ANSWER SHEET

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Existing Building & Energy Conservation: An Advanced Building Code Course - Final Exam

1. Ⓐ Ⓑ Ⓒ Ⓓ	5. Ⓐ Ⓑ Ⓒ Ⓓ	9. Ⓐ Ⓑ Ⓒ Ⓓ	13. Ⓐ Ⓑ Ⓒ Ⓓ	17. Ⓐ Ⓑ Ⓒ Ⓓ
2. Ⓐ Ⓑ Ⓒ Ⓓ	6. Ⓐ Ⓑ Ⓒ Ⓓ	10. Ⓐ Ⓑ Ⓒ Ⓓ	14. Ⓐ Ⓑ Ⓒ Ⓓ	18. Ⓐ Ⓑ Ⓒ Ⓓ
3. Ⓐ Ⓑ Ⓒ Ⓓ	7. Ⓐ Ⓑ Ⓒ Ⓓ	11. Ⓐ Ⓑ Ⓒ Ⓓ	15. Ⓐ Ⓑ Ⓒ Ⓓ	19. Ⓐ Ⓑ Ⓒ Ⓓ
4. Ⓐ Ⓑ Ⓒ Ⓓ	8. Ⓐ Ⓑ Ⓒ Ⓓ	12. Ⓐ Ⓑ Ⓒ Ⓓ	16. Ⓐ Ⓑ Ⓒ Ⓓ	20. Ⓐ Ⓑ Ⓒ Ⓓ

Existing Building & Energy Conservation: An Advanced Building Code Course - Final Exam

1. Section 403.8 of the ***Florida Building Code, Existing Building*** requires the evaluation and potential retrofit of a roof diaphragm where more than _____ % of the roof covering is removed.
   a. 25%
   b. 50%
   c. 75%
   d. 33%

2. Section 406.3 of the ***Florida Building Code, Existing Building*** exempts replacement windows from complying with the _____ provisions in the FBCB provided the specified conditions are met.
   a. emergency escape
   b. controlled opening device
   c. rescue
   d. both a and c

3. Section 702.4 of the ***Florida Building Code, Existing Building*** requires the installation of window opening control devices in Group_____ where an existing window is replaced for the conditions specified.
   a. R-1
   b. R-2
   c. R-3
   d. both b and c

4. How many new exceptions have been added to section 707.3.2 of the ***Florida Building Code, Existing Building?***
   a. 5
   b. 4
   c. 3
   d. 2

5. Table C402.1.4 in the ***Florida Building Code, Energy Conversation*** corrects U-factor errors for "_____" for the Climate Zones 1, 2, 3, 4, 5, 6, and 7.
   a. Mass Walls, Below Grade
   b. Mass Walls, Above Grade
   c. hot box laboratories
   d. continuous insulation

6. According to Section C402.4.1.1 of the ***Florida Building Code, Energy Conversation***, in Climate Zones 1 through 6, not more than _____ percent of the gross above-grade wall area shall be permitted to be vertical fenestration, provided all of the necessary requirements are met.
   a. 20
   b. 30
   c. 40
   d. 50

7. Section C402.5.1 of the ***Florida Building Code, Energy Conversation*** states that air barriers are not required in buildings located in ***Climate Zone*** _____.
   a. 2B
   b. 2C
   c. 1B
   d. 3A

8. Section C402.5.7 of the ***Florida Building Code, Energy Conversation*** was revised to allow an air curtain with a velocity of not less than _____ fps and tested in accordance with ANSI/AMCA 220 to be used as an alternative to a vestibule.
   a. 220
   b. 2.98
   c. 6.56
   d. 4.08

9. Table C403.2.3(9) was added to the ***Florida Building Code, Energy Conversation*** specifying the minimum efficiency requirements for air conditioners and condensing units serving _____.
   a. furnace rooms
   b. computer rooms
   c. boiler rooms
   d. hospital rooms

10. According to section C403.2.4.4 of the ***Florida Building Code, Energy Conversation***, HVAC systems serving zones that are over _____ square feet (2323 m2) in floor area or that span more than one floor and are designed to operate or be occupied nonsimultaneously shall be divided into isolation areas.
    a. 10,000
    b. 15,000
    c. 20,000
    d. 25,000

11. New provisions were added to section C403.2.8 of the *Florida Building Code, Energy Conversation* for kitchen exhaust systems. These provisions are intended to prohibit _____.

a. "short-circuit" hoods
b. backshelf pass-overs
c. clogged ventilation systems
d. over-pressurized adjacent spaces

12. According to section C403.3 Economizers (Prescriptive), economizers are not required for cooling systems for buildings located in which Climate Zones?

a. 1A
b. 1B
c. 1C
d. both 1A and 1B

13. A new exception in section C403.3 Economizers (Prescriptive) permits the required air or water economizer to be eliminated if the minimum code required cooling efficiency of the HVAC unit rated with an IPLV, IEER, or SEER is increased by at least _____%.

a. 5%
b. 7%
c. 17%
d. 15%

14. According to section C404.5.2 Maximum allowable pipe volume method, the volume from the nearest source of heated water to the termination of the fixture supply pipe for a public lavatory faucet shall not be more than ____ ounces.

a. 2 ounces
b. 1.5 ounces
c. 0.06 ounces
d. 0.5 ounces

15. According to section C404.5.2 Maximum allowable pipe volume method, the volume from the nearest source of heated water to the termination of the fixture supply pipe for plumbing fixtures or plumbing appliances other than a public lavatory faucet shall not be more than _____.

a. 2 ounces
b. 0.5 gallon
c. 1.5 liters
d. 2 gallons

16. Section C407.6.3 Exceptional calculation methods is a new section allowing credit for energy- efficiency measures that the _____ energy analysis software is not capable of directly modeling.

a. yearly
b. monthly
c. weekly
d. hourly

17. Section R402.3.2 Glazed fenestration SHGC has been revised to allow dynamic glazing to satisfy the SHGC requirements provided the ratio of upper to lower SHGC is _____ or greater and is automatically controlled to modulate the amount of solar gain into the space.

a. 4.2
b. 2.4
c. 3.2
d. 2.3

18. In section R402.3.5 Sunroom fenestration, the exception has been expanded to include Climate Zones _____.

a. 1
b. 2
c. 3
d. both 2 and 3

19. According to section R402.4.1.2 Testing, the building or dwelling unit shall be tested and verified as having an air leakage rate not exceeding _____ air changes per hour in Climate Zones 1 and 2.

a. five
b. six
c. seven
d. three

20. Changes to section R403.3.1 Insulation (Prescriptive) increase the insulation requirements for return ducts in attics from _____ to _____. These changes make the maximum allowable duct leakage rates prescriptive, allowing performance path trade-offs.

a. R-6 to R-8
b. R-4 to-R-6
c. R-2 to R-4
d. R-8 to R-10

Existing Building & Energy Conservation: An Advanced Building Code Course

Course Introduction

This 2 CE hour *Existing Building & Energy Conservation: An Advanced Building Code Course* discusses select changes in the 6th Edition of the Florida Building Code from the previous 5th Edition of the Florida Building Code. This course focuses on changes made to the Existing Building Code as well as to the Energy Conservation Code. It is important to note that the Florida Building Code 5th Edition was based off of the 2012 International Building Code while the Florida Building Code 6th Edition is based off of the 2015 International Building Code. The Florida Building Code 6th Edition replaced the Florida Building Code 5th Edition as of 12/31/2017.

The following code changes will be covered in this course:

Existing Building

- Chapter 4: Prescriptive Compliance Method
  - Roof diaphragms resisting wind loads in high wind regions
  - Replacement window emergency escape and rescue openings
- Chapter 7: Alterations – Level 1
  - Window opening control devices
  - Roof diaphragms resisting wind loads in high wind regions
  - Roof secondary water barrier for site-built single family residential structures
- Chapter 8: Alterations – Level 2
  - Fire-resistance ratings

Energy Conservation

- Commercial Energy Efficiency
  - Opaque Thermal Envelope Assembly Maximum Requirements, U-Factor Method
  - Increased vertical fenestration area with daylight responsive controls
  - Increased skylight area with daylight responsive controls
  - Air barriers
  - Vestibules
  - Efficiency requirements
  - Zone isolation
  - Kitchen exhaust systems
  - Maximum Net Exhaust Flow Rate, CFM Per Linear Foot of Hood Length
  - Economizers (prescriptive)
  - Efficient heated water supply piping
  - Maximum allowable pipe length method
  - Maximum allowable pipe volume method
  - Water volume determination
  - Piping Volume and Maximum Piping Lengths
  - Exceptional calculations methods
- Residential Energy Efficiency
  - Glazed fenestration SHGC
  - Sunroom fenestration
  - Testing
  - Ducts
  - Compliance software tools (ERI Compliance Alternative)

The *Existing Building & Energy Conservation: Advanced Building Code Course* is provided in accordance with the requirements of the Florida Department of Business and Professional Regulation (DBPR) for the required Advanced Florida Building Code Module.

This course is designed to cover some of the most significant changes from the 5th Edition to the 6th Edition of the Code. However, this course does not cover every change between the codes. Building professionals will have their own areas of expertise making it essential that every architect, engineer, and contractor carefully study the code sections most affecting their professional practice.

Disclaimer: *This course is intended to give the reader information current at the time of publication. This course is not a substitute for professional advice and should not be used for guidance or decisions related to a specific design or construction project. This course is not intended to reflect the opinion of any of the entities, agencies, or organizations identified in the materials.*

EXISTING BUILDING

Chapter 4:
Prescriptive Compliance Method

Section 403: Alterations

403.8 Roof diaphragms resisting wind loads in high wind regions

Where the intended alteration requires a permit for reroofing and involves removal of roofing materials from more than 50 percent of the roof diaphragm of a building or section of a building located where the ultimate design wind speed is greater than 115 mph (51 m/s) in accordance with Figure 1609.3(1) of the *Florida Building Code, Building* as defined in Section 1609 (the HVHZ shall comply with Section 1620) of the *Florida Building Code, Building*, roof diaphragms, connections of the roof diaphragm to roof framing members, and roof-to-wall connections shall be evaluated for the wind loads specified in Section 1609 of the *Florida Building Code, Building*, including wind uplift. If the diaphragms and connections in their current condition are not capable of resisting at least 75 percent of those wind loads, they shall be replaced or strengthened in accordance with the loads specified in Section 1609 of the *Florida Building Code, Building*.

Exceptions:

1. This section does not apply to buildings permitted subject to the *Florida Building Code*.
2. This section does not apply to buildings permitted subject to the 1991 *Standard Building Code*, or later edition, or designed to the wind loading requirements of the ASCE 7-88 or later editions, where an evaluation is performed by a registered design professional to confirm the roof diaphragm, connections of the roof diaphragm to roof framing members, and roof-to-wall connections are in compliance with the wind loading requirements of either of these standards or later editions.
3. Buildings with steel or concrete moment resisting frames shall only be required to have the roof diaphragm panels and diaphragm connections to framing members evaluated for wind uplift.
4. This section does not apply to site-built single-family dwellings. Site-built single-family dwellings shall comply with Sections 706.7 and 706.8.
5. This section does not apply to buildings permitted within the HVHZ after January 1, 1994 subject to the 1994 South Florida Building Code, or later editions, or where the building's wind design is based on the wind loading requirements of ASCE 7-88 or later editions.

Analysis of Code Change: A new section of the code that requires the evaluation and potential retrofit of a roof diaphragm, roof diaphragm connections, and roof-to-wall connections where more than 50% of the roof covering is removed. This requirement has existed for Level 1 alterations, and it is now applicable to the prescriptive compliance method. Five exceptions to this requirement are provided. Exception 4 refers to Sections 706.7 and 706.8 for sitebuilt single family dwellings. Exceptions 1, 2, and 5 apply to buildings permitted to the specified codes. Exception 3 applies to buildings with steel or concrete moment resisting frames.

Section 406: Glass Replacement and Replacement Windows

406.3 Replacement window emergency escape and rescue openings

Where windows are required to provide *emergency escape* and *rescue openings* in Group R-2 and R-3 occupancies, replacement windows shall be exempt from the requirements of Sections 1030.2, 1030.3 and 1030.5 of the *Florida Building Code, Building* provided the replacement window meets the following conditions:

1. The replacement window is the manufacturer's largest standard size window that will fit within the existing frame or existing rough opening. The replacement window shall be permitted to be of the same operating style as the existing window or a style that provides for an equal or greater window opening area than the existing window.
2. The replacement of the window is not part of a change of occupancy.

Analysis of Code Change: A new section exempting replacement windows from complying with the emergency escape and rescue provisions in the FBCB provided the specified conditions are met.

Chapter 7: Alterations – Level 1

Section 702: Building Elements and Materials

702.4 Window opening control devices

In Group R-2 or R-3 buildings containing dwelling units and one- and two-family dwellings and townhouses regulated by the *Florida Building Code, Residential*, window opening control devices complying with ASTM F2090 shall be installed where an existing window is replaced and where all of the following apply to the replacement window:

1. The window is operable;
2. The window replacement includes replacement of the sash and the frame;
3. One of the following applies:

    3.1. In Group R-2 or R-3 buildings containing dwelling units, the top of the sill of the window opening is at a height less than 36 inches (915

mm) above the finished floor; or

3.2. In one- and two-family dwellings and townhouses regulated by the *Florida Building Code, Residential*, the top sill of the window opening is at a height less than 24 inches (610 mm) above the finished floor;

4. The window will permit openings that will allow passage of a 4-inch-diameter (102 mm) sphere when the window is in its largest opened position; and

5. The vertical distance from the top of the sill of the window opening to the finished grade or other surface below, on the exterior of the building, is greater than 72 inches (1829 mm).

The window opening control device, after operation to release the control device allowing the window to fully open, shall not reduce the minimum net clear opening area of the window unit to less than the area required by the *Florida Building Code, Building*.

Exceptions:

1. Operable windows where the top of the sill of the window opening is located more than 75 feet (22 860 mm) above the finished grade or other surface below, on the exterior of the room, space or building, and that are provided with window fall prevention devices that comply with ASTM F2006.

2. Operable windows with openings that are provided with window fall prevention devices that comply with ASTM F2090.

Analysis of Code Change: A new section that requires the installation of window opening control devices in Groups R-2 and R-3 where an existing window is replaced for the conditions specified.

Section 706: Existing Roof

706.7.2 Roof secondary water barrier for site-built single family residential structures

A secondary water barrier shall be installed using one of the following methods when roof covering is removed and replaced:

1. In High-Velocity Hurricane Zone regions:

   a) All joints in structural panel roof sheathing or decking shall be covered with a minimum 4 inch (102 mm) wide strip of self-adhering polymer modified bitumen tape applied directly to the sheathing or decking. The deck and self-adhering polymer modified bitumen tape shall be covered with one of the underlayment systems approved for the particular roof covering to be applied to the roof.

   b) The entire roof deck shall be covered with an approved asphalt impregnated 30# felt underlayment or approved synthetic underlayment installed with nails and tin-tabs in accordance with Section 1518.2, 1518.3 or 1518.4 of the *Florida Building Code, Building*. (No additional underlayment shall be required over the top of this sheet.) The synthetic underlayment shall be fastened in accordance with the manufacturer's recommendations.

2. Outside the High-Velocity Hurricane Zone:

   a) Underlayment shall comply with Section R905.1.1 of the *Florida Building Code, Residential*.

Exceptions:

1. Roof slopes < 2:12 having a continuous roof system shall be deemed to comply with Section 706.7.2 requirements for a secondary water barrier.

2. Clay and concrete tile roof systems installed as required by the Florida Building Code are deemed to comply with the requirements of Section 706.7.2 for Secondary Water Barriers.

Analysis of Code Change: Underlayment provisions for areas outside the HVHZ have been deleted and replaced with a reference to Section R905.1.1 of the FBCR.

Section 707: Structural

707.3.2 Roof diaphragms resisting wind loads in high wind regions

Where roofing materials are removed from more than 50 percent of the roof diaphragm or section of a building located where the ultimate design wind speed, V_{ult}, determined in accordance with Figure 1609.3(1) of the *Florida Building Code, Building*, is greater than 115 mph (51 m/s), as defined in Section 1609 (the High-Velocity Hurricane Zone shall comply with Section 1620) of the *Florida Building Code, Building*, roof diaphragms, connections of the roof diaphragm to roof framing members, and roof-to-wall connections shall be evaluated for the wind loads specified in the *Florida Building Code, Building*, including wind uplift. If the diaphragms and connections in their current condition are not capable of resisting at least 75 percent of those wind loads, they shall be replaced or strengthened in accordance with the loads specified in the *Florida Building Code, Building*.

Exceptions:

1. This section does not apply to buildings permitted subject to the *Florida Building Code*.

2. This section does not apply to buildings permitted subject to the 1991 *Standard Building Code*, or later edition, or designed to the wind loading requirements of the ASCE 7-88 or later editions, where an evaluation is performed by a registered design professional to confirm the roof diaphragm, connections of the roof diaphragm to roof framing

members, and roof-to-wall connections are in compliance with the wind loading requirements of either of these standards or later editions.

3. Buildings with steel or concrete moment resisting frames shall only be required to have the roof diaphragm panels and diaphragm connections to framing members evaluated for wind uplift.

4. This section does not apply to site-built single family dwellings. Site-built single-family dwellings shall comply with Sections 706.7 and 706.8.

5. This section does not apply to buildings permitted within the HVHZ after January 1, 1994 subject to the 1994 South Florida Building Code, or later editions, or where the building's wind design is based on the wind loading requirements of ASCE 7-88 or later editions.

Analysis of Code Change: Five new exceptions to this requirement have been provided. Exception 4 refers to Sections 706.7 and 706.8 for site-built single family dwellings. Exceptions 1, 2, and 5 apply to buildings permitted to the specified codes. Exception 3 applies to buildings with steel or concrete moment resisting frames.

Chapter 8: Alterations – Level 2

Section 803: Building Elements and Materials

803.6 Fire-resistance ratings

Where approved by the code official, buildings where an automatic sprinkler system installed in accordance with Section 903.3.1.1 or 903.3.1.2 of the *Florida Building Code, Building* has been added, and the building is now sprinklered throughout, the required fire-resistance ratings of building elements and materials shall be permitted to meet the requirements of the current building code. The building is required to meet the other applicable requirements of the *Florida Building Code, Building*.

Plans, investigation and evaluation reports, and other data shall be submitted indicating which building elements and materials the applicant is requesting the code official to review and approve for determination of applying the current building code fire-resistance ratings. Any special construction features, including fire-resistance-rated assemblies and smoke-resistive assemblies, conditions of occupancy, means of-egress conditions, fire code deficiencies, approved modifications or approved alternative materials, design and methods of construction, and equipment applying to the building that impact required fire-resistance ratings shall be identified in the evaluation reports submitted.

Analysis of Code Change: A new section permitting, where approved by the code official, buildings where an automatic sprinkler system installed in accordance with Section 903.3.1.1 of the FBCB has been added, and the building is now sprinklered throughout, the required fire-resistance ratings of building elements and materials are permitted to meet the requirements of the current building code.

ENERGY CONSERVATION: COMMERCIAL

Chapter 4: Commercial Energy Efficiency

Section C402: Building Envelope Requirements

C402.1.4 Opaque Thermal Envelope Assembly Maximum Requirements, U-Factor Method

Building thermal envelope opaque assemblies intended to comply on an assembly *U-, C- or F*-factor basis shall have a *U-, C- or F*-factor not greater than that specified in Table C402.1.4. Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the *U-, C- or F*-factor from the "Group R" column of Table C402.1.4. Commercial buildings or portions of commercial buildings enclosing occupancies other than Group R shall use the *U-, C- or F*-factor from the "All other" column of Table C402.1.4. The *C*-factor for the below-grade exterior walls of the building envelope, as required in accordance with Table C402.1.4, shall extend to a depth of 10 feet (3048 mm) below the outside finished ground level, or to the level of the lowest floor, whichever is less. Opaque swinging doors shall comply with Table C402.1.4 and opaque nonswinging doors shall comply with Table C402.1.3.

TABLE C402.1.4

Opaque Thermal Envelope Assembly Maximum Requirements, U-Factor Method[a,b]

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
Roofs																
Insulation entirely above roof deck	U-0.048	U-0.039	U-0.039	U-0.039	U-0.039	U-0.039	U-0.032	U-0.032	U-0.032	U-0.032	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-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	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	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021
Walls, above grade																
Mass	U-0.151	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	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	U-0.052	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	U-0.064	U-0.064	U-0.057	U-0.064	U-0.052	U-0.045	U-0.045
Wood framed and other[c]	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.036	U-0.036
Walls, below grade																
Below-grade wall[c]	C-1.140[e]	C- 1.140[e]	C-1.140[e]	C- 1.140[e]	C-1.140[e]	C- 1.140[e]	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.092	C-0.092	C-0.092	C-0.092
Floors																
Mass[d]	U-0.322[e]	U-0.322[e]	U-0.107	U-0.087	U-0.076	U-0.076	U-0.076	U-0.074	U-0.074	U-0.064	U-0.064	U-0.057	U-0.055	U-0.051	U-0.055	U-0.051
Joints/ framing	U-0.066[e]	U-0.066[e]	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033

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
Slab-on-grade floors																
Unheated slabs	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.54	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
Heated slabs[f]	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-0.65	F-0.65	F-0.58	F-0.58	F-0.55	F-0.55	F-0.55	F-0.55
Opaque doors																
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

For SI: 1 pound per square foot = 4.88kg/m^2 , 1 pound per cubic foot = 16 kg/m^3

ci = Continuous insulation, NR = No requirement, LS = Liner system.

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, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ASHRAE/ISNEA 90.1 Appendix A.

b. Opaque assembly U-factors based on designs tested in accordance with ASTM C1363 shall be permitted. The R-value of continuous insulation shall be permitted to be added to or subtracted from the original tested design.

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

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

1. 35 pounds per square foot of floor surface area; or

2. 25 pounds per square foot of floor surface area where the material weight is not more than 120 pounds per cubic foot.

e. These C-, F- and U-factors are based on assemblies that are not required to contain insulation.

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

Analysis of Code Change: Table C402.1.4 clarifies the use and application of the codes prescriptive building thermal envelope provisions. The updated table modifies the thermal envelope requirements for above-deck roof insulation to be consistent with ASHRAE 90.1. The updated table also corrects U-factor errors for "Mass Walls, Above Grade" for the Climate Zones 1, 2, 3, 4, 5, 6, and 7. New Note b was added to recognize results of hot box laboratory tests conducted in accordance with ASTM C1363 for compliance with the code.

review questions...

The following question will be a review of the content from this section. This question will NOT be graded. The answer to the review question can be found on page 71.

1. **According to Table C402.1.4, what is the U-Factor for Mass Walls, Above Grade in Climate Zone 3 Group R?**
   a. U-0.052
   b. U-0.104
   c. U-0.123
   d. U-0.064

C402.4.1.1 Increased vertical fenestration area with daylight responsive controls.

In Climate Zones 1 through 6, not more than 40 percent of the gross above-grade wall area shall be permitted to be vertical fenestration, provided all of the following requirements are met:

1. In buildings not greater than two stories above grade, not less than 50 percent of the net floor area is within a *daylight zone*.
2. In buildings three or more stories above grade, not less than 25 percent of the net floor area is within a *daylight zone*.
3. *Daylight responsive controls* complying with Section C405.2.3.1 are installed in *daylight zones*.
4. Visible transmittance (VT) of vertical fenestration is not less than 1.1 times solar heat gain coefficient (SHGC).

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

Analysis of Code Change: This section was revised to increase incentives for daylight zones.

C402.4.1.2 Increased skylight area with daylight responsive controls.

The skylight area shall be permitted to be not more than 5 percent of the roof area provided *daylight responsive controls* complying with Section C405.2.3.1 are installed in *daylight zones* under skylights.

Analysis of Code Change: The exceptions in this section were deleted.

C402.5.1 Air barriers.

A continuous air barrier shall be provided throughout the building thermal envelope. The air barriers shall be permitted to be located on the inside or outside of the building envelope, located within the assemblies composing the envelope, or any combination thereof. The air barrier shall comply with Sections C402.5.1.1 and C402.5.1.2.

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

Analysis of Code Change: The exception has been revised to only exempt air barriers in buildings located in *Climate Zone* 2B.

C402.5.7 Vestibules

Building entrances shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time. The installation of one or more revolving doors in the building entrance shall not eliminate the requirement that a vestibule be provided on any doors adjacent to revolving doors.

Exceptions: Vestibules are not required for the following:

1. Buildings in *Climate Zones* 1 and 2.
2. Doors not intended to be used by the public, such as doors to mechanical or electrical equipment rooms, or intended solely for employee use.
3. Doors opening directly from a sleeping unit or dwelling unit.
4. Doors that open directly from a space less than 3,000 square feet (298 m2) in area.
5. Revolving doors.
6. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.
7. Doors that have an air curtain with a velocity of not less than 6.56 feet per second (2 m/s) at the floor that have been tested in accordance with ANSI/AMCA 220 and installed in accordance with the manufacturer's instructions. Manual or automatic controls shall be provided that will operate the air curtain with the opening and closing of the door. Air curtains and their controls shall comply with Section C408.2.3.

Analysis of Code Change: C402.5.7 was revised to allow an air curtain with a velocity of not less than 6.56 fps and tested in accordance with ANSI/AMCA 220 to be used as an alternative to a vestibule.

Section C403: Building Mechanical Systems

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), C403.2.3(8) and C403.2.3(9) 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(10).

The efficiency shall be verified through certification under an approved certification program or, where a certification program does not exist, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements. Where components, such as indoor or outdoor coils, from different manufacturers are used, calculations and supporting data shall be furnished by the designer that demonstrates that the combined efficiency of the specified components meets the requirements herein.

Tables C403.2.3(1) through C403.2.3(11) Efficiency requirements

Analysis of Code Change: The following tables were updated to match the increased equipment efficiency requirements found in ASHRAE 90.1. A new table was added specifying the minimum efficiency requirements for air conditioners and condensing units serving computer rooms.

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[a]
				Before 1/1/2016	As of 1/1/2016	
Air conditioners, air cooled	< 65,000 Btu/h[b]	All	Split System	13.0 SEER	13.0 SEER	AHRI 210/240
			Single Package	13.0 SEER	14.0 SEER[c]	
Through-the-wall (air cooled)	≤ 30,000 Btu/h[b]	All	Split System	12.0 SEER	12.0 SEER	
			Single Package	12.0 SEER	12.0 SEER	
Small-duct high-velocity (air cooled)	< 65,000 Btu/h[b]	< 65,000 Btu/h[b]	Split System	11.0 SEER	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	11.2 EER 11.4 IEER	11.2 EER 12.8 IEER	AHRI 340/360
		All other	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 12.6 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 12.4 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 12.2 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.0 EER 10.1 IEER	10.0 EER 11.6 IEER	
		All other	Split System and Single Package	9.8 EER 9.9 IEER	9.8 EER 11.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.7 EER 9.8 IEER	9.7 EER 11.2 IEER	
		All other	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 11.0 IEER	

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency		Test Procedure[a]
				Before 1/1/2016	As of 1/1/2016	
Air conditioners, water cooled	< 65,000 Btu/h[b]	All	Split System and Single Package	12.1 EER 12.3 IEER	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	12.1 EER 12.3 IEER	12.1 EER 13.9 IEER	AHRI 340/360
		All other	Split System and Single Package	11.9 EER 12.1 IEER	11.9 EER 13.7 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.5 EER 12.5 IEER	12.5 EER 13.9 IEER	
		All other	Split System and Single Package	12.3 EER 12.5 IEER	12.3 EER 13.7 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.4 EER 12.6 IEER	12.4 EER 13.6 IEER	
		All other	Split System and Single Package	12.2 EER 12.4 IEER	12.2 EER 13.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.2 EER 12.4 IEER	12.2 EER 13.5 IEER	
		All other	Split System and Single Package	12.0 EER 12.2 IEER	12.0 EER 13.3 IEER	

Air conditioners, evaporatively cooled	< 65,000 Btu/h[b]	All	Split System and Single Package	12.1 EER 12.3 IEER	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	12.1 EER 12.3IEER	12.1 EER 12.3IEER	AHRI 340/360
		All other	Split System and Single Package	11.9 EER 12.1 IEER	11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.0 EER 12.2 IEER	12.0 EER 12.2 IEER	
		All other	Split System and Single Package	11.8 EER 12.0 IEER	11.8 EER 12.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.9 EER 12.1 IEER	11.9 EER 12.1 IEER	
		All other	Split System and Single Package	11.7 EER 11.9 IEER	11.7 EER 11.9 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.7 EER 11.9 IEER	11.7 EER 11.9 IEER	
		All other	Split System and Single Package	11.5 EER 11.7 IEER	11.5 EER 11.7 IEER	
Condensing units, air cooled	≥ 135,000 Btu/h			10.5 EER 11.8 IEER	10.5 EER 11.8 IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h			13.5 EER 14.0 IEER	13.5 EER 14.0 IEER	
Condensing units, evaporatively cooled	≥ 135,000 Btu/h			13.5 EER 14.0 IEER	13.5 EER 14.0 IEER	

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

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

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

c. Minimum efficiency as of January 1, 2015.

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[a]
				Before 1/1/2016	As of 1/1/2016	
Air cooled (cooling mode)	< 65,000 Btu/h[b]	All	Split System	13.0 SEER[c]	14.0 SEER[c]	AHRI 210/240
			Single Package	13.0 SEER[c]	14.0 SEER[c]	
Through-the-wall, air cooled	≤ 30,000 Btu/h[b]	All	Split System	12.0 SEER	12.0 SEER	
			Single Package	12.0 SEER	12.0 SEER	
Single-duct high-velocity air cooled	< 65,000 Btu/h[b]	All	Split System	11.0 SEER	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 11.2 IEER	11.0 EER 12.0 IEER	AHRI 340/360
		All Other	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 11.8 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.6 EER 10.7 IEER	10.6 EER 11.6 IEER	
		All Other	Split System and Single Package	10.4 EER 10.5 IEER	10.4 EER 11.4 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 10.6 IEER	
		All Other	Split System and Single Package	9.3 EER 9.4 IEER	9.3 EER 9.4 IEER	

Water to Air: Water Loop (cooling mode)	< 17,000 Btu/h	All	86°F entering water	12.2 EER	12.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h	All	86°F entering water	13.0 EER	13.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	86°F entering water	13.0 EER	13.0 EER	
Water to Air: Ground Water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	18.0 EER	18.0 EER	ISO 13256-1
Brine to Air: Ground Loop (cooling mode)	< 135,000 Btu/h	All	77°F entering water	14.1 EER	14.1 EER	ISO 13256-1
Water to Water: Water Loop (cooling mode)	< 135,000 Btu/h	All	86°F entering water	10.6 EER	10.6 EER	ISO 13256-2
Water to Water: Ground Water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	16.3 EER	16.3 EER	
Brine to Water: Ground Loop (cooling mode)	< 135,000 Btu/h	All	77°F entering fluid	12.1 EER	12.1 EER	
Air cooled (heating mode)	< 65,000 Btu/h[b]	--	Split System	7.7 HSPF[c]	8.2 HSPF[c]	AHRI 210/240
		--	Single Package	7.7 HSPF[c]	8.0 HSPF[c]	
Through-the-wall, (air cooled, heating mode)	≤ 30,000 Btu/h[b] (cooling capacity)	--	Split System	7.4 HSPF	7.4 HSPF	
		--	Single Package	7.4 HSPF	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h[b]	--	Split System	6.8 HSPF	6.8 HSPF	

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	3.3 COP	AHRI 340/360
			17°F db/15°F wb outdoor air	2.25 COP	2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)	--	47°F db/43°F wb outdoor air	3.2 COP	3.2 COP	
			17°F db/15°F wb outdoor air	2.05 COP	2.05 COP	
Water to Air: Water Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	--	68°F entering water	4.3 COP	4.3 COP	ISO 13256-1
Water to Air: Ground Water (heating mode)	< 135,000 Btu/h (cooling capacity)	--	50°F entering water	3.7 COP	3.7 COP	
Brine to Air: Ground Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	--	32°F entering fluid	3.2 COP	3.2 COP	
Water to Water: Water Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	--	68°F entering water	3.7 COP	3.7 COP	ISO 13256-2
Water to Water: Ground Water (heating mode)	< 135,000 Btu/h (cooling capacity)	--	50°F entering water	3.1 COP	3.1 COP	
Brine to Water: Ground Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	--	32°F entering fluid	2.5 COP	2.5 COP	

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

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

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

c. Minimum efficiency as of January 1, 2015.

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[a]
PTAC (cooling mode) new construction	All Capacities	95°F db outdoor air	14.0 – (0.300 × Cap/1000) EER[c]	AHRI 310/380
PTAC (cooling mode) replacements[b]	All Capacities	95°F db outdoor air	10.9 - (0.213 × Cap/1000) EER	
PTHP (cooling mode) new construction	All Capacities	95°F db outdoor air	14.0 - (0.300 × Cap/1000) EER	
PTHP (cooling mode) replacements[b]	All Capacities	95°F db outdoor air	10.8 - (0.213 × Cap/1000) EER	
PTHP (heating mode) new construction	All Capacities	--	3.2 - (0.026 × Cap/1000) COP	
PTHP (heating mode) replacements[b]	All Capacities	--	2.9 - (0.026 × Cap/1000) COP	
SPVAC (cooling mode)	< 65,000 Btu/h	95°F db/ 75°F wb outdoor air	9.0 EER	AHRI 390
	≥ 65,000 Btu/h and < 135,000 Btu/h	95°F db/ 75°F wb outdoor air	8.9 EER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	95°F db/ 75°F wb outdoor air	8.6 EER	
SPVHP (cooling mode)	< 65,000 Btu/h	95°F db/ 75°F wb outdoor air	9.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	95°F db/ 75°F wb outdoor air	8.9 EER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	95°F db/ 75°F wb outdoor air	8.6 EER	

SPVHP (heating mode)	< 65,000 Btu/h	47°F db/ 43°F wb outdoor air	3.0 COP	AHRI 390
	≥ 65,000 Btu/h and < 135,000 Btu/h	47°F db/ 43°F wb outdoor air	3.0 COP	
	≥ 135,000 Btu/h and < 240,000 Btu/h	47°F db/ 43°F wb outdoor air	2.9 COP	
Room air conditioners, with louvered sides	< 6,000 Btu/h	--	9.7 SEER	ANSI/AHAM RAC-1
	≥ 6,000 Btu/h and < 8,000 Btu/h	--	9.7 SEER	
	≥ 8,000 Btu/h and < 14,000 Btu/h	--	9.8 SEER	
	≥ 14,000 Btu/h and < 20,000 Btu/h	--	9.7 SEER	
	≥ 20,000 Btu/h	--	8.5 SEER	
Room air conditioners, without louvered sides	< 8,000 Btu/h	--	9.0 EER	
	≥ 8,000 Btu/h and < 20,000 Btu/h	--	8.5 EER	
	≥ 20,000 Btu/h	--	8.5 EER	
Room air-conditioner heat pumps with louvered sides	< 20,000 Btu/h	--	9.0 EER	
	≥ 20,000 Btu/h	--	8.5 EER	
Room air-conditioner heat pumps without louvered sides	< 14,000 Btu/h	--	8.5 EER	
	≥ 14,000 Btu/h	--	8.0 EER	
Room air conditioner casement only	All capacities	--	8.7 EER	ANSI/AHAM RAC-1
Room air conditioner casement-slider	All capacities	--	9.5 EER	

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

"Cap" = The rated cooling capacity of the project in Btu/h. Where the unit's capacity is less than 7000 Btu/h, use 7000 Btu/h in the calculation. Where the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculations.

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

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

c. Before January 1, 2015, the minimum efficiency shall be 13.8 - (0.300 x Cap/1000) EER.

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[d,e]	Test Procedure[a]
Warm air furnaces, gas-fired Non-weatherized Weatherized gas furnace	< 225,000 Btu/h	--	80% AFUE or 80%E_t^c 81% AFUE	DOE 10 CFR, Part 430 or Section 2.39, Thermal Efficiency of ANSI Z 21.47
	≥ 225,000 Btu/h	Maximum capacity[c]	80%E_t^f	Section 2.39, Thermal Efficiency of ANSI Z21.47
Warm air furnaces, oil-fired Non-weatherized Weatherized oil-fired furnace	< 225,000 Btu/h	--	83% AFUE or 80% E_t^c 78% AFUE	DOE 10 CFR, Part 430 or Section 42, Combustion, of UL 727
	≥ 225,000 Btu/h	Maximum capacity[b]	81%E_t^g	Section 42, Combustion, of UL 727
Warm air duct furnaces, gas-fired	All capacities	Maximum capacity[b]	80%E_c	Section 2.10, Efficiency of ANSI Z83.8

Warm air unit heaters, gas-fired	All capacities	Maximum capacity[b]	80%E_c	Section 2.10, Efficiency of ANSI Z83.8
Warm air unit heaters, oil-fired	All capacities	Maximum capacity[b]	80%E_c	Section 40, Combustion, of UL 731
Mobile home furnace, gas-fired	< 225,000 Btu/h	--	80% AFUE	DOE 10 CFR, Part 430
Mobile home furnace, oil-fired	< 225,000 Btu/h	--	80% AFUE	DOE 10 CFR, Part 430

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

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

b. Minimum and maximum ratings as provided for and allowed by the unit's controls.

c. Combination units not covered by the National Appliance Energy Conservation Act of 1987 (NAECA) (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h [19 kW]) shall comply with either rating.

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

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

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

TABLE C403.2.3(5) MINIMUM EFFICIENCY REQUIREMENTS: GAS- AND OIL-FIRED BOILERS				
Equipment Type[a]	**Subcategory or Rating Condition**	**Size Category (Input)**	**Minimum Efficiency[d, e]**	**Test Procedure**
Boilers, hot water	Gas-fired	< 300,000 Btu/h	80% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	80% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	82% E_c	
	Oil-fired[c]	< 300,000 Btu/h	80% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	82% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	84% E_c	
Boilers, steam	Gas-fired	< 300,000 Btu/h	75% AFUE	10 CFR Part 430
	Gas-fired-all, except natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	79% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	79% E_t	
	Gas-fired-natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	77% E_t	
		> 2,500,000 Btu/h[a]	77% E_t	
	Oil-fired[c]	< 300,000 Btu/h	80% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	81% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	81% E_t	

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

a. These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.

b. Maximum capacity – minimum and maximum ratings as provided for and allowed by the unit's controls.

c. Includes oil-fired (residual).

d. Ec = Combustion efficiency (100 percent less flue losses).

e. Et = Thermal efficiency. See referenced standard for detailed information.

TABLE C403.2.3(6)

MINIMUM EFFICIENCY REQUIREMENTS: CONDENSING UNITS, ELECTRICALLY OPERATED

Equipment Type	Size Category	Minimum Efficiency[b]	Test Procedure[a]
Condensing units, air cooled	≥ 135,000 Btu/h	10.1 EER 11.2 IPLV	AHRI 365
Condensing units, water or evaporatively cooled	Condensing units, water or evaporatively cooled	13.1 EER 13.1 IPLV	

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

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

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

TABLE C403.2.3(7)

WATER CHILLING PACKAGES – EFFICIENCY REQUIREMENTS[a, b, d]

Equipment Type	Size Category	Units	Before 1/1/2015		As of 1/1/2015		Test Procedure[c]
			Path A	Path B	Path A	Path B	
Air-cooled chillers	< 150 tons	EER (Btu/W)	≥ 9.562 FL ≥ 12.500 IPLV	NA[c]	≥ 10.100 FL ≥ 13.700 IPLV	≥ 9.700 FL ≥ 15,800 IPLV	AHRI 550/590
	≥ 150 tons		≥ 9.562 FL ≥ 12.500 IPLV	NA[c]	≥ 10.100 FL ≥ 14.000 IPLV	≥ 9.700 FL ≥ 16.100 IPLV	
Air cooled without condenser, electrically operated	All capacities	EER (Btu/W)	Air-cooled chillers without condenser shall be rated with matching condensers and complying with air-cooled chiller efficiency requirements.				

Water cooled, electrically operated positive displacement	< 75 tons	kW/ton	≤ 0.780 FL	≤ 0.800 FL	≤ 0.750 FL	≤ 0.780 FL	AHRI 550/590
			≤ 0.630 IPLV	≤ 0.600 IPLV	≤ 0.600 IPLV	≤ 0.500 IPLV	
	≥ 75 tons and < 150 tons		≤ 0.775 FL	≤ 0.790 FL	≤ 0.720 FL	≤ 0.750 FL	
			≤ 0.615 IPLV	≤ 0.586 IPLV	≤ 0.560 IPLV	≤ 0.490 IPLV	
	≥ 150 tons and < 300 tons		≤ 0.680 FL	≤ 0.718 FL	≤ 0.660 FL	≤ 0.680 FL	
			≤ 0.580 IPLV	≤ 0.540 IPLV	≤ 0.540 IPLV	≤ 0.440 IPLV	
	≥ 300 tons and < 600 tons		≤ 0.620 FL	≤ 0.639 FL	≤ 0.610 FL	≤ 0.625 FL	
			≤ 0.540 IPLV	≤ 0.490 IPLV	≤ 0.520 IPLV	≤ 0.410 IPLV	
	≥ 600 tons		≤ 0.620 FL	≤ 0.639 FL	≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.540 IPLV	≤ 0.490 IPLV	≤ 0.500 IPLV	≤ 0.380 IPLV	
Water cooled, electrically operated centrifugal	< 150 tons	kW/ton	≤ 0.634 FL	≤ 0.639 FL	≤ 0.610 FL	≤ 0.695 FL	
			≤ 0.596 IPLV	≤ 0.450 IPLV	≤ 0.550 IPLV	≤ 0.440 IPLV	
	≥ 150 tons and < 300 tons		≤ 0.634 FL	≤ 0.639 FL	≤ 0.610 FL	≤ 0.635 FL	
			≤ 0.596 IPLV	≤ 0.450 IPLV	≤ 0.550 IPLV	≤ 0.400 IPLV	
	≥ 300 tons and < 400 tons		≤ 0.576 FL	≤ 0.600 FL	≤ 0.560 FL	≤ 0.595 FL	
			≤ 0.549 IPLV	≤ 0.400 IPLV	≤ 0.520 IPLV	≤ 0.390 IPLV	
	≥ 400 tons and < 600 tons		≤ 0.576 FL	≤ 0.600 FL	≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.549 IPLV	≤ 0.400 IPLV	≤ 0.500 IPLV	≤ 0.380 IPLV	
	≥ 600 tons		≤ 0.570 FL	≤ 0.590 FL	≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.539 IPLV	≤ 0.400 IPLV	≤ 0.500 IPLV	≤ 0.380 IPLV	

Air cooled, absorption, single effect	All capacities	COP	≥ 0.600 FL	NA[c]	≥ 0.600 FL	NA[c]	AHRI 560
Water cooled absorption, single effect	All capacities	COP	≥ 0.700 FL	NA[c]	≥ 0.700 FL	NA[c]	
Absorption, double effect, indirect fired	All capacities	COP	≥ 1.000 FL ≥ 1.050 IPLV	NA[c]	≥ 1.000 FL ≥ 1.050 IPLV	NA[c]	
Absorption double effect direct fired	All capacities	COP	≥ 1.000 FL ≥ 1.000 IPLV	NA[c]	≥ 1.000 FL ≥ 1.050 IPLV	NA[c]	

a. The requirements for centrifugal chiller shall be adjusted for nonstandard rating conditions in accordance with Section C403.2.3.1 and are only applicable for the range of conditions listed in Section C403.2.3.1. The requirements for air-cooled, water-cooled positive displacement and absorption chillers are at standard rating conditions defined in the reference test procedure.

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

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

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

TABLE C403.2.3(8)

MINIMUM EFFICIENCY REQUIREMENTS: HEAT REJECTION EQUIPMENT

Equipment Type[a]	Total System Heat Rejection Capacity at Rated Conditions	Subcategory or Rating Condition[i]	Performance Required[b, c, d, g, h]	Test Procedure[e, f]
Propeller or axial fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	≥ 40.2 gpm/hp	CTI ATC-105 and CTI 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	CTI ATC-105 and CTI STD-201
Propeller or axial fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥ 14.0 gpm/hp	CTI ATC-105S and CTI STD-201
Centrifugal fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥ 7.0 gpm/hp	CTI ATC-105S and CTI STD-201
Propeller or axial fan evaporative condensers	All	Ammonia Test Fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb	≥ 134,000 Btu/h·hp	CTI ATC-106
Centrifugal fan evaporative condensers	All	Ammonia Test Fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb	≥110,000 Btu/h·hp	CTI ATC-106

Propeller or axial fan evaporative condensers	All	R-507A Test Fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb	≥ 157,000 Btu/h·hp	CTI ATC-106
Centrifugal fan evaporative condensers	All	R-507A Test Fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb	≥ 135,000 Btu/h·hp	CTI ATC-106
Air-cooled condensers	All	125°F Condensing Temperature 190°F Entering Gas Temperature 15°F subcooling 95°F entering db	≥ 176,000 Btu/h·hp	AHRI 460

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

a. The efficiencies and test procedures for both open- and closed-circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of wet and dry heat exchange sections.

b. For purposes of this table, open circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table 403.2.3(8) divided by the fan nameplate-rated motor power.

c. For purposes of this table, closed-circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table 403.2.3(8) divided by the sum of the fan nameplate-rated motor power and the spray pump nameplate-rated motor power.

d. For purposes of this table, air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan nameplate-rated motor power.

e. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure. The certification requirements do not apply to field-erected cooling towers.

f. Where a certification program exists for a covered product and it includes provisions for verification and challenge of equipment efficiency ratings, then the product shall be listed in the certification program; or, where a certification program exists for a covered product, and it includes provisions for verification and challenge of equipment efficiency ratings, but the product is not listed in the existing certification program, the ratings shall be verified by an independent laboratory test report.

g. Cooling towers shall comply with the minimum efficiency listed in the table for that specific type of tower with the capacity effect of any project-specific accessories and/or options included in the capacity of the cooling tower.

h. For purposes of this table, evaporative condenser performance is defined as the heat rejected at the specified rating condition in the table divided by the sum of the fan motor nameplate power and the integral spray pump nameplate power.

i. Requirements for evaporative condensers are listed with ammonia (R-717) and R-507A as test fluids in the table. Evaporative condensers intended for use with halocarbon refrigerants other than R-507A shall meet the minimum efficiency requirements listed in this table with R-507A as the test fluid.

TABLE C403.2.3(9)	MINIMUM EFFICIENCY AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS		
Equipment Type	**Net Sensible Cooling Capacity[a]**	**Minimum SCOP-127[b] Efficiency Downflow Units / Upflow Units**	**Test Procedure**
Air conditioners, air cooled	< 65,000 Btu/h	2.20 / 2.09	ANSI/ASHRAE 127
	≥ 65,000 Btu/h and < 240,000 Btu/h	2.10 / 1.99	
	≥ 240,000 Btu/h	1.90 / 1.79	
Air conditioners, water cooled	< 65,000 Btu/h	2.60 / 2.49	
	≥ 65,000 Btu/h and < 240,000 Btu/h	2.50 / 2.39	
	≥ 240,000 Btu/h	2.40 /2.29	
Air conditioners, water cooled with fluid economizer	< 65,000 Btu/h	2.55 /2.44	
	≥ 65,000 Btu/h and < 240,000 Btu/h	2.45 / 2.34	
	≥ 240,000 Btu/h	2.35 / 2.24	
Air conditioners, glycol cooled (rated at 40% propylene glycol)	< 65,000 Btu/h	2.50 / 2.39	
	≥ 65,000 Btu/h and < 240,000 Btu/h	2.15 / 2.04	
	≥ 240,000 Btu/h	2.10 / 1.99	
Air conditioners, glycol cooled (rated at 40% propylene glycol) with fluid economizer	< 65,000 Btu/h	2.45 / 2.34	
	≥ 65,000 Btu/h and < 240,000 Btu/h	2.10 / 1.99	
	≥ 240,000 Btu/h	2.05 / 1.94	

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

a. Net sensible cooling capacity: the total gross cooling capacity less the latent cooling less the energy to the air movement system. (Total Gross – latent – Fan Power).

b. Sensible coefficient of performance (SCOP-127): a ratio calculated by dividing the net sensible cooling capacity in watts by the total power input in watts (excluding reheaters and humidifiers) at conditions defined in ASHRAE Standard 127. The net sensible cooling capacity is the gross sensible capacity minus the energy dissipated into the cooled space by the fan system.

TABLE C403.2.3(10) HEAT TRANSFER EQUIPMENT			
Equipment Type	**Subcategory**	**Minimum Efficiency**	**Test Procedure[a]**
Liquid-to-liquid heat exchangers	Plate type	NR	AHRI 400

NR = No Requirement.

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

TABLE C403.2.3(11) MINIMUM EFFICIENCY REQUIREMENTS VARIABLE REFRIGERANT FLOW MULTI-SPLIT AIR CONDITIONERS AND HEAT PUMPS				
Equipment Type	**Size Category**	**Heating Type[a]**	**Minimum Efficiency**	**Test Procedure[b]**
VRF Multi-split Air Conditioners (Air-cooled)	< 65,000 Btu/h	All	13.0 SEER	AHRI 1230 (omit Sections 5.1.2 and 6.6)
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	11.2 EER	
		All other	11.0 EER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)	11.0 EER	
		All other	10.8 EER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric resistance (or none)	10.0 EER	
		All other	9.8 EER	
VRF Multi-split Heat Pumps (Air-cooled)	< 65,000 Btu/h	All	13.0 SEER 7.7 HSPF	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	11.0 EER 3.3 COP	
		All other	10.8 EER 3.3 COP	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)	10.6 EER 3.2 COP	
		All other	10.4 EER 3.2 COP	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric resistance (or none)	9.5 EER 3.2 COP	
		All other	9.8 EER	

VRF Multi-split Air Conditioners (Water-source)	< 17,000 Btu/h	Without heat recovery	12.0 EER 4.2 COP	AHRI 1230 (omit Sections 5.1.2 and 6.6)
		With heat recovery	11.8 EER 4.2 COP	
	≥ 17,000 Btu/h and < 65,000 Btu/h	All	12.0 EER 4.2 COP	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	12.0 EER 4.2 COP	
	≥ 135,000 Btu/h and < 760,000 Btu/h	Without heat recovery	10.0 EER 3.9 COP	
		With heat recovery	9.8 EER 3.9 COP	

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

a. VRAF Multi-split Heat Pumps (air-cooled) with heat recovery fall under the category of "All Other Types of Heating" unless they also have electric resistance heating, in which case it falls under the category for "No Heating or Electric Resistance Heating."

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

review questions...

The following questions will be a review of the content from this section. These questions will NOT be graded. The answers to the review questions can be found on page 71.

2. **According to Table C403.2.3(9), what is the test procedure for water cooled air conditioners serving computer rooms that have a net sensible cooling capacity of < 65,000 Btu/h?**
   a. ANSI/ASHRAE 127
   b. AHRI 400
   c. CTI ATC-105 and CTI STD-201
   d. AHRI 365

3. **According to Table C403.2.3(5), what is the test procedure for gas-fired hot water boilers with a minimum efficiency of 80% AFUE?**
   a. 10 CFR Part 431
   b. Section 2.10, Efficiency of ANSI Z83.8
   c. DOE 10 CFR, Part 430
   d. 10 CFR Part 430

C403.2.4.4 Zone isolation

HVAC systems serving zones that are over 25,000 square feet (2323 m^2) in floor area or that span more than one floor and are designed to operate or be occupied nonsimultaneously shall be divided into isolation areas. Each isolation area shall be equipped with isolation devices and controls configured to automatically shut off the supply of conditioned air and outdoor air to and exhaust air from the isolation area. Each isolation area shall be controlled independently by a device meeting the requirements of Section C403.2.4.2.2. Central systems and plants shall be provided with controls and devices that will allow system and equipment operation for any length of time while serving only the smallest isolation area served by the system or plant.

Exceptions:

1. Exhaust air and outdoor air connections to isolation areas where the fan system to which they connect is not greater than 5,000 cfm (2360 L/s).
2. Exhaust airflow from a single isolation area of less than 10 percent of the design airflow of the exhaust system to which it connects.
3. Isolation areas intended to operate continuously or intended to be inoperative only when all other isolation areas in a zone are inoperative.

Analysis of Code Change: A new section providing the ability to create isolation areas within zones under certain circumstances in order to allow for additional reductions in energy use and operating costs. Criteria is consistent with ASHRAE 90.1.

C403.2.8 Kitchen Exhaust Systems

Replacement air introduced directly into the exhaust hood cavity shall not be greater than 10 percent of the hood exhaust airflow rate. Conditioned supply air delivered to any space shall not exceed the greater of the following:

1. The ventilation rate required to meet the space heating or cooling load.
2. The hood exhaust flow minus the available transfer air from adjacent space where available transfer air is considered that portion of outdoor ventilation air not required to satisfy other exhaust needs, such as restrooms, and not required to maintain pressurization of adjacent spaces.

   Where total kitchen hood exhaust airflow rate is greater than 5,000 cfm (2360 L/s), each hood shall be a factory built commercial exhaust hood listed by a nationally recognized testing laboratory in compliance with UL 710. Each hood shall have a maximum exhaust rate as specified in Table C403.2.8 and shall comply with one of the following:

   1. Not less than 50 percent of all replacement air shall be transfer air that would otherwise be exhausted.
   2. Demand ventilation systems on not less than 75 percent of the exhaust air that are capable of not less than a 50-percent reduction in exhaust and replacement air system airflow rates, including controls necessary to modulate airflow in response to appliance operation and to maintain full capture and containment of smoke, effluent and combustion products during cooking and idle.
   3. Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40 percent on not less than 50 percent of the total exhaust airflow.

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

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

Table C403.2.8

Maximum Net Exhaust Flow Rate, CFM Per Linear Foot of Hood Length

Type of Hood	Light-Duty Equipment	Medium-Duty Equipment	Heavy-Duty Equipment	Extra-Heavy-Duty Equipment
Wall-mounted canopy	140	210	280	385
Single island	280	350	420	490
Double island	175	210	280	385
Eyebrow	175	175	NA	NA
Backshelf/ Pass-over	210	210	280	NA

For SI: 1cfm = 0.4719 L/s; 1 foot = 305 mm.
NA = Not Allowed.

Analysis of Code Change: New provisions were added for kitchen exhaust systems intended to prohibit "short-circuit" hoods. These provisions are consistent with ASHRAE 90.1.

C403.3 through C403.3.4.2 Economizers (prescriptive)

C403.3 Economizers (Prescriptive).

Each cooling system shall include either an air or water economizer complying with Sections C403.3.1 through C403.3.4.

Exceptions: Economizers are not required for the systems listed below.

1. In cooling systems for buildings located in Climate Zones 1A and 1B.

2. In *climate zones* other than 1A and 1B, where individual fan cooling units have a capacity of less than 54,000 Btu/h (15.8 kW) and meet one of the following:

   2.1. Have direct expansion cooling coils.

   2.2. The total chilled water system capacity less the capacity of fan units with air economizers is less than the minimum specified in Table C403.3(1).

   The total supply capacity of all fan-cooling units not provided with economizers shall not exceed 20 percent of the total supply capacity of all fan-cooling units in the building or 300,000 Btu/h (88 kW), whichever is greater.

3. 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) dewpoint temperature to satisfy process needs.
4. Systems that serve residential spaces where the system capacity is less than five times the requirement listed in Table C403.3(1).
5. Systems expected to operate less than 20 hours per week.
6. Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems.
7. The required air or water economizer may be eliminated if the minimum code required cooling efficiency of the HVAC unit rated with an IPLV, IEER or SEER is increased by at least 17 percent. If the HVAC unit is only rated with a full-load metric like EER cooling, then it must be increased by at least 17 percent.
8. Chilled-water cooling systems that are passive (without a fan) or use induction where the total chilled water system capacity less the capacity of fan units with air economizers is less than the minimum specified in Table C403.3(1).
9. Systems that include a heat recovery system in accordance with Section C403.4.5.

Table C403.3(2) Equipment Efficiency Performance Exception for Economizers. Reserved.

C403.3.1 Integrated economizer control.

Economizer systems shall be integrated with the mechanical cooling system and be capable of providing partial cooling even where additional mechanical cooling is required to provide the remainder of the cooling load. Controls shall not be capable of creating a false load in the mechanical cooling systems by limiting or disabling the economizer or any other means, such as hot gas bypass, except at the lowest stage of mechanical cooling.

Units that include an air economizer shall comply with the following:

1. Unit controls shall have the mechanical cooling capacity control interlocked with the air economizer controls such that the outdoor air damper is at the 100-percent open position when mechanical cooling is on and the outdoor air damper does not begin to close to prevent coil freezing due to minimum compressor run time until the leaving air temperature is less than 45°F (7°C).
2. Direct expansion (DX) units that control 75,000 Btu/h (22 kW) or greater of rated capacity of the capacity of the mechanical cooling directly based on occupied space temperature shall have not fewer than two stages of mechanical cooling capacity.
3. Other DX units, including those that control space temperature by modulating the airflow to the space, shall be in accordance with Table C403.3.1.

TABLE C403.3.1
DX COOLING STAGE REQUIREMENTS FOR MODULATING AIRFLOW UNITS

RATING CAPACITY	MINIMUM NUMBER OF MECHANICAL COOLING STAGES	MINIMUM COMPRESSOR DISPLACEMENT[a]
≥ 65,000 Btu/h and < 240,000 Btu/h	3 stages	≤ 35% of full load
≥ 240,000 Btu/h	4 stages	≤ 25% full load

TABLE C403.3(1)
MINIMUM CHILLED-WATER SYSTEM COOLING CAPACITY FOR DETERMINING ECONOMIZER COOLING REQUIREMENTS

CLIMATE ZONES (COOLING)	TOTAL CHILLED-WATER SYSTEM CAPACITY LESS CAPACITY OF COOLING UNITS WITH AIR ECONOMIZERS	
	Local Water-cooled Chilled-water Systems	Air-cooled Chilled-water Systems or District Chilled-Water Systems
1a	No economizer requirement	No economizer requirement
1b, 2a, 2b	960,000 Btu/h	1,250,000 Btu/h
3a, 3b, 3c, 4a, 4b, 4c	720,000 Btu/h	940,000 Btu/h
5a, 5b, 5c, 6a, 6b, 7, 8	1,320,000 Btu/h	1,720,000 Btu/h

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

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

C403.3.2 Economizer heating system impact.

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

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

C403.3.3 Air economizers.

Air economizers shall comply with Sections C403.3.3.1 through C403.3.3.5.

C403.3.3.1 Design capacity.

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

C403.3.3.2 Control signal.

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

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

C403.3.3.3 High-limit shutoff.

Air economizers shall be capable of automatically reducing outdoor air intake to the design minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage. High-limit shutoff control types for specific climates shall be chosen from Table C403.3.3.3. High-limit shutoff control settings for these control types shall be those specified in Table C403.3.3.3.

TABLE C403.3.3.3
HIGH-LIMIT SHUTOFF CONTROL SETTING FOR AIR ECONOMIZERS[b]

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	$T_{OA} > 75^{o}F$	Outdoor air temperature exceeds $75^{o}F$
	5A, 6A	$T_{OA} > 70^{o}F$	Outdoor air temperature exceeds $70^{o}F$
	1A, 2A, 3A, 4A	$T_{OA} > 65^{o}F$	Outdoor air temperature exceeds 65 ^{o}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 with fixed dry-bulb temperatures	All	$h_{OA} > 28$ Btu/lb[a] or $T_{OA} > 75^{o}F$	Outdoor air enthalpy exceeds 28 Btu/lb of dry air[a] or Outdoor air temperature exceeds 75°F
Differential enthalpy with fixed dry-bulb temperature	All	$h_{OA} > h_{RA}$ or $T_{OA >} 75^{o}F$	Outdoor air enthalpy exceeds return air enthalpy or Outdoor air temperature exceeds 75°F

For SI: 1 foot = 305 mm, $^{o}C = (^{o}F - 32)/1.8$, 1 Btu/lb = 2.33 kJ/kg.

a. At altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at 75°F and 50-percent relative humidity. As an example, at approximately 6,000 feet elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.

b. Devices with selectable setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.

C403.3.3.4 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.

C403.3.3.5 Economizer dampers.

Return, exhaust/relief and outdoor air dampers used in economizers shall comply with Section C403.2.4.3.

C403.3.4 Water-side economizers.

Water-side economizers shall comply with Sections C403.3.4.1 and C403.3.4.2.

C403.3.4.1 Design capacity.

Water economizer systems shall be capable of cooling

supply air by indirect evaporation and providing up to 100 percent of the expected system cooling load at outdoor air temperatures of not greater than 50°F (10°C) dry bulb/45°F (7°C) wet bulb.

Exceptions:

1. Systems primarily serving computer rooms in which 100 percent of the expected system cooling load at 40°F (4°C) dry bulb/35°F (1.7°C) wet bulb is met with evaporative water economizers.
2. Systems primarily serving computer rooms with dry cooler water economizers which satisfy 100 percent of the expected system cooling load at 35°F (1.7°C) dry bulb.
3. Systems where dehumidification requirements cannot be met using outdoor air temperatures of 50°F (10°C) dry bulb/45°F (7°C) wet bulb and where 100 percent of the expected system cooling load at 45°F (7°C) dry bulb/40°F (4°C) wet bulb is met with evaporative water economizers.

C403.3.4.2 Maximum pressure drop.

Precooling coils and water-to-water heat exchangers used as part of a water economizer system shall either have a waterside pressure drop of less than 15 feet (45 kPa) of water or a secondary loop shall be created so that the coil or heat exchanger pressure drop is not seen by the circulating pumps when the system is in the normal cooling (noneconomizer) mode.

Analysis of Code Change: These sections have undergone significant revision and reorganization. Notable changes include:

- Increases the cooling capacity threshold for air economizer to be required in DX cooling systems from 33,000 Btu/h to 54,000 Btu/h.
- Enhances the requirements for integrated economizer control and defines DX unit capacity staging requirements.
- Incorporates new provisions and changes for consistency with ASHRAE 90.1
- Improves the cooling efficiency by requiring a water-side economizer for non-fan systems (e.g. radiant cooling, passive chilled beam systems), and for systems with small individual fan systems served by chilled water systems at least 50 tons in size.
- Requires the economizer intake dampers to be labeled, to be low-leakage, and that the low leakage ratings are certified to ensure the design intent and energy savings.
- New exception permits the required air or water economizer to be eliminated if the minimum code required cooling efficiency of the HVAC unit rated with an IPLV, IEER, or SEER is increased by at least 17%. If the HVAC unit is only rated with a full-load metric like EER tcooling then it must be increased by at least 17%.

review questions...

The following question will be a review of the content from this section. This question will NOT be graded. The answer to the review question can be found on page 71.

4. **According to Table C403.3.1, what is the minimum number of mechanical cooling stages required for a modulating airflow unit with a rating capacity of > 240,000 Btu/h?**
   a. 3 stages
   b. 4 stages
   c. 2 stages
   d. 1 stage

Section C404: Service Water Heating (Mandatory)

C404.5 through C404.5.2.1
C404.5 Efficient heated water supply piping.

Heated water supply piping shall be in accordance with Section C404.5.1 or C404.5.2. The flow rate through 1/4-inch (6.4 mm) piping shall be not greater than 0.5 gpm (1.9 L/m). The flow rate through 5/16-inch (7.9 mm) piping shall be not greater than 1 gpm (3.8 L/m). The flow rate through 3/8-inch (9.5 mm) piping shall be not greater than 1.5 gpm (5.7 L/m).

C404.5.1 Maximum allowable pipe length method.

The maximum allowable piping length from the nearest source of heated water to the termination of the fixture supply pipe shall be in accordance with the following. Where the piping contains more than one size of pipe, the largest size of pipe within the piping shall be used for determining the maximum allowable length of the piping in Table C404.5.1.

1. For a public lavatory faucet, use the “Public lavatory faucets” column in Table C404.5.1.
2. For all other plumbing fixtures and plumbing appliances, use the “Other fixtures and appliances” column in Table C404.5.1.

TABLE C404.5.1 PIPING VOLUME AND MAXIMUM PIPING LENGTHS			
NOMINAL PIPE SIZE (inches)	VOLUME (liquid ounces per foot length)	MAXIMUM PIPING LENGTH (feet)	
		Public lavatory faucets	Other fixtures and appliances
1/4	0.33	6	50
5/16	0.5	4	50
3/8	0.75	3	50
1/2	1.5	2	43
5/8	2	1	32
3/4	3	0.5	21
7/8	4	0.5	16
1	5	0.5	13
11/4	8	0.5	8
11/2	11	0.5	6
2 or larger	18	0.5	4

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 liquid ounce = 0.030 L, 1 gallon = 128 ounces.

C404.5.2 Maximum allowable pipe volume method. The water volume in the piping shall be calculated in accordance with Section C404.5.2.1. Water heaters, circulating water systems and heat trace temperature maintenance systems shall be considered sources of heated water.

The volume from the nearest source of heated water to the termination of the fixture supply pipe shall be as follows:

1. For a public lavatory faucet: not more than 2 ounces (0.06 L).
2. For other plumbing fixtures or plumbing appliances; not more than 0.5 gallon (1.89 L).

C404.5.2.1 Water volume determination. The volume shall be the sum of the internal volumes of pipe, fittings, valves, meters and manifolds between the nearest source of heated water and the termination of the fixture supply pipe. The volume in the piping shall be determined from the "Volume" column in Table C404.5.1. The volume contained within fixture shutoff valves, within flexible water supply connectors to a fixture fitting and within a fixture fitting shall not be included in the water volume determination. Where heated water is supplied by a recirculating system or heat-traced piping, the volume shall include the portion of the fitting on the branch pipe that supplies water to the fixture.

Analysis of Code Change: These are new sections addressing the installation of hot water piping so that the delivery is more efficient. Specifies limits on pipe length and pipe volume.

review questions...

The following question will be a review of the content from this section. This question will NOT be graded. The answer to the review question can be found below.

5. **According to Table C404.5.1, what is the maximum piping length of a public lavatory faucet with a nominal pipe size of 3/8 of an inch?**
   a. 6 feet
   b. 4 feet
   c. 3 feet
   d. 2 feet

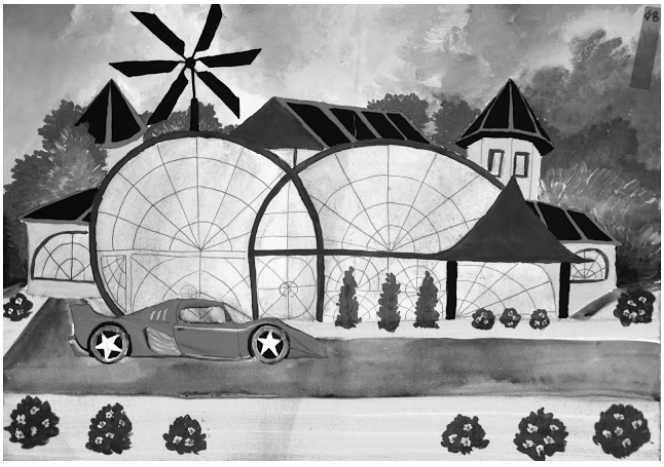
Section C407: Total Building Performance

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

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

Analysis of Code Change: A new section allowing credit for energy- efficiency measures that the hourly energy analysis software is not capable of directly modeling.

ENERGY CONSERVATION: RESIDENTIAL



Chapter 4: Residential Energy Efficiency

Section R402: Building Thermal Envelope

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.

Dynamic glazing shall be permitted to satisfy the SHGC requirements of Table R402.1.2 provided the ratio of the higher to lower labeled SHGC is greater than or equal to 2.4, and the *dynamic glazing* is automatically controlled to modulate the amount of solar gain into the space in multiple steps. *Dynamic glazing* shall be considered separately from other fenestration, and area-weighted averaging with other fenestration that is not *dynamic glazing* shall not be permitted.

> **Exception:** Dynamic glazing is not required to comply with this section when both the lower and higher labeled SHGC already comply with the requirements of Table R402.1.2.

Analysis of Code Change: Revised to allow dynamic glazing to satisfy the SHGC requirements provided the ratio of upper to lower SHGC is 2.4 or greater and is automatically controlled to modulate the amount of solar gain into the space.

R402.3.5 Sunroom fenestration.
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* 2 through 8, the maximum fenestration *U*-factor shall be 0.45 and 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.

Analysis of Code Change: The exception has been expanded to include Climate Zones 2 and 3.

R402.4.1.2 Testing.
The building or dwelling unit shall be tested and verified as having an air leakage rate not exceeding seven air changes per hour in Climate Zones 1 and 2, and three air changes per hour in Climate Zones 3 through 8. Testing shall be conducted in accordance with ANSI/RESNET/ICC 380 and reported at a pressure of 0.2 inch w.g. (50 pascals). Testing shall be conducted by either individuals as defined in Section 553.993(5) or (7), *Florida Statutes*, or individuals licensed as set forth in Section 489.105(3)(f), (g) or (i) or an *approved* third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the *code official*. Testing shall be performed at any time after creation of all penetrations of the *building thermal envelope*.

Exception: Testing is not required for additions, alterations, renovations or repairs of the building thermal envelope of existing buildings in which the new construction is less than 85 percent 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.
6. Supply and return registers, if installed at the time of the test, shall be fully open.

Analysis of Code Change: The blower door testing requirements will be applicable at the effective date of the 6th Edition (2014) FBCEC. Requires an air leakage rate of not less than 7 air changes per hour. Requires testing to be conducted in accordance with ANSI/RESNET/ICC 380.

A new exception to testing has been added for additions, alterations, renovations, or repairs, of the building thermal envelope of existing buildings in which the new construction is less than 85% of the building thermal envelope.

Section R403: Systems

R403.3 through R403.3.5 Ducts.

R403.3 Ducts.

Ducts and air handlers shall be in accordance with Sections R403.3.1 through R403.3.5.

R403.3.1 Insulation (Prescriptive).

Supply and return ducts in attics shall be insulated to a minimum of R-8 where 3 inches (76 mm) in diameter and greater and R-6 where less than 3 inches (76 mm) in diameter. Supply and return ducts in other portions of the building shall be insulated to a minimum of R-6 where 3 inches (76 mm) in diameter or greater and R-4.2 where less than 3 inches (76 mm) in diameter.

Exception: Ducts or portions thereof located completely inside the building thermal envelope.

R403.3.2 Sealing (Mandatory).

All ducts, air handlers, filter boxes and building cavities that form the primary air containment passageways for air distribution systems shall be considered ducts or plenum chambers, shall be constructed and sealed in accordance with Section C403.2.9.2 of the Commercial Provisions of this code and shall be shown to meet duct tightness criteria below.

Duct tightness shall be verified by testing in accordance with ANSI/RESNET/ICC 380 by either individuals as defined in Section 553.993(5) or (7), Florida Statutes, or individuals licensed as set forth in Section 489.105(3)(f), (g) or (i), Florida Statutes, to be "substantially leak free" in accordance with Section R403.3.3.

R403.3.2.1 Sealed air handler.

Air handlers shall have a manufacturer's designation for an air leakage of no more than 2 percent of the design airflow rate when tested in accordance with ASHRAE 193.

R403.3.3 Duct testing (Mandatory).

Ducts shall be pressure tested to determine air leakage by one of the following methods:

1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer's air handler enclosure if installed at the time of the test. All registers shall be taped or otherwise sealed during the test.

2. Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. Registers shall be taped or otherwise sealed during the test.

Exceptions:

1. A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the building thermal envelope.

2. Duct testing is not mandatory for buildings complying by Section 405 of this code.

A written report of the results of the test shall be signed by the party conducting the test and provided to the code official.

R403.3.4 Duct leakage (Prescriptive).

The total leakage of the ducts, where measured in accordance with Section R403.3.3, shall be as follows:

1. Rough-in test: The total leakage shall be less than or equal to 4 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m2) of conditioned floor area where the air handler is installed at the time of the test. Where the air handler is not installed at the time of the test, the total leakage shall be less than or equal to 3 cubic feet per minute (85 L/min) per 100 square feet (9.29 m2) of conditioned floor area.

2. Postconstruction test: Total leakage shall be less than or equal to 4 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m2) of conditioned floor area.

R403.3.5 Building cavities (Mandatory).

Building framing cavities shall not be used as ducts or plenums.

Analysis of Code Change: These changes increase the insulation requirements for return ducts in attics from R-6 to R-8. These changes make the maximum allowable duct leakage rates prescriptive, allowing performance path trade-offs.

Section R406: Energy Rating Index Compliance Alternative

R406.6.1Compliance software tools.

Computer software utilized for demonstration of code compliance shall have been approved by the Florida Building Commission in accordance with requirements of this code**.**

Analysis of Code Change: This section was revised to require computer software utilized for demonstration of code compliance to be approved by the Florida Building Commission in accordance with requirements of this code.

Review Question Answers and Explanations

Review Question 1:

What is the U-Factor for Mass Walls, Above Grade in Climate Zone 3 Group R?

a. U-0.052: *Incorrect. This is the U-Factor for Metal building Walls, Above Grade in Climate Zone 3 Group R*

b. U-0.104: *Correct. This is the U-Factor for Mass Walls, Above Grade in Climate Zone 3 Group R*

c. U-0.123: *Incorrect. This is the U-Factor for Mass Walls, Above Grade in Climate Zone 3 All Other*

d. U-0.064: *Incorrect. This is the U-Factor for Metal framed Walls, Above Grade in Climate Zone 3 Group R*

Review Question 2:

What is the test procedure for water cooled air conditioners serving computer rooms that have a net sensible cooling capacity of < 65,000 Btu/h?

a. ANSI/ASHRAE 127: *Correct. This is the testing procedure for all air conditioners and condensing units serving computer rooms.*

b. AHRI 400: *Incorrect. This is the testing procedure for liquid-to-liquid heat exchangers.*

c. CTI ATC-105 and CTI STD-201: *Incorrect. These are the testing procedures for heat rejection equipment: propeller or axial fan open-circuit cooling towers.*

d. AHRI 365: *Incorrect. This is the testing procedure for electrically operated, air cooled condensing units.*

Review Question 3:

According to Table C403.2.3(5), what is the test procedure for gas-fired hot water boilers with a minimum efficiency of 80% AFUE?

a. 10 CFR Part 431: *Incorrect. This is the testing procedure for gas-fired hot water boilers with a minimum efficiency of 80% E_t or 82% E_c.*

b. Section 2.10, Efficiency of ANSI Z83.8: *Incorrect. This is the testing procedure for gas-fired warm air duct furnaces.*

c. DOE 10 CFR, Part 430: *Incorrect. This is the testing procedure for gas-fired mobile home furnaces.*

d. 10 CFR Part 430: *Correct. This is the testing procedure for gas-fired hot water boilers with a minimum efficiency of 80% AFUE.*

Review Question 4:

According to Table C403.3.1, what is the minimum number of mechanical cooling stages required for a modulating airflow unit with a rating capacity of > 240,000 Btu/h?

a. 3 stages: *Incorrect. This is the minimum number of mechanical cooling stages required for a modulating airflow unit with a rating capacity between ≥ 65,000 Btu/h and < 240,000 Btu/h.*

b. 4 stages: *Correct. This is the minimum number of mechanical cooling stages required for a modulating airflow unit with a ration capacity of ≥ 240,000 Btu/h.*

c. 2 stages: *Incorrect. This option is not viable as it is not presented in Table C403.3.1.*

d. 1 stage: *Incorrect. This option is not viable as it is not presented in Table C403.3.*

Review Question 5:

According to Table C404.5.1, what is the maximum piping length of a public lavatory faucet with a nominal pipe size of 3/8 of an inch?

a. 6 feet: *Incorrect. This is the maximum piping length of public lavatory faucet with a nominal pipe size of 1/4 of an inch.*

b. 4 feet: *Incorrect. This is the maximum piping length of public lavatory faucet with a nominal pipe size of 5/16 of an inch.*

c. 3 feet: *Correct. This is the maximum piping length of public lavatory faucet with a nominal pipe size of 3/8 of an inch.*

d. 2 feet: *Incorrect. This is the maximum piping length of public lavatory faucet with a nominal pipe size of 1/2 of an inch.*