Build a Better House at Lower Cost by Controlling Air Infiltration

Makers of Enviro-Dri® Weather-Resistant Barrier

TREMCO Barrier Solutions

Tremco Barrier Solutions
Speaker & Background

- Dr. Jim Wells PhD. - Technical Director, TBS
  - Graduated & Taught Engineering at Purdue
    Aeronautics, Astronautics & Engineering Sciences
  - Over 30 years R&D in Construction Products
    - Owens Corning: Insulation & Roofing Systems -15 years
    - Koch Materials: Highway Systems – 5 years
    - Residential Barrier Systems – 10+ years

Tremco Barrier Solutions
RPM Company Background

Maximum Return on Construction Cost
Waste and Value

- **Waste** is a bad thing
- Eliminating waste **adds value –** a good thing
- Resources saved can be used elsewhere to **add value**
- Using more resources than needed to meet the 2009, 2012 or any code is **waste**
- Using resources efficiently to meet your energy goals **adds value** (eliminating waste)
- Focus: getting maximum value from your resources

Build a Better House at Lower Cost
Learning Objectives

- **The course objectives are to understand:**
  - The value of the performance path to meet energy codes
  - The value of added insulation diminishes
  - The power of reducing air infiltration in meeting code
  - Improved construction methods to control air infiltration

Your three friends

Maximum Return on Construction Cost
Meeting Energy Codes

- Two methods to show code compliance
  - Prescriptive
    Use the list; **the list determines your cost**
  - Performance
    Use performance; **you choose the best way**
    Performance method required by Energy Star and most utility incentive programs

Energy Codes: Waste and Value

IECC Prescriptive Codes: CZ 5

Prescriptive Elements Z5	2003*	2006	2009	2012
Window-U	0.41	0.35	0.35	0.32
Glazing SHGC	NR	NR	NR	NR
Ceiling R	38	38	38	49
Frame Wall R	17	19, 13+5	20, 13+5	20, 13+5
Bsmt Wall R	9.5	10/13	10/13	15/19
Air Infiltration (ACH50)	NA (7.0)	NA (7.0)	NA (7.0)	3.0

* approximate values for new simplified climate zones

Northern Missouri

Maximum Return on Construction Cost

IECC Prescriptive Code – CZ 4

Prescriptive Elements Z4	2003*	2006	2009	2012
Window-U	0.48	0.40	0.35	0.35
Glazing SHGC	NR	NR	NR	0.40
Ceiling R	38	38	38	49
Frame Wall R	13	13	13	20, 13+5
Bsmt Wall R	8	10/13	10/13	10/13
Air Infiltration (ACH50)	NA (7.0)	NA (7.0)	NA (7.0)	3.0

* approximate values for new simplified climate zones

2012 - Columbia, Independence, Springfield, & ~ Kansas City areas

2009 - St Louis area

Maximum Return on Construction Cost

Diminishing Value of Insulation

- The first R is the best R
- The value of adding insulation diminishes
- To reduce energy loss by 50%, double the R

Example: Energy lost through a ceiling area

R-value Added	Total R-value	BTU Used	BTU Saved
0	R-1	100	0
1	R-2	50	50
2	R-4	25	25
4	R-8	12	12
8	R-16	6	6
16	R-32	3	3

- **The first R saved 50, the last 16-Rs added saved 3**

Maximum Return on Construction Cost

Diminishing Value of Insulation

- Example: 2-Story with 1,350 Ft^2 ceiling area

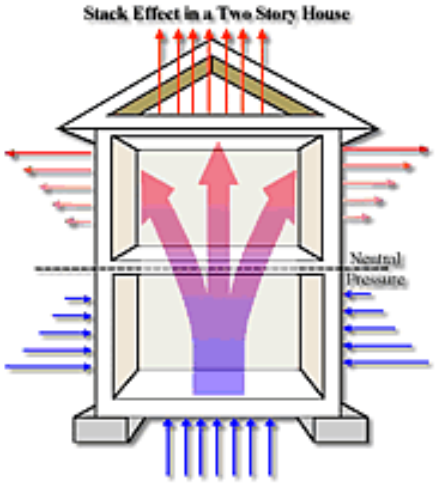
Ceiling R-value	Annual Heating & Cooling vs. Ceiling R				
	MM-BTU	$	$ Saved	% Saved	Total Saved
Unins.	56.7	$318	0	0	0
5	22.3	$126	$192	60%	60%
10	15.0	$84	$42	13%	74%
20	8.1	$46	$38	12%	86%
38	3.8	$21	$25	8%	93%
49	2.6	$15	$6	2%	95%
100	0.6	$3	$12	4%	99%
1000	0	$0	$3	1%	100%
CZ 5			**$318**	**100%**	100%

R-38 to R-49: Even simple payback calculation exceeds 50 years, a very poor value

Moisture Dynamics
Air Infiltration & Moisture

Conditions for air infiltration

- Pressure difference (high to low)
- Holes, gaps, and cracks allowing air flow



Driving forces

- Temperature difference (stack effect)
- Wind
- Mechanical systems imbalance

ACH50 (test result) and ACHn (reality)

- ACHn (per day) is approx 1.3 times ACH50 (per hour)
- ACH_{50} (1 – 7) is approximately ACHn=(3 – 9) (0-18+)

Maximum Return on Construction Cost
Lowering ACH vs. Adding R-value

- Example: 2-Story with 1,350 Ft^2 ceiling area

Air Infiltration ACH_{50}	Annual Heat & Cool - ACH_{50}				
	MM-BTU	$	$ Saved	% Saved	Total Saved
7	32.4	$165	0	0	0
6	26.2	$133	$32	19%	19%
5	20.2	$103	$30	18%	38%
4	16.5	$74	$29	18%	55%
3	9.3	$47	$27	16%	72%
2	4.6	$23	$24	15%	86%
1	1.3	$6	$17	10%	96%
0	0	$0	$6	4%	100%
CZ 5			**$165**	**100%**	100%

Maximum Return on Construction Cost

Diminishing Value of Insulation

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R-38 to R-49: Even simple payback calculation exceeds 50 years, a very poor value

Maximum Return on Construction Cost
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CZ 5			**$165**	**100%**	100%

Maximum Return on Construction Cost Meeting Energy Codes

- The annual energy cost shows the striking difference in the value created by lowering ACH vs. more ceiling insulation
- Other ways to benefit from the value created
  - Occupant comfort (ACH_{50} vs ACHn)
  - Right-sizing HVAC equipment
  - Lower initial construction costs

Eliminate High-cost, Low-value Construction Alternatives & Costs

Equal $ Energy Savings Insulation vs. ACH50		
Ceiling R-value R-38 to R-49	or	**ACH50** 7.0 to 6.8
Frame Wall R-value R-15(2x4) to R-20(2x6)	or	**ACH50** 7.0 to 6.1
R-20(2x6) to R-20(2x6)+R-5	or	7.0 to 6.2
Window U-value U 0.35 to U 0.32	or	**ACH50** 7.0 to 6.7

Ceiling, Wall, and Window Changes or ACH50 from 7.0 to 5.6 or 5.7

Maximum Return on Construction Cost
Meeting Energy Codes

- We can use this higher-value construction alternative to meet current and future energy codes more economically.
- Higher value now and later
  - 2009 or 2012 IECC now, 2015 IECC later
  - And beyond code programs and incentives
- Example: 2,700 ft^2 two story with basement

Maximum Return on Construction Cost

Whole House Impact – CZ 4

Performance Path - Equal energy Performance Minimizing Additional Construction Costs

Code	Frame Walls	Ceiling	Bsmt Walls	ACH_{50}	Construction Cost Avoided
09 IECC CZ4	R-13	R-38	R-10 Cont	7.0	0.0
Performance	R-13	R-38	None	3.3	$ 650.00

Code	Frame Walls	Ceiling	Bsmt Walls	ACH_{50}	Construction Cost Avoided
12 IECC CZ4	R-20, R-13+5	R-49	R-10 Cont	3.0	0.0
Performance	R-15	R-38 Bln	R-5 Cont	2.5	$ 2,069.00

Meet 2009-based Code more economically today, and 2012 / 2015 later.

Maximum Return on Construction Cost

Whole House Impact – CZ 5

Performance Path - Equal Energy Performance
Minimizing Additional Construction Costs

Code	Frame Walls	Ceiling	Bsmt Walls	Windows	ACH_{50}	Construction Cost Avoided
09 IECC CZ5	R-20, R-13+5c	R-38	R-10 Cont	U-0.35	7.0	0.0
Performance	R-15	R-38	R-5 Cont	U-0.35	4.9	$ 1,515.00

Code	Frame Walls	Ceiling	Bsmt Walls	Windows	ACH_{50}	Construction Cost Avoided
12 IECC CZ5	R-20, R-13+5c	R-49	R-15	U-0.32	3.0	0.0
Performance	R-15	R-38	R-10 Cont	U-0.35	3.0	$ 2,069.00 +

Meet 2009-based Code more economically today, and 2012 / 2015 later.

Maximum Return on Construction Cost

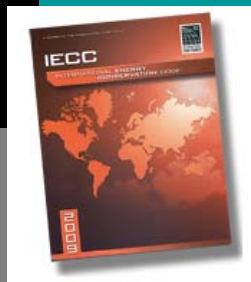
Meeting 2012 code and More

- Use the insulation/air change trade-off that best suits your building practice
- Ceiling – wall - crawl insulations, window U-value
- Right size HVAC equipment & maintain comfort
- Stay with 2x4 walls if desired
- Energy raters/designers have the tools and help you meet your energy goals most advantageously

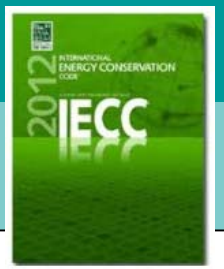
- the Performance Path is your friend

Maximum Return on Construction Cost Performance Path: Process & FAQ

- **The performance path is your friend, but is it complicated?**
- **NO, and it allows you to reach your energy goals at lower cost**
- ***Handout on Process and FAQ***
  - ***Process (performance vs. prescriptive)***
  - ***FAQ***



Performance Path Process



- **Process parallels the prescriptive process**
- **There are mandatory requirements in both paths**
- **Generates HERS rating, required for:**
  - Energy Star, Utility Rebates, Above-code Programs
- **Not all raters are alike, with same focus**
  - Make certain that your rater is working ***for you***
  - Your Rater **may** provide building science consulting on structural options, best practices and warranty concerns
  - Your Rater **may** help you qualify for available tax credits and various High Performance Home Certifications
  - Some do only ACH and Duct testing and give you only the test results

Performance Path Compliance Certificates

Performance Path – Compliance documentation

- Your Rater helps you meet your energy goal and provides the compliance documentation
  - Meet code, Energy Star, tax credits, utility incentives, etc.

Maximum Return on Construction Cost
Summary and a Question

- **Summary**
  - Added insulation value diminishes
  - Controlling air changes adds consistent value
  - Controlling air changes can lower construction cost
  - Controlling air changes helps maximize any utility incentives
  - The performance path can help you meet you energy goals at **lower construction** cost vs. Res check

- **But what about building too tight?**

Building the Right Tightness
Science & History

- **Air changes** and **permeability** are not the same.
  - Air (with water vapor) passes through holes - ACH
    - Moisture laden air can condense and add water to walls
    - You can't assume that the uncontrolled air will actually dry out an affected area (inconsistent)
    - **Uncontrolled air movement is a problem not a solution**
  - Water vapor passes through solids without holes - perms
    - Perms dry out all wall cavities at predictable rates
    - You can't increase perms by adding more material
      - Perms of OSB plus anything is less than OSB alone: 4-6 at high RH
    - **Only extremes of vapor diffusion could ever cause a problem**
      - **Normally it helps solve, not cause, problems**

Building the Right Tightness
Allow Vapor Diffusion for Drying

- **Conditions for vapor diffusion**
  - Water vapor pressure difference
    (vapor moves from high to low vapor pressure)
  - Vapor permeable transmission medium
    - Vapor can flow through permeable solid materials
      Wood, some polymers, organic material – Yes
      Glass, metal, non-porous inorganic material – No
- **Factors that Determine Amount and Rate**
  - Size of the vapor pressure difference
    - determined by temperature and relative humidity
  - Permeability of the medium

Building the Right Tightness
Permeability and Air Leakage

- **System perms of OSB Plus WRB**
  - In humid environment, OSB alone = 4-6 perms,
  - OSB plus anything is lower perm than OSB alone
    - Using OSB perms = 4.0
    - OSB plus Tyvek(58) is ~ 3.7 perms, plus low-perm wrap(6) is ~ 2.4 perms
    - OSB plus Enviro-Dri (16) is ~ 3.2 perms
    - Difference is small and of no consequence
    - Amount of vapor transmitted (1/4 to 1/2 cup during heating season) is far less than the framing absorbs (5 – 6 cups per 2x4 wall cavity)
  - Permeability is ***not*** the issue
  - Uncontrolled air flow is the issue

Building the Right Tightness

Permeability and Air Leakage

- ***Uncontrolled air movement can introduce over 100 times the moisture into walls than by diffusion!***
- **Moisture Control Priorities**
  - Stop liquid water leaks
  - Stop uncontrolled air movement
  - Maintain permeability for drying
  - Use wood frame construction –(*hygric buffering*)
- **Is it Too tight? In what sense?**
  - Uncontrolled air movement: the goal is zero
  - Vapor diffusion: prudent for more fail safe walls

Building the Right Tightness

Science & History

- **Nationally Recognized Building Science Consultants**
  - **Joe Lstiburek, President Building Science Corporation**
    with extensive building science credentials and practical experience
    "The solution to moisture issues in walls is to decrease wetting potential, not trying to increase drying potential" "Build it tight and ventilate right."
  - **Steve Easley, Principle S.C. Easley & Associates**
    with extensive building science credentials and practical experience
    "my field experience has taught me that leaky building shells cause problems and increase chances for mold growth." "Build tight, ventilate right"

- tight, permeable construction is your friend

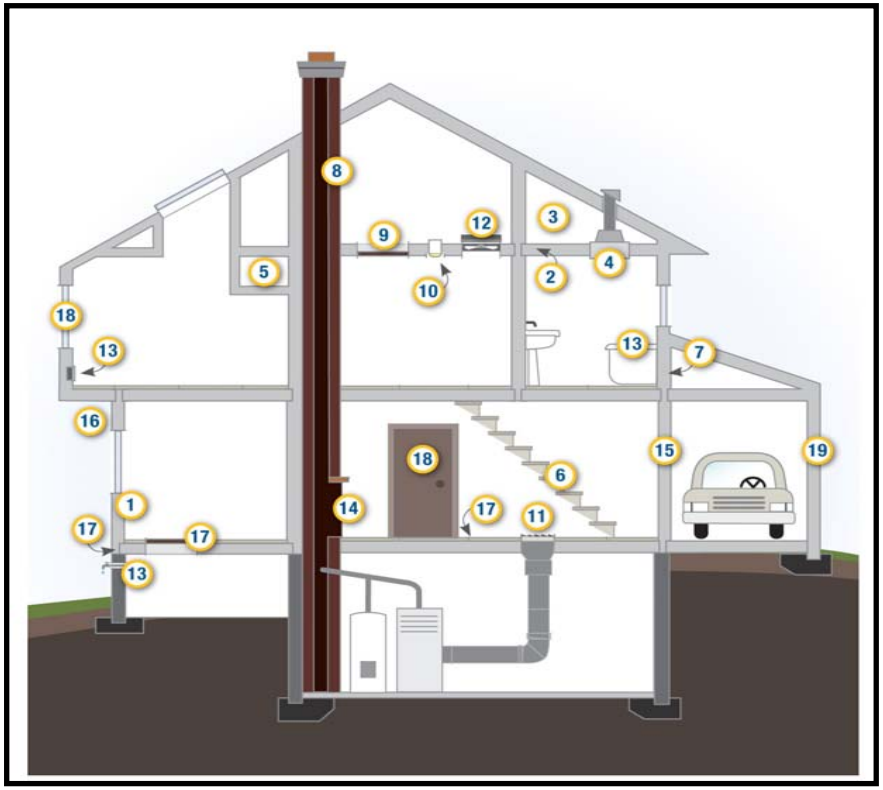
Building Better Homes
Controlling Air Infiltration

- **Focus – controlling air flow**
  - Ceilings, knee walls & attic details
  - Chases & penetrations
  - Windows/doors
  - **Walls**
- **Air Moves Through Holes; fix the holes**
  - Know where they are
  - Create a continuous air barrier with to minimize holes
  - Do it **E**ffectively, **E**fficiently, **E**conomically, 3 Es

Building Better Homes
Controlling Air Infiltration

GOOD REFERENCE:

***Air Sealing*, Building America Best Practice Series, PNNL & ORNL, 2010**



RETROFIT TECHNIQUES AND TECHNOLOGIES **AIR SEALING**

Air Sealing List

Each of these items is addressed on the following pages.

Air Barrier	Completion Guidelines
1. Air Barrier and Thermal Barrier Alignment	Air barrier is in alignment with the thermal barrier (insulation).
2. Attic Air Sealing	Top plates and wall-to-ceiling connections are sealed.
3. Attic Kneewalls	Air barrier is installed at the insulated boundary (kneewall transition or roof, as appropriate).
4. Duct Shaft/Piping Shaft and Penetrations	Openings from attic to conditioned space are sealed.
5. Dropped Ceiling/Soffit	Air barrier is fully aligned with insulation; all gaps are fully sealed.
6. Staircase Framing at Exterior Wall/Attic	Air barrier is fully aligned with insulation; all gaps are fully sealed.
7. Porch Roof	Air barrier is installed at the intersection of the porch roof and exterior wall.
8. Flue or Chimney Shaft	Opening around flue is closed with flashing, and any remaining gaps are sealed with fire-rated caulk or sealant.
9. Attic Access/Pull-Down Stair	Attic access panel or drop-down stair is fully gasketed for an air-tight fit.
10. Recessed Lighting	Fixtures are provided with air-tight assembly or covering.
11. Ducts	All ducts should be sealed, especially in attics, vented crawlspaces, and rim areas.
12. Whole-House Fan Penetration at Attic	An insulated cover is provided that is gasketed or sealed to the opening from either the attic side or ceiling side of the fan.
13. Exterior Walls	Service penetrations are sealed and air sealing is in place behind or around shower/tub enclosures, electrical boxes, switches, and outlets on exterior walls.
14. Fireplace Wall	Air sealing is completed in framed shaft behind the fireplace or at fireplace surround.
15. Garage/Living Space Walls	Air sealing is completed between garage and living space. Pass-through door is weather stripped.
16. Cantilevered Floor	Cantilevered floors are air sealed and insulated at perimeter or joist transition.
17. Rim Joists, Sill Plate, Foundation, and Floor	Rim joists are insulated and include an air barrier. Junction of foundation and sill plate is sealed. Penetrations through the bottom plate are sealed. All leaks at foundations, floor joists, and floor penetrations are sealed. Exposed earth in crawlspace is covered with Class I vapor retarder overlapped and taped at seams.
18. Windows and Doors	Space between window/door jambs and framing is sealed.
19. Common Walls Between Attached Dwelling Units	The gap between a gypsum shaft wall (i.e., common wall) and the structural framing between units is sealed.

***Air Sealing*, Building America Best Practice Series, PNNL & ORNL, 2010**

Building Better Homes
Controlling Air Infiltration

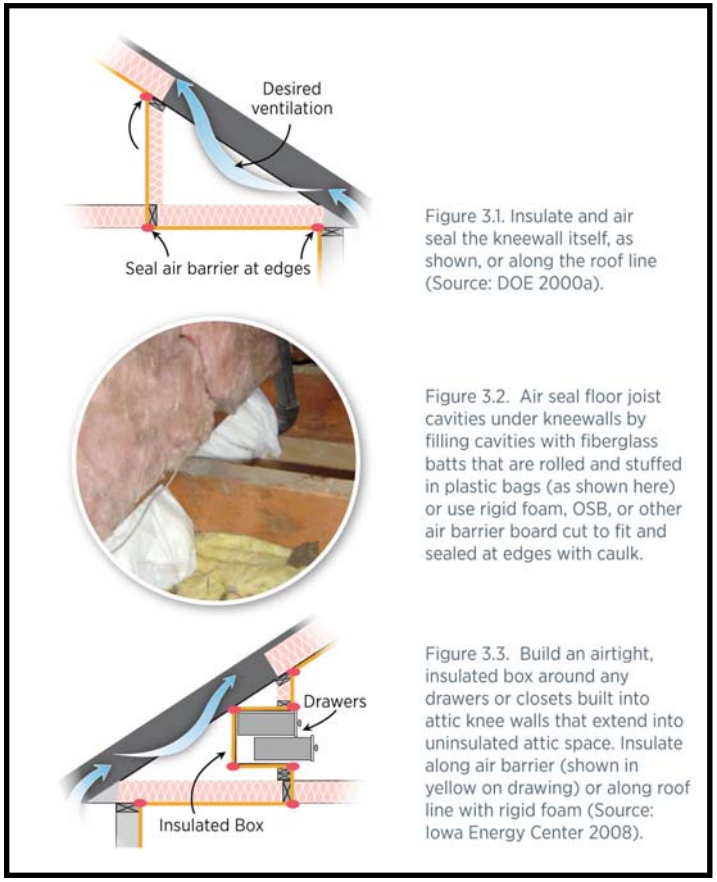


Figure 3.1. Insulate and air seal the kneewall itself, as shown, or along the roof line (Source: DOE 2000a).

Figure 3.2. Air seal floor joist cavities under kneewalls by filling cavities with fiberglass batts that are rolled and stuffed in plastic bags (as shown here) or use rigid foam, OSB, or other air barrier board cut to fit and sealed at edges with caulk.

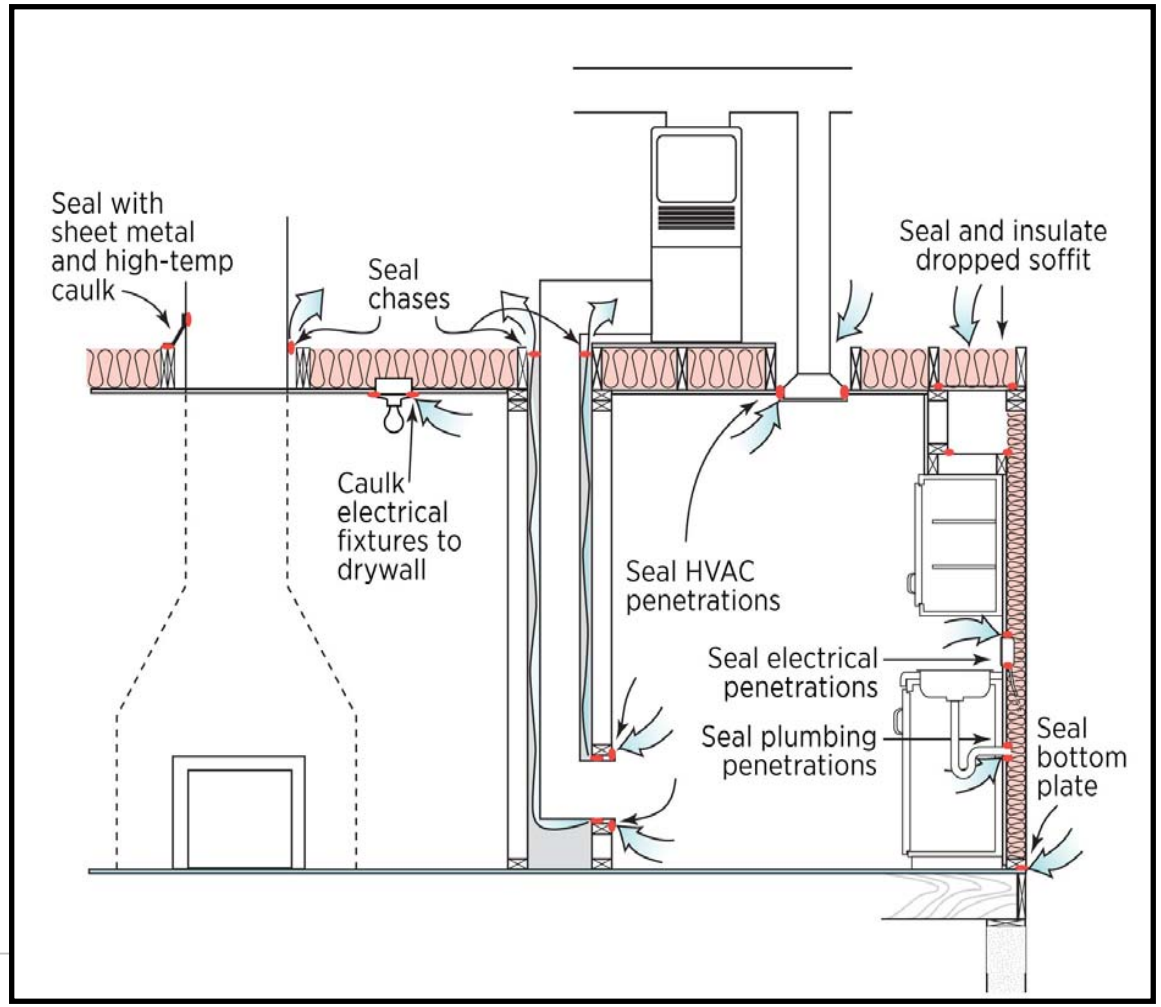
Figure 3.3. Build an airtight, insulated box around any drawers or closets built into attic knee walls that extend into uninsulated attic space. Insulate along air barrier (shown in yellow on drawing) or along roof line with rigid foam (Source: Iowa Energy Center 2008).

Cape Cod Issues

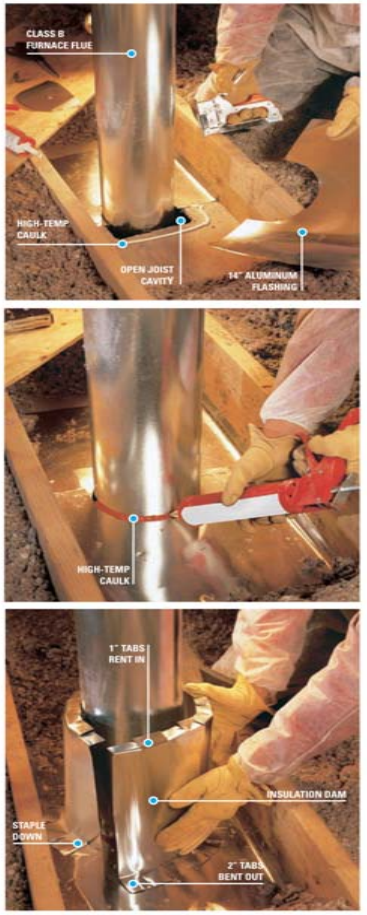
- **Continuous air barriers**
- Insulate and seal knee walls
- Air seal floor joist cavities
- Make drawers/closets airtight

***Air Sealing*, Building America Best Practice Series, PNNL & ORNL, 2010**

Building Better Homes
Controlling Air Infiltration



Chases & vents



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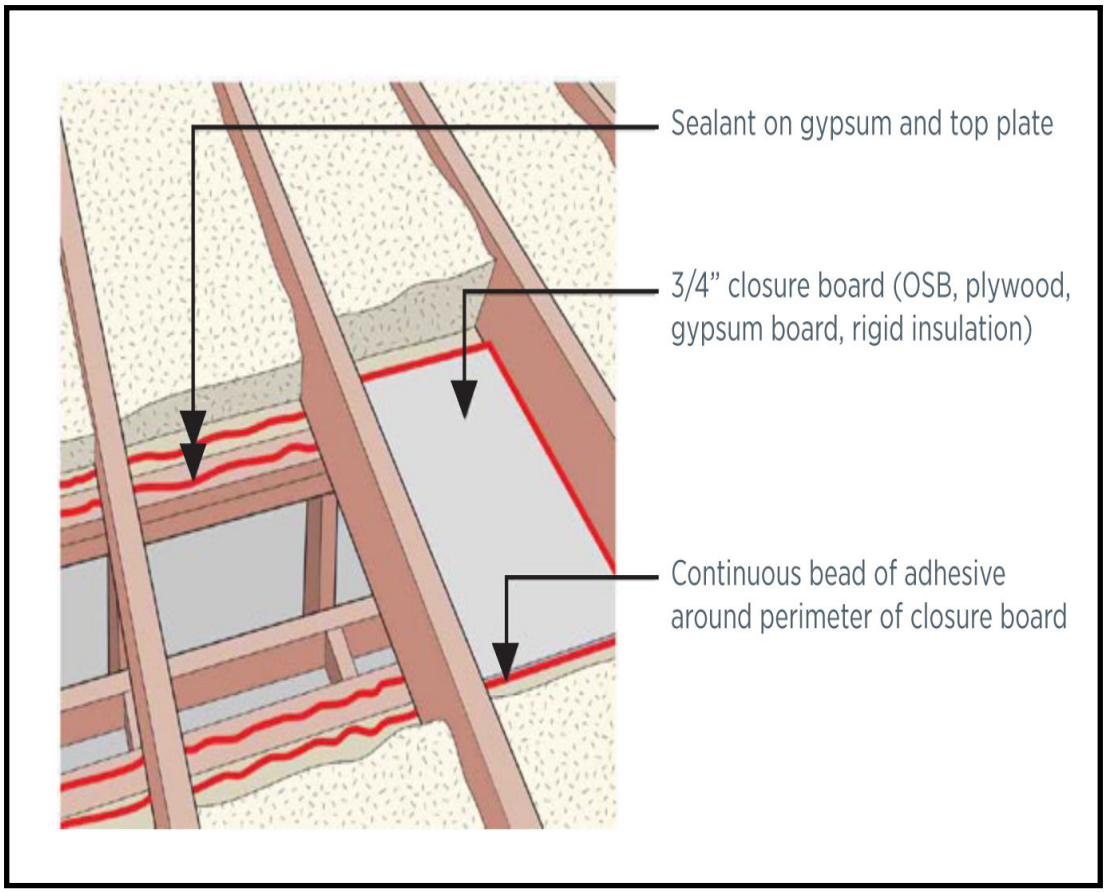
Building Better Homes
Controlling Air Infiltration



Dropped Ceilings

&

Soffits

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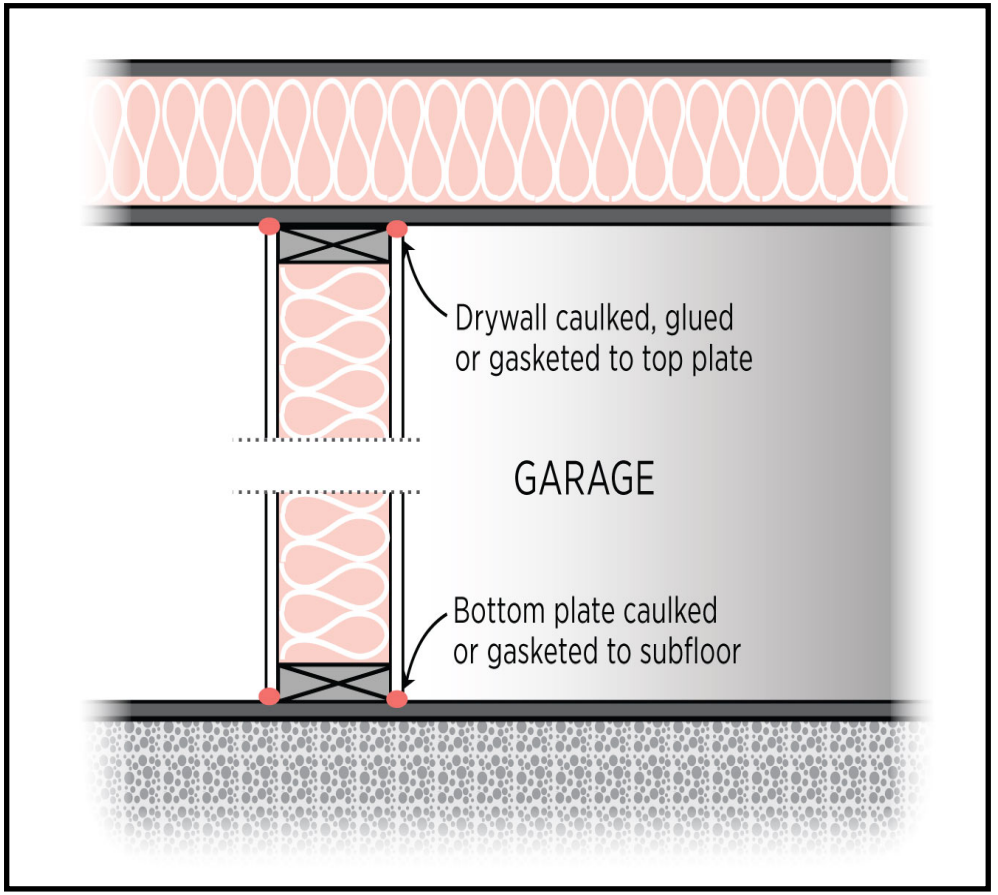
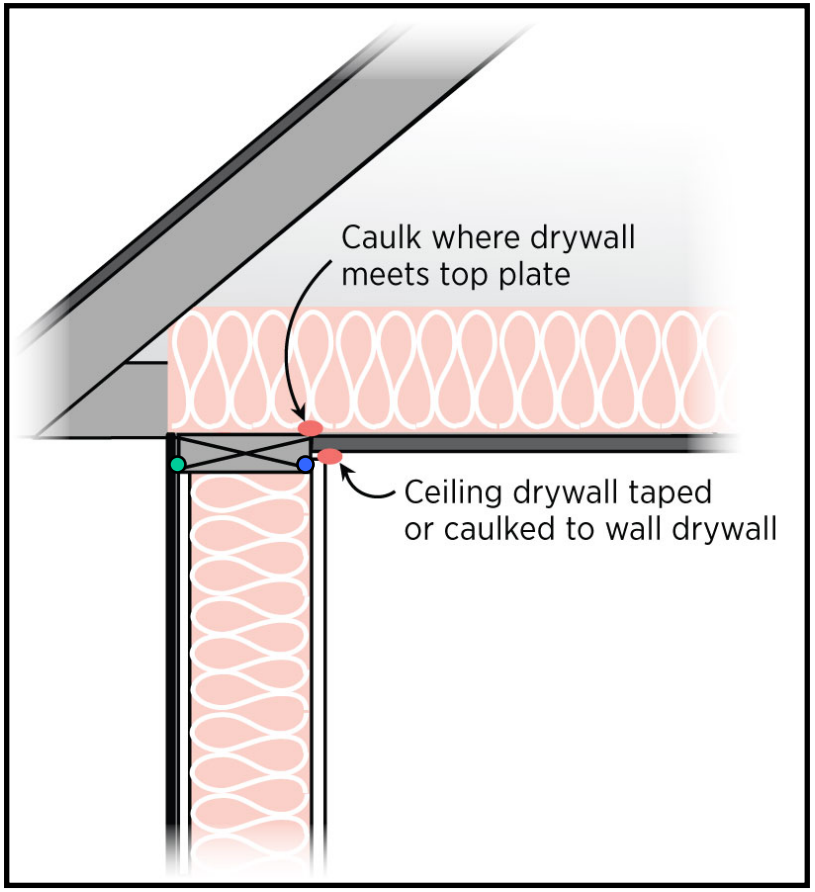
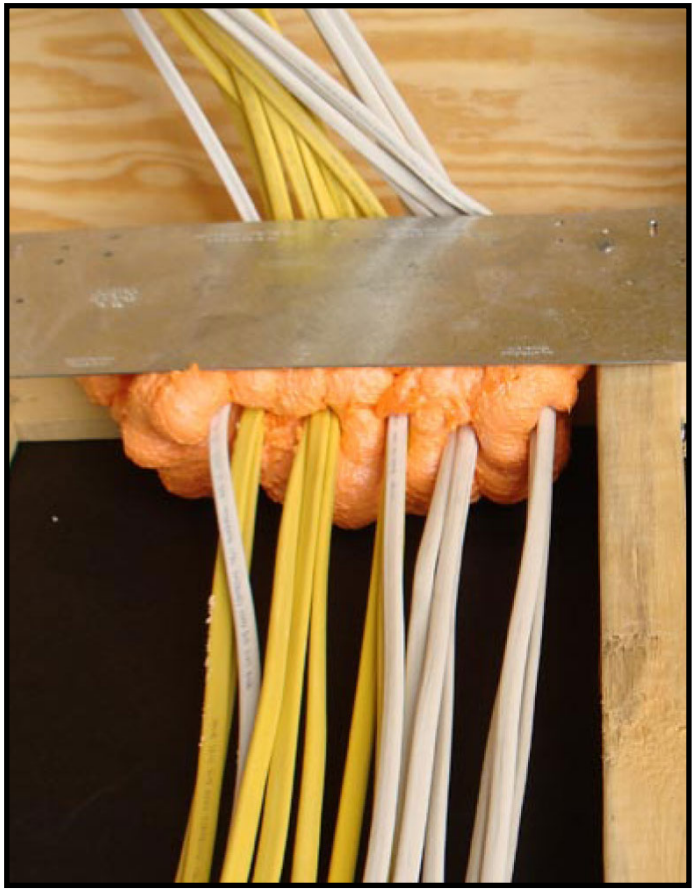
Building Better Homes
Controlling Air Infiltration



Garages

Building Better Homes
Controlling Air Infiltration





Air Sealing, **Building America Best Practice Series, PNNL & ORNL, 2010**

Building Better Homes
Controlling Air Infiltration

- Focus – controlling air flow
  - **Walls**
- Methods – how to do it
  - Interior
  - Exterior

Building Better Homes
Products and Practices-Interior

- AIP – standard practice, not very effective

Building Better Homes
Products and Practices-Interior

- Owens Corning Energy Complete air sealing

Effective but expensive alternative to reduce air infiltration

Building Better Homes
Products and Practices-Interior

- Spray foam insulation and air barrier

Effective but expensive alternative to reduce air infiltration

Building Better Homes
Products and Practices-Interior

- “Dense pack cellulose”

Building Better Homes
Products and Practices-Exterior

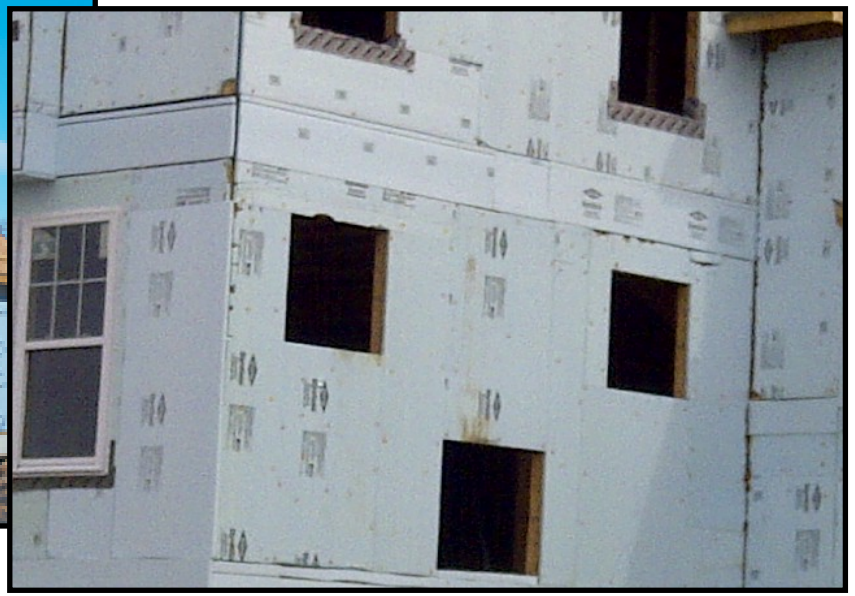
- Housewrap sheet-applied

Controlling Air Infiltration

Exterior Methods

- ***Extruded foam sheathing – less than 1 perm.***

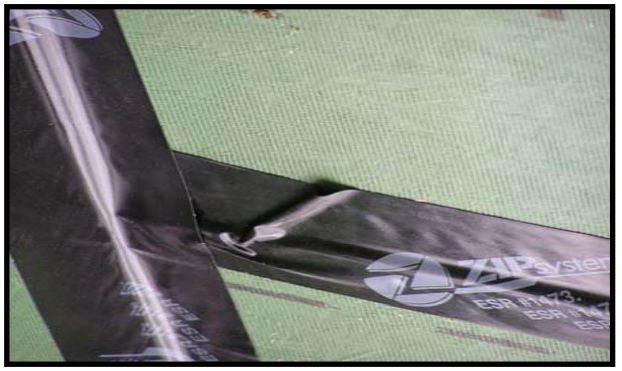
  Sheathing and air barrier when seams are taped.



Controlling Air Infiltration

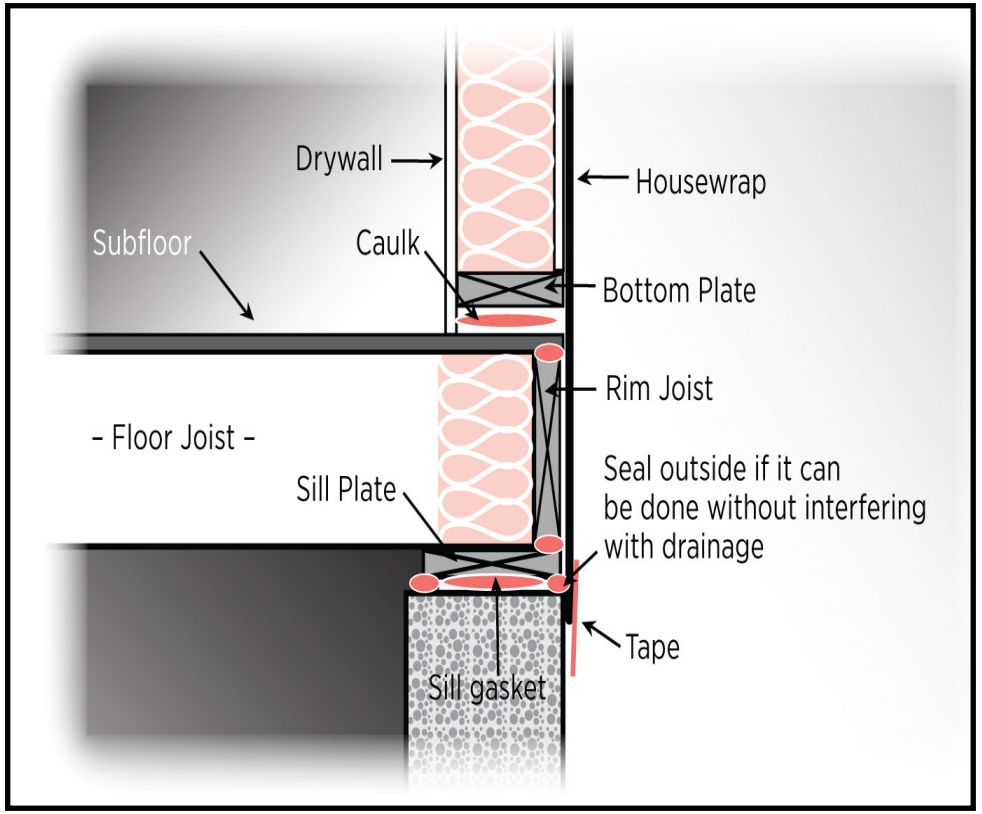
Exterior Methods

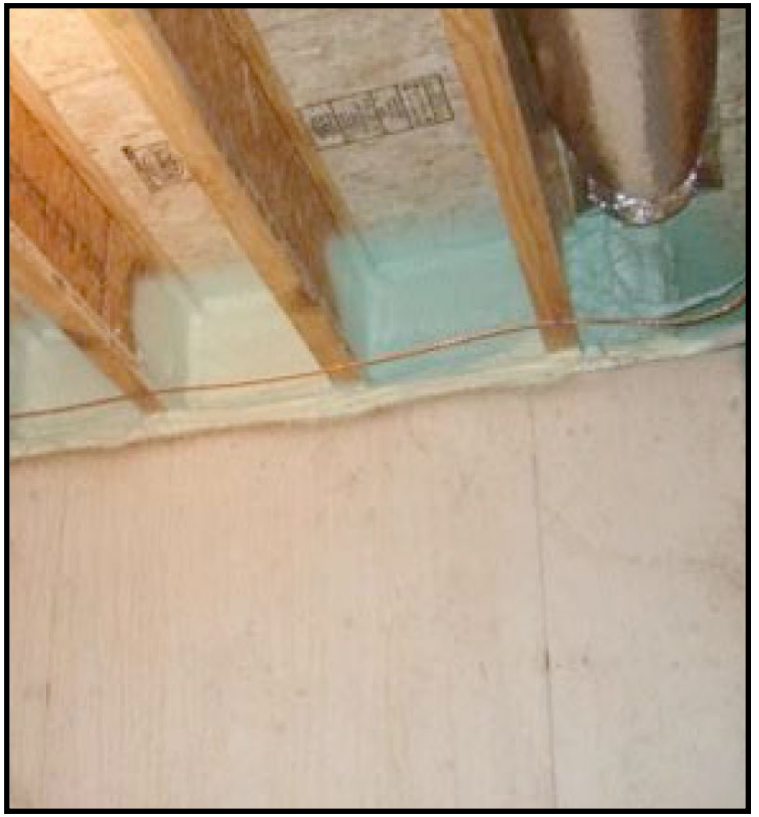
- ***Factory applied surface and tape.***



Tape edges – like flashing without counter-flashing

Building Better Homes
Controlling Air Infiltration





Interior Sealing: Rim & Band Joists

Air Sealing, **Building America Best Practice Series, PNNL & ORNL, 2010**

Liquid-applied WRB Performance

- Liquid-applied - moisture and air control (DuPont) the next generation in wall moisture and air control

Liquid-applied WRB Performance and Issues

- Liquid-applied - moisture and air control (Sto)

(Enviro-Dri)

Building Better Homes
Products and Practices-Exterior

- TBS fluid applied - Moisture and air control

- a liquid-applied air/water barrier is your friend

Sheet-applied WRB Performance Issues / Application

- **Common issues**
  - Water can flow between system and sheathing & then into wall
  - Hundreds / thousands of nails penetrate system
  - Significant water and air leakage

Sheet-applied WRB Performance Issues / Application

- **Pennsylvania (PA) State Study Motivation**
  - There was/is little technical information as to the merits of using housewraps
  - The objective was to investigate the in-service performance of housewraps.
- **PA house wrap use survey detail**
  - 93 percent did not tape or otherwise seal joint locations
  - 73 percent did not tape or render the window/housewrap joint air or water tight
  - 70 percent used staples; many installations using staples had tears or holes
- **Conclusions**
  - Few installers seem to follow manufacturer's installation instructions
  - Using staples can lead to tearing and stretching of the housewrap
  - Each of the proprietary housewraps has very different in-place performance
- **Common problems, but fixable with diligence**

Sheet-applied WRB Performance Issues / Durability

Sheet-applied protection under normal/severe conditions

Sheet-applied WRB Performance and Issues

Sheet-applied WRB Performance Issues / Inherent

- **Even without installation issues, felt and wraps leak water**
- **Surfactants make wraps leak, that don't leak pure water**
  - Lowers the surface tension of water, flows through smaller spaces; an example is clean water vs. soapy water on car wax
  - Many sources: soluble resins from cedar, siding, paints, **stucco & mortar additives**, and power-washing
- **All wraps leaked through the sheet w/ "real-world" wetting**
  - **Wraps tested with 3.5" water solution for 2 hours (70 mph wind)**
  - Some wraps lost 10%, some 80% in 15 minutes, some 100% in 2 hrs (0 mph wind)
  - 15-pound felt lost 30%
  - Liquid-applied WRBs must pass 22" water column for 5 hours (NO Leaks)
- **Wraps also have water-condensing issue**
  - Hot sun drives water vapor through high-perm wrap,
  - Vapor trapped between wrap and lower perm sheathing condenses
  - Condensed water wets the sheathing but can't exit through wrap
- **http://bct.nrc.umass.edu/index.php/publications/by-title/housewraps-felt-paper-and-weather-penetration-barriers**

Building Better Homes
Products and Practices-Exterior

- TBS fluid applied - Moisture and air control

- a liquid-applied air/water barrier is your friend

Building the Right Tightness
Robust (Forgiving) Walls

- **Stop Liquid Water Leaks**
  - Liquid-applied WRB systems perform significantly better than wraps
- **Reduce Wetting Potential –via uncontrolled air flow**
  - Liquid-applied WRBs significantly reduce uncontrolled air flow
  - Can replace other AIP wall elements
  - Enviro-Dri 8’ x 8’ wall section tests indicate 90% reduction potential
- **Maintain Good Drying Potential – via vapor diffusion**
  - Interior/Exterior vapor pressure difference & system perms
  - Enviro-Dri/OSB has a similar diffusion rate as wrap & OSB combination
- **Liquid-applied WRBs and wood framing form a robust system**
  - Can buffer significantly more water than system allows to enter
  - Can use economical fiberglass insulation

Liquid-Applied WRB Systems

Wrap-up

- **Quiz: To meet Energy Codes and get the most value for your construction $, what are your three friends?**

Liquid-Applied WRB Systems

Wrap-up

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Liquid-Applied WRB Systems

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Liquid-Applied WRB Systems

Wrap-up

- **Quiz: To meet Energy Codes and get the most value for your construction $, what are your three friends?**

  - the Performance Path is your friend

  - tight, permeable construction is your friend

  - a liquid-applied air/water barrier is your friend

AIA Course Detail
Conclusions/Questions

- ***Questions and Comments ?***

End of AIA Course Content

Building Better Homes

Envelope Moisture and Air Control

Enviro-Dri®

Weather-Resistant Barrier Systems

- Extends protection from sill to roof line
- Code-approved water-resistive barrier
- Superior alternative to house wraps and taped systems
- Single system provides moisture and air control
- Helps maximize value of your construction dollars in meeting code, or qualifying for above-code rebates and incentives

Build a Better House at Lower Cost by Controlling Air Infiltration

Makers of Enviro-Dri® Weather-Resistant Barrier

TREMCO Barrier Solutions