Moisture Drive & Code-Compliant Building Envelopes

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ABTG / ARES Consulting

ABTG

Applied Building Technology Group (ABTG) is committed to using sound science and generally accepted engineering practice to develop research supporting the reliable design and installation of foam sheathing. ABTG's educational program work with respect to foam sheathing is supported by the Foam Sheathing Committee (FSC) of the American Chemistry Council.

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Foam sheathing research reports, code compliance documents, educational programs and best practices can be found at www.continuousinsulation.org.

Foam Plastic Applications for Better Building

OUTLINE

A. THE BUILDING THERMAL ENVELOPE (BTE)

B. CODE-COMPLIANT THERMAL INSULATION

C. CODE-COMPLIANT WATER/AIR/VAPOR CONTROL
   I. FUNDAMENTALS OF MOISTURE CONTROL
   II. WATER VAPOR CONTROL
   III. AIR LEAKAGE CONTROL
   IV. RAINWATER INTRUSION CONTROL

D. ADDITIONAL RESOURCES & APPLICATIONS

E. QUESTIONS

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A. THE BUILDING THERMAL ENVELOPE (BTE)

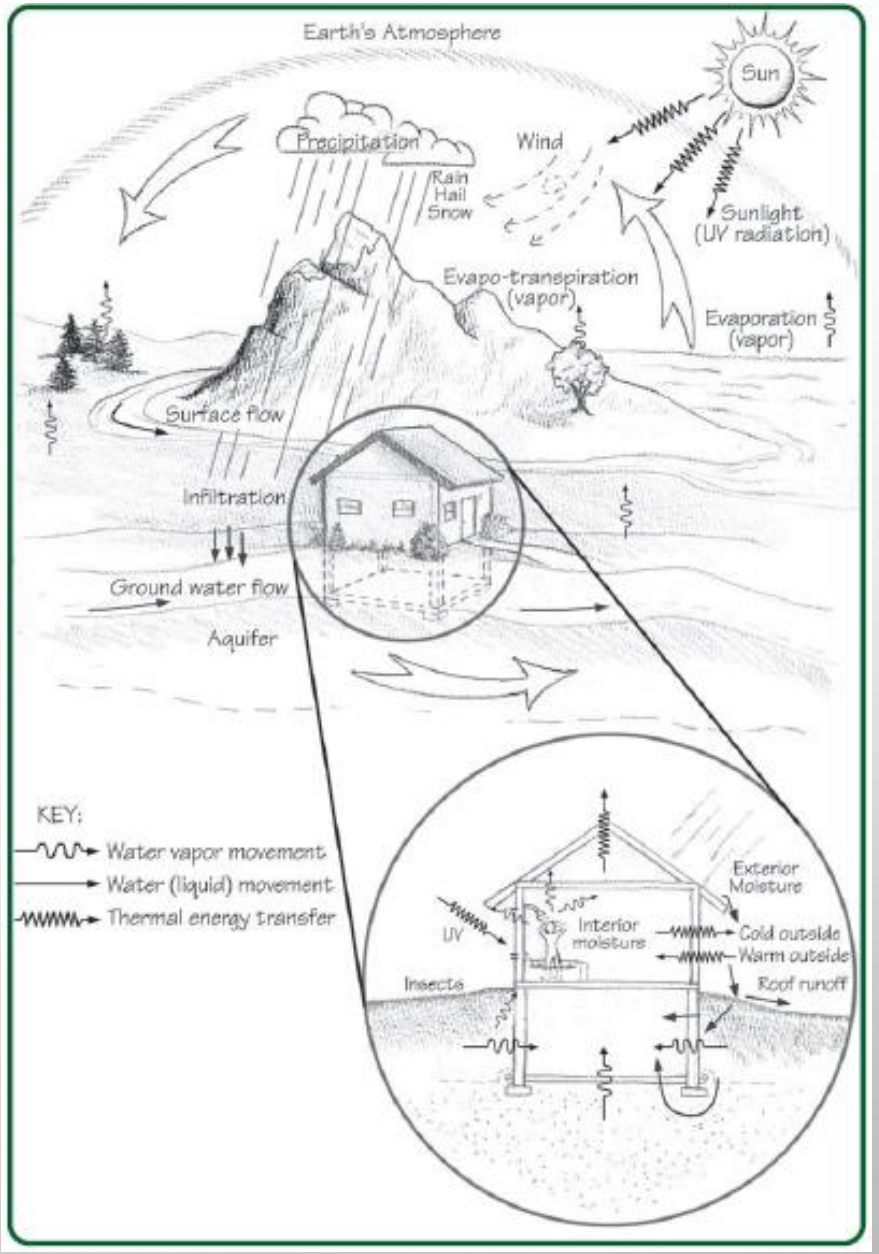
- THE PRIMARY FUNCTION OF A BUILDING ENVELOPE IS TO SEPARATE THE INDOOR FROM THE OUTDOOR ENVIRONMENT.

  "WITHOUT A GOOD BUILDING ENVELOPE, THE PREVIOUS HVAC SYSTEM AND DESIGN ACTIONS BECOME MORE DIFFICULT AND COSTLY, AND UNCERTAIN IN THEIR EFFECTIVENESS."

  SOURCE: ABTG RR NO. 2006-01, P10, HTTPS://WWW.CONTINUOUSINSULATION.ORG/TOPICAL-LIBRARY/HEALTHY-BUILDINGS

- The BTE is an integrated system which also supports the design and function of other building systems.

  "It is like the skin that protects the internal parts of your body; it is the largest organ of the body."



Source: HUD, Durability by Design

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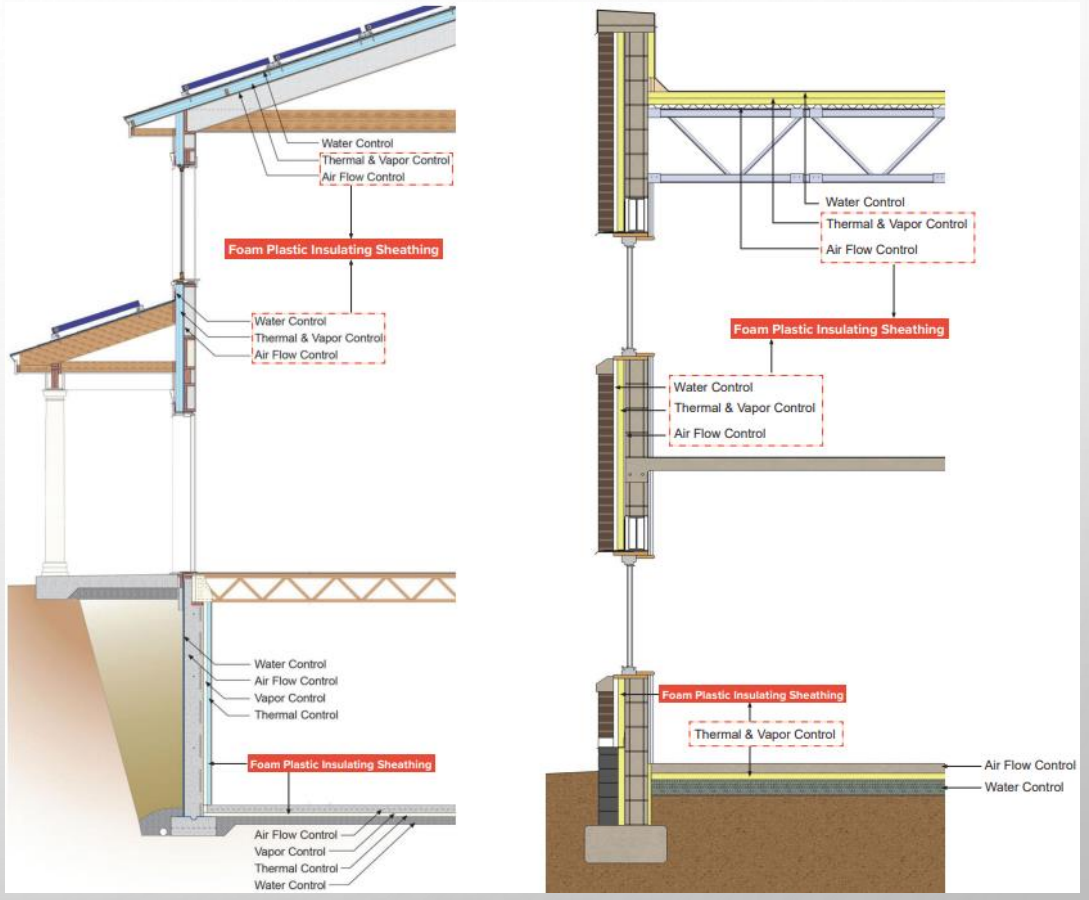
WHY IS THE BTE IMPORTANT?

- 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 FOR THE BUILDING.
    - THIS LAST POINT IS WHY BUILDING ENVELOPE HAS SUCH A FOCUS IN THE ENERGY CODE

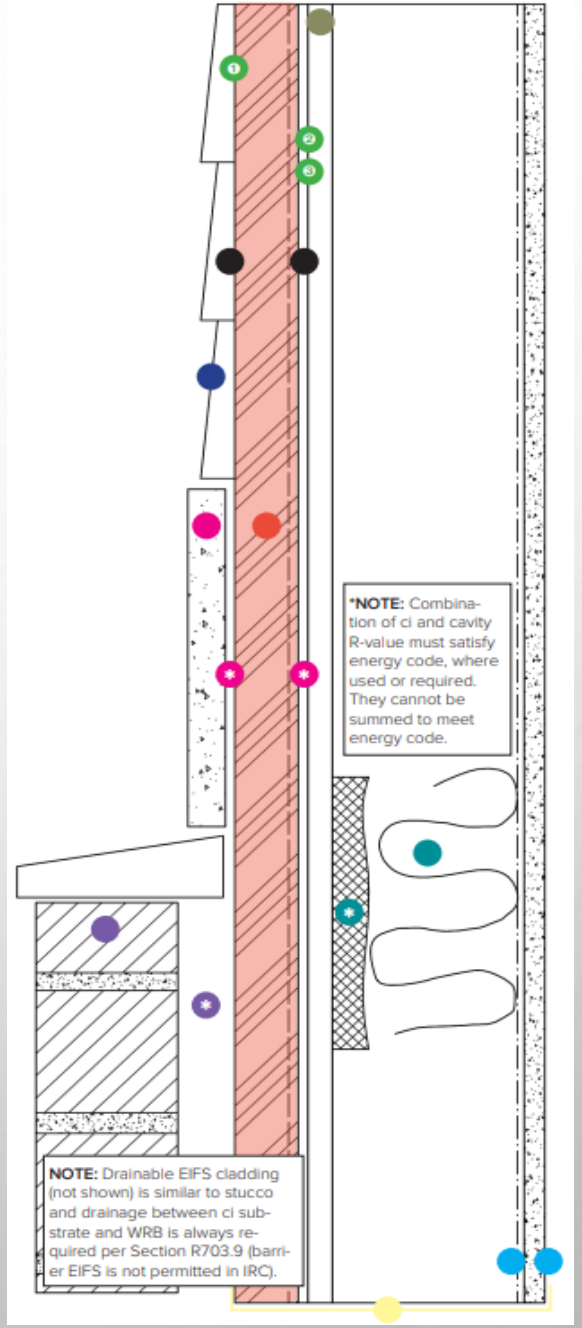


FUNCTIONS OF THE BUILDING THERMAL ENVELOPE (BTE)

- IN ADDITION TO **FIRE SAFETY, STRUCTURAL SAFETY,** 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]
- SOME "LAYERS" OR MATERIALS CAN PERFORM **MULTIPLE FUNCTIONS** DEPENDING ON DESIGN APPROACH AND MATERIAL PROPERTIES
- VAST NUMBER OF OPTIONS FOR WALL CONFIGURATION:

  5 VR X 5 AB X 5 CI X 5 CAVITY X 6 WRB X 5 STR SHTG X 9 CLADDING = **168,750** POSSIBILITIES

➢ NOT ALL OPTIONS ARE EQUAL IN PERFORMANCE BUT ALL MAY MEET MINIMUM CODE REQUIREMENTS



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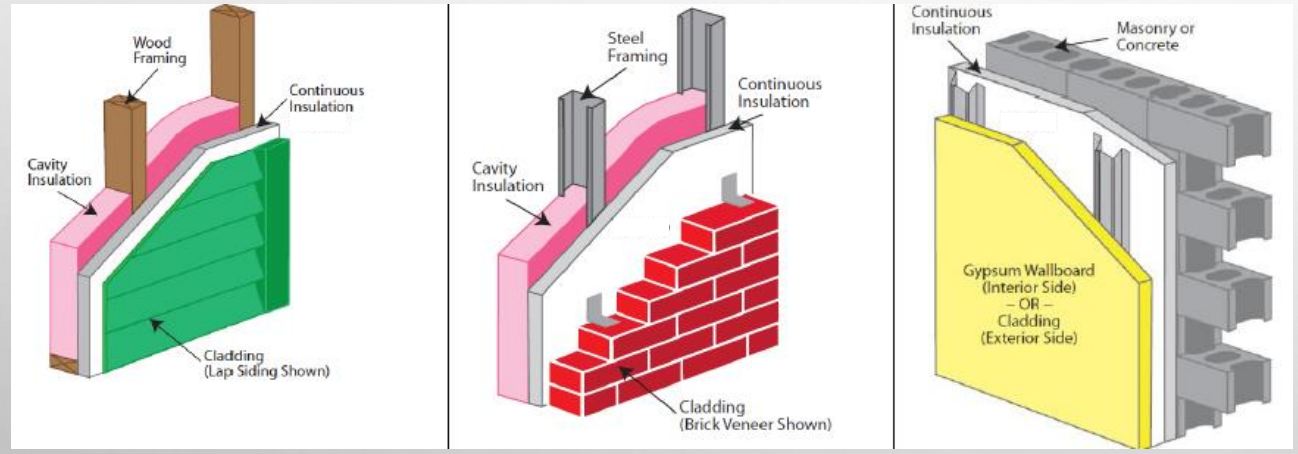
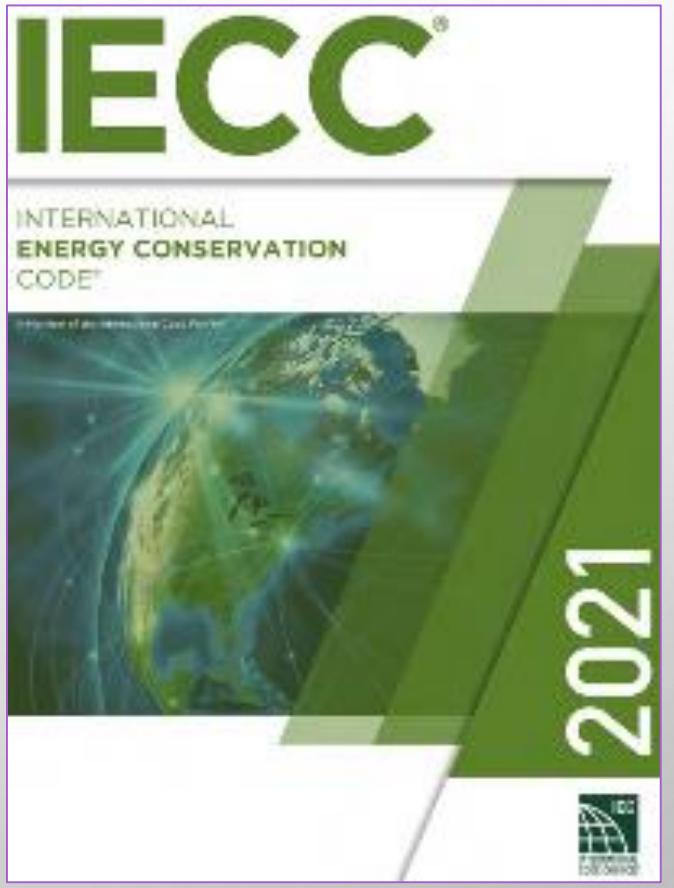
B. CODE-COMPLIANT THERMAL INSULATION

- PRESCRIPTIVE R-VALUE & U-FACTOR REQUIREMENTS
- INSULATION METHODS





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CLIMATE ZONES

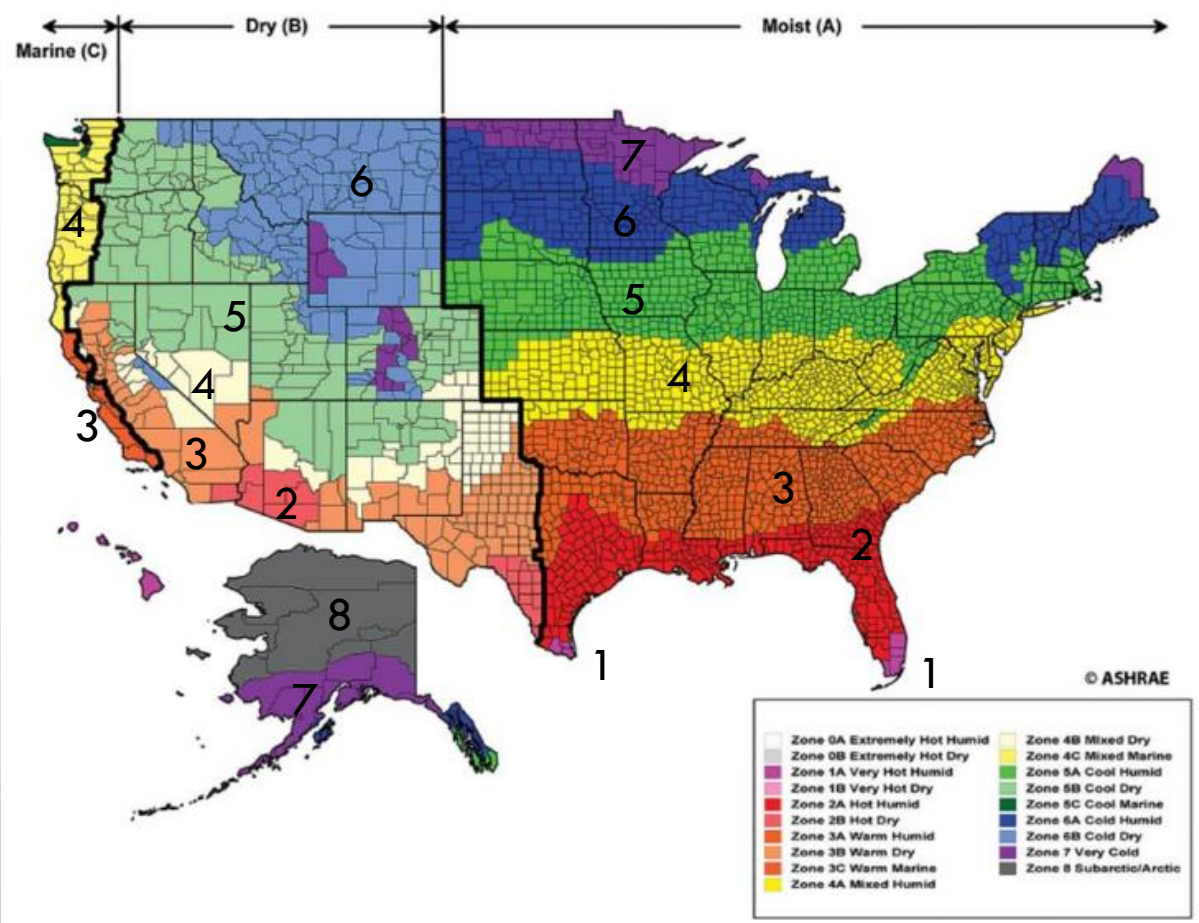

Figure 3.4.2. U.S. Climate Zone Map
(Source: ©ASHRAE www.ashrae.org Standard 169, 2013)

IECC Figure C301.1 & R301.1

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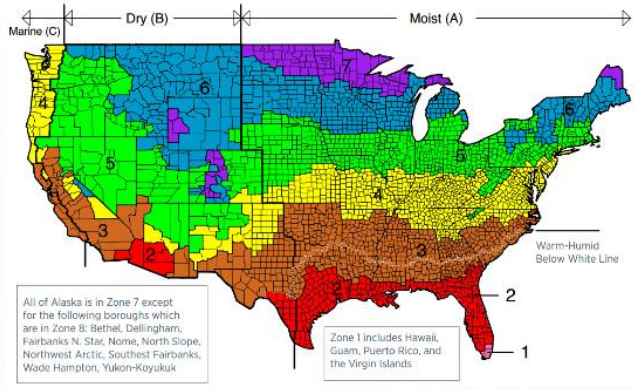
PRESCRIPTIVE R-VALUE & U-FACTOR REQUIREMENTS

IECC Commercial
Tables C402.1.3 & C402.1.4

Climate Zone	Building Use	Mass	Metal Framed*		Wood Framed	
		2021 IECC	2018 IECC	2021 IECC	2018 IECC	2021 IECC
0 and 1	All other	R-5.7ci (U-0.151)	R13+5ci (U-0.077)	R13+5ci (U-0.077)	R13+3.8ci or R20 (U-0.064)	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)		
3	All other					
	Group R	R-9.5ci (U-0.104)				
4 Except Marine	All other					
	Group R	R-11.4ci (U-0.090)		R13+10ci (U-0.055)		R13+7.5ci or R20+3.8ci (U-0.051)
5 and Marine 4	All other				R13+7.5ci or R20+3.8ci (U-0.051)	
	Group R	R-13.3ci (U-0.080)				
6	All other			R13+12.5ci (U-0.049)		
	Group R	R-15.2ci (U-0.071)				
7	All other					
	Group R		R13+15.6ci (U-0.052)	R13+15.6ci (U-0.042)		
8	All other	R-25ci (U-0.037)	R13+7.5ci (U-0.064)	R18+18.8ci (U-0.037)	R13+15.6ci or R20+10ci (U-0.036)	R13+18.8ci (U-0.032)
	Group R		R13+17.5ci (U-0.045)			

* Cavity insulation is only 40-50% effective on CFS walls, so ci is prescribed for all climate zones.



IECC Residential Provisions
Tables R402.1.2 & 402.1.3

Climate Zone	Wood Frame Walls	
	2018 IECC	2021 IECC**
0, 1 and 2	R13 (U-0.084)	R13 or R0+10ci (U-0.084)
3	R20 or R13+5ci (U-0.060)	R20 or R13+5ci or R0+15ci (U-0.060)
4 except Marine		R30 or R20+5ci or R13+10ci or R20ci (U-0.045)
5 and Marine 4		
6	R20+5ci or R13+10ci (U-0.045)	
7 and 8		

** Cavity only, Ci only, and Hybrid options available for all climate zones.

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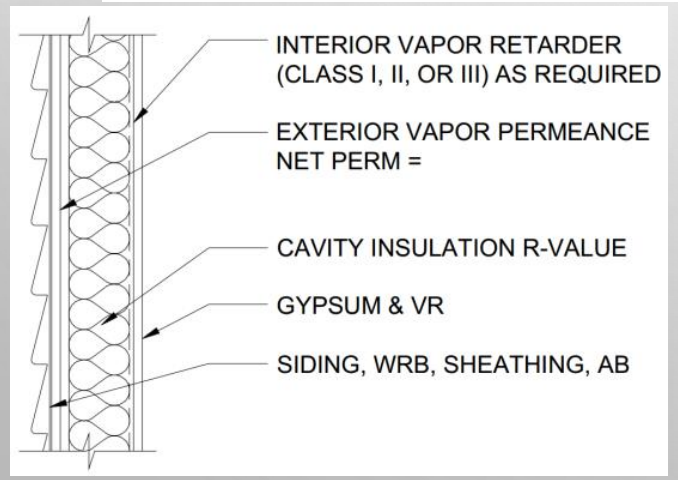
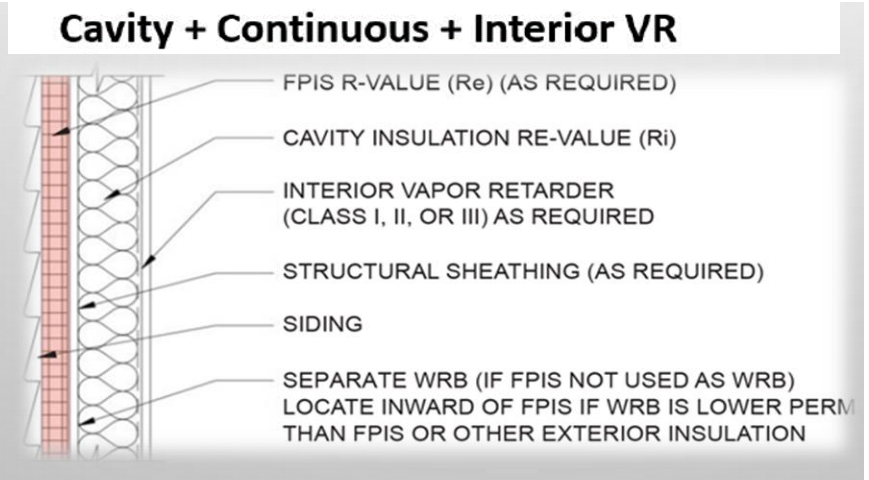
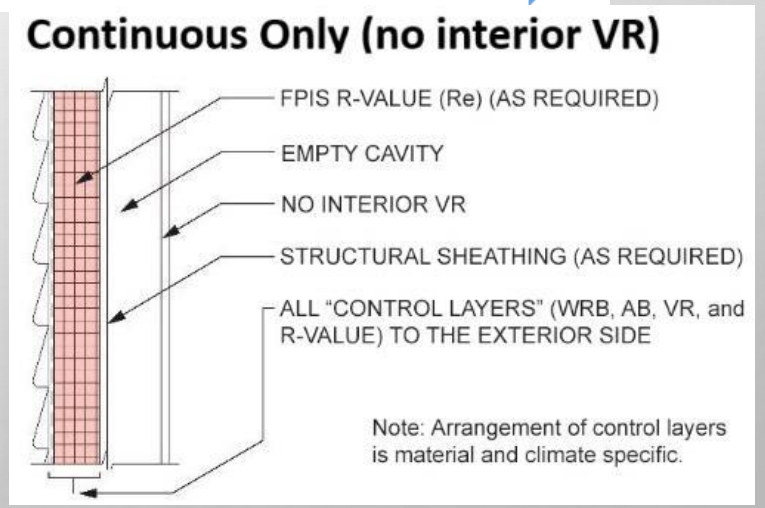
THREE BASIC METHODS FOR INSULATING LIGHT-FRAME *EXTERIOR WALLS*

1. ***CAVITY INSULATION ONLY*** ("TRADITIONAL" METHOD)
2. ***CAVITY INSULATION + CONTINUOUS INSULATION*** ("HYBRID" METHOD)
3. ***CONTINUOUS INSULATION (CI) ONLY*** ("PERFECT WALL" METHOD)

CAVITY INSULATION ONLY ➔ CAVITY + CONTINUOUS HYBRID ➔ CONTINUOUS ONLY







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- ***CONTINUOUS INSULATION*** (CI):

  INSULATION THAT IS UNCOMPRESSED

  …AND CONTINUOUS ACROSS

  ALL STRUCTURAL MEMBERS

  …WITHOUT THERMAL BRIDGES

  OTHER THAN FASTENERS AND SERVICE OPENINGS.

  (IBC, IRC, IECC AND ASHRAE 90.1 DEFINITION)

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C. CODE-COMPLIANT WATER/AIR/VAPOR CONTROL

I. FUNDAMENTALS OF MOISTURE CONTROL

II. WATER VAPOR CONTROL

III. AIR LEAKAGE CONTROL (AB)

IV. RAIN WATER CONTROL (WRB & FLASHING)

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I. FUNDAMENTALS OF MOISTURE CONTROL

- SUCCESSFUL MOISTURE CONTROL REQUIRES AN INTEGRATED APPROACH TO 5 KEY BUILDING SCIENCE CONCEPTS:
    1. **CONTROL RAIN WATER INTRUSION** (E.G., CONTINUOUS WATER-RESISTIVE BARRIER (WRB))
    2. **CONTROL AIR LEAKAGE** (E.G., CONTINUOUS AIR BARRIER (AB))
    3. **CONTROL INDOOR RELATIVE HUMIDITY** (E.G., BUILDING VENTILATION & DE-HUMIDIFICATION)
    4. **CONTROL WATER VAPOR** (E.G., OPTIMIZED BALANCE OF WETTING AND DRYING THROUGH STRATEGIC USE OF INSULATION AND VAPOR RETARDERS)
    5. **CONTROL INITIAL CONSTRUCTION MOISTURE** (E.G., PREVENT ENCLOSURE OF WET MATERIALS)
- ALL ARE IMPORTANT, ALL VARY IN SIGNIFICANCE, ALL HAVE INTER-DEPENDENCIES.
- THESE 5 CONCEPTS ARE CAPTURED IN THE FOLLOWING **3 RULES**:
    1. **KEEP WATER VAPOR (HUMID AIR) AWAY FROM COOL SURFACES**
    2. **MINIMIZE AIR LEAKAGE INTO AND THROUGH BUILDING ENVELOPE ASSEMBLIES**
    3. **AVOID RAIN WATER INTRUSION**

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II. WATER VAPOR CONTROL (RULE #1)

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.

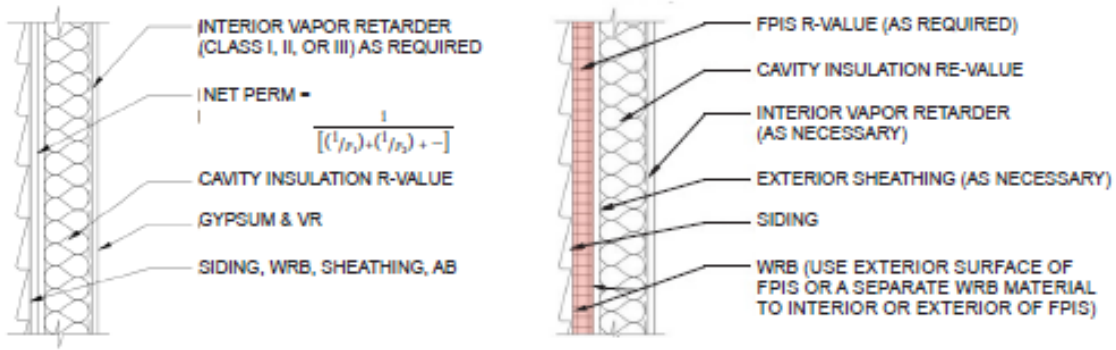
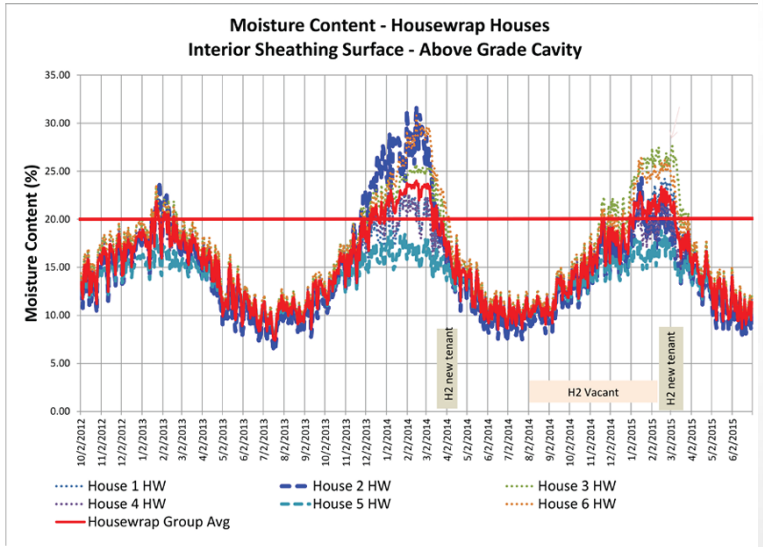
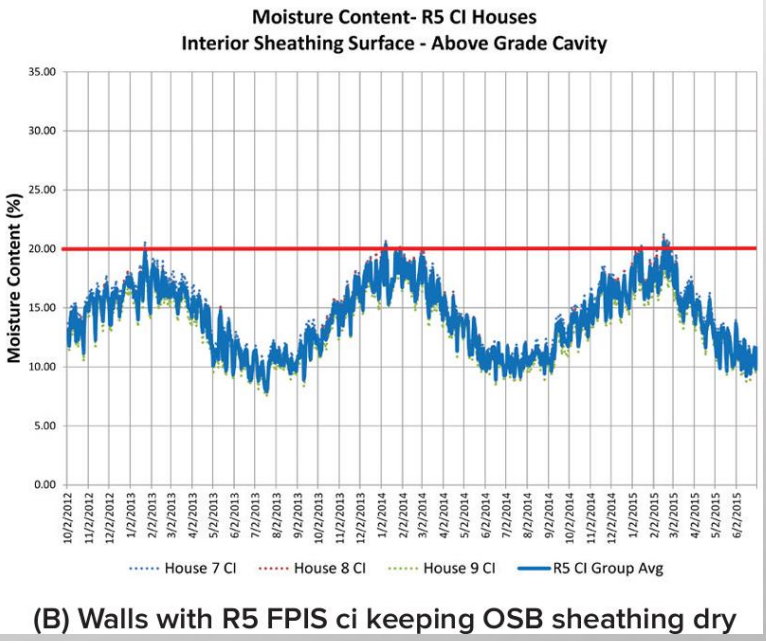


Figure 1. Cavity insulation only vs. wall with FPIS ci insulation (see Figure 2 for performance comparison)

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

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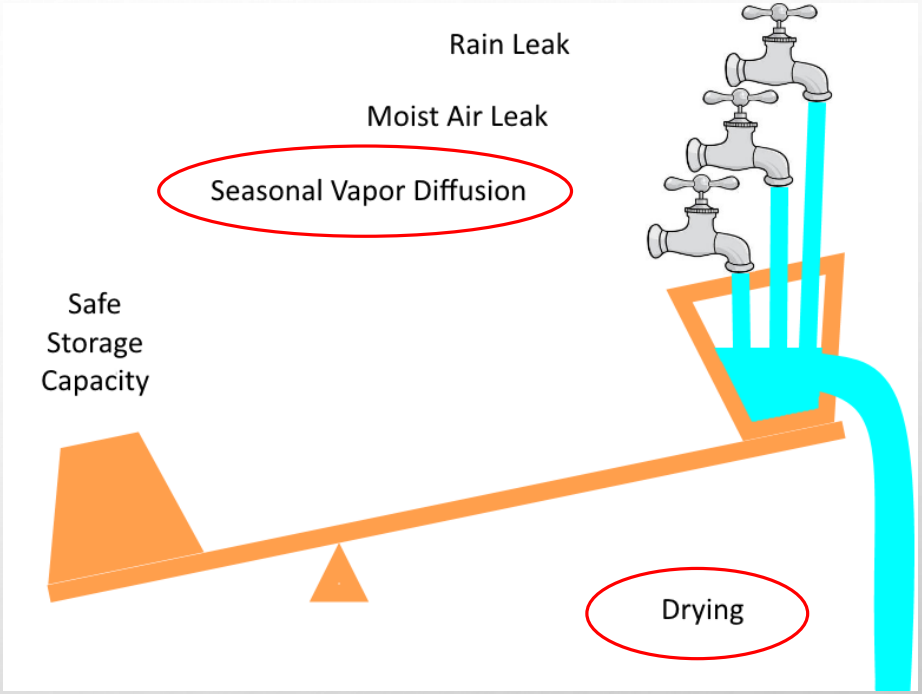
DRIVER = VAPOR PRESSURE DIFFERENTIAL

- IT IS A BALANCING ACT!
- DIRECTION THROUGH BTE CHANGES SEASONALLY!
- MUST BALANCE OVERALL SEASONAL AND ANNUAL:
  - RISK OF RAIN WATER WETTING
  - RISK OF AIR-LEAKAGE WETTING
  - RISK OF VAPOR DIFFUSION WETTING VS. DRYING
- R-VALUE AND RELATIVE WVP OF MATERIALS AND THEIR LOCATION WITHIN THE ASSEMBLY MATTERS
  - ABILITY OF MATERIALS TO STORE AND TOLERATE MOISTURE ALSO MATTERS
- **GOAL:** DRYING > WETTING TO CONTROL RISK OF MOLD OR WATER-SENSITIVE MATERIAL DEGRADATION



http://buildingscience.com/documents/digests/bsd-114-interior-insulation-retrofits-of-load-bearing-masonry-walls-in-cold-climates

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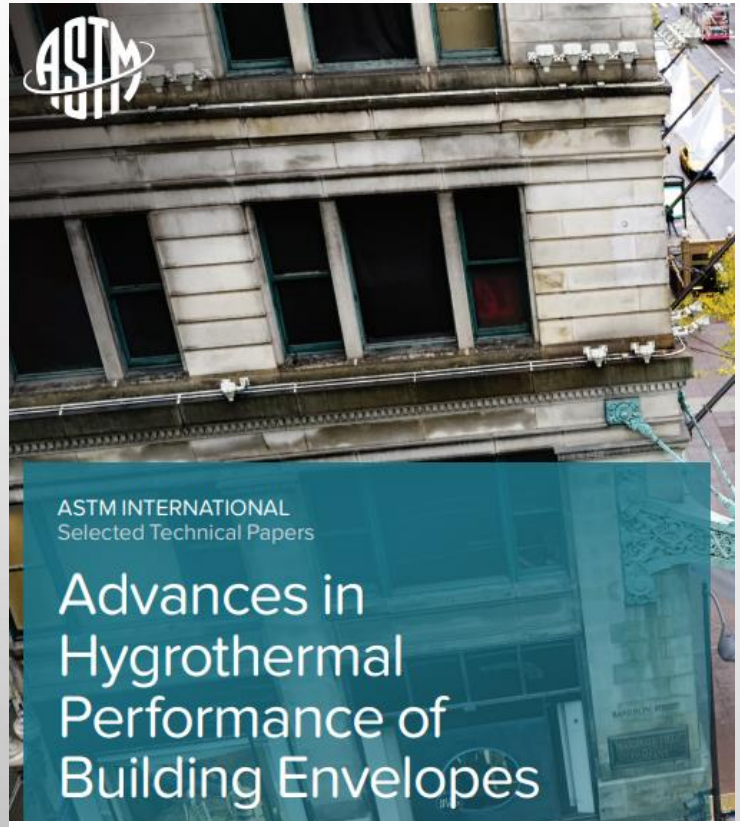
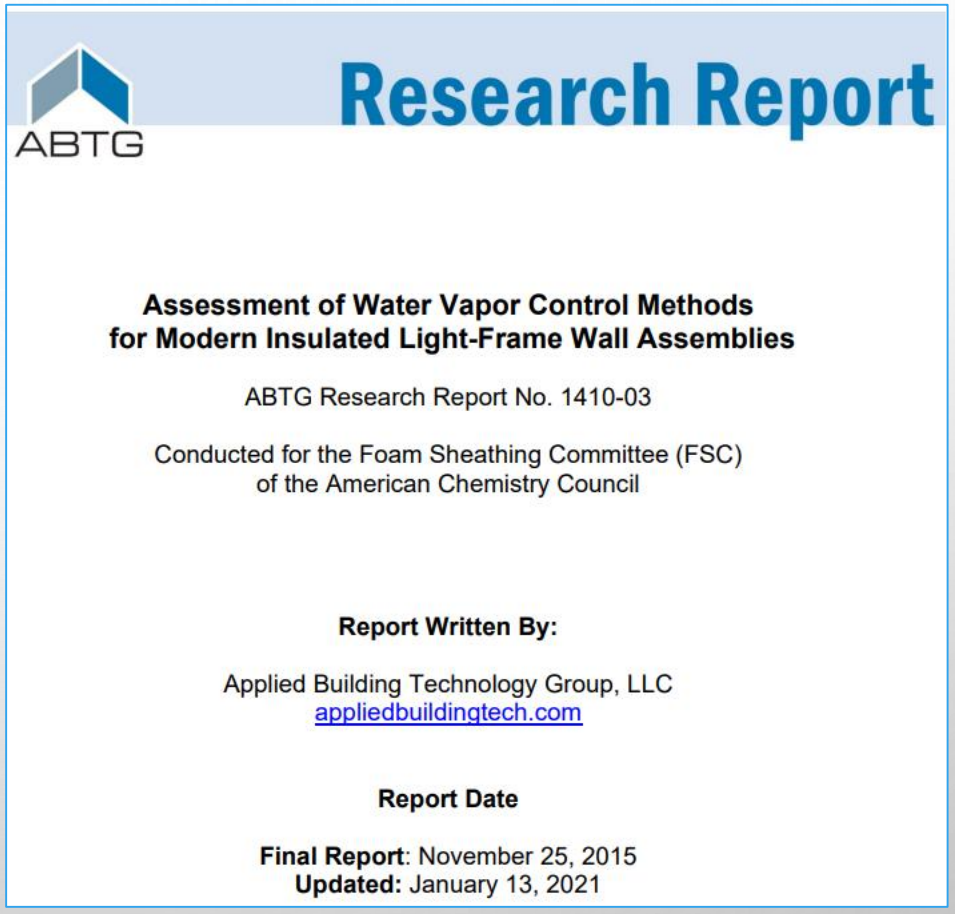
RESEARCH LEADING TO 2021/2024 IRC & IBC PROVISIONS



STP1599

Assessment of Hygrothermal Performance and Design Guidance for Modern Light-Frame Wall Assemblies

https://www.astm.org/DIGITAL_LIBRARY/STP/PAGES/STP159920160097.htm



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Research Report

Assessment of Water Vapor Control Methods for Modern Insulated Light-Frame Wall Assemblies

ABTG Research Report No. 1410-03

Conducted for the Foam Sheathing Committee (FSC)
of the American Chemistry Council

Report Written By:

Applied Building Technology Group, LLC
appliedbuildingtech.com

Report Date

Final Report: November 25, 2015
Updated: January 13, 2021

https://www.appliedbuildingtech.com/rr/1410-03

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RESEARCH FINDINGS

- SURVEYED MULTIPLE FIELD, TEST HUT, AND MODELING STUDIES
- COMPARED TO U.S. AND CANADIAN CODE AND PRACTICES
- CONFIRMED WHERE PRACTICES WERE WORKING WELL
- CONDUCTED ANALYSIS WHERE REFINEMENTS NEEDED
- PEER REVIEWED
- COMBINED BEST OF U.S. AND CANADIAN PRACTICES TO RESULT IN 2021 IBC/IRC
- ASSUMED WORST-CASE LOW PERMEANCE CONDITIONS FOR CI AND/OR EXTERIOR MATERIAL LAYERS TO ENSURE ROBUST PRESCRIPTIVE PROVISIONS
- UNANIMOUS APPROVAL AT CODE HEARINGS INCLUDING MAJOR STAKEHOLDERS

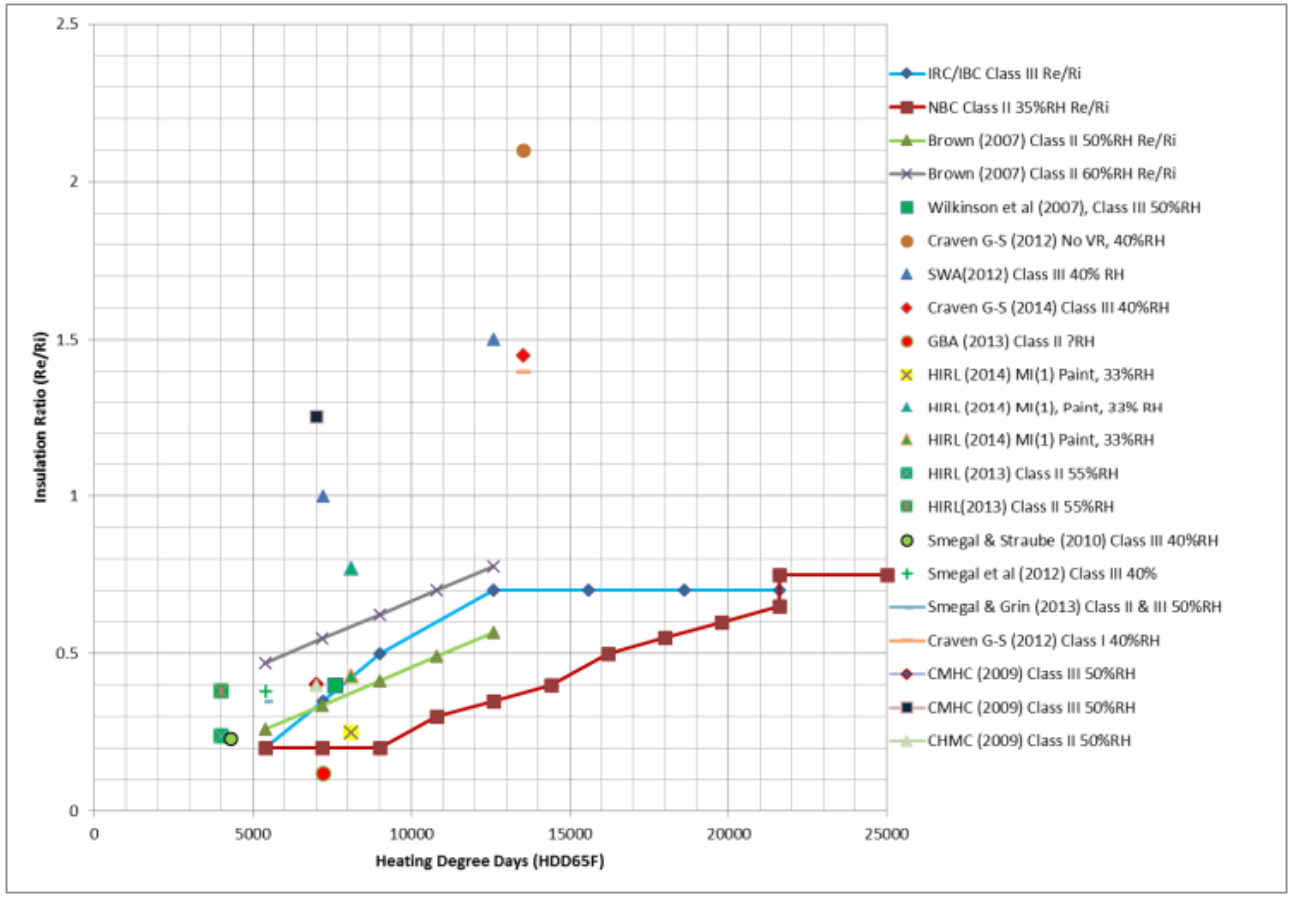

Figure 14: *IRC/IBC* and NBC Wall Insulation Ratio Requirements Compared to Data Points from Various Modeling, Test Hut, Case Studies, and Field Monitoring Studies Reported in the Literature

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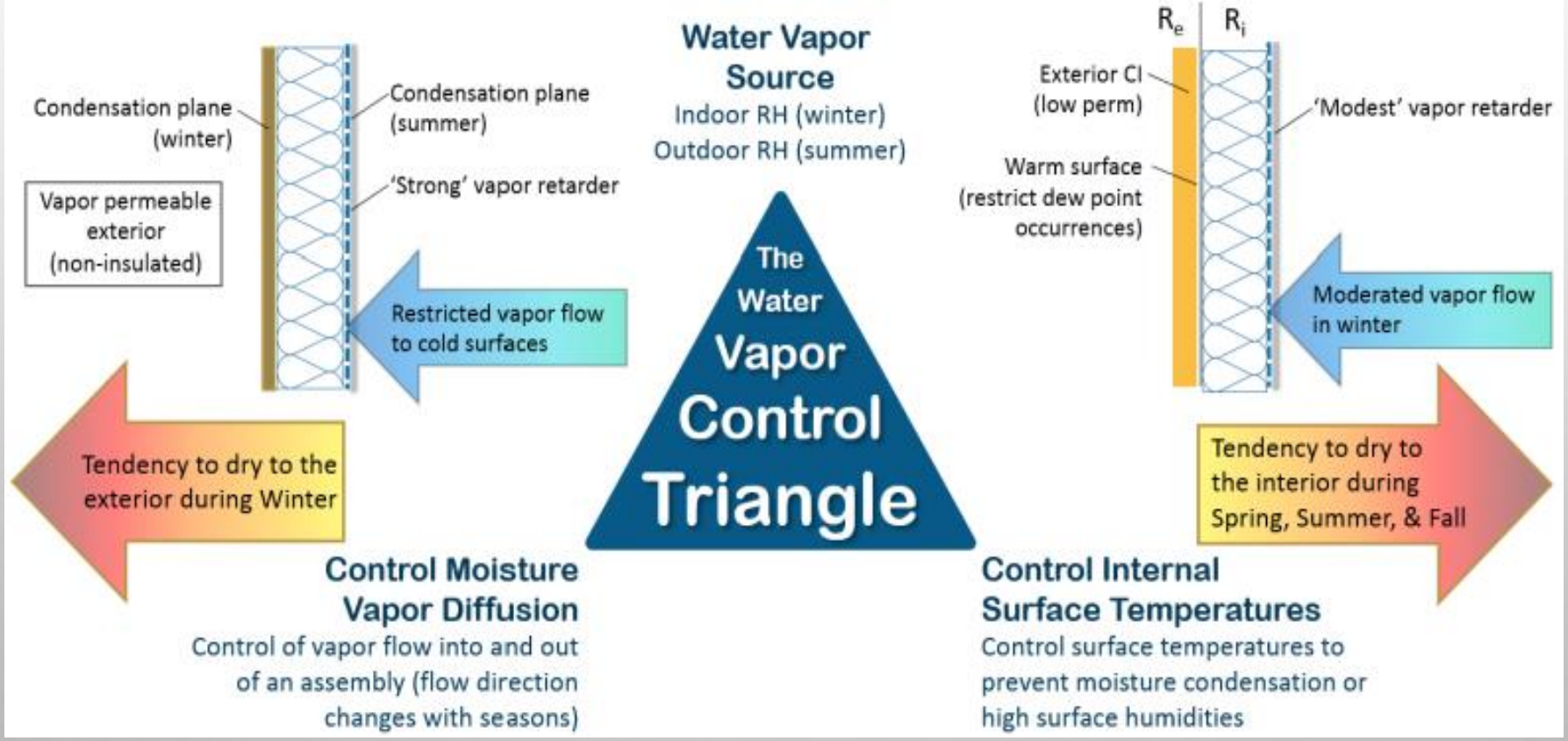
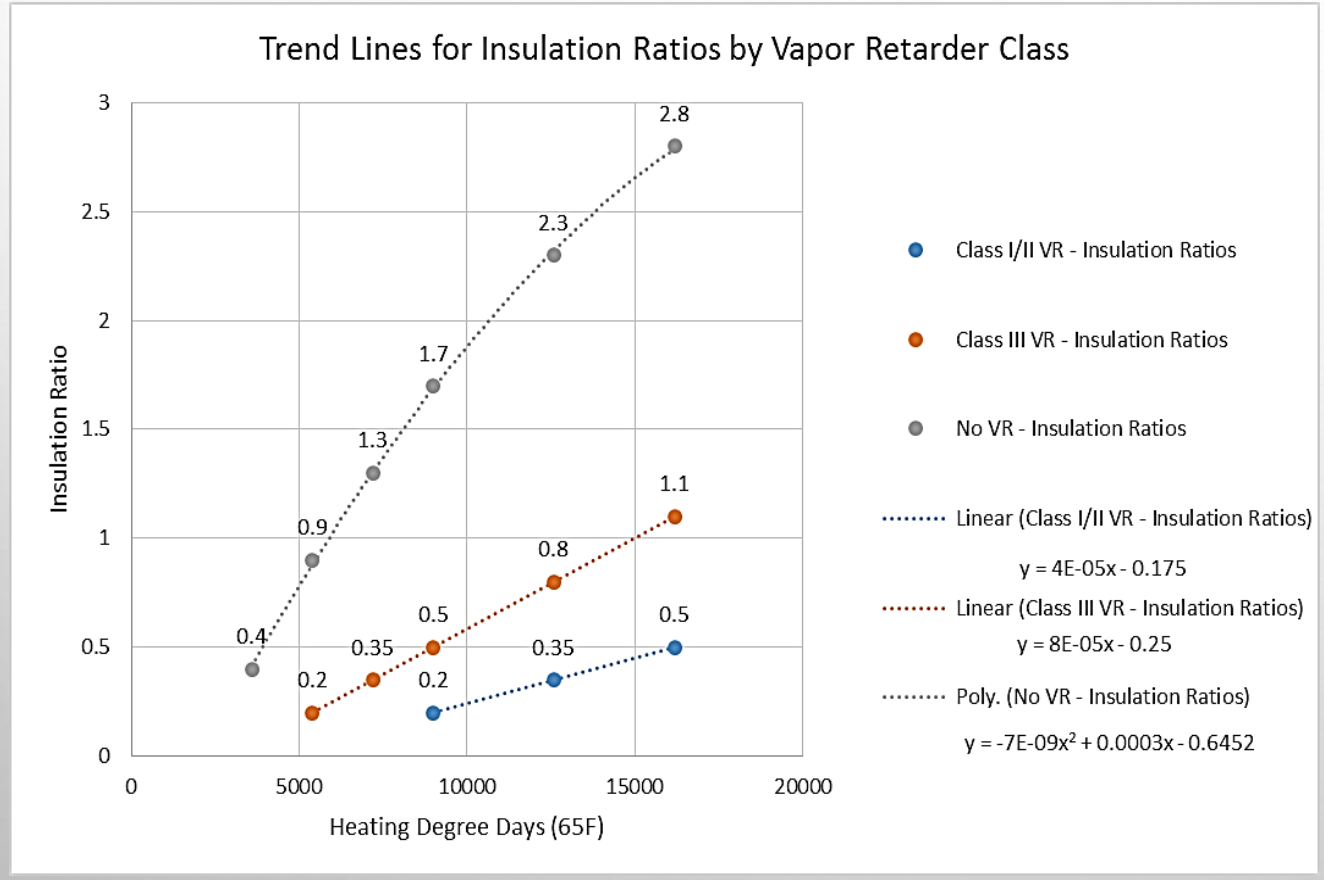
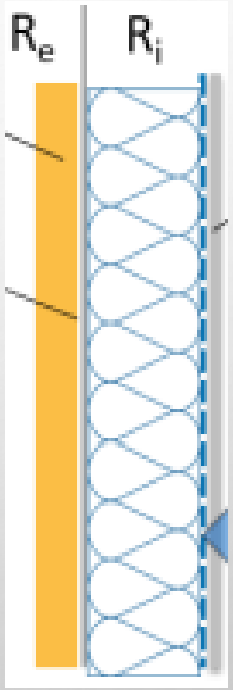
VAPOR CONTROL PRINCIPLES

- TWO APPROACHES TO CONTROL WATER VAPOR:
  - PERMEANCE CONTROLLED DESIGN (PERMEANCE RATIO)
  - TEMPERATURE CONTROLLED DESIGN (INSULATION RATIO, IR = RE/RI)



INSULATION RATIO (GRAPHIC FORMAT) (TEMPERATURE-CONTROLLED DESIGN)





Source: http://www.appliedbuildingtech.com/rr/1410-03

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INSULATION RATIO (TABULATED FORMAT)

(BASIS OF 2021/2024 IBC AND IRC FOR WALLS WITH CONTINUOUS INSULATION)

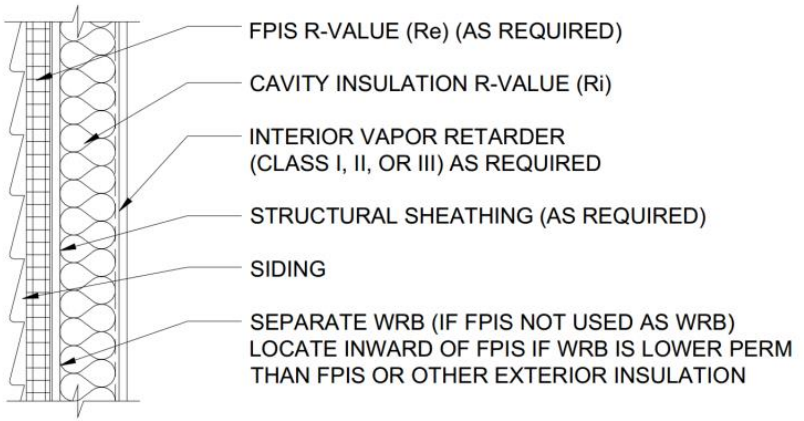
MINIMUM INSULATION RATIO OR CONTINUOUS INSULATION R-VALUE FOR LIGHT-FRAME WALLS WHERE EXTERIOR CONTINUOUS INSULATION (ci) IS USED [a,b,c,d]

Climate Zone (Fig. 2)	Maximum Heating Degree Days (65F basis)	Interior Vapor Retarder (VR) Class			
		Class I	Class II	Class III	No VR[e]
1	N/A	NP	NP[f]	R-2ci minimum	R-2ci minimum
2	N/A	NP	NP[f]	R-2ci minimum	R-2ci minimum
3	3,600	NP	R-2ci minimum	R-2ci minimum	0.4
4	5,400	NP	R-2ci minimum	0.2	0.9
5	7,200	0.2	0.2	0.35	1.3
6	9,000	0.2	0.2	0.5	1.7
7	12,600	0.35	0.35	0.8	2.3
8[g]	16,200	0.5	0.5	1.1	2.8

For SI: 1 heating degree day (65°F basis) = 0.56 heating degree days (18°C basis)

NP = indicated vapor retarder class is not permitted in the indicated Climate Zone.

Table Notes & Commentary:



Source: http://www.appliedbuildingtech.com/rr/1701-01

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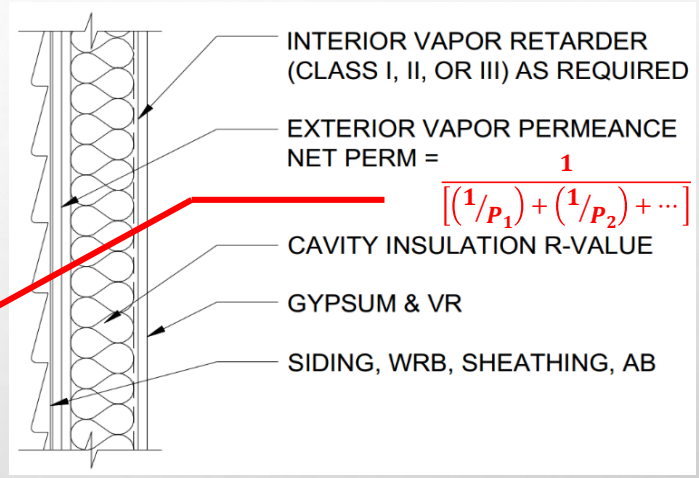
PERMEANCE RATIO
(NOT INCLUDED IN 2021 OR 2024 IBC AND IRC)

MINIMUM NET WATER VAPOR PERMEANCE (WVP)
FOR MATERIAL LAYERS LOCATED ON THE EXTERIOR SIDE OF WALL STUDS [a,b,c]

Climate Zone (Fig. 2)	Interior Vapor Retarder Class		
	Class I	Class II	Class III
1	NP	NP[d]	No minimum
2	NP	NP[d]	No minimum
3	NP	No minimum	No minimum
4	0.5 perm (Marine 4) and otherwise NP	0.5 perm	3 perm
5	0.5 perm	3 perm	5 perm
6	1 perm	5 perm	15 perm
7	1 perm	15 perm	NP
8[e]	1.5 perm	NP	NP

For SI: 1 perm = 57.2 ng/s-m^2-Pa
NP = indicated vapor retarder class is not permitted in the indicated Climate Zone
Table Notes & Commentary:



NOTE: Applies to walls with vapor/air permeable cavity insulation only, or with continuous insulation not meeting minimum insulation ratio (previous table).

Source: http://www.appliedbuildingtech.com/rr/1701-01

Requires determination of net water vapor permeance of all layers on the exterior side of the wall and comparison to minimum required permeance (table) for a given climate zone and interior vapor retarder class.

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CODE-COMPLIANT WATER VAPOR CONTROL

- IBC SECTION 1404.3 VAPOR RETARDERS
- IRC SECTION R702.7 VAPOR RETARDERS
- 2021 CODE INCLUDES MAJOR IMPROVEMENTS
- 2024 CODE INCLUDES SOME INCREMENTAL ENHANCEMENTS/OPTIONS
- WATER VAPOR CONTROL PER BUILDING CODE MUST BE COORDINATED WITH ENERGY CODE INSULATION REQUIREMENTS
  - INSULATION AND VAPOR RETARDERS WORK TOGETHER AND VARY IN APPLICATION BY CLIMATE
  - THE CODE HAS TAKEN A COMPLICATED BUILDING SCIENCE MATTER AND SIMPLIFIED IT INTO PRESCRIPTIVE RULES OR “LOOK-UP” TABLES
  - USE OF CONTINUOUS INSULATION PROVIDES A SIMPLE AND ROBUST WAY TO ADDRESS THERMAL AND WATER VAPOR CONTROL PERFORMANCE

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3-STEP GUIDE FOR WATER VAPOR CONTROL CODE COMPLIANCE
(BASED ON 2021 IBC/IRC)

SATISFIES RULE #1 – KEEP WATER VAPOR AWAY FROM COOL SURFACES

QUICK GUIDE
Foam Plastic Applications for Better Building

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 2021 International Residential Code (IRC) and 2021 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. For greater flexibility and to automate the application of this reference guide, 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 grater than 1.0 and less than or equal to 10.0.

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

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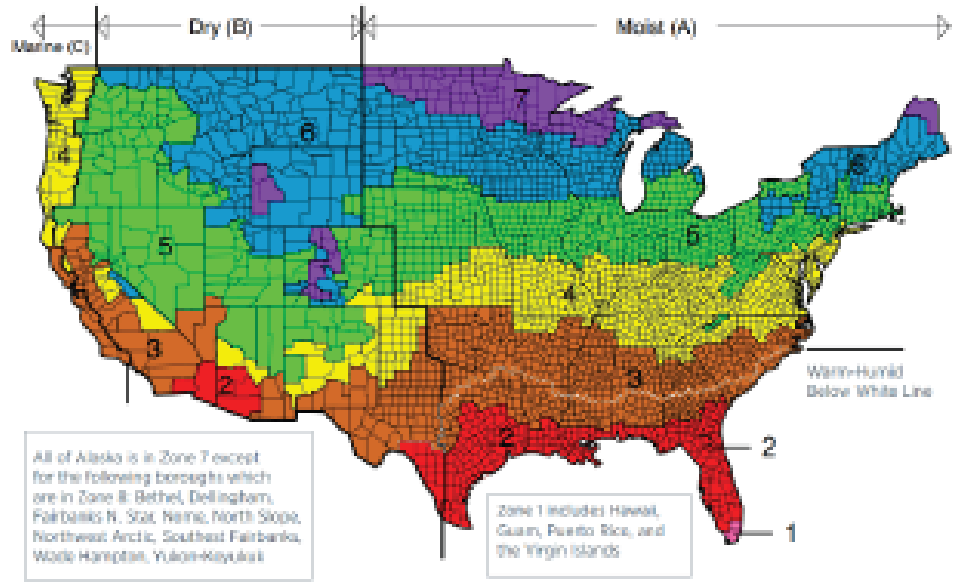
3-STEP GUIDE (CONT'D)

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:



U.S. Climate Zones

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. Class I and II vapor retarders with vapor permeance greater than 1 perm when measured by ASTM E96 water method (Procedure B) shall be allowed on the interior side of any frame wall in all climate zones.

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.

c. 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 R702.7(4) and the Class II vapor retarder shall have a vapor permeance of greater than 1 perm when measured by ASTM E96 water method (Procedure B).

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3-STEP GUIDE (CONT'D)

- CI EXAMPLE 1: CZ 5, CLASS III VR
  - TABLE R702.7(3):
  - USE MIN. R-5CI ON A 2X4 WALL WITH R13 CAVITY – BUT DOESN'T MEET ENERGY CODE (R13+10CI) ☹
  - USE MIN. R-7.5CI ON A 2X6 WALL WITH R20 – BUT THIS EXCEEDS MINIMUM ENERGY CODE (R20+5CI) ☺☺
- CI EXAMPLE 2: CZ 5, CLASS II VR
  - TABLE R702.7(4):
  - USE MIN. R-5CI ON 2X6 WALL WITH R20 CAVITY
  - MATCHES ENERGY CODE (R20+5CI) ☺
- CLASS II INTERIOR VR MUST BE "SMART"
  - PROMOTES DRYING TO INTERIOR
  - 2024 ALSO INCLUDES CLASS I "SMART"
    - CALLED "RESPONSIVE VAPOR RETARDERS"
  - ALLOWS USE OF CLASS I OR II CI MATERIAL ON EXTERIOR WITHOUT CREATING A "DOUBLE VAPOR BARRIER" WALL (E.G., AVOIDS LOW DRYING POTENTIAL)

STEP 3: DETERMINE MINIMUM R-VALUE REQUIREMENTS FOR CI

For use of FPIS ci with Class II or III interior vapor retarders (per Step 2), determine the minimum ci R-value required to control water vapor using IRC Tables R702.7(3) or R702.7(4) as applicable. The ci and cavity insulation amounts provided must also comply with the local energy code.

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 II VAPOR RETARDER

CLIMATE ZONE	CLASS II VAPOR RETARDERS PERMITTED FOR:
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

NOTE: When using a Class II interior vapor retarder, it must comply with the "smart" vapor retarder requirements of footnote 'c' of IRC Table R702.7(2) above (e.g., coated kraft paper facer complies). Use of a Class I "smart" vapor retarder will provide equal or better performance. Smart vapor retarders prevent OUTWARD moisture movement into walls in the winter and become vapor permeable for increased INWARD drying potential in the summer, which compliments the "warm wall" water vapor control provided by FPIS ci. A Class III interior vapor retarder is sufficiently vapor permeable at all times such that it is not required to be a "smart" vapor retarder but it requires more FPIS ci (i.e., a warmer wall) to prevent condensation in the winter.

TIP:
While not required, using more than the code minimum ci R-values shown above will further improve water vapor control and protection of the building envelope.

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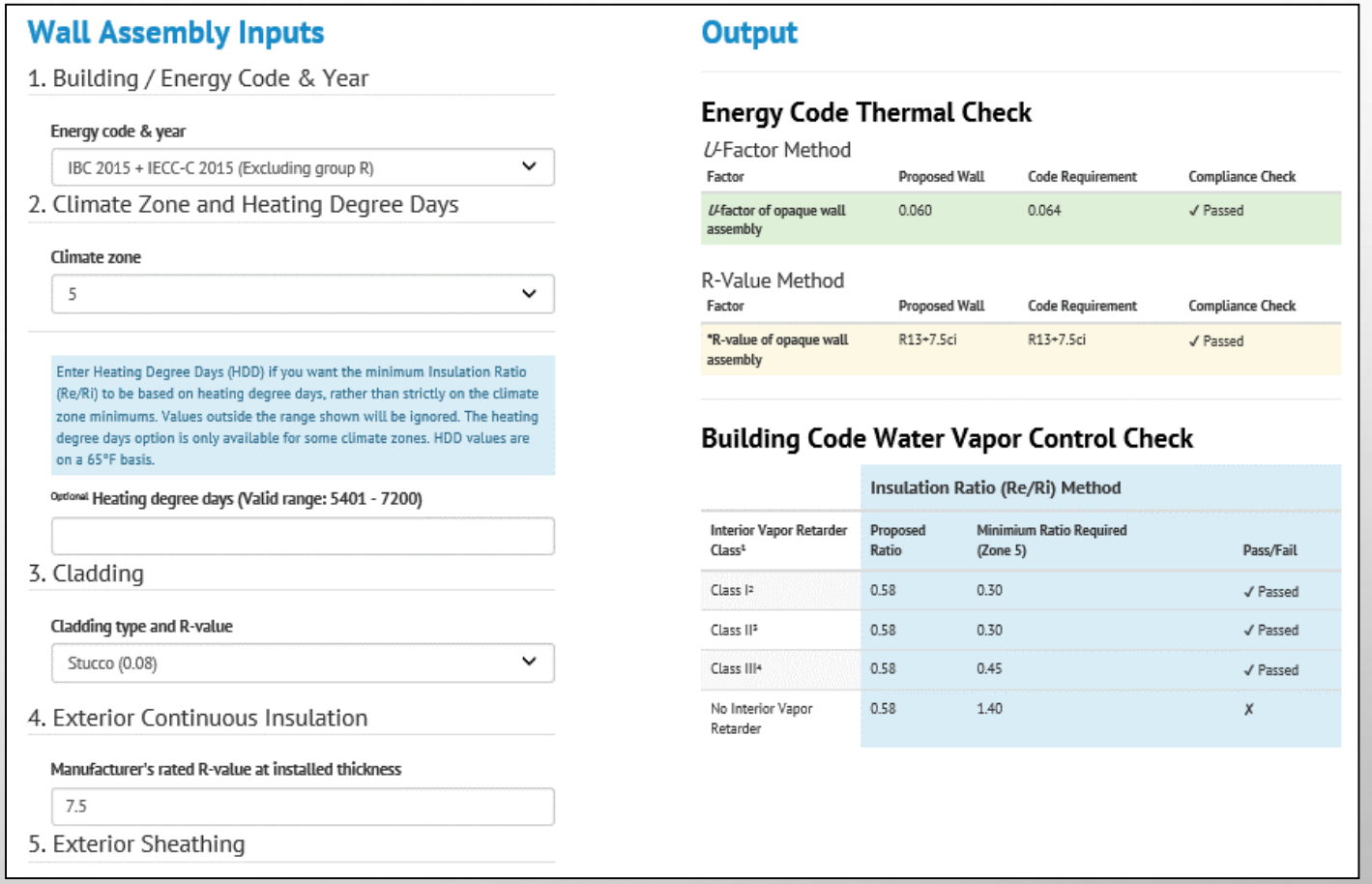
SIMPLIFIED ENERGY & WATER VAPOR CODE COMPLIANCE

- IMPLEMENTS R-VALUE AND U-FACTOR CHECKS PER IECC & ASHRAE 90.1
- 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)
- LIVE DEMO…(AS TIME ALLOWS)



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[3]	0.58	0.30	✓ Passed
Class III[4]	0.58	0.45	✓ Passed
No Interior Vapor Retarder	0.58	1.40	✗

https://www.continuousinsulation.org/calculators

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SUPPLEMENTAL DESIGN CONSIDERATIONS

CAN YOU HAVE TOO MUCH PERMEANCE?

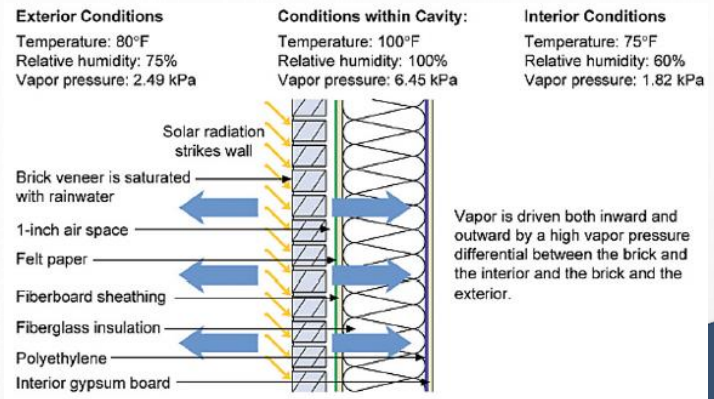
YES! (IN SOME CONDITIONS)

RECOMMENDATION:

THE NET WVP OF EXTERIOR LAYERS BETWEEN THE CLADDING AND SHEATHING (E.G., THE WRB OR CONTINUOUS INSULATION) SHOULD NOT EXCEED ~10 PERM

- THIS PREVENTS **SOLAR-DRIVEN INWARD MOISTURE MOVEMENT**, WHERE DIRECT-APPLIED (UNVENTED) RESERVOIR CLADDING (ADHERED VENEER, STUCCO, ETC.) IS USED.

ALTERNATIVE: BACK-VENTILATE & DRAIN RESERVOIR CLADDING (LIKE BRICK VENEER) – NEW STUCCO WRB REQUIREMENTS IN 2021/2024 IBC AND IRC FOR "MOIST" AND "MARINE" CLIMATE REGIMES.



Inward Moisture Movement Due to Solar Radiation

High sheathing moisture content

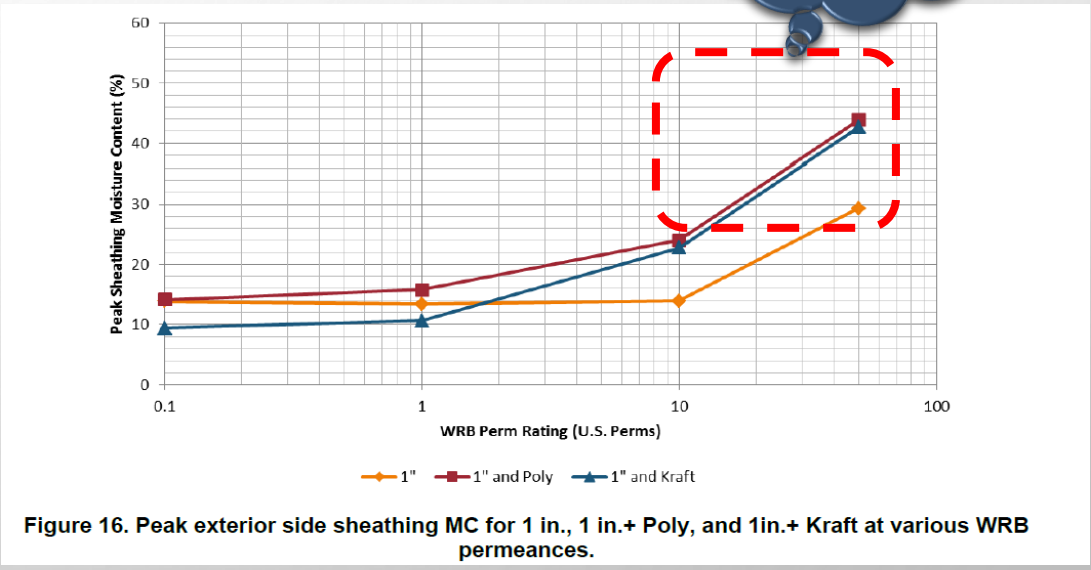


Figure 16. Peak exterior side sheathing MC for 1 in., 1 in.+ Poly, and 1in.+ Kraft at various WRB permeances.

Source: Lepage & Lstiburek (2013). Moisture Durability with Vapor-Permeable Insulating Sheathing. US DOE, Building Technologies Office, Building America Program

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SUPPLEMENTAL DESIGN CONSIDERATIONS

CAN YOU HAVE TOO LITTLE PERMEANCE? - YES!

RECOMMENDATION: AVOID "DOUBLE VAPOR BARRIER" WALLS! **BUT…**

i. THE ISSUE IS NOT NECESSARILY WITH A DOUBLE VAPOR RETARDER WALL (ALL MATERIALS ON INTERIOR AND EXTERIOR OF A WALL HAVE SOME LEVEL OF VAPOR RETARDANCE).

ii. IN 2021/2024 IBC AND IRC, CLASS I INTERIOR VAPOR RETARDERS (THAT ARE NOT "SMART" OR "RESPONSIVE") ARE NOT PERMITTED IN CLIMATE ZONES 1-4, SO THIS RECOMMENDATION APPLIES MAINLY TO THE CLIMATE ZONES 5-8 AND PARTICULARLY THE "MOIST" AND "MARINE" CLIMATE REGIMES.

iii. USE OF A CLASS I OR II "SMART" (RESPONSIVE) VAPOR RETARDER IS NOW CONSERVATIVELY REQUIRED IN 2021/2024 IBC AND IRC FOR WALLS WITH EXTERIOR CI

   i. PROMOTES INWARD DRYING WHILE STILL RESTRICTING OUTWARD (WINTER) VAPOR MOVEMENT.

   ii. THIS EFFECTIVELY RESOLVES THE DOUBLE VAPOR BARRIER ISSUE WITH USE OF LOW PERM EXTERIOR CI.

- FOR ADDITIONAL INFO ON **DOUBLE VAPOR BARRIERS**, REFER TO: "DOUBLING DOWN: HOW COME DOUBLE VAPOR BARRIERS WORK? (DR. LSTIBUREK, *ASHRAE JOURNAL*, JAN. 2016)

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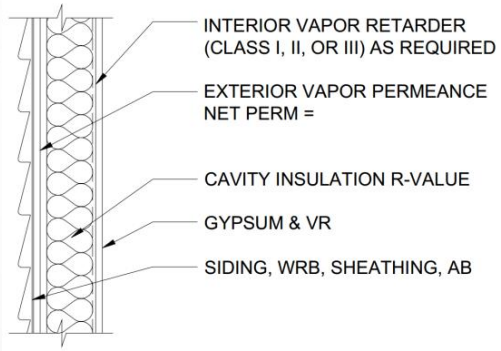
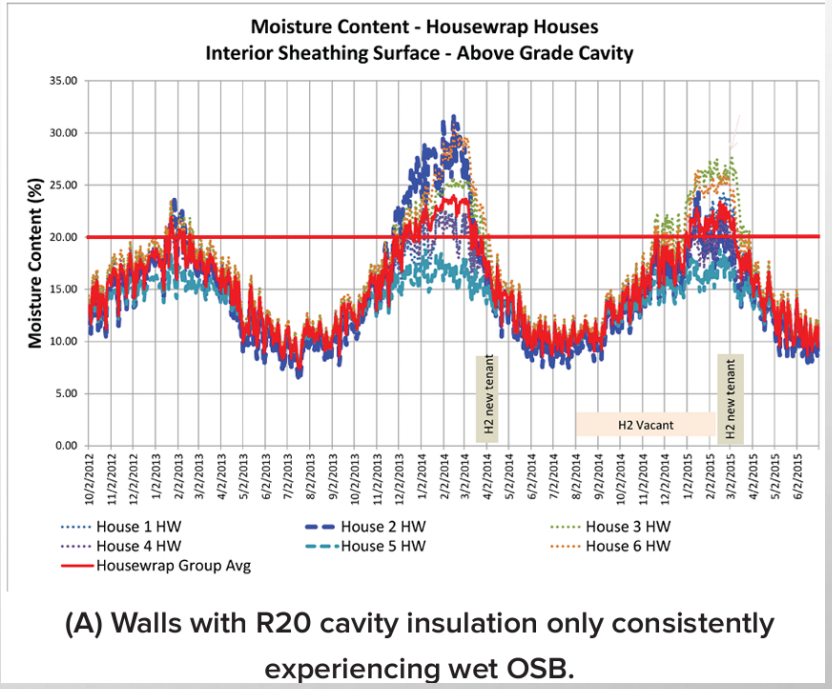
SUPPLEMENTAL DESIGN CONSIDERATIONS

DRYING POTENTIAL ("BREATHABILITY") IS NOT A "CURE ALL" FOR WALLS AND COMPONENTS THAT ALLOW WATER INTRUSION.

- TAKEN TO AN EXTREME, IT CAN LEAD TO:
  - A FALSE SENSE OF SECURITY IN "BREATHABILITY"
  - INATTENTION TO THE PRIMARY CONCERN WITH PREVENTING WATER LEAKS WITH PROPER WRB AND FLASHING INSTALLATION TOGETHER WITH PROPER USE OF INSULATION AND VAPOR RETARDERS TO CONTROL WATER VAPOR.
- WALLS WITH HIGH EXTERIOR VAPOR PERMEABILITY (OUTWARD DRYING POTENTIAL) AND INADEQUATE INTERIOR VR (EVEN THOUGH CODE COMPLIANT) WILL PASS WATER VAPOR THROUGH COLD HYDROPHILIC EXTERIOR LAYERS (E.G., OSB, GYPSUM SHEATHING, ETC.) CAUSING THEM TO:
  - HAVE A HIGH WETTING POTENTIAL! (I.E., ADSORB MOISTURE TO HIGH LEVELS IN THE WINTER, EVEN WITHOUT PRESENCE OF CONDENSATION AND WITH ADEQUATE DRYING IN WARMER SEASONS TO AVOID VISIBLE MOLD GROWTH).
  - THIS HIGH SEASONAL MOISTURE CYCLING CAN DEGRADE EXTERIOR SHEATHING STRUCTURAL PROPERTIES, CAUSE EXPANSION/BUCKLING, AND ALSO IMPACT DURABILITY AND APPEARANCE OF CLADDINGS (PARTICULARLY IF UNVENTILATED).
- **SOLUTION:** USE A CLASS I RESPONSIVE VAPOR RETARDER IN CZ 5-8 FOR THESE WALLS WITH HIGH EXTERIOR "BREATHABILITY".





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

Inadequate moisture control in a code-compliant "breathable" 2x6 wall in CZ 5 with vapor-permeable cavity insulation only and a Class II (kraft) interior vapor retarder.

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III. AIR LEAKAGE CONTROL (RULE #2)

Drivers = air pressure differential = f(stack effect + wind + unbalanced mechanical ventilation)

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

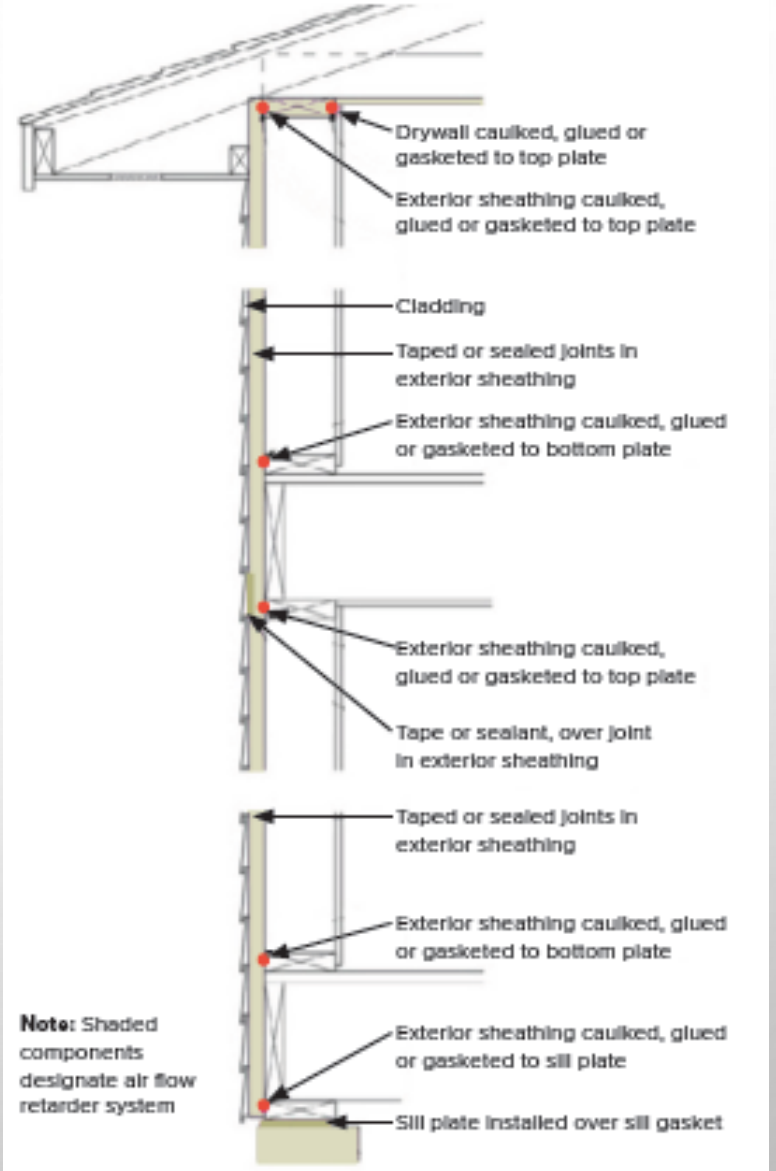
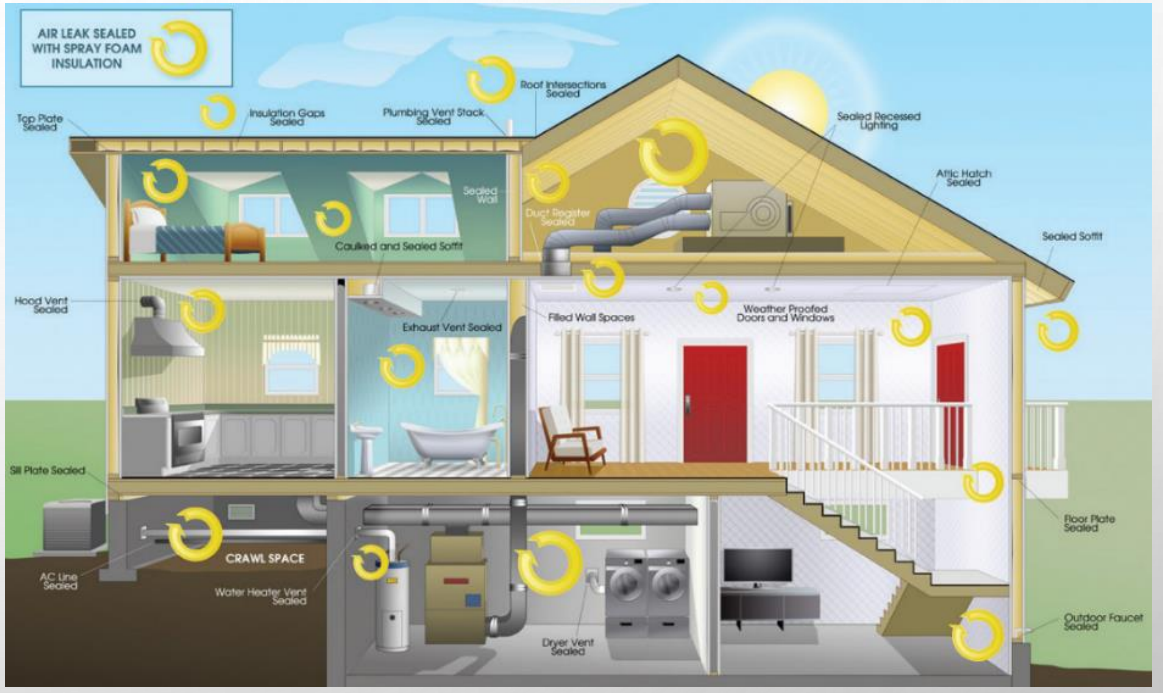


Figure 3. FPIS ci installed as an air barrier exterior sheathing.

CODE-COMPLIANT AIR LEAKAGE CONTROL

- 2021 IECC-C SECTION C402.5 (TESTING OPTIONAL, AIR BARRIER ALWAYS)
- 2021 IECC-R SECTION R402.4 (TESTING ALWAYS, AIR BARRIER ALWAYS)
  - SEE CODE FOR DETAILS FOR AB INSTALLATION, TEST METHODS (BLOWER DOOR), AND MAXIMUM LEAKAGE RATES (CFM/FT^2) OR AIR-CHANGES PER HOUR (ACH)

- *NOTE: WHILE MAINLY AN ENERGY CODE COMPLIANCE CONCERN, AIR BARRIERS ALSO PLAY AN IMPORTANT ROLE IN CONTROL OF WATER VAPOR IN COORDINATION WITH IBC/IRC VAPOR RETARDER PROVISIONS.*



https://www.americanchemistry.com/industry-groups/spray-foam-coalition-sfc

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FPIS CI & SPF AS AIR BARRIERS

- AIR BARRIER (AB)
  - MOST FOAM SHEATHING PRODUCTS MEET AIR BARRIER MATERIAL REQUIREMENTS (AIR PERMEABILITY TEST)
    - CHECK MANUFACTURER DATA/LABEL
  - IECC C402.5.1.3 LISTS "DEEMED-TO-COMPLY" PRODUCTS, E.G.:
    - FPIS (XPS AND POLYISO OF MIN ½" THICK)
    - CCSPF OF MIN. 1.5" THICK AND 1.5 PCF DENSITY
    - OCSPF OF MIN. 4.5" THICK AND 1.5 PCF DENSITY
  - KEY TO GOOD AIR BARRIER SYSTEM IS SEALING OF JOINTS, PENETRATIONS, AND TRANSITIONS.
  - BEST PRACTICE IS DUAL AIR BARRIER TO ENCAPSULATE AIR-PERMEABLE INSULATION (IF USED) – CODE ONLY REQUIRES ON ONE SIDE INSULATION.
  - SINGLE COMPONENT/CANISTER SPF IS USED AS AN AIR SEALANT FOR JOINTS & CRACKS (NOT INSULATION)

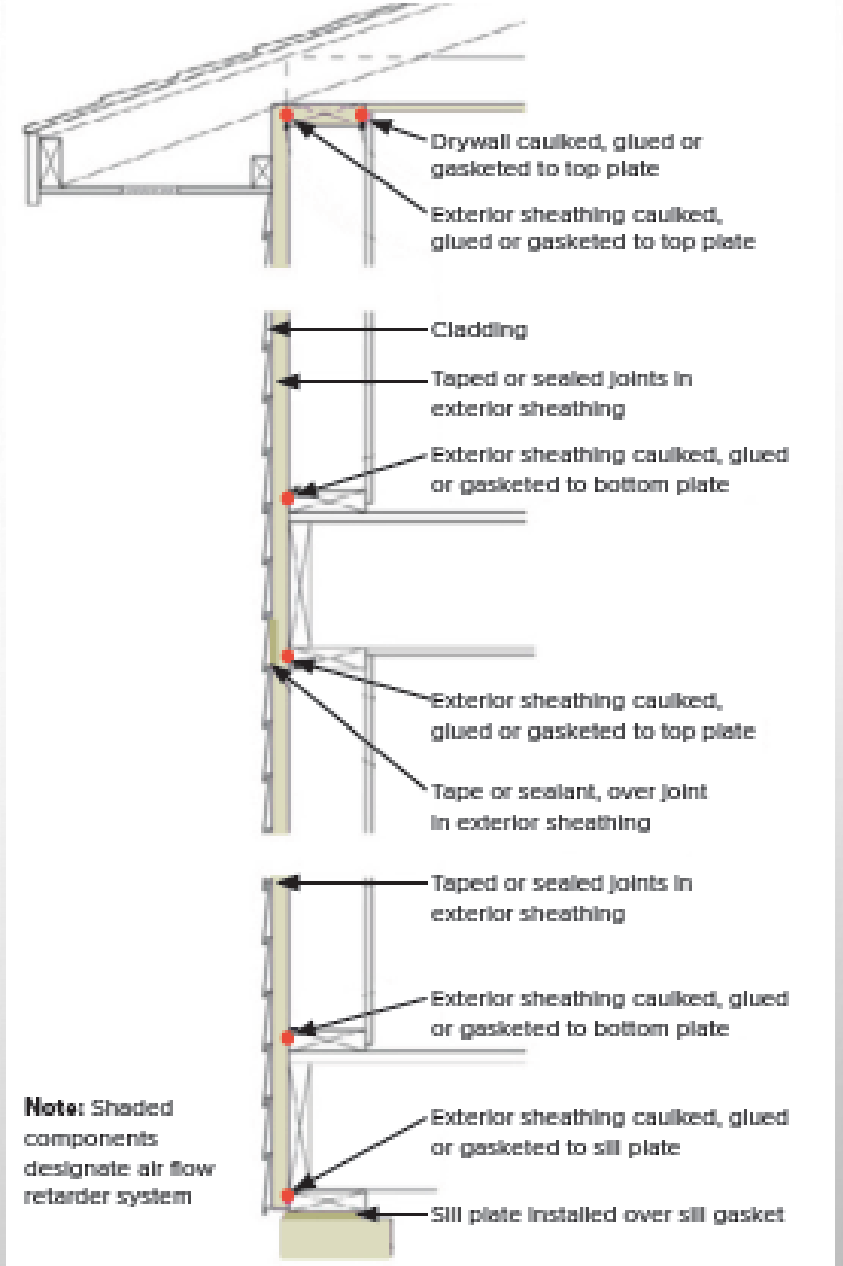

Figure 3. FPIS ci installed as an air barrier exterior sheathing.

IV. CONTROL RAINWATER INTRUSION (RULE #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.

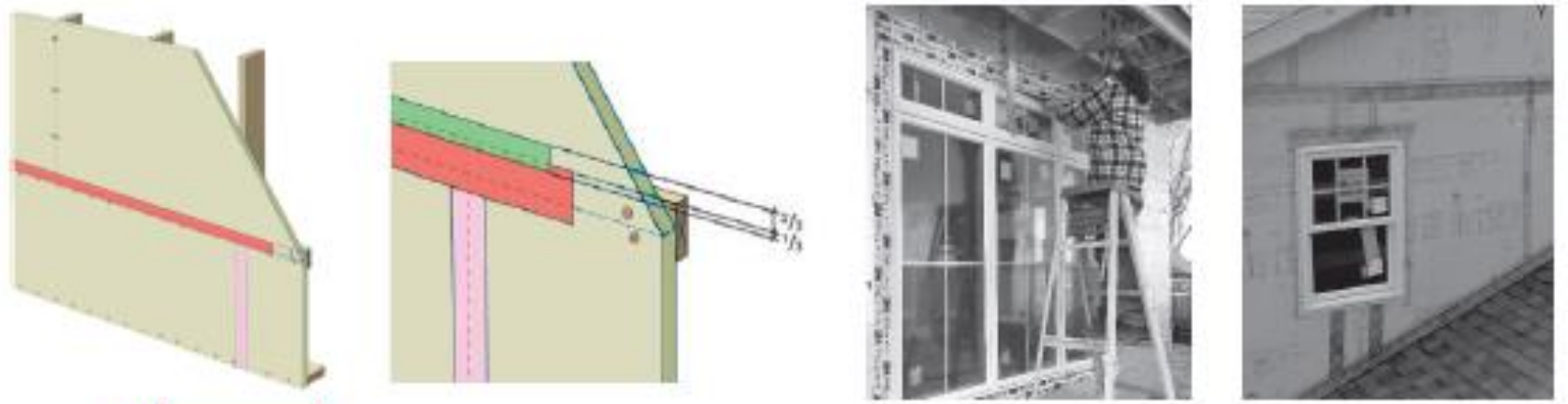

Figure 4. FPIS WRB System installation using joint tapes and adhered flashings; refer to manufacturer installation instructions for specific details.

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

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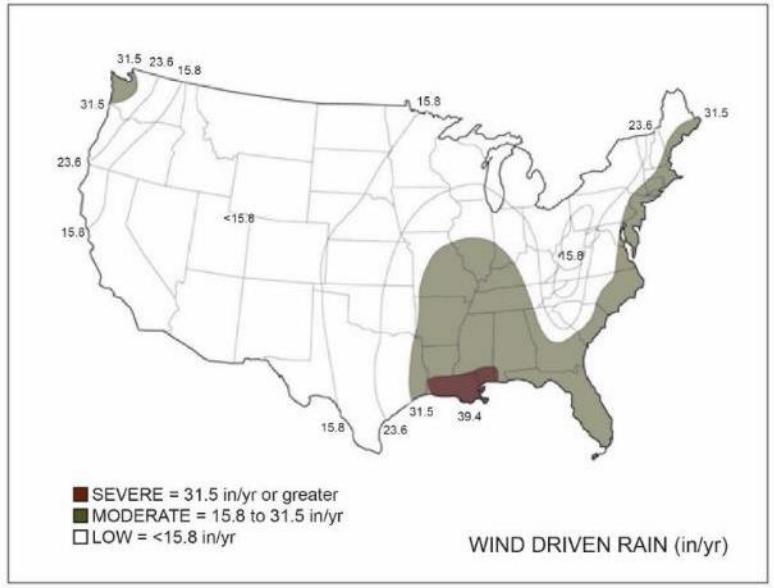
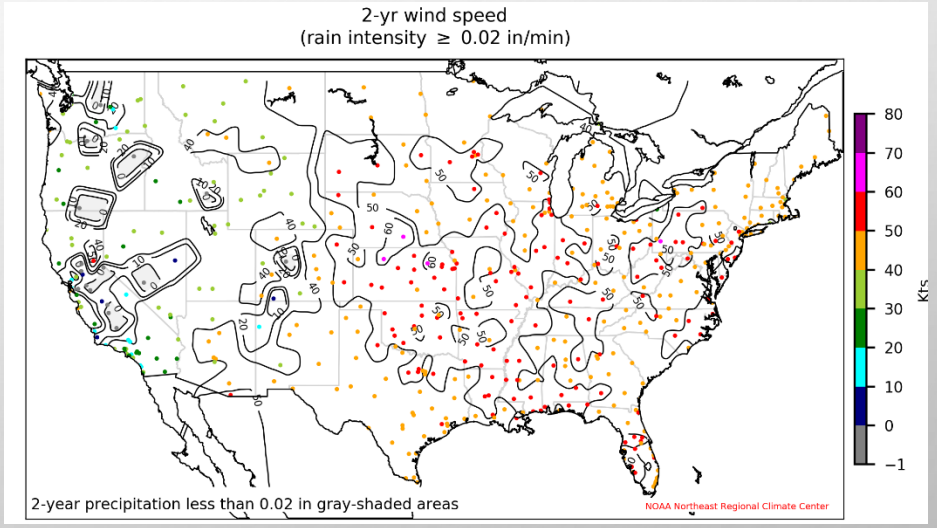
DRIVER = WIND-DRIVEN RAIN

- RAIN WATER INTRUSION IS OFTEN THE PRIMARY FACTOR ASSOCIATED WITH OBSERVED FAILURE OR SUCCESS OF MOISTURE CONTROL
  - WIND DRIVEN RAIN (WDR) IS THE PRIMARY HAZARD (SEE MAPS)
- IF RAIN WATER IS NOT ADEQUATELY CONTROLLED, OTHER CONTROL MEASURES CAN BE RENDERED INEFFECTIVE (AIR BARRIERS, VAPOR RETARDERS, DRYING POTENTIAL, ETC.)
- CONCEPT IS SIMPLE: KEEP WATER OUT!



Annual Average Wind Driven Rain Receipt (in/yr)
(map based on UofGA research)
(http://www.huduser.gov/portal/publications/reports/Guide-Durability-by-Design.html)



WDR Hazard Map for United States

Source: Cornell University, NOAA Northeast Climate Data Center (DRAFT)

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IBC/IRC WRB CODE REQUIREMENTS

IBC 1403.2 / IRC R703.2 WATER-RESISTIVE BARRIER. …CONTINUOUS…FLASHED… SHALL COMPLY WITH ONE OF THE FOLLOWING:

1. NO. 15 FELT COMPLYING WITH ASTM D226, TYPE 1.
2. ASTM E2556, TYPE I OR II.
3. FOAM PLASTIC INSULATING SHEATHING WATER-RESISTIVE BARRIER SYSTEMS COMPLYING WITH SECTION 1402.2 AND INSTALLED IN ACCORDANCE WITH MANUFACTURER'S INSTALLATION INSTRUCTIONS.

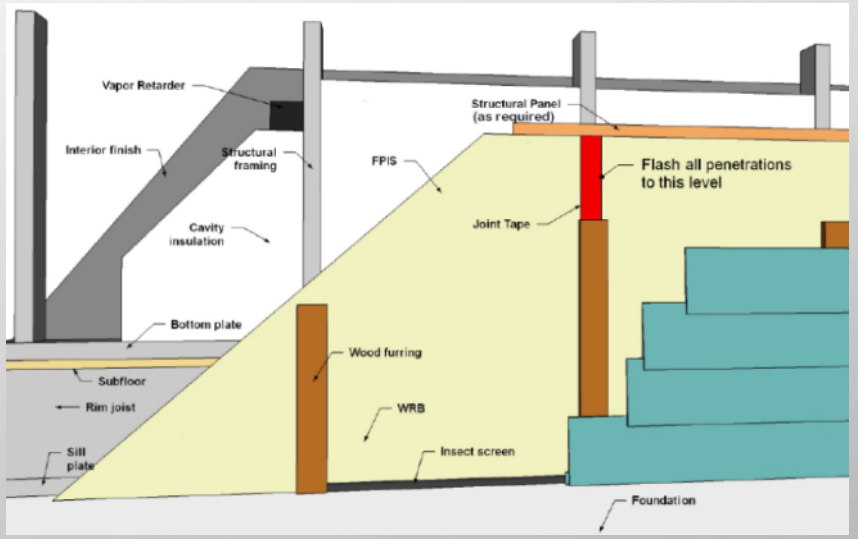
NEW 2024

4. ASTM E331 IN ACCORDANCE WITH SECTION 1402.2.
5. OTHER APPROVED MATERIALS INSTALLED IN ACCORDANCE WITH THE MANUFACTURER'S INSTALLATION INSTRUCTIONS.

FPIS ci can be used as WRB, air barrier, and means to control water vapor (multi-functional):

For guidance on use of FPIS ci as a WRB, refer to:
https://www.continuousinsulation.org/applications/WRB

For listing of code-compliant FPIS WRB systems refer to:
https://www.drjengineering.org/drr/1410-05



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FOUR WRB STRATEGIES WITH FPIS CI

- SIMPLEST AND MOST EFFICIENT SOLUTION USES FPIS CI AS WRB SYSTEM
  - SIMPLIFIES WINDOW FLASHING FOR FINNED FENESTRATION
- OTHER STRATEGIES MAY BE NECESSARY DEPENDING ON WINDOW LOCATION (INNY VS. OUTTY WINDOW) AND WINDOW, CLADDING, AND TRIM DETAILING

WRB Strategy	Pros	Cons
FPIS-ci used as the WRB	1. System resistance to water penetration (highest of all WRB criteria) 2. Simple flashing detailing when used with flanged fenestration units (see STEP 3B). 3. Cost-effective (eliminates a separate WRB material layer) 4. Can be used to effectively control water vapor in coordination with vapor retarder selection (STEP 3C)	1. Only applies to FPIS-ci products that have been tested and approved for WRB application (refer to manufacturer code compliance data - DrJ FSC report). 2. Must use manufacturer specified joint sealing treatments (joint tapes and adhered flashing) 3. Requires proper conditions for application of joint sealing treatments.
Separate WRB layer applied behind FPIS on wall substrate	1. Separate WRB layer is protected by FPIS-ci. 2. With proper R-value of FPIS-ci, the permeance of the WRB and sheathing is less of a concern when coordinated with interior vapor retarder selection (STEP 3C). 3. With reservoir claddings like stucco or adhered veneers the FPIS-ci layer prevents inward vapor drives through higher perm WRBs.	1. Additional cost of WRB separate from FPIS-ci 2. Potential for more complex and less reliable flashing details at windows if flanges are flush with FPIS-ci and back of siding as usually detailed while WRB is recessed from the flange (STEP 3B). 3. May need to use more expensive wrap to create small gap for drainage behind FPIS-ci.
Separate WRB layer applied over FPIS and directly behind cladding	1. Easier to flash windows to WRB if window flanges are placed flush with outside of wall (on plane with FPIS-ci outer surface). 2. Not preferred location for WRB behind stucco and adhered veneers which will prevent drainage unless an additional drainage layer or gap is provided between the WRB and stucco.	1. Additional cost of WRB separate from FPIS-ci 2. Difficulty attaching WRB layer through FPIS-ci layer. 3. WRB should be higher perm than FPIS-ci layer in cold climates or mixed climates. 4. WRB layer is not protected by FPIS-ci. 5. Added metal penetrations/thermal bridges through FPIS-ci layer.
Dual WRB: FPIS-ci is used as the primary WRB layer with a separate WRB layer applied behind FPIS	1. Perhaps the most “fail-safe” installation. 2. Otherwise Pros are similar to Strategy #2.	1. The most costly WRB installation. 2. Otherwise Cons are similar to Strategy #2.

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FPIS CI WRB SYSTEMS, JOINT TAPE, & FLASHING

Also serves as air barrier.

"Outty window install

EXAMPLE OF “INNY” WINDOW INSTALL

- FOR ANY THICKNESS OF FPIS
- FOR BLOCK FRAME AND FINNED WINDOWS
- CAN BE USED FOR NEW OR RETROFIT (RESIDING WITH ADDED CI)
- REQUIRES USE OF **SEPARATE WRB BEHIND FPIS CI** FLASHED TO WINDOW TRIM EXTENSION (OR WINDOW FIN)

IBC FLASHING REQUIREMENTS

2024 IBC FLASHING PROVISIONS (SIMILAR FOR 2024 IRC):

1404.4 FLASHING. FLASHING SHALL BE INSTALLED IN SUCH A MANNER SO AS TO PREVENT MOISTURE FROM ENTERING THE *EXTERIOR* WALL OR TO REDIRECT THAT MOISTURE TO THE SURFACE OF THE EXTERIOR WALL *COVERING* OR TO A *WATER-RESISTIVE BARRIER* COMPLYING WITH SECTION 1403.2 AND THAT IS PART OF A MEANS OF DRAINAGE COMPLYING WITH SECTION 1402.2.

FLASHING SHALL BE INSTALLED AT THE PERIMETERS OF EXTERIOR DOOR AND WINDOW ASSEMBLIES IN ACCORDANCE WITH SECTION 1404.4.1, PENETRATIONS AND TERMINATIONS OF *EXTERIOR WALL* ASSEMBLIES, *EXTERIOR WALL* INTERSECTIONS WITH ROOFS, … ETC.

1404.4.1 FENESTRATION FLASHING. FLASHING OF THE FENESTRATION TO THE WALL ASSEMBLY SHALL COMPLY WITH THE FENESTRATION MANUFACTURER'S INSTRUCTIONS OR, FOR CONDITIONS NOT ADDRESSED BY THE FENESTRATION MANUFACTURER'S INSTRUCTIONS, SHALL COMPLY WITH ONE OF THE FOLLOWING:

1. THE WATER-RESISTIVE BARRIER MANUFACTURER'S FLASHING INSTRUCTIONS;
2. THE FLASHING MANUFACTURER'S FLASHING INSTRUCTIONS;
3. A FLASHING DESIGN OR METHOD OF A REGISTERED DESIGN PROFESSIONAL; OR,
4. OTHER APPROVED METHODS.

New in 2024 – to match 2024 IRC

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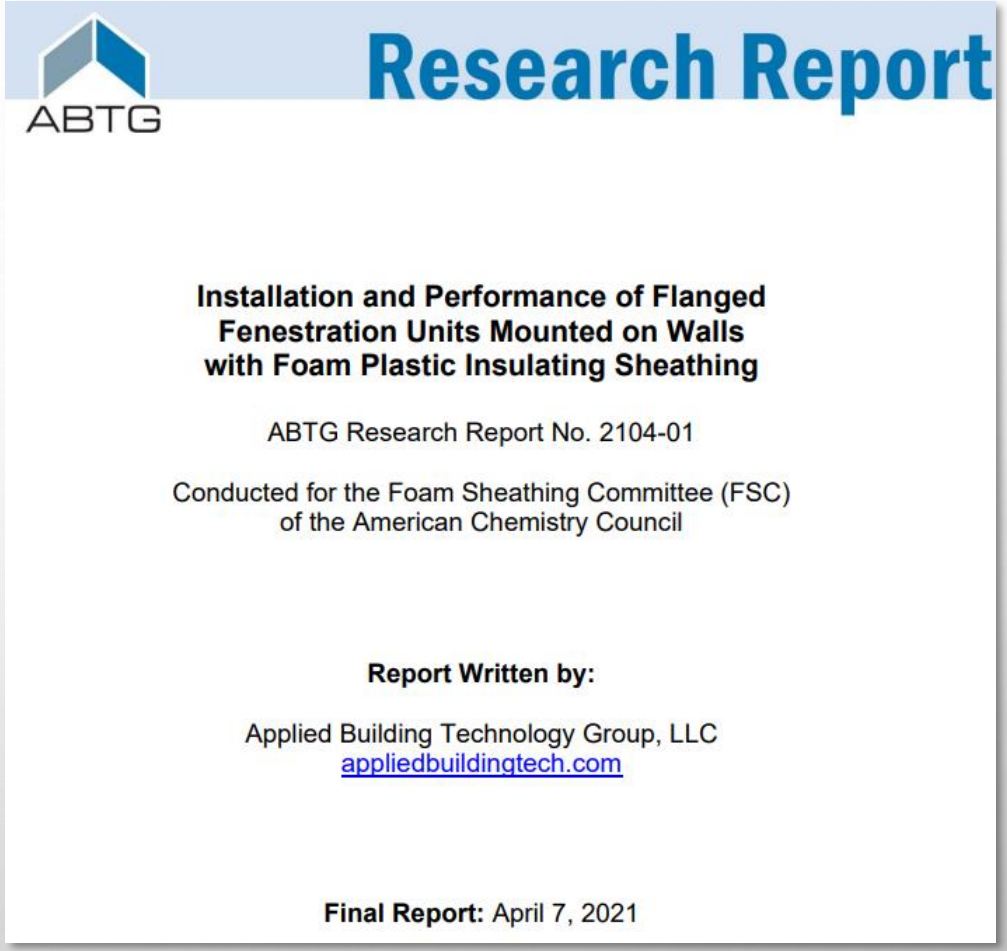
IBC/IRC FENESTRATION INSTALLATION COMPLIANCE

- INSTALLED PERFORMANCE TESTING
- FIELD INSTALLATION EXPERIENCE
- RECOMMENDED INSTALLATION INSTRUCTIONS

For more information, refer to:
https://www.continuousinsulation.org/window-installation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Research Report

Installation and Performance of Flanged Fenestration Units Mounted on Walls with Foam Plastic Insulating Sheathing

ABTG Research Report No. 2104-01

Conducted for the Foam Sheathing Committee (FSC)
of the American Chemistry Council

Report Written by:

Applied Building Technology Group, LLC
appliedbuildingtech.com

Final Report: April 7, 2021

https://www.appliedbuildingtech.com/rr/2104-01

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INSTALLED PERFORMANCE TESTING

- ~150 TESTS ON ~30 WALL ASSEMBLY SPECIMENS BY INDEPENDENT SOURCES (HIRL & CBI)
- INTEGRALLY-FLANGED WINDOW TYPES (SH, DH, C, AND HS; VINYL AND WOOD FRAMES; SINGLE AND MULLED; OPENINGS UP TO 6-FT WIDE; 30 TO 400 LB WINDOW UNIT WEIGHT)
- THREE FPIS TYPES (XPS, EPS, AND PIR), 1” AND 2" THICK, AND 15 AND 25 PSI COMPRESSIVE RESISTANCE
- FPIS WRB SYSTEMS INSTALLED AND FLASHED PER MANUFACTURERS’ SPECIFICATIONS
- FGIA/AAMA TIR-504-2020 FENESTRATION INSTALLATION EVALUATION METHOD (AIR LEAKAGE, WATER RESISTANCE, THERMAL CYCLING, DESIGN PRESSURE, REPEAT WATER TEST, STRUCTURAL PRESSURE)

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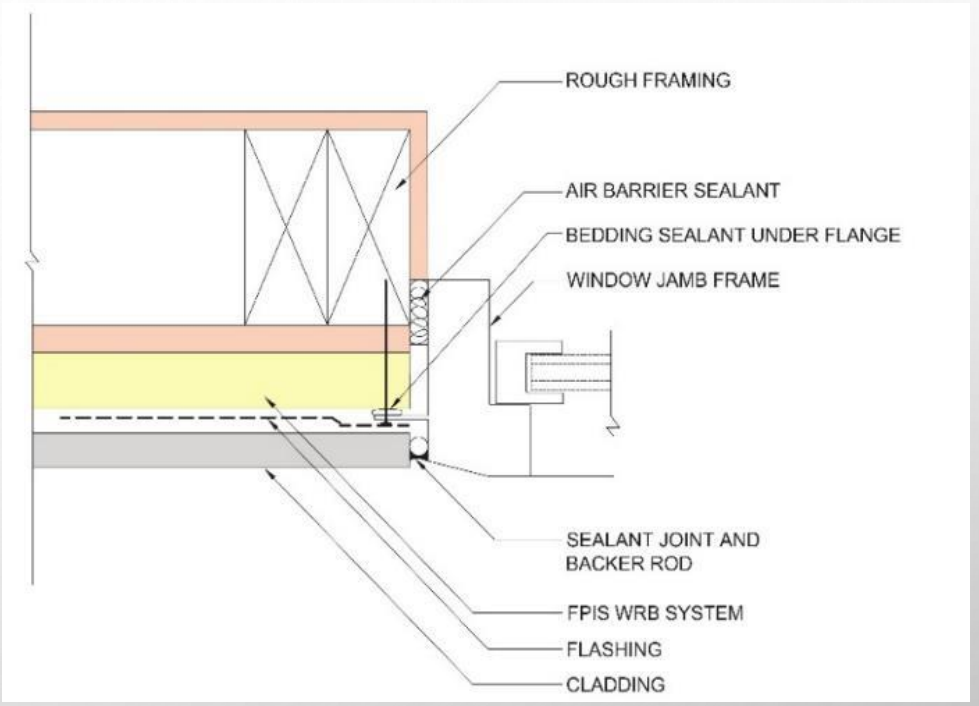
EXAMPLES OF HISTORICALLY ACCEPTED PRACTICE (≤ 1.5" FPIS CI)



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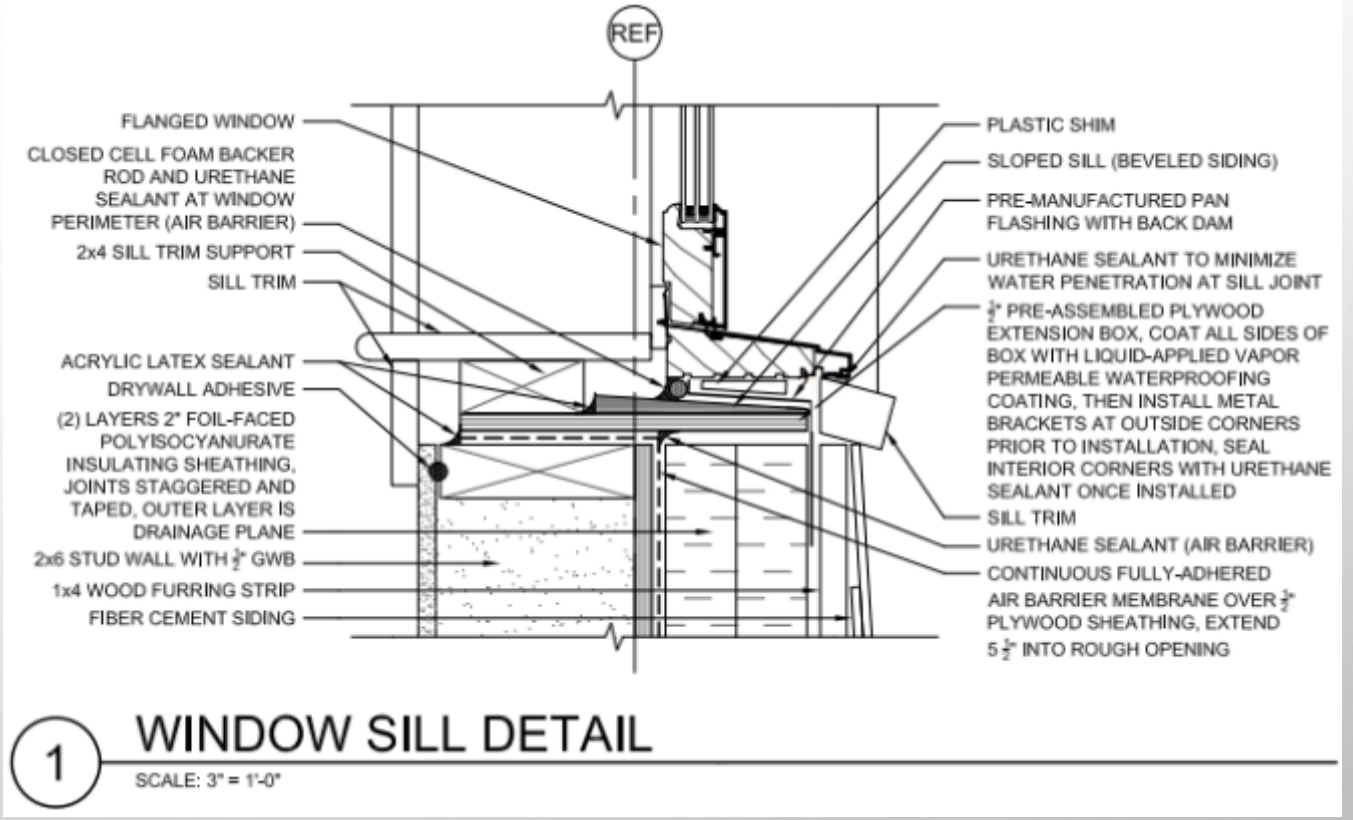
EXAMPLES OF HISTORICALLY ACCEPTED PRACTICE (> 1.5” FPIS CI)

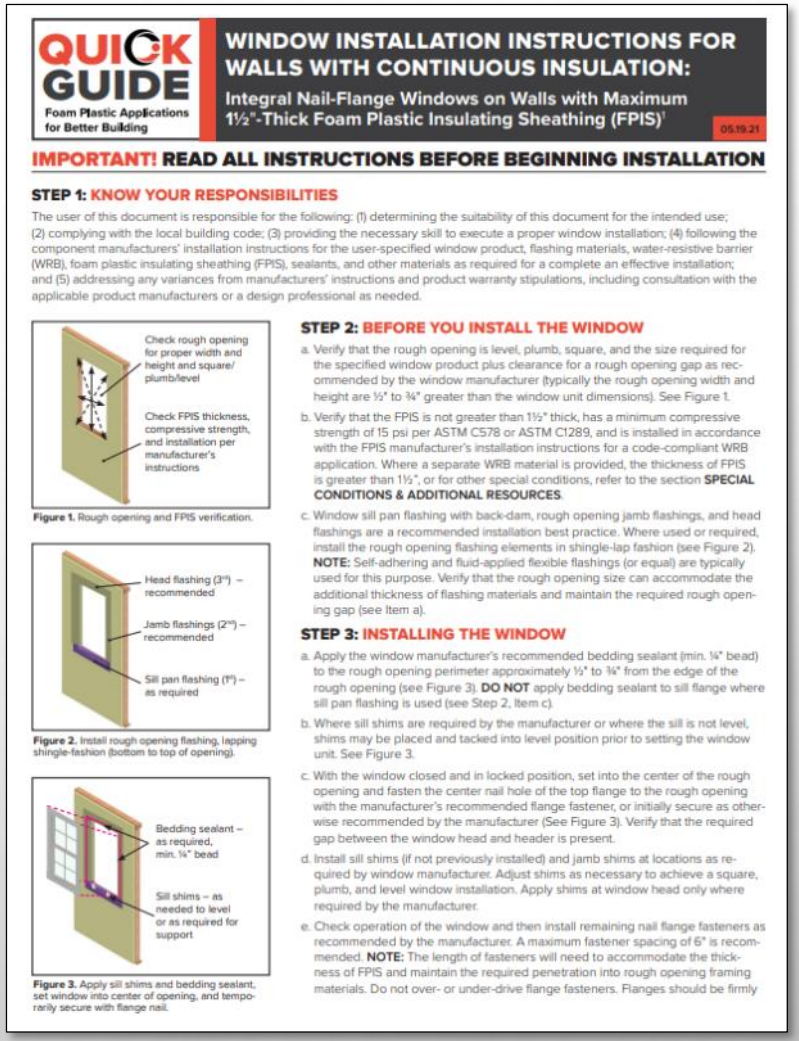
- PLYWOOD WINDOW BUCK WITH 4"-THICK FPIS CI
- 2X WOOD BUCKS ALSO USED (ESPECIALLY FOR MASONRY/CONCRETE CONSTRUCTION)
- NOTE: FOR TYPE I-IV CONSTRUCTION (IBC), THE WINDOW-WALL INTERFACE ALSO MUST COMPLY WITH NFPA 285 TESTED ASSEMBLY AND ENGINEERING ANALYSIS.
  - APPLIES REGARDLESS OF FPIS THICKNESS.
  - SEE EXAMPLES NEXT TWO SLIDES.



Source: www.nist.gov/system/files/nzertf-architectural-plans3-june2011.pdf

RECOMMENDED INSTALLATION INSTRUCTIONS

- FOR FPIS OF MINIMUM 15 PSI COMPRESSION RESISTANCE AND MAXIMUM 1.5" THICKNESS:
  - USE FENESTRATION MANUFACTURER SHIM AND FASTENER SCHEDULE
    - ADJUST FASTENER LENGTH TO MAINTAIN EMBEDMENT IN FRAMING
  - USE WRB OR WINDOW MANUFACTURER FLASHING INSTRUCTIONS
- FOR FPIS > 1.5" THICK:
  - USE WINDOW BUCK OR SIMILAR SUPPORT METHOD
    - SOME MANUFACTURERS OFFER SPECIALTY SUPPORT BRACKETS
  - OTHERWISE, SAME AS ABOVE FOR REMAINING INSTALLATION DETAILS
- FOR ANY TYPE AND THICKNESS OF FPIS: OPTION TO USE AN “INNY” WINDOW INSTALL
- IF WINDOW MANUFACTURER INSTRUCTIONS ADDRESS THE SPECIFIC APPLICATION WITH FPIS, USE THOSE INSTRUCTIONS.
- NOTE: IF NFPA 285 APPLIES (TYPE I-IV CONSTRUCTION), THE WINDOW-WALL INTERFACE MUST COMPLY WITH THE FPIS MANUFACTURER’S TESTED ASSEMBLY AND ENGINEERING ANALYSIS, REGARDLESS OF FPIS THICKNESS.
  - REFER TO THE MANUFACTURER DATA AND STANDARD DETAILS



QUICK GUIDE
Foam Plastic Applications for Better Building

WINDOW INSTALLATION INSTRUCTIONS FOR WALLS WITH CONTINUOUS INSULATION:
Integral Nail-Flange Windows on Walls with Maximum 1½"-Thick Foam Plastic Insulating Sheathing (FPIS)[1]

05.19.21

IMPORTANT! READ ALL INSTRUCTIONS BEFORE BEGINNING INSTALLATION

STEP 1: KNOW YOUR RESPONSIBILITIES

The user of this document is responsible for the following: (1) determining the suitability of this document for the intended use; (2) complying with the local building code; (3) providing the necessary skill to execute a proper window installation; (4) following the component manufacturers' installation instructions for the user-specified window product, flashing materials, water-resistive barrier (WRB), foam plastic insulating sheathing (FPIS), sealants, and other materials as required for a complete an effective installation; and (5) addressing any variances from manufacturers' instructions and product warranty stipulations, including consultation with the applicable product manufacturers or a design professional as needed.

Figure 1. Rough opening and FPIS verification.

Figure 2. Install rough opening flashing, lapping shingle-fashion (bottom to top of opening).

Figure 3. Apply sill shims and bedding sealant, set window into center of opening, and temporarily secure with flange nail.

STEP 2: BEFORE YOU INSTALL THE WINDOW

a. Verify that the rough opening is level, plumb, square, and the size required for the specified window product plus clearance for a rough opening gap as recommended by the window manufacturer (typically the rough opening width and height are ½" to ¾" greater than the window unit dimensions). See Figure 1.

b. Verify that the FPIS is not greater than 1½" thick, has a minimum compressive strength of 15 psi per ASTM C578 or ASTM C1289, and is installed in accordance with the FPIS manufacturer's installation instructions for a code-compliant WRB application. Where a separate WRB material is provided, the thickness of FPIS is greater than 1½", or for other special conditions, refer to the section **SPECIAL CONDITIONS & ADDITIONAL RESOURCES**.

c. Window sill pan flashing with back-dam, rough opening jamb flashings, and head flashings are a recommended installation best practice. Where used or required, install the rough opening flashing elements in shingle-lap fashion (see Figure 2). **NOTE:** Self-adhering and fluid-applied flexible flashings (or equal) are typically used for this purpose. Verify that the rough opening size can accommodate the additional thickness of flashing materials and maintain the required rough opening gap (see Item a).

STEP 3: INSTALLING THE WINDOW

a. Apply the window manufacturer's recommended bedding sealant (min. ¼" bead) to the rough opening perimeter approximately ½" to ¾" from the edge of the rough opening (see Figure 3). **DO NOT** apply bedding sealant to sill flange where sill pan flashing is used (see Step 2, Item c).

b. Where sill shims are required by the manufacturer or where the sill is not level, shims may be placed and tacked into level position prior to setting the window unit. See Figure 3.

c. With the window closed and in locked position, set into the center of the rough opening and fasten the center nail hole of the top flange to the rough opening with the manufacturer's recommended flange fastener, or initially secure as otherwise recommended by the manufacturer (See Figure 3). Verify that the required gap between the window head and header is present.

d. Install sill shims (if not previously installed) and jamb shims at locations as required by window manufacturer. Adjust shims as necessary to achieve a square, plumb, and level window installation. Apply shims at window head only where required by the manufacturer.

e. Check operation of the window and then install remaining nail flange fasteners as recommended by the manufacturer. A maximum fastener spacing of 6" is recommended. **NOTE:** The length of fasteners will need to accommodate the thickness of FPIS and maintain the required penetration into rough opening framing materials. Do not over- or under-drive flange fasteners. Flanges should be firmly

For additional information, refer to:
https://www.continuousinsulation.org/applications/window-installation

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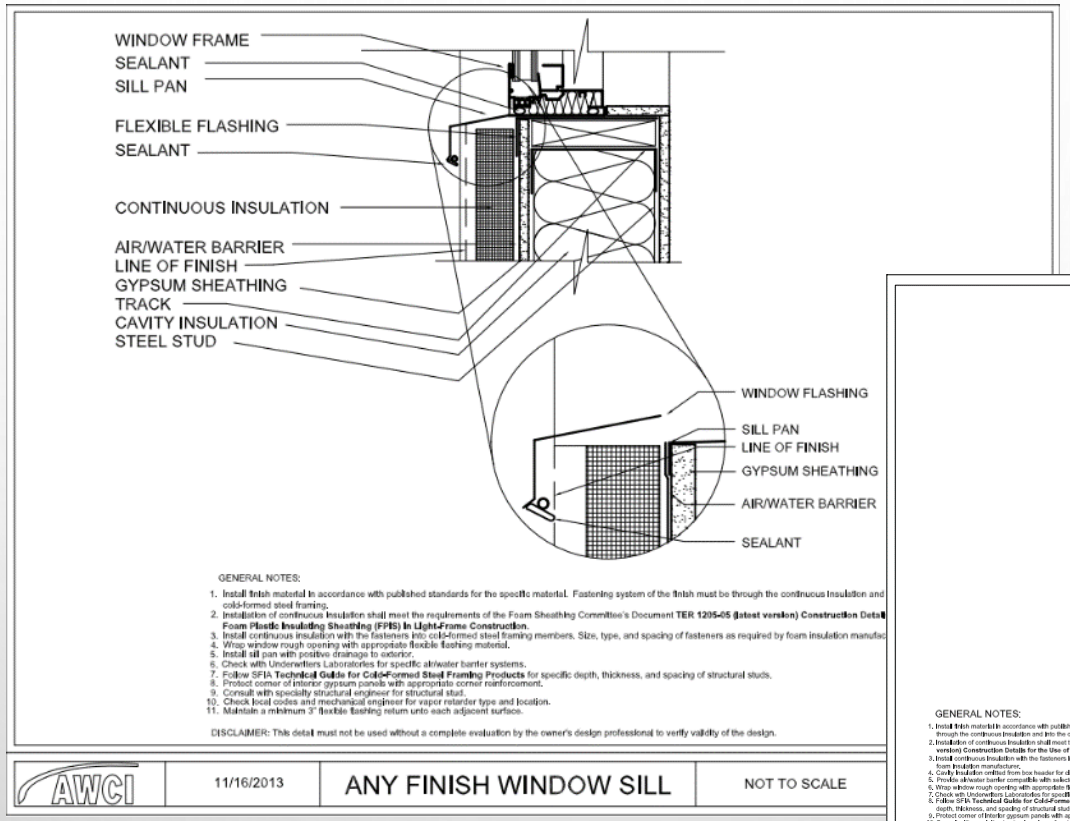
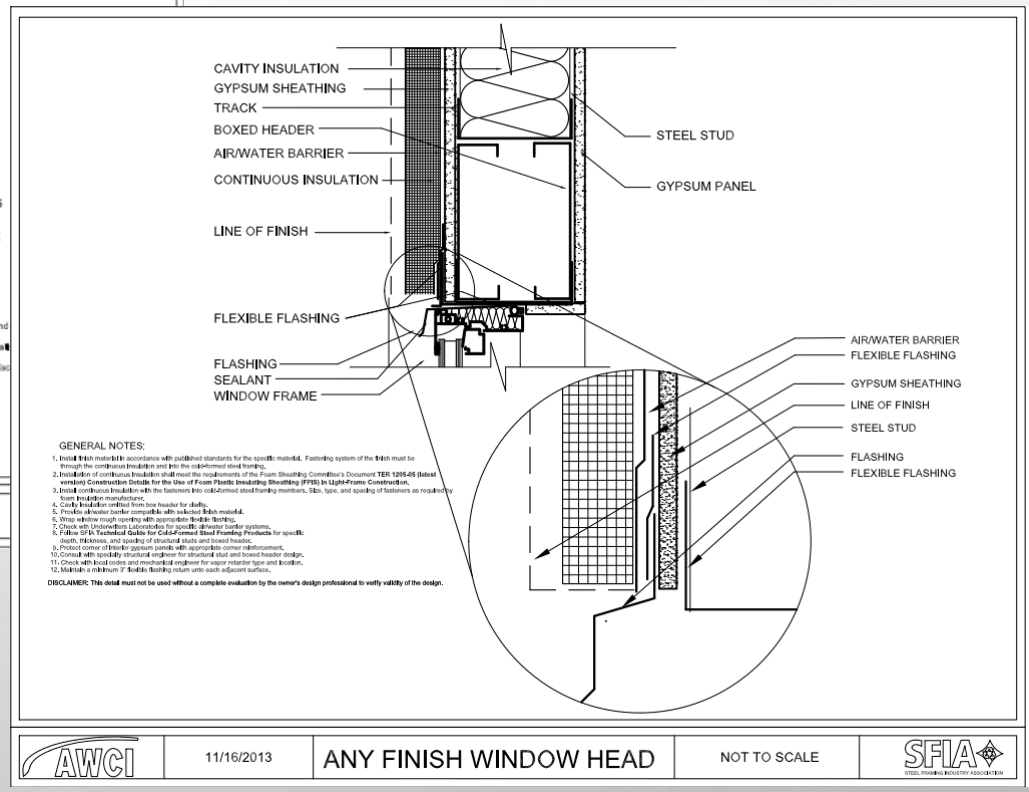
EXAMPLE DETAILS FROM AWCI/SFIA

- VARIOUS CAD DETAILS FOR CI ON STEEL FRAME WALL ASSEMBLIES
- DETAILS USED FOR FENESTRATION FLASHING & SUPPORT MUST ALSO COMPLY WITH NFPA 285 TESTED ASSEMBLY OR ENGINEERING ANALYSIS FOR TYPE I – IV BUILDING APPLICATIONS (DOES NOT APPLY TO TYPE V CONSTRUCTION)





http://www.awcitechnologycenter.org/content/cad-detail-library

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D. ADDITIONAL RESOURCES & APPLICATIONS

FS200.1 STANDARD FOR FPIS CI 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)
  - USE FPIS MANUFACTURER DATA TO DEMONSTRATE COMPLIANCE (ASTM E84, ASTM E119, NFPA 285, ETC. – AS APPLICABLE)

https://www.appliedbuildingtech.com/standards

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QUICK GUIDE
Foam Plastic Applications for Better Building

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).

01.12.24

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 layter (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 Sidings (vinyl, wood, aluminum, fiber-cement, etc.)
Specify and install lap sidings 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 in moist or marine climate regions.

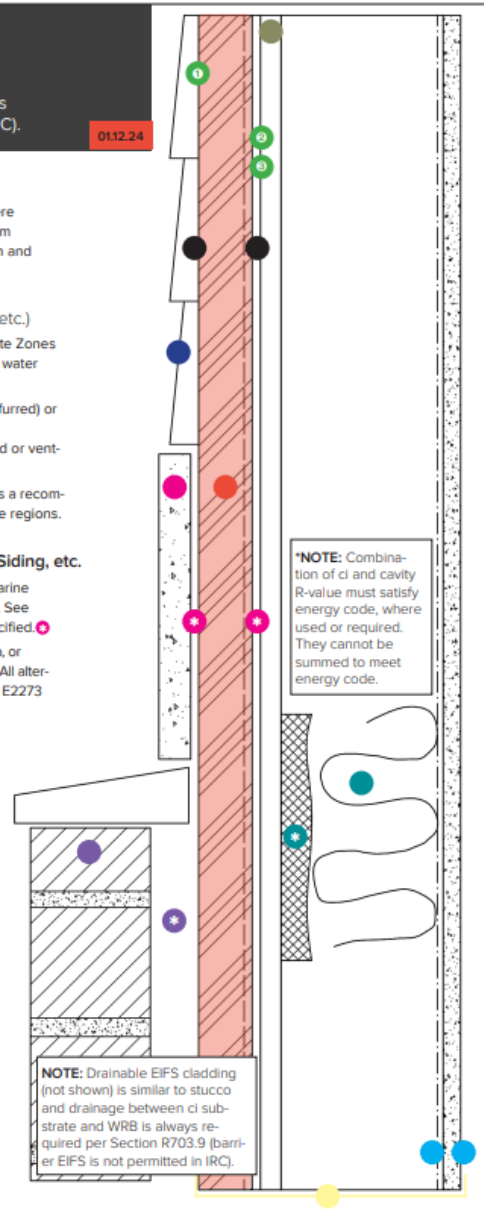
Stucco, Adhered Masonry Veneer, Cement Panel Siding, etc.
Specify and install WRB per IRC Section R703.7.3. In Moist/Marine climate regions, a minimum 3/16" drainage space is required. See drainage space location options based on WRB location specified.

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 buildilng 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 of 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.

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

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

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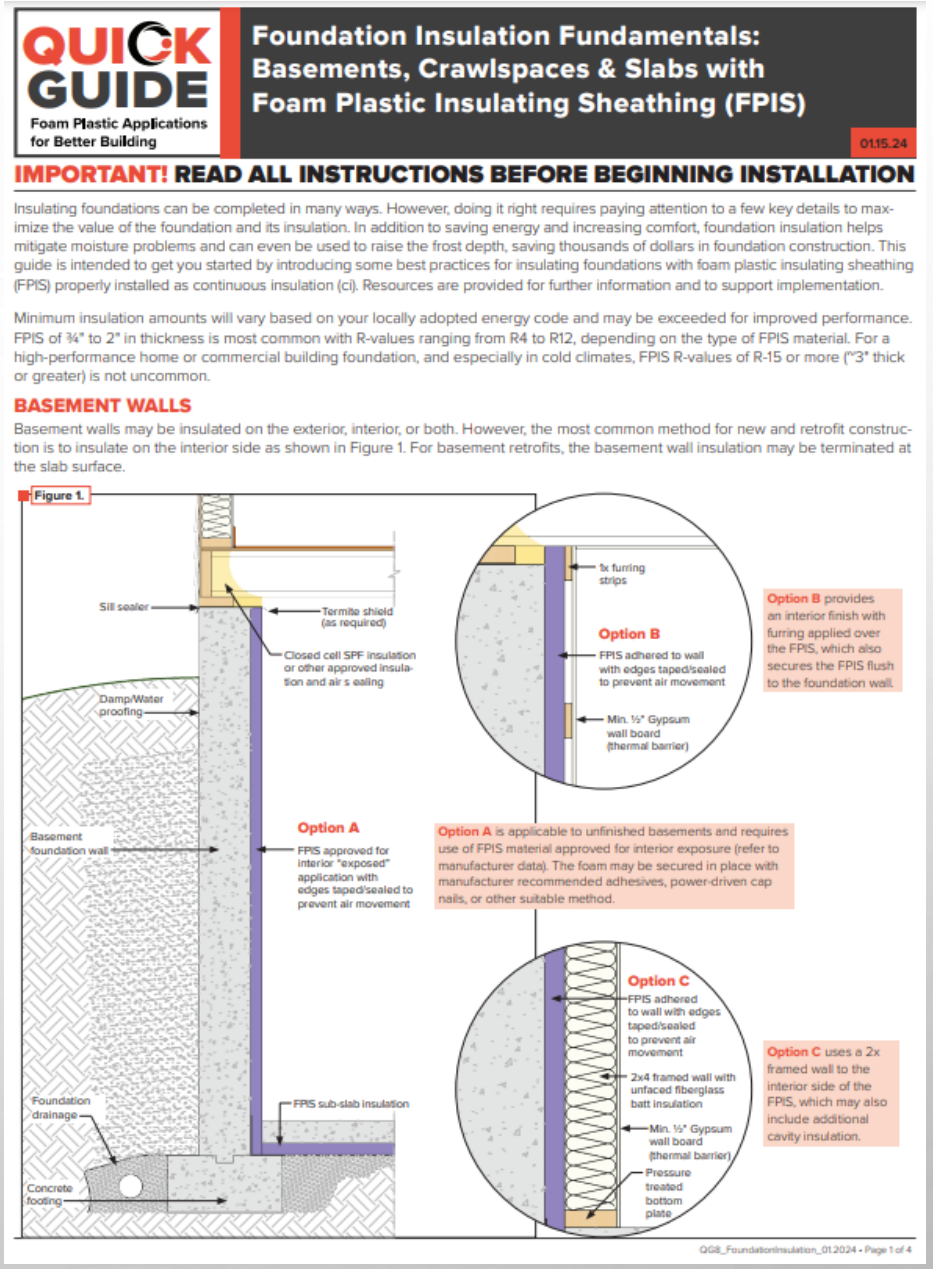
QUICK GUIDE FOR FPIS FOUNDATION APPLICATIONS

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



QUICK GUIDE
Foam Plastic Applications for Better Building

Foundation Insulation Fundamentals: Basements, Crawlspaces & Slabs with Foam Plastic Insulating Sheathing (FPIS)

01.15.24

IMPORTANT! READ ALL INSTRUCTIONS BEFORE BEGINNING INSTALLATION

Insulating foundations can be completed in many ways. However, doing it right requires paying attention to a few key details to maximize the value of the foundation and its insulation. In addition to saving energy and increasing comfort, foundation insulation helps mitigate moisture problems and can even be used to raise the frost depth, saving thousands of dollars in foundation construction. This guide is intended to get you started by introducing some best practices for insulating foundations with foam plastic insulating sheathing (FPIS) properly installed as continuous insulation (ci). Resources are provided for further information and to support implementation.

Minimum insulation amounts will vary based on your locally adopted energy code and may be exceeded for improved performance. FPIS of ¾" to 2" in thickness is most common with R-values ranging from R4 to R12, depending on the type of FPIS material. For a high-performance home or commercial building foundation, and especially in cold climates, FPIS R-values of R-15 or more (~3" thick or greater) is not uncommon.

BASEMENT WALLS

Basement walls may be insulated on the exterior, interior, or both. However, the most common method for new and retrofit construction is to insulate on the interior side as shown in Figure 1. For basement retrofits, the basement wall insulation may be terminated at the slab surface.

Figure 1.

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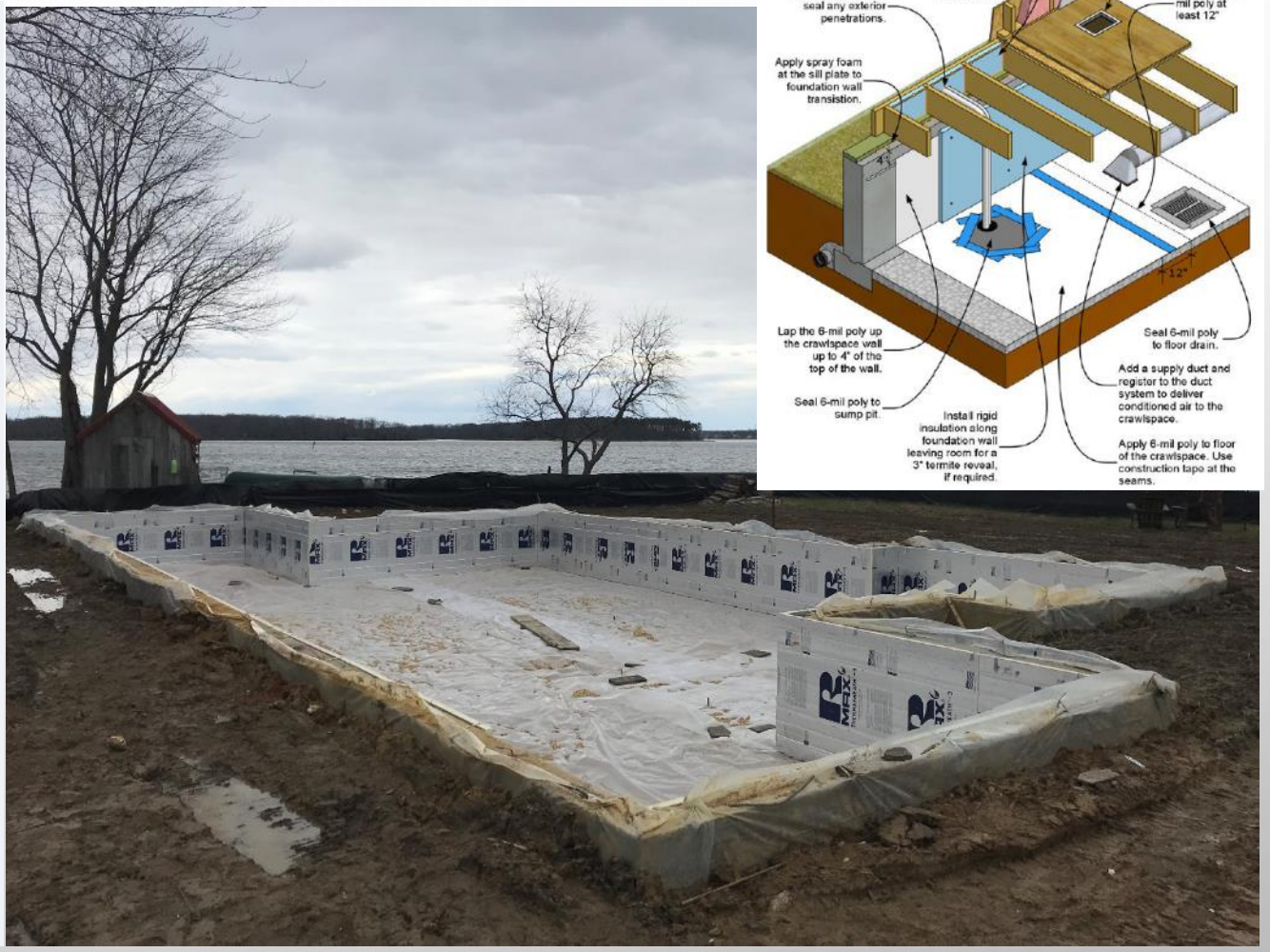
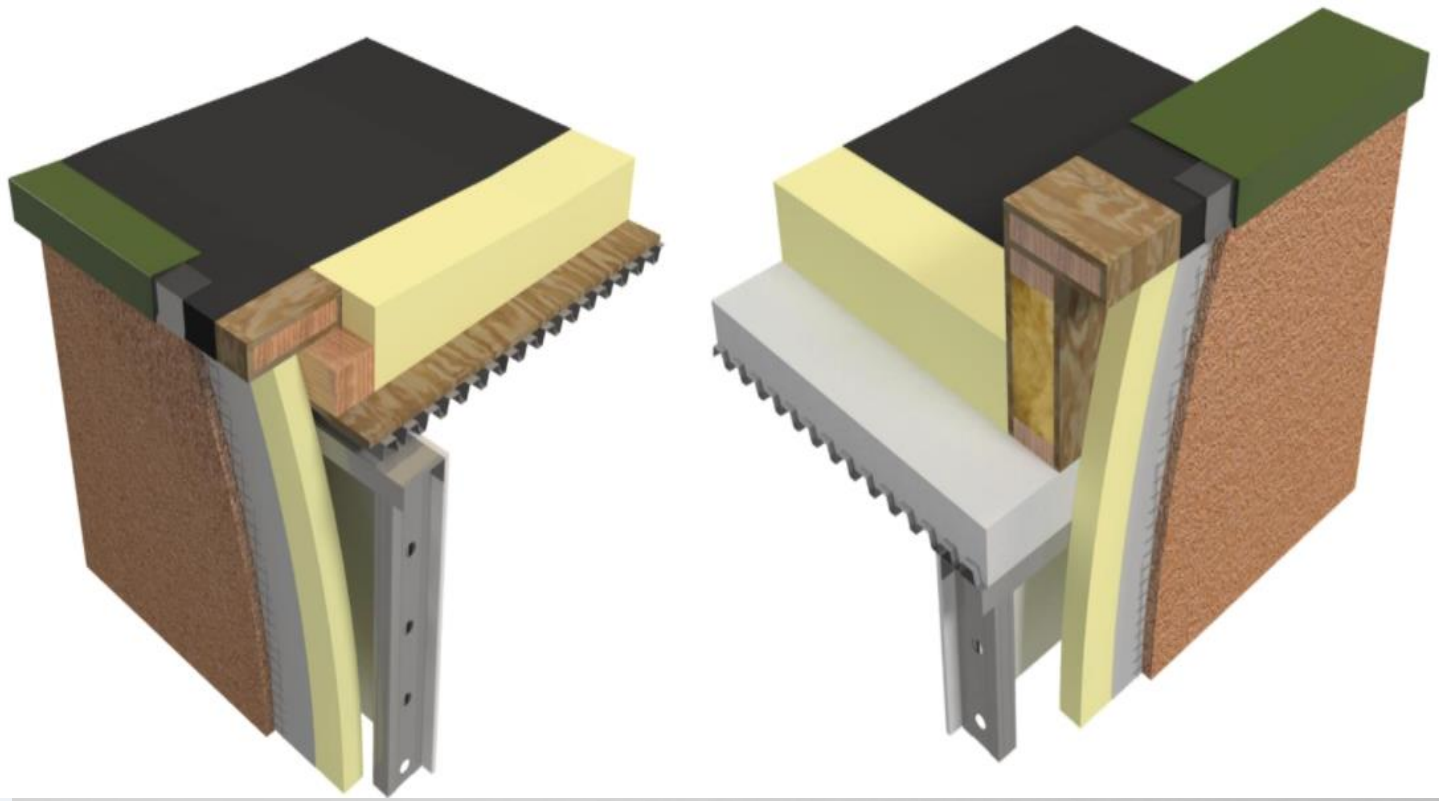
IBC/IRC – UNVENTED CRAWLSPACES

- ALLOWS DUCTWORK IN CONDITIONED SPACE; WARM FLOOR; NO MOIST AIR FOUNDATION VENTS; STORAGE SPACE
- PLACE INSULATION ONLY AT CRAWLSPACE PERIMETER, NOT BETWEEN EVERY JOIST
- REQUIRES CONDITIONED AIR SUPPLY
- REFER TO IRC SECTION R408.3



APPLICATIONS:
INSULATION ENTIRELY ABOVE ROOF DECK

- FPIS CI COMMONLY USED FOR LOW-SLOPE ROOFS AS “ABOVE DECK” CONTINUOUS INSULATION
  - UNDER ROOF MEMBRANE (MOST COMMON)
  - OVER ROOF MEMBRANE (PROTECTED MEMBRANE ROOF SYSTEM) – NEW PROVISIONS IN 2024 IBC
- ALSO, USED FOR STEEP SLOPE ROOFS



RAISED FLOORS / ELEVATED BUILDINGS

- FLOOR OVER UNCONDITIONED SPACE (E.G., VENTED CRAWLSPACE OR RAISED COASTAL FOUNDATION, ETC.)
  - FPIS PROVIDE CONTINUOUS INSULATION AND AIR-BARRIER
    - MUST BE APPROVED FOR INTERIOR EXPOSURE IF NO THERMAL BARRIER (E.G., GYPSUM PANELS)
  - ALSO USEFUL FOR FLOOR OVERHANGS, PARTICULAR IF ADJOINING WALLS HAVE FPIS CI
- CAN ALSO USE SPF FOR FLOOR CAVITIES AND PERIMETER (BAND/RIM JOIST INSULATION AND AIR SEALING)
  - SPF HAS R-VALUES AS MUCH AS R-7 AND CAN ACHIEVE HIGH R-VALUES IN SHALL FLOOR CAVITIES (ESPECIALLY USEFUL FOR RETRO-FIT)

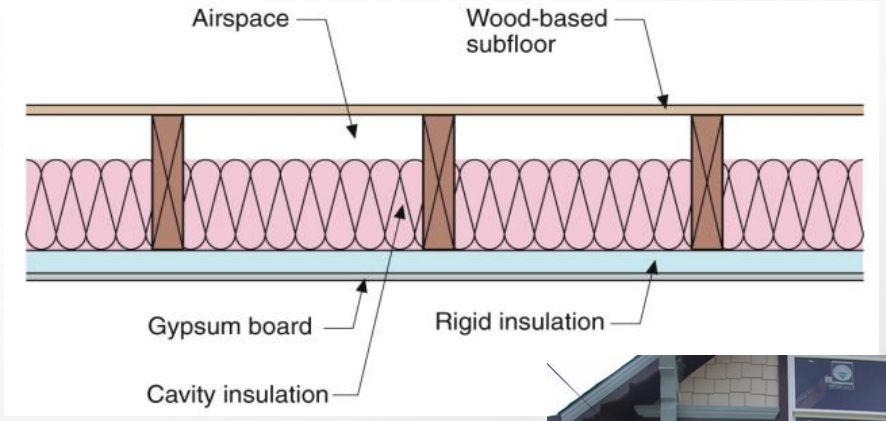


Photo by Shaunna Mozingo

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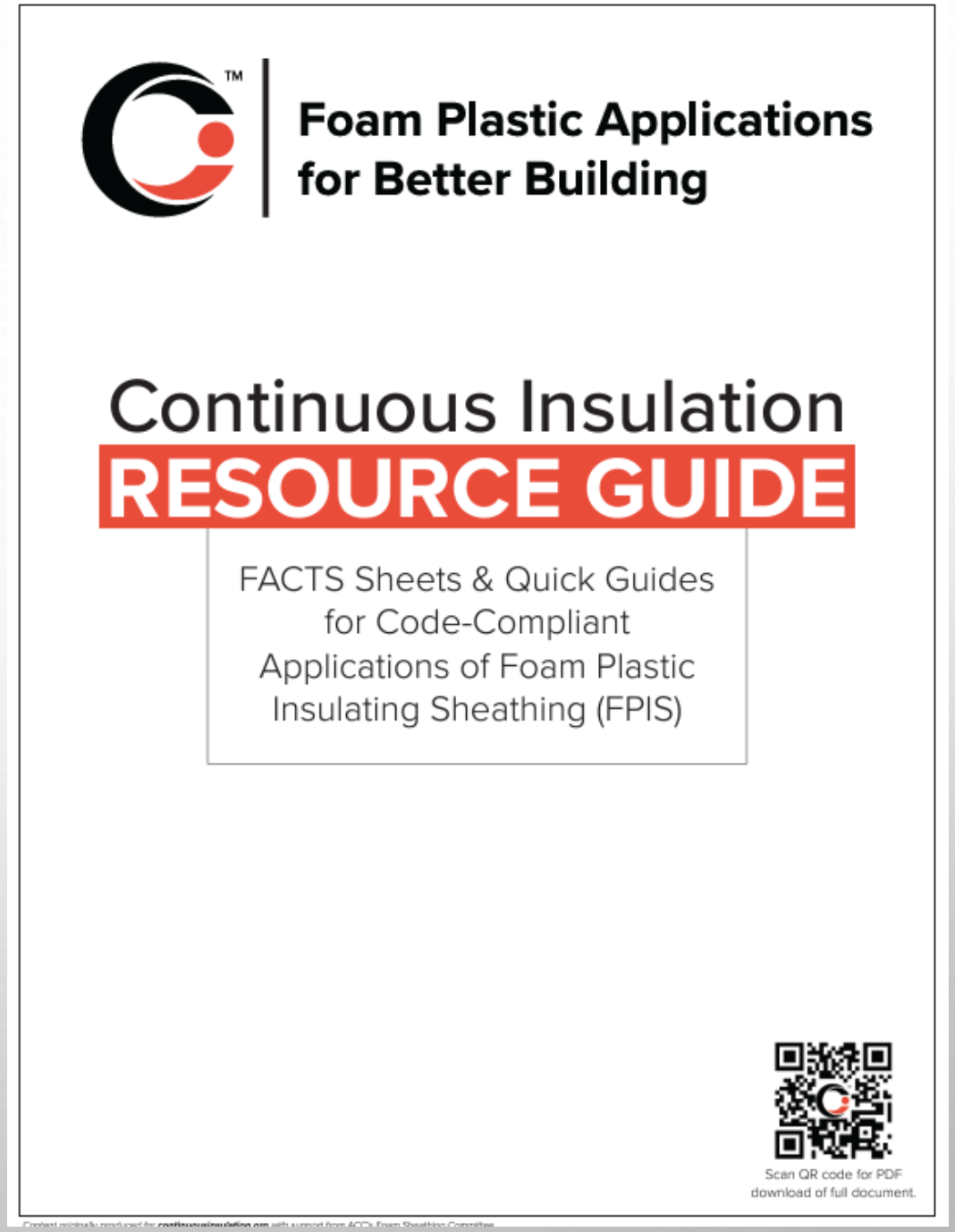
CI RESOURCE GUIDE



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THANK YOU!

QUESTIONS?

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