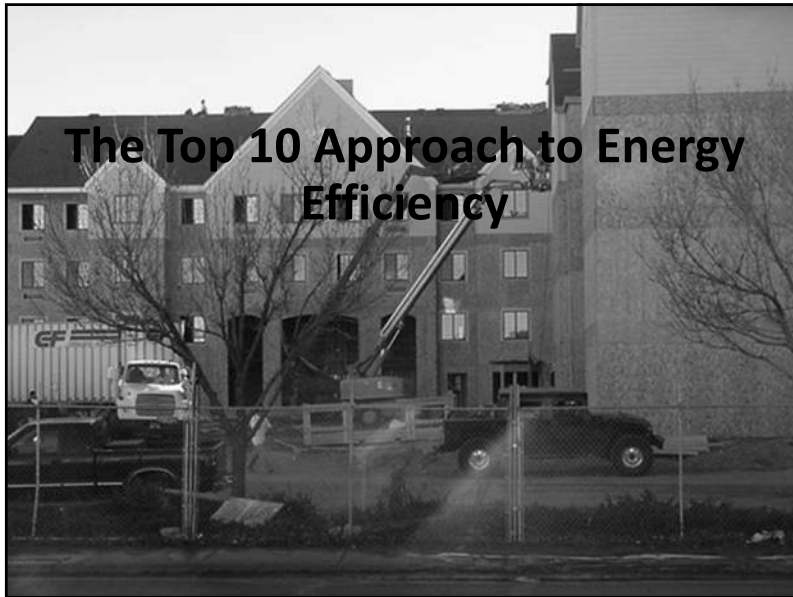


# The Top 10 Approach to Energy Efficiency





1


## The Top 10 Approach to Energy Efficiency

1. Building as a System
2. Building Shell
3. Assemblies...Do they Dry?
4. Thermal Envelope
5. Air Tightness
6. Ventilation
7. HVAC Design
8. Controls
9. Is it there?
10. Does it Work?

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3

Instructor

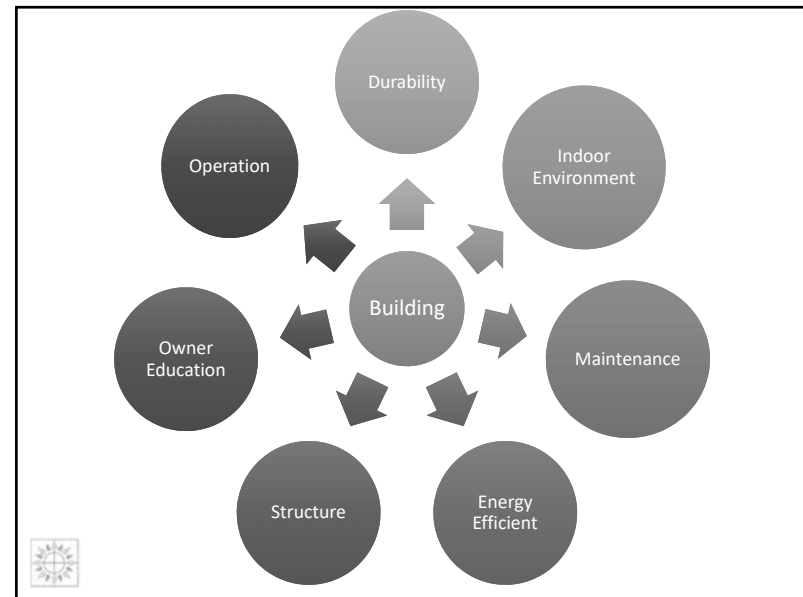


**Gil Rossmiller**

- In the construction industry for over 40 years
- ICC – IRC Plumbing & Mechanical Code Development Committee 2009/2012
- ICC- IECC Commercial Energy Code Development Committee 2015/2018
- ICC- IECC Residential Energy Code Development Committee 2021/2024
- Code Correlation Committee
- 2003-2016 Building Official  
Parker, Colorado

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2





4

### Systems Integration + Applied Building Science



**Synergy**

- Two or more things working together to achieve something they could not achieve alone
- Envelope + Mechanical + Lighting
- Touch one system, affect another System.

5

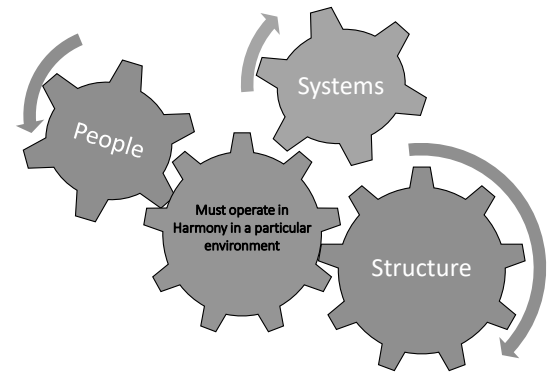

### Does the code require Harmony/System Integration?

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7

### System Harmony is the Goal


6

**IECC 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

**IBC Purpose**

The purpose of this code is to establish the minimum requirements to provide a reasonable level of safety, health and general welfare through structural strength, means of egress, stability, sanitation, light and ventilation, energy conservation, and for providing a reasonable level of life safety and property protection from the hazards of fire, explosion or dangerous conditions, and to provide a reasonable level of safety to fire fighters and emergency responders during emergency operations.



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## Building Shell



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9

9

### R703.1 General

Exterior walls shall provide the building with a weather-resistant exterior the exterior wall envelope shall include flashing as described in Section R703.4.

#### R703.1.1 Water resistance

shall be designed and constructed that prevent water within the wall assembly by providing a means of draining to the exterior water that enters the assembly.



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## Definitions (IRC) R202

### • EXTERIOR WALL

- An above-grade wall that defines the exterior boundaries of a building. Includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and basement walls with an average below-grade wall area that is less than 50 percent of the total opaque and nonopaque area of that enclosing side.



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### R703.2 Water-resistive barrier

One layer of No. 15 asphalt felt complying with ASTM D 226 or other approved water-resistive barrier material shall be applied horizontally, with the upper layer lapped over the lower layer not less than 2 inches lapped not less than 6 inches at joints shall be continuous to the top of walls and terminated at penetrations and building appendages in a manner to meet the requirements of the exterior wall envelope as described in Section R703.1.



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**R703.4 Flashing**

Approved corrosion-resistant flashing shall be applied shingle-fashion in a manner to prevent entry of water into the wall cavity or penetration of water to the building structural framing components. Flashing shall be installed at the following locations...



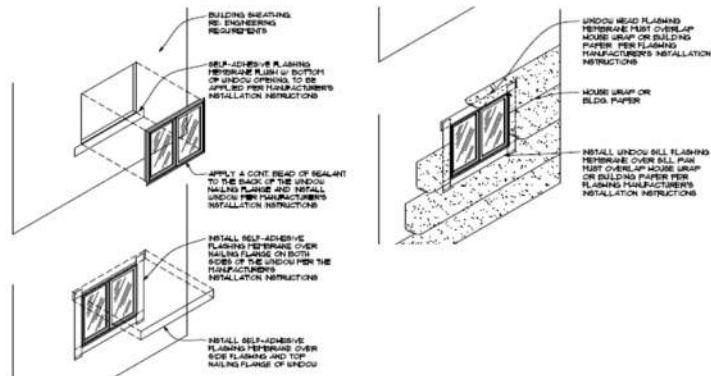
13

2. At the intersection of chimneys or other masonry construction



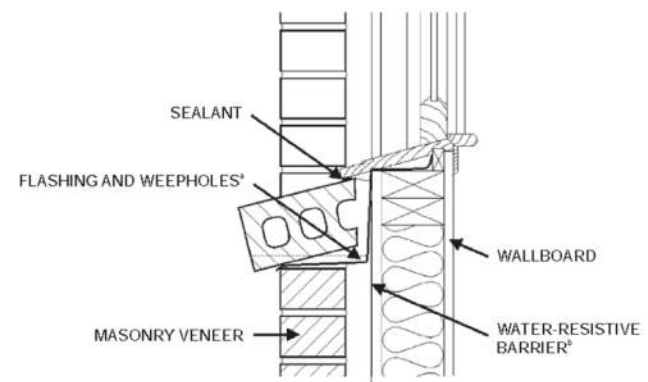
15

1. Exterior window and door openings



14

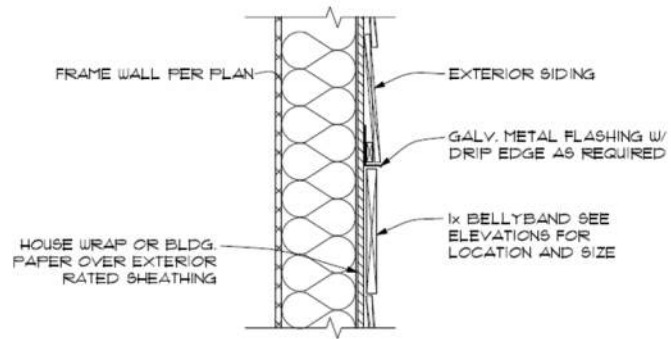
3. Under and at the ends of masonry, wood or metal copings and sills.



16



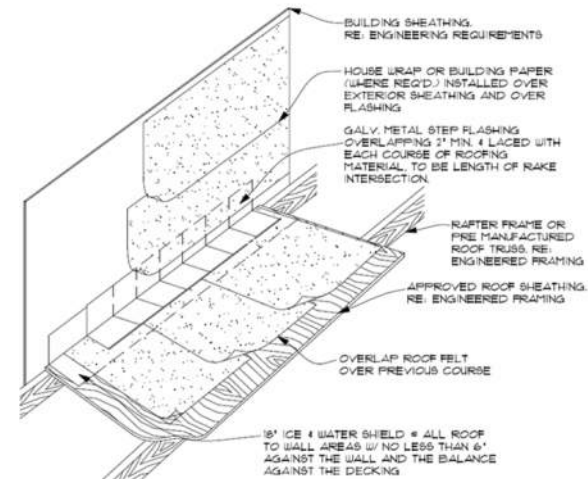
4. Continuously above all projecting wood trim.



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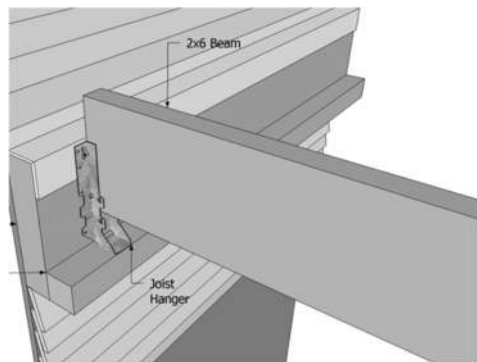
6. At wall and roof intersections



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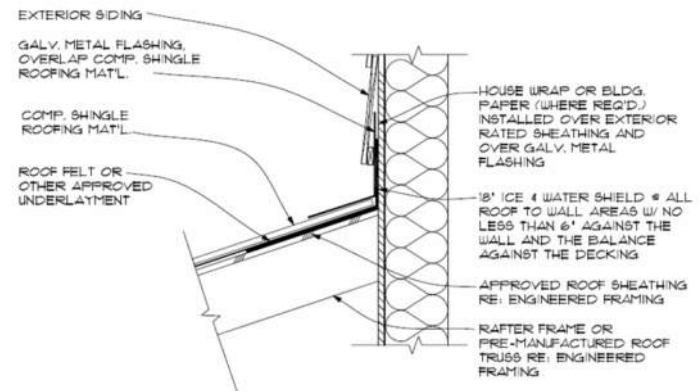
5. Where exterior porches, decks or stairs attach to a wall or floor assembly of wood-frame construction.



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6. At wall and roof intersections

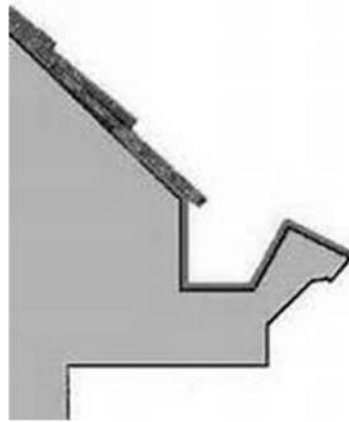


[Link to Plans](#)

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### 7. At built-in gutters.



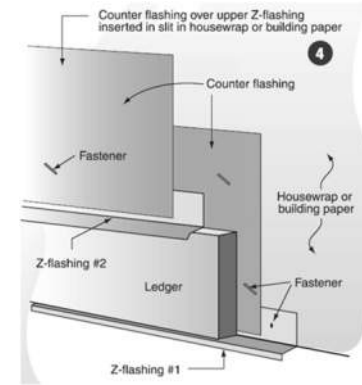
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21

### Construction Documents IBC

- Construction documents for all buildings shall describe the exterior wall envelope in sufficient detail to determine compliance with this code. The construction documents shall provide details of the exterior wall envelope as required, including flashing, intersections with dissimilar materials, corners, end details, control joints, intersections at roof, eaves or parapets, means of drainage, water-resistive membrane and details around openings.



23

23

### Definitions (IBC) 1402

#### EXTERIOR WALL COVERING

- A material or assembly of materials applied on the exterior side of exterior walls for the purpose of providing a weather-resisting barrier, insulation or for aesthetics, including but not limited to, veneers, siding, exterior insulation and finish systems, architectural trim and embellishments such as cornices, soffits, facias, gutters and leaders.

#### EXTERIOR WALL

- A wall, bearing or nonbearing, that is used as an enclosing wall for a building, other than a fire wall, and that has a slope of 60 degrees or greater with the horizontal plane.

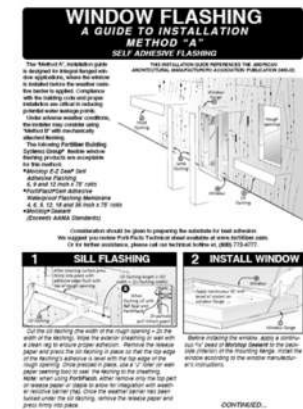


22

22

### Construction Documents IBC

- The construction documents shall include manufacturer's installation instructions that provide supporting documentation that the proposed penetration and opening details described in the construction documents maintain the weather resistance of the exterior wall envelope.
- The supporting documentation shall fully describe the exterior wall system which was tested, where applicable, as well as the test procedure used.



24

24

### The Problem

- Improper installation of exterior finishes and weather protection
- Water intrusion into the wood structure
- MOLD!

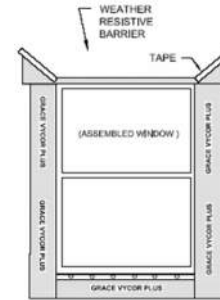


25

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### Flashing IBC

- Flashing shall be installed in such a manner so as to prevent moisture from entering the wall or to redirect it to the exterior.
  - Perimeters of exterior door and window assemblies
  - Penetrations and terminations of exterior wall assemblies
  - Exterior wall intersections with roofs, chimneys, porches, decks, balconies and similar projections
  - Built-in gutters and similar locations where moisture could enter the wall.

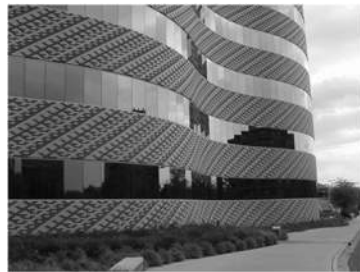


27

27

### Exterior Walls IBC

- Exterior walls shall provide the building with a weather resistant exterior wall envelope.
- The exterior wall envelope shall be designed and constructed in such a manner as to prevent the accumulation of water within the wall assembly
  - water-resistive barrier behind the exterior veneer,
  - A means for draining water that enters the assembly to the exterior of the veneer,



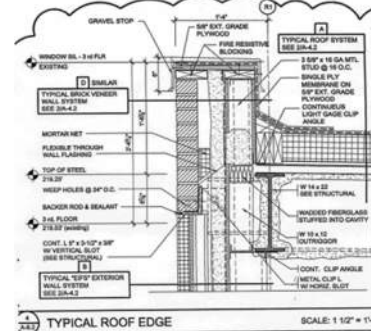
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### Flashing IBC

- Flashing shall be installed in such a manner so as to prevent water from entering the wall and roof through joints in copings, through moisture-permeable materials and at intersections with parapet walls and other penetrations through the roof plane.



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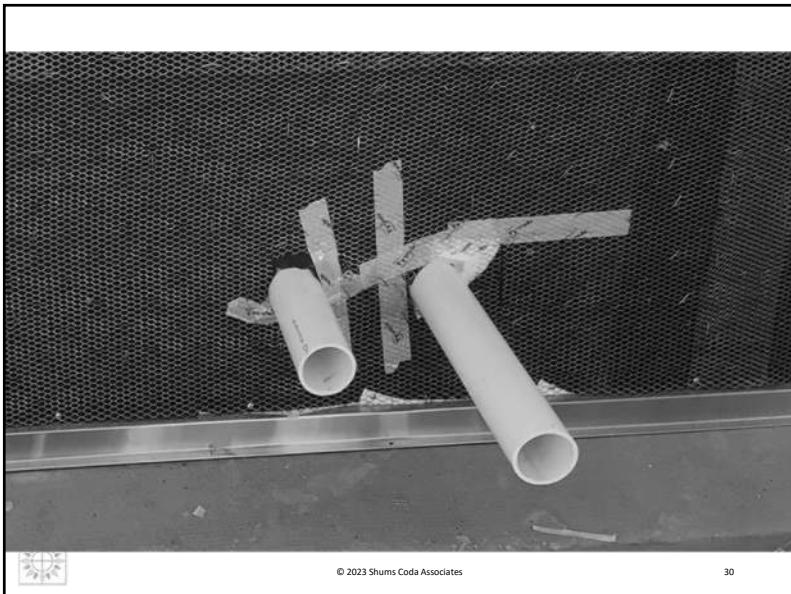




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31



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### Roofing IBC

- Roof decks shall be covered with approved roof coverings secured to the building or structure in accordance with the provisions of this chapter.
- Roof coverings shall be designed in accordance with this code, and installed in accordance with this code and the manufacturer's approved instructions.



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### Assemblies.....Do they Dry?



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### TABLE 1404.3(1)VAPOR RETARDER MATERIALS AND CLASSES

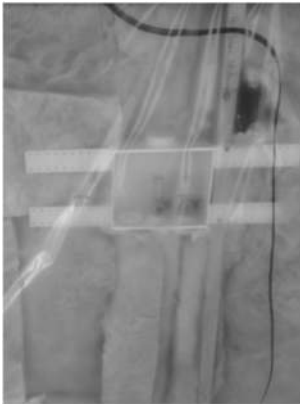
VAPOR RETARDER CLASS	ACCEPTABLE MATERIALS
I	Sheet polyethylene, nonperforated aluminum foil, or other approved materials with a perm rating of less than or equal to 0.1
II	Kraft-faced fiberglass batts or vapor retarder paint or other approved materials, applied in accordance with the manufacturer's instructions for a perm rating greater than 0.1 and less than or equal to 1.0
III	Latex paint, enamel paint, or other approved materials, applied in accordance with the manufacturer's instructions for a perm rating of greater than 1.0 and less than or equal to 10

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### 1404.3 Vapor retarders

Vapor retarder materials shall be classified in accordance with Table 1404.3(1). A vapor retarder shall be provided on the interior side of frame walls in accordance with Tables 1404.3(2) and 1404.3(3), or an approved design using accepted engineering practice for hygrothermal analysis. The appropriate climate zone shall be selected in accordance with Chapter 3 of the International Energy Conservation Code.



Where a Class II vapor retarder is used in combination with foam plastic insulating sheathing installed as continuous insulation on the exterior side of frame walls, the continuous insulation shall comply with Table 1404.3(4) and the Class II vapor retarder shall have a vapor permeance greater than 1 perm when measured by ASTM E96 water method (Procedure B). Use of a Class I interior vapor retarder in frame walls with a Class I vapor retarder on the exterior side shall require an approved design

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### TABLE 1404.3(2)VAPOR RETARDER OPTIONS


CLIMATE ZONE	VAPOR RETARDER CLASS		
	I	II	III <sup>a</sup>
1, 2	Not permitted	Not Permitted	Permitted
3	Not permitted	Permitted	Permitted
4 (except Marine)	Not permitted	Permitted	See <a href="#">Table 1404.3(3)</a>
Marine 4, 5, 6, 7, 8	Permitted	Permitted	See <a href="#">Table 1404.3(3)</a>

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**TABLE 1404.3(3) CLASS III VAPOR RETARDERS**


ZONE	CLASS III VAPOR RETARDERS PERMITTED FOR: <sup>a, b</sup>
4	Vented cladding over wood structural panels Vented cladding over fiberboard Vented cladding over gypsum Continuous insulation with $R$ -value $\geq R$ -2.5 over $2 \times 4$ wall Continuous insulation with $R$ -value $\geq R$ -3.75 over $2 \times 6$ wall
5	Vented cladding over wood structural panels Vented cladding over fiberboard Vented cladding over gypsum Continuous insulation with $R$ -value $\geq R$ -5 over $2 \times 4$ wall Continuous insulation with $R$ -value $\geq R$ -7.5 over $2 \times 6$ wall
6	Vented cladding over fiberboard Vented cladding over gypsum Continuous insulation with $R$ -value $\geq R$ -7.5 over $2 \times 4$ wall Continuous insulation with $R$ -value $\geq R$ -11.25 over $2 \times 6$ wall
7	Continuous insulation with $R$ -value $\geq R$ -10 over $2 \times 4$ wall Continuous insulation with $R$ -value $\geq R$ -15 over $2 \times 6$ wall
8	Continuous insulation with $R$ -value $\geq R$ -12.5 over $2 \times 4$ wall Continuous insulation with $R$ -value $\geq R$ -20 over $2 \times 6$ wall


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**1404.3.2 Hybrid insulation for moisture control with Class III vapor retarders**

For the purposes of compliance with Table 1404.3(3), the combined moisture control of spray foam plastic insulation and continuous insulation shall be permitted to be counted toward the continuous R value requirement




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a. Vented cladding shall include vinyl lap siding, polypropylene, or horizontal aluminum siding, brick veneer with airspace as specified in this code, and other approved vented claddings.


b. The requirements in this table apply only to insulation used to control moisture in order to permit the use of Class III vapor retarders. The insulation materials used to satisfy this option also contribute to but do not supersede the thermal envelope requirements of the International Energy Conservation Code.

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**TABLE 1404.3(4) CONTINUOUS INSULATION WITH CLASS II VAPOR RETARDER**

CLIMATE ZONE	PERMITTED CONDITIONS <sup>a</sup>
3	Continuous insulation with $R$ -value $\geq R$ -2
4, 5, 6	Continuous insulation with $R$ -value $\geq R$ -3 over $2 \times 4$ wall Continuous insulation with $R$ -value $\geq R$ -5 over $2 \times 6$ wall
7	Continuous insulation with $R$ -value $\geq R$ -5 over $2 \times 4$ wall Continuous insulation with $R$ -value $\geq R$ -7.5 over $2 \times 6$ wall
8	Continuous insulation with $R$ -value $\geq R$ -7.5 over $2 \times 4$ wall Continuous insulation with $R$ -value $\geq R$ -10 over $2 \times 6$ wall

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a. In addition to the vapor retarder, spray foam with a maximum permeance of 1.5 perms at the installed thickness, applied to the interior cavity side of wood structural panels, fiberboard, insulating sheathing or gypsum is deemed to comply with the continuous insulation requirement only for the moisture control purposes of this table where the spray foam R-value plus any continuous insulation R-value provided equals or exceeds the specified continuous insulation R-value.

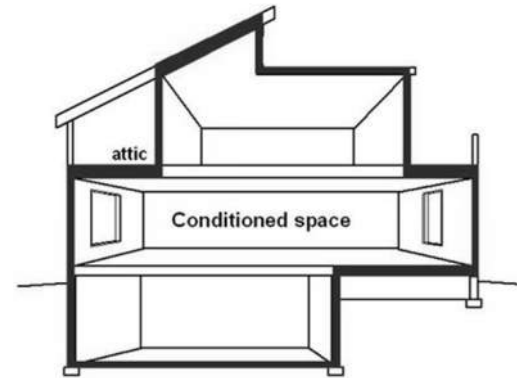


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### Thermal Envelope



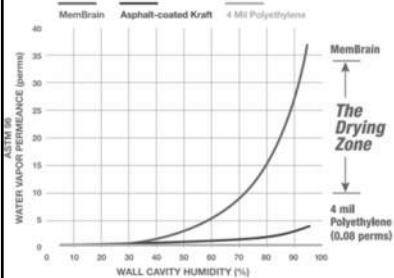
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### CertianTeed Membrain

MemBrain can adapt from fully closed to open (<1 to 35 perms) to provide greater drying capability.



MemBrain can adapt from <1 to 35 perm to keep moisture out of the cavity in the winter while letting it escape when cavity humidity increases in the summer.

#### MemBrain Delivers Proven Barrier Technology

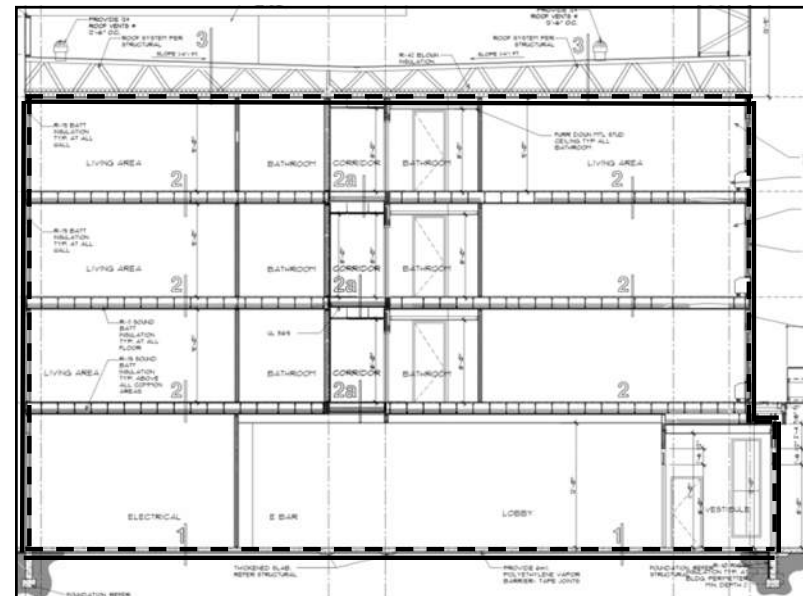
- Proven performance backed by more than a decade of usage and performance data worldwide
- Meets Class A fire retarder specifications, ASTM E84, for flame spread



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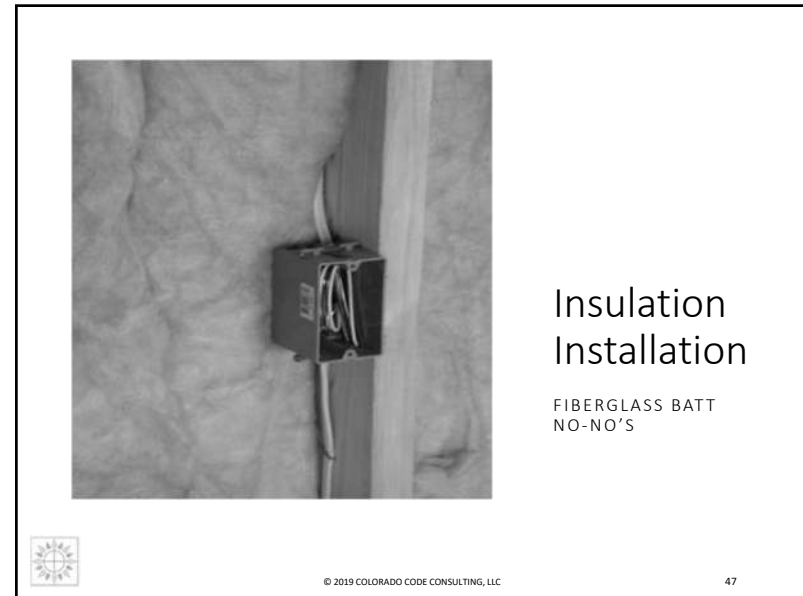
SHGC:	.8
FENESTRATION U-FACTOR:	.28
SKYLIGHT U-FACTOR:	.55
EXTERIOR WALLS:	R-20
ROOF/ATTIC/RAFTERS:	R-49
FLOORS:	R-38
SLAB:	R-10
BASEMENT CONCRETE WALLS:	R-15 CONTINUOUS
BASEMENT FRAMED WALL CAVITY:	R-19
CRAWL SPACE WALLS:	R-19



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## Insulation Installation

FIBERGLASS BATT  
NO-NO'S



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## Insulation Installation

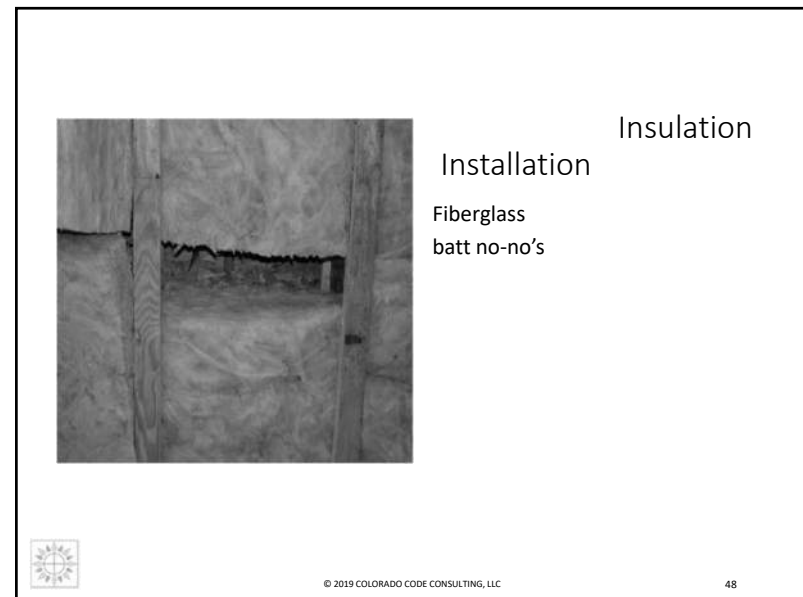
FIBERGLASS BATT  
NO-NO'S



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## Insulation Installation


Fiberglass  
batt no-no's




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Insulation Installation  
Fiberglass batt no -no's




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**WHY?**



**Everything begins and ends with the thermal envelope**




**Can't work by insulation alone**




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Insulation Installation  
Fiberglass batt no -no's



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**CONTROLLING THERMAL FLOW**

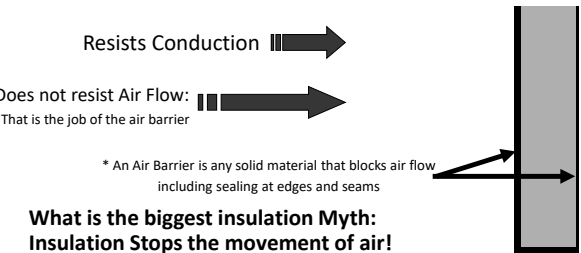

**Most insulation is NOT an air barrier**

Resists Conduction →

Does not resist Air Flow: →  
That is the job of the air barrier

\* An Air Barrier is any solid material that blocks air flow including sealing at edges and seams

**What is the biggest insulation Myth:  
Insulation Stops the movement of air!**





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### Insulation




Insulation traps pockets of air  
Stagnate Air Pockets create the R-value

### Air Barrier



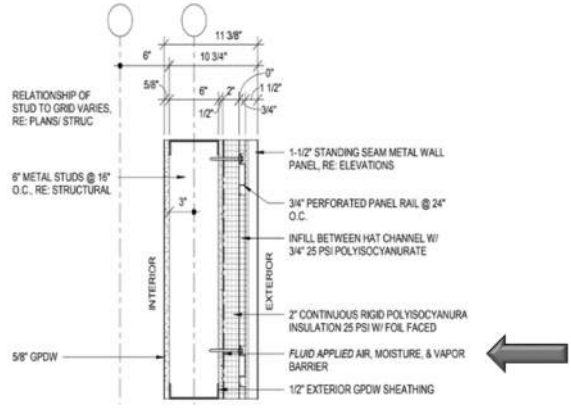
Stopping the movement of air from scrubbing away the stagnate air pocket  
**Now it works**



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### EXTERIOR WALL TYPES LEGEND



RELATIONSHIP OF STUD TO GRID VARIES, RE: PLANS/STRUC

8" METAL STUDS @ 16" O.C. RE: STRUCTURAL

1-1/2" STANDING SEAM METAL WALL PANEL, RE: ELEVATIONS

3/4" PERFORATED PANEL RAIL @ 24" O.C.

INFILL BETWEEN HAT CHANNEL W/ 3/4" 25 PSI POLYSOCYANURATE


2" CONTINUOUS RIGID POLYSOCYANURATE INSULATION 25 PSI W/ FOIL FACED

FLUID APPLIED AIR, MOISTURE, & VAPOR BARRIER

1/2" EXTERIOR GPDW SHEATHING

5/8" GPDW

**KEEP THIS IN MIND**



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### Air Barrier Definitions

**2012 IECC**

**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.

**2015 IECC**


**AIR BARRIER.** Materials 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.

**2018 IECC**

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

**2021 IECC**

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



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### 2021 IECC – Air Leakage

**C402.5 Air leakage—thermal envelope**


- Comply with Sections C402.5.1 through C402.5.11.1


OR

- Test in accordance with Section C402.5.2 or C402.5.3
- Where testing then also comply with Sections C402.5.7, C402.5.8 and C402.5.9



**Testing Approach**





<https://www.buildings.com/features/article/2023/01/air-leakage-testing-a-hot-button-or-hot-air>

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**C402.5** - Comply with Sections C402.5.1 through C402.5.11.1

*2021 Approach*

**C402.5.1 Air barriers.**  
 A continuous air barrier shall be provided throughout the building thermal envelope. The continuous air barriers shall be located on the inside or outside of the building thermal envelope, located within the assemblies composing the building thermal envelope, or any combination thereof. The air barrier shall 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.

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**C402.5** - Comply with C402.5.1 through C402.5.11.1

*Prescriptive Approach*

**C402.5.1.1 Air barrier construction.**  
 The continuous air barrier shall be constructed to comply with the following:

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

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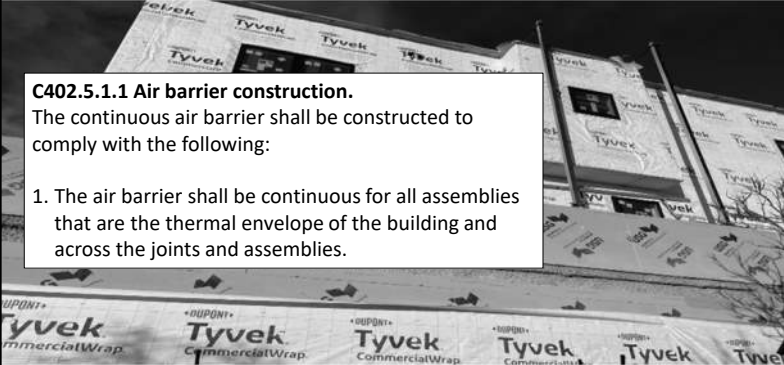

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**C402.5** - Comply with C402.5.1 through C402.5.11.1

*2021 Approach*

**C402.5.1.1 Air barrier construction.**  
 The continuous air barrier shall be constructed to comply with the following:

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

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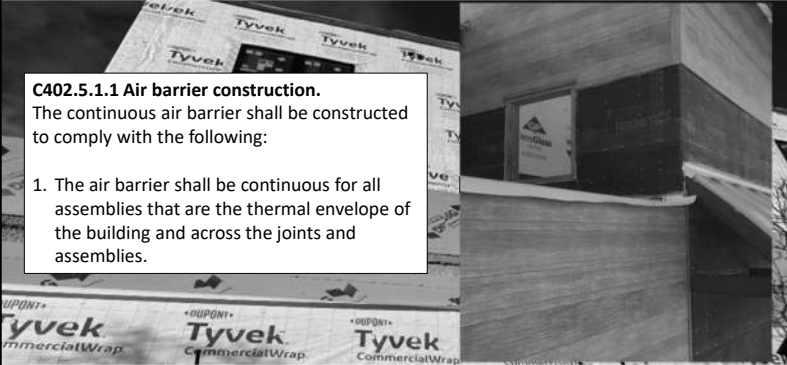

58

**C402.5** - Comply with C402.5.1 through C402.5.11.1

*2021 Approach*

**C402.5.1.1 Air barrier construction.**  
 The continuous air barrier shall be constructed to comply with the following:

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


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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

*2021 Approach*



**C402.5.1.1 Air barrier construction.**  
The continuous air barrier shall be constructed to comply with the following:

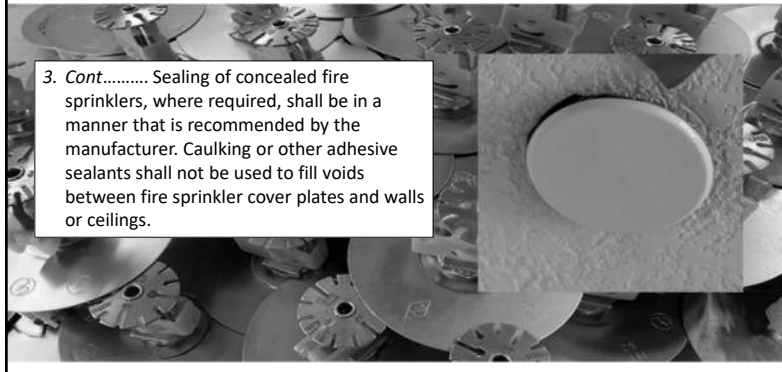
2. Air barrier joints and seams shall be sealed, including sealing transitions in places and changes in materials. The joints and seals shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair its ability to resist positive and negative pressure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




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**C402.5 - Comply with C402.5.1 through C402.5.11.1**



3. Cont..... Sealing of concealed fire sprinklers, where required, shall be in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.



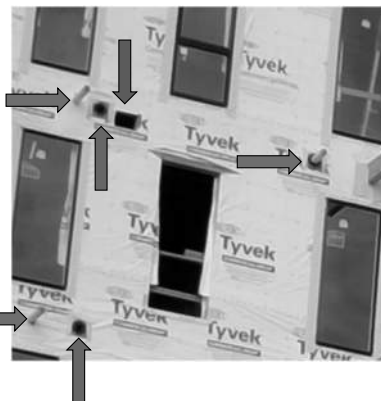

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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

**C402.5.1.1 Air barrier construction.**  
The continuous air barrier shall be constructed to comply with the following

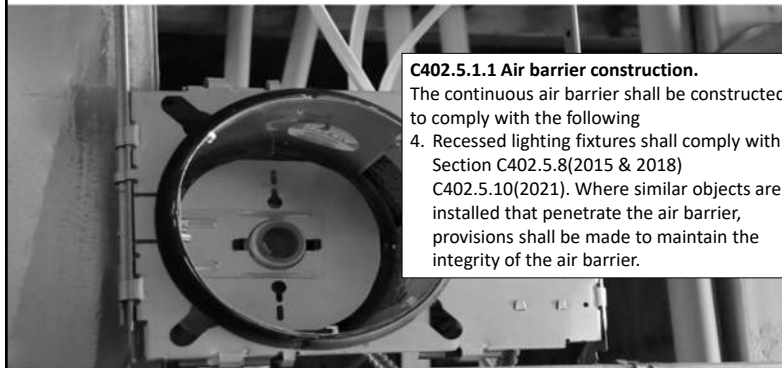
3. Penetrations of the air barrier shall be caulked, gasketed or otherwise sealed in a manner compatible with the construction materials and location. Sealing shall allow for expansion, contraction and mechanical vibration. Joints and seams associated with penetrations shall be sealed in the same manner or taped. Sealing materials shall be securely installed around the penetration so as not to dislodge, loosen or otherwise impair the penetrations' ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation.

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**C402.5 - Comply with C402.5.1 through C402.5.11.1**



**C402.5.1.1 Air barrier construction.**  
The continuous air barrier shall be constructed to comply with the following

4. Recessed lighting fixtures shall comply with Section C402.5.8(2015 & 2018) C402.5.10(2021). Where similar objects are installed that penetrate the air barrier, provisions shall be made to maintain the integrity of the air barrier.



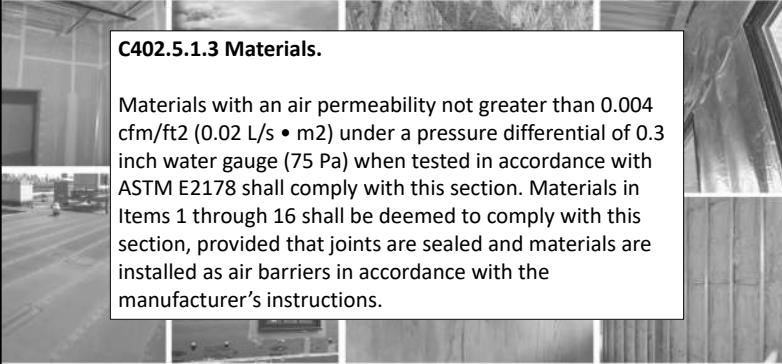

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**C402.5** - Comply with C402.5.1 through C402.5.11.1

**C402.5.1.3 Materials.**

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



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**C402.5** - Comply with C402.5.1 through C402.5.11.1

**C402.5.1.3 Materials.**

1. Plywood with a thickness of not less than 3/8 inch
2. Oriented strand board having a thickness of not less than 3/8 inch
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch

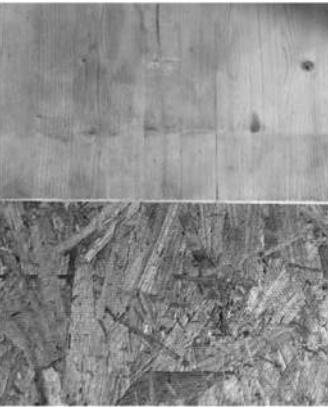

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**C402.5** - Comply with C402.5.1 through C402.5.11.1

**C402.5.1.3 Materials.**

1. Plywood with a thickness of not less than 3/8 inch
2. Oriented strand board having a thickness of not less than 3/8 inch



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**C402.5** - Comply with C402.5.1 through C402.5.11.1

**C402.5.1.3 Materials.**

1. Plywood with a thickness of not less than 3/8 inch
2. Oriented strand board having a thickness of not less than 3/8 inch
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch






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**C402.5.1.3 Materials.**

1. Plywood with a thickness of not less than 3/8 inch
2. Oriented strand board having a thickness of not less than 3/8 inch
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch
5. Closed-cell spray foam having a minimum density of 1.5 pcf (2.4 kg/m3) and having a thickness of not less than 1 1/2 inches






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**C402.5.1.3 Materials.**

1. Plywood with a thickness of not less than 3/8 inch
2. Oriented strand board having a thickness of not less than 3/8 inch
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch
5. Closed-cell spray foam having a minimum density of 1.5 pcf (2.4 kg/m3) and having a thickness of not less than 1 1/2 inches
6. Open-cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m3) and having a thickness of not less than 4.5 inches
7. Exterior or interior gypsum board having a thickness of not less than 1/2 inch
8. Cement board having a thickness of not less than 1/2 inch






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**C402.5.1.3 Materials.**

1. Plywood with a thickness of not less than 3/8 inch
2. Oriented strand board having a thickness of not less than 3/8 inch
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch
5. Closed-cell spray foam having a minimum density of 1.5 pcf (2.4 kg/m3) and having a thickness of not less than 1 1/2 inches
6. Open-cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m3) and having a thickness of not less than 4.5 inches






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**C402.5.1.3 Materials.**

1. Plywood with a thickness of not less than 3/8 inch
2. Oriented strand board having a thickness of not less than 3/8 inch
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch
5. Closed-cell spray foam having a minimum density of 1.5 pcf (2.4 kg/m3) and having a thickness of not less than 1 1/2 inches
6. Open-cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m3) and having a thickness of not less than 4.5 inches
7. Exterior or interior gypsum board having a thickness of not less than 1/2 inch
8. Cement board having a thickness of not less than 1/2 inch
9. Built-up roofing membrane
10. Modified bituminous roof membrane
11. Fully adhered single-ply roof membrane (2015/2018)
11. Single-ply roof membrane (2021)



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**C402.5.1.3 Materials.**

1. Plywood with a thickness of not less than 3/8 inch
2. Oriented strand board having a thickness of not less than 3/8 inch
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch
5. Closed-cell spray foam having a minimum density of 1.5 pcf (2.4 kg/m<sup>3</sup>) and having a thickness of not less than 1 1/2 inches
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
7. Exterior or interior gypsum board having a thickness of not less than 1/2 inch
8. Cement board having a thickness of not less than 1/2 inch
9. Built-up roofing membrane
10. Modified bituminous roof membrane
11. Single-ply membrane

**12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than 5/8 inch**

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**C402.5.1.3 Materials.**

1. Plywood with a thickness of not less than 3/8 inch
2. Oriented strand board having a thickness of not less than 3/8 inch
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch
5. Closed-cell spray foam having a minimum density of 1.5 pcf (2.4 kg/m<sup>3</sup>) and having a thickness of not less than 1 1/2 inches
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
7. Exterior or interior gypsum board having a thickness of not less than 1/2 inch
8. Cement board having a thickness of not less than 1/2 inch
9. Built-up roofing membrane
10. Modified bituminous roof membrane
11. Single-ply membrane
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than 5/8 inch
13. Cast-in-place and precast concrete

**14. Fully grouted concrete block masonry**

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**C402.5.1.3 Materials.**

1. Plywood with a thickness of not less than 3/8 inch
2. Oriented strand board having a thickness of not less than 3/8 inch
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch
5. Closed-cell spray foam having a minimum density of 1.5 pcf (2.4 kg/m<sup>3</sup>) and having a thickness of not less than 1 1/2 inches
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
7. Exterior or interior gypsum board having a thickness of not less than 1/2 inch
8. Cement board having a thickness of not less than 1/2 inch
9. Built-up roofing membrane
10. Modified bituminous roof membrane
11. Fully adhered single-ply roof membrane or Single-ply membrane
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than 5/8 inch

**13. Cast-in-place and precast concrete**

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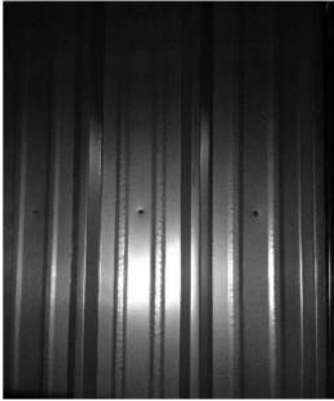

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**C402.5.1.3 Materials.**

1. Plywood with a thickness of not less than 3/8 inch
2. Oriented strand board having a thickness of not less than 3/8 inch
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch
5. Closed-cell spray foam having a minimum density of 1.5 pcf (2.4 kg/m<sup>3</sup>) and having a thickness of not less than 1 1/2 inches
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
7. Exterior or interior gypsum board having a thickness of not less than 1/2 inch
8. Cement board having a thickness of not less than 1/2 inch
9. Built-up roofing membrane
10. Modified bituminous roof membrane
11. Single-ply roof membrane
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than 5/8 inch
13. Cast-in-place and precast concrete
14. Fully grouted concrete block masonry

**15. Sheet steel or aluminum**

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### C402.5.1.3 Materials.

1. Plywood with a thickness of not less than 3/8 inch
2. Oriented strand board having a thickness of not less than 3/8 inch
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch
5. Closed-cell spray foam having a minimum density of 1.5 pcf (2.4 kg/m<sup>3</sup>) and having a thickness of not less than 1 1/2 inches
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
7. Exterior or interior gypsum board having a thickness of not less than 1/2 inch
8. Cement board having a thickness of not less than 1/2 inch
9. Built-up roofing membrane
10. Modified bituminous roof membrane
11. Single-ply roof membrane
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than 5/8 inch
13. Cast-in-place and precast concrete
14. Fully grouted concrete block masonry
15. Sheet steel or aluminum
16. Solid or hollow masonry constructed of clay or shale masonry units



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### C402.5 - Comply with C402.5.1 through C402.5.8(2015 & 2018) or C402.5.11.1(2021)

# WHAT MATERIALS ARE NOT LISTED?

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### C402.5 - Comply with C402.5.1 through C402.5.8(2015 & 2018) or C402.5.11.1(2021)

#### C402.5.1.4 Assemblies.

Assemblies of materials and components with an average air leakage not greater than 0.04 cfm/ under a pressure differential of 0.3 inch of water gauge (w.g.)(75 Pa) when tested in accordance with ASTM E2357, ASTM E1677, ASTM D8052 or ASTM E283 shall comply with this section. Assemblies listed in Items 1 through 3 shall be deemed to comply, provided that joints are sealed and the requirements of Section C402.5.1.1 are met.

1. Concrete masonry walls coated with either one application of block filler or two applications of a paint or sealer coating.
2. Masonry walls constructed of clay or shale masonry units with a nominal width of 4 inches or more.
3. A Portland cement/sand parge, stucco or plaster not less than 1/2 inch in thickness.




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### C402.5 - Comply with C402.5.1 through C402.5.11.1

**2021 Approach**



#### DensGlass® Sheathing

Product Comparison	1/2" (12.7 mm) DensGlass® Sheathing	5/8" (15.8 mm) DensGlass® Fireguard®
	Width nominal <sup>1</sup>	4' (1219 mm) ± 3/32" (2.4 mm)
Length standard <sup>2</sup>	8' 0" (2438 mm) ± 1/4" (6 mm)	8' 0" (2438 mm) ± 1/4" (6 mm)
Weight nominal lbs per sq ft (kg/m <sup>2</sup> )	13.5 lb	13.5 lb
Bending radius (minimum) <sup>3</sup>	8' (2438 mm) <sup>2</sup>	8' (2438 mm) <sup>2</sup>
Backing strength - 8x8 (lb/ft <sup>2</sup> )(N/m <sup>2</sup> ) (Minimum - not design value)	>600	>600
Tensile strength - parallel, 8x8 (lb/ft <sup>2</sup> )(N/m <sup>2</sup> ) (8 mesh direction)	>800 (300)	>1000 (400)
Compressive strength	min. 3000 psi (20688 kPa)	min. 3000 psi (20688 kPa)
Handled deflection <sup>4</sup>	±2.0" (51 mm)	±1.0" (25 mm)
Permeance, perm (imp/ft <sup>2</sup> )	<0.1 (2.9)	<0.1 (2.9)
R Value, R-Value (SI) (R-Value, °C/W)	0.08 (0.007)	0.1 (0.008)
Combustibility	Noncombustible	Noncombustible
Linear expansion with moisture change, inch/ft <sup>2</sup> (mm/m) (SI) (SI)	0.25 x 10 <sup>-4</sup>	0.25 x 10 <sup>-4</sup>
Surface burning characteristics per ASTM E84 or CAN/ULC S102	0/0	0/0
Flame spread/smoke developed	0/0	0/0
Coefficient of thermal expansion, inch/in (mm/m) <sup>5</sup>	6.5 x 10 <sup>-6</sup> (118.2 x 10 <sup>-6</sup> )	6.5 x 10 <sup>-6</sup> (118.2 x 10 <sup>-6</sup> )


**2021, 2018, & 2015 IECC Materials.**

Materials with an air permeability not greater than 0.004 cfm/ft<sup>2</sup> (0.02 L/s x m<sup>2</sup>) under a pressure differential of 0.3 inch water gauge (75 Pa) when tested in accordance with ASTM E2178 shall comply with this section.

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**C402.5 - Comply with C402.5.1 through C402.5.11.1**



**Water- and Air-Resistive Barriers**

Building codes, standards and programs are requiring the use of water and air resistive barriers. In most cases, these barriers are applied over the exterior sheathing. DensGlass® Sheathing has been widely accepted as a preferred substrate for all recognized types of water and air resistive barriers.

- Self-adhered sheet materials
- Fluid applied membranes
- Spray polyurethane foam (medium density closed cell)
- Mechanically attached flexible sheet (includes #15 asphalt felt and synthetic wraps)
- Boardstock air barrier – rigid foam core

For a list of air barrier materials, accessories and components, see the Air Barrier Association of America (ABAA) website ([www.aibarrier.org](http://www.aibarrier.org)).


Where joint protection is required or desired, two methods may be used. **Method 1)** Apply minimum 3/8" (9 mm) bead of sealant to joints and trowel to provide a layer approximately 2" (51 mm) wide by 1/16" (2 mm) thick spanning the joint. Use backer rod for openings larger than 1/8" (3 mm). **Method 2)** Apply glass mesh joint tape to all joints, overlapping at intersections by the width of the tape. Apply approximately 3/8" (9 mm) bead of caulk along the joint. Embed the caulk into the entire surface of the tape with a trowel. Use backer rod for openings larger than 1/8" (3 mm). Follow manufacturer's installation recommendations for use with DensGlass Sheathing, and design authority specifications.

**Protection of Penetrations**

All penetrations should be protected to prevent air and water infiltration. Follow building code, door/window manufacturer or design authority's recommendations for flashing around openings, abutments to dissimilar materials and wall terminations.

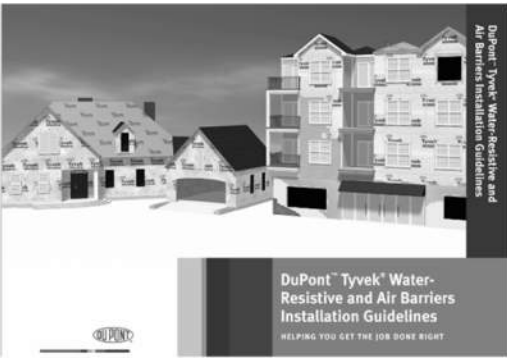
**Air Barrier Compliance**

For the International Energy Conservation Code® (IECC), gypsum sheathing, such as DensGlass Sheathing complies with the prescriptive code language for use as a continuous air barrier when the joints and openings are properly sealed.



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**C402.5.1.3 Materials.**

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

7. Exterior or interior gypsum board having a thickness of not less than 1/2 inch (12.7 mm).


When installed as they were tested



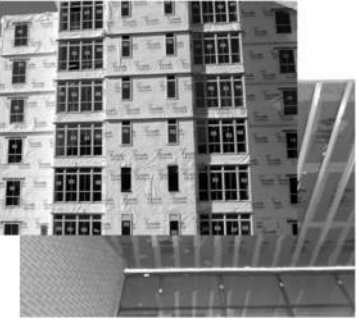

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**AIR BARRIER.** One or more materials joined together in a continuous manner to restrict or prevent the passage of air through the building thermal envelope and its assemblies



**WATER-RESISTIVE BARRIER.**  
A material behind an exterior wall covering that is intended to resist liquid water that has penetrated behind the exterior covering from further intruding into the exterior wall assembly.

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**Water-Resistive Barrier (WRB) Code Requirements**

The 2015 International Residential Code (Section R703.1.1 Water Resistance) requires that "the exterior wall envelope shall be designed and constructed in a manner that prevents the accumulation of water within the wall assembly by providing a water-resistant barrier behind the exterior veneer as required by Section R703.2 and a means of draining to the exterior water that enters the assembly." Section R703.2 (Water-resistive barrier) states that "one layer of No. 15 asphalt felt, free from holes and breaks, complying with ASTM D 226 for Type 1 felt or other approved water-resistive barrier shall be applied over studs or sheathing of all exterior walls. Such felt or material shall be applied horizontally, with the upper layer lapped over the lower layer not less than 2 inches (51 mm). Where joints occur, felt shall be lapped not less than 6 inches (152 mm). The felt or other approved material shall be continuous to the top of walls and terminated at penetrations and building appendages in a manner to meet the requirements of the exterior wall envelope as described in Section R703.1."

The 2015 International Building Code (Section 1403.2 Weather Protection) requires that "exterior walls shall provide the building with a weather resistant exterior wall envelope. The exterior wall envelope shall include flashing, as described in Section 1405.4. The exterior wall envelope shall be designed and constructed in such a manner as to prevent the accumulation of water within the wall assembly by providing a water-resistive barrier behind the exterior veneer, as described in Section 1404.2, and a means for draining water that enters the assembly to the exterior. Section 1404.2 (Water-resistive barrier) states that "not fewer than one layer of No. 15 asphalt felt, complying with ASTM D 226 for Type 1 felt or other approved materials, shall be attached to the studs or sheathing, with flashing as described in Section 1405.4, in such a manner as to provide a continuous water-resistive barrier behind the exterior veneer."

- DuPont™ Tyvek® IntactWrap®
- DuPont™ Tyvek® DrainWrap™
- DuPont™ Tyvek® CommercialWrap®
- DuPont™ Tyvek® CommercialWrap® D
- ICC-ESR-1993: DuPont™ Tyvek® ThermalWrap™ LE
- And Industry Standard ASTM E 2556 Type II Standard Specification for Vapor Permeable Flexible Sheet Water-Resistive Barriers Intended for Mechanical Attachment

Air leakage control and air barriers are required in the IECC-2015 Sections R402.4 and C402.4. Specifically, Section C402.5 identifies three compliance options for air barriers. DuPont™ Tyvek® WRBs comply with the option detailed in Section C402.5.1.2.1 "C402.5.1.2.1 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 (75 Pa) when tested in accordance with ASTM E 2178 shall comply with this section." Tyvek® WRBs have been tested in accordance with ASTM E2178 and have an air permeability less than 0.02 L/s × m<sup>2</sup>.


DuPont™ Tyvek® WRBs have been tested to the following standards:

- ASTM E 1677 Standard Specification for an Air Retarder (AR) Material or System for Low-Rise Framed Building Walls
- ASTM E 2178 Standard Test Method for Air Permeance of Building Materials
- ASTM E96-05 Water Vapor Transmission
- ATCC 127 Water Penetration Resistance
- ASTM E 84 Standard Test Method for Surface Burning Characteristics of Building Materials

The application of DuPont™ Tyvek® WRBs is governed by the code adopted and enforced by the local jurisdiction. Consult your jurisdiction to assure compliance with the local building code.

When installed as they were tested

when tested in accordance with ASTM E2357, ASTM E1677, ASTM D8052 or ASTM E283



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Air leakage control and air barriers are required in the IECC-2015 Sections R402.4 and C402.4. Specifically, Section C402.5 identifies three compliance options for air barriers. DuPont™ Tyvek® WRBs comply with the option detailed in Section C402.5.1.2.1: "C402.5.1.2.1 Materials. Materials with an air permeability no greater than 0.004 cfm/ft<sup>2</sup> (0.02 L/s x m<sup>2</sup>) under a pressure differential of 0.3 inches water gauge (75 Pa) when tested in accordance with ASTM E 2178 shall comply with this section." Tyvek® WRBs have been tested in accordance with ASTM E2178 and have air permeability less than 0.02 L/s x m<sup>2</sup>.

DuPont™ Tyvek® WRBs have been tested to the following standards:

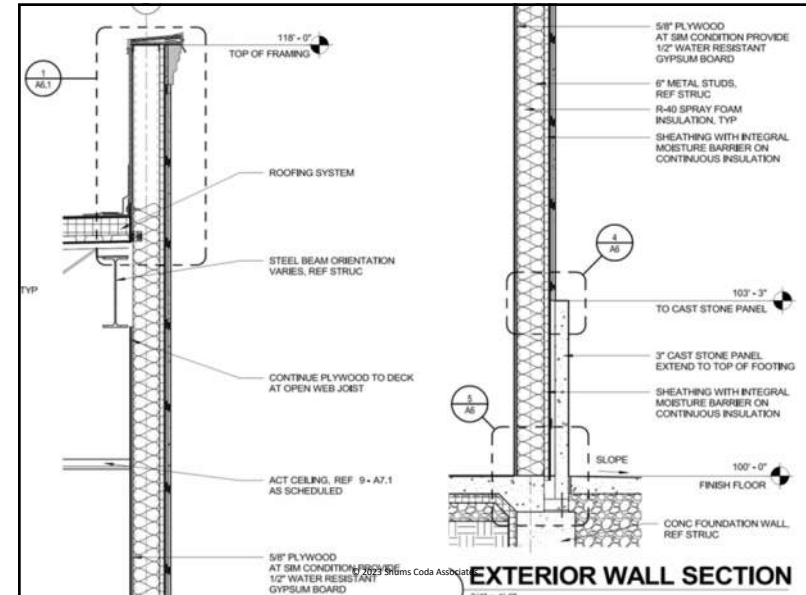
- ASTM E 1677 Standard Specification for an Air Retarder (AR) Material or System for Low-Rise Framed Building Walls.
- ASTM E 2178 Standard Test Method for Air Permeance of Building Materials
- ASTM E96-05 Water Vapor Transmission
- ATCC 127 Water Penetration Resistance
- ASTM E 84 Standard Test Method for Surface Burning Characteristics of Building Materials

When installed as they were tested

when tested in accordance with ASTM E2357, ASTM E1677, ASTM D8052 or ASTM E283



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**STEP 7 (FOR AIR BARRIER INSTALLATIONS)**


When installing as an air barrier, the horizontal seams must be taped. The use of 3" Tyvek® Tape is required for both vertical and horizontal seams of Tyvek® StuccoWrap® and Tyvek® DrainWrap® for air barrier installations.

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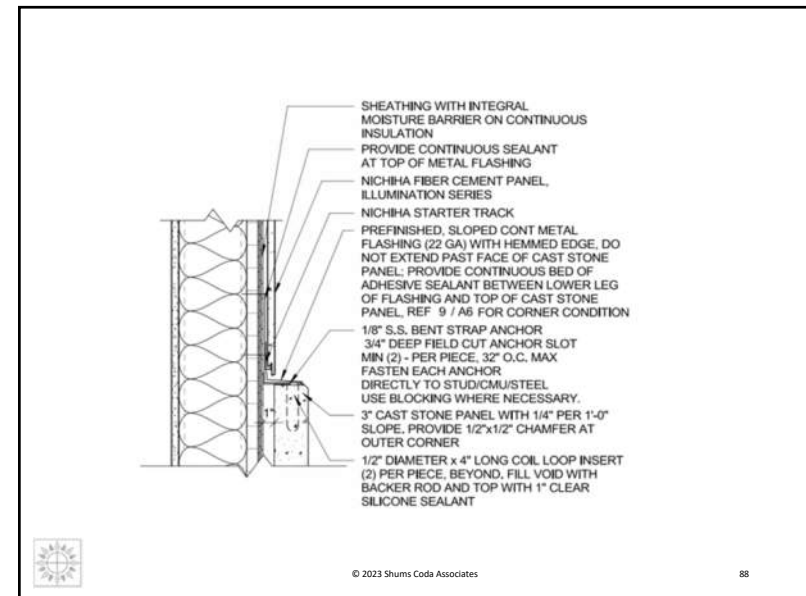
**STEP 8 (FOR AIR BARRIER INSTALLATIONS)**

Taping or sealing all terminations of Tyvek® WRBs (including, but not limited to, roof-wall and bottom of the wall interfaces) using Tyvek® Tape, DuPont™ Residential Sealant (or recommended sealant), DuPont™ StraightFlash™, or DuPont™ Flashing Tape is required when installing as an air barrier.\*

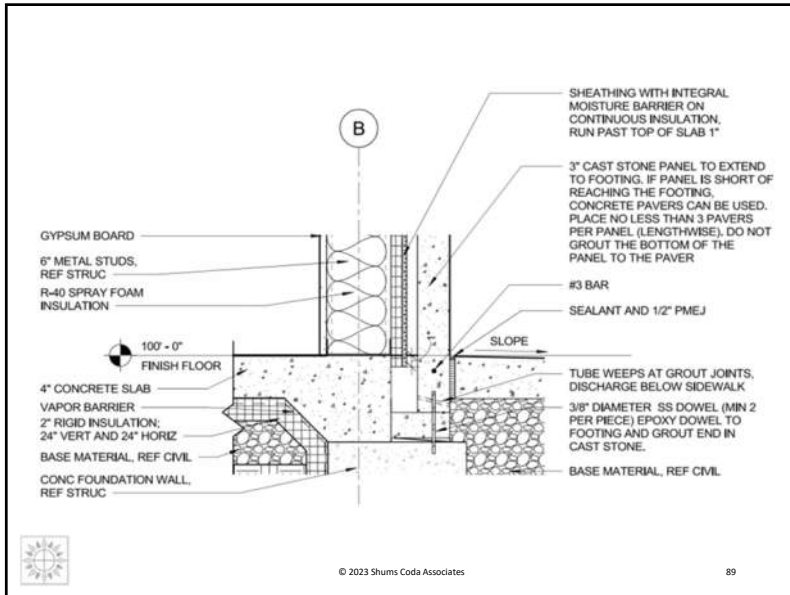
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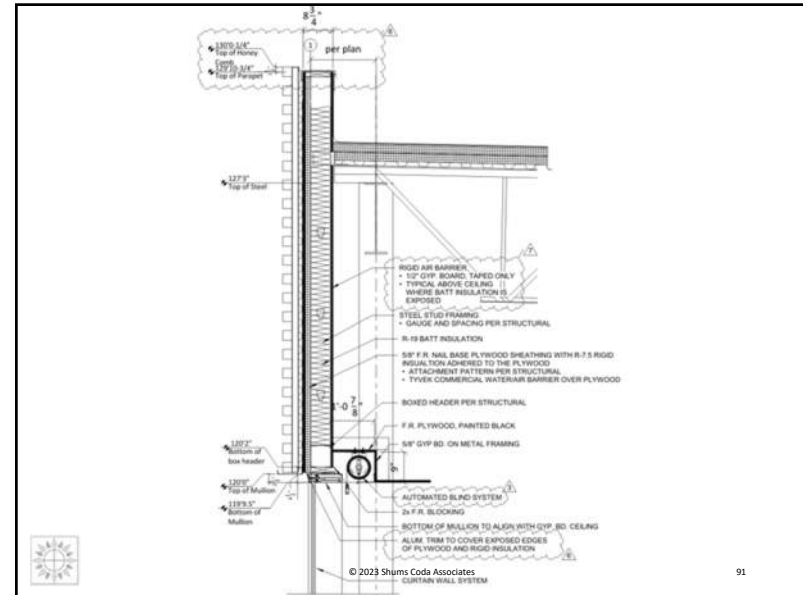
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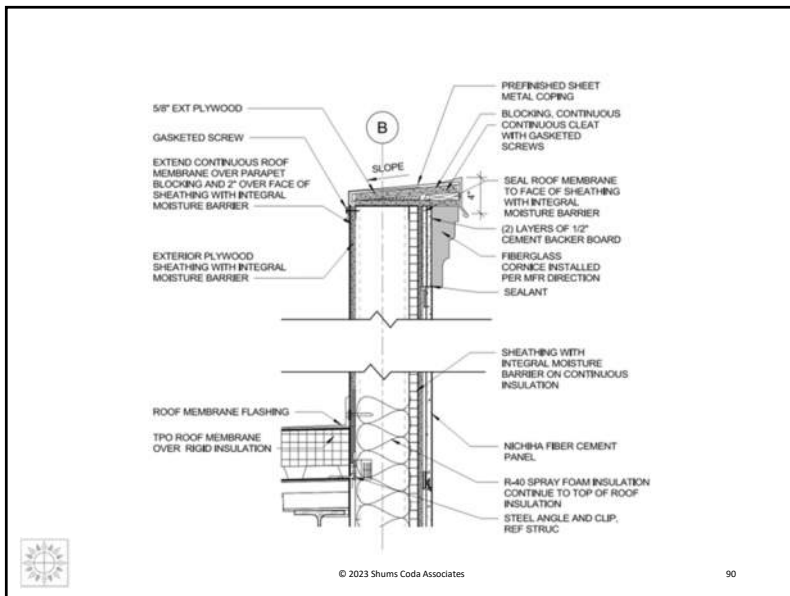
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Foam as an air sealant?



Material	Thickness (minimum)
Plywood	3/8 in.
Oriented strand board	3/8 in.
Extruded polystyrene insulation board	1/2 in.
Foil-faced urethane insulation board	1/2 in.
Closed cell spray foam minimum density of 1.5 pcf	1-1/2 in.
Open cell spray foam density between 0.4 and 1.5 pcf	4.5 in.
Exterior gypsum sheathing or interior gypsum board	1/2 in.
Cement board	1/2 in.
Built up roofing membrane	
Modified bituminous roof membrane	
Fully adhered single-ply roof membrane	
A Portland cement/sand parge, stucco, or gypsum plaster	5/8 in.
Cast-in-place and precast concrete	
Sheet metal or aluminum	
Solid or hollow masonry constructed of clay or shale masonry units	

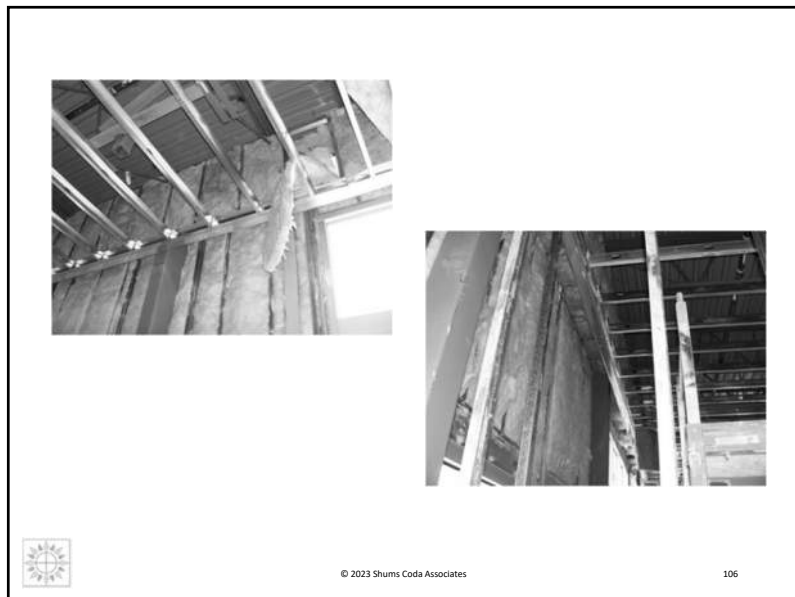


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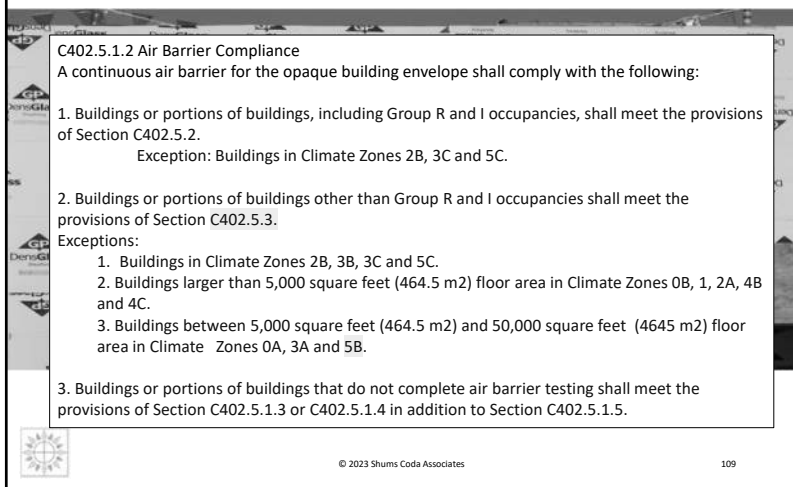


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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

**C402.5.1.2 Air Barrier Compliance**  
 A continuous air barrier for the opaque building envelope shall comply with the following:

- Buildings or portions of buildings, including Group R and I occupancies, shall meet the provisions of Section C402.5.2.  
 Exception: Buildings in Climate Zones 2B, 3C and 5C.
- Buildings or portions of buildings other than Group R and I occupancies shall meet the provisions of Section C402.5.3.  
 Exceptions:
  - Buildings in Climate Zones 2B, 3B, 3C and 5C.
  - Buildings larger than 5,000 square feet (464.5 m<sup>2</sup>) floor area in Climate Zones 0B, 1, 2A, 4B and 4C.
  - Buildings between 5,000 square feet (464.5 m<sup>2</sup>) and 50,000 square feet (4645 m<sup>2</sup>) floor area in Climate Zones 0A, 3A and 5B.
- Buildings or portions of buildings that do not complete air barrier testing shall meet the provisions of Section C402.5.1.3 or C402.5.1.4 in addition to Section C402.5.1.5.



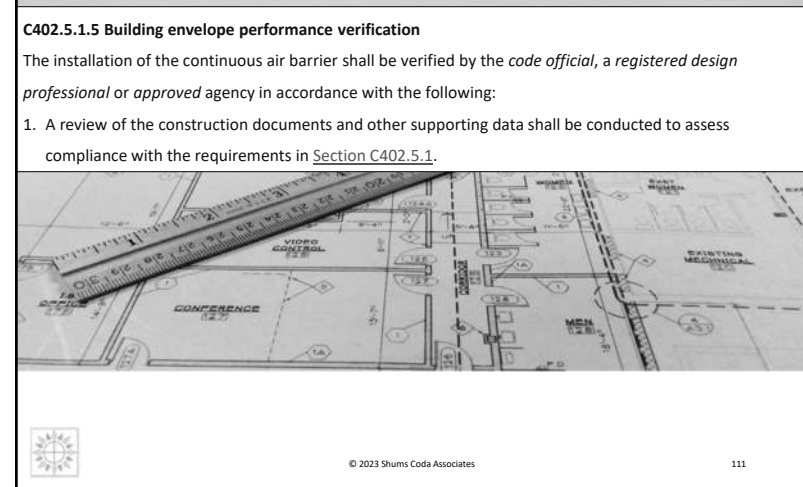
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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

**C402.5.1.5 Building envelope performance verification**  
 The installation of the continuous air barrier shall be verified by the *code official*, a *registered design professional* or *approved agency* in accordance with the following:

- A review of the construction documents and other supporting data shall be conducted to assess compliance with the requirements in [Section C402.5.1](#).




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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

*2021 Approach*

**C402.5.1.5 Building envelope performance verification.**  
 The installation of the continuous air barrier shall be verified by the *code official*, a *registered design professional* or *approved agency* in accordance with the following:



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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

**C402.5.1.5 Building envelope performance verification**

- Inspection of continuous air barrier components and assemblies shall be conducted during construction while the air barrier is still accessible for inspection and repair to verify compliance with the requirements of [Sections C402.5.1.3](#) and [C402.5.1.4](#).

↑ **Materials**      **Assemblies**




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**C402.5** - Comply with C402.5.1 through C402.5.11.1

*2021 Approach*



**C402.5.1.5 Building envelope performance verification.**



3. A final commissioning report shall be provided for inspections completed by the *registered design professional* or *approved agency*. The commissioning report shall be provided to the building owner or owner's authorized agent and the *code official*. The report shall identify deficiencies found during the review of the construction documents and inspection and details of corrective measures taken. © 2023 Shums Coda Associates 113

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**C402.5** - Comply with C402.5.1 through C402.5.11.1

**C402.5.1.2 Air Barrier Compliance**  
 A continuous air barrier for the opaque building envelope shall comply with the following:


1. Buildings or portions of buildings, including Group R and I occupancies, shall meet the provisions of Section [C402.5.2](#).  
 Exception: Buildings in Climate Zones 2B, 3C and 5C.

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**C402.5** - Comply with C402.5.1 through C402.5.11.1



**C402.5.1.5 Building envelope performance verification.**

The installation of the continuous air barrier shall be verified by the *code official*, a *registered design professional* or *approved agency* in accordance with the following:

1. A review of the construction documents and other supporting data shall be conducted to assess compliance with the requirements in [Section C402.5.1](#).
2. Inspection of continuous air barrier components and assemblies shall be conducted during construction while the air barrier is still accessible for inspection and repair to verify compliance with the requirements of [Sections C402.5.1.3](#) and [C402.5.1.4](#).
3. A final commissioning report shall be provided for inspections completed by the *registered design professional* or *approved agency*. The commissioning report shall be provided to the building owner or owner's authorized agent and the *code official*. The report shall identify deficiencies found during the review of the construction documents and inspection and details of corrective measures taken. © 2023 Shums Coda Associates 114

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**C402.5** - Comply with C402.5.1 through C402.5.11.1

**C402.5.2 Dwelling and sleeping unit enclosure testing.**

The *building thermal envelope* shall be tested in accordance with [ASTM E779](#), [ANSI/RESNET/ICC 380](#), [ASTM E1827](#) or an equivalent method approved by the *code official*. The measured air leakage shall not exceed 0.30 cfm/ft<sup>2</sup> of the testing unit enclosure area at a pressure differential of 0.2 inch water gauge (50 Pa). Where multiple dwelling units or sleeping units or other occupiable conditioned spaces are contained within one *building thermal envelope*, each unit shall be considered an individual testing unit, and the building air leakage shall be the weighted average of all testing unit results, weighted by each testing unit's enclosure area. Units shall be tested separately with an unguarded blower door test as follows:

1. Where buildings have fewer than eight testing units, each testing unit shall be tested.
2. For buildings with eight or more testing units, the greater of seven units or 20 percent of the testing units in the building shall be tested, including a top floor unit, a ground floor unit and a unit with the largest testing unit enclosure area. For each tested unit that exceeds the maximum air leakage rate, an additional two units shall be tested, including a mixture of testing unit types and locations. © 2023 Shums Coda Associates 116

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**C402.5 - Comply with C402.5.1 through C402.5.11.1**


**C402.5.2 Dwelling and sleeping unit enclosure testing.**  
 The *building thermal envelope* shall be tested in accordance with [ASTM E779](#), [ANSI/RESNET/ICC 380](#), [ASTM E1827](#) or an equivalent method approved by the *code official*. The measured air leakage shall not exceed **0.30 cfm/ft<sup>2</sup>** (1.5 L/s m<sup>2</sup>) of the testing unit enclosure area at a pressure differential of 0.2 inch water gauge (**50 Pa**).

**R402.4.1.2 Testing (RESIDENTIAL AIR TESTING REQUIREMENTS- not the full sections)**

**Exception:** When testing individual *dwelling units*, an air leakage rate not exceeding **0.30** cubic feet per minute per square foot [0.008 m<sup>3</sup>/(s × m<sup>2</sup>)] of the dwelling unit enclosure area, tested in accordance with [ANSI/RESNET/ICC 380](#), [ASTM E779](#) or [ASTM E1827](#) and reported at a pressure of 0.2 inch w.g. (**50 Pa**), shall be permitted in all climate zones for:

1. Attached single and multiple-family building *dwelling units*.
2. Buildings or *dwelling units* that are 1,500 square feet (139.4 m<sup>2</sup>) or smaller.

**.30 cfm/ft<sup>2</sup> is equal to about 5 ach**



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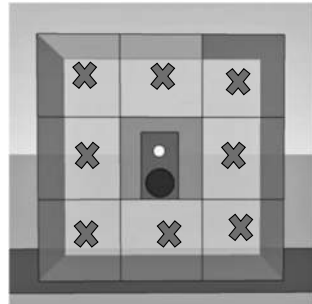
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**C402.5 - Comply with C402.5.1 through C402.5.11.1**


**Unguarded Blower Door Test**

Single point measures dwelling unit air leakage using single blower door fan.

One at a time



<https://www.greenbuildingadvisor.com/article/testing-air-leakage-in-multifamily-buildings>




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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

**C402.5.2 Dwelling and sleeping unit enclosure testing.**  
 The *building thermal envelope* shall be tested in accordance with [ASTM E779](#), [ANSI/RESNET/ICC 380](#), [ASTM E1827](#) or an equivalent method approved by the *code official*. The measured air leakage shall not exceed **0.30 cfm/ft<sup>2</sup>** (1.5 L/s m<sup>2</sup>) of the testing unit enclosure area at a pressure differential of 0.2 inch water gauge (**50 Pa**).

Where multiple dwelling units or sleeping units or other occupiable conditioned spaces are contained within one *building thermal envelope*, each unit shall be considered an individual testing unit, and the building air leakage shall be the weighted average of all testing unit results, weighted by each testing unit's enclosure area. Units shall be tested separately with an **unguarded** blower door test as follows:



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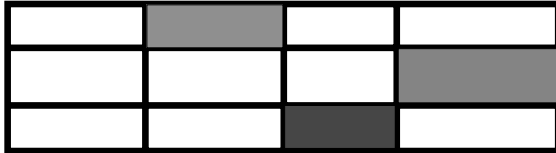

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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

**C402.5.2 Dwelling and sleeping unit enclosure testing.**  
 Units shall be tested separately with an unguarded blower door test as follows:

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

**7 units – or 20%**

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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

**C402.5.3 Building thermal envelope testing.**  
 The *building thermal envelope* shall be tested in accordance with ASTM E779, ANSI/RESNET/ICC 380, ASTM E3158 or ASTM E1827 or an equivalent method approved by the code official. The measured air leakage shall not exceed 0.40 cfm/ft<sup>2</sup> (2.0 L/s × m<sup>2</sup>) of the *building thermal envelope* area at a pressure differential of 0.3 inch water gauge (75 Pa). Alternatively, portions of the building shall be tested and the measured air leakages shall be area weighted by the surface areas of the building envelope in each portion. The weighted average test results shall not exceed the whole building leakage limit. In the alternative approach, the following portions of the building shall be tested:

1. The entire envelope area of all stories that have any spaces directly under a roof.
2. The entire envelope area of all stories that have a building entrance, exposed floor, or loading dock, or are below grade.
3. Representative above-grade sections of the building totaling at least 25 percent of the wall area enclosing the remaining conditioned space.

**Exception:** Where the measured air leakage rate exceeds 0.40 cfm/ft<sup>2</sup> (2.0 L/s × m<sup>2</sup>) but does not exceed 0.60 cfm/ft<sup>2</sup> (3.0 L/s × m<sup>2</sup>), a diagnostic evaluation using smoke tracer or infrared imaging shall be conducted while the building is pressurized along with a visual inspection of the air barrier. Any leaks noted shall be sealed where such sealing can be made without destruction of existing building components. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the code official and the building owner, and shall be deemed to comply with the requirements of this section.



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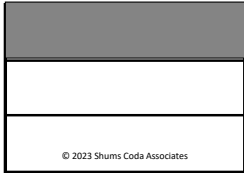

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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

**C402.5.3 Building thermal envelope testing.**

Alternatively, portions of the building shall be tested and the measured air leakages shall be area weighted by the surface areas of the building envelope in each portion. The weighted average test results shall not exceed the whole building leakage limit. In the alternative approach, the following portions of the building shall be tested:

- ➡ 1. The entire envelope area of all stories that have any spaces directly under a roof.
2. The entire envelope area of all stories that have a building entrance, exposed floor, or loading dock, or are below grade.
3. Representative above-grade sections of the building totaling at least 25 percent of the wall area enclosing the remaining conditioned space.


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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

**C402.5.3 Building thermal envelope testing**

The *building thermal envelope* shall be tested in accordance with ASTM E779, ANSI/RESNET/ICC 380, ASTM E3158 or ASTM E1827, or an equivalent method approved by the code official. The measured air leakage shall not exceed 0.40 cfm/ft<sup>2</sup> (2.0 L/s × m<sup>2</sup>) of the *building thermal envelope* area at a pressure differential of 0.3 inch water gauge (75 Pa).



<https://www.familyhandyman.com/list/what-is-a-blower-door-test/>



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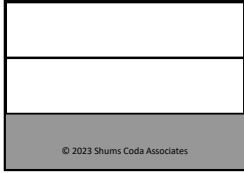

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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

**C402.5.3 Building thermal envelope testing.** *2021 Approach*

Alternatively, portions of the building shall be tested and the measured air leakages shall be area weighted by the surface areas of the building envelope in each portion. The weighted average test results shall not exceed the whole building leakage limit. In the alternative approach, the following portions of the building shall be tested:

1. The entire envelope area of all stories that have any spaces directly under a roof.
- ➡ 2. The entire envelope area of all stories that have a building entrance, exposed floor, or loading dock, or are below grade.
3. Representative above-grade sections of the building totaling at least 25 percent of the wall area enclosing the remaining conditioned space.

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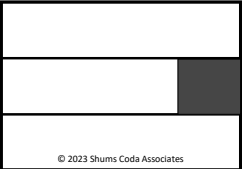
124

**C402.5** - Comply with C402.5.1 through C402.5.11.1

**C402.5.3 Building thermal envelope testing.** *2021 Approach*

Alternatively, portions of the building shall be tested and the measured air leakages shall be area weighted by the surface areas of the building envelope in each portion. The weighted average test results shall not exceed the whole building leakage limit. In the alternative approach, the following portions of the building shall be tested:


1. The entire envelope area of all stories that have any spaces directly under a roof.
2. The entire envelope area of all stories that have a building entrance, exposed floor, or loading dock, or are below grade.
- ➔ 3. Representative above-grade sections of the building totaling at least 25 percent of the wall area enclosing the remaining conditioned space.



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**C402.5** - Comply with C402.5.1 through C402.5.11.1



Sections that support the physical air barrier material for the assembly


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**C402.5** - Comply with C402.5.1 through C402.5.11.1

**C402.5.3 Building thermal envelope testing** *2021 Approach*


**Exception:** Where the measured air leakage rate exceeds 0.40 cfm/ft<sup>2</sup> but does not exceed 0.60 cfm/ft<sup>2</sup>, a diagnostic evaluation using smoke tracer or infrared imaging shall be conducted while the building is pressurized along with a visual inspection of the air barrier. Any leaks noted shall be sealed where such sealing can be made without destruction of existing building components. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the code official and the building owner, and shall be deemed to comply with the requirements of this section.



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**C402.5** - Comply with C402.5.1 through C402.5.11.1

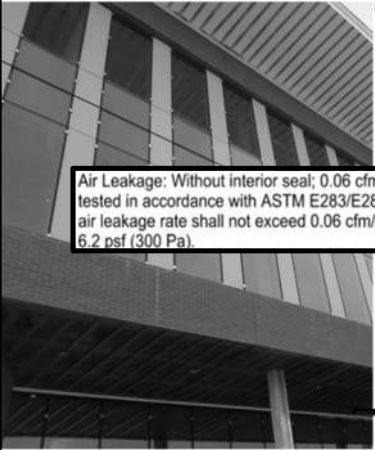


FENESTRATION ASSEMBLY	MAXIMUM RATE (CFM/FT <sup>2</sup> )	TEST PROCEDURE	FENESTRATION ASSEMBLY	MAXIMUM RATE (CFM/FT <sup>2</sup> )	TEST PROCEDURE
Windows	0.20 <sup>a</sup>	AAMA/WDMA/CSA101/LS 2/A440 or NFRC 400	Windows	0.20 <sup>a</sup>	AAMA/WDMA/CSA101/LS 2/A440 or NFRC 400
Sliding doors	0.20 <sup>a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

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**C402.5 - Comply with C402.5.1 through C402.5.11.1**



**2.03 ALUMINUM-FRAMED STOREFRONT**

A. Aluminum-Framed Storefront: Factory fabricated aluminum framing members with anfil, and raised flashings, anchorage and attachment devices.

1. Glazing Rabbit: For 1 inch insulating glazing.
2. Vertical Mullion Dimensions: 2 inches wide by 4-1/2 inches deep.
3. Finish: The design intent is to match existing aluminum storefront finish.
  - a. Factory finish all surfaces that will be exposed in completed assemblies.
  - b. Coat concealed metal surfaces that will be in contact with cementitious materials or dissimilar metals with titanium paint.
4. Finish Color: As selected by Architect from manufacturer's standard line.
5. Fabrication: Joints and corners flush, hairline, and weatherproof, accurately fitted and secured, prepared to receive anchors and hardware, fasteners and attachments concealed from view; reinforced as required for exposed loads.
6. Construction: Eliminate noises caused by wind and thermal movement, prevent vibration

**Air Leakage:** Without interior seal; 0.06 cfm/sq ft maximum leakage of storefront wall area when tested in accordance with ASTM E283/E283M at 1.6 psf pressure difference. With interior seal, air leakage rate shall not exceed 0.06 cfm/ft<sup>2</sup> (0.3 l/s · m<sup>2</sup>) at a static air pressure differential of 6.2 psf (300 Pa).

10. Perimeter Clearance: Minimize space between framing members and adjacent construction while allowing expected movement.

11. Maintain continuous air barrier and/or vapor retarder seal throughout assembly, primarily in line with inside pane of glazing and inner sheet of infill panel, and heel bead of glazing compound.

B. Performance Requirements:

1. Wind Loads: Design and size components to withstand the specified load requirements without damage or permanent set, when tested in accordance with ASTM E330/E330M, using loads 1.5 times the design wind loads and 10 second duration of maximum load.
  - a. Design Wind Loads: Comply with requirements of ASCE 7.
  - b. Member Deflection: Limit member deflection to 1/175 in any direction, with full recovery of glazing materials.
2. Water Penetration Resistance on Manufactured Assembly: No uncontrolled water on interior face, when tested in accordance with ASTM E331 at pressure differential of 10 psf.
 

**Air Leakage:** Without interior seal; 0.06 cfm/sq ft maximum leakage of storefront wall area when tested in accordance with ASTM E283/E283M at 1.6 psf pressure difference. With interior seal, air leakage rate shall not exceed 0.06 cfm/ft<sup>2</sup> (0.3 l/s · m<sup>2</sup>) at a static air pressure differential of 6.2 psf (300 Pa).

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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

**C402.5.4(2018 IECC) C402.5.6(2021 IECC)**  
**Doors and access openings to shafts, chutes, stairways and elevator lobbies.**

Doors and access openings from conditioned space to shafts, chutes stairways and elevator lobbies not within the scope of the fenestration assemblies covered by Section C402.5.4 shall be gasketed, weather-stripped or sealed.

**Exceptions:**

1. Door openings required to comply with Section 716 of the *International Building Code*.
2. Doors and door openings required to comply with UL 1784 by the *International Building Code*.



2021 Approach

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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

**C402.5.5 Rooms containing fuel-burning appliances.**

In *Climate Zones* 3 through 8, where combustion air is supplied through openings in an exterior wall to a room or space containing a space-conditioning fuel-burning appliance, one of the following shall apply:

1. The room or space containing the appliance shall be located outside of the *building thermal envelope*.
2. The room or space containing the appliance shall be enclosed and isolated from conditioned spaces inside the *building thermal envelope*. Such rooms shall comply with all of the following:
  - 2.1. The walls, floors and ceilings that separate the enclosed room or space from conditioned spaces shall be insulated to be not less than equivalent to the insulation requirement of below-grade walls as specified in Table C402.1.3 or Table C402.1.4.
  - 2.2. The walls, floors and ceilings that separate the enclosed room or space from conditioned spaces shall be sealed in accordance with Section C402.5.1.1.
  - 2.3. The doors into the enclosed room or space shall be fully gasketed.
  - 2.4. Water lines and ducts in the enclosed room or space shall be insulated in accordance with Section C403.
  - 2.5. Where an air duct supplying combustion air to the enclosed room or space passes through *conditioned space*, the duct shall be insulated to an *R*-value of not less than R-8.

**Exception:**

1. Direct vent appliances with both intake and exhaust pipes installed continuous to the outside.
2. Fireplaces and stoves complying with Section R402.4.2 and Section R1006 of the *International Residential Code*

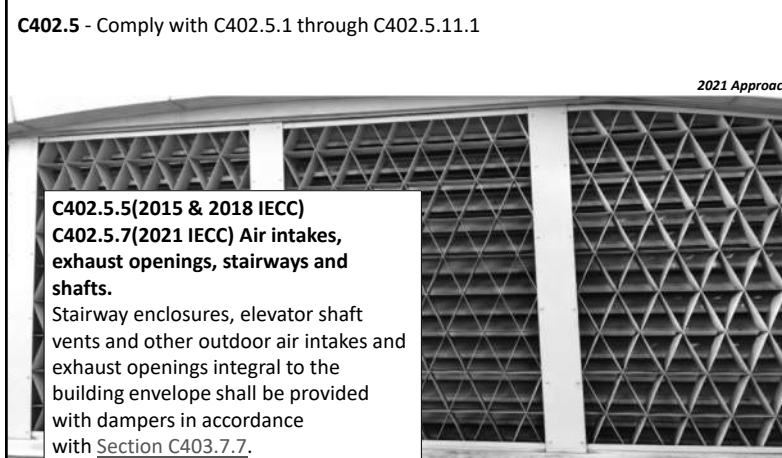
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**C402.5 - Comply with C402.5.1 through C402.5.11.1**

**C402.5.5(2015 & 2018 IECC) C402.5.7(2021 IECC)**  
**Air intakes, exhaust openings, stairways and shafts.**

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



2021 Approach

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**C402.5 - Comply with C402.5.1 through C402.5.8(2015 & 2018) or C402.5.11.1(2021)**

*2021 Approach*

**C402.5.6(2015 & 2018 IECC)C402.5.8(2021 IECC) Loading dock weather seals.**  
Cargo door openings and loading door openings shall be equipped with weather seals that restrict infiltration and provide direct contact along the top and sides of vehicles that are parked in the doorway.

2015 IECC Difference of section – didn't include in the information about direct contact along top and sides, but contains this requirement

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**C402.5 - Comply with C402.5.1 through C402.5.8(2015 & 2018) or C402.5.11.1(2021)**

*2021 Approach*

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**DOOR SCHEDULE**

Door Name	Number	Type	Dimensions	Door Material	Door Frame	Frame Material	Glazing	Hardware	Manufacturer	Notes
100AA	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100BB	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100CC	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100EE	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100G	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100I	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100J	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100K	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100L	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100M	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100N	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100O	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100P	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100Q	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100R	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100S	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100T	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100U	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100V	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100X	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100Y	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	
100Z	1	17'-0" x 7'-0"	17'-0" x 7'-0"	STEEL	STEEL	STEEL	None	1	OT	

**SECTION 083323 - OVERHEAD COILING DOORS**

1 Hardware Door manufacturer OT

**A. Weatherseals for Exterior Doors:** Equip each exterior door with weather-stripping gaskets fitted to entire perimeter of door for a weathertight installation, unless otherwise indicated.

- At door head, use 1/8 in (3 mm) thick, replaceable, continuous sheet secured to inside of hood.
- At door jambs, use replaceable, adjustable, continuous, flexible, 1/8 in (3 mm) thick seals of flexible vinyl, rubber, or neoprene. ←

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**C402.5 - Comply with C402.5.1 through C402.5.8(2015 & 2018) or C402.5.11.1(2021)**

*2021 Approach*


**C402.5.7(2015 & 2018 IECC) C402.5.9(2021 IECC) 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.

All building entrances  
All doors in vestibule must have self-closing devices  
Interior and exterior not open at the same time  
Revolving doors do not exclude vestibule requirement for doors adjacent to revolving doors

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**C402.5** - Comply with C402.5.1 through C402.5.8(2015 & 2018) or C402.5.11.1(2021)



**C402.5.7(2015 & 2018 IECC) C402.5.9(2021 IECC)**  
**Exceptions:**


1. Buildings in Climate Zones 0 through 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 m<sup>2</sup>) 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.

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**C402.5** - Comply with C402.5.1 through C402.5.8(2015 & 2018) or C402.5.11.1(2021)

**2021 Approach**

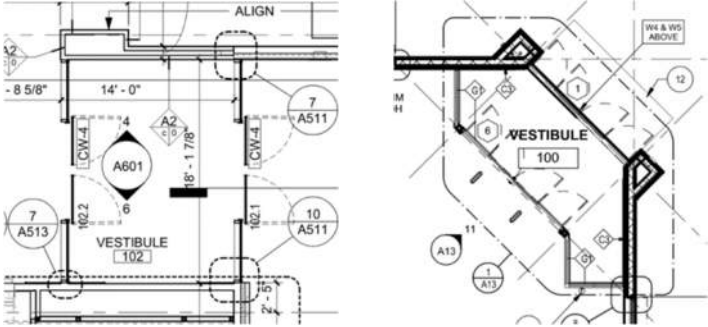


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**C402.5** - Comply with C402.5.1 through C402.5.8(2015 & 2018) or C402.5.11.1(2021)

**2021 Approach**



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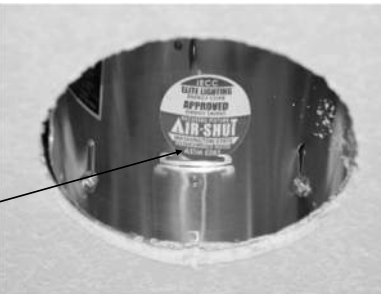
**C402.5** - Comply with C402.5.1 through C402.5.8(2015 & 2018) or C402.5.11.1(2021)

**2021 Approach**

**C402.5.8(2015 & 2018)**  
**C402.5.10(2021 IECC) Recessed lighting.**

Recessed luminaires installed in the *building thermal envelope* shall be all of the following:


1. IC-rated.
2. Labeled as having an air leakage rate of not more 2.0 cfm when tested in accordance with ASTM E283 at a 1.57 psf pressure differential.
3. Sealed with a gasket or caulk between the housing and interior wall or ceiling covering.



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**C402.5** - Comply with C402.5.1 through C402.5.8(2015 & 2018) or C402.5.11.1(2021) **2021 Approach**



**C402.5.11 Operable openings interlocking.**  
Where occupancies utilize operable openings to the outdoors that are larger than 40 square feet (3.7 m<sup>2</sup>) in area, such openings shall be interlocked with the heating and cooling system so as to raise the cooling setpoint to 90°F (32°C) and lower the heating setpoint to 55°F (13°C) whenever the operable opening is open. The change in heating and cooling setpoints shall occur within 10 minutes of opening the operable opening.

**Exceptions:**

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

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## R402.4 Air leakage

**R402.4.1.1 Installation**  
The components of the building thermal envelope as indicated in Table R402.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1, as applicable to the method of construction.

Where required by the code official, an approved third party shall inspect all components and verify compliance.

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
General requirements	A continuous air barrier shall be installed in the building envelope.	Air-permeable insulation shall not be used as a sealing material.
Breaks or joints in the air barrier shall be sealed.	Breaks or joints in the air barrier shall be sealed.	
Roofs	The roof shall be constructed to prevent air leakage through the roof assembly. The roof shall be constructed to prevent air leakage through the roof assembly. The roof shall be constructed to prevent air leakage through the roof assembly.	
Walls	The exterior walls shall be constructed to prevent air leakage through the walls. The exterior walls shall be constructed to prevent air leakage through the walls. The exterior walls shall be constructed to prevent air leakage through the walls.	
Windows, skylights and doors	The windows, skylights and doors shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1. The windows, skylights and doors shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1.	
Roof joints	The roof joints shall be sealed to prevent air leakage through the roof joints. The roof joints shall be sealed to prevent air leakage through the roof joints. The roof joints shall be sealed to prevent air leakage through the roof joints.	
Floors, including conditioned basement and crawlspace	The floors shall be constructed to prevent air leakage through the floors. The floors shall be constructed to prevent air leakage through the floors. The floors shall be constructed to prevent air leakage through the floors.	
Basement crawl spaces and attics	The basement crawl spaces and attics shall be sealed to prevent air leakage through the basement crawl spaces and attics. The basement crawl spaces and attics shall be sealed to prevent air leakage through the basement crawl spaces and attics.	
Mobile garages	The mobile garages shall be sealed to prevent air leakage through the mobile garages. The mobile garages shall be sealed to prevent air leakage through the mobile garages. The mobile garages shall be sealed to prevent air leakage through the mobile garages.	
Garage openings	The garage openings shall be sealed to prevent air leakage through the garage openings. The garage openings shall be sealed to prevent air leakage through the garage openings. The garage openings shall be sealed to prevent air leakage through the garage openings.	
Recessed lighting	The recessed lighting shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1. The recessed lighting shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1.	
Penetrations in the air barrier	The penetrations in the air barrier shall be sealed to prevent air leakage through the penetrations. The penetrations in the air barrier shall be sealed to prevent air leakage through the penetrations. The penetrations in the air barrier shall be sealed to prevent air leakage through the penetrations.	
Roofs	The roofs shall be constructed to prevent air leakage through the roofs. The roofs shall be constructed to prevent air leakage through the roofs. The roofs shall be constructed to prevent air leakage through the roofs.	
Walls	The exterior walls shall be constructed to prevent air leakage through the walls. The exterior walls shall be constructed to prevent air leakage through the walls. The exterior walls shall be constructed to prevent air leakage through the walls.	
Windows, skylights and doors	The windows, skylights and doors shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1. The windows, skylights and doors shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1.	
Roof joints	The roof joints shall be sealed to prevent air leakage through the roof joints. The roof joints shall be sealed to prevent air leakage through the roof joints. The roof joints shall be sealed to prevent air leakage through the roof joints.	
Floors, including conditioned basement and crawlspace	The floors shall be constructed to prevent air leakage through the floors. The floors shall be constructed to prevent air leakage through the floors. The floors shall be constructed to prevent air leakage through the floors.	
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Garage openings	The garage openings shall be sealed to prevent air leakage through the garage openings. The garage openings shall be sealed to prevent air leakage through the garage openings. The garage openings shall be sealed to prevent air leakage through the garage openings.	
Recessed lighting	The recessed lighting shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1. The recessed lighting shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1.	
Penetrations in the air barrier	The penetrations in the air barrier shall be sealed to prevent air leakage through the penetrations. The penetrations in the air barrier shall be sealed to prevent air leakage through the penetrations. The penetrations in the air barrier shall be sealed to prevent air leakage through the penetrations.	
Roofs	The roofs shall be constructed to prevent air leakage through the roofs. The roofs shall be constructed to prevent air leakage through the roofs. The roofs shall be constructed to prevent air leakage through the roofs.	
Walls	The exterior walls shall be constructed to prevent air leakage through the walls. The exterior walls shall be constructed to prevent air leakage through the walls. The exterior walls shall be constructed to prevent air leakage through the walls.	
Windows, skylights and doors	The windows, skylights and doors shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1. The windows, skylights and doors shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1.	
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Floors, including conditioned basement and crawlspace	The floors shall be constructed to prevent air leakage through the floors. The floors shall be constructed to prevent air leakage through the floors. The floors shall be constructed to prevent air leakage through the floors.	
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Garage openings	The garage openings shall be sealed to prevent air leakage through the garage openings. The garage openings shall be sealed to prevent air leakage through the garage openings. The garage openings shall be sealed to prevent air leakage through the garage openings.	
Recessed lighting	The recessed lighting shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1. The recessed lighting shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1.	
Penetrations in the air barrier	The penetrations in the air barrier shall be sealed to prevent air leakage through the penetrations. The penetrations in the air barrier shall be sealed to prevent air leakage through the penetrations. The penetrations in the air barrier shall be sealed to prevent air leakage through the penetrations.	


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## R402.4 Air leakage

**R402.4 Air leakage**  
The building thermal envelope shall be constructed to limit air leakage in accordance with the requirements of Sections R402.4.1 through R402.4.5.

**R402.4.1 Building thermal envelope**  
The building thermal envelope shall comply with Sections R402.4.1.1 through R402.4.1.3. The sealing methods between dissimilar materials shall allow for differential expansion and contraction.




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## R402.4 Air leakage

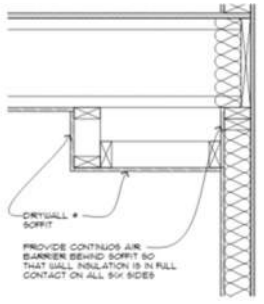
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
General requirements	A continuous air barrier shall be installed in the building envelope.	Air-permeable insulation shall not be used as a sealing material.
Breaks or joints in the air barrier shall be sealed.	Breaks or joints in the air barrier shall be sealed.	



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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Ceiling/attic	The air barrier in any dropped ceiling or soffit shall be aligned with the insulation and any gaps in the air barrier shall be sealed.  Access openings, drop down stairs or knee wall doors to unconditioned attic spaces shall be sealed.	The insulation in any dropped ceiling/soffit shall be aligned with the air barrier.



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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Windows, skylights and doors	The space between framing and skylights, and the jambs of windows and doors, shall be sealed.	—



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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Walls	The junction of the foundation and sill plate shall be sealed.  The junction of the top plate and the top of exterior walls shall be sealed.  Knee walls shall be sealed.	Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance, R-value, of not less than R-3 per inch. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.



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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Rim joists	<u>Rim joists shall include an exterior air barrier.<sup>b</sup></u>  <u>The junctions of the rim board to the sill plate and the rim board and the subfloor shall be air sealed.</u>	<u>Rim joists shall be insulated so that the insulation maintains permanent contact with the exterior rim board.<sup>b</sup></u>



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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Floors, including cantilevered floors and floors above garages	The air barrier shall be installed at any exposed edge of insulation.	Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of subfloor decking. Alternatively, floor framing cavity insulation shall be in contact with the top side of sheathing, or continuous insulation installed on the underside of floor framing and extending from the bottom to the top of all perimeter floor framing members.

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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Shafts, penetrations	Duct and flue shafts to exterior or unconditioned space shall be sealed. Utility penetrations of the air barrier shall be caulked, gasketed or otherwise sealed and shall allow for expansion, contraction of materials and mechanical vibration.	Insulation shall be fitted tightly around utilities passing through shafts and penetrations in the building thermal envelope to maintain required R-value.

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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Basement crawl space and slab foundations	Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder/air barrier in accordance with Section R402.2.10. Penetrations through concrete foundation walls and slabs shall be air sealed. Class 1 vapor retarders shall not be used as an air barrier on below-grade walls and shall be installed in accordance with Section R702.7 of the International Residential Code.	Crawl space insulation, where provided instead of floor insulation, shall be installed in accordance with Section R402.2.10. Conditioned basement foundation wall insulation shall be installed in accordance with Section R402.2.8.1. Slab-on-grade floor insulation shall be installed in accordance with Section R402.2.10.


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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Narrow cavities	Narrow cavities of 1 inch or less that are not able to be insulated shall be air sealed.	Batts to be installed in narrow cavities shall be cut to fit or narrow cavities shall be filled with insulation that on installation readily conforms to the available cavity space.

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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Garage separation	Air sealing shall be provided between the garage and conditioned spaces.	Insulated portions of the garage separation assembly shall be installed in accordance with Sections R303 and R402.2.7.



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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Plumbing, wiring or other obstructions	All holes created by wiring, plumbing or other obstructions in the air barrier assembly shall be air sealed.	Insulation shall be installed to fill the available space and surround wiring, plumbing, or other obstructions, unless the required R-value can be met by installing insulation and air barrier systems completely to the exterior side of the obstructions.



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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be sealed in accordance with Section R402.4.5.	Recessed light fixtures installed in the building thermal envelope shall be airtight and IC rated, and shall be buried or surrounded with insulation.



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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Shower/tub on exterior wall	The air barrier installed at exterior walls adjacent to showers and tubs shall separate the wall from the shower or tub.	Exterior walls adjacent to showers and tubs shall be insulated.



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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Electrical/phone box on exterior walls	The air barrier shall be installed behind electrical and communication boxes. <b>Alternatively</b> , air-sealed boxes shall be installed.	—



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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Concealed sprinklers	Where required to be sealed, concealed fire sprinklers shall only be sealed in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.	—



a. Inspection of log walls shall be in accordance with the provisions of ICC 400.  
b. Air barrier and insulation full enclosure is not required in unconditioned/ventilated attic spaces and at rim joists.

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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION <sup>a</sup>		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
HVAC register boots	HVAC supply and return register boots that penetrate building thermal envelope shall be sealed to the subfloor, wall covering or ceiling penetrated by the boot.	—




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## R402.4 Air leakage

### R402.4.2 Fireplaces

New wood-burning fireplaces shall have tight-fitting flue dampers or doors, and outdoor combustion air. Where using tight-fitting doors on factory-built fireplaces listed and labeled in accordance with UL 127, the doors shall be tested and listed for the fireplace.



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## R402.4 Air leakage

### R402.4.3 Fenestration air leakage

Windows, skylights and sliding glass doors shall have an air infiltration rate of not greater than 0.3 cfm per square foot, and for swinging doors, not greater than 0.5 cfm per square foot, when tested in accordance with NFRC 400 or AAMA/WDMA/CSA 101/I.S.2/A440 by an accredited, independent laboratory and listed and labeled by the manufacturer



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## R402.4 Air leakage

### R402.4.5 Recessed lighting

Recessed luminaires installed in the building thermal envelope shall be sealed to limit air leakage between conditioned and unconditioned spaces. Recessed luminaires shall be IC-rated and labeled as having an air leakage rate of not greater than 2.0 cfm when tested in accordance with ASTM E283 at a pressure differential of 1.57 psf.

Recessed luminaires shall be sealed with a gasket or caulked between the housing and the interior wall or ceiling covering



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## R402.4 Air leakage

### R402.4.4 Rooms containing fuel-burning appliances

In Climate Zones 3 through 8, where open combustion air ducts provide combustion air to open combustion fuel burning appliances, the appliances and combustion air opening shall be located outside the building thermal envelope or enclosed in a room, isolated from inside the thermal envelope. Such rooms shall be sealed and insulated in accordance with the envelope requirements of Table R402.1.2, where the walls, floors and ceilings shall meet not less than the basement wall R-value requirement. The door into the room shall be fully gasketed and any water lines and ducts in the room insulated in accordance with Section R403. The combustion air duct shall be insulated where it passes through conditioned space to a minimum of R-8.



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### R402.4.6 Electrical and communication outlet boxes (air-sealed boxes)

Electrical and communication outlet boxes installed in the building thermal envelope shall be sealed to limit air leakage between conditioned and unconditioned spaces. Electrical and communication outlet boxes shall be tested in accordance with NEMA OS 4, Requirements for Air-Sealed Boxes for Electrical and Communication Applications, and shall have an air leak-age rate of not greater than 2.0 cubic feet per minute at a pressure differential of 1.57 psf (75 Pa).

Electrical and communication outlet boxes shall be marked "NEMA OS 4" or "OS 4" in accordance with NEMA OS 4.

Electrical and communication outlet boxes shall be installed per the manufacturer's instructions and with any supplied components required to achieve compliance with NEMA OS 4

## R402.4 Air leakage



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## R402.4 Air leakage

### R402.4.1.2 Testing

The building or dwelling unit shall be tested for air leakage. The maximum air leak-age rate for any building or dwelling unit under any compliance path shall not exceed 5.0 air changes per hour or 0.28 cubic feet per minute (CFM) per square foot of dwelling unit enclosure area. Testing shall be conducted in accordance with ANSI/RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals)

Exception....



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## R402.4 Air leakage

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, where installed at the time of the test, shall be open.
4. Exterior or interior terminations for continuous ventilation systems shall be sealed.
5. Heating and cooling systems, where installed at the time of the test, shall be turned off.
6. Supply and return registers, where installed at the time of the test, shall be fully open.

Exception

When testing individual dwelling units, an air leakage rate not exceeding 0.30 cubic feet per minute per square foot of the dwelling unit enclosure area, tested in accordance with ANSI/RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pa), shall be permitted in all climate zones for:

1. Attached single and multiple-family building dwelling units.
2. Buildings or dwelling units that are 1,500 square feet or smaller.



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## R402.4 Air leakage

Exception

For heated, attached private garages and heated, detached private garages accessory to one-and two-family dwellings and townhouses not more than three stories above grade plane in height, building envelope tightness and insulation installation shall be considered acceptable where the items in Table R402.4.1.1, applicable to the method of construction, are field verified.

Where required by the code official, an approved third party independent from the installer shall inspect both air barrier and insulation installation criteria. Heated, attached private garage space and heated, detached private garage space shall be thermally isolated from all other habitable, conditioned spaces in accordance with Sections R402.2.12 and R402.3.5, as applicable



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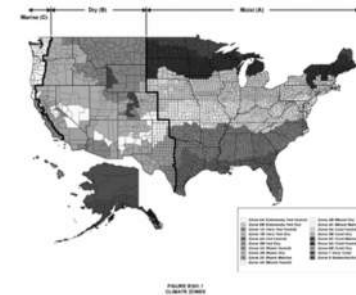
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## R402.4 Air leakage

### R402.4.1.3 Leakage rate

When complying with Section R401.2.1, the building or dwelling unit shall have an air leakage rate not exceeding 5.0 air changes per hour in Climate Zones 0, 1 and 2, and 3.0 air changes per hour in Climate Zones 3 through 8, when tested in accordance with Section R402.4.1.2.



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### Montana Amendment

(g) Subsection R402.4.1.2, Testing, is deleted and replaced with the following: The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding four air changes per hour in Climate Zone 6. 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 party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope.

During testing:

- "(i) exterior windows and doors, fireplace and stove doors shall be closed, but not sealed;
- "(ii) dampers shall be closed, but not sealed, including exhaust, intake, makeup air, back draft and flue dampers;
- "(iii) interior doors shall be open;
- "(iv) exterior openings for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;
- "(v) heating and cooling system(s) shall be turned off;
- "(vi) "B" or "L" vents, combustion air vents, and dryer vents shall be sealed; and
- "(vii) supply and return registers, where installed at the time of test, shall be fully open.



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### C403.3.1 Equipment sizing



The output capacity of heating and cooling equipment shall be not greater than that of the smallest available equipment size that exceeds the loads calculated in accordance with Section C403.1.1.

A single piece of equipment providing both heating and cooling shall satisfy this provision for one function with the capacity for the other function as small as possible, within available equipment options.



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COOLING COIL PEAK				CLG SPACE PEAK				HEATING COIL PEAK				TEMPERATURES			
Peaked at Time: Outside Air				Mo/Hr: 7 / 15				Mo/Hr: Heating Design				SADB			
QADB/Wh/HR: 65 / 65 / 61				QADB: 96				QADB: 9				Cooling			
Space				Space				Space Peak				Cooling			
Sens. + Lat.				Sens. + Lat.				Space Sens.				Return			
Btu/h				Btu/h				Btu/h				Ra Plenum			
%				%				%				75.0			
%				%				%				70.0			
Envelope Loads				Envelope Loads				Envelope Loads				Return			
Skyline Solar				Skyline Solar				Skyline Solar				Ret/RA			
Skyline Cond				Skyline Cond				Skyline Cond				Fa M/TD			
Roof Cond				Roof Cond				Roof Cond				Fa W/TD			
Glass Solar				Glass Solar				Glass Solar				Fa Fract			
Glass Door Cond				Glass Door Cond				Glass Door Cond				0.0			
Wall Cond				Wall Cond				Wall Cond				0.0			
Partition/Door				Partition/Door				Partition/Door				0.0			
Floor				Floor				Floor				0.0			
Adjacent Floor				Adjacent Floor				Adjacent Floor				0.0			
Infiltration				Infiltration				Infiltration				0.0			
Sub Total				Sub Total				Sub Total				0.0			
Internal Loads				Internal Loads				Internal Loads				0.0			
Lights				Lights				Lights				0.0			
People				People				People				0.0			
Misc				Misc				Misc				0.0			
Sub Total				Sub Total				Sub Total				0.0			
Ceiling Load				Ceiling Load				Ceiling Load				0.0			
Ventilation Load				Ventilation Load				Ventilation Load				0.0			
Adj. Air Trans Heat				Adj. Air Trans Heat				Adj. Air Trans Heat				0.0			
Dehumid. On Sizing				Dehumid. On Sizing				Dehumid. On Sizing				0.0			
On/Unk Sizing				On/Unk Sizing				On/Unk Sizing				0.0			
Exhaust Heat				Exhaust Heat				Exhaust Heat				0.0			
Sub. Fan Heat				Sub. Fan Heat				Sub. Fan Heat				0.0			
Ret. Fan Heat				Ret. Fan Heat				Ret. Fan Heat				0.0			
Duct Heat P/loss				Duct Heat P/loss				Duct Heat P/loss				0.0			
Underflr Sup IR P/loss				Underflr Sup IR P/loss				Underflr Sup IR P/loss				0.0			
Supply Air Leakage				Supply Air Leakage				Supply Air Leakage				0.0			
Grand Total				Grand Total				Grand Total				0.0			

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#### HVAC Performance IECC Section C403.3 Heating and cooling equipment efficiencies

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

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE <sup>b</sup>
Air conditioners, air cooled	< 65,000 Btu/h <sup>b</sup>	All	Split system, three phase and applications outside US single phase <sup>b</sup>	13.0 SEER before 1/1/2023 13.4 SEER2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023
			Single-package, three phase and applications outside US single phase <sup>b</sup>	14.0 SEER before 1/1/2023 13.4 SEER2 after 1/1/2023	AHRI 210/240—2023 after 1/1/2023

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

172

**C403.5: Economizers Reorganized** the mechanical section of the code to put all economizer requirements in one location, making clarifications. Also making more consistent with ASHRAE 90.1.

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### C403.4 Heating and cooling system controls

**C403.4.1.1 Heat pump supplementary heat**  
Heat pumps having supplementary electric resistance heat shall have controls that limit supplemental heat operation to only those times when one of the following applies:

1. The vapor compression cycle cannot provide the necessary heating energy to satisfy the thermostat setting.
2. The heat pump is operating in defrost mode.
3. The vapor compression cycle malfunctions.
4. The thermostat malfunctions.

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### C403.4 Heating and cooling system controls

**C403.4.1 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, not fewer than one humidity control device shall be provided for each humidity control system.

**Exception:** Independent perimeter systems that are designed to offset only building envelope heat losses, gains or both serving one or more perimeter zones also served by an interior system provided that both of the following conditions are met:

1. The perimeter system includes not fewer than one thermostatic control zone for each building exposure having exterior walls facing only one orientation (within  $\pm 45$  degrees) for more than 50 contiguous feet.
2. The perimeter system heating and cooling supply is controlled by thermostats located within the zones served by the system

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### C403.4 Heating and cooling system controls

**C403.4.2 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 and having a manual shutoff switch located with ready access.

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### C403.4 Heating and cooling system controls

#### C403.4.2.3 Automatic start and stop

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

Automatic stop controls shall be provided for each HVAC system with direct digital control of individual zones. The automatic stop controls shall be configured to reduce the HVAC system's heating temperature setpoint and increase the cooling temperature setpoint by not less than 2°F before scheduled unoccupied periods based on the thermal lag and acceptable drift in space temperature that is within comfort limits.



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### Demand Controlled Ventilation IECC

#### Section C403.7.1

#### Exceptions:

Systems with energy recovery per C403.7.4

Multiple zone systems without direct digital control of single zones communicating with central control panel

Multi-Zone systems with design outdoor airflow 750 cfm

Spaces where supply airflow rate minus any makeup or outgoing transfer air requirement < 1,200 cfm

Ventilation provided for process loads only

Spaces where more than 75 percent of the space design outdoor airflow is required for makeup air that is exhausted from the space or transfer air that is required for makeup air that is exhausted from other spaces.

Spaces with one of the following occupancy classifications as defined in Table 403.3.1.1 of the International Mechanical Code: correctional cells, education laboratories, barber, beauty and nail salons, and bowling alley seating areas.



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### Demand Controlled Ventilation IECC

#### Section C403.7.1

DCV shall be provided for all single-zone systems required to comply with Sections C403.5 through C403.5.3 and each zone with spaces > 500 ft<sup>2</sup> and the average occupant load ≥ 25 15 people/1000 ft<sup>2</sup> of floor area as established by Table 403.3.1.1 of the International Mechanical Code, where the HVAC system has:

- ✓ An air-side economizer, or
- ✓ Automatic modulating control of the outdoor air damper, or
- ✓ A design outdoor airflow > 3,000 cfm



*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.



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### C403.7.2 Enclosed parking garage ventilation controls

Enclosed parking garages used for storing or handling automobiles operating under their own power shall employ carbon monoxide detectors applied in conjunction with nitrogen dioxide detectors and automatic controls configured to stage fans or modulate fan average airflow rates to 50 percent or less of design capacity, or intermittently operate fans less than 20 percent of the occupied time or as required to maintain acceptable contaminant levels in accordance with International Mechanical Code provisions. Failure of contamination-sensing devices shall cause the exhaust fans to operate continuously at design airflow.



- Exceptions:
1. Garages with a total exhaust capacity less than 22,500 8,000 cfm with ventilation systems that do not utilize heating or mechanical cooling.
  2. Garages that have a garage area to ventilation system motor nameplate power ratio that exceeds 1,125 cfm/hp and do not utilize heating or mechanical cooling.



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### C403.7.4 Energy recovery systems

#### C403.7.4.1 Nontransient dwelling units

Nontransient dwelling units shall be provided with outdoor air energy recovery ventilation systems with an *enthalpy recovery ratio* of not less than 50 percent at cooling design condition and not less than 60 percent at heating design condition.

Exceptions:

1. Nontransient dwelling units in Climate Zone 3C.
2. Nontransient dwelling units with not more than 500 square feet (46 m2) of conditioned floor area in Climate Zones 0, 1, 2, 3, 4C and 5C.
3. Enthalpy recovery ratio requirements at heating design condition in Climate Zones 0, 1 and 2.
4. Enthalpy recovery ratio requirements at cooling design condition in Climate Zones 4, 5, 6, 7 and 8.

#### ENTHALPY RECOVERY RATIO

Change in the enthalpy of the outdoor air supply divided by the difference between the outdoor air and entering exhaust air enthalpy, expressed as a percentage

The enthalpy (H) of a thermodynamic system is defined as the sum of its internal energy and the product of its pressure and volume



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### C403.7.6 Automatic control of HVAC systems serving guestrooms

Automatic control of HVAC systems serving guest rooms in Group R-1 buildings containing over 50 guests rooms.



2. When the guestroom is unrented and unoccupied, the controls shall automatically raise the cooling setpoint not higher than 60°F to not lower than 80°F and lower the heating setpoint to. Unrented and unoccupied guestroom mode shall be initiated within 16 hours of the guestroom being continuously occupied or where a *networked guestroom control system* indicates that the guestroom is unrented and the guestroom is unoccupied for more than 20 minutes. A *networked guestroom control system* that is capable of returning the thermostat setpoints to default occupied setpoints 60 minutes prior to the time a guestroom is scheduled to be occupied is not precluded by this section. Cooling that is capable of limiting relative humidity with a setpoint not lower than 65-percent relative humidity during unoccupied periods is not precluded by this section



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### C403.7.6 Automatic control of HVAC systems serving guestrooms

Automatic control of HVAC systems serving guest rooms in Group R-1 buildings containing over 50 guests rooms.



#### C403.7.6.1 Temperature setpoint controls.

Controls shall be provided on each HVAC system that are capable of and configured with three modes of temperature control:

1. When the guestroom is rented but unoccupied, the controls shall automatically raise the cooling setpoint and lower the heating setpoint by not less than 4°F from the occupant setpoint within 30 minutes after the occupants have left the guestroom.



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### C403.7.6 Automatic control of HVAC systems serving guestrooms

Automatic control of HVAC systems serving guest rooms in Group R-1 buildings containing over 50 guests rooms.



3. When the guestroom is occupied, HVAC setpoints shall return to their occupied setpoints once occupancy is sensed.



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### C403.12.3 Piping insulation

Piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table C403.12.3.



**Exceptions:**

1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this code.
2. Factory-installed piping within room fan-coils and unit ventilators tested and rated according to AHRI 440 (except that the sampling and variation provisions of Section 6.5 shall not apply) and AHRI 840, respectively.
3. Piping that conveys fluids that have a design operating temperature range between 60°F (15°C) and 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).
7. In radiant heating systems, sections of piping intended by design to radiate heat.



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### Controls IECC

#### Section C403.13.2 Snow Melt Systems



Photo courtesy of Karl Baker, K energy

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
- ✓ an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F



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### Heating Outside a Building IECC

#### Section C403.13.1

Systems are to be radiant systems

Controlled by an occupancy sensing device or timer switch

- ✓ So system is automatically deenergized when no occupants are present



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### C403.13.3 Freeze protection system controls.

Freeze protection systems, such as heat tracing of outdoor piping and heat exchangers, including self-regulating heat tracing, shall include automatic controls configured to shut off the systems when outdoor air temperatures are above 40°F or when the conditions of the protected fluid will prevent freezing.



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### C403.14 Operable opening interlocking controls (New)

The heating and cooling systems shall have controls that will interlock these mechanical systems to the set temperatures of 90° F for cooling and 55° F for heating when the conditions of Section C402.5.8 exist. The controls shall configure to shut off the systems entirely when the outdoor temperatures are below 90° For above 55° F

C402.5.8 Loading Dock Seals



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### Service Water Heating IECC Section C404

Table C404.2 Minimum Performance of Water-Heating Equipment

Water Heater Types Covered

- Electric Storage
- Gas and Oil Storage
- Instantaneous Water Heaters – Gas and Oil
- Hot water boilers – gas and oil
- Pool heaters
- Unfired storage tanks



Heat Traps (C404.3)

Piping Insulation (C404.4)

Efficient Piping(C404.5)

Circulation & Temperature Maintenance (C404.6)

Demand Recirculation (C404.7)

Drain Heat Recovery(C404.8)

Pools and Spas (C404.9)

Portable Spas (C404.10)

SWH Commissioning(C404.11)



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### C402.5.11 Operable openings interlocking (New)

Where occupancies utilize operable openings to the outdoors that are larger than 40 square feet in area, such openings shall be interlocked with the heating and cooling system so as to raise the cooling setpoint to 90°F and lower the heating setpoint to 55°F whenever the operable opening is open. The change in heating and cooling setpoints shall occur within 10 minutes of opening the operable opening.



Exceptions:

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



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### C404.2 Service water-heating equipment performance efficiency

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

TABLE C404.2 MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED <sup>a</sup>	TEST PROCEDURE
Water heaters, electric	≤ 12 kW <sup>b</sup>	Water-heater <sup>c</sup> ≥ 20 gallons and ≤ 120 gallons	0.93 – 0.00131V <sub>in</sub> EF	DOE 10 CFR Part 610
		Resistance ≤ 20 gallons and ≤ 55 gallons	0.960 – 0.0003V <sub>in</sub> EF	
		Grid-enabled <sup>d</sup> > 75 gallons and ≤ 120 gallons	1.061 – 0.00168V <sub>in</sub> EF	
	> 12 kW	Resistance	(0.3 + 27V <sub>in</sub> ) <sup>e</sup> %In	ANSI Z21.10.2
Storage water heaters, gas	≤ 75,000 Btu/h	Heat pump > 55 gallons and ≤ 120 gallons	2.057 – 0.00113V <sub>in</sub> EF	DOE 10 CFR Part 610
		≤ 20 gallons and > 55 gallons	0.675 – 0.0019V <sub>in</sub> EF	DOE 10 CFR Part 610
> 75,000 Btu/h and ≤ 155,000 Btu/h	> 55 gallons and ≤ 100 gallons	0.8012 – 0.00078V <sub>in</sub> EF	80% E <sub>h</sub>	
	< 4,000 Btu/hr/gal	iQHW + 119.1 V <sub>in</sub> Btu/h		
> 155,000 Btu/h	< 4,000 Btu/hr/gal	80% E <sub>h</sub>	iQHW + 119.1 V <sub>in</sub> Btu/h	ANSI Z21.10.3
	< 4,000 Btu/hr/gal	iQHW + 119.1 V <sub>in</sub> Btu/h		



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**C404.2.1 High input service water-heating systems**

Gas-fired water-heating equipment installed in new buildings shall be in compliance with this section.

Where a singular piece of water-heating equipment serves the entire building and the input rating of the equipment is 1,000,000 Btu/h or greater, such equipment shall have a thermal efficiency,  $E_v$ , of not less than 92 percent.

Where multiple pieces of water-heating equipment serve the building and the combined input rating of the water-heating equipment is 1,000,000 Btu/h or greater, the combined input-capacity-weighted-average thermal efficiency,  $E_v$ , shall be not less than 90 percent.

Exceptions:

1. Where not less than 25 percent of the annual service water-heating requirement is provided by on-site renewable energy or site-recovered energy, the minimum thermal efficiency requirements of this section shall not apply.
2. The input rating of water heaters installed in individual dwelling units shall not be required to be included in the total input rating of service water-heating equipment for a building.
3. The input rating of water heaters with an input rating of not greater than 100,000 Btu/h (29.3 kW) shall not be required to be included in the total input rating of service water-heating equipment for a building.



**C404.4 Insulation of piping**

Piping from a water heater to the termination of the heated water fixture supply pipe shall be insulated in accordance with Table C403.12.3.

On both the inlet and outlet piping of a storage water heater or heated water storage tank, the piping to a heat trap or the first 8 feet of piping, whichever is less, shall be insulated.

Piping that is heat traced shall be insulated in accordance with Table C403.12.3 or the heat trace manufacturer's instructions.

Tubular pipe insulation shall be installed in accordance with the insulation manufacturer's instructions.

Pipe insulation shall be continuous except where the piping passes through a framing member.

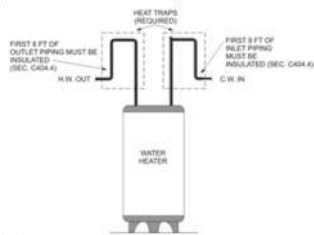
The minimum insulation thickness requirements of this section shall not supersede any greater insulation thickness requirements necessary for the protection of piping from freezing temperatures or the protection of personnel against external surface temperatures on the insulation.

Exception: Tubular pipe insulation shall not be required on the following:



**C404.3 Heat traps for hot water storage tanks.**

Storage tank-type water heaters and hot water storage tanks that have vertical water pipes connecting to the inlet and outlet of the tank shall be provided with integral heat traps at those inlets and outlets or shall have pipe-configured heat traps in the piping connected to those inlets and outlets. Tank inlets and outlets associated with solar water heating system circulation loops shall not be required to have heat traps.



For SI: 1 foot = 304.8 mm.

Commentary Figure C404.3(1)

HEAT TRAP AND INSULATION REQUIREMENTS FOR NONCIRCULATING SYSTEMS  
(Courtesy of U.S. Department of Energy, Office of Building Technology, State and Community Programs, www.enr.gov/energy.gov)



TABLE C403.12.3 MINIMUM PIPE INSULATION THICKNESS (in inches)

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	INSULATION CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE (inches)				
	Conductivity Btu × in./(h × ft² × °F) <sup>b</sup>	Mean Rating Temperature, °F	< 1	1 to < 1½	1½ 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	50	0.5	1.0	1.0	1.0	1.5

Thermal conductivity

Mean Temperature °F	k*	Mean Temperature °C	k*
50	0.22	10	0.032
75	0.23	25	0.034
100	0.24	50	0.037
150	0.27	100	0.043
200	0.29	125	0.047
250	0.32	150	0.051
300	0.35	175	0.056
350	0.39	200	0.062
400	0.43	225	0.068
450	0.48	250	0.075
500	0.54	275	0.082

k-value is the rate of heat flow through a homogeneous material

Simple conversion from K to R value  
Insulation thickness divided by your k-value at 75°F Mean Temperature



<http://commercial.owenscorning.com/assets/0/321/401/0067167-c5f6-4eda-8a55-9de806e3541.pdf>



**C404.4 Insulation of piping**

Exception: Tubular pipe insulation shall not be required on the following:

1. The tubing from the connection at the termination of the fixture supply piping to a plumbing fixture or plumbing appliance.



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**C404.4 Insulation of piping**

Exception: Tubular pipe insulation shall not be required on the following:

3. Piping from user-controlled shower and bath mixing valves to the water outlets.



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**C404.4 Insulation of piping**

Exception: Tubular pipe insulation shall not be required on the following:

2. Valves, pumps, strainers and threaded unions in piping that is 1 inch or less in nominal diameter.

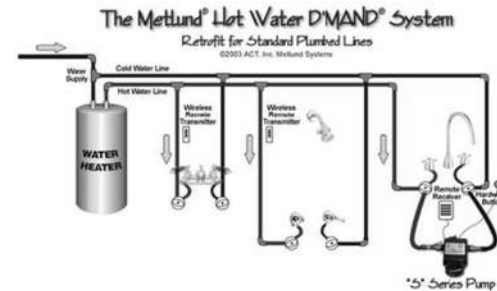


198

**C404.4 Insulation of piping**

Exception: Tubular pipe insulation shall not be required on the following:

4. Cold-water piping of a demand recirculation water system.



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**C404.4 Insulation of piping**

Exception: Tubular pipe insulation shall not be required on the following:

5. Tubing from a hot drinking-water heating unit to the water outlet.



<https://waterpurification.com/best-hot-water-dispenser/>



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Exception: Tubular pipe insulation shall not be required on the following:

7. Piping surrounded by building insulation with a thermal resistance (R-value) of not less than R-3



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**C404.4 Insulation of piping**

Exception: Tubular pipe insulation shall not be required on the following:

6. Piping at locations where a vertical support of the piping is installed



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**C404.5 Heated water supply piping**

Heated water supply piping shall be in accordance with Section C404.5.1 or C404.5.2. The flow rate through 1/4-inch piping shall be not greater than 0.5 gpm. The flow rate through 5/16-inch piping shall be not greater than 1 gpm. The flow rate through 3/8-inch piping shall be not greater than 1.5 gpm.



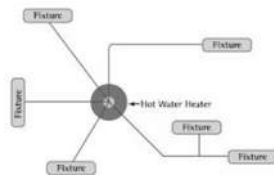
204

**Maximum Allowed Pipe Length Method IECC**  
Section C404.5.1

Maximum allowed piping length from nearest source of heated water to termination of the fixture supply pipe:

Where piping contains more than one size, the largest size of pipe within the piping shall be used for determining the max. allowable length of piping in Table C404.5.1

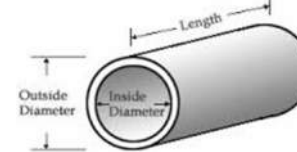
- Public lavatory faucet, use “Public Lavatory faucets” column in Table C404.5.1
- All other plumbing fixtures and plumbing appliances use “Other fixtures and appliances” column in Table C404.5.1



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**Maximum Allowed Pipe Volume Method IECC**  
Section C404.5.2

- Water heaters, circulating water systems, and heat trace temperature maintenance systems to be considered sources of heated water
- The volume in the piping shall be determined from the “Volume” column in Table C404.5.1 or from Table C404.5.2.1.
- Volume from the nearest source of heated water to the termination of the fixture supply pipe as follows:
  - Public lavatory faucet: ≤ 2 ounces
  - Other plumbing fixtures or plumbing appliances: ≤ 0.5 gallon



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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
1 1/4	8	0.5	8
1 1/2	11	0.5	6
2 or larger	18	0.5	4



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TABLE C404.5.2.1 INTERNAL VOLUME OF VARIOUS WATER DISTRIBUTION TUBING

Nominal Size (inches)	OUNCES OF WATER PER FOOT OF TUBE								
	Copper Type M	Copper Type L	Copper Type K	CPVC CTS SDR 11	CPVC SCH 40	CPVC SCH 80	PE-RT SDR 9	Composite ASTM F1281	PEX CTS SDR 9
3/8	1.06	0.97	0.84	N/A	1.17	—	0.64	0.63	0.64
1/2	1.69	1.55	1.45	1.25	1.89	1.46	1.18	1.31	1.18
3/4	3.43	3.22	2.90	2.67	3.38	2.74	2.35	3.39	2.35
1	5.81	5.49	5.17	4.43	5.53	4.57	3.91	5.56	3.91
1 1/4	8.70	8.36	8.09	6.61	9.66	8.24	5.81	8.49	5.81
1 1/2	12.18	11.83	11.45	9.22	13.20	11.38	8.09	13.88	8.09
2	21.08	20.58	20.04	15.79	21.88	19.11	13.86	21.48	13.86



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**C404.6.1 Circulation systems**

Heated-water circulation systems shall be provided with a circulation pump.

The system return pipe shall be a dedicated return pipe or a cold water supply pipe.

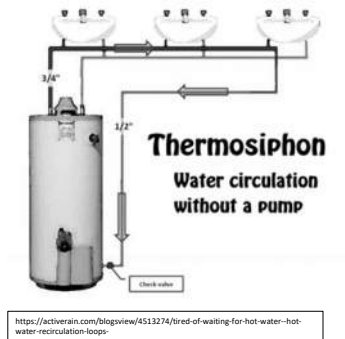
Gravity and thermo-siphon circulation systems shall be prohibited.

Controls for circulating hot water system pumps shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is not a demand for hot water.

The controls shall limit the temperature of the water entering the cold water piping to not greater than 104°F

Controls for circulating hot water system pumps shall start the pump based on the identification of a demand for hot water within the occupancy.

The controls shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is not a demand for hot water.



<https://activerain.com/blog/view/4513274/tired-of-waiting-for-hot-water-hot-water-recirculation-loop>



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**C404.6.2 Heat trace systems**

Electric heat trace systems shall comply with IEEE 515.1.

Controls for such systems shall be able to automatically adjust the energy input to the heat tracing to maintain the desired water temperature in the piping in accordance with the times when heated water is used in the occupancy.

Heat trace shall be arranged to be turned off automatically when there is not a demand for hot water.

**C404.6.3 Controls for hot water storage**

The controls on pumps that circulate water between a water heater and a heated-water storage tank shall limit operation of the pump from heating cycle startup to not greater than 5 minutes after the end of the cycle.



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**C404.6.1 Demand recirculation controls**

Demand recirculation water systems shall have controls that start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture, or sensing the flow of hot or tempered water to a fixture fitting or appliance

2. The controls shall limit the temperature of the water entering the cold water piping to not greater than 104°F.



<https://www.builtbustar.com/projects/conservation/recirc/recircenergy.htm>



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Project Information	
For:	Colorado ED Inst.
Notes:	
Design Information	
Weather: Denver, CO, US	
Winter Design Conditions	
Outside db	-3 °F
Inside db	73 °F
Design TD	73 °F
Summer Design Conditions	
Outside db	80 °F
Inside db	75 °F
Design TD	15 °F
Daily range	51
Relative humidity	50 %
Moisture difference	-38 grains
Heating Summary	
Structure	2048 Btu/h
Ducts	0 Btu/h
Central vent (64 dth)	-4213 Btu/h
Outside air	0 Btu/h
Humidification	0 Btu/h
Piping	0 Btu/h
Equipment load	30680 Btu/h
Infiltration	
Method	Simplified
Construction quality	Average
Fireplaces	0
Area (ft²)	Heating 3003
Volume (ft³)	Cooling 3003
Air change/hour	Heating 14464
Equip AVF (dth)	Cooling 0.15
	Equip 67
	36
Sensible Cooling Equipment Load Sizing	
Structure	14878 Btu/h
Ducts	0 Btu/h
Central vent (64 dth)	877 Btu/h
Outside air	0 Btu/h
Shower	0 Btu/h
Use manufacturer's data	y
Rate/wing multiplier	1.00
Equipment sensible load	15756 Btu/h
Latent Cooling Equipment Load Sizing	
Structure	274 Btu/h
Ducts	0 Btu/h
Central vent (64 dth)	-128 Btu/h
Outside air	0 Btu/h
Equipment latent load	0 Btu/h
Equipment Total Load (Sens+Lat)	15756 Btu/h
Req. total capacity at 0.85 SHR	1.5 ton
Heating Equipment Summary	
Make	Carrier
Type	Carrier
Model	58HC3040-12x
APR ref	144278
Efficiency	92.1 AFUE
Heating input	40000 Btu/h
Heating output	33194 Btu/h
Temperature rise	44 °F
Actual air flow	434 cfm
Air flow factor	0.021 cfm/Btu/h
Static pressure	0.70 in H <sub>2</sub> O
Source	Furnacast
Cooling Equipment Summary	
Make	Carrier
Type	BASE 13 PUSONAC
Cond	24ARB124A.W01
Coil	CAP-24AA-14TOR
APR ref	3205056
Efficiency	Y1.0 EER, 13 SEER
Sensible cooling	19535 Btu/h
Latent cooling	2715 Btu/h
Total cooling	21900 Btu/h
Actual air flow	165 cfm
Air flow factor	0.067 cfm/Btu/h
Static pressure	0.70 in H <sub>2</sub> O
Load sensible heat ratio	1.00



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Winter Design Conditions	
Outside db	-3 °F
Inside db	70 °F
Design TD	73 °F

Heating Summary	
Structure	26468 Btuh
Ducts	0 Btuh
Central vent (64 cfm)	4213 Btuh
Outside air	
Humidification	0 Btuh
Piping	0 Btuh
Equipment load	30680 Btuh

Infiltration	
Method	Simplified
Construction quality	Average
Fireplaces	0

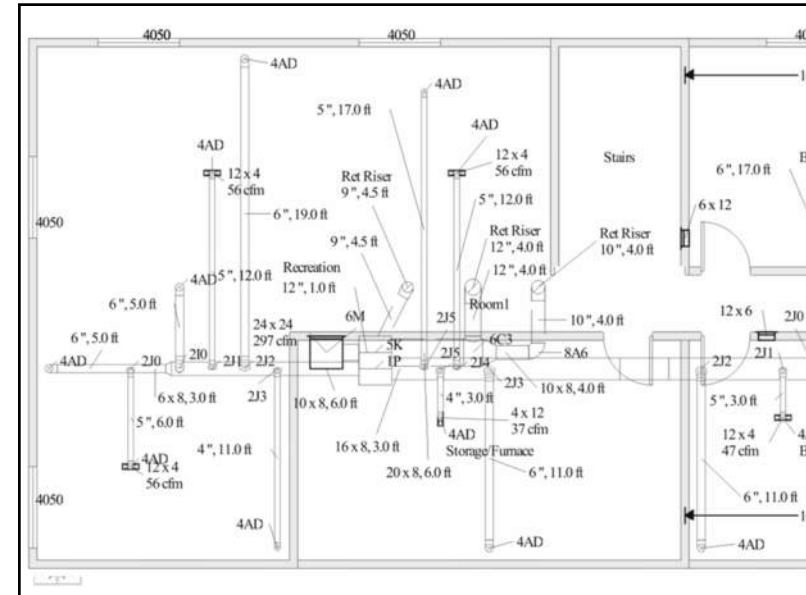
  

	Heating	Cooling
Area (ft <sup>2</sup> )	3600	3600
Volume (ft <sup>3</sup> )	14464	14464
Air changes/hour	0.28	0.15
Equiv AVF (cfm)	67	36

Heating Equipment Summary	
Make	Carrier
Trade	Carrier
Model	58MCB040-12x
AHRI ref	144278
Efficiency	92.1 AFUE
Heating input	40000 Btuh
Heating output	33156 Btuh
Temperature rise	44 °F
Actual air flow	830 cfm
Air flow factor	0.031 cfm/Btuh
Static pressure	0.70 in H <sub>2</sub> O
Space thermostat	

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Summer Design Conditions	
Outside db	90 °F
Inside db	75 °F
Design TD	15 °F
Daily range	H
Relative humidity	50 %
Moisture difference	-36 gr/lb

Sensible Cooling Equipment Load Sizing	
Structure	14878 Btuh
Ducts	0 Btuh
Central vent (64 cfm)	877 Btuh
Outside air	
Blower	0 Btuh
Use manufacturer's data	y
Rate/swing multiplier	1.00
Equipment sensible load	15756 Btuh

Latent Cooling Equipment Load Sizing	
Structure	274 Btuh
Ducts	0 Btuh
Central vent (64 cfm)	-1281 Btuh
Outside air	
Equipment latent load	0 Btuh
Equipment Total Load (Sens+Lat)	15756 Btuh
Req. total capacity at 0.85 SHR	1.5 ton

Cooling Equipment Summary	
Make	Carrier
Trade	BASE 13 PURONAC
Cond	24ABB324(A)W31
Coil	CAP**2414A**+TDR
AHRI ref	3250356
Efficiency	11.0 EER, 13 SEER
Sensible cooling	18835 Btuh
Latent cooling	2765 Btuh
Total cooling	21600 Btuh
Actual air flow	995 cfm
Air flow factor	0.067 cfm/Btuh
Static pressure	0.70 in H <sub>2</sub> O
Load sensible heat ratio	1.00

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### R403.3 Ducts

#### R403.3.5 Duct testing

Ducts shall be pressure tested in accordance with ANSI/RESNET/ICC 380 or ASTM E1554 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. 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.

**Exception:** A duct air-leakage test shall not be required for ducts serving ventilation systems that are not integrated with ducts serving heating or cooling systems



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### R403.3 Ducts

#### R403.3.6 Duct leakage

The total leakage of the ducts, where measured in accordance with Section R403.3.5, shall be as follows:

1. Rough-in test: The total leakage shall be less than or equal to 4.0 cubic feet per minute per 100 square feet 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 3.0 cubic feet per minute per 100 square feet of conditioned floor area.
2. Postconstruction test: Total leakage shall be less than or equal to 4.0 cubic feet per minute per 100 square feet of conditioned floor area.
3. Test for ducts within thermal envelope: Where all ducts and air handlers are located entirely within the building thermal envelope, total leakage shall be less than or equal to 8.0 cubic feet per minute per 100 square feet of conditioned floor area.



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### R403.6 Mechanical ventilation

#### R403.6.2 Whole-dwelling mechanical ventilation system fan efficacy

Fans used to provide whole-dwelling mechanical ventilation shall meet the efficacy requirements of Table R403.6.2 at one or more rating points. Fans shall be tested in accordance with HVI 916 and listed. The airflow shall be reported in the product listing or on the label.

TABLE R403.6.2  
WHOLE-DWELLING MECHANICAL VENTILATION SYSTEM FAN EFFICACY\*

FAN LOCATION	AIRFLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)
HRV, ERV	Any	1.2 cfm/watt
In-line supply or exhaust fan	Any	3.8 cfm/watt
Other exhaust fan	< 90	2.8 cfm/watt
Other exhaust fan	≥ 90	3.5 cfm/watt
Air-handler that is integrated to tested and listed HVAC equipment	Any	1.2 cfm/watt

Fan efficacy shall be reported in the product listing or shall be derived from the input power and airflow values reported in the product listing or on the label. Fan efficacy for fully ducted HRV, ERC, balanced, and in-line fans shall be determined at a static pressure of not less than 0.2 inch w.c.

Fan efficacy for ducted range hoods, bathroom and utility room fans shall be determined at a static pressure of not less than 0.1 inch w.c.



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### R403.6 Mechanical ventilation

#### R403.6.1 Heat or energy recovery ventilation

Dwelling units shall be provided with a heat recovery or energy recovery ventilation system in Climate Zones 7 and 8.

The system shall be balanced with a minimum sensible heat recovery efficiency of 65 percent at 32°F at a flow greater than or equal to the design airflow.



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### R403.6 Mechanical ventilation

#### R403.6.3 Testing

Mechanical ventilation systems shall be tested and verified to provide the minimum ventilation flow rates required by Section R403.6. Testing shall be performed according to the ventilation equipment manufacturer's instructions, or by using a flow hood or box, flow grid, or other airflow measuring device at the mechanical ventilation fan's inlet terminals or grilles, outlet terminals or grilles, or in the connected ventilation ducts. 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.

#### Exception

Kitchen range hoods that are ducted to the outside with 6-inch or larger duct and not more than one 90-degree elbow or equivalent in the duct run.



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**C408.1.1 Building operations and maintenance information**

The building operations and maintenance documents shall be provided to the owner and shall consist of:

- manufacturers’ information,
- specifications and recommendations;
- programming procedures and data points;
- narratives;

and other means of illustrating to the owner how the building, equipment and systems are intended to be installed, maintained and operated.

Required regular maintenance actions for equipment and systems shall be clearly stated on a readily visible label.


The label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product

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**C408.2 Mechanical systems and service water-heating systems commissioning and completion requirements**

Prior to the final mechanical and plumbing inspections

Registered design professional or approved agency shall provide evidence of mechanical systems commissioning and completion in accordance with the provisions of this section



Construction document notes shall clearly indicate:

- Provisions for commissioning and completion requirements in accordance with this section

Copies of all documentation shall be given to the owner or owner’s authorized agent and made available to the code official upon request

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**C408.2 Mechanical systems and service water-heating systems commissioning and completion requirements**

Exceptions:

Mechanical systems and service water heater systems in buildings where the total mechanical equipment capacity is less than:

- 480,000 Btu/h cooling capacity and 600,000 Btu/h combined service water-heating and space-heating capacity.

Systems included in Section C403.3 (*Economizers*) that serve individual dwelling units and sleeping units



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### C408.2.1 Commissioning plan

A commissioning plan shall be developed by a registered design professional and include the following items:

- 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
- A listing of the specific equipment, appliances or systems to be tested and a description of the tests to be performed
- Functions to be tested including, but not limited to, calibrations and economizer controls
- Conditions under which the test will be performed. Testing shall affirm winter and summer design conditions and full outside air conditions
- Measurable criteria for performance



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### C408.3.1 Functional testing

Prior to passing final inspection, the registered design professional or approved agency shall provide evidence that the lighting control systems have been tested to ensure that control hardware and software are calibrated, adjusted, programmed and in proper working condition in accordance with the construction documents and manufacturer's instructions. Functional testing shall be in accordance with Sections C408.3.1.1 through C408.3.1.3 for the applicable control type.



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