable document indicating the information from sections M2304.1.1  
7 through M2304.1.2 shall be provided to and maintained by the building owner.  
8 The building owner shall provide a copy of the construction documents or a  
9 comparable document indicating the information from sections M2304.1.1  
10 through M2304.1.2 to any purchasers and subsequent owners of the building or  
11 any part thereof.

12 M2304.1.4. Main Electrical Service Panel.

- 13 1. The main electrical service panel shall have a minimum busbar rating of no  
14 less than 200 amps.
- 15 2. The main electrical service panel shall have a reserved space to allow for the  
16 installation of double pole circuit breakers for a future solar electric  
17 installation.

18 A. Location. The reserved space shall be positioned at the opposite (load)  
19 end from the input feeder location or main circuit location.

20 A.B. Marking. The reserved spaces shall be permanently marked as  
21 “For Future Solar Electric.”

22 (~~nnkk~~) Section G2404.7, "Flood hazard," is repealed and reenacted to read:

23 G2404.7 Flood hazard. In floodplains, as established in Title 9, Land Use Code, B.R.C.  
24 1981, the appliance, equipment, and system installations regulated by this code shall be located  
25 or installed in accordance with the provisions of Title 9, Land Use Code, B.R.C. 1981.

(~~ooH~~) Items 2 and 3 of Section G2427.8, "Venting system termination location," are  
amended by adding a new sentence to the end of each Items 2 and 3, reading:

Vents shall terminate a minimum of 18 inches (46 mm) above finished grade in the  
immediate vicinity of each vent.

(~~ppmm~~) Section P2503.7, "Water supply system testing," is repealed and reenacted  
to read:

P2503.7 Water supply system testing. Upon completion of the water supply system or a  
portion of it, the system or portion completed shall be tested and proved tight under a water  
pressure of not less than the working pressure of the system or by an air test of not less than 100  
psi (689.5 kPa). This pressure shall be held for not less than 15 minutes. The water used for tests  
shall be obtained from a potable water source.

1 ~~(qqm)~~ The Exception to Section P2601.2, "Connections to drainage system," is deleted  
in its entirety.

2 ~~(rrø)~~ Section P2601.3, "Flood hazard areas," is repealed and reenacted to read:

3 P2601.3 Flood hazard areas. In floodplains, as established in Title 9, Land Use Code,  
4 B.R.C. 1981, plumbing fixtures, drains, and appliances shall be located or installed in accordance  
with the provisions of Title 9, Land Use Code, B.R.C. 1981.

5 ~~(sspp)~~ The first sentence of Section P2602.2, "Flood-resistant installation," is repealed  
6 and reenacted to read:

7 In floodplains, as established in Title 9, Land Use Code, B.R.C. 1981:

8 Items 1 and 2 remain unchanged.

9 ~~(ttqq)~~ Table P2903.2, "Maximum Flow Rates and Consumption for Plumbing Fixtures  
10 and Fixture Fittings," shall be repealed and reenacted to read:

<u>PLUMBING FIXTURE</u> <u>OR FIXTURE FITTING</u>	<u>PLUMBING FIXTURE</u> <u>OR FIXTURE FITTING</u>
Lavatory Faucet	1.5 gpm at 60 psi
Shower Head	2.0 gpm at 60 psi
Sink Faucet	1.5 gpm at 60 psi
Water closet	1.28 gallons per flushing cycle

11 For SI: 1 gallon per minute = 3.785 L/m.

12 1 pound per square inch = 6.895 kPa.

13 a. A handheld shower spray is also a shower head.

14 b. B. Consumption tolerances shall be determined from referenced standards.

15 ~~(uu)~~ Section P3001.3, "Flood-resistant installation," is repealed and reenacted to read:

16 P3001.3 Flood-resistant installation. In floodplains, as established in Title 9, Land Use  
17 Code, B.R.C. 1981, drainage, wastes, and vent systems shall be located and installed to prevent  
18 infiltration of floodwaters into the systems and discharges from the systems into floodwaters.

19 ~~(vvff)~~ Section P3009, "Gray water recycling systems," is deleted in its entirety.

20 ~~(wwss)~~ Section P3101.5, "Flood resistance," is repealed and reenacted to read:

21 P3101.5 Flood resistance. In floodplains, as established in Title 9, Land Use Code,  
22 B.R.C. 1981, vents shall be located or installed in accordance with the provisions of Title 9,  
23 Land Use Code, B.R.C. 1981.

24 ~~(xxtt)~~ A new Section E3804, "Solar photovoltaic power systems," is added to read:

1 E3804 Solar photovoltaic power systems. Solar photovoltaic power systems shall meet  
2 the provisions of sections 605.11 through 605.11.3.2.3 of the City of Boulder Fire Code.

3 ~~(yyuu)~~ New Subsections E3901.13, “Electric vehicle charging requirements for new  
4 construction,” and E3901.14, “Electric vehicle charging requirements for renovations,” are added  
5 to read:

6 E3901.13 Electric vehicle charging requirements for new construction. Every new  
7 dwelling unit in a detached one- and two-family dwelling or townhouse shall include the  
8 following in at least one of the provided off-street parking spaces:

- 9 1. A 240-volt dedicated electric vehicle charging receptacle outlet, and
- 10 2. A 120-volt dedicated electric vehicle charging receptacle outlet.

11 The electric vehicle charging receptacle outlets shall be labeled as an electric vehicle  
12 outlet.

13 E3901.14 Electric vehicle charging requirements for renovations. For every dwelling  
14 unit where a garage is converted to habitable space, at least one 120-volt or 240-volt  
15 dedicated electric vehicle charging receptacle outlet shall be provided adjacent to at least  
16 one of any provided parking spaces.

17 **Exception:** A dedicated charging outlet is not required if off-street parking is not  
18 provided.

19 The electric vehicle charging receptacle outlets shall be labeled as an electric vehicle  
20 outlet.

21 ~~(zz)~~Section E4209.3, "Accessibility," is amended by adding the following to the end of  
22 the section:

23 Equipment shall be accessed by a panel with a minimum size of 12 inches (305 mm).

24 ~~(aaa~~vv~~)~~ Appendix F, “Radon Control Method,” is hereby repealed and reenacted to read  
25 as follows:

## APPENDIX F

### RADON CONTROL METHOD

26 The requirements of Appendix F to the 2015 edition of the *International Residential*  
27 *Code of the International Code Council shall hereby be complied with which appendix is hereby*  
28 adopted by reference as part of the City of Boulder Residential Code and have the same force  
29 and effect as though fully set forth in this subsection, except as specifically amended by the  
30 provisions of this subsection.

1           **(bbb)** Section AJ102.5, "Flood hazard areas," is repealed and reenacted to read:

2           AJ102.5 Flood hazard areas. Work performed in existing buildings located in a  
3 floodplain, as established by Title 9, Land Use Code, B.R.C. 1981, shall be done in accordance  
4 with the applicable provisions of Title 9, Land Use Code, B.R.C. 1981.

4           **(cccww)** A new footnote notation "b" is added to the heading and a new footnote  
5 "b" is added to AP Table AP103.3(2), "Load values assigned to fixtures," reading:

6           b. For the purpose of determining the largest instantaneous demand required in order  
7 to size a water meter, or for determining the amount of the plant investment fee, this table is  
8 repealed and replaced by the Fixture Unit/GPM Demand Chart and PIF Computation sheet found  
9 at Appendix A to Chapter 11-1, "Water Utility," B.R.C. 1981.

8           Section 3. Chapter 10-6, B.R.C. 1981, is amended to read:

9           **Chapter 6 - Electrical Code**

10           10-6-1. - Legislative Intent.

11           The purpose of this chapter is to protect the public health and safety by regulating the  
12 installation, alteration, or repair of or addition to electrical conductors or equipment installed  
13 within or on any structure in the city. The city council hereby adopts the 2011 edition of the  
14 *National Electrical Code* with certain amendments and deletions thereto found to be in the best  
15 interests of the residents of the city.

16           Ordinance Nos. 5177 (1989); 5310 (1990); 5571 (1993); 5851 (1996); 7566 (2007); 7925 (2013)

17           10-6-2. - Adoption of the National Electrical Code With Modifications.

18           (a) The 2011 edition of the *National Electrical Code* of the National Fire Protection Association  
19 is hereby adopted by reference as the City of Boulder Electrical Code or electrical code and  
20 has the same force and effect as though fully set forth in this chapter, except as specifically  
21 amended by the provisions of this chapter.

22           (b) This code shall be administered in accordance with Chapter 1, Administration, of the 2012  
23 edition of the International Building Code and Appendix K, Administrative Provisions, of  
24 the 2012 edition of the International Building Code, as adopted, respectively, with  
25 amendments, by Section 10-5-2, "Adoption of the International Building Code With  
Modifications," B.R.C. 1981.

(c) The following definition is added to part "I. General" of Article 100, "Definitions":

**Dried in.** The building or structure is protected from weather in that all openings can be  
closed, the roofing material is installed, and the exterior walls provide the building or  
structure with a weather-resistant exterior wall envelope.

(d) A new Subsection 210.52 (J), "Electric Vehicle Charging Requirements," shall be added to  
read:

1 Electric Vehicle Charging Requirements. Every newly permitted multi-family dwelling  
2 with more than twenty-five parking spaces shall include the following:

3 (1) 10 percent of parking spaces shall have one 240-volt and one 120-volt dedicated  
4 charging receptacle outlet.

5 (a) Accessible Spaces. Ten percent of accessible parking spaces, but in no case less  
6 than one accessible parking space, shall have one 240-volt and one 120 volt  
7 dedicated charging receptacle outlet. Parking in accessible spaces where electric  
8 vehicle supply equipment is installed shall not be limited to electric vehicles  
9 when no other comparable accessible space is available.

10 (2) At least one parking space shall have a Level 2 dual port electric vehicle charging  
11 station.

12 (e) A new Section 210.53, Electric Vehicle Charging Requirements for New Commercial  
13 Structures,” shall be added to read:

14 Electric Vehicle Charging Requirements for New Commercial Structures. Every newly  
15 permitted commercial structure with more than twenty-five parking spaces shall include the  
16 following:

17 (1) 10 percent of parking spaces shall have one 240-volt and one 120-volt dedicated  
18 charging receptacle outlet.

19 (a) Accessible Spaces. Ten percent of accessible parking spaces, but no less than  
20 one accessible parking space, shall have one 240-volt and one 120 volt  
21 dedicated charging receptacle outlet. Parking in accessible spaces where  
22 electric vehicle supply equipment is installed shall not be limited to electric  
23 vehicles when no other comparable accessible space is available.

24 (2) At least one parking space shall have a Level 2 dual port electric vehicle charging  
25 station.

(3) Buildings serving an R-1 or R-2 occupancy shall have a Level 2 dual port charging  
station in one percent, but no less than one, parking space.

(f) Subsection 210.70(A)(3) is repealed and reenacted to read:

(3) Storage or Equipment Spaces. For attics, underfloor spaces, utility rooms, and  
basements, at least one lighting outlet controlled by a wall switch shall be installed  
where these spaces are used for storage or contain equipment requiring servicing. The  
control wall switch shall be located at the usual point of entry to such space. The  
lighting outlet shall be provided at or near the equipment requiring servicing.

(eg) The first sentence of Section 230.2, "Number of services," is repealed and reenacted to read:

**230.2. Number of services.** A building or other structure shall be supplied by only one  
service unless permitted in sections 230.2(A) through (D) and approved prior to permit  
issuance or prior to the start of any electrical work indicated on the permit.

(fh) A new item (3) is added to Section 230.2(B), "Special occupancies," to read:

1 (3) Fire areas separated by a minimum two-hour fire wall as defined by the building code  
2 may be considered as separate buildings for the purpose of calculating the number of  
services if approved by the building official.

3 (~~g~~i) A new item (4) is added to Section 230.2(C), "Capacity Requirements," to read:

4 (4) Where the existing service is being used to capacity and has been properly maintained.

5 (~~h~~j) Subsection 230.40, concerning the number of service-entrance conductor sets, is amended  
6 by deleting exceptions 3 and 4.

7 (~~i~~k) Subsection 230.70(A)(1), concerning the location of service equipment disconnecting  
8 means, is repealed and reenacted to read:

9 (a) Readily Accessible Location. The service disconnecting means shall be installed at a  
10 readily accessible location either immediately adjacent to or attached to the outside of a  
11 building or structure, or inside nearest the point of entrance of the service conductors.

12 (1) Service entrance conductors shall not exceed ten feet maximum developed length  
13 unspliced between the meter housing and the main disconnect. This allows the  
14 service entrance conductors to run within the building up to ten feet and to  
15 terminate at the disconnecting means.

16 (2) Electrical rooms containing building main disconnects located within a structure  
17 shall be located near the point of service entrance and on the exterior wall with a  
18 door leading directly outside. The door shall be identified with three-inch-high  
19 lettering stating "Electrical Equipment Room."

20 (~~j~~l) Section 250.146, concerning connecting receptacle grounding terminal to box, is amended  
21 by deleting items (A), (B), and (C).

22 (~~k~~m) A new Section 310.12, "Conductor identification," is added to read:

23 **310.12 Conductor identification.** The colors of ungrounded conductors shall be black, red,  
24 and blue for 120/208 volt systems and brown, orange, and yellow for 277/480 volt systems.

25 (~~l~~n) A new item (6) is added to Section 334.10, "Uses permitted," to read:

(6) Type NM, Type NMC, and Type NMS shall not be installed in any building or any  
structure until the building or structure is completely dried in.

(~~m~~o) The second sentence of the introductory portion of Subsection 404.8(A), concerning the  
location of switches, is repealed and reenacted to read:

They shall be installed such that the center of the grip of the operating handle of the switch  
or circuit breaker, when in its highest position, will not be more than six feet seven inches  
nor less than three feet above the floor or working platform if within a building, or exterior  
grade or a working platform if on the exterior of a building.

(~~p~~n) Subsection 517.13(A), concerning grounding of receptacles and fixed electric equipment in  
patient care areas, is amended by adding a sentence to read:

Receptacles and electrical outlets within examining rooms, treatment rooms, and similar  
areas where the patient may come in contact with electrical devices in these rooms shall be  
listed hospital grade and identified as such.

1 (~~oq~~) Subsection 680.73, "Accessibility," is amended by adding the following:

2 Equipment shall be accessed by a panel with a minimum size of twelve inches by twelve  
3 inches.

4 (~~pr~~) A new Subsection (I) is added to Section 690.4, "Installation," to read:

5 (I) Compliance with Fire Code. Solar photovoltaic power systems shall be installed in  
6 accordance with the requirements of sections 605.11.1 through 605.11.4 of the City of  
7 Boulder Fire Code.

8 (~~qs~~) Subsection 690.9(C), "Photovoltaic source circuits," concerning direct current solar  
9 photovoltaic source conductors entering into a building, add the following text:

10 (1) Rooftop mounted solar photovoltaic array systems whose source conductor circuits are  
11 entering the building shall be protected against overcurrent at their source on the roof  
12 before entering the building.

13 Ordinance Nos. 4984 (1986); 5125 (1988); 5177 (1989); 5310 (1990); 5462 (1992); 5571 (1993);  
14 5851 (1996); 6015 (1998); 7566 (2007); 7623 (2008); 7925 (2013)

15 10-6-3. - Electrical Permit Fees.

16 Electrical permit fees are those prescribed by Subsection 4-20-8(a), B.R.C. 1981.

17 Ordinance Nos. 4984 (1986); 5851 (1996); 7566 (2007); 7925 (2013)

18 Section 4. Chapter 10-6, B.R.C. 1981, is amended to read:

19 . . .

20 10-6-2. - Adoption of the National Electrical Code With Modifications.

21 (a) The 2011 edition of the *National Electrical Code* of the National Fire Protection Association  
22 is hereby adopted by reference as the City of Boulder Electrical Code or electrical code and  
23 has the same force and effect as though fully set forth in this chapter, except as specifically  
24 amended by the provisions of this chapter.

25 (b) This code shall be administered in accordance with Chapter 1, Administration, of the 2012  
edition of the International Building Code and Appendix K, Administrative Provisions, of  
the 2012 edition of the International Building Code, as adopted, respectively, with  
amendments, by Section 10-5-2, "Adoption of the International Building Code With  
Modifications," B.R.C. 1981.

(c) The following definition is added to part "I. General" of Article 100, "Definitions":

**Dried in.** The building or structure is protected from weather in that all openings can be  
closed, the roofing material is installed, and the exterior walls provide the building or  
structure with a weather-resistant exterior wall envelope.

(d) Subsection 210.70(A)(3) is repealed and reenacted to read:

1 (3) Storage or Equipment Spaces. For attics, underfloor spaces, utility rooms, and  
2 basements, at least one lighting outlet controlled by a wall switch shall be installed  
3 where these spaces are used for storage or contain equipment requiring servicing. The  
control wall switch shall be located at the usual point of entry to such space. The  
lighting outlet shall be provided at or near the equipment requiring servicing.

4 (e) The first sentence of Section 230.2, "Number of services," is repealed and reenacted to read:

5 **230.2. Number of services.** A building or other structure shall be supplied by only one  
6 service unless permitted in sections 230.2(A) through (D) and approved prior to permit  
issuance or prior to the start of any electrical work indicated on the permit.

7 (f) A new item (3) is added to Section 230.2(B), "Special occupancies," to read:

8 (3) Fire areas separated by a minimum two-hour fire wall as defined by the building code  
may be considered as separate buildings for the purpose of calculating the number of  
services if approved by the building official.

9 (g) A new item (4) is added to Section 230.2(C), "Capacity Requirements," to read:

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11 (h) Subsection 230.40, concerning the number of service-entrance conductor sets, is amended  
by deleting exceptions 3 and 4.

12 (i) Subsection 230.70(A)(1), concerning the location of service equipment disconnecting  
13 means, is repealed and reenacted to read:

14 (a) Readily Accessible Location. The service disconnecting means shall be installed at a  
readily accessible location either immediately adjacent to or attached to the outside of a  
building or structure, or inside nearest the point of entrance of the service conductors.

15 (1) Service entrance conductors shall not exceed ten feet maximum developed length  
16 unspliced between the meter housing and the main disconnect. This allows the  
service entrance conductors to run within the building up to ten feet and to  
17 terminate at the disconnecting means.

18 (2) Electrical rooms containing building main disconnects located within a structure  
shall be located near the point of service entrance and on the exterior wall with a  
door leading directly outside. The door shall be identified with three-inch-high  
19 lettering stating "Electrical Equipment Room."

20 (j) Section 250.146, concerning connecting receptacle grounding terminal to box, is amended  
by deleting items (A), (B), and (C).

21 (k) A new Section 310.12, "Conductor identification," is added to read:

22 **310.12 Conductor identification.** The colors of ungrounded conductors shall be black, red,  
23 and blue for 120/208 volt systems and brown, orange, and yellow for 277/480 volt systems.

24 (l) A new item (6) is added to Section 334.10, "Uses permitted," to read:

25 (6) Type NM, Type NMC, and Type NMS shall not be installed in any building or any  
structure until the building or structure is completely dried in.

1 (m) The second sentence of the introductory portion of Subsection 404.8(A), concerning the  
2 location of switches, is repealed and reenacted to read:

3 They shall be installed such that the center of the grip of the operating handle of the switch  
4 or circuit breaker, when in its highest position, will not be more than six feet seven inches  
5 nor less than three feet above the floor or working platform if within a building, or exterior  
6 grade or a working platform if on the exterior of a building.

7 (n) Subsection 517.13(A), concerning grounding of receptacles and fixed electric equipment in  
8 patient care areas, is amended by adding a sentence to read:

9 Receptacles and electrical outlets within examining rooms, treatment rooms, and similar  
10 areas where the patient may come in contact with electrical devices in these rooms shall be  
11 listed hospital grade and identified as such.

12 (o) Subsection 680.73, "Accessibility," is amended by adding the following:

13 Equipment shall be accessed by a panel with a minimum size of twelve inches by twelve  
14 inches.

15 (p) A new Subsection (I) is added to Section 690.4, "Installation," to read:

16 (I) Compliance with Fire Code. Solar photovoltaic power systems shall be installed in  
17 accordance with the requirements of sections 605.11.1 through 605.11.4 of the City of  
18 Boulder Fire Code.

19 (q) Subsection 690.9(C), "Photovoltaic source circuits," concerning direct current solar  
20 photovoltaic source conductors entering into a building, add the following text:

21 (1) Rooftop mounted solar photovoltaic array systems whose source conductor circuits are  
22 entering the building shall be protected against overcurrent at their source on the roof  
23 before entering the building.

24 Ordinance Nos. 4984 (1986); 5125 (1988); 5177 (1989); 5310 (1990); 5462 (1992); 5571 (1993);  
25 5851 (1996); 6015 (1998); 7566 (2007); 7623 (2008); 7925 (2013)

26 Section 5. Chapter 10-7, B.R.C. 1981, is amended to read:

27 . . .

## 28 **Chapter 7 - Energy Conservation Code.**

29 10-7-1. - Legislative Intent.

30 The purpose of this chapter is to protect the public health, safety, and welfare by  
31 encouraging the conservation of scarce energy resources through the regulation of building  
32 construction standards to minimize energy consumption for heating, cooling, lighting, and  
33 ventilating structures in the city and to encourage building design utilizing green building  
34 techniques.

35 Ordinance Nos. 7566 (2007); 7925 (2013)

1 10-7-2. - Energy Conservation Code.

2 (a) Council adopts by reference the ~~2012 *International Energy* 2017 *City of Boulder Energy*~~ Conservation Code of the International Code Council which shall have the same force and  
3 effect as though fully set forth in the Boulder Revised Code, 1981, with the amendments  
4 specified below. This chapter and the 2017 City of Boulder Energy Conservation Code shall  
5 be administered, applied, and interpreted in accordance with and as part of Chapter 10-5,  
6 "Building Code," B.R.C. 1981. ~~This chapter is also intended to comply with and be~~  
7 ~~interpreted and enforced so as to comply with 42 U.S.C. Section 6297(f)(3) and any other~~  
8 ~~federal requirements to avoid preemption. For purposes of 42 U.S.C. Section 6297(f)(3),~~  
9 ~~"new construction" shall be interpreted to include all work that triggers the requirements~~  
10 ~~established in this chapter.~~

11 (b) Exception 3 of Section C101.4.3 is repealed and reenacted as follows:

12 3.1. ~~For an interior remodel of a residential structure, where the work authorized by a~~  
13 ~~building permit under Chapter 10 5, "Building Code," B.R.C. 1981, does not alter more than~~  
14 ~~500 square feet of the existing conditioned space, existing ceiling, wall, or floor cavities~~  
15 ~~exposed during construction are exempt from meeting the provisions for new construction~~  
16 ~~provided that exposed wall framing cavities are insulated to their fullest depth, but no less~~  
17 ~~than R-13, and attics and exposed or accessible floor/ceiling assemblies separating~~  
18 ~~conditioned spaces from unconditioned spaces are insulated to their fullest depth, but no less~~  
19 ~~than R-38 wherever possible. All replacement fenestration shall meet the prescriptive~~  
20 ~~requirements of Table R402.1.1 or R402.1.3. Portions of basements and crawlspaces~~  
21 ~~separating conditioned spaces from unconditioned spaces shall meet the prescriptive~~  
22 ~~requirements of Table R402.1.1 or R402.1.3 for climate zone 5 wherever possible. The~~  
23 ~~provisions of section R402.2 shall apply.~~

24 3.2. ~~For additions to residential structures where the work authorized by a building permit~~  
25 ~~under Chapter 10 5, "Building Code," B.R.C. 1981, does not add more than 500 square feet,~~  
26 ~~building envelope components shall meet the provisions of Table R402.1.1 or R402.1.3, and~~  
27 ~~applicable portions of Chapter 10 7.5, "Green Building and Green Points Program," B.R.C.~~  
28 ~~1981. The provisions of section R402.2 shall apply.~~

29 3.3. ~~Remodels of nonresidential structures where the work authorized by a building permit~~  
30 ~~under Chapter 10 5, "Building Code," B.R.C. 1981, does not alter more than 500 square~~  
31 ~~feet.~~

32 (c) Section C102.1.1 is repealed and reenacted as follows:

33 ~~**C102.1.1 Above code programs.** Except for those residential structures and portions of~~  
34 ~~structures exempt from this code, the requirements of Chapter 10 7.5, "Green Building and~~  
35 ~~Green Points Program," B.R.C. 1981, shall be used to demonstrate compliance with the~~  
36 ~~energy efficiency components of this code.~~

37 (d) Section C103.1 is repealed and reenacted to read as follows:

38 ~~**C103.1 General.** Construction documents and other supporting data shall be submitted in~~  
39 ~~one or more sets with each application for a permit. The construction documents and designs~~  
40 ~~submitted under the provisions of this chapter shall be prepared by and bear the stamp of a~~

1 Colorado licensed professional engineer or architect. Documents submitted for the purposes  
2 of section C507 shall be submitted by a Colorado licensed engineer, architect, or a  
3 professional who demonstrates the knowledge and experience to perform such calculations.  
Where special conditions exist, the code official is authorized to require additional  
4 construction documents to be prepared by a licensed professional.

4 **Exceptions:**

- 5 1. The code official may waive the submission of construction documents and other  
6 supporting data if the official finds that the nature of the work does not require  
7 review of the documents or data to obtain compliance. This waiver authority does  
not apply to documents required to be prepared by a licensed architect or engineer.

7 ~~(e) Sections C103.3 through C103.5 are deleted.~~

8 ~~(f) Section C104.3, "Final inspection," is amended by adding a new paragraph to read:~~

9 The applicant must provide at time of final inspection of a commercial building written  
10 verification which bears the stamp of a licensed architect or engineer or special inspector as  
described in section 107.3.4 of the 2012 edition of the *International Building Code* that the  
11 structure conforms with the provisions of Chapter 4.

11 ~~(g) Sections C104.5 through C104.8.1 are deleted.~~

12 ~~(h) Section C107, "Fees," is deleted.~~

13 ~~(i) Section C108, "Stop work order," is deleted.~~

14 ~~(j) Section C109, "Board of Appeals," is deleted.~~

15 ~~(k) Section C202, the definition of "Code Official" is repealed and reenacted to read:~~

Code official is the city manager.

16 ~~(l) Section C401.1 is repealed and reenacted to read:~~

17 **C401.1 Scope.** The requirements contained in this chapter are applicable to new commercial  
18 buildings and additions to or remodels of commercial buildings. Commercial buildings shall  
19 exceed the energy efficiency requirements of ASHRAE/IESNA Standard 90.1 Energy  
Standard for Building Except for Low-Rise Residential Buildings by at least 30 percent or  
other approved equivalent design criteria.

20 **C401.1.1 Alternative approaches for compliance.** The following methods of  
21 compliance may be used in place of the approach described in section 401.1 above:

- 22 1. Buildings of 20,000 square feet or less may be designed to a prescriptive  
23 standard as detailed in this chapter or through other measures that result in a  
24 building that is at least 30 percent more energy efficient than the 2012 IECC.  
25 2. Commercial core and shell buildings that have 50 percent or less finished floor  
area may divide the 30 percent energy efficiency requirement between the core  
and shell building design and the future interior tenant finish design. The  
energy efficiency savings percentages assigned to each element of the building

1 shall be designated at the time of the submittal of the building permit for the  
2 core and shell permit.

3 3. ~~The construction documents for remodeling an existing commercial envelope,  
4 mechanical and lighting systems shall demonstrate compliance with this  
5 section in one of the following ways described below. The construction  
6 documents shall include compliance documentation that demonstrates that:~~

7 ~~A. The altered building area or systems will meet the requirements of section  
8 C407, Total Building Performance, 2012 IECC, and the resulting  
9 compliance package shows an altered building area or system that is 30  
10 percent more energy efficient than the 2012 IECC;~~

11 ~~B. The remodel area will meet a set of prescriptive requirements approved by  
12 the city manager that are at least 30 percent more efficient than the 2012  
13 IECC; or~~

14 ~~C. The remodel area meets the 2012 IECC requirements and is submitted  
15 with an energy efficiency implementation plan prepared by a licensed  
16 architect or registered professional engineer which shows how the process  
17 will contribute to future energy efficiency improvements to bring the  
18 building up to 30 percent above the 2012 IECC.~~

19 **Exception:** ~~If the work is limited to mechanical equipment replacement, the  
20 replacement equipment shall meet the requirements of sections C403 and C404.~~

21 (m) ~~Section C401.2, "Application," is repealed and reenacted to read:~~

22 **~~C401.2 Application.~~**

23 1. ~~Buildings larger than 20,000 square feet must demonstrate compliance through  
24 third party performance modeling that is approved by the city manager.~~

25 2. ~~Commercial buildings of 20,000 square feet or less, meeting the requirements of  
this section C401 through the alternate approach of compliance found in section  
C401.1.1 subparagraph 1. by demonstrating that a building or system is 30 percent  
more energy efficient than the 2012 IECC, shall also comply with:~~

a. ~~The requirements of sections C402, C403, C404, C405, and C406; or~~

b. ~~The requirements of sections C407, C402.4, C403.2, C404, C405.2, C405.3,  
C405.4, C405.6, and C405.7.~~

(n) ~~Section C401.2.1 is deleted.~~

(o) ~~The first sentence of Section C407.3 is repealed and reenacted to read as follows:~~

~~Compliance based on total building performance requires that a proposed building (proposed  
design) be shown to have an annual energy cost that is at least 85 percent less than the  
annual energy cost of the standard reference design.~~

(p) ~~Section R101.4.3, "Additions, alteration, renovations, and repairs," a new subsection is  
added previous to the exceptions to read as follows:~~

1 ~~**R101.4.3.1.** All permit applications involving demolition, new construction, and remodels  
2 and/or additions of residential buildings greater than 500 square feet shall meet the  
3 requirements of this code and Chapter 10 7.5, "Green Building and Green Points Program,"  
4 B.R.C. 1981 as applicable.~~

5 ~~(q) Exception 3 of Section R101.4.3 is repealed and reenacted as follows:~~

6 ~~3.1. For an interior remodel of a residential structure, where the work authorized by a  
7 building permit under Chapter 10 5, "Building Code," B.R.C. 1981, does not alter more than  
8 500 square feet of the existing conditioned space, existing ceiling, wall, or floor cavities  
9 exposed during construction are exempt from meeting the provisions for new construction,  
10 provided that exposed wall framing cavities are insulated to the fullest depth, but not less  
11 than R 13, and attics and exposed or accessible floor/ceiling assemblies separating  
12 conditioned spaces from unconditioned spaces are insulated to their fullest depth, but no less  
13 than R 38 wherever possible. All replacement fenestration shall meet the prescriptive  
14 requirements of Table R402.1.1 or R402.1.3. Portions of basements and crawlspaces  
15 separating conditioned spaces from unconditioned spaces shall meet the prescriptive  
16 requirements of Table R402.1.1 or R402.1.3 for climate zone 5 wherever possible. The  
17 provisions of section R402.2 shall apply.~~

18 ~~3.2. For additions to residential structures where the work authorized by a building permit  
19 under Chapter 10 5, "Building Code," B.R.C. 1981, does not add more than 500 square feet,  
20 building envelope components shall meet the provisions of Table R402.1.1 or R402.1.3, and  
21 applicable portions of Chapter 10 7.5, "Green Building and Green Points Program," B.R.C.  
22 1981. The provisions of section 402.2 shall apply.~~

23 ~~(r) Section R102.1.1 is repealed and reenacted as follows:~~

24 ~~**R102.1.1 Above code programs.** Except for those residential structures and portions of  
25 structures exempt from this code, the requirements of Chapter 10 7.5, "Green Building and  
Green Points Program," B.R.C. 1981, shall be used to demonstrate compliance with the  
energy efficiency components of this code.~~

~~(s) Section R103.1 is repealed and reenacted to read as follows:~~

~~**R103.1 General.** Construction documents and other supporting data shall be submitted in  
one or more sets with each application for a permit. The construction documents and designs  
submitted under the provisions of this chapter shall be prepared by and bear the stamp of a  
Colorado licensed professional engineer or architect. Documents submitted for the purposes  
of section R405 shall be submitted by a Colorado licensed engineer, architect, or a  
professional who demonstrates the knowledge and experience to perform such calculations.  
Where special conditions exist, the code official is authorized to require additional  
construction documents to be prepared by a licensed professional.~~

### **Exceptions:**

1. ~~The code official may waive the submission of construction documents and  
other supporting data if the official finds that the nature of the work does not  
require review of the documents or data to obtain compliance. This waiver~~

1 authority does not apply to documents required to be prepared by a licensed  
2 architect or engineer.

3 ~~(t) Sections R103.3 through R103.5 are deleted.~~

4 ~~(u) Sections R104.5 through R104.8.1 are deleted.~~

5 ~~(v) Section R107, "Fees," is deleted.~~

6 ~~(w) Section R108, "Stop Work Order," is deleted.~~

7 ~~(x) Section R109, "Board of Appeal," is deleted.~~

8 ~~(y) Section R202, the definition of "Code Official" is repealed and reenacted to read:~~

9 Code official is the city manager.

10 Ordinance Nos. 7172 (2001); 7566 (2007); 7620 (2008); 7925 (2013) ; 7963 (2014)

11 10-7-3. - Regulations.

12 The city manager may make reasonable interpretive and administrative regulations to aid in  
13 applying this chapter under the procedures of Chapter 1-4, "Rulemaking," B.R.C. 1981,  
14 including rules establishing methods for showing compliance with the requirements of this  
15 chapter.

16 Ordinance No. 7925 (2013)

17 Section 6. Chapter 10-7.5, B.R.C. 1981, is amended to read:  
18 repealed:

19 **Chapter 7.5 – Green Building and Green Points Program**

20 ~~10-7.5 1. Legislative Intent and Purpose.~~

21 ~~The purpose of this chapter is to protect the public health safety and welfare by regulating  
22 residential construction with the intent to conserve energy, water, and other natural resources,  
23 and preserve the health of our environment through optional and mandatory requirements related  
24 to design, construction, operations, recycling, and deconstruction. This chapter has the following  
25 additional purposes:~~

~~(a) It provides criteria for rating the environmental performance of residential construction  
practices and provides guidelines for documentation that demonstrates conformance with the  
criteria;~~

~~(b) It encourages cost effective and sustainable residential building methods, by encouraging  
conservation of fossil fuels, water, and other natural resources, reduction of greenhouse gas  
emissions, recycling of construction materials, reducing solid waste, and improving indoor  
air quality;~~

~~(c) It identifies the specific requirements for complying with the Green Points Program and how  
the program interfaces and exceeds the 2012 International Energy Conservation Code  
adopted in Chapter 10-7, "Energy Conservation Code," B.R.C. 1981;~~

- 1 ~~(d) It includes mandatory green building requirements to ensure that construction waste and~~  
2 ~~deconstruction materials are recycled, reused, or otherwise diverted from land fills, and~~  
3 ~~minimum requirements to ensure that dwellings are constructed in an efficient manner ;~~
- 4 ~~(e) It includes provisions intended to provide for joint administration with the processing of~~  
5 ~~building permits for remodeling, adding on, and constructing dwelling units; and~~
- 6 ~~(f) It is intended to comply with, and be interpreted and enforced so as to comply with, 42~~  
7 ~~U.S.C. Section 6297(f)(3) and any other federal requirements to avoid preemption. For~~  
8 ~~purposes of 42 U.S.C. Section 6297(f)(3), "new construction" shall be interpreted to include~~  
9 ~~all work that triggers the requirements established in this chapter.~~

10 Ordinance Nos. 7565 (2007); 7925 (2013)

11 ~~10-7.5.2. Scope and Administration.~~

12 ~~(a) Scope. The provisions of this chapter apply to the following:~~

- 13 ~~(1) New construction, remodels, or additions to a dwelling, including, without limitation,~~  
14 ~~single-unit dwellings, multi-unit dwellings, and dwellings within mixed-use~~  
15 ~~developments.~~
- 16 ~~(2) Any two or more building permits for the same structure that are applied for in any~~  
17 ~~twelve-month period shall be considered as one application for the purpose of meeting~~  
18 ~~the requirements of Sections 10-7.5-3, "Mandatory Green Building Requirements," and~~  
19 ~~10-7.5-4, "Resource Conservation - Green Points," B.R.C. 1981.~~
- 20 ~~(3) The requirements of this chapter shall apply to construction activities of all types of~~  
21 ~~dwellings unless the context clearly indicates otherwise.~~
- 22 ~~(4) The requirements of this chapter are in addition to and do not replace the requirements~~  
23 ~~within the Boulder Revised Code, including, without limitation, all of the life safety~~  
24 ~~codes, the historic preservation ordinance, the land use code, and the City of Boulder~~  
25 ~~Design and Construction Standards.~~

26 ~~(b) Administration. The Green Points Program shall be administered applied, and interpreted in~~  
27 ~~accordance with chapter 1, "Administration," chapter 2, "Definitions," of the International~~  
28 ~~Building Code (IBC) and the International Residential Code (IRC) as adopted with~~  
29 ~~amendments by Sections 10-5-2, "Adoption of International Building Code With~~  
30 ~~Modifications," and 10-5.5-2, "Adoption of International Residential Code With~~  
31 ~~Modifications," B.R.C. 1981.~~

32 ~~(c) Inspection and Compliance. No person shall fail to comply with the requirements of this~~  
33 ~~chapter. No person shall construct in violation of a Green Points approval. All approvals and~~  
34 ~~inspections of Green Point's applications and requirements shall be done in conjunction with~~  
35 ~~a residential building permit application and field inspections. An application shall be made~~  
36 ~~on a form that is approved by the city manager. The applicant shall demonstrate compliance~~  
37 ~~with all of the provisions of this chapter prior to the issuance of a certificate of occupancy by~~  
38 ~~the city manager.~~

39 ~~(d) Exceptions. Any structure that includes dwellings that are pursuing a U.S. Green Building~~  
40 ~~Council's LEED™ (Leadership in Energy and Environmental Design) Silver Certification or~~  
41 ~~comparable green building rating certification or higher will be exempt from the Green~~

1 ~~Points requirements. No person that applies for this exception shall fail to complete the~~  
2 ~~LEED™ certification process and receive such certification within six months after the final~~  
3 ~~inspection on the building permit. The city manager may grant an extension to this time~~  
4 ~~period if a request is made by the applicant and the applicant demonstrates a good cause as~~  
5 ~~to why additional time is needed to complete the certification.~~

6 Ordinance Nos. 7565 (2007); 7621 (2008); 7925 (2013)

7 ~~10-7.5-3. Mandatory Green Building Requirements.~~

8 ~~(a) Energy Efficiency – New Dwelling Units. An applicant for a building permit for each new~~  
9 ~~dwelling shall demonstrate that the building is more energy efficient than a building that~~  
10 ~~meets the minimum requirements of Chapter 10-7, "Energy Conservation Code," B.R.C.~~  
11 ~~1981. Table 1A lists the minimum energy efficiency requirements.~~

12 **TABLE 1A – Tiers for Energy Efficiency Thresholds**

13

<i>Type of Project</i>	<i>Square Footage</i>	<i>Energy Efficiency Thresholds Above Code</i>
New Construction	Up to 3,000	14 percent more energy efficient than 2012 IECC (HERS 60)
	3,001 – 5,000	43 percent more energy efficient than 2012 IECC (HERS 50)
	5,001 and up	64 percent more energy efficient than 2012 IECC (HERS 25)
Multi-Unit Dwellings	Applies to all	14 percent more energy efficient than 2012 IECC (HERS 60)

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22 ~~(b) Thresholds for Application of New Construction Standards to Entire Building as the Result~~  
23 ~~of an Addition. Any addition which meets any of the thresholds described below will require~~  
24 ~~that the conditioned floor area of the entire building be upgraded to meet new construction~~  
25 ~~standards for energy efficiency in Subsection 10-7.5-3(a), B.R.C. 1981.~~

~~(1) The addition is 100 percent or more than the conditioned floor area of the existing~~  
~~dwelling unit and the dwelling unit will have a total conditioned floor area after the~~  
~~addition to the dwelling unit that is up to 3,000 sq. ft. in size.~~

1 ~~(2) The addition is 50 percent or more than the conditioned floor area of the existing~~  
2 ~~dwelling unit and the dwelling unit will have a total conditioned floor area after the~~  
3 ~~addition to the dwelling unit that is from 3,001 to 5,000 sq. ft. in size.~~

4 ~~(3) The addition is 25 percent or more than the conditioned floor area of the existing~~  
5 ~~dwelling unit and the dwelling unit will have a total conditioned floor area after the~~  
6 ~~addition to the dwelling unit that is over 5,001 sq. ft. in size.~~

7 ~~(c) Energy Efficiency Additions and Remodels. An applicant for a building permit for a~~  
8 ~~remodel or an addition to a dwelling that does not exceed the thresholds in Subsection (b)~~  
9 ~~above shall demonstrate that it meets the energy efficiency requirements of this section. A~~  
10 ~~building permit for an addition to or a remodel of a dwelling unit shall meet one of the~~  
11 ~~following standards:~~

12 ~~(1) Requirement if upgrading the energy efficiency of the entire structure. The applicant~~  
13 ~~may demonstrate that the entire building meets the HERS requirements that are~~  
14 ~~described in Table 1B below; or~~

15 ~~(2) Requirement for the new addition or the area of the house that is subject to a remodel.~~  
16 ~~The applicant may demonstrate that the addition or the area of the building subject to a~~  
17 ~~remodel meets the requirement of the IECC for the remodel area or addition as~~  
18 ~~described in Table 1B below. Building permits under this requirement shall also meet~~  
19 ~~the following:~~

20 ~~(A) Complete a blower door test before application for the building permit to determine~~  
21 ~~whether the building has a fresh air infiltration rate of no more than 0.5 natural air~~  
22 ~~changes per hour (NACH) compliance rating. If this standard is exceeded, then the~~  
23 ~~applicant shall meet the requirement of paragraph (B).~~

24 ~~(B) Improve, repair and seal the dwelling unit, verified by a subsequent blower door~~  
25 ~~test and prior to a certificate of occupancy or completion that demonstrates that:~~

~~(i) for buildings that had an air infiltration rate of 1.0 NACH or greater, then the~~  
~~building shall have a NACH 50 percent or less than the original blower door~~  
~~test;~~

~~(ii) for all other buildings, the building has an air infiltration rate of not greater~~  
~~than 0.5 NACH compliance rating.~~

**Table 1B – Energy Efficiency Thresholds for Remodels and Additions**

<i>Total Conditioned Area</i>	<i>HERS Rating</i>	<i>Increased Efficiency Above the 2012 IECC</i>
Up to 3,000 sq. ft.	70	5 percent
3,001–5,000 sq. ft.	60	15 percent

5,001 sq. ft. and up	50	30 percent
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- ~~(3) Remodels—Limitations. A remodel that does not substantially remove the interior finish of the thermal envelope of the conditioned space is not required to meet the energy efficiency requirements of Table 1B.~~
- ~~(d) Compliance with Energy Efficiency Requirements. A dwelling that is required to meet the energy efficiency requirements for new construction shall demonstrate that it meets such standard by:
 
  - ~~(1) Using the Home Energy Rating System (HERS). The HERS rating will be used for the verification of energy performance of new construction. A HERS rating shall be performed by a rater accredited by the Residential Energy Services Network (RESNET);~~
  - ~~(2) For multidwelling projects, through a HERS rating sampling protocol authorized and approved by the city manager; or~~
  - ~~(3) For multidwelling projects, by demonstrating that the energy efficiency has been achieved by using the methodology in section R405, "Simulated Performance Alternative" or section C407, "Total Building Performance" of the 2012 International Energy Conservation Code.~~~~
- ~~(e) Energy Audit. An applicant for a building permit for an addition to a dwelling or a remodel of a dwelling shall be required to obtain an energy audit. The applicant shall provide proof of the completion of the energy audit with a building permit application. The energy audit of the house shall quantify the annual energy performance of the building according to generally accepted standards for energy audits approved by the city manager. An energy audit or an optional HERS rating report will indicate how efficiently the building is operating and where inefficiencies are occurring.~~
- ~~(f) Construction Waste Recycling. An applicant for a building permit for a new dwelling or an addition to a dwelling shall demonstrate that a minimum of 50 percent of construction waste is recycled. Waste diversion calculations and tracking spreadsheet form must be provided at project completion which shows that the minimum recycling requirements have been met. No person shall fail to complete the diversion calculations and tracking spreadsheet or recycle construction waste as required by this section.~~
- ~~(g) Demolition Management. An applicant proposing to demolish the dwelling, as that term is defined in Section 10-7.5-7, "Definitions," B.R.C. 1981, shall demonstrate through a deconstruction plan that at least 65 percent of material by weight from deconstruction of the existing structure, including concrete and asphalt, will be diverted from the landfill. Verification of deconstruction plan compliance must be provided prior to final inspection. No person shall fail to follow or otherwise implement an approved deconstruction plan.~~

Ordinance Nos. 7565 (2007); 7621 (2008); 7925 (2013)

~~10-7.5-4. Resource Conservation—Green Points.~~

(a) ~~Schedule for Green Points. Residential building permit applicants are required to earn green points according to the schedule in Table 2. An applicant proposing to increase the floor area of the existing building pursuant to Subsection 10-7.5-3(b), "Thresholds for Application of New Construction Standards to Entire Building as the Result of an Addition," B.R.C. 1981, shall be required to earn the amount of green points required for the new construction of a new dwelling of the same size as the existing dwelling with such addition.~~

**TABLE 2 -- Green Points Requirements**

<i>Project Description</i>	<i>Square Footage Thresholds</i>	<i>Green Point Requirements<sup>1,2</sup></i>
New construction of single unit dwellings	1,501—3,000	20
	3,001—5,000	40
	5,001 and up	60
Additions to a dwelling	500—1,000	15
	1,001—2,000	20
	2,001—3,000	30
	3,001 and up	45
Interior remodels of a dwelling	500—1,000	10
	1,001—2,000	15
	2,001—3,000	20
	3,001 and up	30
Multi-unit Dwellings: <sup>3</sup> final tenant finish of a unit in a multi-unit dwelling	1,001—2,000	10
	2,001—3,000	20

	3,001 and up	30
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~~1. One green point is awarded for each HERS rating score below the HERS index rating requirement.~~

~~2. The green point values listed in Subsections 10 7.5 4(e) and (f) only apply to those projects that are not required to have a HERS index rating.[0]~~

~~3. Each dwelling in a multi-unit dwelling shall be required to meet the green point requirements separately.~~

~~(b) Site Development:~~

~~(1) Landscaping:~~

~~(A) Organic Soil Amendments: 2 points.~~

~~(B) Xeriscape Landscaping: 1-4 points.~~

~~(i) Reduce turf areas to a minimum: 1 point.~~

~~(ii) All planting beds mulched with wood chips at least 3" deep: 1 point.~~

~~(iii) Appropriate use of xeric (low water demand) plants grouped by water needs: 1 point.~~

~~(iv) Zoned Irrigation System: 1 point.~~

~~(2) Shading of Hardscapes:~~

~~(A) Preserve Existing Mature Trees on Site: Up to 5 Points (1 Point per tree).~~

~~(B) Plant Shade Trees: Up to 5 Points (1 Point per tree).~~

~~(3) Surface Water Management - Permeable Sites: 1-4 Points. Points are awarded according to the following:~~

<i>Percentage of Site That is Permeable</i>	<i>Points</i>
<del>≥ or equal to 50%</del>	<del>1</del>
<del>≥ or equal to 75%</del>	<del>2</del>
<del>≥ or equal to 90%</del>	<del>3</del>
<del>100%</del>	<del>4</del>

1 ~~(4) High Efficiency Automatic Irrigation: Up to 2 points. Points are awarded according to~~  
2 ~~the following:~~

3 ~~(A) 75% Efficiency Rating: 1 point.~~

4 ~~(B) 95% Efficiency Rating: 2 points.~~

5 ~~(e) Building Rehabilitation: Up to 10 points. Points are awarded according to the following:~~

6 ~~(1) Complete and appropriate rehabilitation and/or retrofitting of windows and doors: up to~~  
7 ~~3Points. .5 point for each window.~~

8 ~~(2) Storm System: up to 2 points. Installation of appropriate interior or exterior storm~~  
9 ~~systems. .5 point for each window.~~

10 ~~(3) The property is a contributing building within a historic district or designated as an~~  
11 ~~individual landmark pursuant to Chapter 9-11, "Historic Preservation," B.R.C. 1981: 5~~  
12 ~~points.~~

13 ~~(d) Waste Management.~~

14 ~~(1) Reuse Existing Building: Up to 5 points. Incorporate portions of existing structures in~~  
15 ~~remodel and addition projects according to the following:~~

16 ~~(A) Save 50% of exterior walls (external sheathing and framing): 3 points.~~

17 ~~(B) Save 75% of exterior walls (external sheathing and framing): 5 points.~~

18 ~~(2) Remodels, Additions, and Demolition: Up to 3 points. Green points will be awarded on~~  
19 ~~waste diversion on existing buildings (additions, remodels, or complete demolitions~~  
20 ~~classified as an "entire structure" on a demolition permit) beyond the mandatory waste~~  
21 ~~diversion requirements. Points will be awarded for additional diversion according to the~~  
22 ~~following:~~

23 ~~(A) 75% deconstruction material diverted from landfills: 2 points.~~

24 ~~(B) 85% deconstruction material diverted from landfills: 3 points.~~

25 ~~(3) New Construction Waste Recycling: Up to 3 points. Green points will be awarded on~~  
26 ~~waste diversion beyond the mandatory waste diversion requirements. Points will be~~  
27 ~~awarded according to the following:~~

28 ~~(A) 75% waste material diverted from landfills: 2 points.~~

29 ~~(B) 85% waste material diverted from landfills: 3 points.~~

30 ~~(e) Energy Efficiency.~~

31 ~~(1) Insulation. Points will be awarded according to the following:~~

32 ~~(A) Minimum R-19 cavity plus R-5 sheathing wall insulation: 2 points.~~

33 ~~(B) Minimum R-49 ceiling: 2 points.~~

34 ~~(C) Exterior minimum R-10 insulation installed for the full height of a basement or~~  
35 ~~foundation wall: 2 Points.~~

36 ~~(D) Insulated Pre-cast Concrete Foundation: 2 points.~~

1 ~~(E) Insulated Concrete Forms: 2 points.~~

2 ~~(2) Windows: Up to 10 points. New windows or replacement windows installed as part of a remodel or an addition. Points will be awarded as follows:~~

3 ~~(A) National Fenestration Rating Council (NFRC): Up to 5 points. Rated Window with Maximum U Value of 0.34 or lower: .5 point for each window, up to 5 points.~~

4 ~~(B) NFRC Rated Window with Maximum Solar Heat Gain Coefficient (SHGC) of 0.55: .5 point for each window, up to 5 points. Exception: South facing glass.~~

5 ~~(3) Air Sealing of an Existing Building. Points will be awarded when a HERS rating is applied to the existing structure preconstruction, then a post rating after construction showing:~~

6 ~~(A) Ten percent net increase in initial HERS rating\*: 2 points.~~

7 ~~(B) No net increase in initial HERS rating\*: 3 points.~~

8 ~~(C) Decrease in initial HERS rating\*: 5 points.~~

9 ~~\*Because of the variability of existing construction, projecting the final HERS rating can be difficult and planning for contingencies if the planned HERS rating is not achieved should be done.~~

10 ~~(4) Heating, Ventilation and Air Conditioning (HVAC) Systems. Points will be awarded according to the following:~~

11 ~~(A) HVAC Commissioning: 3 points. Testing for duct leakage, firing rate, and refrigerant charge.~~

12 ~~(B) Ground Source Heat Pump: Up to 10 points. Points will be awarded according to the following:~~

13 ~~(i) 30—39% calculations from a heating/cooling load bin analysis: 4 points.~~

14 ~~(ii) 40—49% calculations from a heating/cooling load bin analysis: 6 points.~~

15 ~~(iii) 50—59% calculations from a heating/cooling load bin analysis: 8 points.~~

16 ~~(iv) 60—69% calculations from a heating/cooling load bin analysis: 10 points.~~

17 ~~(C) Direct Vent Combination Space/Water Heating System: 2 points.~~

18 ~~(D) Zoned, Hydronic Radiant Heating: 2 points.~~

19 ~~(E) Passive Cooling: 2-5 points (one point per item). Points will be awarded for passive cooling systems using any two or more of the techniques described below:~~

20 ~~(i) Exterior vertical shading devices for east and west facing glass.~~

21 ~~(ii) Reflective films or glass on east and west facing windows.~~

22 ~~(iii) Radiant, heat reflective barriers installed in the attic space.~~

23 ~~(iv) Landscaping that shades east and west facing glazing during the cooling season (June to September).~~

~~(v) South window overhang sized to effectively shade the window during the cooling season (June to September).~~

~~(F) Whole House Fan: 2 points.~~

~~(G) Evaporative Cooling: 3 points.~~

~~(5) Water Heater:~~

~~(A) Tank-less Water Heater: 2 points.~~

~~(B) Point of Use Water Heater: 2 points.~~

~~(6) Lighting, Appliances, and Electricity:~~

~~(A) ENERGY STAR Advanced Lighting Package (ALP): 5 Points. The ALP shall meet the following minimum specifications:~~

High Use Rooms	Kitchen, Dining Room, Living Room, Family Room, Bathroom(s), Hall(s)/Stairways	50% of Total Number of Fixtures
Medium/Low Use Rooms	Bedroom, Den, Office, Basement, Laundry Room, Garage, Closet(s) and all other rooms	25% of Total Number of Fixtures
Outdoor	Outdoor Lighting Affixed to the structure or Freestanding Pole(s), Except for landscape and solar lighting	50% of Total Number of Fixtures including all flood lighting

~~(B) Efficient Light Controls: Up to 2 points. Efficient lighting controls include occupancy sensors, dimming controls, and automatic daylight dimming controls.~~

~~(i) 4 control devices: 1 point.~~

~~(ii) 6 control devices: 2 points.~~

~~(C) Energy Efficient Appliances: Up to 6 Points. Points are awarded according to the following:~~

~~(i) ENERGY STAR rated refrigerator: 2 points.~~

~~(ii) ENERGY STAR rated clothes washer: 2 points.~~

~~(iii) ENERGY STAR rated freezer: 1 point.~~

~~(iv) ENERGY STAR rated dishwasher: 1 point.~~

1 ~~(f) Solar.~~

2 ~~(1) Passive Solar Heating Design: 6-12 points. Design with passive solar heating elements~~  
3 ~~of south-facing glazing, appropriate thermal mass and building overhangs.~~

4 ~~(A) 40–49% verifying calculations of the solar heat gain fraction: 6 points.~~

5 ~~(B) 50–59% verifying calculations of the solar heat gain fraction: 8 points.~~

6 ~~(C) 60–69% verifying calculations of the solar heat gain fraction: 10 points.~~

7 ~~(D) >70% verifying calculations of the solar heat gain fraction: 12 points.~~

8 ~~(2) Solar Thermal Domestic Hot Water System: 8 points. Systems must be sized to provide~~  
9 ~~at least 50% of the domestic hot water load.~~

10 ~~(3) Solar Thermal Space Heating or Pool/Spa System: 3 points. Systems must be designed~~  
11 ~~to offset a minimum of 15% of the annual space heating or pool or spa load.~~

12 ~~(4) Pre-Plumb for Solar Thermal System Retrofit: 2 points.~~

13 ~~(5) Active Solar Electric System: 6-12 points. Design and install an active solar~~  
14 ~~(photovoltaic) system to meet the electrical load of the building according to the~~  
15 ~~following schedule:~~

16 ~~(A) 30–39% solar electricity or equivalent to 2 KW system: 6 Points.~~

17 ~~(B) 40–49% solar electricity or equivalent to a 3 KW system: 8 Points.~~

18 ~~(C) 50–59% solar electricity or equivalent to a 4 KW system: 10 Points.~~

19 ~~(D) >60% solar electricity or equivalent larger than 5 KW system: 12 Points.~~

20 ~~(6) Pre-Wire for Future Solar Electric Installation Retrofit: 2 points.~~

21 ~~(g) Water Efficiency. High Efficiency Fixtures: 2-6 Points. Points will be awarded for~~  
22 ~~installation of high efficiency (low flow) fixtures follows:~~

23 ~~(1) 25% of all fixtures: 2 points.~~

24 ~~(2) 50% of all fixtures: 4 points.~~

25 ~~(3) 75% of all fixtures: 6 points.~~

~~(h) Material Efficient Framing and Structure.~~

~~(1) Advanced Framing Techniques: Up to 10 points. Points will be awarded as follows:~~

~~(A) 24" On-Center Framing: 2 points.~~

~~(B) Insulated Headers: 2 points.~~

~~(C) Energy Efficient Roof Trusses: 2 points.~~

~~(D) HVAC Ducts Within Conditioned Spaces: 2 points.~~

~~(E) Minimum 12-inch Roof Overhangs: 2 points.~~

~~(2) Structural Insulated Panels (SIPs): Up to 8 points. Points will be awarded as follows:~~

~~(A) At least 50% of exterior walls: 5 points.~~

~~(B) At least 50% of exterior walls and roof: 8 points.~~

~~(3) Structural Alternatives to Wood: Up to 8 points. Points will be awarded as follows:~~

~~(A) At least 50% of exterior walls: 5 points.~~

~~(B) At least 50% of exterior walls and roof: 8 points.~~

~~(i) Sustainable Products:~~

~~(1) FSC-Certified Tropical Woods or No Tropical Wood: Up to 6 Points. Points will be awarded as follows:~~

~~(A) 2 BF of FSC lumber per SQ/FT of floor area (2 BF/SQ. FT.): 2 points.~~

~~(B) 3 BF of FSC lumber per SQ/FT of floor area (3 BF/SQ. FT.): 4 points.~~

~~(C) 50% or more of dimensional lumber in total BF is FSC, excluding engineered wood products: 6 points.~~

~~(2) Environmentally Preferred Materials: Up to 10 Points. Points will be awarded for environmentally preferred materials as follows:~~

~~(A) Recycled content: 2 points.~~

~~(B) Reclaimed: 2 points.~~

~~(C) Bio-based: 2 points.~~

~~(D) Agricultural residue: 2 points.~~

~~(E) Low or no Volatile Organic Compounds (VOCs) emissions: 2 points.~~

~~(3) Locally Sourced Materials: Products that are environmentally preferable and/or extracted, processed, and manufactured within 500 miles of the city are considered local. A maximum of 1.5 points can be earned for any single component listed in the Environmentally Preferable Products Chart regardless of the amount by which a minimum performance threshold is exceeded. A "recycled content" product must contain a minimum of 25% post-consumer recycled content except as noted otherwise above. Post-industrial (pre-consumer) recycled content is counted at half the rate of post-consumer content. Points will be awarded as shown on the Environmentally Preferable Products Chart below:~~

**ENVIRONMENTALLY PREFERABLE PRODUCTS CHART**

<i>Assembly</i>	<i>Component</i>	<i>Product Specification Types (See Note 1)</i>		
		<i>Specifications</i>	<i>Emission Specifications</i>	<i>Local</i>
Exterior Wall	Framing	FSC-certified		X

1	Exterior Wall	Framing	Finger jointed studs (vertical use only for structural components)		X
2					
3					
4	Exterior Wall	Siding or masonry	Recycled content or FSC certified		X
5					
6	Floor	Flooring	Linoleum, cork, bamboo, FSC-certified or reclaimed wood, sealed concrete, recycled content flooring, or combination in 45% of home's floor area.	Carpet & pad: comply with Carpet and Rug Institute's Green Label Plus Program	X
7					
8					
9					
10					
11					
12	Floor	Flooring	BONUS ½ for 90% of home	BONUS ½ for NO carpet in home	
13					
14	Floor	Framing	FSC certified		X
15					
16	Foundation	Cement	Fly ash or slag as replacement for, not addition to, cement content (min. 30%)		X
17					
18	Interior Wall	Framing	FSC certified		X
19					
20	Interior Wall	Framing	Finger Jointed, (vertical use only for structural components)		X
21					
22					
23	Interior Walls AND Ceilings	Gypsum board	Recycled content		X
24					
25					

1	Interior Walls AND millwork	Paint		Comply with Green Seal Standard GS-11, Paints, First Edition, May 20, 1993	
2					
3					
4					
5	Interior Walls AND millwork	Wood finishes		VOC concentrations of 150 gpl or less	
6					
7	Landscape	Decking or patio material	Recycled content or FSC-certified		X
8					
9					
10	Other	Cabinets	Recovered, recycled content, or FSC-certified	Wood and/or agrifiber products with no added urea-formaldehyde resins	X
11					
12					
13					
14	Other	Counters	Recycled content	Wood and/or agrifiber products with no added urea-formaldehyde resins	
15					
16					
17	Other	Doors (not incl. garage)	Recycled content or FSC-certified	Wood and/or agrifiber products with no added urea-formaldehyde resins	X
18					
19					
20					
21	Other	Trim	Recovered, recycled content, or FSC-certified	Wood and/or agrifiber products with no added urea-formaldehyde resins	
22					
23					
24	Other	Adhesives		VOC concentrations of	
25					

1		and sealants		70 gpl or less	
2	Other	Windows	Recycled content or FSC certified		X
3	Roof	Framing	FSC certified		X
4	Roof	Roofing	Recycled content or vegetated (min. 200 sf)		X
5	Roof AND Floor AND Wall	Insulation	Recycled content (min 20%)	Comply with State of California, DHS, "Practice for Testing of VOCs from Building Materials using Small Chambers"	X
6	Roof, Floor, Wall (2 of 3)	Sheathing	Recycled content or FSC certified		X

~~(j) Indoor Air Quality.~~

- ~~(1) ENERGY STAR's Indoor Air Quality Package Requirements: 10 points.~~
- ~~(2) Mechanical Ventilation: Up to 5 Points. Points will be awarded as follows:~~
  - ~~(A) Installation of a kitchen exhaust fan: 1 point.~~
  - ~~(B) Bath exhaust fans with timer or humidistat controls: 1 point.~~
  - ~~(C) Ventilation integrated in the HVAC system: 1 point.~~
  - ~~(D) Incorporating Heat Recovery Ventilation: 2 points.~~
- ~~(3) High Efficiency HVAC Filter: 1 point.~~
- ~~(4) Radon Mitigation: Up to 2 Points. Points will be awarded as follows:~~
  - ~~(A) Passive System: 1 point.~~
  - ~~(B) Active System: 2 points.~~
- ~~(5) Attached Garage Exhaust Fan: 1 point.~~

1 ~~(k) Homeowner Information. Operations and Maintenance Binder: 1 Point. The builder shall~~  
2 ~~provide a binder to be left in the dwelling for future occupants that includes the four of the~~  
3 ~~following items:~~

4 ~~(1) The Green Points checklist.~~

5 ~~(2) Home Energy Audit or HERS certificate.~~

6 ~~(3) The equipment manufacturer's installation manuals, except for manuals required to be~~  
7 ~~affixed to the equipment.~~

8 ~~(4) Copies of operations and maintenance instructions for equipment installed in the home.~~

9 ~~(m) Design Process and Innovation.~~

10 ~~(1) Green Building Consultants: 2 points.~~

11 ~~(2) ENERGY STAR Builder: 1 point.~~

12 ~~(3) Innovation Points: Up to 10 Points. Points are awarded for products, designs, or~~  
13 ~~technologies which minimize the environmental impact of the house in a tangible and~~  
14 ~~demonstrable way beyond the methods outlined in the Green Points Program.~~

15 Ordinance Nos. 7565 (2007); 7621 (2008)

16 ~~10 7.5 5. Alteration or Modification.~~

17 ~~(a) Alteration and Modification. The city manager may make reasonable alterations or~~  
18 ~~modifications in the award of green points or the requirements of this chapter if the manager~~  
19 ~~finds that the strict application of the green points and mandatory green standards:~~

20 ~~(1) Creates practical difficulties in the construction of a residential unit; or~~

21 ~~(2) Causes undue waste; or~~

22 ~~(3) The proposed alteration or modification is equivalent to existing mandatory green~~  
23 ~~building requirements or green points; or~~

24 ~~(4) Is necessary to remove barriers for the construction of housing that is affordable to~~  
25 ~~households, as that term is used in Chapter 9 13, "Inclusionary Housing," B.R.C. 1981;~~  
26 ~~or~~

27 ~~(5) Requires an alteration to an individual landmark or a contributing building in a historic~~  
28 ~~district that would not be eligible for approval as part of a landmark alteration~~  
29 ~~certificate; and~~

30 ~~(6) When the purposes of this chapter are otherwise met through such alteration or~~  
31 ~~modification.~~

32 ~~(b) Appeal. An applicant for an alteration or a modification that has been denied by the city~~  
33 ~~manager may appeal the determination by filing an appeal within fourteen days after the~~  
34 ~~denial. Within sixty days after the appeal is filed, unless a different time is mutually agreed~~  
35 ~~upon by the applicant and the city manager, the Board of Zoning Adjustment and Building~~  
36 ~~Appeals will consider the appeal pursuant to the hearing requirements of Chapter 1 3,~~  
37 ~~"Quasi Judicial Hearings," B.R.C. 1981.~~

1 Ordinance Nos. 7565 (2007); 7701 (2010)

2 ~~10 7.5 6. Regulations.~~

3 ~~The city manager may make reasonable interpretive and administrative regulations to aid in~~  
4 ~~applying this chapter under the procedures of Chapter 1-4, "Rulemaking," B.R.C. 1981. The city~~  
5 ~~manager is authorized to adopt rules related to the award of green points that provide for~~  
6 ~~equivalent benefits as for similar green point awards in this chapter. The purpose of this grant of~~  
7 ~~rulemaking authority is to allow the city manager to consider green point awards for technology~~  
8 ~~and products that were not contemplated at the time of the adoption of this chapter that will~~  
9 ~~provide benefits that are consistent with the purposes of this chapter.~~

7 Ordinance Nos. 7565 (2007); 7577 (2007)

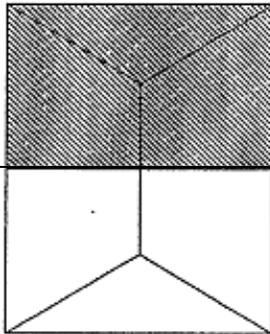
8 ~~10 7.5 7. Definitions.~~

9 ~~(a) The following terms used in this chapter have the following meaning unless the context~~  
10 ~~clearly indicates otherwise:~~

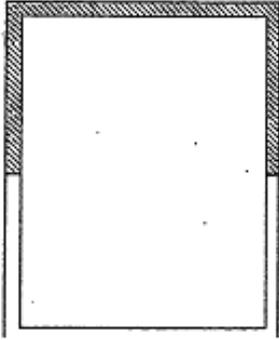
11 ~~*Addition* An extension or increase in floor area of a building or structure of 500 sq. ft. or~~  
12 ~~greater.~~

13 ~~*Demolition or demolish* means an act or process which removes one or more of the~~  
14 ~~following. The shaded area illustrates the maximum amount that may be removed without~~  
15 ~~constituting demolition.~~

16 ~~(a) Fifty percent or more of the roof area as measured in plan view (see diagram):~~



17 ~~(b) Fifty percent or more of the exterior walls of a building as measured contiguously around~~  
18 ~~the "building coverage" as defined in Section 9-16-1, "Definitions," B.R.C., 1981 (see~~  
19 ~~diagram).~~



1  
2  
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4  
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6  
7 A wall shall meet the following minimum standards to be considered a retained exterior wall:

- 8 (1) ~~The wall shall retain studs or other structural elements, the exterior wall finish and the fully~~  
9 ~~framed and sheathed roof above that portion of the remaining building to which such wall is~~  
10 ~~attached.~~  
11 (2) ~~The wall shall not be covered or otherwise concealed by a wall that is proposed to be placed~~  
12 ~~in front of the retained wall; and~~  
13 (3) ~~Each part of the retained exterior walls shall be connected contiguously and without~~  
14 ~~interruption to every other part of the retained exterior walls.~~

15 ~~FSC means the Forest Stewardship Council. FSC certified lumber products are accredited~~  
16 ~~and abides by criteria that ensure responsible management of the world's forests.~~

17 ~~Home Energy Rating System Index or HERS Index means a rating system where an index of~~  
18 ~~100 represents the energy use of the "American Standard Building" and an index of zero~~  
19 ~~indicates that the Proposed Building uses no net purchased energy (a Zero Energy Building).~~

20 ~~Remodel means an interior reconfiguration or upgrade of an existing structure of 500 sq. ft.~~  
21 ~~or greater and the work required to complete the reconfiguration or upgrade requires a building~~  
22 ~~permit.~~

23 ~~Residential Energy Services Network or RESNET means an organization that sets the~~  
24 ~~standards of quality, and increases the opportunity for ownership of high performance buildings~~  
25 ~~and ensures the success of the building energy performance certification industry.~~

~~(b) Words defined in Section 1-2-1, "Definitions," and Section 10-1-1, "Definitions," B.R.C.~~  
~~1981, have the meanings there expressed if not differently defined by this chapter.~~

Ordinance Nos. 7565 (2007); 7621 (2008)

Section 7. Section 10-10-2, "Adoption of the International Plumbing Code With  
Modifications," is amended to read:

**10-10-2. - Adoption of the International Plumbing Code With Modifications.**

(a)

1 The 2012 edition of the *International Plumbing Code* , published by the International  
2 Code Council, including Appendix E, "Sizing of Water Piping System," is hereby adopted  
3 by reference as the City of Boulder Plumbing Code or plumbing code, and has the same  
4 force and effect as though fully set forth in this chapter, except as specifically amended by  
5 the provisions of this chapter.

6 (b)

7 Except for sections 101, 102, and 107, Chapter 1 is repealed. This code shall be  
8 administered in accordance with Chapter 1, "Administration," of the International  
9 Building Code as adopted, with amendments, by Section 10-5-2, "Adoption of  
10 International Building Code With Modifications," B.R.C. 1981.

11 (c)

12 Section 101.1, "Title," is repealed and reenacted to read:

13 **101.1 Title.** These regulations shall be known as the Plumbing Code for the City of  
14 Boulder or plumbing code and will be referenced herein as "this code."

15 (d)

16 The Exception to Section 301.3, "Connections to drainage system," is deleted in its  
17 entirety.

18 (e)

19 Section 312.5, "Water supply system test," is amended by deleting the words "for piping  
20 systems other than plastic" and by modifying the test pressure required from 50 psi (344  
21 kPa) to 100 psi (688 kPa).

22 (f)

23 Section 504.7.1 "Piping for safety pan drains shall be of those materials listed in Table  
24 605.4," is repealed.

25 (g) Table 604, "Water Distribution System Design Criteria Required Capacity at Fixture  
Supply Pipe Outlets," is repealed and reenacted to read:

26 TABLE 604.4  
27 WATER DISTRIBUTION SYSTEM DESIGN CRITERIA REQUIRED  
28 CAPACITY AT FIXTURE SUPPLY PIPE OUTLETS

<u>PLUMBING FIXTURE OR FIXTURE FITTING</u>	<u>MAXIMUM FLOW RATE OR QUANTITY</u>
<u>Lavatory, private</u>	<u>1.5 gpm at 60 psi</u>
<u>Lavatory, public (metering)</u>	<u>0.25 gallon per metering cycle</u>
<u>Lavatory, public (no metering)</u>	<u>0.5 gpm at 60 psi</u>
<u>Shower head</u>	<u>2.0 gpm at 80 psi</u>
<u>Sink Faucet</u>	<u>1.5 gpm at 60 psi</u>
<u>Urinal</u>	<u>1.0 gallon per flushing cycle</u>
<u>Water Closet</u>	<u>1.28 gallons per flushing cycle</u>

29 For SI: 1 gallon = 3.785L, 1 gallon per minute = 3.785 L/m,

1 1 pound per square inch = 6.895 kPa.

2 a. A hand-held shower spray is a shower head.

3 b. Consumption tolerances shall be determined from referenced standards.

4 (h)

5 Section 610, "Disinfection of potable water system," is repealed.

6 (hi)

7 Section 605.3 is amended by adding a new paragraph to read:

8 Water service line pipe between the water meter and building shall be Type K copper if it is in the public right of way, a public utility easement, or on other public property.

9 (ij)

10 Section 712.4.2, "Capacity," is amended by the addition of a new sentence to read:

11 Sewage pumps and sewage ejectors serving public fixtures shall be provided with dual pumps and ejectors arranged to operate independently in case of overload or failure.

12 (jk)

13 Section 903.1, "Roof extension," is repealed and reenacted to read:

14 **903.1 Roof extension.** Open vent pipes that extend through a roof shall be terminated not less than 6 inches above the roof, except that where a roof is to be used for any purpose other than weather protection, the vent extensions shall terminate not less than 7 feet above the roof.

15 (kl)

16 Section 1003.1, "Where required," is amended by adding the following:

17 Grease, oil, and sand interceptors shall hold a minimum capacity of 750 gallons and shall be remotely located.

18 (lm)

19 Section 1003.3, "Grease interceptors," is amended by adding the following:

20 Grease interceptors shall not receive the drainage and retain grease from more than four fixtures. A grease interceptor shall not be connected to heated water fixtures, including, without limitation, dishwashers, and shall not be connected before waste disposal units, including, without limitation, garbage disposals and grinders.

21 (mn)

22 Section 1003.4, "Oil separators required," is repealed.

23 (no)

24 Section 1101.3, "Prohibited drainage," is repealed and reenacted to read:

25 **1101.3 Prohibited drainage.** No rain, surface, or subsurface water shall be connected to or discharged into any drainage system, unless first approved by the code official.

1 (~~op~~)

Section 1106.1, "General," is repealed and reenacted to read:

2 **1106.1 General.** The size of the vertical conductors and leaders, building storm drains,  
3 building storm sewers, and any horizontal branches of such drains or sewers shall be  
4 based on the 100-year hourly rainfall rate of 2.5 inches per hour or other approved local  
weather data.

5 (~~pq~~)

Chapter 13, "Gray Water Recycling Systems," is deleted in its entirety.

6 (~~qr~~)

7 Table E103.3(2), "Load Values Assigned to Fixtures," is amended by the addition of a  
new sentence to read:

8 For the purpose of determining the largest instantaneous demand required in order to size  
9 a water meter, or for determining the amount of the plant investment fee, this table is  
repealed and replaced by the Fixture Unit/GPM Demand Chart and PIF Computation  
Sheet found at Appendix A to Chapter 11-1, "Water Utility," B.R.C. 1981.

10 (~~rs~~)

11 Table E103.3(3), "Table for Estimating Demand," is amended by the addition of a new  
sentence to read:

12 For the purpose of determining the largest instantaneous demand required in order to size  
13 a water meter, or for determining the amount of the plant investment fee, this table is  
repealed and replaced by the Fixture Unit/GPM Demand Equations and PIF Computation  
14 Sheets found at Appendix A to Chapter 11-1, "Water Utility," B.R.C. 1981.

15 Ordinance Nos. 4879 (1985); 4984 (1986); 5050 (1987); 5177 (1989); 5493 (1992); 5781  
(1996); 6065 (1999); 6065 (1999); 7024 (1999); 7566 (2007); 7925 (2013)

16  
17 Section 8. The city council deems it appropriate to adopt by reference the "2017 City of  
18 Boulder Energy Conservation Code." The city council orders that at least one copy of the "2017  
19 City of Boulder Energy Conservation Code" being considered for adoption by reference in this  
20 ordinance be on file with the city clerk and open for public inspection during the business hours  
21 of the city. Such copy shall be certified to be true by the mayor and the clerk.

22 Section 9. The city council orders and directs the city manager to make any additional  
23 citation, renumbering, and reference changes not included in this ordinance that are necessary to  
24 properly implement this ordinance and the 2017 City of Boulder Energy Conservation Code.  
25

1 The city council authorizes the city manager to change the formatting and layout of the 2017  
2 City of Boulder Energy Conservation Code.

3 Section 10. This ordinance is necessary to protect the public health, safety, and welfare  
4 of the residents of the city, and covers matters of local concern.

5  
6 Section 11. The city council intends that the sections, paragraphs, clauses, and phrases of  
7 this ordinance and the codes adopted herein by references be severable. If any phrase, clause,  
8 sentence, paragraph or section of this code or the codes adopted herein by reference is declared  
9 unconstitutional or invalid by the valid judgement or decree of any court of competent  
10 jurisdiction, such unconstitutionality or invalidity does not affect any of the remaining phrases,  
11 clauses, sentences, paragraphs and sections of this code or the codes adopted herein, unless it  
12 appears to the court that the valid provisions of the section or ordinance are so essentially and  
13 inseparably connected with, and so dependent upon, the void provision that it cannot be  
14 presumed the council would have enacted the valid provisions without the void one; or unless the  
15 court determines that the valid provisions, standing alone, are incomplete and are incapable of  
16 being executed in accordance with the legislative intent. If provision of an exception invalidates  
17 a prohibition, but the prohibition without the exception would be valid, then it is council's intent  
18 in such cases that the exception be severed and the prohibition upheld.

19  
20 Section 12. This ordinance shall take effect 60 days after final passage. It shall be  
21 applied to building permit applications submitted after the effective date. Building permits  
22 applied for before the effective date shall be considered under the program in effect at the time of  
23 application.

1           Section 13. The city council deems it appropriate that this ordinance be published by title  
2 only and orders that copies of this ordinance be made available in the office of the city clerk for  
3 public inspection and acquisition.  
4

5  
6           INTRODUCED, READ ON FIRST READING, AND ORDERED PUBLISHED BY  
7 TITLE ONLY this \_\_\_\_ day of \_\_\_\_\_, 2016.  
8

9  
10 \_\_\_\_\_  
Suzanne Jones  
Mayor

11 Attest:

12  
13 \_\_\_\_\_  
Lynette Beck  
City Clerk

14  
15           READ ON SECOND READING, PASSED, ADOPTED, AND ORDERED  
16 PUBLISHED BY TITLE ONLY this \_\_\_\_ day of \_\_\_\_\_, 2016.  
17

18  
19 \_\_\_\_\_  
Suzanne Jones  
Mayor

20 Attest:

21  
22 \_\_\_\_\_  
Lynette Beck  
City Clerk