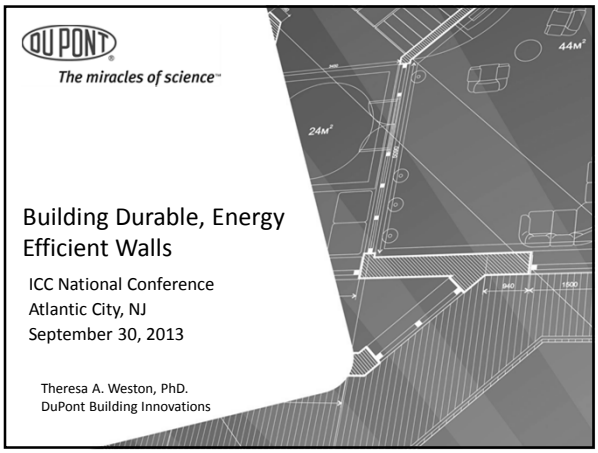


Learning Objectives

- Review energy code requirements for wall assemblies and systems.
- Understand the durability challenges presented by highly insulated walls
- Understand key interfaces in building assemblies and water / air management details
- Understand assembly testing and durability assessment.

Building durability is a key sustainability attribute

A building component /system cannot be energy or resource efficient unless it is durable.

Durable, Energy Efficient

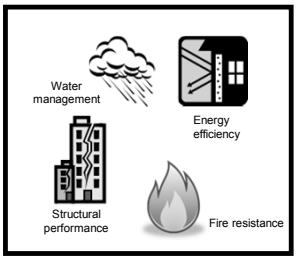
- **ENERGY EFFICIENT**
  - **THERMAL MANAGEMENT**
    - ❖INSULATION
    - ❖AIR BARRIERS
- **DURABLE**
  - **MOISTURE MANAGEMENT**
    - ❖WATER BARRIERS
    - ❖FLASHING
    - ❖AIR BARRIERS
    - ❖VENTILATION & DRAINAGE
    - ❖MAXIMIZE DRYING POTENTIAL

Energy Efficiency Codes - 2012 More Stringent

CODES	RESIDENTIAL	COMMERCIAL
International Energy Conservation Code	IECC Ch. 4	IECC Ch. 5
International Residential Code	IRC Ch. 11	
American Society of Heating, Refrigeration and Air Conditioning	ASHRAE 90.2	ASHRAE 90.1
GREEN STANDARDS	ICC-700 (NAHB)	ASHRAE 189
		IgCC
CERTIFICATION PROGRAMS	EnergyStar®	LEED (USGBC)

Higher required insulation levels and air sealing requirements for energy efficiency

REQUIREMENTS



VS

COST

"Durability and cost were seen as the key factors in choosing green products by respondents to the BD&C White Paper Survey."

Green-product attributes

(rated by importance to user)

Ability to last the life of the building . . 4.38

Cost vs. equivalent conventional product 4.27

Availability of product to job site 4.16

Use of renewable resources 4.01

From Building Design & Construction White Paper on Sustainability, November 2003

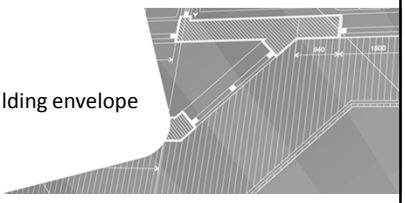
Nationally, construction defect losses run into the billions.

- 69% of all construction defect claims are related to moisture penetration through the building envelope (2007 Study by University of Florida)
- The availability of general liability insurance for homebuilders and subcontractors has become increasingly limited and more expensive
  - *"The companies are finding it more difficult than five years ago to tap insurance to cover payments to homeowners because insurers have added so many exceptions, said Dave Stern, vice president at West Coast Casualty Service Inc., an insurance adjuster in Westlake Village, California. In California, "basically, the thing leaks, it's the builder that's liable," Stern said."*
- Some moisture problems are blamed on increasing energy efficiency
  - *"Building codes adopted in the 1970s and strengthened through the '80s and early '90s, required greater energy efficiency. Paradoxically, the demise of the drafty house had an unintended consequence: When moisture penetrates today's walls, they tend to stay wet."*

Sources: "Building Defects Spoil Homeowners' Dreams, The Oregonian, June 19, 2005; "Homebuilder Shares Undermined by Creeping Costs of Construction Boom Flaws", Bloomberg, February 10, 2011; Grosskopf and Lucas, "Identifying the Causes of Moisture-Related Defect Litigation in U.S.Building Construction", CIB64 2008 The construction and building research conference of the Royal Institution of Chartered Surveyors, Dublin Institute of Technology, 4-5 September 2008.

Section 1

Energy efficient building envelope code requirements



SECTION 1

Changes in Building Energy Codes

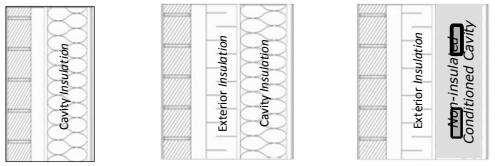
Envelope Criteria for Reduced Envelope Loads:

- Thermal insulation:
  - Higher Insulation R-value
  - Continuous Insulation (c.i.)
- Air Leakage Control:
  - Continuous Air Barrier
  - Building Envelope Airtightness

SECTION 1

Design Options for Insulated Walls

(Framed Walls)



Traditional Wall Design
Stud Cavity Insulation only

Hybrid Wall Design
Cavity Insulation and Exterior Insulation

Exterior Insulated Wall Design (Exulation)
Exterior Insulation only

SECTION 1

Thermal Bridging & Continuous Insulation

Continuous Insulation (c.i.): insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings.

Thermal bridges are "regions of relatively high heat flow conductance in a building envelope."(1)

(1) Joseph Lstiburek and John Carmody, 1993. Moisture Control Handbook, Van Nostrand Reinhold, New York, NY.

SECTION 1

Impact of Thermal Bridging

on Effective Installed R-Value for Steel-Framed Walls

	Actual Cavity Depth, inch	Rated R-Value	Effective R-value
16" o.c.	3.5 inch depth	R-11	R-5.5
		R-13	R-6.0
		R-15	R-6.4
	6.0 inch depth	R-19	R-7.1
		R-21	R-7.4
24" o.c.	3.5 inch depth	R-11	R-6.6
		R-13	R-7.2
		R-15	R-7.8
	6.0 inch depth	R-19	R-8.6
		R-21	R-9.0

Source: ASHRAE 90.1, TABLE A3.3 Assembly U-Factors for Steel-Frame Walls

SECTION 1

Continuous Insulation Requirements (IECC-2006, -2009, -2012)

Steel-Framed, Above-Grade Walls

1. *Higher insulation R-value*
2. *Continuous insulation in all climates*

Climate Zone	Min. R-Value, IECC: Non-Residential Buildings			Min. R-Value, IECC: Residential Buildings		
	IECC 2006	IECC 2009	IECC 2012	2006	2009	2012
1	R-13.0	R-13.0	R-13 + R-5ci	R-13.0	R-13.0	R-13 + R-5ci
2	R-13.0	R-13.0	R-13 + R-5ci	R-13.0	R-13.0	R-13 + R-7.5ci
3	R-13.0	R-13 + R-3.8c.i.	R-13 + R-7.5ci	R-13.0	R-13 + R-3.8c.i.	R-13 + R-7.5ci
4	R-13.0	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.	R-13.0	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.
5	R-13 + R-3.8c.i.	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.	R-13 + R-3.8c.i.	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.
6	R-13 + R-3.8c.i.	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.	R-13 + R-3.8c.i.	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.
7	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.	R-13 + R-15.6c.i.
8	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.	R-13 + R-7.5c.i.	R-13 + R-17.5c.i.

c.i. = continuous insulation, uninterrupted by structural members

SECTION 1

Continuous Insulation Requirements (ASHRAE 90.1-2004, -2007, -2010)

Steel-Framed, Above-Grade Walls

1. *Higher insulation R-value*
2. *Continuous insulation in all climates*

Climate Zone	Min. R-Value, ASHRAE 90.1: **Non-Residential**			Min. R-Value, ASHRAE 90.1: **Residential**		
	2004	***2007***	***2012 Addendum****	***2004***	***2007***	***2012 Addendum****
1	**R-13.0**	**R-13.0**	**R-13.0**	**R-13.0**	**R-13.0**	**R-13.0**
2	**R-13.0**	**R-13.0**	**R-13 + R-3.8c.i.**	**R-13.0**	**R-13 + R-7.5c.i.**	**R-13 + R-7.5c.i.**
3	**R-13.0**	**R-13 + R-3.8c.i.**	**R-13 + R-5.0c.i.**	**R-13 + R-3.8c.i.**	**R-13 + R-7.5c.i.**	**R-13 + R-7.5c.i.**
4	**R-13.0**	**R-13 + R-7.5c.i.**	**R-13 + R-7.5c.i.**	**R-13 + R-7.5c.i.**	**R-13 + R-7.5c.i.**	**R-13 + R-7.5c.i.**
5	**R-13 + R-3.8c.i.**	**R-13 + R-7.5c.i.**	**R-13 + R-10.0c.i.**	**R-13 + R-7.5c.i.**	**R-13 + R-7.5c.i.**	**R-13 + R-10.0c.i.**
6	**R-13 + R-3.8c.i.**	**R-13 + R-7.5c.i.**	**R-13 + R-12.5c.i.**	**R-13 + R-7.5c.i.**	**R-13 + R-7.5c.i.**	**R-13 + R-12.5c.i.**
7	**R-13 + R-7.5c.i.**	**R-13 + R-7.5c.i.**	**R-13 + R-12.5c.i.**	**R-13 + R-7.5c.i.**	**R-13 + R-15.6c.i.**	**R-13 + R-15.6c.i.**
8	**R-13 + R-7.5c.i.**	**R-13 + R-7.5c.i.**	**R-13 + R-18.8c.i.**	**R-13+ R-10.0c.i.**	**R-13 + R-18.8c.i.**	**R-13 + R-18.8c.i.**

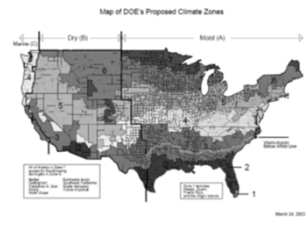
c.i. = continuous insulation, uninterrupted by structural members

* ASHRAE 90.1 2012 Addendum is currently out for 45-day public review from March 23, 2012 to May 7, 2012.

SECTION 1

Prescriptive R-value Requirements: Residential Wood-Frame Wall

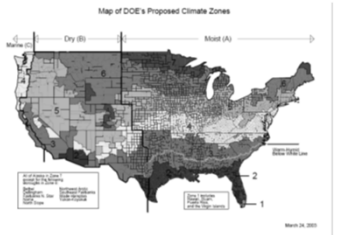
RESIDENTIAL BUILDING. For this code, includes R-3 buildings, as well as R-2 and R-4 buildings three stories or less in height above grade.



CLIMATE ZONE	2006 IECC	2009 IECC	2012 IECC
1	13	13	13
2	13	13	13
3	13	13	20 or 13+5
4 X-MARINE	13	13	20 or 13+5
4 MARINE	19 or 13+5	20 or 13+5	20 or 13+5
5	19 or 13+5	20 or 13+5	20 or 13+5
6	19 or 13+5	20 or 13+5	20+5 or 13+10
7	21	21	20+5 or 13+10
8	21	21	20+5 or 13+10

SECTION 1

Prescriptive R-value Requirements: Commercial Group R Wood-Frame Wall

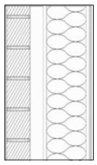
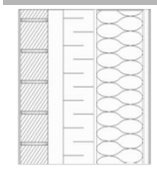
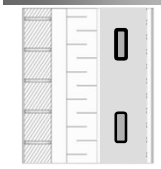


CLIMATE ZONE	2006 IECC	2009 IECC	2012 IECC
1	13	13	20 or 13+3.8ci
2	13	13	20 or 13+3.8ci
3	13	13	20 or 13+3.8ci
4 X-MARINE	13	13+3.8ci	20 or 13+3.8ci
4 MARINE	13	13+3.8ci	13+7.5ci or 20+3.8ci
5	13	13+3.8ci	13+7.5ci or 20+3.8ci
6	13	13+7.5ci	13+7.5ci or 20+3.8ci
7	13	13+7.5ci	13+7.5ci or 20+3.8ci
8	13+7.5ci	13+15ci	13+15.6ci or 20+10ci

SECTION 1

Wall Design & Energy Code Compliance

(Typical Steel Framed Wall)

Will not meet Energy Codes most climates*	Energy Codes Compliant, all climates	Could meet Energy Codes in warm climates
		
Traditional Wall Design	Hybrid Wall Design	Exterior Insulated Wall Design *(Exulation)*

* No climate zones per IECC; Except for climate zone 1, per ASHRAE 90.1

SECTION 1

IECC Commercial Building Envelope Air Leakage Requirements

2006 / 2009	*"**Sealing of the building envelope.** Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor permeable wrapping material. Sealing materials spanning joints between construction materials shall allow for expansion and contraction of the construction materials."*
2012	***C402.4.1 Air barriers.*** *A continuous air barrier shall be provided throughout the building thermal envelope. The air barriers shall be permitted to be located on the inside or outside of the building envelope, located within the assemblies composing the envelope, or any combination thereof. The air barrier shall comply with Sections C402.4.1.1 and C402.4.1.2.* ***Exception:*** *Air barriers are not required in buildings located in Climate Zones 1, 2 and 3.*
Air barrier compliance options.	*C402.4.1.2.1* ***Materials.*** *Materials with an air permeability no greater than* ***0.004 cfm/ft² (0.02 L/s · m²)*** *under a pressure differential of 0.3 inches water gauge (w.g.) (75 Pa) when tested in accordance with* ***ASTM E 2178*** *shall comply with this section..*
	C402.4.1.2.2 Assemblies. *Assemblies of materials and components with an average air leakage not to exceed* ***0.04 cfm/ft² (0.2 L/s · m²)*** *under a pressure differential of 0.3 inches of water gauge (w.g.)(75 Pa) when tested in accordance with* ***ASTM E 2357, ASTM E 1677 or ASTM E 283*** *shall comply with this section*
	C402.4.1.2.3 Building test. *The completed building shall be tested and the air leakage rate of the building envelope shall not exceed* ***0.40 cfm/ft2 at a pressure differential of 0.3 inches water gauge (2.0 L/s · m2 at 75 Pa)*** *in accordance with* ***ASTM E 779*** *or an equivalent method approved by the code official.*

SECTION 1

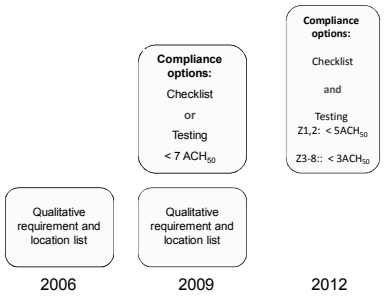
ASHRAE 90.1 Envelope Air Leakage Requirements

2007	**5.4.3.1 Building Envelope Sealing.** The following areas of the *building envelope* shall be sealed, caulked, gasketed, or weather-stripped to minimize air leakage:
2010	**5.4.3.1 *Continuous Air Barrier*.** The entire *building envelope* shall be designed and constructed with a *continuous air barrier*. **Exceptions to 5.4.3.1:** a. *Semiheated spaces* in climate zones 1 thru 6. b. Single wythe concrete masonry buildings in climate zone 2B **5.4.3.1.1 Air Barrier Design**. The air barrier shall be designed and noted in the following manner: a. All air barrier components of each *building envelope* assembly shall be clearly identified or otherwise noted on *construction documents*. b. The joints, interconnections, and penetrations of the air barrier components including lighting *fixtures* shall be detailed or otherwise noted. c. The *continuous air barrier* shall extend over all surfaces of the *building envelope* (at the lowest floor, exterior *walls*, and ceiling or *roof*). d. The *continuous air barrier* shall be designed to resist positive and negative pressures from wind, stack effect, and mechanical *ventilation*. **5.4.3.1.2 Air Barrier Installation** The following areas of the *continuous air barrier* in the *building envelope* shall be wrapped, sealed, caulked, gasketed, or taped in an approved manner to minimize air leakage:
Air barrier compliance options.	Materials that have an air permeance not exceeding 0.004 cfm/ft2 under a pressure differential of 0.3 in. w.g. (1.57psf) when tested in accordance with ASTM E 2178.
	Assemblies of materials and components (sealants, tapes, etc.) that have an average air leakage not to exceed 0.04 cfm/ft2 under a pressure differential of 0.3 in. w.g. (1.57psf) when tested in accordance with ASTM E 2357 ASTM E 1677, ASTM E 1680 or ASTM E283;

SECTION 1

Residential Air Leakage – Code Changes

IECC Residential Building Envelope Air Leakage Requirements



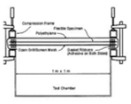
SECTION 1

IECC Air Leakage Requirements - 2012

and

Residential
2009 – Option Checklist or BD
2012 – Required Checklist and BD

Material Testing | Assembly Testing | Whole Building Testing



or

or

Commercial
2012 – 3 Options

SECTION 1

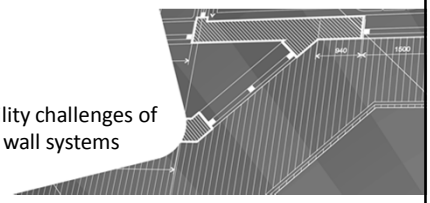
North America Air Barrier Standards

Air Infiltration Requirements [cfm/ft² @ 0.3 in w.g., 75Pa]	**Materials** (ASTM E2178)		**Assemblies** (ASTM E2357 or E1677)		**Whole Building (ASTM E779)**
NBC (National Building Code of Canada, 1990)	**0.004**		**--**		**--**
Massachusetts, Minnesota, New Hampshire, Georgia, Oregon, Washington, New York, *etc*…	**0.004**		**--**		**--**
ASHRAE 90.1 (2010)	**0.004**	*or*	**0.04**		**--**
USACE(2008); **NAVFAC** (2011)	**0.004**		**--**	*AND*	**0.25**
Washington State (2010)	**0.004**		**--**		**0.25**
GSA (2010) **USAF** (2011)	**0.004**	*or*	**0.04**	*AND*	**0.40**
ASHRAE189.1 (2009) I**ECC** (2012)	**0.004**	*or*	**0.04**	*or*	**0.40**
IgCC (2012)	--		**--**		**0.25**

Abbreviations: ASHRAE – American Society of Heating, Refrigeration and air Conditioning Engineers; USACE - US Army Corps of Engineers; GSA - General Services Administration; NAVFAC - Naval Facilities Engineering Command; USAF- United States Air Force; IgCC – International Green Construction Code

Section 2

Moisture durability challenges of highly insulated wall systems



SECTION 2

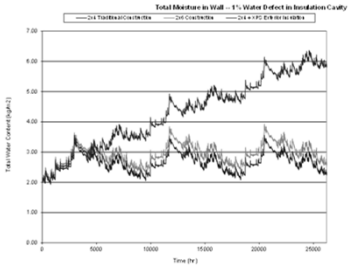
Increased R-value and Durability

- Building codes require higher levels of thermal insulation
  - » The way additional thermal insulation is added to framed wall assemblies is critical to their durability
- Increasing the insulation may result in an increased risk of moisture related issues
  - » Analysis is required to predict the potential moisture risks due to increasing the R-value

Source: High R Walls for the Pacific Northwest – A Hygrothermal Analysis of Various Exterior Wall Systems. Building Science Corporation, Jonathan Smegal, MASc, John Straube, PhD, P.Eng

SECTION 2

Climate Zone 5 - 1% rain defect



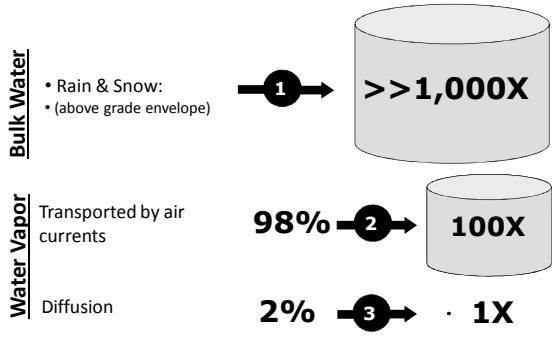
SECTION 2

Moisture Sources

- Moisture can move as:
  - » Liquid water
  - » Water Vapor
- Moisture can come from three sources:
  - » Exterior moisture
  - » Interior moisture due to occupant use
  - » Construction moisture

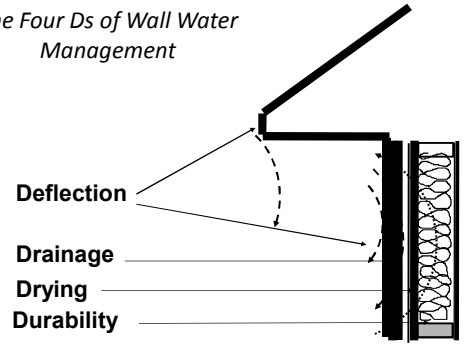
SECTION 3

Rating of Moisture Sources in Buildings



SECTION 3

The Four Ds of Wall Water Management



SECTION 3

Managing Bulk Water

- Redundancy – Cladding + Second Line of Defense
  - Water-resistive barriers
  - Flashing
- Material Choice
  - Performance – Water & Resistance
  - Allow Drying
  - Durability
- Installation – Continuity
  - Shingling correctly
  - Beware of hidden water traps

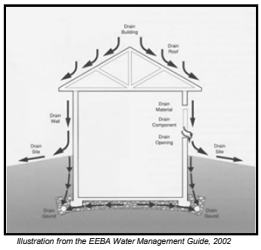
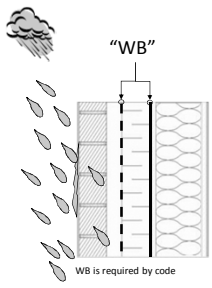


Illustration from the EEBA Water Management Guide, 2002

SECTION 2

Managing Bulk Water: Water Barrier (WB)



- First Line of Defense: Cladding
  - *Reduce* moisture load on the cladding
  - *Minimize* the number and size of holes in the cladding
  - *Manage* the driving forces across the cladding
- Second Line of Defense: WB
  - *Intercept* water that passes through first line of defense
  - *Dissipate* the water effectively to the exterior

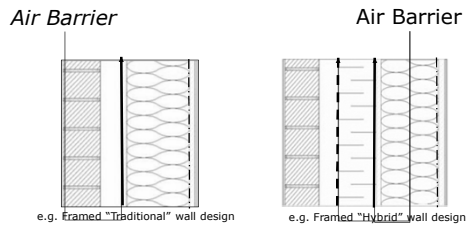
Different Detailing and sequencing for the 2 options

SECTION 2

Managing Moisture Transported by Air Currents: Continuous Air Barrier

Air Leakage is: Unplanned/Unpredictable/Unintentional Airflow

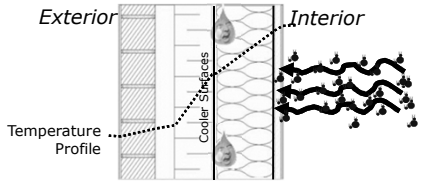
Air Leakage needs: (1) A Driving Force (Δ Pressure) and
(2) A Pathway (Unintended Opening)



SECTION 2

Air Transported Moisture

Heating Climates/Season

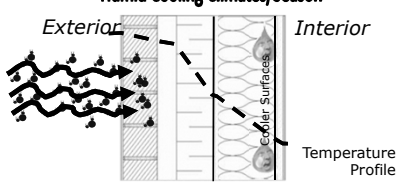


- Interior, moisture-laden air Exfiltration could lead to condensation on cooler exterior surfaces
- Repeated condensation events coupled with slow drying rates could lead to moisture problems

SECTION 2

Air Transported Moisture

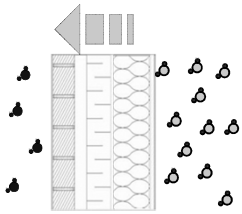
Humid Cooling Climates/Season



- Exterior, moisture-laden air Infiltration could lead to condensation on cooler interior surfaces
- Repeated condensation events coupled with slow drying rates could lead to moisture problems

SECTION 2

Water Vapor Diffusion



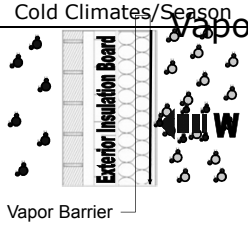
1. Driving Force:
   Concentration difference (Vapor Pressure Difference)
2. Pathway:
   Vapor Permeable Materials

From Higher to Lower Concentration

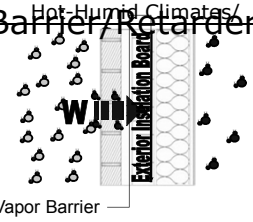
SECTION 2

Managing Water Vapor Diffusion: Vapor Barrier/Retarder

Cold Climates/Season



Hot-Humid Climates/



Vapor Barrier must be located on the side w/ higher moisture concentration

Hybrid Walls may unintentionally have multiple Vapor Retarders

SECTION 2

Moisture Management and Durability

Building assemblies may periodically get wet, or start out wet, yet are still durable and can have an acceptable performance

Repeated wetting followed by repeated drying can provide acceptable performance

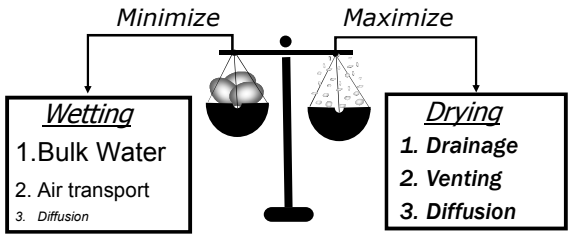
if

during the wet period, materials do not stay wet long enough to deteriorate

Source: Vapor Barriers and Wall Design, Research Report – 0410m November-2004, Joseph Lstiburek

SECTION 2

Manage the Moisture Balance to Avoid Potential Long Term Durability Risks

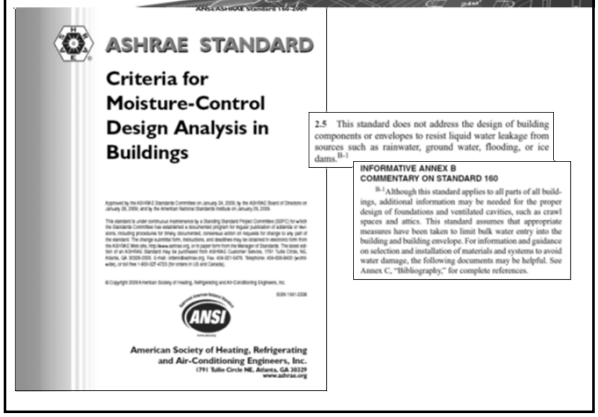


SECTION 2

Moisture & Condensation Analysis Tools

- Dew Point Analysis: Steady-state dew point temperature calculations
- WUFI (Wärme Und Feuchte Instationär *or* Transient Heat and Moisture): Transient hygrothermal modeling
- ANSI/ASHRAE Standard 160: Criteria for Moisture-Control Design Analysis in Buildings

SECTION 2


ASHRAE STANDARD

Criteria for Moisture-Control Design Analysis in Buildings

2.5 This standard does not address the design of building components or envelopes to resist liquid water leakage from sources such as rainwater, ground water, flooding, or ice dams.[B-1]

INFORMATIVE ANNEX B
COMMENTARY ON STANDARD 160

B-1 Although this standard applies to all parts of all buildings, additional information may be needed for the proper design of foundations and ventilated cavities, such as crawl spaces and attics. This standard assumes that appropriate measures have been taken to limit bulk water entry into the building and building envelope. For information and guidance on selection and installation of materials and systems to avoid water damage, the following documents may be helpful. See Annex C, "Bibliography," for complete references.

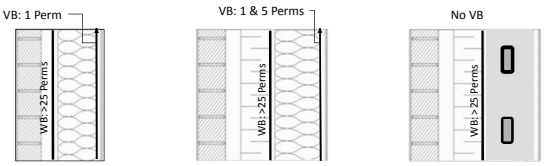
ANSI

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org

SECTION 2

Example: WUFI Moisture Analysis

- Climate: Historical weather data for Chicago, IL (climate zone 5A) were used to simulate the exterior climate conditions and to calculate the hygrothermal response of wall assemblies below
- Interior Conditions: Medium internal moisture conditions were used for simulation (50% +/- 10% RH and 69.8°F +/- 1.8 °F)
- Wall Design: Traditional, hybrid & exulation walls were compared; The use of vapor barrier/retarder for each wall is per current codes
- Calculation Period: Simulations were run for a 3-year period, but 1-year results will be shown



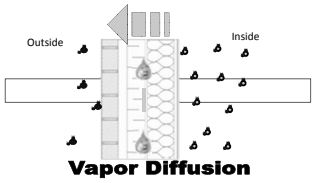
Traditional Wall Design | Hybrid Wall Design | Exterior Insulation Wall Design *(Exulation)*

SECTION 2

Wintertime Condensation

There are 2 potential sources for wintertime condensation:
- vapor diffusion and
- air leakage (air exfiltration)

Diffusion condensation potential can be estimated by analyzing the moisture content of the sheathing throughout the year

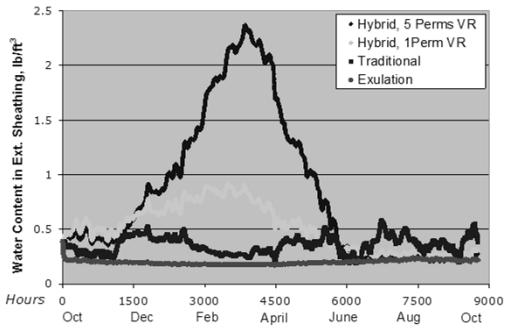


Vapor Diffusion

SECTION 2

Diffusion Condensation Potential

Water Content in Exterior Sheathing: Comparison



SECTION 2

Wintertime Diffusion Condensation: SUMARY

Diffusion condensation potential can be estimated by analyzing the moisture content of the sheathing throughout the year:

- Hybrid walls have ***the highest condensation potential*** due to interior moisture diffusion; Condensation potential is highest when higher vapor permeability Vapor Retarders (5Perms) are used on the inside (allowed by code to provide some diffusion drying to the inside)
- Traditional walls have ***low condensation potential*** due to interior moisture diffusion
- Exulation walls have ***no condensation potential*** due to interior moisture diffusion

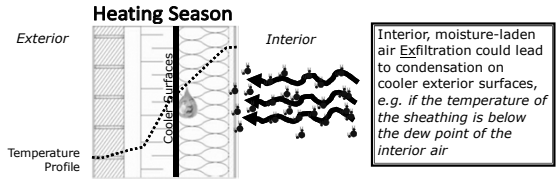
Increasing Condensation potential due to diffusion

SECTION 2

Wintertime Condensation

Air leakage condensation potential can be estimated by determining the hourly dew point of the interior air, and the temperature of the potential condensation plane:

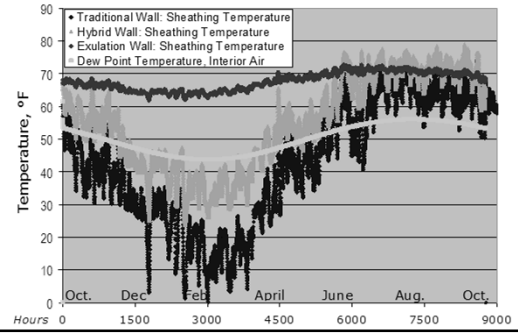
- When the temperature of the condensation plane is below the dew point of the interior air, condensation would occur if air exfiltration reaches the condensation plane.



Interior, moisture-laden air Exfiltration could lead to condensation on cooler exterior surfaces, *e.g. if the temperature of the sheathing is below the dew point of the interior air*

SECTION 2

Air Leakage Condensation Potential: *Heating Season, Air Exfiltration*



SECTION 2

Wintertime Condensation Potential

"The number of hours of potential condensation are dependent on both the interior moisture loads and exterior temperatures, and therefore should be used as a comparison between the wall systems, but the actual numbers are relative to the conditions, and therefore it is difficult to define failure criteria."

Source: High R Walls for the Pacific Northwest – A Hygrothermal Analysis of Various Exterior Wall Systems. Building Science Corporation, Jonathan Smegal, MASc, John Straube, PhD, P.Eng

SECTION 2

Wintertime Air Leakage Condensation: SUMARY

- *Air leakage condensation potential* can be estimated by determining the hourly dew point of the interior air, and the temperature of the potential condensation plane.
  - When the temperature of the condensation plane is below the dew point of the interior air, condensation would occur if air exfiltration reaches condensation plane

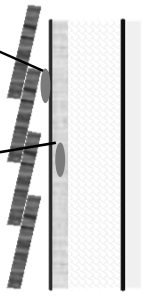
Increasing condensation potential due to air leakage

- » Traditional walls have *the highest condensation potential* due to air leakage (exfiltration)
- » Hybrid walls have *lower condensation potential* due to air leakage (exfiltration)
- » Exulation walls have *no condensation potential* due to air leakage (exfiltration)

SECTION 2

Adding Rain Intrusion

ASHRAE 160: 1% of Rain on the water-resistive barrier



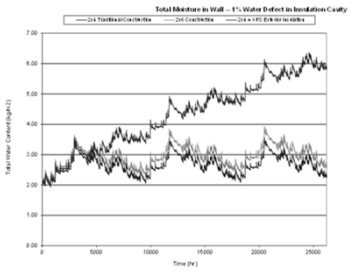
SECTION 2

Wall Assemblies

Simulated Wall Constructions					
Wall Assembly	Stud Wall	Sheathing	Continuous Insulation	Water-Resistive Barrier	Cladding
1	2x4	OSB	none	20 perm SBPO	Fiber-Cement Siding
2	2x6	OSB	none	20 perm SBPO	Fiber-Cement Siding
3	2x4	OSB	1" XPS	20 perm SBPO	Fiber-Cement Siding

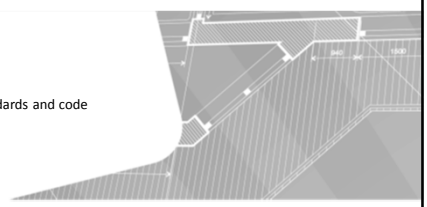
SECTION 2

Climate Zone 5 - 1% rain defect



Section 3

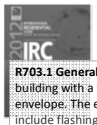
Water management standards and code requirements



SECTION 3

"Weather Protection" Code Provisions

1403.2 Weather protection. Exterior walls shall provide the building with a weather-resistant *exterior wall envelope*. The *exterior wall envelope* shall include flashing, as described in Section 1405.4. The *exterior wall envelope* shall be designed and constructed in such a manner as to prevent the accumulation of water within the wall assembly by providing a *water-resistive barrier* behind the exterior veneer, as described in Section 1404.2, and a means for draining water that enters the assembly to the exterior. Protection against condensation in the *exterior wall* assembly shall be provided in accordance with Section 1405.3.



R703.1 General. Exterior walls shall provide the building with a weather-resistant exterior wall envelope. The exterior wall envelope shall include flashing as described in Section R703.8.

R703.1.1 Water resistance. The exterior wall envelope shall be designed and constructed in a manner that prevents the accumulation of water within the wall assembly by providing a water-resistant barrier behind the exterior veneer as required by Section R703.2 and a means of draining to the exterior water that enters the assembly. Protection against condensation in the exterior wall assembly shall be provided in accordance with Section R702.7 of this code.

- **Water-resistive barrier**
- **Means of draining water**
- **Flashing**
- **Protection against condensation**

SECTION 3

"Weather Protection" Code Requirements

Water-resistive barrier

Means of draining water

Flashing

Protection against condensation

SECTION 3

Water-Resistive Barrier Code Provisions

1404.2 Water-resistive barrier. A minimum of one layer of No.15 asphalt felt, complying with ASTM D 226 for Type 1 felt or other *approved* materials, shall be attached to the studs or sheathing, with flashing as described in Section 1405.4, in such a manner as to provide a continuous *water-resistive barrier* behind the *exterior wall* veneer.

IR703.2 Water-resistive barrier. One layer of No. 15 asphalt felt, free from holes and breaks, complying with ASTM D226 for Type 1 felt or other approved water-resistive barrier shall be applied over studs or sheathing of all exterior walls. Such felt or material shall be applied horizontally, with the upper layer lapped over the lower layer not less than 2 inches (51 mm). Where joints occur, felt shall be lapped not less than 6 inches (152 mm). The felt or other approved material shall be continuous to the top of walls and terminated at penetrations and building appendages in a manner to meet the requirements of the exterior wall envelope as described in Section R703.1.

Performance = Material + Installation

SECTION 3

Water-Resistive Barriers (WRBs)

➔ Traditional: Building felts & papers
Code reference material
No.15 asphalt felt, complying with ASTM D 226 for Type 1 felt

➔ **WRBs Approved by Alternate Methods Criteria**
For example, newer class of synthetic housewraps were introduced in 1979.

SECTION 3

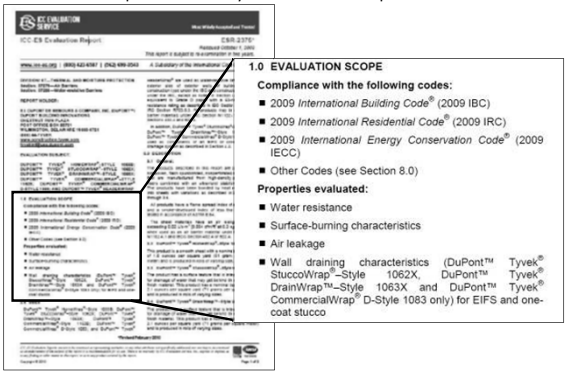
Water-Resistive Barriers




- Building Papers / Felts
- Building Wraps
  - Perforated Wraps
  - Non-Perforated Wraps
  - Specialty Wraps
  - Self-Adhesive Wraps
- Fluid Applied
- Sheathings
  - Foam Sheathing
  - WRB Laminated Wood-Based Sheathing
  - Laminated Fibrous Sheathing

SECTION 3

Example: DuPont™ Tyvek® evaluation report: ESR-2375



1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2009 *International Building Code*® (2009 IBC)
- 2009 *International Residential Code*® (2009 IRC)
- 2009 *International Energy Conservation Code*® (2009 IECC)
- Other Codes (see Section 8.0)

Properties evaluated:

- Water resistance
- Surface-burning characteristics
- Air leakage
- Wall draining characteristics (DuPont™ Tyvek® StuccoWrap®–Style 1062X, DuPont™ Tyvek® DrainWrap™–Style 1063X and DuPont™ Tyvek® CommercialWrap® D-Style 1083 only) for EIFS and one-coat stucco

SECTION 3

How are Water-Resistive Barriers Evaluated?

	Material	ICC-ES Criteria	Installation
Prescriptive Requirement	#15 Felt (ASTM D226 Type I)		Horizontally Lapped
Alternate Materials	Grade D Building Paper	AC38	Horizontally Lapped
	Housewraps	AC38	Horizontally Lapped
	SelfAdhered Membranes	AC38 or AC148	Horizontally Lapped
	Foam Plastic Sheathing	AC71	Joint Treatment tested per AC71
	Fluid Applied	AC212	Joint Treatment tested per AC212
	Water-Resistive Membranes Factory Bonded to Wood –based Structural Sheathing	AC310	Joint Treatment tested per AC310
	Laminated Fibrous Board Sheathing	AC382	Joint Treatment tested per AC382

SECTION 3

How are Water-Resistive Barriers Evaluated?

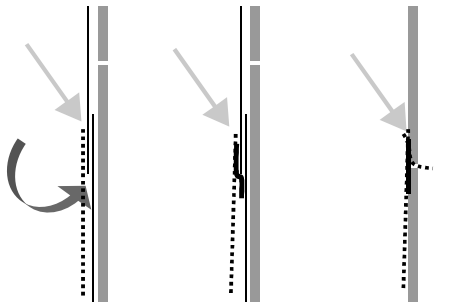
	Material	ICC-ES Criteria	Installation
Prescriptive Requirement	#15 Felt (ASTM D226 Type I)		Horizontally Lapped
Alternate Materials	Grade D Building Paper	AC38 (10)	Horizontally Lapped
	Housewraps	AC38 (29)	Horizontally Lapped
	SelfAdhered Membranes	AC38 or AC148	Horizontally Lapped
	Foam Plastic Sheathing	AC71 (6)	Joint Treatment tested per AC71
	Fluid Applied	AC212 (2)	Joint Treatment tested per AC212
	Water-Resistive Membranes Factory Bonded to Wood –based Structural Sheathing	AC310 (1)	Joint Treatment tested per AC310
	Laminated Fibrous Board Sheathing	AC382 (1)	Joint Treatment tested per AC382

SECTION 3

How are Water-Resistive Barriers Evaluated?

	Material	ICC-ES Criteria	Installation
Prescriptive Requirement	#15 Felt (ASTM D226 Type I)		Horizontally Lapped
Alternate Materials	Grade D Building Paper	AC38	Horizontally Lapped
	Housewraps	AC38	Horizontally Lapped
	SelfAdhered Membranes	AC38 or AC148	Horizontally Lapped
	Foam Plastic Sheathing	AC71	Joint Treatment tested per AC71
	Fluid Applied	AC212	Joint Treatment tested per AC212
	Water-Resistive Membranes Factory Bonded to Wood –based Structural Sheathing	AC310	Joint Treatment tested per AC310
	Laminated Fibrous Board Sheathing	AC382	Joint Treatment tested per AC382

SECTION 3



Traditional shingling | Shingling with taped seams | Taped sheathing joints

SECTION 3

"XPS and polyisocyanurate have commonly been utilized as a moisture barrier, but recent building science research has shown that these products **may not be as dimensionally stable as initially thought.** There is some evidence that the insulation boards shrink enough (up to 5/8") that **simply taping the joints may not be sufficient to maintain the drainage plane long term**."

— *Energy Efficient and Green Technology Building Template Guide for the State of Maryland, prepared for Maryland Energy Administration – Energy Efficiency Programs by Steven Winter Associates, January 10, 2007*

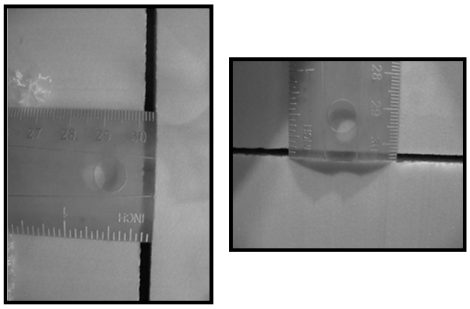
"Builders considering using foam sheathing as a WRB need more than code approval; **they also need to be assured that rigid foam products are dimensionally stable enough to shed water dependably."**

— *"Planning for Foam Shrinkage," Energy Design Update, Vol. 26, No. 9, September 2006.*

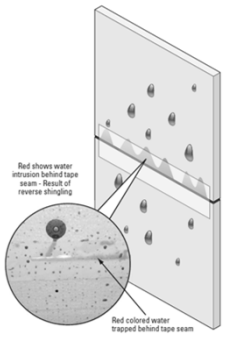
SECTION 3

Full Wall Assembly Testing

Gaps developed due to thermal cycling between 20°F and 140°F



SECTION 3



SECTION 3

Stucco & Stone WRB Requirements

	IBC 2003	IBC 2006+	IRC 2003	IRC 2006	IRC 2009
STUCCO	2 layers Grade D paper over wood-based sheathing"	2 layers Grade D paper (or a layer WRB + intervening layer) over wood-based sheathing"	WRB	2 layers Grade D paper (or a layer WRB + intervening layer) over wood-based sheathing"	2 layers Grade D paper (or a layer WRB + intervening layer) over wood-based sheathing"
STONE (direct applied)	2 layers of WRB	2 layers of WRB	WRB (treated as grout-filled masonry)	WRB (treated as grout-filled masonry)	2 layers Grade D paper (or a layer WRB + intervening layer) over wood-based sheathing" (referenced to stucco construction)

SECTION 3

Changes 2012 IBC & IRC

2009

2510.6 Water-resistive barriers. Water-resistive barriers shall be installed as required in Section 1404.2 and, where applied over wood-based sheathing, shall include a water-resistive vapor-permeable barrier with a performance at least equivalent to two layers of Grade D paper.

2012

2510.6 Water-resistive barriers. Water-resistive barriers shall be installed as required in Section 1404.2 and, where applied over wood-based sheathing, shall include a water-resistive vapor-permeable barrier with a performance at least equivalent to two layers of Grade D paper. The individual layers shall be installed independently such that each layer provides a separate continuous plane and any flashing (installed in accordance with Section 1405.4) intended to drain to the water-resistive barrier is directed between the layers.

SECTION 3

Changes 2012 IBC:
Adhered Masonry Veneer

2012 IBC *NEW SECTION*

1405.10.1 Exterior adhered masonry veneer. Exterior adhered masonry veneer shall be installed in accordance with section 1405.10 and in accordance with the manufacturer's instructions.

1405.10.1.1 Water-resistive barriers. Water-resistive barriers shall be installed as required in Section 2510.6.

1405.10.1.2 Flashing at foundation. A corrosion-resistant screed or flashing of a minimum 0.019-inch (0.48 mm) or 26 gauge galvanized or plastic with a minimum vertical attachment flange of 3 1/2 inches (89 mm) shall be installed to extend a minimum of 1 inch (25 mm) below the foundation plate line on exterior stud walls in accordance with Section 1405.4. The water-resistive barrier shall lap over the exterior of the attachment flange of the screed or flashing.

1405.10.2 Interior adhered masonry veneers. Interior adhered masonry veneers shall have a maximum weight of 20 psf (0.958 kg/m2) and shall be installed in accordance with Section 1405.10. Where the interior adhered masonry veneer is supported by wood construction, the supporting members shall be designed to limit deflection to 1/600 of the span of the supporting members.

SECTION 3

"Weather Protection" Code Requirements

Water-resistive barrier

Means of draining water

Flashing

Protection against condensation

SECTION 3

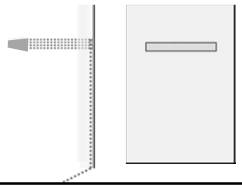
Drainage Requirements

- Only two building systems (EIFS, one-coat stucco) are currently required to demonstrate drainage
  - ICC-ES AC-235, AC-11
  - ASTM E2273
- Materials incorporated
  - Grooved foam
  - Textured water-resistive barriers
- NAHB Stone/Stucco Position Paper (December 2008)
  - Recommends "rain-screen" constructions

SECTION 3

Drainage Measurement

Method	Sample Type	Sample Size	Description	Performance Requirements	Code Reference
ASTM E2273	Wall System	4' by 8'	Spray (3.4 L/m²*min) for 75 min Collect water every 15 min during spray and after 60 min.	Minimum draining efficiency of 90% (EIFS & Stucco)	ICC-ES AC-11, ICC-ES AC-235,
				Minimum draining efficiency of 75%	Oregon Residential Code



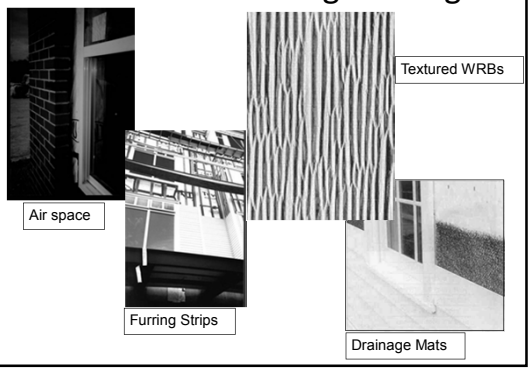
SECTION 3

Oregon Residential Code Drainage Requirement

- **R703.1.1 Exterior Wall Envelope. To promote building durability, the exterior wall envelope shall be installed in a manner that water that enters the assembly can drain to the exterior. The envelope shall consist of an exterior veneer, a water-resistive barrier (wrb) as required in R703.2, a minimum 1/8" (3mm) space between the wrb and the exterior veneer, and integrated flashings as required in R703.8. The required space shall be formed by the use of any non-corrodible furring strip, drainage mat or drainage board. The envelope shall provide proper integration of flashings with the water-resistive barrier, the space provided and the exterior veneer. These components, in conjunction, shall provide a means of draining water that enters the assembly to the exterior.**
- **Exceptions:**
- 1. **A space is not required where the exterior veneer is installed over a water-resistive barrier complying with section R703.2 which is manufactured in a manner to enhance drainage and meets the 75% drainage efficiency requirement of ASTM E2273 or other recognized national standards.**

SECTION 3

Methods of Adding Drainage



SECTION 3

"Weather Protection" Code Requirements

Water-resistive barrier

Means of draining water

Flashing

Protection against condensation

SECTION 3

Water-Resistive Barrier Code Provisions

1405.4 Flashing. Flashing shall be installed in such a manner so as to prevent moisture from entering the wall or to redirect it to the exterior. Flashing shall be installed at the perimeters of exterior door and window assemblies, penetrations and terminations of *exterior wall* assemblies, *exterior wall* intersections with roofs, chimneys, porches, decks, balconies and similar projections and at built-in gutters and similar locations where moisture could enter the wall. Flashing with projecting flanges shall be installed on both sides and the ends of copings, under sills and continuously above projecting *trim*.

R703.8 Flashing. *Approved* corrosion-resistant flashing shall be applied shingle fashion in a manner to prevent entry of water into the wall cavity or penetration of water to the building structural framing components. Self-adhered membranes used as flashing shall comply with AAMA 711. The flashing shall extend to the surface of the exterior wall finish. *Approved* corrosion-resistant flashings shall be installed at all of the following locations:

1. Exterior window and door openings. Flashing at exterior window and door openings shall extend to the surface of the exterior wall finish or to the water-resistive barrier for subsequent drainage. Flashing at exterior window and door openings shall be installed in accordance with one or more of the following:
   - 1.1. The fenestration manufacturer's installation and flashing instructions, or for applications not addressed in the fenestration manufacturer's instructions, in accordance with the flashing manufacturer's instructions. Where flashing instructions or details are not provided, pan flashing shall be installed at the sill of exterior window and door openings. Pan flashing shall be sealed or sloped in such a manner as to direct water to the surface of the exterior wall finish or to the water-resistive barrier for subsequent drainage. Openings using pan flashing shall also incorporate flashing or protection at the head and sides.
   - 1.2. In accordance with the flashing design or method of a registered design professional.
   - 1.3. In accordance with other approved methods.

SECTION 3

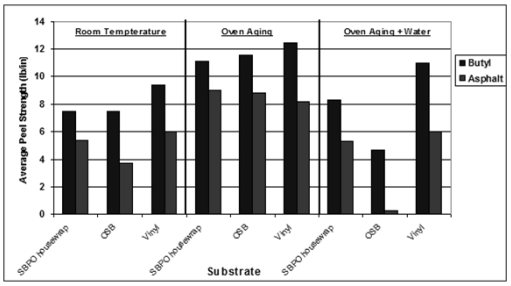
Flashing Code Requirements: AAMA 711 Testing

- Physical Property Requirements:
  Tensile strength, peel adhesion to common substrates, cold temperature pliability
- Performance Requirements:
  Nail sealability, adhesion after temperature cycling, minimum widths
- Durability:
  Properties after UV aging, thermal exposure, water immersion
- **Does not include testing of wall/window integration**

Property	Test Method	Minimum Requirement
Section 5.1		
Tensile Strength-Fabric and Thermoplastics	ASTM D 412, Method A, Die C	985 kPa (143 psi) minimum
Tensile Strength-Polymer Modified Bitumen	ASTM D 1970, Section 7.3	985 kPa (143 psi) minimum
Elongation-Woven/Nonwoven Textile Fabrics	ASTM D 5034	0.3 50 mm (2.0 lbs/in) minimum
Section 5.3		
Water Penetration Annual Static		
-After 24 hours @ 23°C ± 1°C (73°F ± 2°F) & 50% RH	ASTM D 1970, Section 7.9, modified per 5.2.1.	Must Pass 31 mm (1.2 in) of water
-After thermal cycling (10 cycles)		Must Pass
Water Penetration Annual Static (ME)		
-After 24 hours @ 23°C ± 1°C (73°F ± 2°F) & 50% RH -After thermal cycling (10 cycles)	ASTM E 331/E 547, or modified test per Annex 1	Must Pass Must Pass
Section 5.4		
90° Peel Adhesion (initial)		
After 24 hours @ 23°C ± 1°C (73°F ± 2°F) & 50% RH	ASTM D 3330, Method F	0.20 50 mm (1.5 lbs/in) minimum
All Substrate Substrates		
Section 5.6		
Accelerated UV Aging (14 days) 90° Peel Adhesion	ASTM G 154, UVA cycle 1 ASTM D 3330, Method F	0.20 50 mm (1.5 lbs/in) minimum *NOTE 1: change from original appearance*
Appearance	Visual	
Section 5.7		
Thermal Temperature Exposure Level 1 - 50°C (122°F) 7 days Level 2 - 85°C (149°F) 7 days Level 3 - 80°C (176°F) 7 days	ASTM D 3330, Method F	0.20 50 mm (1.5 lbs/in) minimum *NOTE 2: change from original appearance*
Appearance	Visual	
Section 5.8		
Thermal Cycling (10 cycles) 90° Peel Adhesion (See Section 5.8 for temperatures)	AAMA (TBD), Section 7.3 ASTM D 3330, Method F, Section 14	0.20 50 mm (1.5 lbs/in) minimum *NOTE 3: change from original appearance*
Appearance	Visual	
Section 5.9		
Cold Temperature Flexibility	ASTM C 765	Must Pass -18°C (0°F)
Section 5.5		
Adhesion after water immersion	AAMA 800, Section 2.4.1.3.2.2 & 2.4.1.4.3 Test B	0.2401 mm (1.5 lbs/in) minimum
Section 5.2		
Resistance to Peel	Annex 2	Report Only

SECTION 3

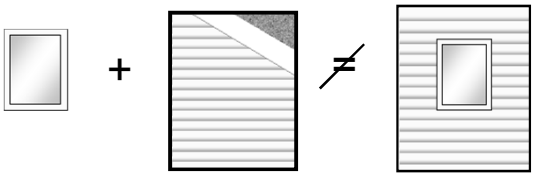
AAMA 711 : Adhesion Testing



Adhesion of membrane is dependent on type of adhesive, substrate, and exposure conditions

SECTION 6

Testing Installed Performance



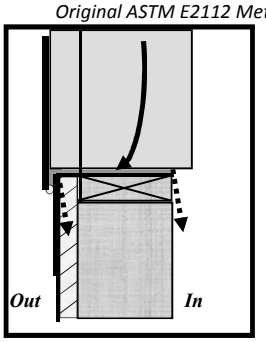
Performance = Material + Installation

•Window and Wall usually tested separately, should be tested as installed unit.

SECTION 6

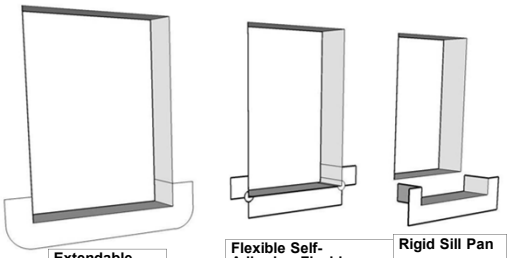
Barrier Method Flashing/Caulked Bottom Flange

Original ASTM E2112 Methods (A, A1, B, B1)



SECTION 6

Sill Pan Flashing Used in Drainable Installations



Extendable Self-Adhering Flashing

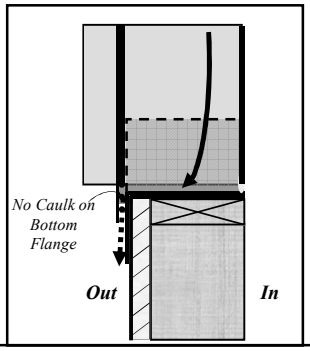
Flexible Self-Adhering Flashing (with Corner Patches)

Rigid Sill Pan

SECTION 6

Revised ASTM E2112 Drainage Method

Sill Pan Flashing / Bottom Flange Open to Drain



ASTM E2112-07 Drainage Method: Sill Pan Flashing / Bottom Flange Open to Drain

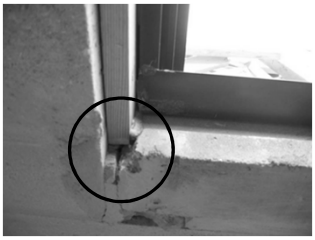
Photo Credits: ASTM

SECTION 6

Common Errors

SECTION 6

Common Errors



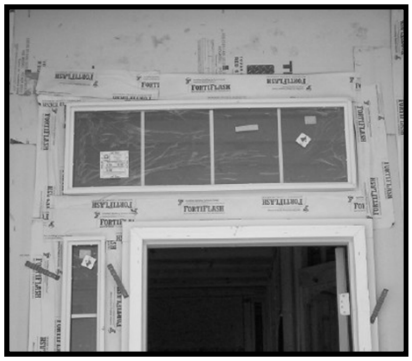
SECTION 6

Common Errors

Reversed shingling and detached flashing gaps between the window, flashing and WRB

SECTION 6

Common Errors



SECTION 3

"Weather Protection" Code Requirements

Water-resistive barrier

Means of draining water

Flashing

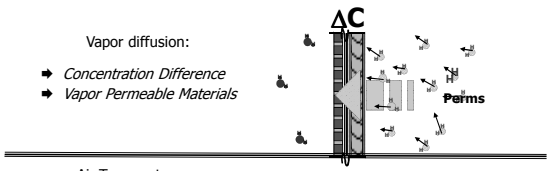
Protection against condensation

SECTION 3

Vapor Diffusion vs. Air Transported Moisture

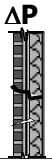
Vapor diffusion:

- *Concentration Difference*
- *Vapor Permeable Materials*



Air Transport:

- *Pressure Difference*
- *Leaky materials/assemblies*



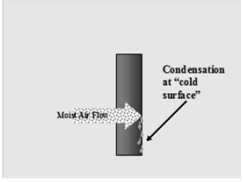
Water vapors get a " Free Ride"

Cfm/ft²

Est. 98% of all water vapor movement

SECTION 3

Moisture Carried by Air Leakage



Air Currents…

- **…account for 90x more moisture vapor entering a wall cavity than diffusion.**
- **…reduce the effectiveness of the insulation.**
- **…reduce overall comfort**
- **…can place unnecessary stress on HVAC System**

SECTION 3

Water-Resistive Barrier Code Provisions

1405.3 Vapor retarders. Class I or II vapor retarders shall be provided on the interior side of frame walls in Zones 5, 6, 7, 8 and Marine 4. The appropriate zone shall be selected in accordance with Chapter 3 of the *International Energy Conservation Code*.

Exceptions:

1. Basement walls.
2. Below-grade portion of any wall.
3. Construction where moisture or its freezing will not damage the materials.

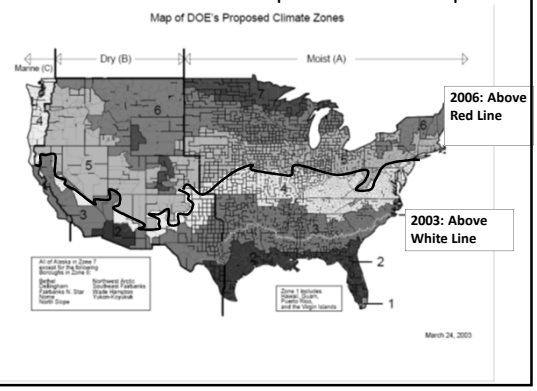
R702.7 Vapor retarders. Class I or II vapor retarders are required on the interior side of frame walls in Climate Zones 5, 6, 7, 8 and Marine 4.

Exceptions:

1. Basement walls.
2. Below grade portion of any wall.
3. Construction where moisture or its freezing will not damage the materials.

SECTION 3

Where are interior vapor retarders required?



SECTION 3

How are vapor retarders defined?

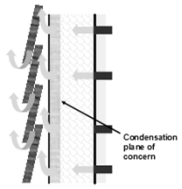
- 2006
- Vapor Retarder: < 1 perm

- I-codes 2009+
- Different Classes of Vapor Retarders:
  - **Class I: 0.1 perm or less**
    - **Sheet polyethylene, non-perforated aluminum foil**
  - **Class II: 0.1 < perm ≤ 1.0 perm**
    - **Kraft faced fiberglass batts or low perm paint (paint with 0.1 < perm ≤ 1.0)**
  - **Class III: 1.0 < perm ≤ 10 perm**
    - **Latex or enamel paint**

SECTION 3

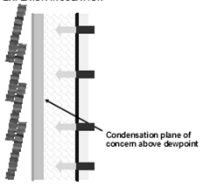
Since 2009 – Class III Vapor Retarders allowed in cold climates

VENTILATED CLADDING



Includes vinyl and brick with airspace

EXTERIOR INSULATION



Specific sheathing R-Values dependent on climate.

SECTION 3

I-codes 2012: Condensation Protection Requirements

R702.7.3 Minimum clear air spaces and vented openings for vented cladding. For the purposes of this section, vented cladding shall include the following minimum clear air spaces. Other openings with the equivalent vent area shall be permitted.

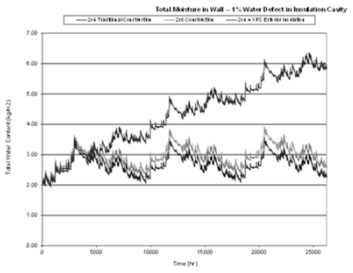
1. Vinyl lap or horizontal aluminum siding applied over a weather resistive barrier as specified in Table R703.4.
2. Brick veneer with a clear airspace as specified in Table R703.7.4.
3. Other approved vented claddings.

TABLE R702.7.1
CLASS III VAPOR RETARDERS

CLIMATE ZONE	CLASS III VAPOR RETARDERS PERMITTED FOR:[a]
Marine 4	Vented cladding over wood structural panels. Vented cladding over fiberboard. Vented cladding over gypsum. Insulated sheathing with *R*-value ≥ 2.5 over 2 × 4 wall. Insulated sheathing with *R*-value ≥ 3.75 over 2 × 6 wall.
5	Vented cladding over wood structural panels. Vented cladding over fiberboard. Vented cladding over gypsum. Insulated sheathing with *R*-value ≥ 5 over 2 × 4 wall. Insulated sheathing with *R*-value ≥ 7.5 over 2 × 6 wall.
6	Vented cladding over fiberboard. Vented cladding over gypsum. Insulated sheathing with *R*-value ≥ 7.5 over 2 × 4 wall. Insulated sheathing with *R*-value ≥ 11.25 over 2 × 6 wall.
7 and 8	Insulated sheathing with *R*-value ≥ 10 over 2 × 4 wall. Insulated sheathing with *R*-value ≥ 15 over 2 × 6 wall.

SECTION 3

Climate Zone 5 – 1% rain defect



SECTION 3

New Language 2015 IBC

1405.3 Vapor retarders. Vapor retarders as described in Section 1405.3.3 shall be provided in accordance with Sections 1405.3.1 and 1405.3.2, or an approved design using accepted engineering practice for hygrothermal analysis.

1405.3.1 Class I and II Vapor Retarders. Class I or II vapor retarders shall not be provided on the interior side of frame walls in Zones 1 and 2. Class I vapor retarders shall not be provided on the interior side of frame walls in Zones 3 and 4. Class I or II vapor retarders shall be provided on the interior side of frame walls in Zones 5, 6, 7, 8 and Marine 4. The appropriate zone shall be selected in accordance with Chapter 3 of the *International Energy Conservation Code*.

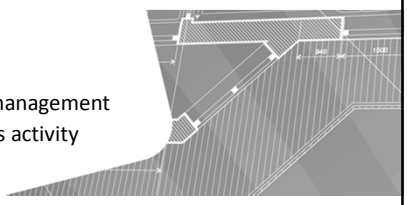
Exceptions:

1. Basement walls.
2. Below-grade portion of any wall.
3. Construction where moisture or its freezing will not damage the materials.
4. Conditions where Class III vapor retarders are required in Section 1405.3.2.

1405.3.12 Class III vapor retarders. Class III vapor retarders shall be permitted where any one of the conditions in Table 1405.3.1 is met. Only Class III vapor retarders shall be used on the interior side of frame walls where foam plastic insulating sheathing with perm rating of less than 1 perm is applied in accordance with Table 1405.3.1 on the exterior side of the frame wall.

Section 4

Update on water management code and standards activity



SECTION 4

Managing Bulk Water

- Redundancy – Cladding + Second Line of Defense
  - Water-resistive barriers
  - Flashing
- Material Choice
  - Performance – Water & Resistance
  - Allow Drying
  - Durability
- Installation -- Continuity
  - Shingling correctly
  - Beware of hidden water traps

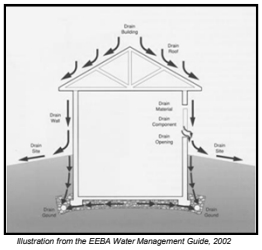


Illustration from the EEBA Water Management Guide, 2002

SECTION 4

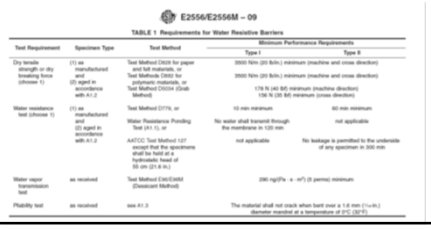
New Material Standards

SECTION 4

ASTM E2556-09

Standard Specification for Vapor Permeable Flexible Sheet Water-Resistive Barriers Intended for Mechanical Attachment

- Consensus standard which can be referenced in specifications, etc.
- Referenced in 2015 IBC, Section 2510.6
- Based on ICC-ES AC-38
- Includes building felt, building paper and building wraps
- Two types of WRB based on water resistance (perforated vs. non-perforated)



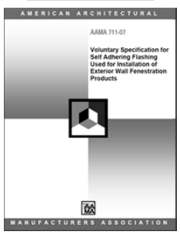
E2556/E2556M – 09

TABLE 1 Requirements for Water Resistive Barriers

Test Requirement	Specimen Type	Test Method	Minimum Performance Requirements	
			Type I	Type II
Dry tensile strength or dry breaking force (choose 1)	(1) as manufactured and (2) aged in accordance with A1.2	Test Method D828 for paper and felt materials, or Test Methods D882 for polymeric materials, or Test Method D5034 (Grab Method)	3500 N/m (20 lb/in.) minimum (machine and cross direction)	3500 N/m (20 lb/in.) minimum (machine and cross direction)
				178 N (40 lbf) minimum (machine direction)
				156 N (35 lbf) minimum (cross direction)
Water resistance test (choose 1)	(1) as manufactured and (2) aged in accordance with A1.2	Test Method D779, or	10 min minimum	60 min minimum
		Water Resistance Ponding Test (A1.1), or	No water shall transmit through the membrane in 120 min	not applicable
		AATCC Test Method 127 except that the specimens shall be held at a hydrostatic head of 55 cm (21.6 in.)	not applicable	No leakage is permitted to the underside of any specimen in 300 min
Water vapor transmission test	as received	Test Method E96/E96M (Desiccant Method)	290 ng/(Pa · s · m²) (5 perms) minimum	
Pliability test	as received	see A1.3	The material shall not crack when bent over a 1.6 mm (1/16-in.) diameter mandrel at a temperature of 0°C (32°F)	

SECTION 4

Flashing Materials

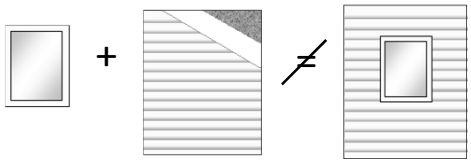


SECTION 4

New Installation Standards

SECTION 4

Testing Systems



- Window and Wall usually tested separately, should be tested as installed unit

SECTION 4

Test Assembly: fenestration product, fasteners, sealant, flashing components and weather resistant barrier shall be included. Exterior cladding, interior perimeter cavity insulation and expanding foam shall not be applied to the test mockup for this evaluation.

The completed mockup shall be preloaded prior to testing using 10 positive cycles of 480 Pa (10 psf) followed by 10 negative cycles of 480 Pa (10 psf).

Test for air leakage in accordance with ASTM E 283 at a pressure differential of 75 Pa (1.57 psf).

Test for water penetration resistance in accordance with ASTM E 331 at a minimum test pressure of 150 Pa (3.0 psf) for 60 minutes.

The entire mockup shall be subjected to 14 twelve hour durability cycles in accordance with ASTM E 2264 Method A, Level 1:
- *Exterior Temperature Exposure*
  - Level 1 49°C (120 °F)
  - Level 2 3°C (150 °F)
  - Level 3 82°C (180 6°F)

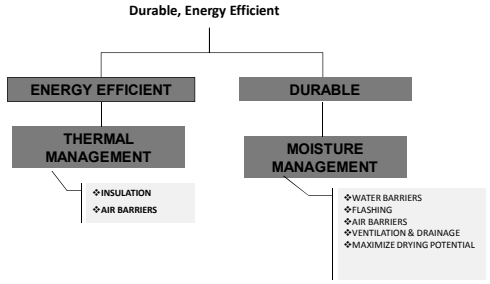
Exterior Low Ambient Air Temperature: –30°C (–22°F)

Following cycling, the mockup shall again be tested for air leakage and water penetration resistance

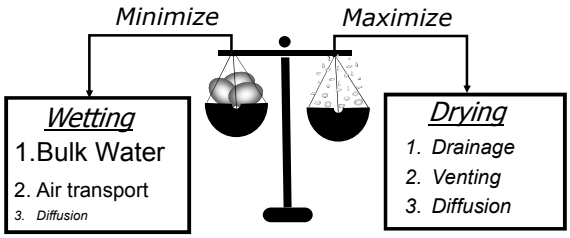
The entire mockup shall be tested for structural loads in accordance with ASTM E 330 at a minimum test pressure of 1440 Pa (30 psf) positive and negative.

Building durability is a key sustainability attribute

A building component /system cannot be energy or resource efficient unless it is durable.



Good Design and Practice



Good enclosure water management design and detailing will minimize the risk of wetting, but drying potential must ALWAYS be considered