

Ci by Climate Zone in Commercial Energy & Building Codes

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**Foam Plastic Applications
for Better Building**

Outline

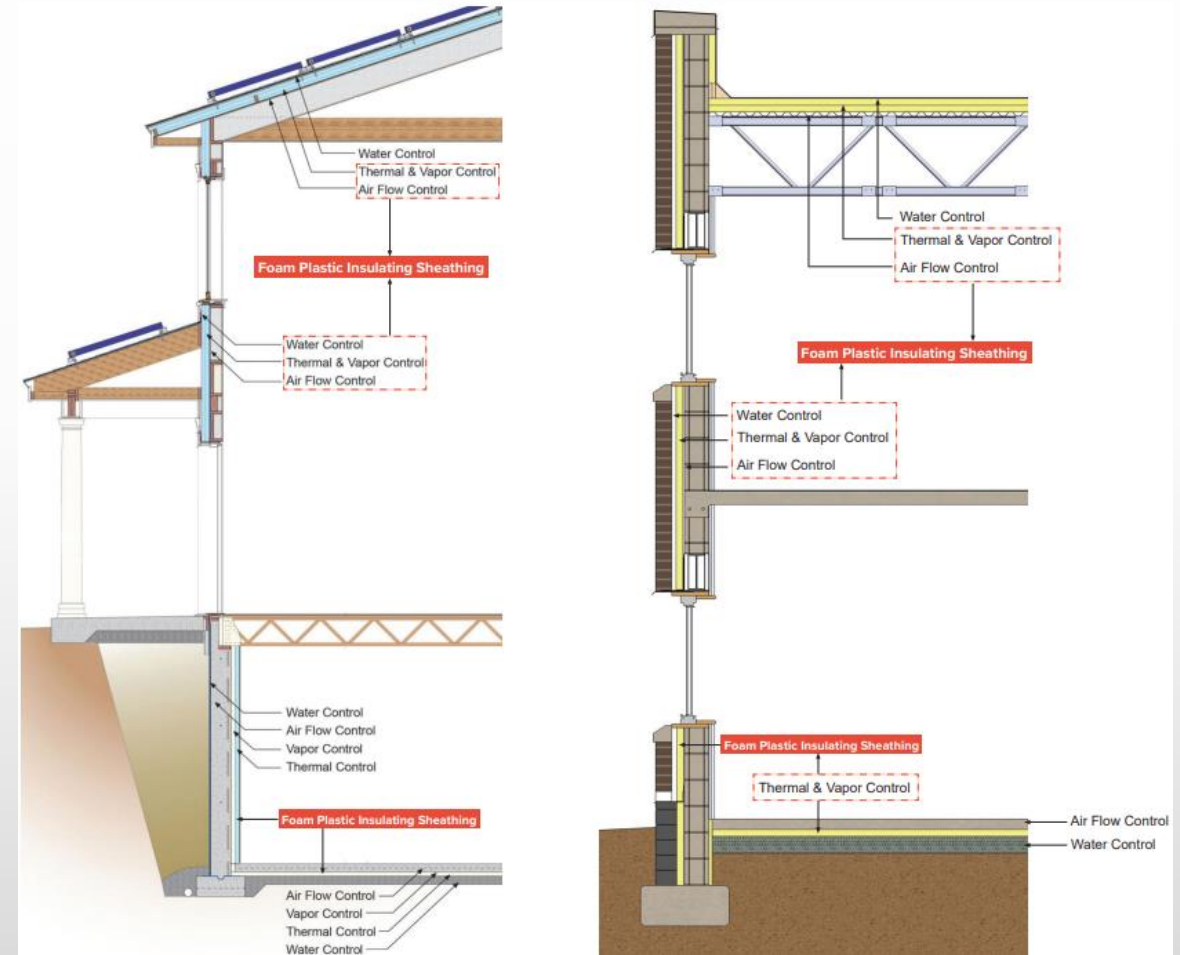
- The Building Thermal Envelope & Continuous Insulation (Ci)
- Commercial Energy Code
- Commercial Building Code
- Resources to help put it all together

What is the building thermal envelope (BTE)?

- The BTE separates the indoor from the outdoor environment.
- The BTE is an integrated system which also supports the design and function of other building systems.

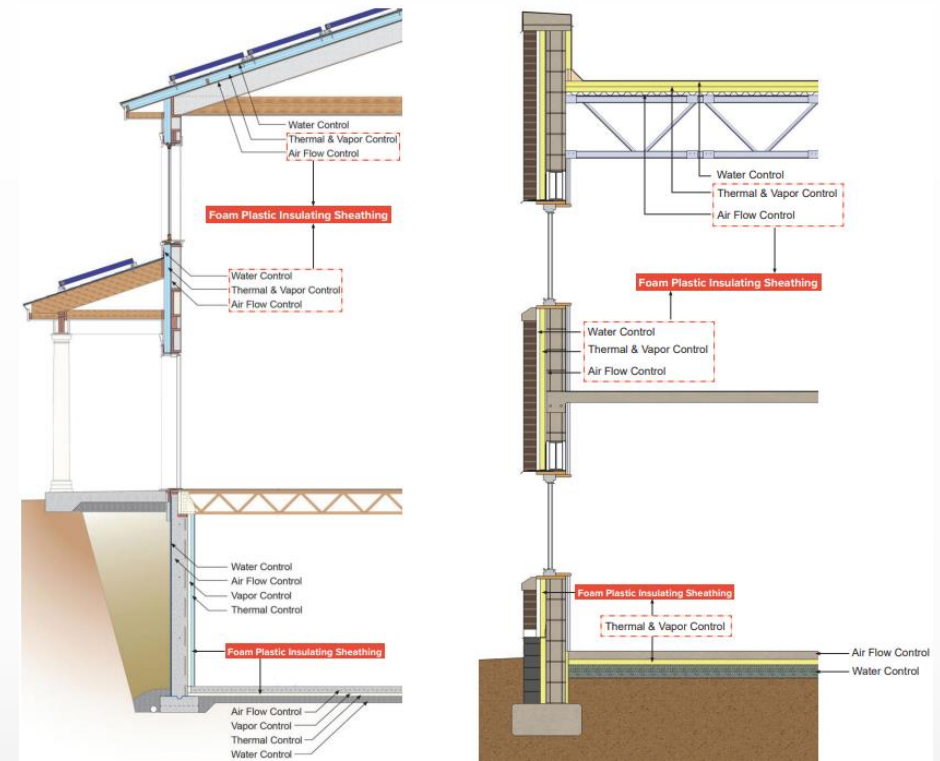
IECC Definition:

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



Why is the BTE important?

- Allows indoor environment (conditioned space) to be controlled for comfort, productivity, and health
- Major factor in sizing HVAC equipment
- Protects the structure and its contents from the outdoor environment (wind, rain, U/V radiation, temperature and humidity cycling, etc.)
- Determines the life-cycle operational cost, energy use (heating/cooling), and carbon footprint/handprint for the building.



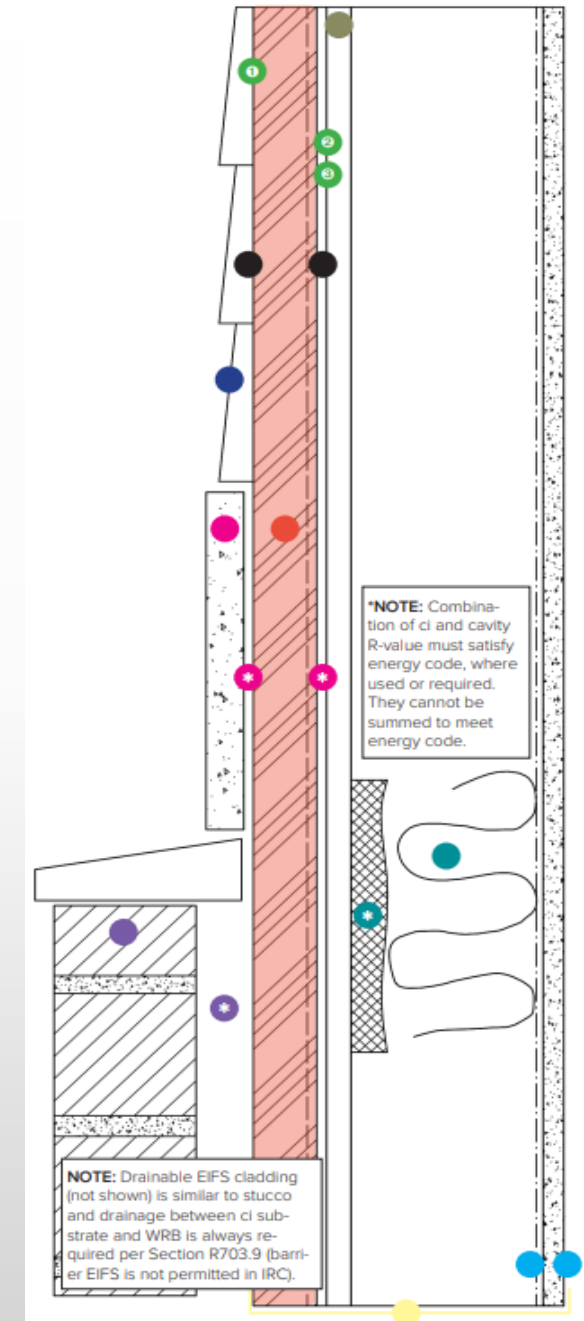
“Without a good building envelope, ...HVAC system and design actions become more difficult and costly, and uncertain in their effectiveness [to control the indoor environment].”

Source: ABTG RR No. 2006-01, p10,
<https://www.continuousinsulation.org/topical-library/healthy-buildings>

RESOURCE: <https://www.continuousinsulation.org/sustainability>

Functions of the BTE

- In addition to fire safety, structural safety, sound control, and durability the BTE must address the following control layers (functions):
 - **Water** control layers [cladding + continuous water-resistive barrier (WRB) + flashing to control water intrusion]
 - **Air** control layer [continuous air barrier (AB) to control air leakage]
 - **Thermal** control layer [continuity of thermal insulation to control heat loss/gain and surface temperatures]
 - **Water vapor** control layer [use of vapor retarders (VR) in coordination with insulation strategy and climate]
- All functions must be satisfied at least to the minimum extent required by the building and energy code.
- Some “layers” or materials can perform multiple functions depending on design approach and material properties



What is Ci?

- Two building thermal envelope insulation components are defined in the IECC & ASHRAE 90.1{}:
 - **CAVITY INSULATION.** Insulating material located between framing members.
 - **CONTINUOUS INSULATION (ci):** Insulation that is {uncompressed and} continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope.
- Various insulation material options for each, but with different performance attributes and functional capabilities for energy code and building code compliance.

Without Ci

Cavity insulation only

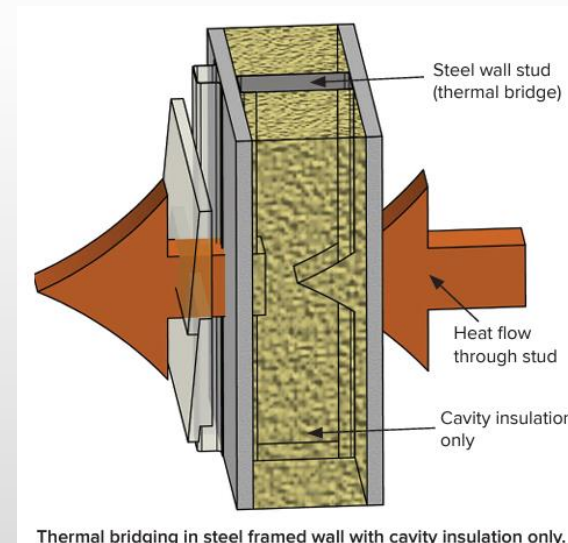


With Ci

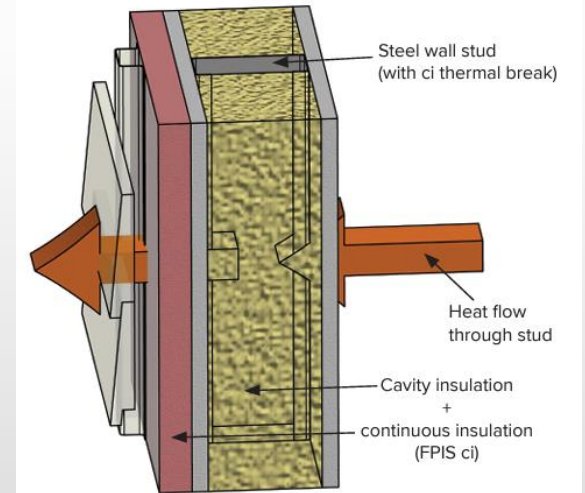
Cavity + Ci insulation (or Ci only)



Source: Dryvit/Dow



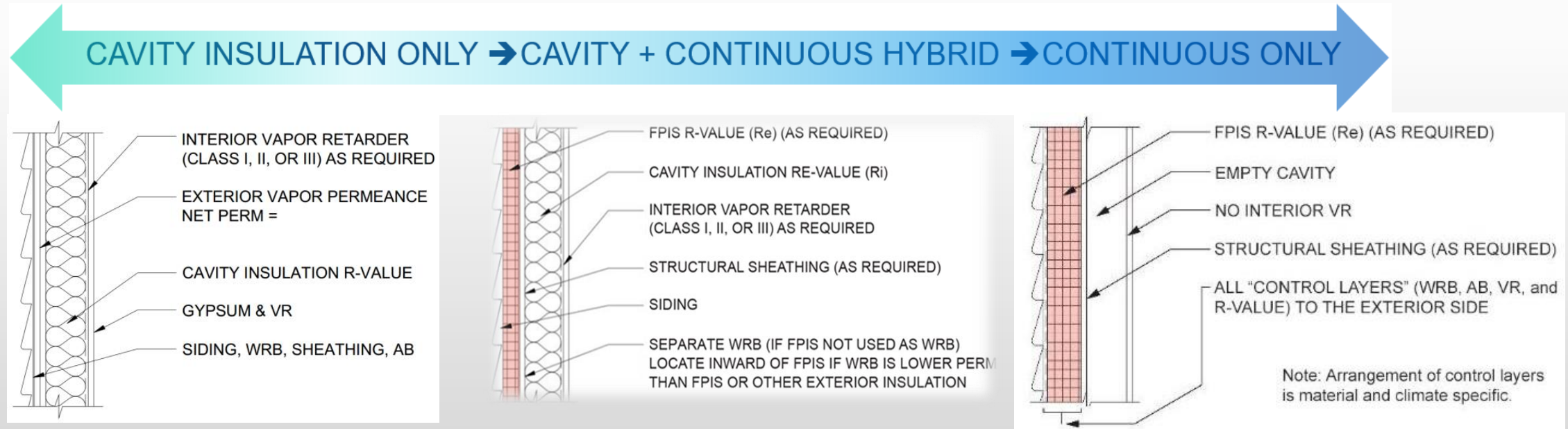
Thermal bridging in steel framed wall with cavity insulation only.



Thermal bridging in steel framed wall with cavity insulation and foam plastic insulating sheathing (FPIS) continuous insulation (ci).

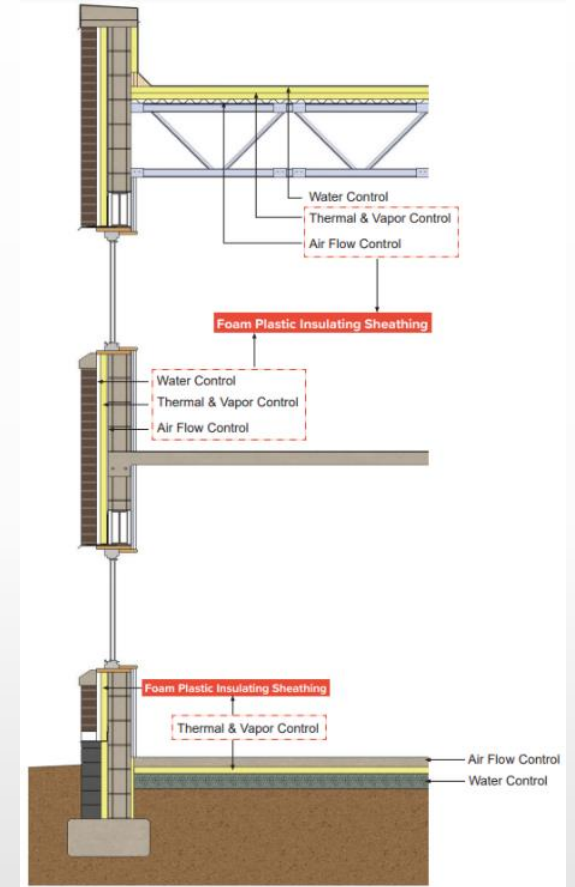
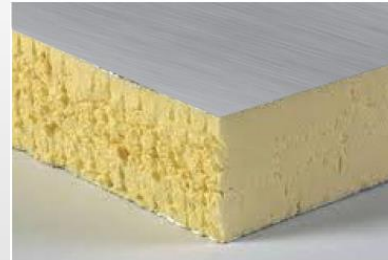
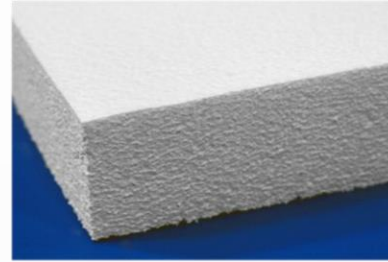
Typical Methods for Insulating *Exterior Walls*

1. **Cavity insulation only** (traditional method)
2. **Cavity insulation + continuous insulation** (common choice for modern code-compliant or high-performance walls)
3. **Continuous insulation (ci) only** (the “perfect wall” with all control layers to the exterior – maximum protection and thermal performance)

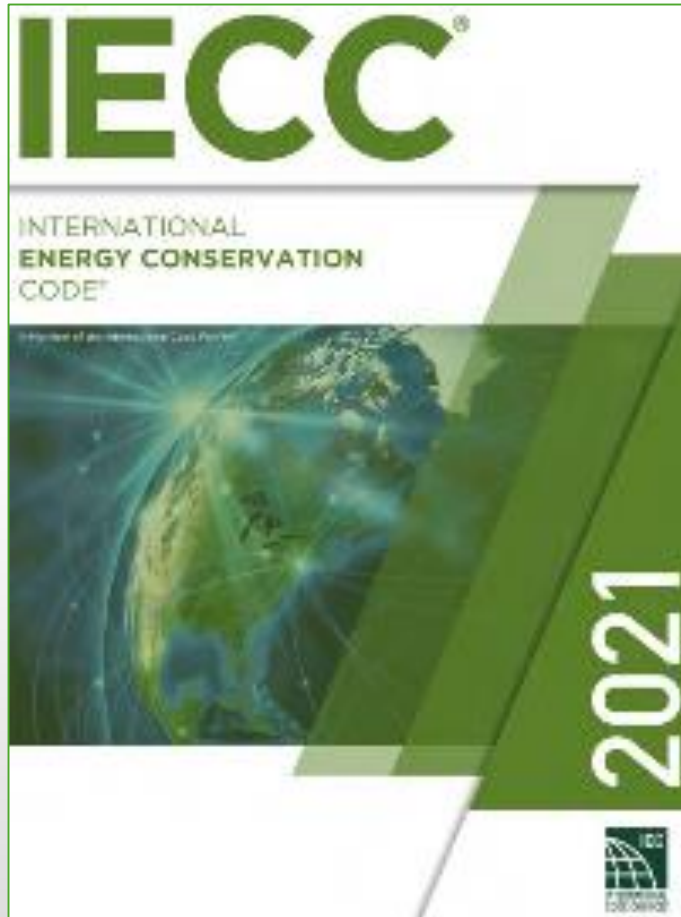


Multi-functional Capabilities of Ci

- EXAMPLE: Foam Plastic Insulating Sheathing (FPIS); i.e. “rigid board”
- Applications: walls, roofs, floors, and foundations (residential and commercial)
- BTE Functional Capabilities of FPIS:
 - IECC - Thermal Insulation (Ci)
 - IECC - Air barrier (AB)
 - IBC/IRC – Water vapor control/retarders (VR)
 - IBC/IRC – Water-resistive barrier (WRB) system
 - IBC/IRC – Foundation/footing frost protection
- More multi-functional capabilities =
 - ➔ satisfy multiple code requirements
 - ➔ simpler assemblies
 - ➔ optimized cost vs. performance



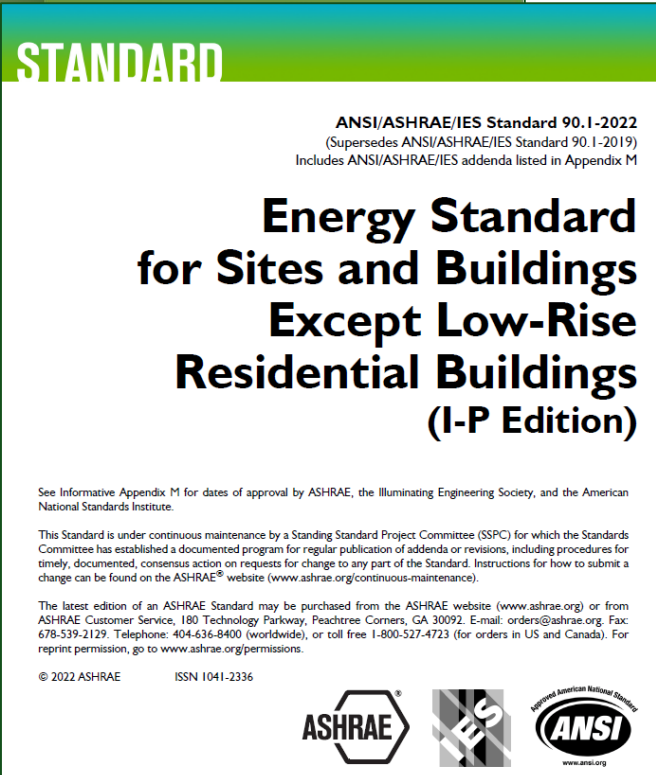
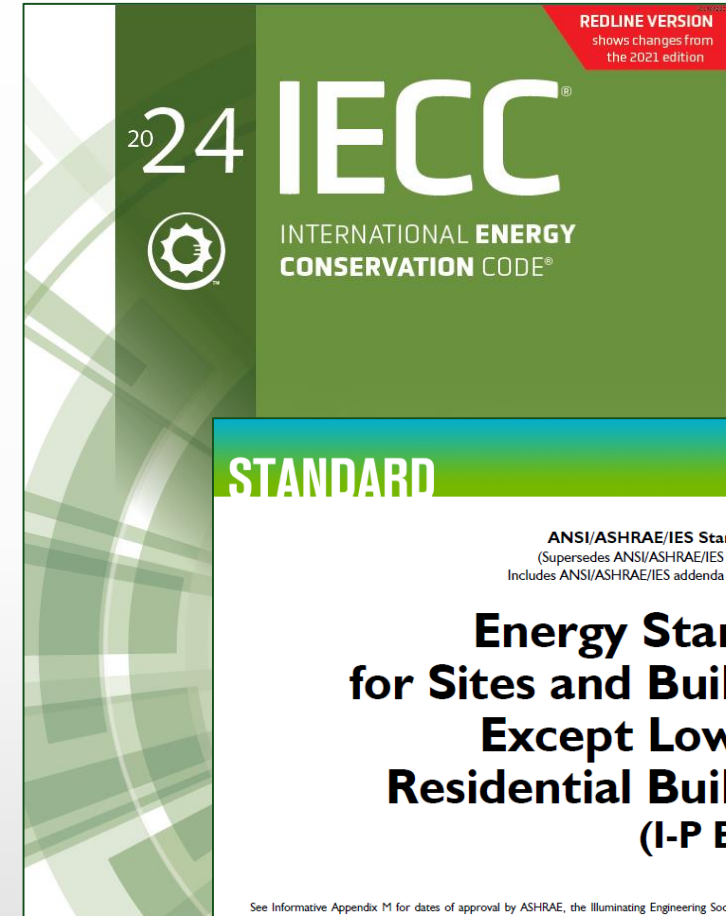
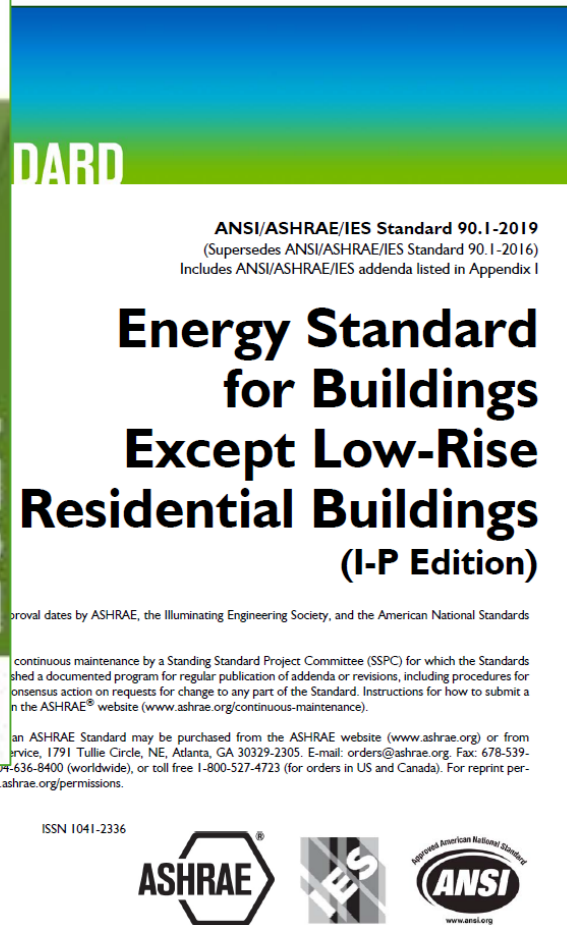
Commercial Energy Codes



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ISSN 1041-2336



See Informative Appendix M for dates of approval by ASHRAE, the Illuminating Engineering Society, and the American National Standards Institute.

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C301 Climate Zone & C302 Design Conditions

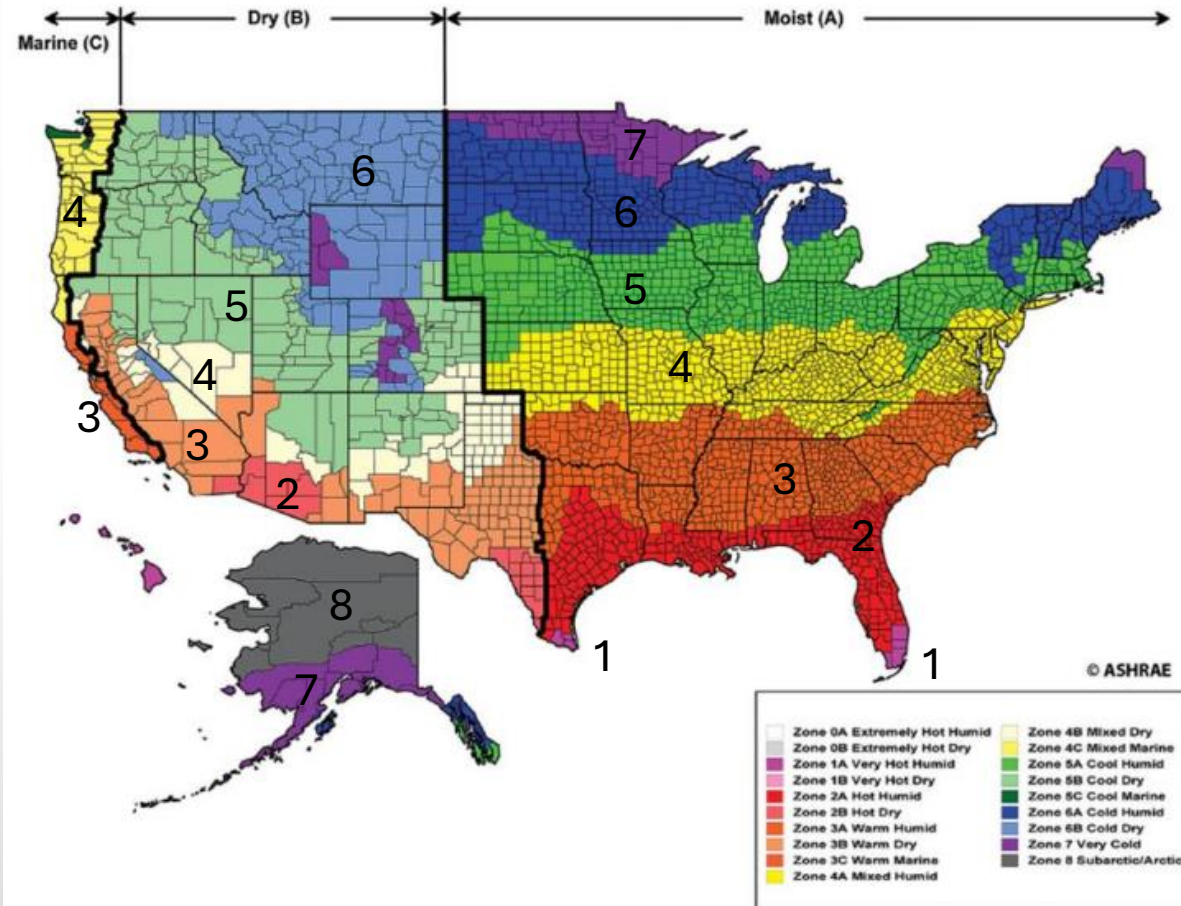


Figure 3.4.2. U.S. Climate Zone Map

(Source: ©ASHRAE www.ashrae.org Standard 169, 2013)

IECC Figure C301.1

SECTION C302 DESIGN CONDITIONS

C302.1 Interior design conditions. The interior design temperatures used for heating and cooling load calculations shall be a maximum of 72°F (22°C) for heating and minimum of 75°F (24°C) for cooling.

Choose your compliance path

- **C401.2.1 International Energy Conservation Code**

1. Prescriptive Compliance (Sections C402 – C406 and C408)

For BTE per C402, the following choices:

- Prescriptive minimum R-value insulation components
- Prescriptive maximum assembly U-factor
- Prescriptive component performance trade-offs (i.e. COMcheck)
- + Additional Efficiency Credits (C408)

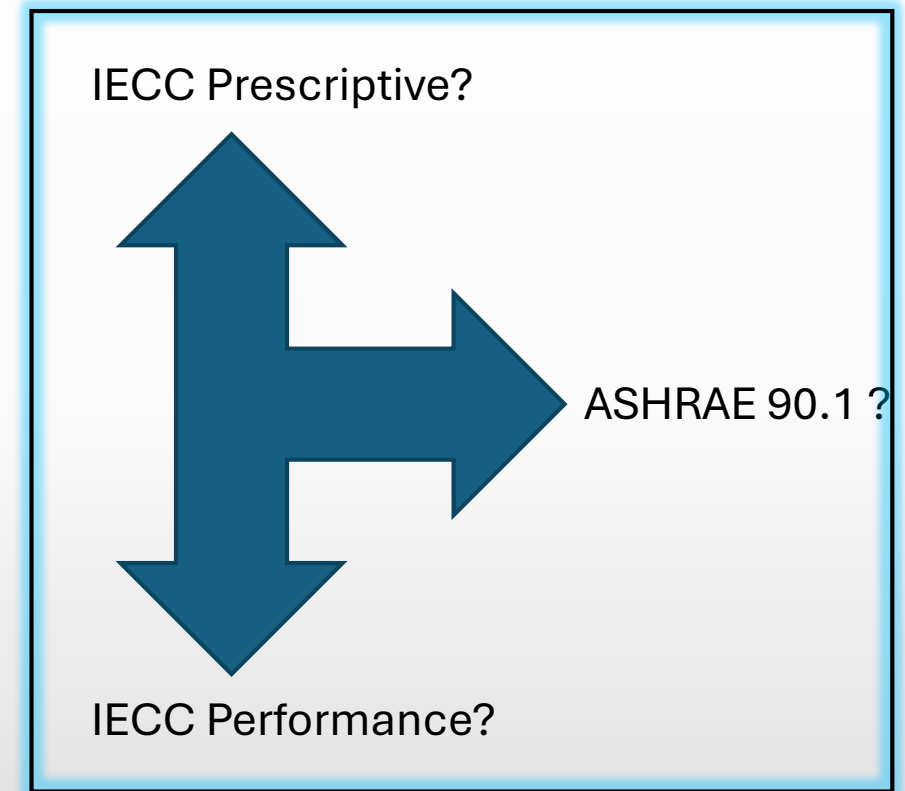
OR

2. Total Building Performance (Section C407)

OR

- **C401.2.2 ASHRAE 90.1**

- Also has prescriptive and performance paths for compliance



Opaque Envelope – Minimum R-value Method

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD^a

CLIMATE ZONE	0 AND 1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8		
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	
Roofs																	
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci	
Metal buildings ^b	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-25 + R-11 + R-11 LS	R-25 + R-11 + R-11 LS	
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-60	R-60	R-60	R-60	
Walls, above grade																	
Mass ^f	R-5.7ci ^c	R-5.7ci ^c	R-5.7ci ^c	R-7.6ci	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal building	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-17ci	R-13 + R-19.5ci	R-13 + R-19.5ci	R-13 + R-19.5ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-10ci	R-13 + R-10ci	R-13 + R-10ci	R-13 + R-10ci	R-13 + R-12.5ci	R-13 + R-12.5ci	R-13 + R-12.5ci	R-13 + R-15.6ci	R-13 + R-18.8ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci
Walls, below grade																	
Below-grade wall ^d	NR	NR	NR	NR	NR	NR	R-7.5ci	R-10ci	R-7.5ci	R-10ci	R-10ci	R-10ci	R-15ci	R-15ci	R-15ci	R-15ci	R-15ci
Floors																	
Mass ^e	NR	NR	R-6.3ci	R-8.3ci	R-10ci	R-10ci	R-14.6ci	R-14.6ci	R-14.6ci	R-16.7ci	R-16.7ci	R-16.7ci	R-20.9ci	R-20.9ci	R-23ci	R-23ci	R-23ci
Joist/framing	R-13	R-13	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-38	R-38	R-38	R-38	R-38	R-38
Slab-on-grade floors																	
Unheated slabs	NR	NR	NR	NR	NR	R-10 for 24" below	R-15 for 24" below	R-15 for 24" below	R-15 for 24" below	R-20 for 24" below	R-20 for 24" below	R-20 for 24" below	R-20 for 48" below	R-20 for 48" below	R-20 for 48" below	R-20 for 48" below	R-25 for 48" below
Heated slabs ^g	R-7.5 for 12" below + R-5 full slab	R-7.5 for 12" below + R-5 full slab	R-7.5 for 12" below + R-5 full slab	R-7.5 for 12" below + R-5 full slab	R-10 for 24" below + R-5 full slab	R-10 for 24" below + R-5 full slab	R-15 for 24" below + R-5 full slab	R-15 for 24" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab

2024 IECC – added equivalent prescriptive R-value options for steel and wood framed walls...

TABLE C402.1.3
OPAQUE BUILDING THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD^a

CLIMATE ZONE	0 AND 1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
Walls, above grade																
Metal framed ^{h,i}	R-13 + R-5ci R-0 + R-10ci or R-13 + R-5ci or R-20 + R-3.8ci	R-13 + R-5ci R-0 + R-10ci or R-13 + R-5ci or R-20 + R-3.8ci	R-13 + R-5ci R-0 + R-10ci or R-13 + R-5ci or R-20 + R-3.8ci	R-13 + R-7.5ci R-0 + R-12.6ci or R-13 + R-7.5ci or R-20 + R-6.3ci	R-13 + R-7.5ci R-0 + R-12.6ci or R-13 + R-7.5ci or R-20 + R-6.3ci	R-13 + R-7.5ci R-0 + R-12.6ci or R-13 + R-7.5ci or R-20 + R-6.3ci	R-13 + R-7.5ci R-0 + R-12.6ci or R-13 + R-7.5ci or R-20 + R-6.3ci	R-13 + R-7.5ci R-0 + R-12.6ci or R-13 + R-7.5ci or R-20 + R-6.3ci	R-13 + R-10ci R-0 + R-15.2ci or R-13 + R-10ci or R-20 + R-9ci	R-13 + R-10ci R-0 + R-15.2ci or R-13 + R-10ci or R-20 + R-9ci	R-13 + R-12.5ci R-0 + R-17.3ci or R-13 + R-12.5ci or R-20 + R-11ci	R-13 + R-12.5ci R-0 + R-17.3ci or R-13 + R-12.5ci or R-20 + R-11ci	R-13 + R-12.5ci R-0 + R-17.3ci or R-13 + R-12.5ci or R-20 + R-11ci	R-13 + R-15.6ci R-0 + R-21ci or R-13 + R-15.6ci or R-20 + R-14.3ci	R-13 + R-18.8ci R-0 + R-24ci or R-13 + R-18.8ci or R-20 + R-17.5ci	R-13 + R-18.8ci R-0 + R-24ci or R-13 + R-18.8ci or R-20 + R-17.5ci
Wood framed and other ^{h,i}	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-27.5ci or R-13 + R-18.8ci or R-20 + R-14ci	R-0 + R-27.5ci or R-13 + R-18.8ci or R-20 + R-14ci

h. The first value is cavity insulation; the second value is continuous insulation. Therefore, “R-0 + R-12ci” means R-12 continuous insulation and no cavity insulation; “R-13 + R-3.8ci” means R-13 cavity insulation and R-3.8 continuous insulation; “R-20” means R-20 cavity insulation and no continuous insulation. R-13, R-20 and R-27 cavity insulation, as used in this table, apply to a nominal 4-inch, 6-inch and 8-inch-deep wood or cold-formed steel stud cavities, respectively.

i. Where the required R-value in **Table C402.1.3** is met by using continuous insulation such that cavity insulation is not required, the R-value is applicable to any wall framing spacing.

Also added new Table C402.1.2.1.7 – effective U-factors / R-values for spandrel panels (opaque wall)

Summary of IECC Prescriptive R-value & U-factor Requirements for Walls

2021 IECC - Tables C402.1.3 & C402.1.4; 2024 IECC - Tables C402.1.2 & C402.1.3

Climate Zone	Building Use	Mass	Metal Framed			Wood Framed				
		2018/2021/2024 IECC	2018 IECC	2021 IECC	2024 IECC	2018 IECC	2021 IECC	2024 IECC		
0 and 1	All other	R-5.7ci (U-0.151)	R13+5ci (U-0.077)	R13+5ci (U-0.077)	R0+10ci or R13+5ci or R20+3.8ci (U-0.077)	R13+3.8ci or R20 (U-0.064)	R13+3.8ci or R20 (U-0.064)	R0+12ci or R13+3.8ci or R20 (U-0.064)		
	Group R									
2	All other									
	Group R	R-7.6ci (U-0.123)	R13+7.5ci (U-0.064)	R13+7.5ci (U-0.064)	R0+12.6ci or R13+7.5ci or R20+6.3ci (U-0.064)					
3	All other									
	Group R	R-9.5ci (U-0.104)								
4 Except Marine	All other	R-11.4ci (U-0.090)							R13+10ci (U-0.055)	R0+15.2ci or R13+10ci or R20+9ci (U-0.055)
	Group R									
5 and Marine 4	All other	R-13.3ci (U-0.080)				R13+12.5ci (U-0.049)	R0+17.3ci or R13+12.5ci or R20+11ci (U-0.049)			
	Group R									
6	All other			R-15.2ci (U-0.071)	R13+15.6ci (U-0.052)			R13+15.6ci (U-0.042)	R0+21ci or R13+15.6ci or R20+14.3ci (U-0.042)	
	Group R									
7	All other	R13+17.5ci (U-0.045)			R13+18.8ci (U-0.037)	R0+24ci or R13+18.8ci or R20+17.5ci (U-0.037)				
	Group R									
8	All other	R-25ci (U-0.037)	R13+7.5ci (U-0.064)	R13+18.8ci (U-0.037)	R0+24ci or R13+18.8ci or R20+17.5ci (U-0.037)	R13+15.6ci or R20+10ci (U-0.036)	R13+18.8ci (U-0.032)	R0+27.5ci or R13+18.8ci or R20+14ci (U-0.032)		
	Group R									

Opaque Envelope – R-value Method

- Example application of Table C402.1.3 for Climate Zone 5

- Assume: Office building (use “all other” category, not Group R)

- Roof (“insulation entirely above deck”): R-30
- Above-grade walls: R-13+10ci (“metal framed” = cold-formed steel)
- Foundation (below grade walls): R-7.5ci
- Floors (over unconditioned space): R-30 (steel frame)
R-14.6ci (mass floor)
- Floor (slab on grade): R-15 for 24” below

F-factor equivalent = R-10 for 36” below

2024 IECC:
R-0 + 15.2ci
R-13 + 10ci
R-20 + 9ci

CLIMATE ZONE	5 AND MARINE 4	
	All other	Group R
Insulation entirely above roof deck	R-30ci	R-30ci
Metal buildings ^b	R-19 + R-11 LS	R-19 + R-11 LS
Attic and other	R-49	R-49
Mass ^f	R-11.4ci	R-13.3ci
Metal building	R-13 + R-14ci	R-13 + R-14ci
Metal framed	R-13 + R-10ci	R-13 + R-10ci
Wood framed and other	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci
Below-grade wall ^d	R-7.5ci	R-10ci
Mass ^e	R-14.6ci	R-16.7ci
Joist/framing	R-30	R-30
Unheated slabs	R-15 for 24” below	R-20 for 24” below
Heated slabs ^e	R-15 for 36” below+ R-5 full slab	R-15 for 36” below+ R-5 full slab

Opaque Envelope – Maximum U-, C-, F-Factor Method

TABLE C402.1.4
OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, U-FACTOR METHOD^{a, b}

CLIMATE ZONE	0 AND 1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	U-0.048	U-0.039	U-0.039	U-0.039	U-0.039	U-0.039	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.028	U-0.028	U-0.028	U-0.028
Metal buildings	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.031	U-0.029	U-0.029	U-0.029	U-0.026	U-0.026
Attic and other	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.017	U-0.017	U-0.017	U-0.017
Walls, above grade																
Mass ^e	U-0.151	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	U-0.071	U-0.037	U-0.037
Metal building	U-0.079	U-0.079	U-0.079	U-0.079	U-0.079	U-0.052	U-0.052	U-0.050	U-0.050	U-0.050	U-0.050	U-0.050	U-0.044	U-0.039	U-0.039	U-0.039
Metal framed	U-0.077	U-0.077	U-0.077	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.055	U-0.055	U-0.049	U-0.049	U-0.049	U-0.042	U-0.037	U-0.037
Wood framed and other ^c	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.032	U-0.032
Walls, below grade																
Below-grade wall ^c	C-1.140 ^e	C-1.140 ^e	C-1.140 ^e	C-1.140 ^e	C-1.140 ^e	C-1.140 ^e	C-0.119	C-0.092	C-0.119	C-0.092	C-0.092	C-0.063	C-0.063	C-0.063	C-0.063	C-0.063
Floors																
Mass ^d	U-0.322 ^e	U-0.322 ^e	U-0.107	U-0.087	U-0.074	U-0.074	U-0.057	U-0.051	U-0.057	U-0.051	U-0.051	U-0.051	U-0.042	U-0.042	U-0.038	U-0.038
Joist/framing	U-0.066 ^e	U-0.066 ^e	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027
Slab-on-grade floors																
Unheated slabs	F-0.73 ^e	F-0.73 ^e	F-0.73 ^e	F-0.73 ^e	F-0.73 ^e	F-0.54	F-0.52	F-0.52	F-0.52	F-0.51	F-0.51	F-0.434	F-0.51	F-0.434	F-0.434	F-0.424
Heated slabs ^f	F-0.69	F-0.69	F-0.69	F-0.69	F-0.66	F-0.66	F-0.62	F-0.62	F-0.62	F-0.62	F-0.62	F-0.602	F-0.602	F-0.602	F-0.602	F-0.602
Opaque doors																
Nonswinging door	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31
Swinging door ^h	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37
Garage door < 14% glazing ⁱ	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31

Example use of U-factor next slide

Opaque Envelope – U-, C-, F-Factor Method

- Example cold-formed steel frame wall
U-factor calculation (C402.1.4.2, Eq 4-1):

NEW 2024: Deletes Eq 4-1 and references AISI S250 standard. But, standard only addresses studs at layout spacing (omits tracks and headers and built-up studs). Significantly underestimates actual wall U-factor. Suggest retaining Eq 4-1 and limit AISI S250 for use on tall curtain walls without framing other than layout studs.

C402.1.4.2 Thermal resistance of cold-formed steel walls. U-factors of walls with cold-formed steel studs shall be permitted to be determined in accordance with Equation 4-1.

$$U = 1/[R_s + (ER)] \quad (\text{Equation 4-1})$$

where:

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

ER = The effective R-value of the cavity insulation with steel studs as specified in Table C402.1.4.2.

TABLE C402.1.4.2
EFFECTIVE R-VALUES FOR STEEL STUD WALL ASSEMBLIES

NOMINAL STUD DEPTH (inches)	SPACING OF FRAMING (inches)	CAVITY R-VALUE (insulation)	CORRECTION FACTOR (F_c)	EFFECTIVE R-VALUE (ER) (Cavity R-Value $\times F_c$)
3 1/2	16	13	0.46	5.98
		15	0.43	6.45
3 1/2	24	13	0.55	7.15
		15	0.52	7.80
6	16	19	0.37	7.03
		21	0.35	7.35
6	24	19	0.45	8.55
		21	0.43	9.03
8	16	25	0.31	7.75
	24	25	0.38	9.50

	3-1/2" Stud	6" Stud	Any stud size
	16"oc	16"oc	Any spacing
	13+10ci	20+9ci	0+15.2ci
Cavity Rated R-value	13	20	0.9
Correction Factor (F_c)	0.46	0.36	1
Core Wall Eff. R-value (ER)	5.98	7.2	0.9
Ci R-value	10	9	15.2
5/8" Gyp (interior)	0.56	0.56	0.56
5/8" Gyp (exterior)	0.56	0.56	0.56
Stucco	0.08	0.08	0.08
Interior air film	0.68	0.68	0.68
Exterior air film	0.17	0.17	0.17
Rs	12.05	11.05	17.25
U-Factor	0.055	0.055	0.055
Effective R-value	18.0	18.3	18.2

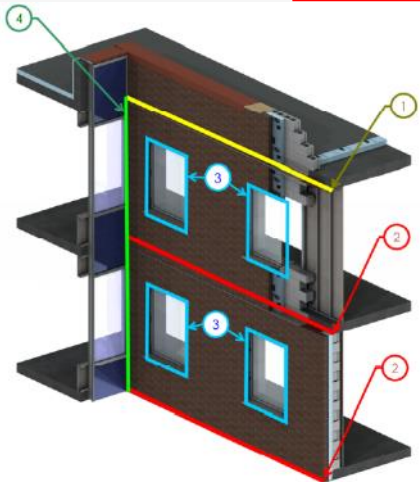
U-factor per Eq 4-1 \leq U-factor 0.055 required by Table C402.1.4 (OK)



Opaque Envelope – R-value Method

- Again, definitions matter...

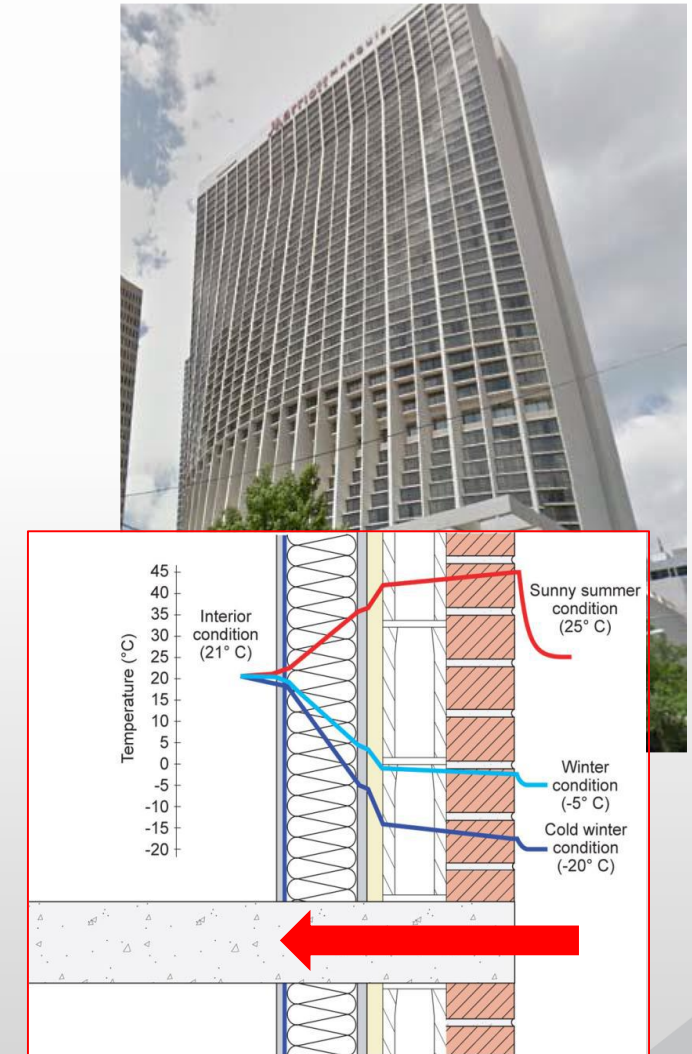
WALL, ABOVE-GRADE. A wall associated with the *building thermal envelope* that is more than 15 percent above grade and is on the exterior of the building or any wall that is associated with the *building thermal envelope* that is not on the exterior of the building. This includes, but is not limited to, between-floor spandrels, peripheral edges of floors, roof knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and skylight shafts.



Source: BC Hydro BETB Guide, Morrison Hershfield LTD

NOTE: Thermal bridging at assembly intersections (e.g., wall-floor, wall-roof, window-wall, etc.) must be addressed to avoid unaccounted heat flows that can significantly impact performance of the building thermal envelope.

NEW 2024 IECC: Prescriptive and performance-based thermal bridging provisions in C402.7 & C407 enable compliance with this definition; similar requirements in ASHRAE 90.1-2022 Section 5.5.5, Chapter 12 & Appendix G (modeling), and Appendix A.10. [CZ 0-3 exempted]

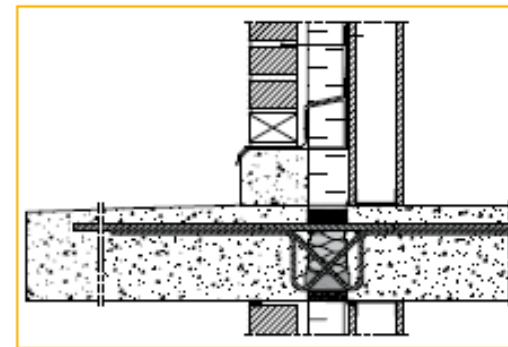


Examples of Mitigated Linear Thermal Bridges (Balconies)



Suspended and separately supported balconies with shear tab or offset shelf-angle point connection to building

OR...

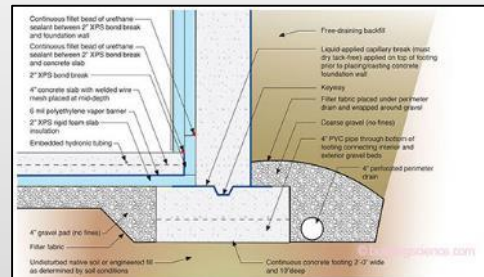
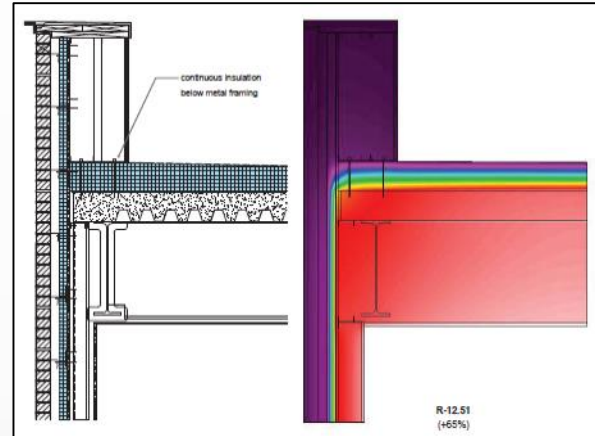
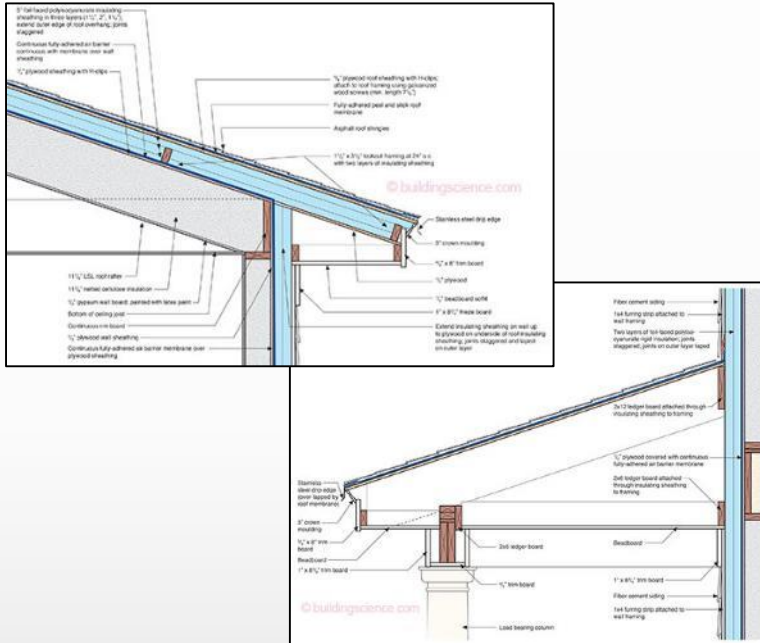


Cantilevered Balcony Structural Thermal Break

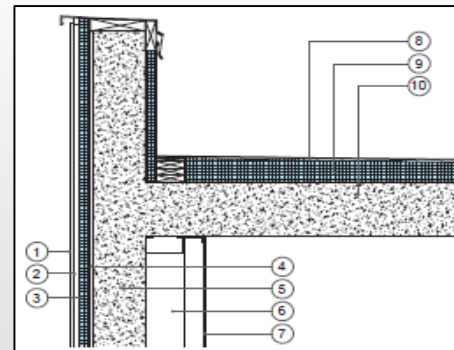
Source: Google search

More Examples of Mitigated Linear Thermal Bridges

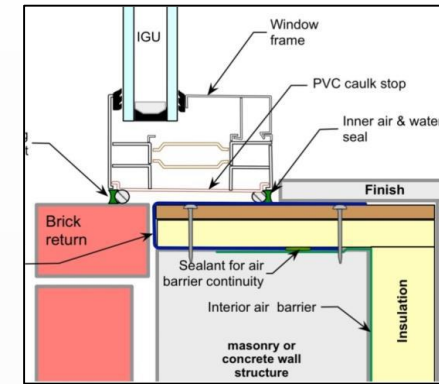
(non-exhaustive “commodity” details)



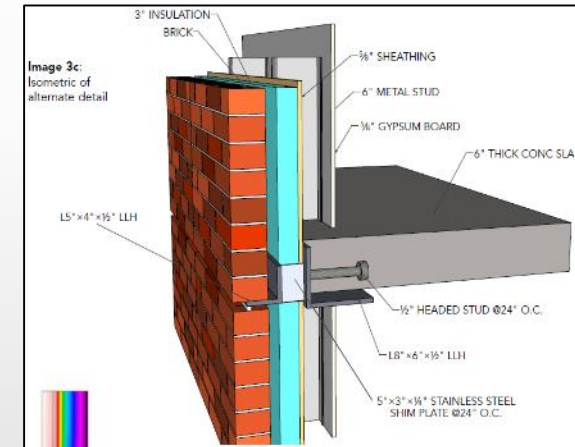
Example Details from BSI-081: Zeroing In (J. Lstiburek, Building Science Corp) as used on NIST NZERTF Project



INSULATED PARAPET DETAILS (Payette/AIA report)



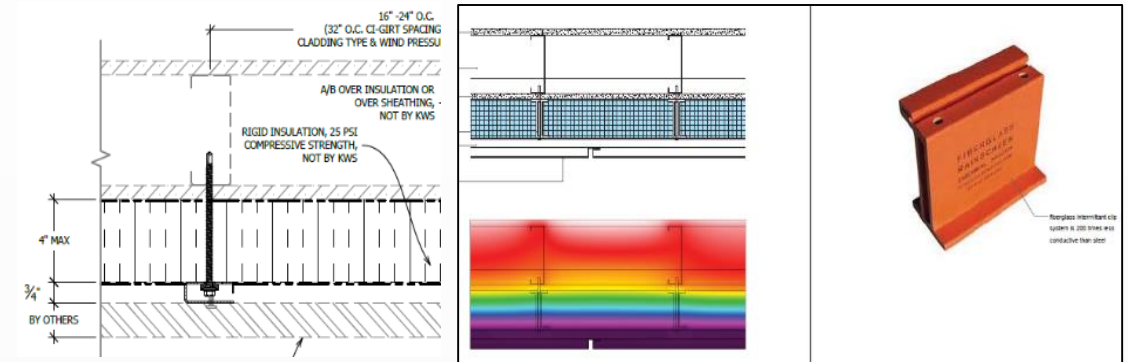
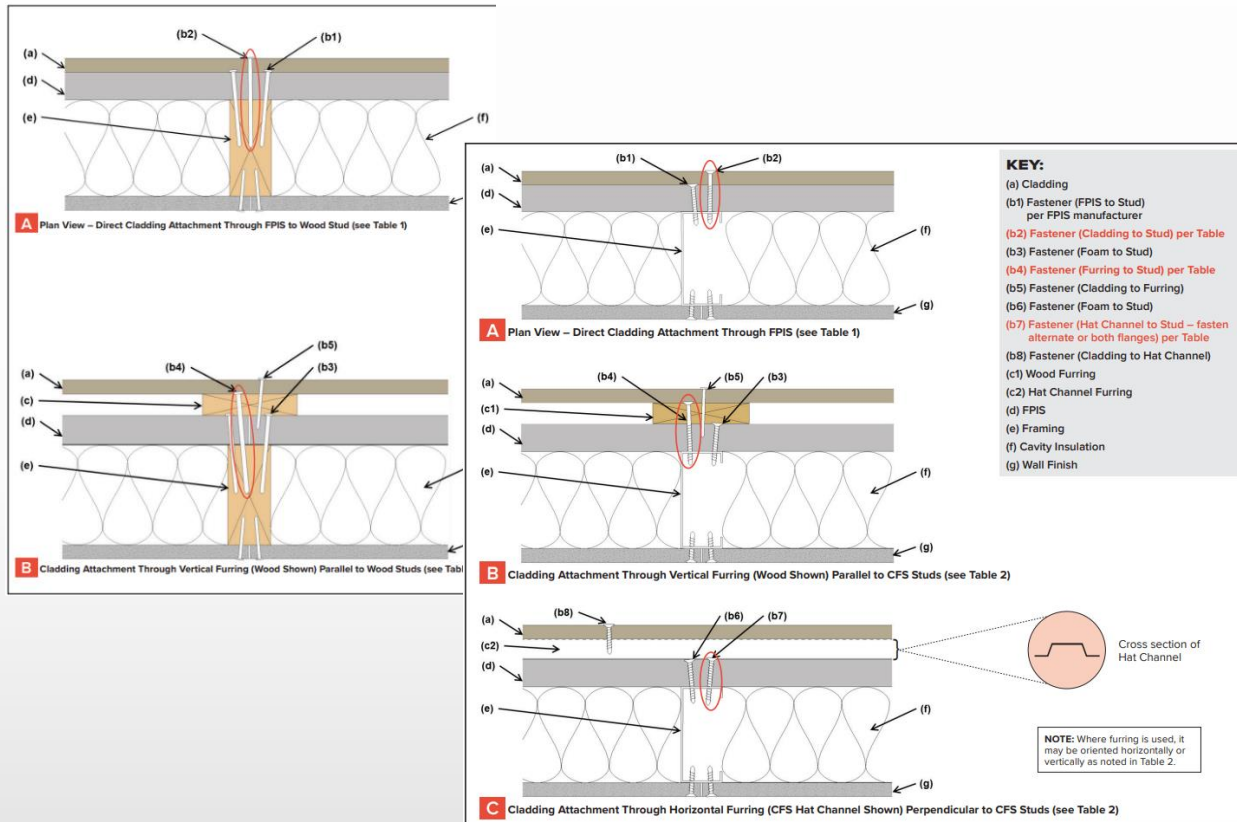
INSULATED WINDOW ROUGH OPENING DETAIL (USACE report)



OFFSET SHELF ANGLE (AISC/SEI article)

NOTE: Coordinate detailing at floor-wall and fenestration with NFPA 285 tested assemblies and approved engineering analysis details (applies to Type I-IV buildings, not Type V wood frame).

Cladding Connections and Supports



Low thermal conductivity furring/cladding/ledger supports

Sources: Payette/AIA report and product info from Google search

See 2021 IBC Section 2603.12 and .13 (2024 IBC Section 1404.5) for fastening cladding or furring through FPIS ci. Z-furring penetrating through exterior insulation is cavity insulation – doesn't meet continuous insulation definition. See also: <https://www.continuousinsulation.org/cladding-connections>

GOAL: Avoid continuous linear cladding supports like metal Z-furring penetrating *continuous insulation* which would not meet building and energy code definition for ci; instead, use “point” connections through continuous insulation to offset furring (or fasten cladding directly through FPIS ci to framing).

2021 IECC C402.5 Air Leakage

- C402.5.1 Air barriers
 - C402.5.1.1 Air barrier construction
 - C402.5.1.2 Air barrier compliance
 - C402.5.1.3 Materials
 - C402.5.1.4 Assemblies
 - C402.5.1.5 Verification
- C402.5.2 Dwelling and sleeping unit enclosure testing
- C402.5.3 Building thermal envelope testing
- C402.5.4 Air leakage of fenestration
- Other related requirements (Section C402.5.5 – C402.5.11)

NEW for 2024 IECC:

- Re-organization of requirements
- Testing expanded to cover more buildings
- Air leakage rate decreased from 0.40 cfm/ft² to 0.35 cfm/ft² @ 75Pa
- Exception for failed test allowing up to 0.60 cfm/ft² is reduced to 0.45 cfm/ft²
- For Group R-2 and I-1 buildings, it changed from 0.30 cfm/ft² to 0.27 cfm/ft² @ 50 Pa

2021 IECC - C402.5 Air Leakage Compliance

- **PRESCRIPTIVE:** Comply with Sections C402.5.1 through C402.5.11.1 (basically the entirety of C402.5)
OR
- **PERFORMANCE:** Tested in accordance with Section C402.5.2 or C402.5.3
 - Including requirements of C402.5.7, C402.5.8, and C402.5.9
- Testing can always be done, if specified, but it is now required in certain conditions for 2021* and 2024 IECC.
(* *subject to interpretation*)

C402.5 Air leakage—thermal envelope. The *building thermal envelope* shall comply with Sections C402.5.1 through Section C402.5.11.1, or the building *thermal envelope* shall be tested in accordance with Section C402.5.2 or C402.5.3. Where compliance is based on such testing, the building shall also comply with Sections C402.5.7, C402.5.8 and C402.5.9.



Source: <https://www.swinter.com/>

When is air leakage testing required? (2021 IECC)

- **Section C402.5.1.2** - Compliance (testing vs. air barrier install/inspection) varies by building occupancy group with exceptions based on climate zone and building size (**FYI - ASHRAE 90.1-2019 has same maximum leakage rate of 0.40 cfm/ft², but requires testing in nearly all cases**)
- Table below based on interpretation of C402.5 that testing was not intended to be optional and is required in many cases per specific requirements in C402.5.1.2 with exceptions:

Building Occupancy	Testing Requirements	Exceptions by Building Size and Climate Zone	Climate Zones where testing required
Group R & I	Section C402.5.2 (max ALR=0.30 cfm/ft ² @ 50Pa)	Any Size: 2B, 3C, and 5C	0, 1, 2A, 3A/B, 4, 5A/B, 6, 7, 8
All Other Groups	Section C402.5.3 (max ALR = 0.40 cfm/ft ² @ 75 Pa)	SF ≤ 5,000: 2B, 3B, 3C and 5C	0, 1, 2A, 3A, 4, 5A/B, 6, 7, 8
		5,000 < SF < 50,000: 0, 1, 2, 3, 4B/C and 5B/C	4A, 5A, 6, 7, 8
		SF ≥ 50,000: 0B, 1, 2, 3B/C, 4B/C, and 5C	0A, 3A, 4A, 5A/B, 6, 7, 8
Any building where testing is excepted above and not otherwise specified	Comply with Sections C402.5.1.3, C402.5.1.4, and C402.5.1.5 (materials, assemblies, and inspection/verification) – These are not required when testing, but often done to ensure achieving test requirement.		

When is air leakage testing required? (2024 IECC)

- **Section C402.6.2** – Max air leakage rate reduced to 0.35 cfm/ft² @ 75 Pa with fewer exceptions to compliance by whole building testing:
 - Climate Zone 2B exempted from testing or any air barrier installation/inspection requirement for all buildings.
 - Buildings (other than Group I and R) > 25,000 sf in CZ 0-4 that comply with periodic field inspection/verification of C402.6.2.3 are exempted from testing
 - Group I-1 and R-2 buildings are permitted to do dwelling/sleeping unit testing method (C402.6.2.2) at ALR = 0.27 cfm/ft² @ 50 Pa in lieu of whole building testing (C402.6.2.1)
- ASHRAE 90.1-2022, Section 5.4.3.1:
 - Only single wythe CMU buildings exempt in CZ 2B
 - Buildings < 10,000 sf → whole building test (to same leakage rate as IECC)
 - Buildings ≥ 10,000 sf → either test or do periodic field inspection/verification

Air Barrier Tips

- Key to good air barrier system is sealing of joints, gaps, penetrations, and transitions.
- Best practice is dual air barrier to encapsulate air-permeable insulation (if used) – not required by code.
- Multi-functional Ci considerations
 - Most foam sheathing products meet air barrier material requirements (air permeability test)
 - Check manufacturer data/label
 - Some are “deemed-to-comply” (e.g., XPS and Polyiso min. ½” thick) per IECC, but not in ASHRAE 90.1
 - Tape foam sheathing joints per manufacturer instructions (also required if the FPIS ci is used as the WRB system)
 - Integrate with air/water control at fenestration and roof/foundation.

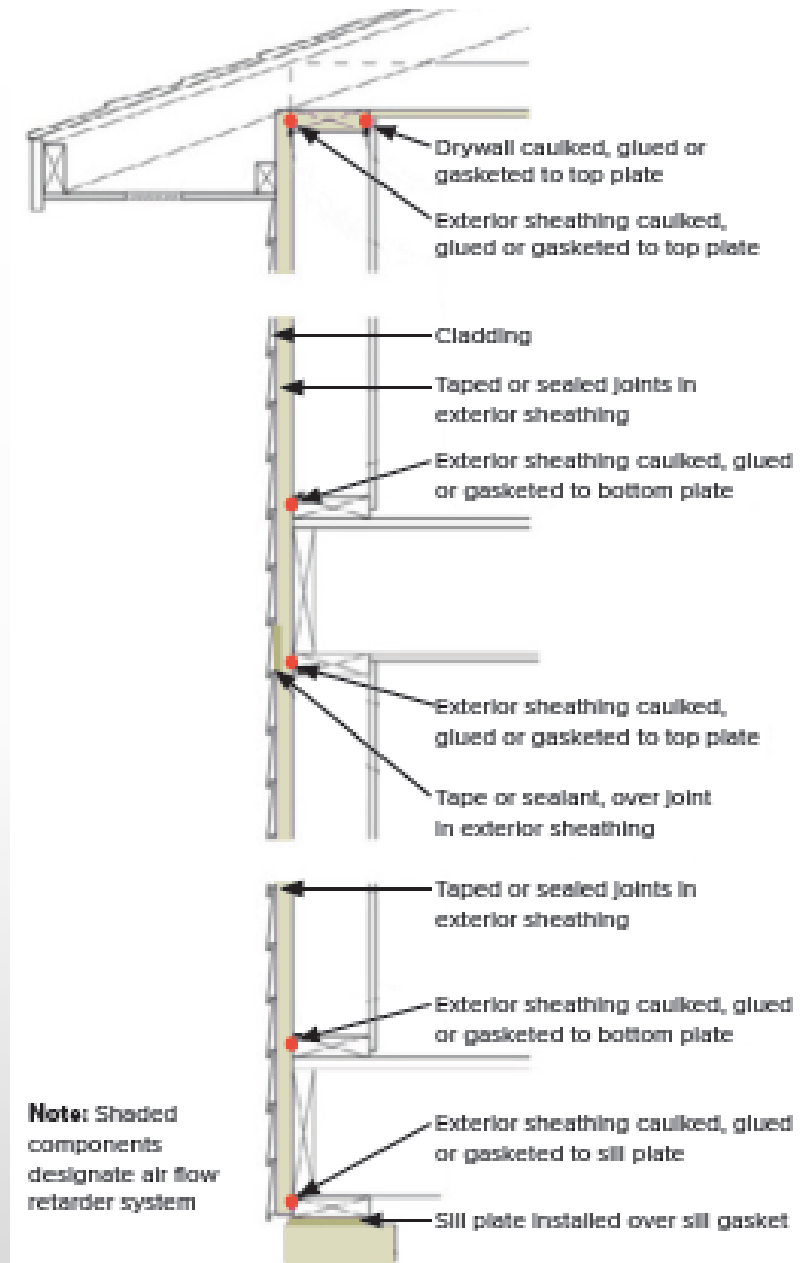
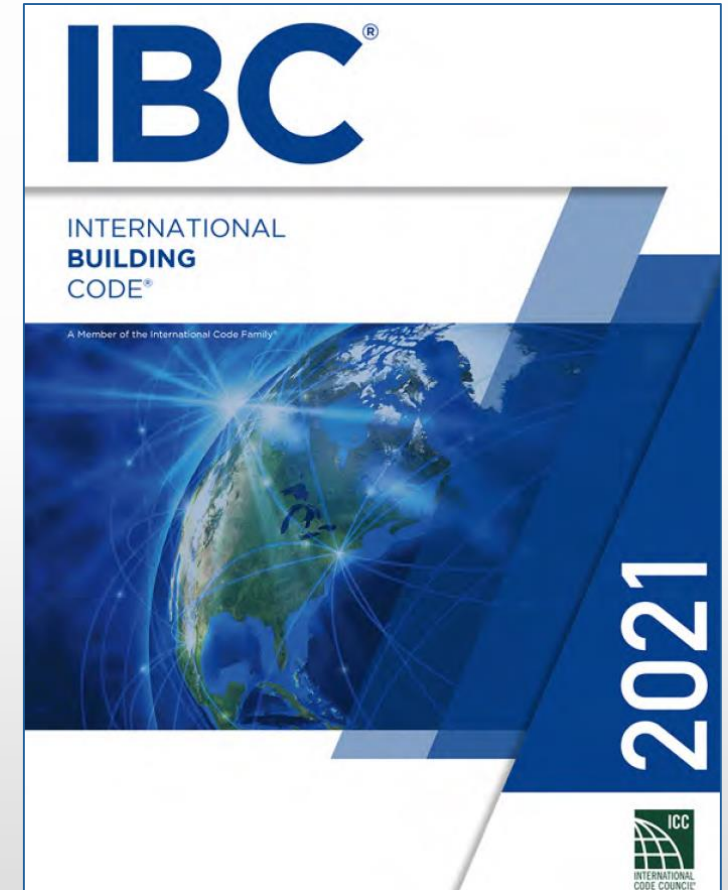


Figure 3. FPIS ci Installed as an air barrier exterior sheathing.

Commercial Building Code

- Requirements that vary by energy code climate zones include:
 - **IBC Section 1404.3** - Vapor control (vapor retarders coupled with insulation strategy)
 - **IBC Section 1202.3** – Unvented roofs for vapor control
 - **IBC Section 2510.6** - Drainage of conventional stucco cladding for Moist(A) and Marine(C) climate regimes
 - Foam sheathing also helps mitigate severe inward vapor drives that can occur with “reservoir” claddings like stucco.
- Other Requirements (fire, WRB, flashing, cladding attachment, wind resistance, etc.) don’t vary by energy code climate zones
 - See additional resources at end of presentation for code compliance and design guidance on these topics



Rule #1 of 3

Moisture Control for Wall Assemblies: Building Robust Walls with Foam Plastic Insulating Sheathing (FPIS) Continuous Insulation (ci)

07.27.21

RULE #1: Keep Water Vapor (Humid Air) Away from Cool Surfaces!

When installed in accordance with modern building code and energy code requirements for continuous insulation and water vapor control (see CI's [Quick Guide: Water Vapor Control and wall calculators](#)), FPIS ci keeps water-sensitive materials inside the wall dry by maintaining a temperature above the dew point. Simply use the right R-value of FPIS ci for the wall assembly based on the climate zone and an appropriately specified interior vapor retarder (or no interior vapor

retarder) to control outward vapor diffusion in the winter and maintain inward vapor diffusion (drying) in the warmer seasons. This approach results in much dryer walls with a more stable moisture content throughout all seasons of the year in comparison to walls that rely exclusively on the traditional use of interior vapor retarders without any temperature control provided by FPIS ci, as shown in Figures 1 and 2. Learn more about the use of FPIS for water vapor control [here](#).

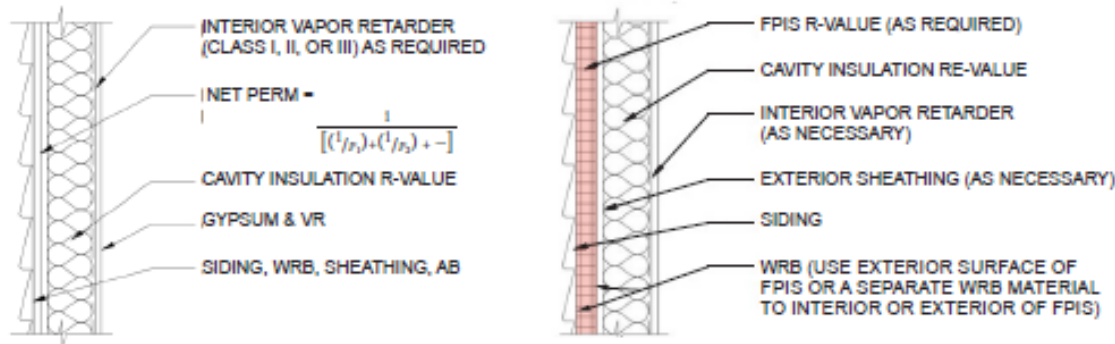
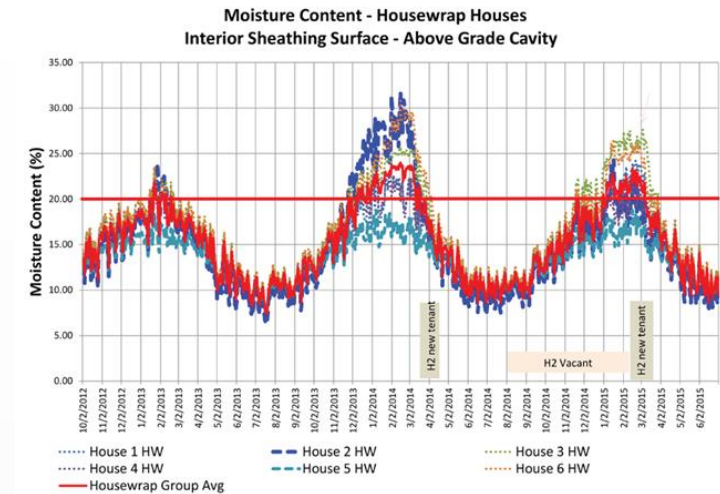
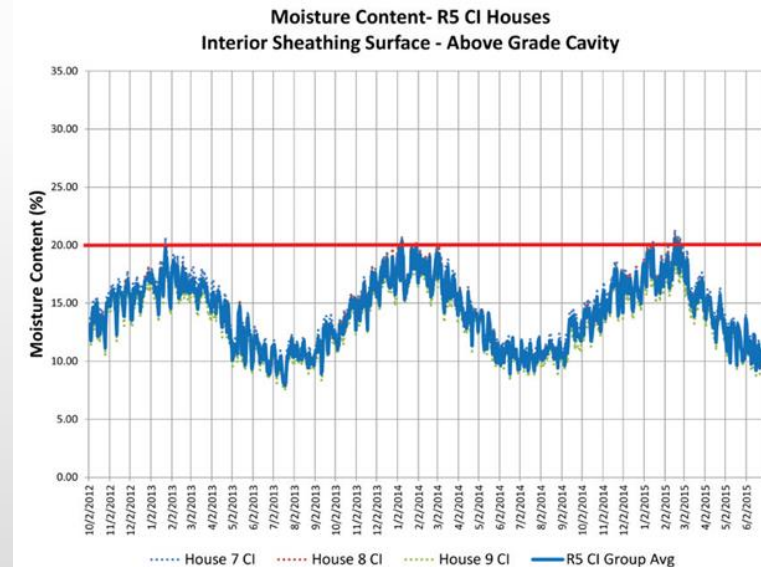


Figure 1. Cavity Insulation only vs. wall with FPIS ci Insulation (see Figure 2 for performance comparison)

<https://www.continuousinsulation.org/resources/facts-ci>



(A) Walls with R20 cavity insulation only consistently experiencing wet OSB.



(B) Walls with R5 FPIS ci keeping OSB sheathing dry

Figure 2. Comparison of 12 actual walls with and without R5 FPIS ci

Rule #2 of 3

RULE #2: Minimize Air Leakage!

Leakage of moist air from the indoors or outdoors into or through a building assembly can easily override the function of vapor retarders. Minimize air leakage by following energy code requirements for use of continuous air barriers and sealing of joints and gaps. It's not just an energy code concern (although it does save a lot of energy).

When RULE #1 is followed and the FPIS ci is installed per Figure 3 as a code compliant air barrier, walls are less vulnerable to the consequence of air leakage for two reasons: (1) the FPIS ci will help limit air infiltration from the exterior (especially if it is also used as the WRB system, see RULE #3), and (2) it will also reduce the potential for moist air to condensate on or be adsorbed by moisture-sensitive materials inside the wall because it controls the temperature of those materials. Find more information on use of FPIS as an air barrier [here](https://www.continuousinsulation.org/resources/facts-ci).

<https://www.continuousinsulation.org/resources/facts-ci>

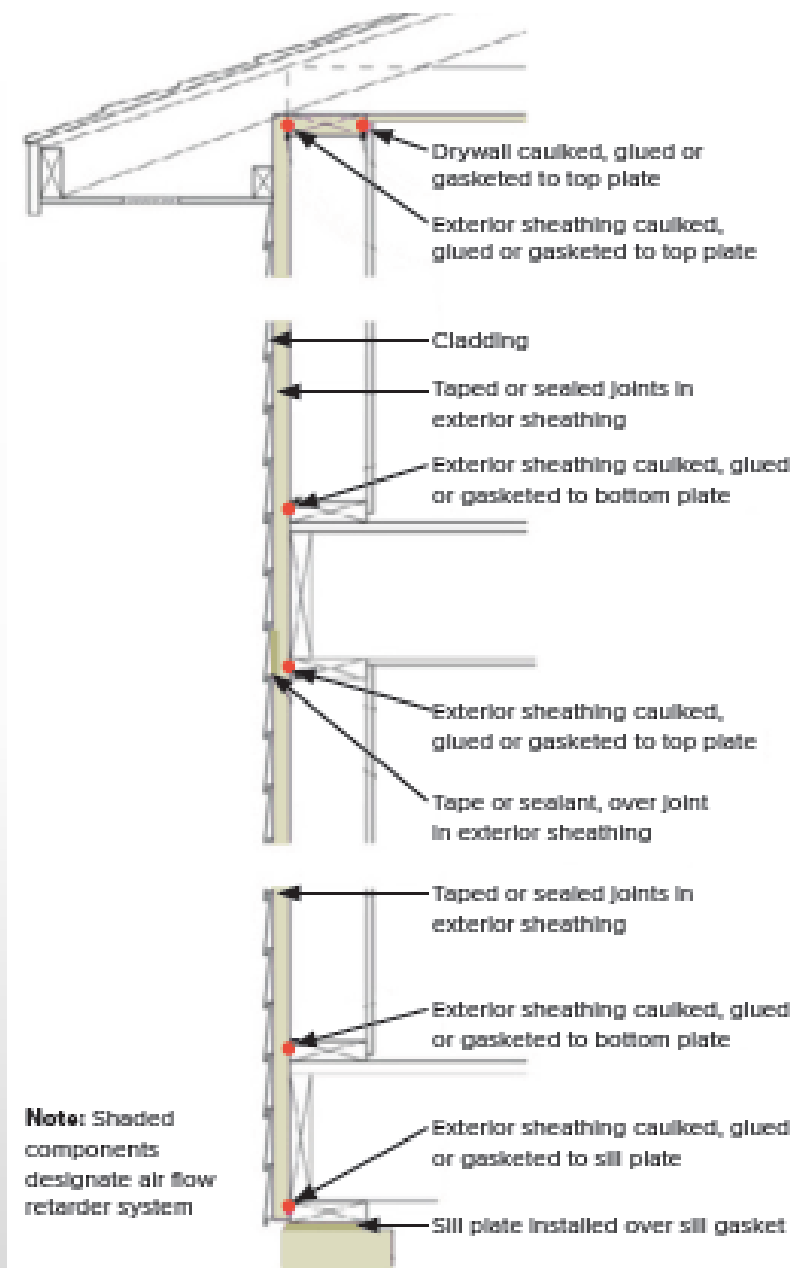


Figure 3. FPIS ci Installed as an air barrier exterior sheathing.

Rule #3 of 3

RULE #3: Avoid Rain Water Intrusion!

Most importantly, keep rain water out of walls by proper use of cladding, drainage, water-resistive barrier (WRB), and flashing as required by the building code and good practice. Many FPIS ci products can be used as a code-approved WRB system when installed in accordance with the manufacturer's installation instructions. Approved FPIS WRB systems use durable joint treatments (e.g., joint tapes) and flashing materials (e.g., adhered or fluid-applied flexible flashings) as shown in Figure 4. FPIS WRB systems are subject to some of the most stringent wall assembly water-resistance test requirements. Find more information on FPIS WRB systems [here](https://www.continuousinsulation.org/resources/facts-ci).

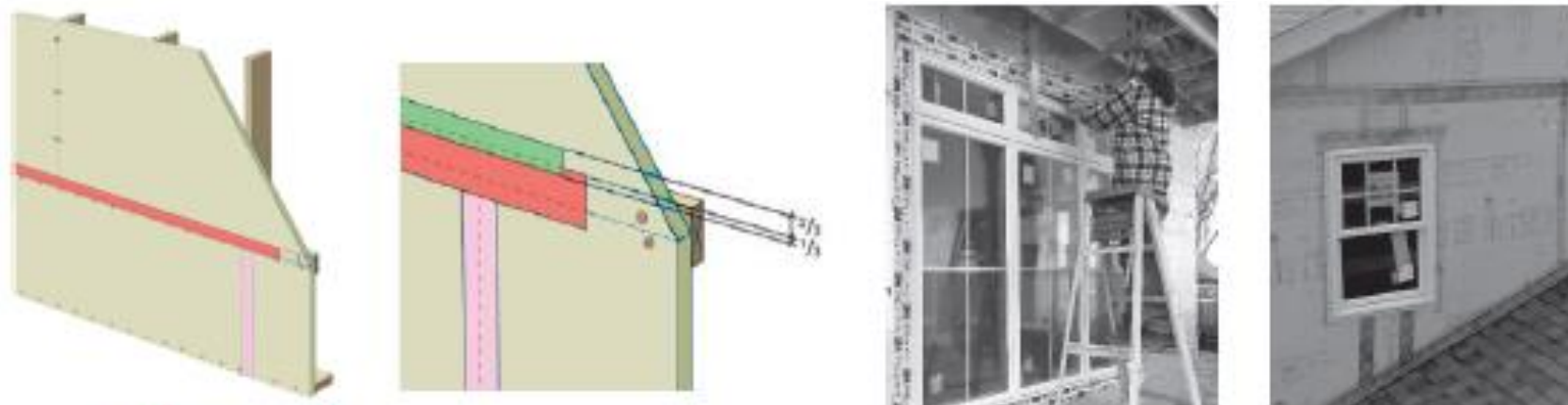


Figure 4. FPIS WRB System Installation using joint tapes and adhered flashings; refer to manufacturer installation instructions for specific details.


<https://www.continuousinsulation.org/resources/facts-ci>

IBC Section 1404.3 Vapor Retarders

- 2021 IBC includes major improvements for water vapor control with Ci
- 2024 IBC adds some incremental enhancements/options
 - Class I and II “responsive vapor retarders” are defined for Ci applications
 - Added provisions for the “perfect wall” (all control layers on exterior)
- Water vapor control per building code must be coordinated with energy code insulation requirements

3-Step Guide for Water Vapor Control Code Compliance (based on 2024 IBC/IRC)

Satisfies Rule #1 of 3 –
Keep Water Vapor
Away from Cool
Surfaces



3 STEPS FOR CODE-COMPLIANT USE OF WATER VAPOR RETARDERS and Foam Plastic Insulating Sheathing (FPIS) Continuous Insulation (ci)

07.27.21

This reference guide summarizes key requirements and options in the 2024 International Residential Code (IRC) and 2024 International Building Code (IBC) for design and construction of code-compliant and moisture-resistant frame walls using foam plastic insulating sheathing (FPIS) as continuous insulation (ci). When used in a code-compliant manner, FPIS ci protects walls against the effects of moisture by keeping walls warm to prevent condensation while maximizing drying to the interior with proper vapor retarder specification.

Follow the three steps below for code-compliant water vapor control. The wall assembly design must also be coordinated with minimum energy code insulation requirements. For greater flexibility and to automate the application of this reference guide and energy code compliance, refer to these wall calculators. Various moisture control research reports and other practical guides are also available here.

For a summary of key concepts and principles for moisture control, refer to FACTS: Moisture Control for Wall Assemblies.

STEP 1: KNOW INTERIOR VAPOR RETARDER CLASSES

Use the following definitions for water vapor retarder classes when specifying interior vapor retarders in accordance with Steps 2 and 3:

TABLE R702.7(1) VAPOR RETARDER MATERIALS AND CLASSES

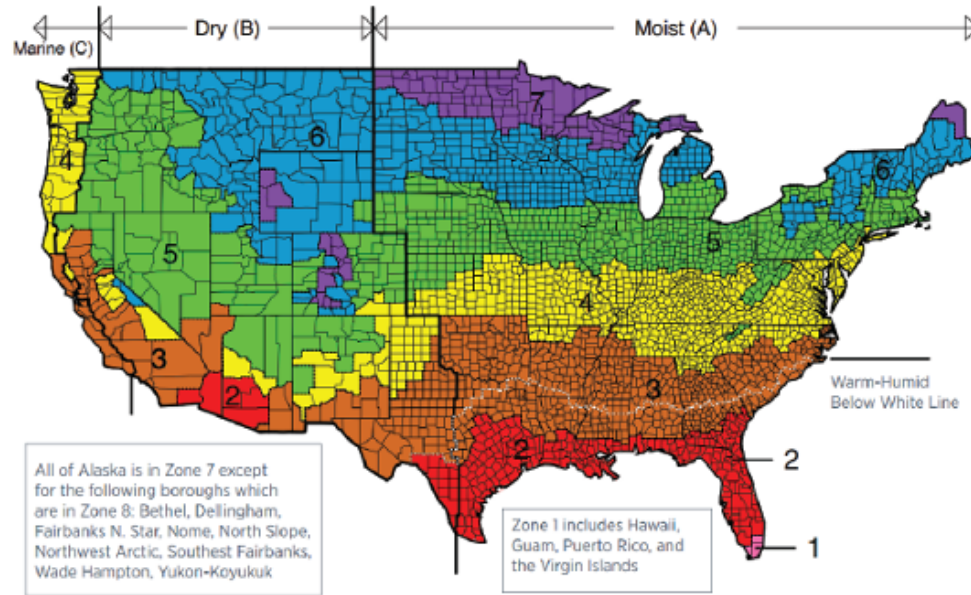
CLASS	ACCEPTABLE MATERIALS
I	Sheet polyethylene, nonperforated aluminum foil, or other approved materials with a perm rating of less than or equal to 0.1.
II	Kraft-faced fiberglass batts, vapor retarder paint, or other approved materials applied in accordance with the manufacturer's installation instructions 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 installation instructions for a perm rating of greater than 1.0 and less than or equal to 10.0.

<https://www.continuousinsulation.org/resources/quick-guides>

3-Step Guide (cont'd)

STEP 2: CONSIDER PERMITTED INTERIOR VAPOR RETARDERS

Select a “permitted” vapor retarder for the interior side of frame walls based on the Climate Zones as outlined in IRC Table R702.7(2), paying attention to footnotes and other table references. In Climate Zones 4-8, no interior vapor retarder is required where complying with Table R702.7(5).



U.S. Climate Zones

RESPONSIVE VAPOR RETARDER is defined as a “material complying with a vapor retarder class of Class I or Class II but which also has a vapor permeance of 1 perm or greater in accordance with ASTM E96, water method (Procedure B).”

TABLE R702.7(2) VAPOR RETARDER OPTIONS

CLIMATE ZONE	VAPOR RETARDER CLASS		
	CLASS I ^a	CLASS II ^a	CLASS III
1, 2	Not Permitted	Not Permitted	Permitted
3, 4 (except Marine 4)	Not Permitted	Permitted ^c	Permitted
Marine 4, 5, 6, 7, 8	Permitted ^b	Permitted ^c	See Table R702.7(3)

- A responsive vapor retarder shall be allowed on the interior side of any frame wall in all climate zones.
- In frame walls, use of a Class I interior vapor retarder that is not a responsive vapor retarder on the interior side with a Class I vapor retarder on the exterior side shall require an approved design.
- Where a Class I or II vapor retarder is used in combination with foam plastic insulating sheathing or insulated siding installed as continuous insulation on the exterior side of frame walls, the continuous insulation shall comply with Table R702.7(4) and the Class I or II vapor retarder shall be a responsive vapor retarder.

3-Step Guide (cont'd)

STEP 3: DETERMINE MINIMUM R-VALUE REQUIREMENTS FOR CI

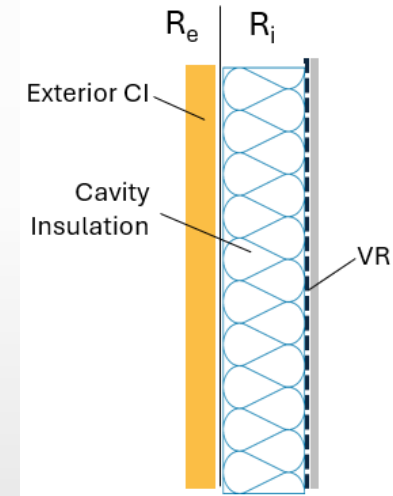
TABLE R702.7(3) CLASS III VAPOR RETARDERS

(only requirements for ci are shown)

CLIMATE ZONE	CLASS III VAPOR RETARDERS PERMITTED FOR:
4 Marine	ci with R-value ≥ 2.5 over 2 x 4 wall
	ci with R-value ≥ 3.75 over 2 x 6 wall
5	ci with R-value ≥ 5 over 2 x 4 wall
	ci with R-value ≥ 7.5 over 2 x 6 wall
6	ci with R-value ≥ 7.5 over 2 x 4 wall
	ci with R-value ≥ 11.25 over 2 x 6 wall
7	ci with R-value ≥ 10 over 2 x 4 wall
	ci with R-value ≥ 15 over 2 x 6 wall
8	ci with R-value ≥ 12.5 over 2 x 4 wall
	ci with R-value ≥ 20 over 2 x 6 wall

TABLE R702.7(4) CONTINUOUS INSULATION (ci) WITH CLASS I or II RESPONSIVE VAPOR RETARDER

CLIMATE ZONE	PERMITTED CONDITIONS
3	ci with R-value ≥ 2
4, 5, 6	ci with R-value ≥ 3 over 2 x 4 wall
	ci with R-value ≥ 5 over 2 x 6 wall
7	ci with R-value ≥ 5 over 2 x 4 wall
	ci with R-value ≥ 7.5 over 2 x 6 wall
8	ci with R-value ≥ 7.5 over 2 x 4 wall
	ci with R-value ≥ 10 over 2 x 6 wall



- **Example 1: CZ 5 with Class III VR**
 - IRC Table R702.7(3) or IBC 1404.3(3):
 - Use min. R-5ci on a R13 2x4 wood frame wall (e.g., R13+5ci)
 - Energy code requires R13+7.5ci (OK, exceeds minimum Ci R-value for vapor control)
 - Use min. R-7.5ci on a R20 2x6 wood frame wall
 - Exceeds energy code R20+3.8ci which doesn't work for vapor control (unless flash & batt in cavity, e.g., R13 batt + R7 ccSPF in cavity with R3.8ci on exterior)
 - Alternatively consider using Class I or II RVR (Example 2)
- **Example 2: CZ 5, Class I or II Responsive Vapor Retarder**
 - IRC Table R702.7(4) or IBC Table 1404.3(4):
 - Use min. R-5ci on 2x6 wall with R20 cavity (e.g., R20+5ci wall)
 - Exceeds minimum energy code for 2x6 WFW (i.e., R20+3.8ci) and could use R19+5ci to get closer to minimum energy code (by equivalent U-factor compliance)
 - Class I or II VR must be “responsive vapor retarders” (RVR) to minimize outward diffusion wetting while promoting inward diffusion drying
 - Class II RVR = kraft paper facer
 - Class I RVR = proprietary membranes
- Generally, steel frame walls require more Ci R-value in energy code and thus usually satisfy these vapor control requirements.

3-Step Guide (cont'd)

STEP 3: DETERMINE MINIMUM R-VALUE REQUIREMENTS FOR CI

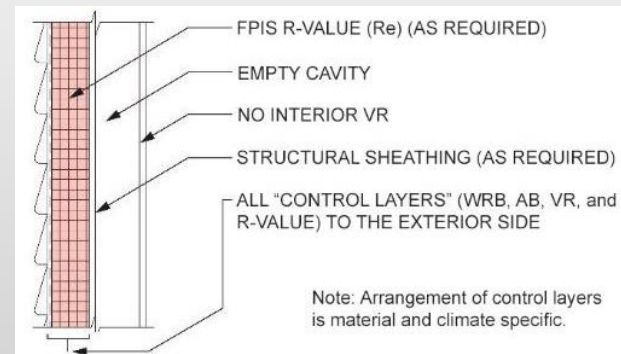
- **Example 3:** CZ 5, No interior vapor retarder, exterior Ci only
 - Table R702.7(5) or IBC 1404.3(5)
 - Generally, the minimum ci R-values for moisture control are less than the energy code requires for exterior Ci-only walls.
 - Therefore, if complying with energy code minimums these vapor control requirements are met.
- Footnotes are important!
 - There still must be a max 1 perm vapor retarder but on the exterior side of the wall and to the interior side of the Ci insulation, unless the Ci insulation or its interior facer is a vapor retarder.

TABLE R702.7(5) CONTINUOUS INSULATION (ci) ON WALLS WITHOUT A CLASS I, II OR III INTERIOR VAPOR RETARDER^a

CLIMATE ZONE	PERMITTED CONDITIONS ^{b,c}
4	ci with R-value ≥ 4.5
5	ci with R-value ≥ 6.5
6	ci with R-value ≥ 8.5
7	ci with R-value ≥ 11.5
8	ci with R-value ≥ 14

a. The total insulating value of materials to the interior side of the exterior continuous insulation, including any cavity insulation, shall not exceed R-5. Where the R-value of materials to the interior side of the exterior continuous insulation exceeds R-5, an approved design shall be required.

b. A water vapor control material layer having a permeance not greater than 1 perm in accordance with ASTM E96 Procedure A (dry cup) shall be placed on the exterior side of the wall and to the interior side of the exterior continuous insulation. The exterior continuous insulation shall be permitted to serve as the vapor control layer where, as its installed thickness or with a facer on its interior face, the exterior continuous insulation is a Class I or II vapor retarder.



Resources to help put it all together



Foam Plastic Applications
for Better Building

[FPIS PRODUCTS](#) [TOOLS](#) [RESOURCES](#) [APPLICATIONS](#) [COMMERCIAL](#) [RESIDENTIAL](#) [BY AUDIENCE](#) [ABOUT](#) [SEARCH](#)

Continuous Insulation: Simplify Your Building Envelope

Robust solutions for cost-effective, code-compliant, comfortable spaces.

What is Continuous Insulation?

Unlike typical insulation installed between framing members, continuous insulation (ci) provides uninterrupted thermal insulation for unparalleled performance. Foam plastic products can also serve as the water resistive barrier and air barrier for a structure, providing a 3-in-1 building envelope solution.

Regardless of the name – from the more common “foam board” or “foam panel” to the code-defined “foam plastic insulating sheathing (FPIS)” – the science behind this approach to ci is worth spending some time on!

[APPLICATIONS](#)

[BENEFITS](#)

[WHAT'S NEW](#)

[FAQS](#)

Commercial



Residential



Simplified Energy & Water Vapor Code Compliance

- Implements R-value and U-factor checks per IECC & ASHRAE 90.1
- Automates vapor control check per IBC/IRC (including insulation ratio and permeance ratio checks)
- Flexible, More Solutions than Code, More Precise
- Wood and Steel framing
- 2-minute wall design and optimization (or compliance check)

Wall Assembly Inputs

1. Building / Energy Code & Year

Energy code & year

IBC 2015 + IECC-C 2015 (Excluding group R)

2. Climate Zone and Heating Degree Days

Climate zone

5

Enter Heating Degree Days (HDD) if you want the minimum Insulation Ratio (Re/Ri) to be based on heating degree days, rather than strictly on the climate zone minimums. Values outside the range shown will be ignored. The heating degree days option is only available for some climate zones. HDD values are on a 65°F basis.

Optional Heating degree days (Valid range: 5401 - 7200)

3. Cladding

Cladding type and R-value

Stucco (0.08)

4. Exterior Continuous Insulation

Manufacturer's rated R-value at installed thickness

7.5

5. Exterior Sheathing

Output

Energy Code Thermal Check

U-Factor Method

Factor	Proposed Wall	Code Requirement	Compliance Check
U-Factor of opaque wall assembly	0.060	0.064	✓ Passed

R-Value Method

Factor	Proposed Wall	Code Requirement	Compliance Check
*R-value of opaque wall assembly	R13+7.5ci	R13+7.5ci	✓ Passed

Building Code Water Vapor Control Check

	Insulation Ratio (Re/Ri) Method		
Interior Vapor Retarder Class ¹	Proposed Ratio	Minimum Ratio Required (Zone 5)	Pass/Fail
Class I ²	0.58	0.30	✓ Passed
Class II ²	0.58	0.30	✓ Passed
Class III ⁴	0.58	0.45	✓ Passed
No Interior Vapor Retarder	0.58	1.40	X

<https://www.continuousinsulation.org/calculators>

Ci Resource Guide



Scan QR code for PDF
download of full document.



**Foam Plastic Applications
for Better Building**

Continuous Insulation **RESOURCE GUIDE**

FACTS Sheets & Quick Guides
for Code-Compliant
Applications of Foam Plastic
Insulating Sheathing (FPIS)

Moisture Control for Frame Walls Code Compliant Wall Detailing

Integration of code-compliance requirements and best practices for moisture control of frame wall assemblies (based on 2021 IRC).

0112.24

FIGURE KEY:

ci = continuous insulation
VR = vapor retarder
AB = air barrier
WRB = water-resistive barrier
FPIS = foam plastic insulating sheathing
EIFS = exterior insulation & finish system
ccSPF = closed-cell spray foam

Flashing (IRC Section R703.4):

Flashing at siding transitions, fenestration, and other wall penetrations or details not shown; flash to the designated WRB layer (location in wall may vary) and kick-out to exterior or cladding where required at weeps, etc.

Cladding Connections

(IRC Section R703.3):

For connections through FPIS refer also to IRC Section R703.15.

Use codes below to access additional resources designed to help support proper implementation of the code compliance and best practice information illustrated in this guide.



Wall Calculators



FACTS Sheet Library



Quick Guide Library

Structural Sheathing

Specify and install structural sheathing per IRC Chapter 6 where used for wall bracing. Examples include OSB, plywood, gypsum sheathing, fiberboard, diagonal wood boards, etc. (Wood let-in and metal brace options not shown.)

Lap Siding (vinyl, wood, aluminum, fiber-cement, etc.)

Specify and install lap siding per IRC Section R703. In Climate Zones 4-8 where using a Class III interior VR, two options to control water vapor are provided in Table R702.7(3):

- (1) Without exterior ci – siding must be back-vented (e.g., furred) or vented siding (e.g., vinyl).
- (2) With exterior ci – siding not required to be back-vented or vented siding.

Back venting or vented siding is otherwise not required but is a recommended best practice, especially in moist or marine climate regions.

Stucco, Adhered Masonry Veneer, Cement Panel Siding, etc.

Specify and install WRB per IRC Section R703.7.3. In Moist/Marine climate regions, a minimum 3/16" drainage space is required. See drainage space location options based on WRB location specified.

Alternative drainage methods include drainage matt, drain wrap, or channeled back of FPIS with separate WRB on its interior side. All alternatives must have minimum 90% drainage efficiency per ASTM E2273 or E2925.

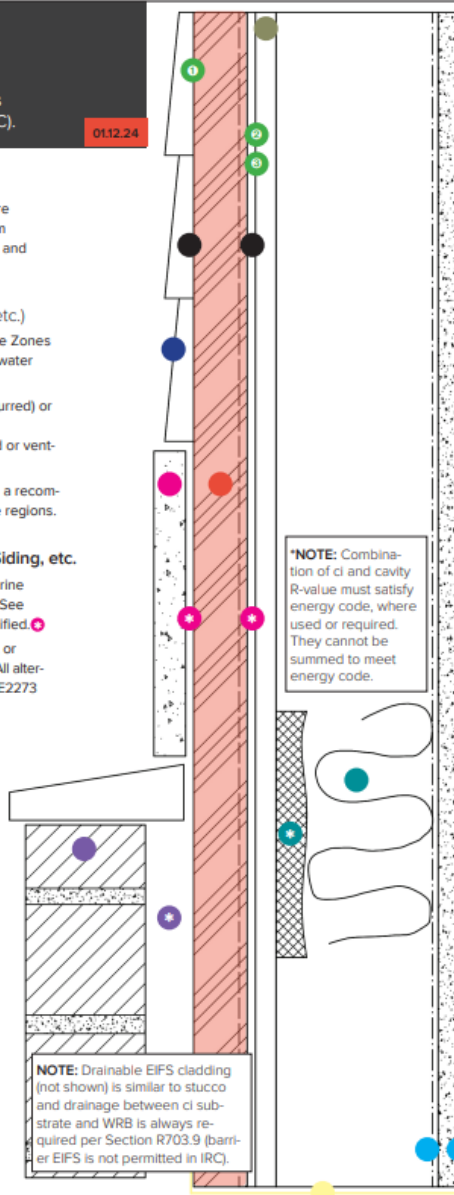
Anchored Masonry Veneer (stone & brick)

1" ventilation and draining space required for all anchored stone or brick veneer in all climate zones (see Section R703.8).

Also qualifies as vented cladding for use of Class III VR on walls without exterior ci per Table R702.7(3).

Air Barrier (AB)

A continuous AB is used in all climate zones to achieve required whole building air-change-per-hour (ACH) limits per energy code and to protect wall from moist air intrusion. The designated AB material layer must have joints, seams, gaps, intersections, and penetrations sealed. AB material can be the WRB, the ci, the structural sheathing, the ccSPF cavity insulation, the VR, or gypsum wallboard. Any material or combination thereof must meet energy code requirements for AB material properties (i.e., essentially air impermeable). Recommended best practice is to provide AB on both sides of air-permeable insulation materials (i.e., on exterior and interior sides of wall cavity) for improved thermal performance and moisture control.



Water-Resistive Barrier (WRB)

Specify and install a WRB in accordance with IRC Section R703.2. WRB material and location options include:

- ① Surface of FPIS WRB System w/ taped joints - FPIS surface used as WRB
- ② Separate WRB behind ci - Any ci insulation type not used as WRB
- ③ Membrane (wrap), spray-applied, or WRB wall sheathing (no ci)

Drainage Space (location based on WRB option used)

Where required, located between cladding and WRB (see above). See requirements for reservoir cladding types (brick, stucco, adhered veneer, etc.).

Where not required, use as recommended best practice.

Continuous Insulation (ci)*

Where used, ci R-value must meet IRC Table R702.7(2) and Table R702.7(3) or (4) as applicable based on Climate Zone and the interior VR Class specified. The required minimum ci R-values ensure adequate temperature control to prevent condensation and moisture accumulation within the wall. Increasing ci R-values above code-minimums will further improve thermal performance and moisture control.

Where non-vapor permeable (< 5 perm) ci is used (e.g., FPIS), it will mitigate inward vapor drive from reservoir claddings (e.g., stucco, adhered veneer, brick, etc.). For similar reasons, it is recommended to use a moderate to low perm WRB (e.g., < 20 perm) behind a vapor permeable ci material.

Cavity Insulation*

If ccSPF is used at thickness to achieve 1.5 perms or less, the R-value can be combined with ci R-value to meet ci requirements of Tables R702.7(3) or (4) to decrease the exterior ci thickness/ R-value required, but ccSPF must still be treated as cavity insulation for energy code compliance.

Interior Vapor Retarder (VR)^{1,2}

Use of a Class I interior VR (that is not "smart") in frame walls with a Class I exterior VR is not permitted without an approved design. Double vapor "barriers" should be avoided.

An interior vapor retarder is not required in Climate Zones 1, 2, and 3. Responsive ("smart") Class I or II VRs are allowed on interior side of any frame wall in all Climate Zones.

If ci used or required: Specify VR per Table R702.7(2) in coordination with ci and cavity insulation R-values per Tables R702.7(3) or (4) as applicable. Class I/II VR must be "smart" VR if ci is FPIS (e.g., non-vapor permeable), otherwise use Class III VR.

If ci not used: Specify VR per Table R702.7(2) with best practice recommendation to specify Class I "smart" VR in Climate Zones 5-8 and install as an air barrier. Use of a Class III VR without ci is not recommended even though permitted.

NOTES ON VAPOR RETARDER CLASSES AND RESPONSIVE VAPOR RETARDERS:

1. Vapor retarder classes are defined in Table R702.2(1) and include Class I (e.g., poly), Class II (e.g., coated kraft paper facer), and Class III (e.g., vapor retarder latex paint per manufacturer's instructions). Class I has vapor permeance of 0.1 or less, Class II is 0.1 to 1 perms, and Class III is 1 to 10 perms.
2. A responsive or "smart" vapor retarder is Class I or II (i.e., 1 perm or less) that becomes more vapor open in a humid environment such that drying occurs when needed. Regular vapor retarders are classified on the basis of "dry cup" vapor permeance measurements at low humidity conditions. Responsive vapor retarders are additionally required to have a permeance of greater than 1 perm when measured by the "wet cup" method of ASTM E96 at a moderately high humidity condition. Coated kraft paper facer is a Class II responsive vapor retarder. Class I responsive vapor retarders are typically proprietary films or membrane products.

DISCLAIMER While reasonable effort has been made to ensure the accuracy of the information presented, the actual design, suitability and use of this information for any particular application is the responsibility of the user. Where used in the design of buildings, the design, suitability and use of this information for any particular building is the responsibility of the Owner or the Owner's authorized agent. The information contained herein is provided "as is."

Contact us.



Owned and operated by the Applied Building Technology Group with support from the Foam Sheathing Committee (FSC) of the American Chemistry Council, continuousinsulation.org provides informational resources intended to assist the foam plastic insulating sheathing industry, using sound science to develop research supporting the reliable, efficient, and economic design and installation of foam sheathing.



"Cheat Sheet"

Integrated, Code-Compliant
Moisture Control

(center-fold of
the Ci Resource
Guide)

ANSI FS200.1 Standard for FPIS Applications

- Scope

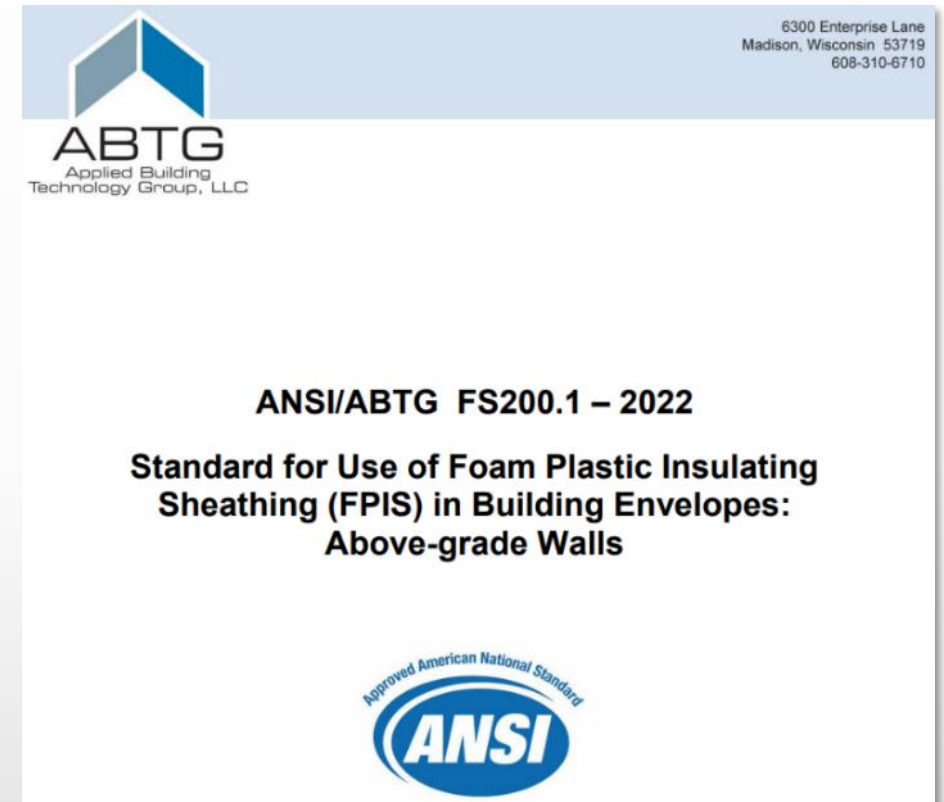
- Above-grade frame walls
- Labeling & Quality Assurance
- Wind resistance
- WRB (water resistance)
- Vapor Control
- Window installation
- Cladding installation

- Addresses

- Performance criteria (design)
- Evaluation/testing criteria by application
- Prescriptive criteria (“cook-book” design and installation)

- Exclusions

- Refer to locally applicable code for fire safety requirements (e.g., IBC Chapter 14 and 26; IRC Section R316)
- Refer to FPIS manufacturer data to demonstrate compliance (ASTM E84, ASTM E119, NFPA 285, etc. – as applicable)



<https://www.appliedbuildingtech.com/standards>

THANK YOU!

Questions?

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