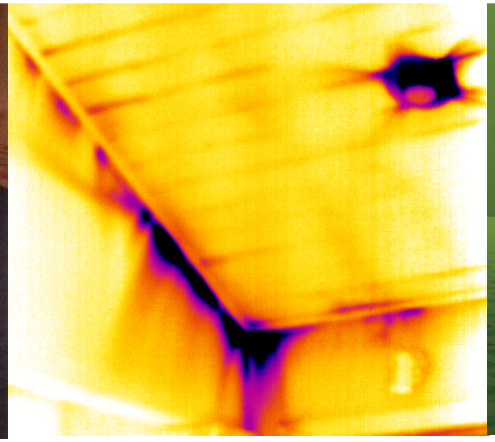
Montana Residential Energy Code Update - 2014

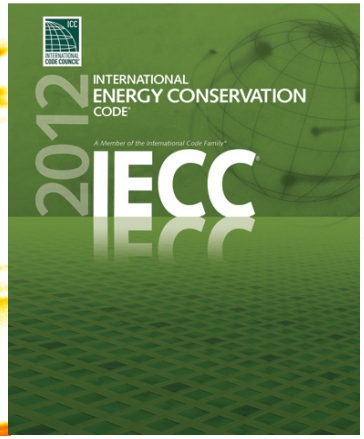
Montana Department of Environmental Quality

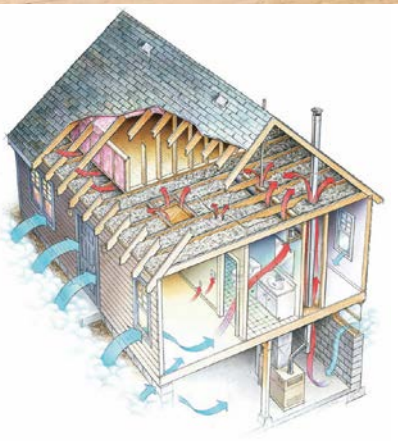
Funded by Montana Department of Environment Quality

NCAT NATIONAL CENTER FOR APPROPRIATE TECHNOLOGY

Presented by Dale Horton Architect







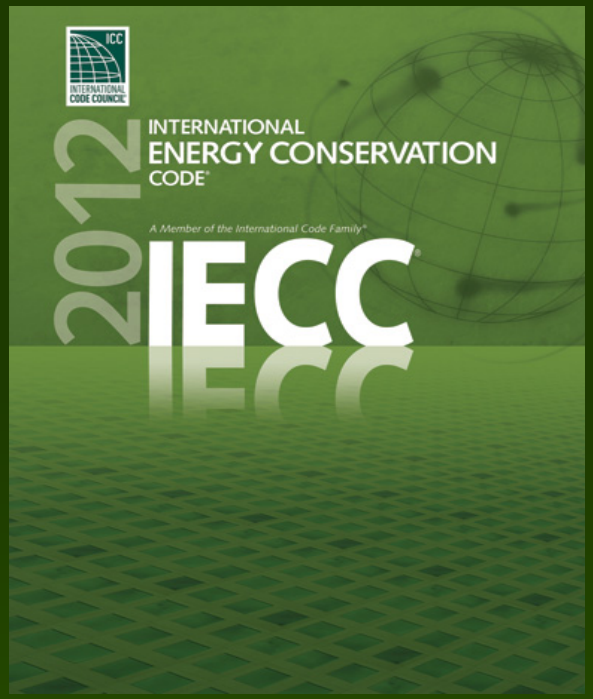
Air, heat, and water vapor moved easily through the building envelopes of early structures.

During the 1940's and 1950's insulation was introduced, primarily for comfort.

During the 1980’s and 1990’s more insulation was added and homes were built tighter.

- ✓ International Building Code
- ✓ International Mechanical Code
- ✓ International Fuel Gas Code
- ✓ International Property Maintenance Code
- ✓ International Fire Code
- ✓ International Zoning Code
- ✓ International Plumbing Code
- ✓ International Existing Building Code
- ✓ International Private Sewage Disposal Code
- ✓ International Performance Code
- ✓ International Residential Code
- ✓ **International Energy Conservation Code**
- ✓ International Wildlife-Urban Interface Code

ICC Code Development Process



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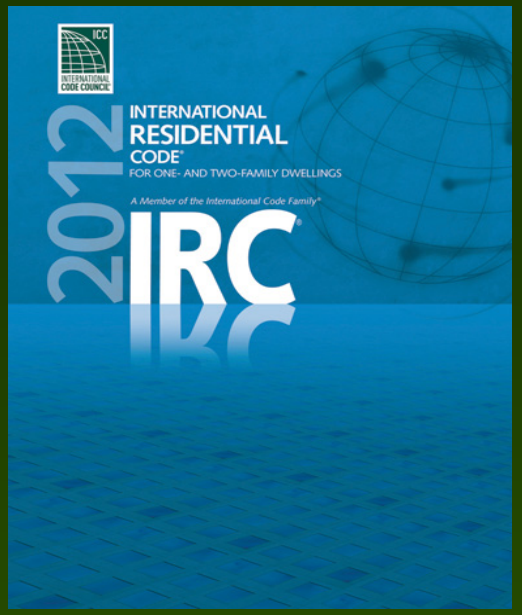
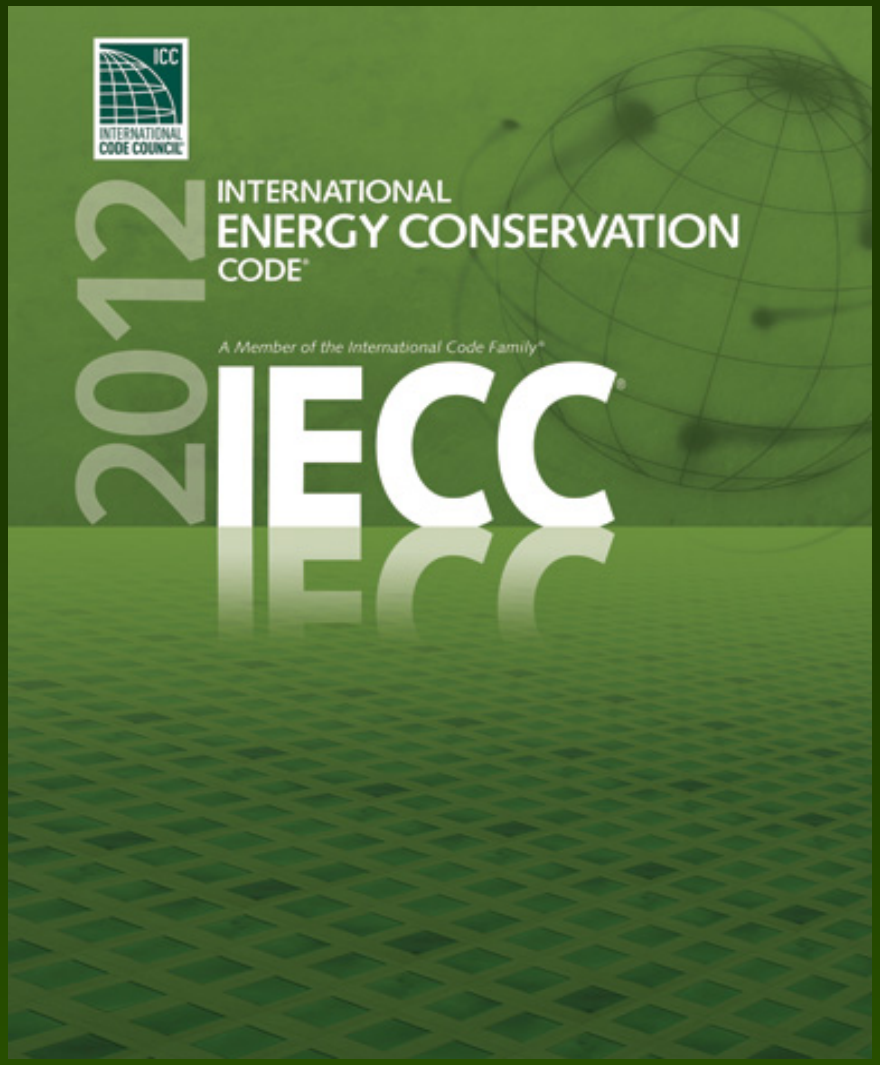
Source: Yellowstone NP Photo Archives

A Statewide Energy Code



Not Statewide



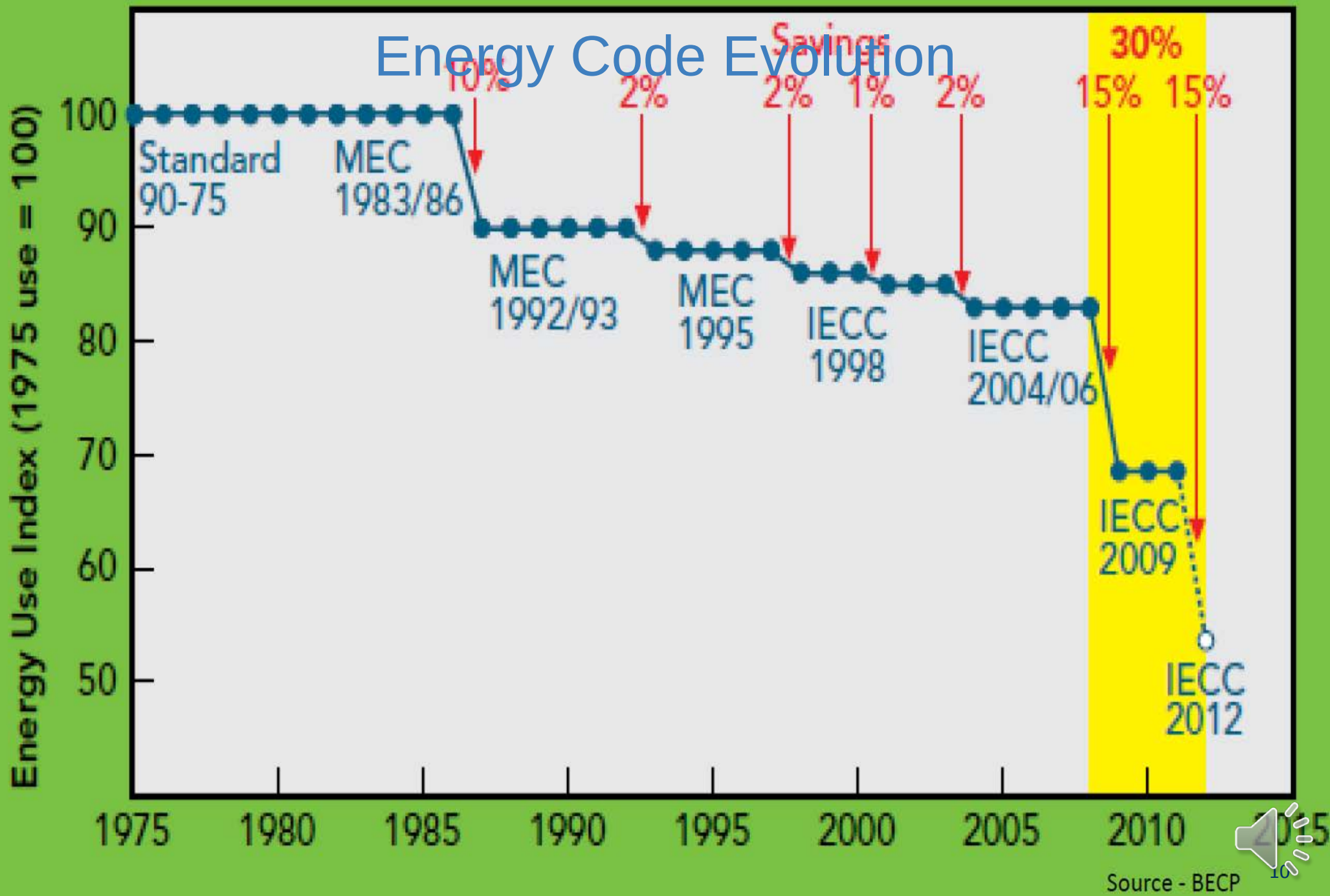
2012 IECC Economics

MTDEQ and USDOE 2012 IECC Economics

Savings and cost of implementing the 2012 IECC vs the exising Montana State Energy Code

	USDOE	MT DEQ
Floor Area (SF)	**2400**	**Weighted**
Weighted Annual Savings	**$310**	**$233**
Life Cycle Cost Savings	**$4,105**	**$4,043**
Implementation Cost Estimate	**$2,558**	**$3,175**
Simple Payback	**7.3**	**12.8**
Annual Mortgage Increase	**$130**	
Net Annual Cash Flow Savings	**$180**	

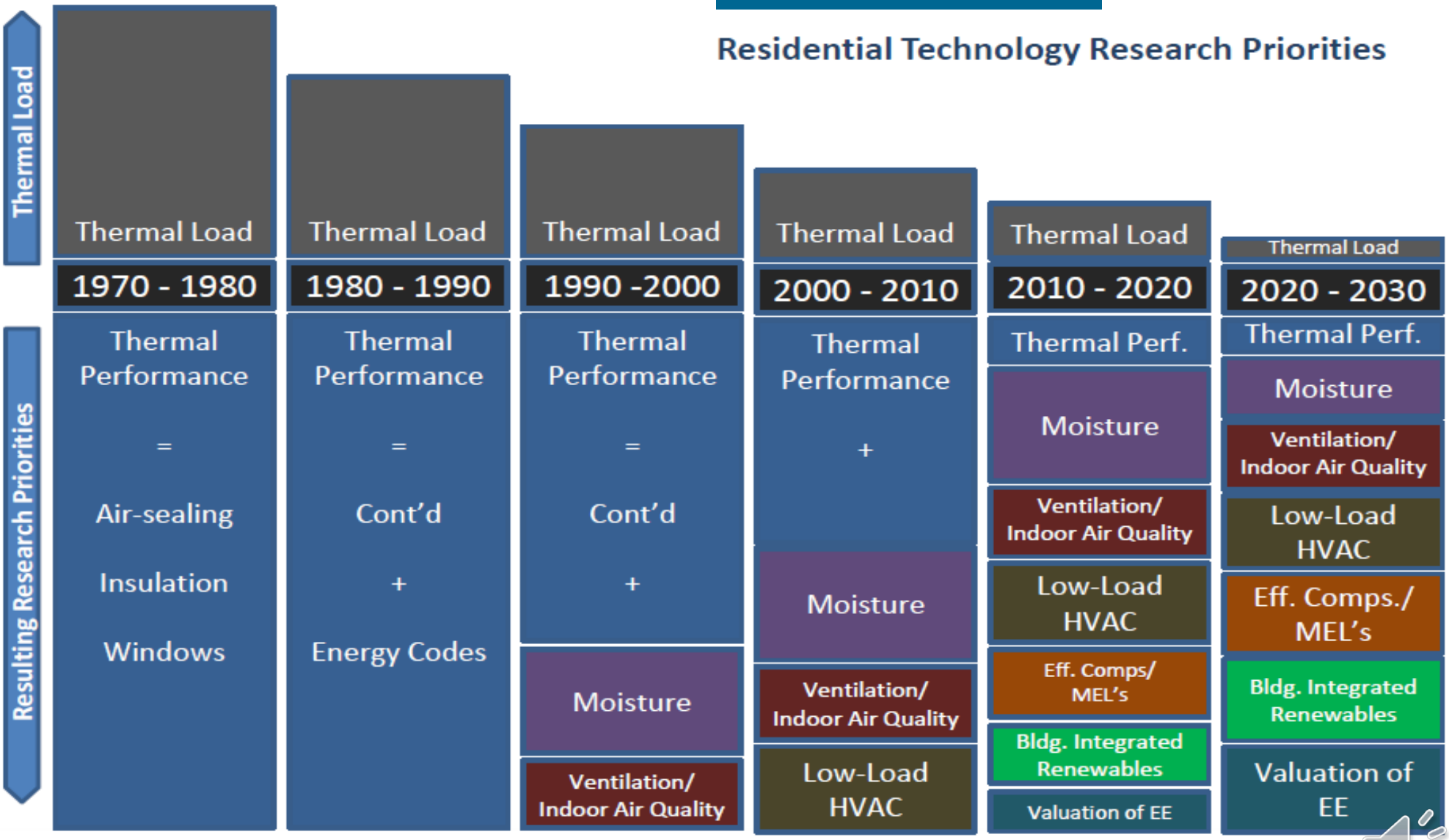
Energy Code Evolution



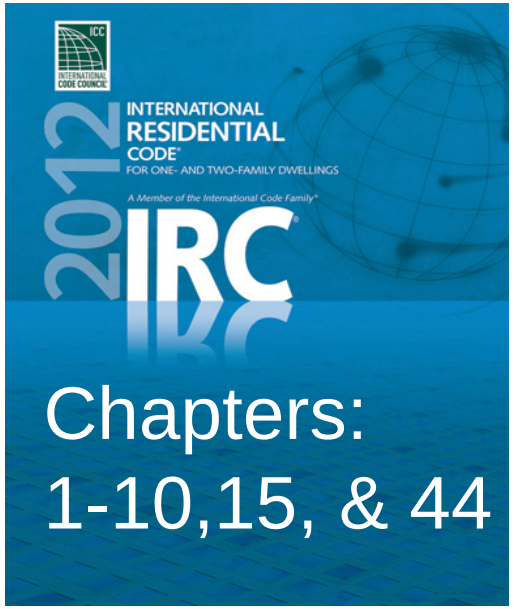
Source - BECP

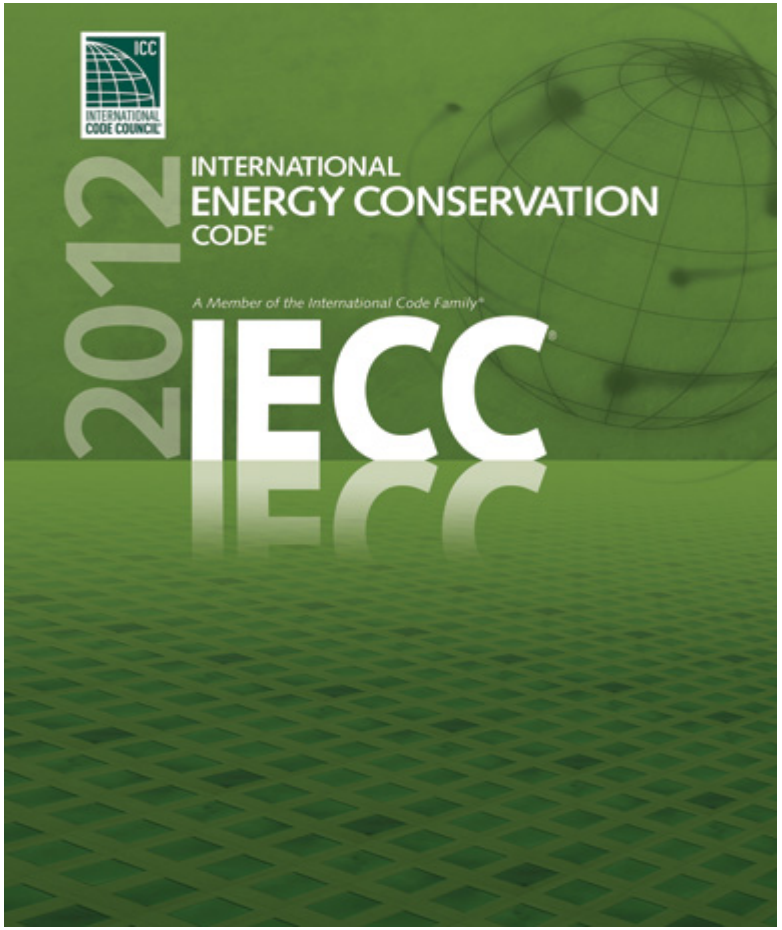
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Residential Technology Research Priorities

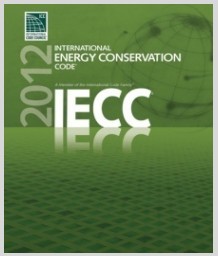
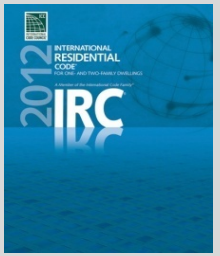


The Montana State Codes as Amended

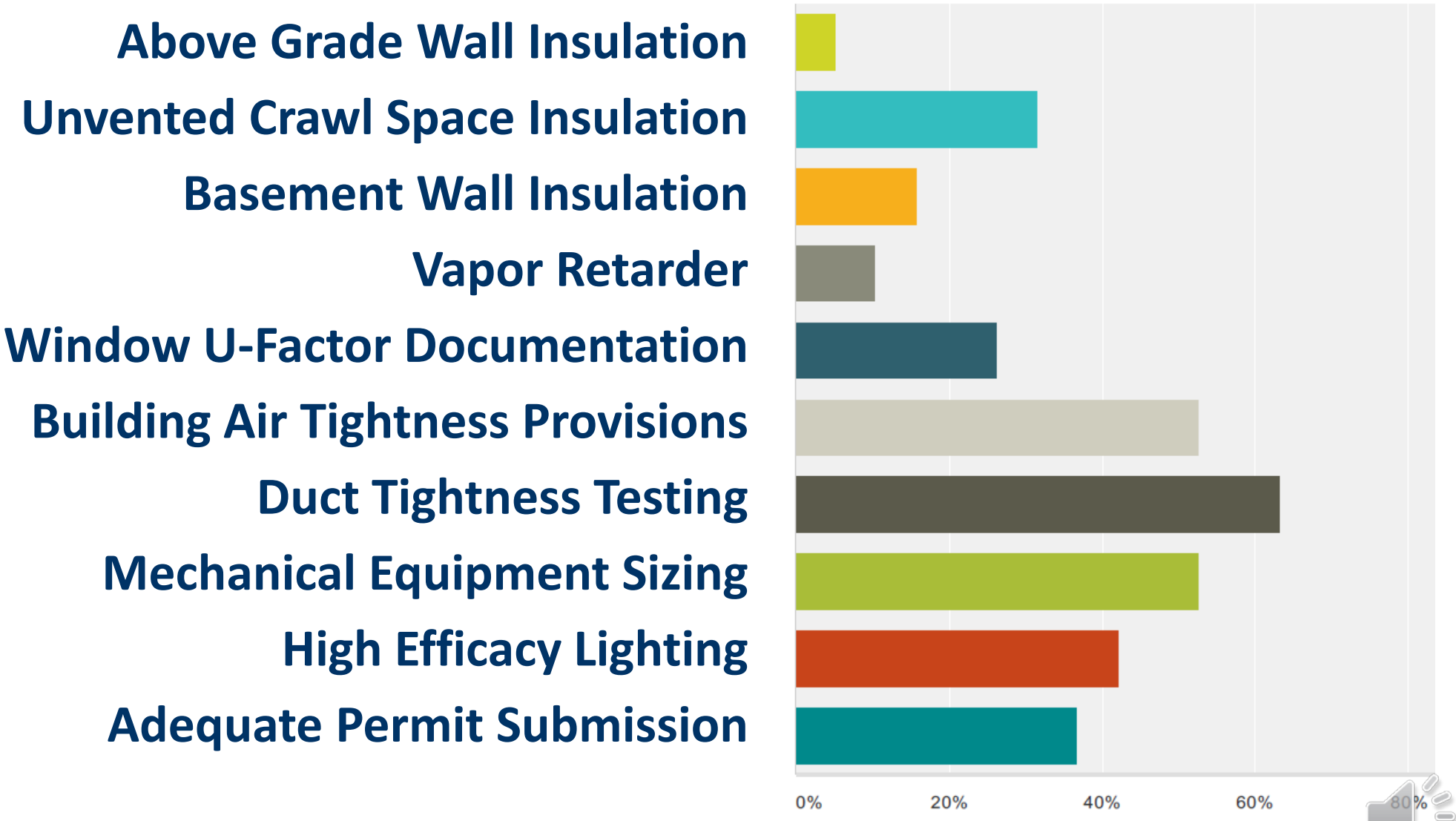




I-Codes Overlap and Interact

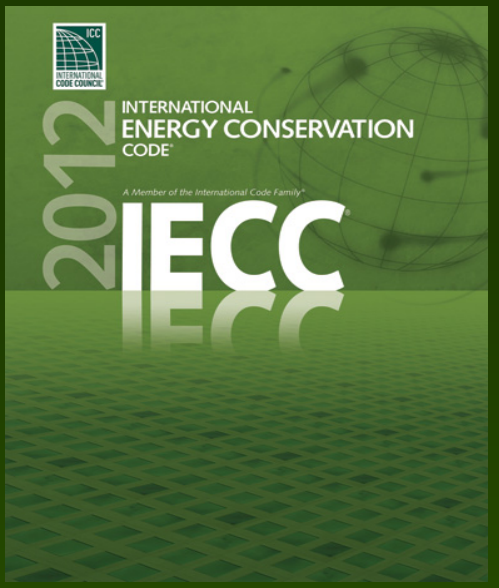
Topic	 IECC	 IRC	IMC
HVAC Sizing	■		
Insulation Values	■		
Window/Skylight U-Factors	■		
House Tightening	■		
Duct Sealing and Tightening	■		■
Lighting Efficiency	■		
Foam Thermal Properties		■	
Vapor Retarders		■	
Crawlspace Ventilation		■	
Mechanical Ventilation		■	■

Montana Code Official Survey



R101.3

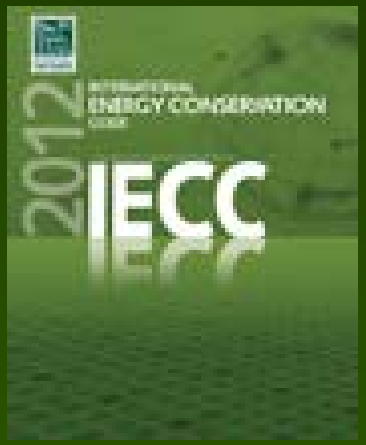
"…shall regulate the design and construction of buildings for the effective use and conservation of energy over the life of each building."



Organization of 2012 IECC

Chapter	Commerical Section
1	Scope and Administration
2	Definitions
3	General Requirements
4	**Commercial Energy Efficiency**
5	Referenced Standards

Chapter	Residential Section
1	Scope and Administration
2	Definitions
3	General Requirements
4	**Residential Energy Efficiency**
5	Referenced Standards



Residential Building Definition

- Detached one and two family dwellings
- Multiple single family dwellings and townhouses
- Group R-2, R-3, R-4 <= 3 stories in height

Additions, Alterations, Renovations, and Repairs

R101.4.3

Additions - Treat as a stand-alone building or with whole building.

Alterations, Renovations, & Repairs where permit is required. Note the exceptions!

Construction Document Requirements

R103.1

…sufficient clarity to indicate the location, nature and extent of work proposed,…

- Insulation materials and R-value
- Fenestration U-factors and SHGCs
- Mechanical system design criteria
- Mechanical and service water heating system and equipment types, sizes and efficiencies
- Equipment and system controls
- Fan motor HP and controls
- Duct sealing, duct and pipe insulation
- Lighting fixture schedule; wattage and control narrative
- Air sealing details

Current Code vs. 2012 IECC as amended

Cut to the Chase **- Major Changes**

- **More efficient windows (U-0.33 to U-0.32)**
- **More efficient skylights (U-0.60 to U-0.55)**
- **More efficient crawlspace walls (R-10/19 to R-15/19)**
- **Mandatory whole-house pressure test (1 yr transition)**
- **Mandatory thermal envelope tightness checklist**
- **More stringent duct leakage test**
- **Mandatory mechanical ventilation**
- **Mandatory 75% high efficacy lamps**
- **RESCheck will now be ”better than code” (it had been “easier than code”)**

Current Code vs. 2012 IECC as Amended

Cut to the Chase – Major Non-changes

- **Wall insulation requirement is unchanged (IECC requires added R5 insulation sheathing)***
- **Maximum House Air Tightness is unchanged (4 ACH50)***
- **Retains prohibition on envelope-equipment trade-offs**
- **May use building cavities as return ducts***
- **DHW distribution pipe requirements – minimal changes***

*** - Montana Amendments**

R401.2

Compliance

Envelope Compliance

+

Mandatory Provisions

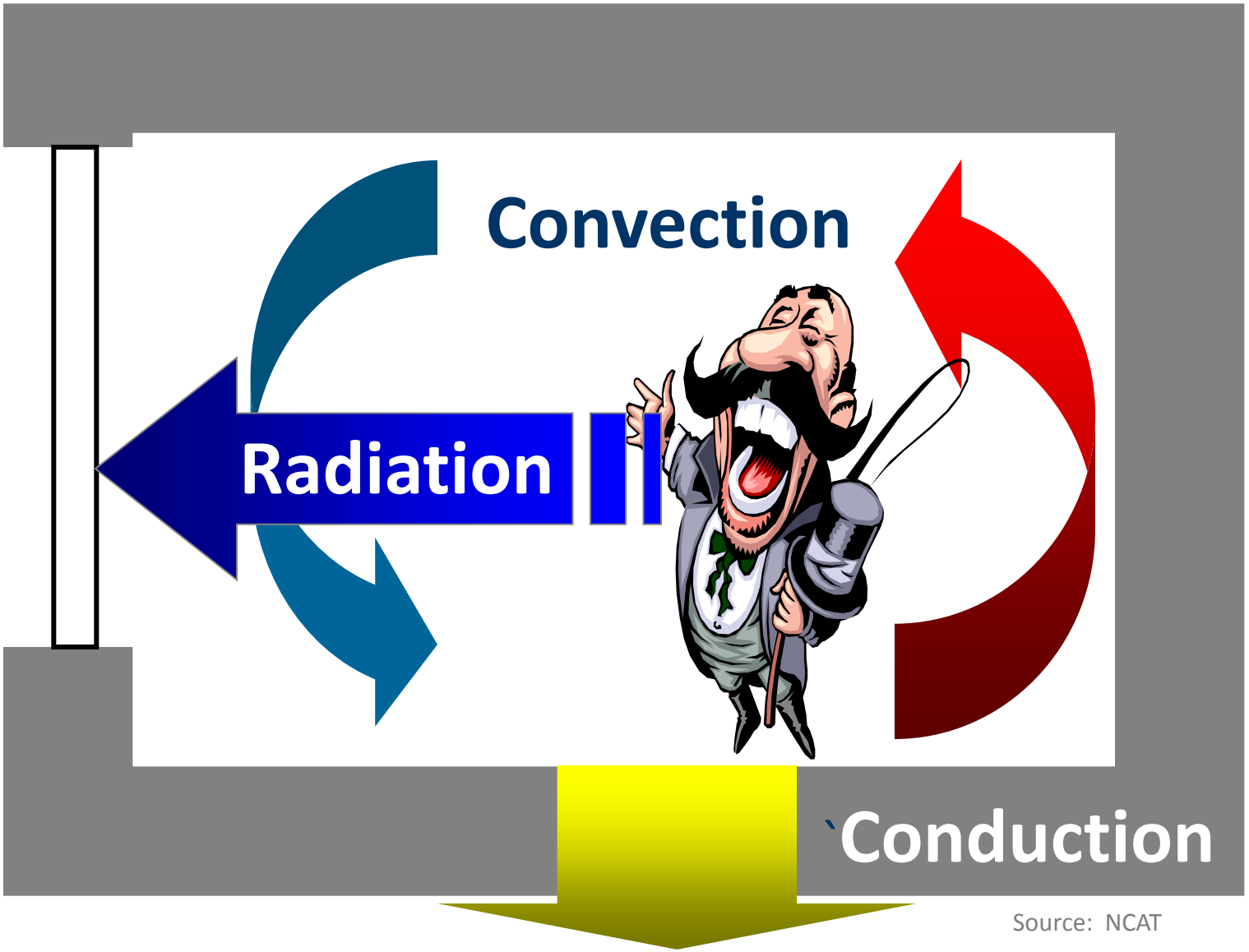
Prescriptive Path

- R-Value Computation
- U-Factor Alternative
- Total UA Alternative

OR

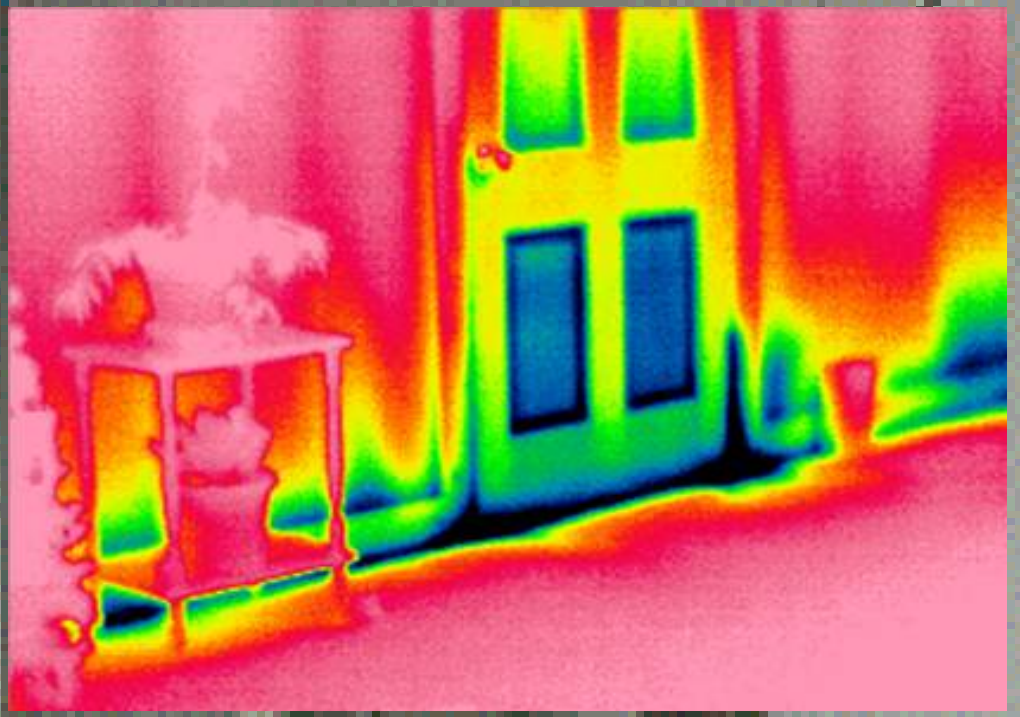
Performance Path

The 3 Heat Transfer Mechanisms



Source: NCAT

Conduction

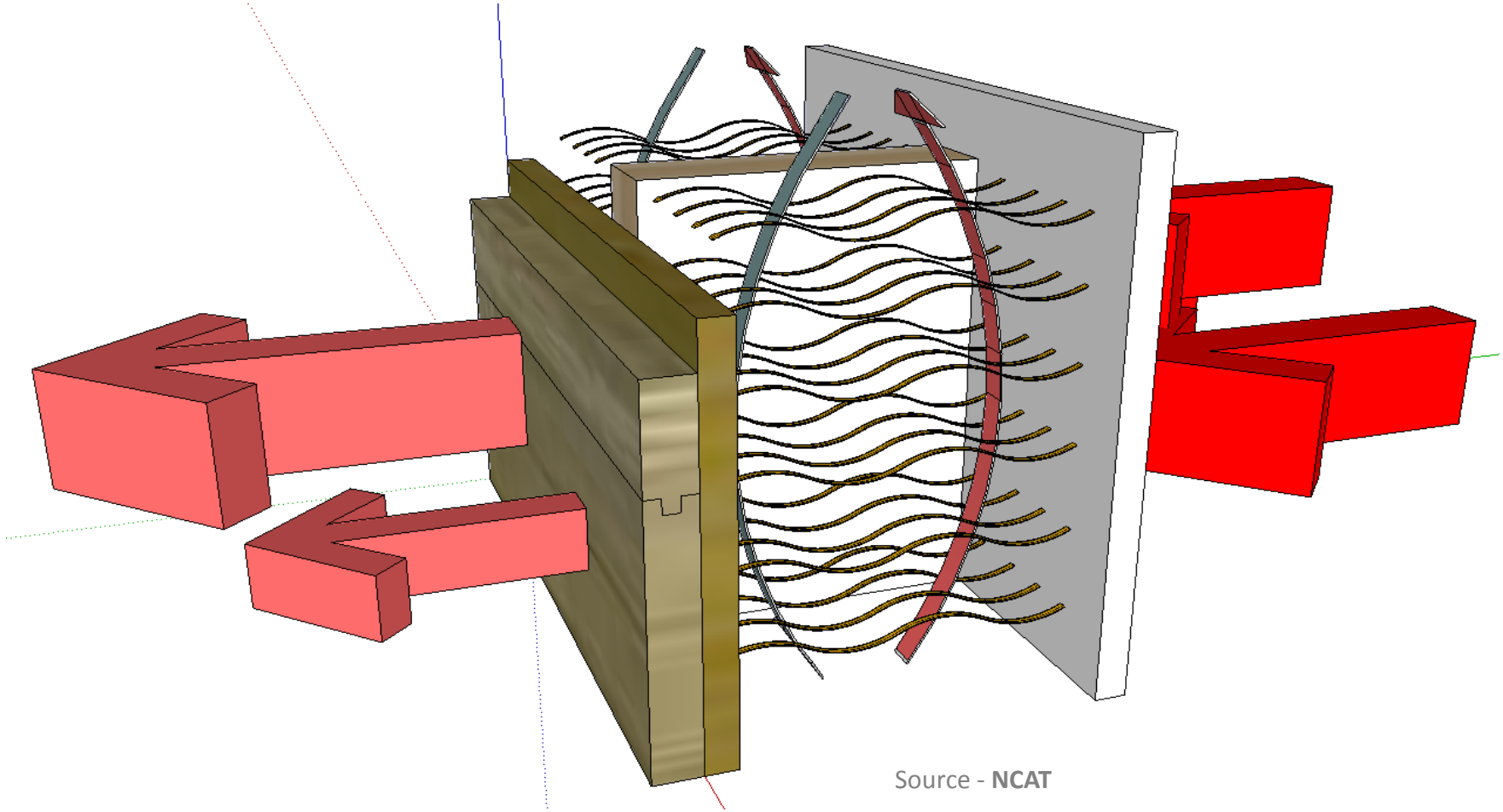


Convection

Radiation

Heat Transfer Through Walls

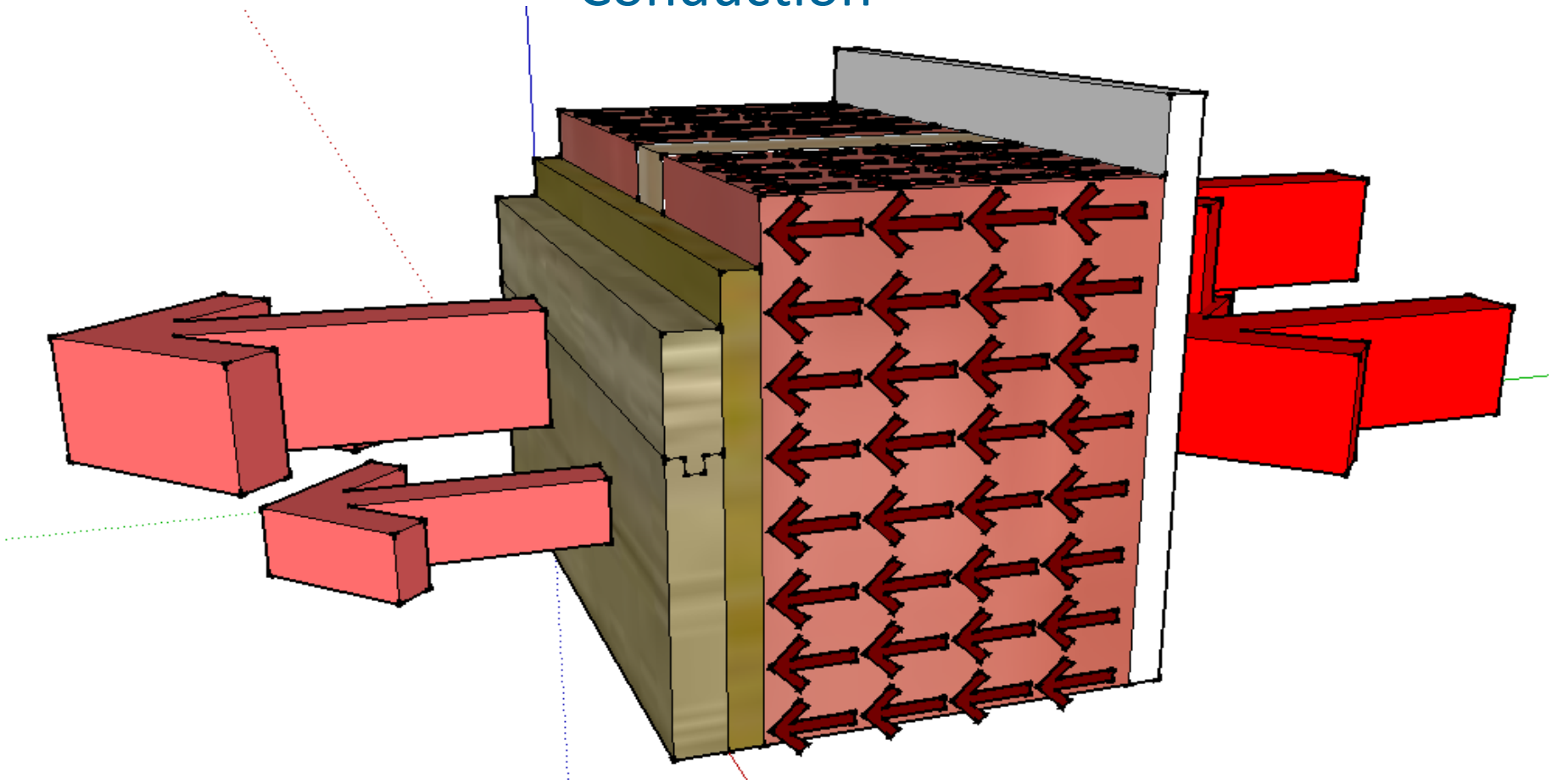
Convection & Radiation



Source - **NCAT**

Heat Transfer Through Walls

Conduction



Source - **NCAT**

R-Values and U-Values

R-Values Measure Thermal Resistance

R-Values are additive (R-1 + R-1 = R-2)

R-Value is the inverse of U-value

R=1/U and U=1/R

British Thermal Unit (Btu) = Amount of heat required to raise one pound of water 1^{o} F.

R-Values and Diminshing Returns

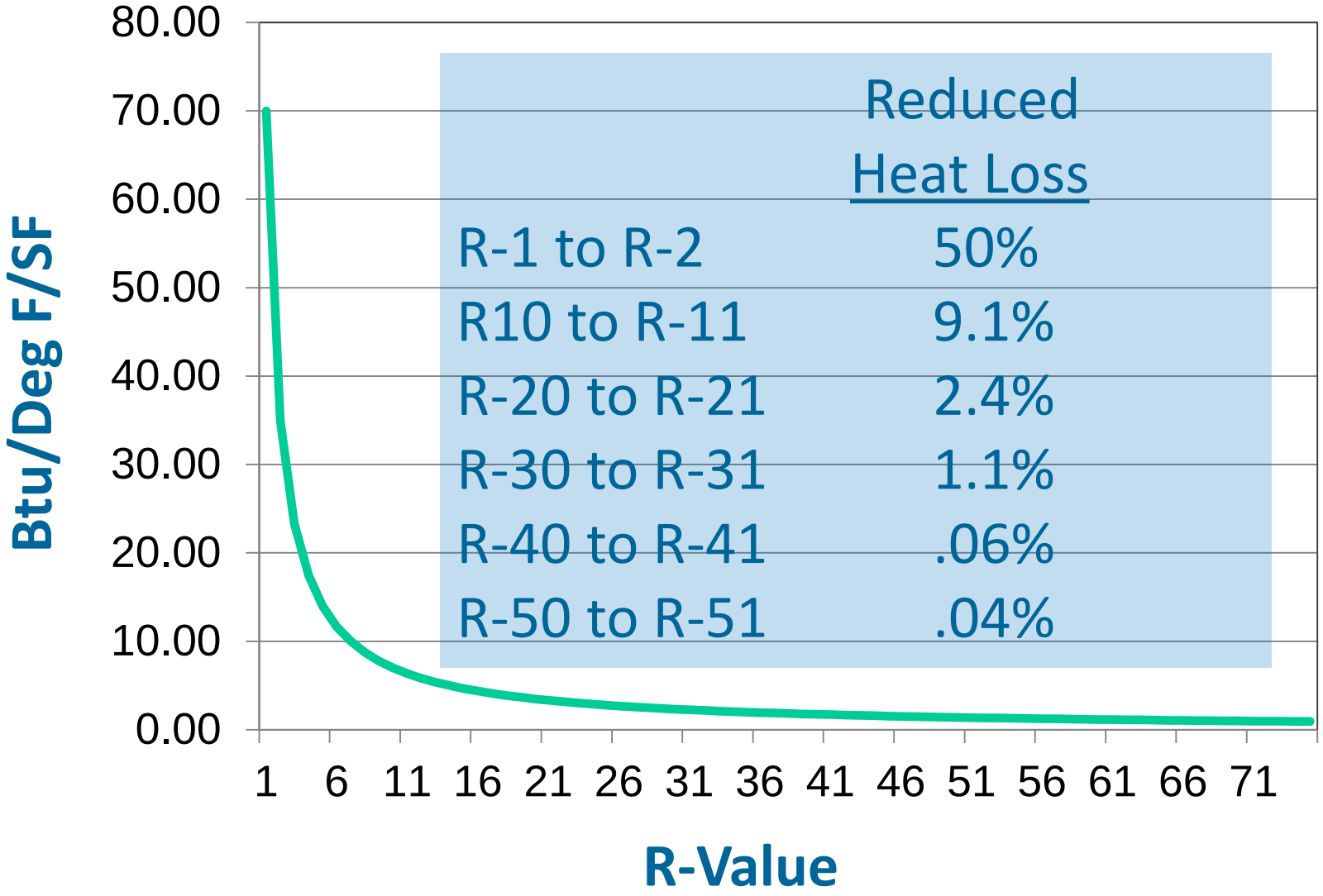


TABLE R402.1.1 (Amended)										
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT										
CLIMATE ZONE	FENESTRATION *U*-FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c] WALL R-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.4	0.65	0.25	38	13	4/6	13	0	0	0
3	0.35	0.55	0.25	38	13	8/13	19	5/13[f]	0	5/13
4 except Marine	0.35	0.55	0.4	49	20 or 13+5[h]	8/13	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.32	0.55	NR	49	20 or 13+5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.32	0.55	NR	49	21 or 13+5[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.32	0.55	NR	49	20+5 or 13+10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

R402.1.1
Table of R-Values and U-Factors

Table R402.1.3								
EQUIVALENT U-FACTORS								
CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	FRAME WALL U-FACTOR	MASS WALL U-FACTOR	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR	CRAWL SPACE WALL U-FACTOR
1	0.50	0.75	0.035	0.082	0.197	0.064	0.360	0.477
2	0.40	0.65	0.030	0.082	0.165	0.064	0.360	0.477
3	0.35	0.55	0.030	0.057	0.098	0.047	0.091	0.136
4 except Marine	0.35	0.55	0.026	0.057	0.098	0.047	0.059	0.065
5 & Marine 4	0.32	0.55	0.026	0.057	0.082	0.033	0.050	0.055
6	0.32	0.55	0.026	~~0.048~~ **0.054**	0.060	0.033	0.050	0.055
7 and 8	0.32	0.55	0.026	0.048	0.057	0.028	0.050	0.055

R402.1.3
Table of U-Factors

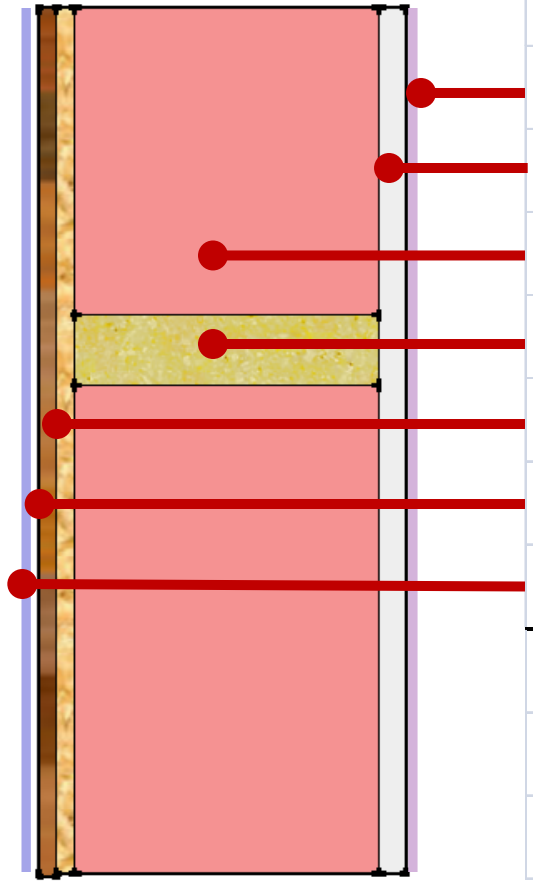
Table R402.1.3

EQUIVALENT U-FACTORS

CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	FRAME WALL U-FACTOR	MASS WALL U-FACTOR	FLOOR U-FACTOR	BASEMENTWALL U-FACTOR	CRAWL SPACE WALL U-FACTOR
1	0.50	0.75	0.035	0.082	0.197	0.064	0.360	0.477
2	0.40	0.65	0.030	0.082	0.165	0.064	0.360	0.477
3	0.35	0.55	0.030	0.057	0.098	0.047	0.091	0.136
4 except Marine	0.35	0.55	0.026	0.057	0.098	0.047	0.059	0.065
5 & Marine 4	0.32	0.55	0.026	0.057	0.082	0.033	0.050	0.055
6	0.32	0.55	0.026	~~0.048~~ **0.054**	0.060	0.033	0.050	0.055
7 and 8	0.32	0.55	0.026	0.048	0.057	0.028	0.050	0.055

Designer is allowed to use the R-Value table for some components and U-Value table for others.

Calculating Assembly U-Factors



	R-Value Cavity		R-Value Framing
Inside air film	0.68		0.68
Gypsum board	0.45		0.45
Cavity insulation	21.00		-------
5.5” Stud	-------		6.80
Exterior sheathing	0.50		0.50
Exterior siding	1.00		1.00
Outside Air Film	0.17		0.17
Total R-value	23.80		9.60
U-Value	0.042		0.104
Area Fraction	0.80		0.20

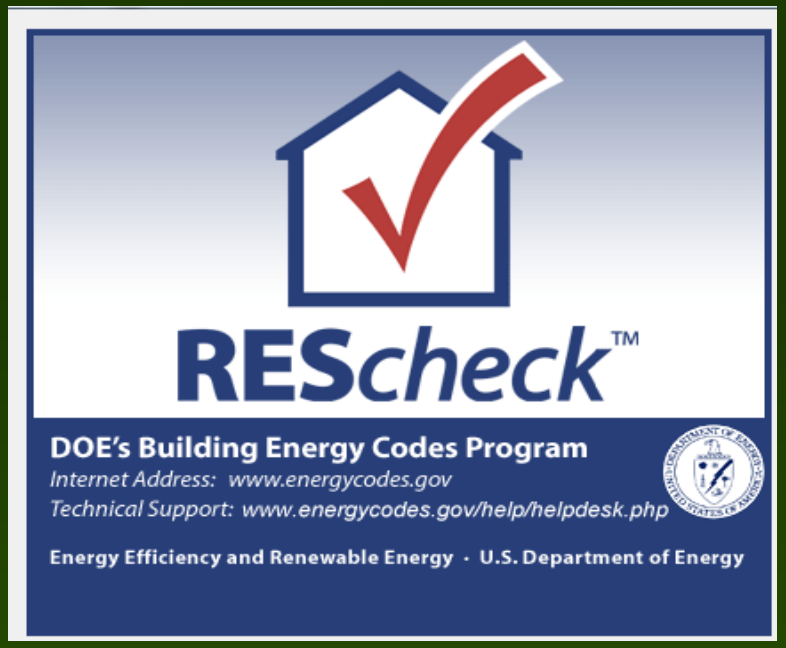
Area Weighted U-Factor = $(Area1_{Frac} \times U1) + (Area2_{Frac} + Area2)$

Area Weighted U-Factor = (0.8 x 0.042) + (0.2 x 0.104) = 0.054

Area Weighted R-Value = (1/.054) = 18.38

Total UA Alternative

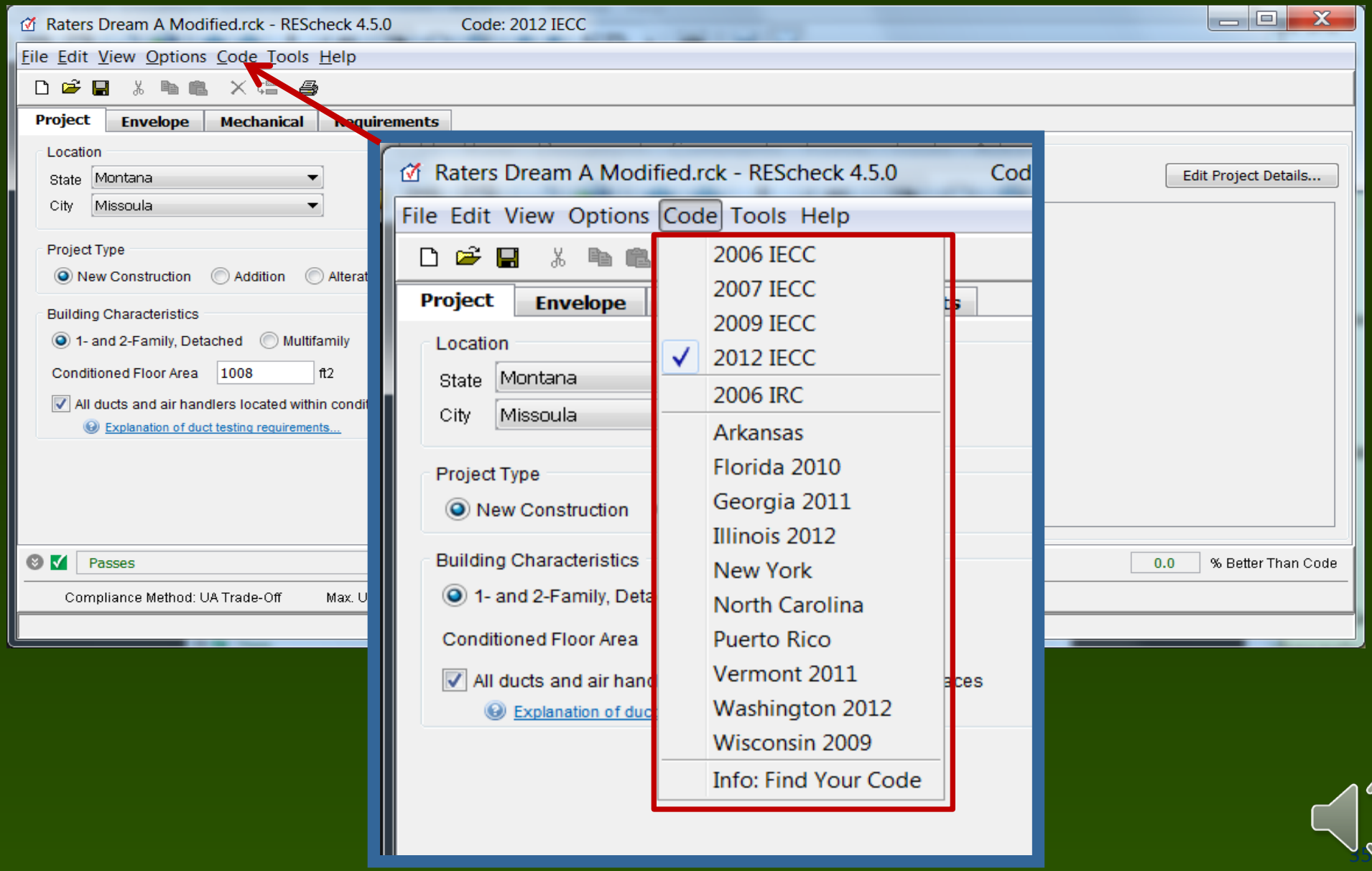
$$UATotal = (A \times U_1) + (A \times U_2) + \ldots$$



UA < UA
Proposed Standard

www.energycodes.gov/rescheck

Select the Appropriate Code Edition



log-wall-test.v1.rck - REScheck 3.7 Release 1b Code: 2003 IECC

File Edit View Options Code Tools Help

Project Envel

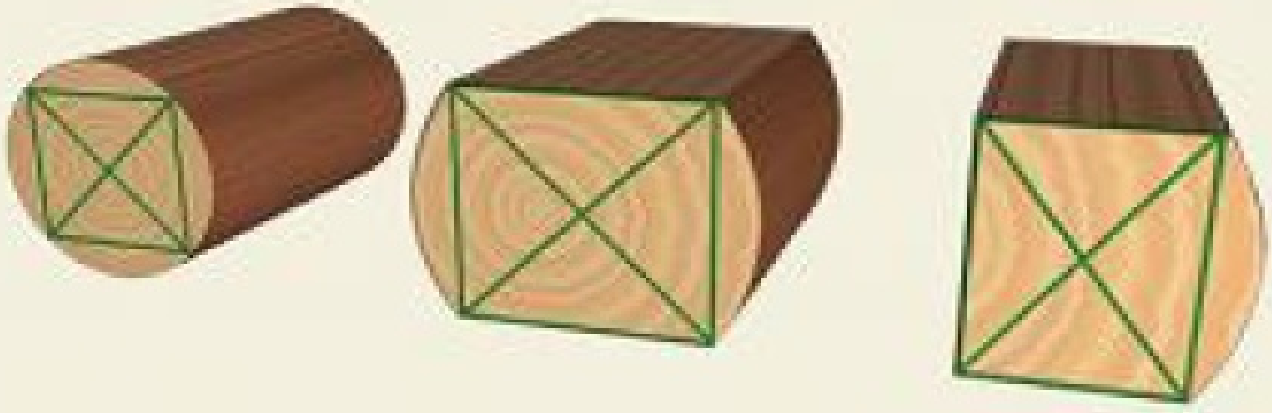
Ceiling Skylight

	Component
	Building
1	Ceiling 1
2	Skylight 1
3	Ceiling 2
4	Wall 1
5	Window 1
6	Window 2
7	Door 1
8	Door 2
9	Wall 2
10	Window 3
11	Wall 3
12	Window 4
13	Floor 1

Log Wall Details

Wood Species: Hem-Fir (HF)

Log Thickness (nominal width): 6 inch



The log thickness is the area of the log profile divided by its stack height, rounded to the nearest inch. The inscribed rectangle may be used to establish dimensions of non-rectangular log profiles.

Help OK Cancel

Compliance Passes Max UA 382 Your UA 343 10.2 % Better Than Code

Click the Assembly fields to display a list of assembly choices. "Other" assembly types are editable.

R402.1.1 Table of R-Values and U-Factors

Insulation and Fenestration Requirements by Component

	CLIMATE ZONE	FENESTRATION *U*- FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c] WALL R-VALUE
2009 IECC*	6	0.33	0.60	NR	49	21 or 13+5[h]	15/19	30[g]	15/19	10, 4 ft	10/19
2012 IECC*	6	0.32	0.55	NR	49	21 or 13+5[h]	15/20	30[g]	15/19	10, 4 ft	15/19
2012 IECC	6	0.32	0.55	NR	49	20+5 or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19

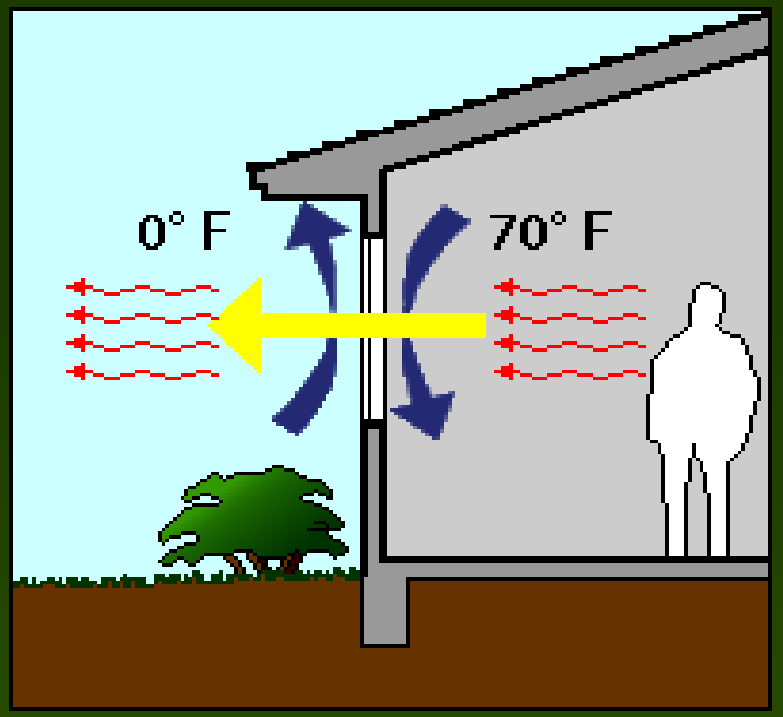
* - With Montana Amendments

Window U-Factor

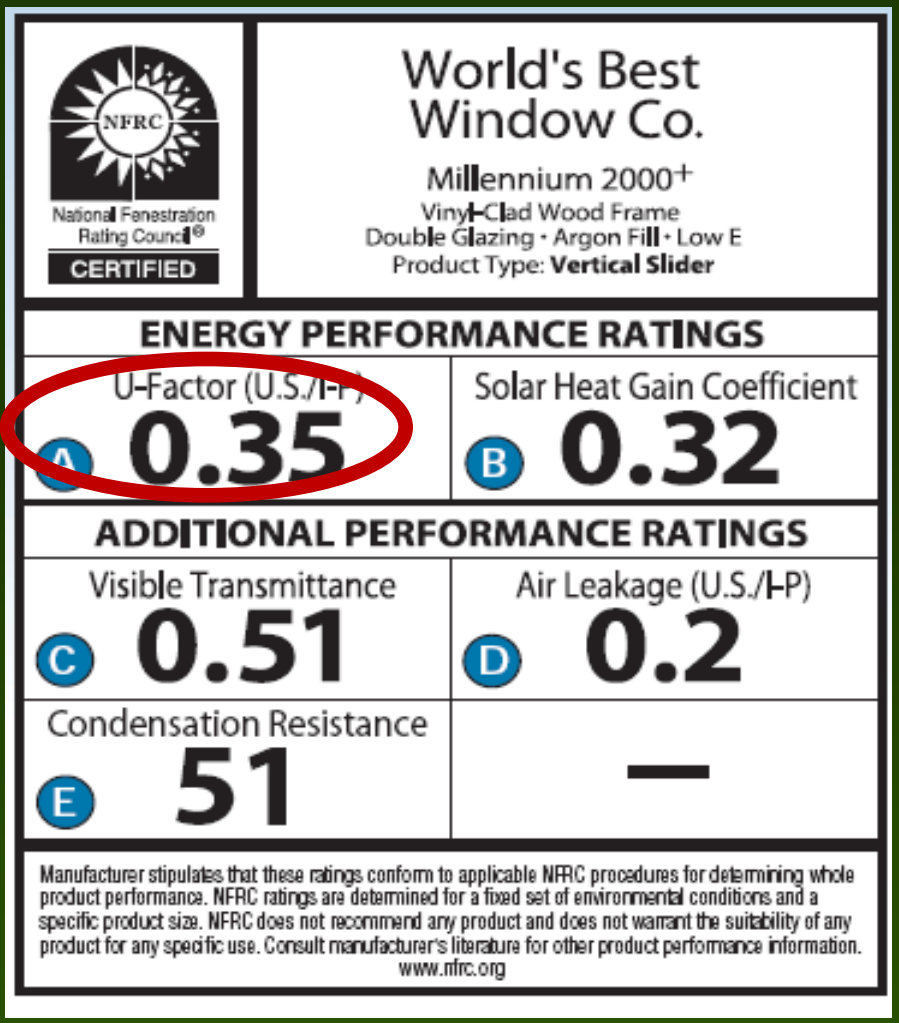
R402.1.1

from 0.32 U-Factor to 0.33

Lower means less heat loss.



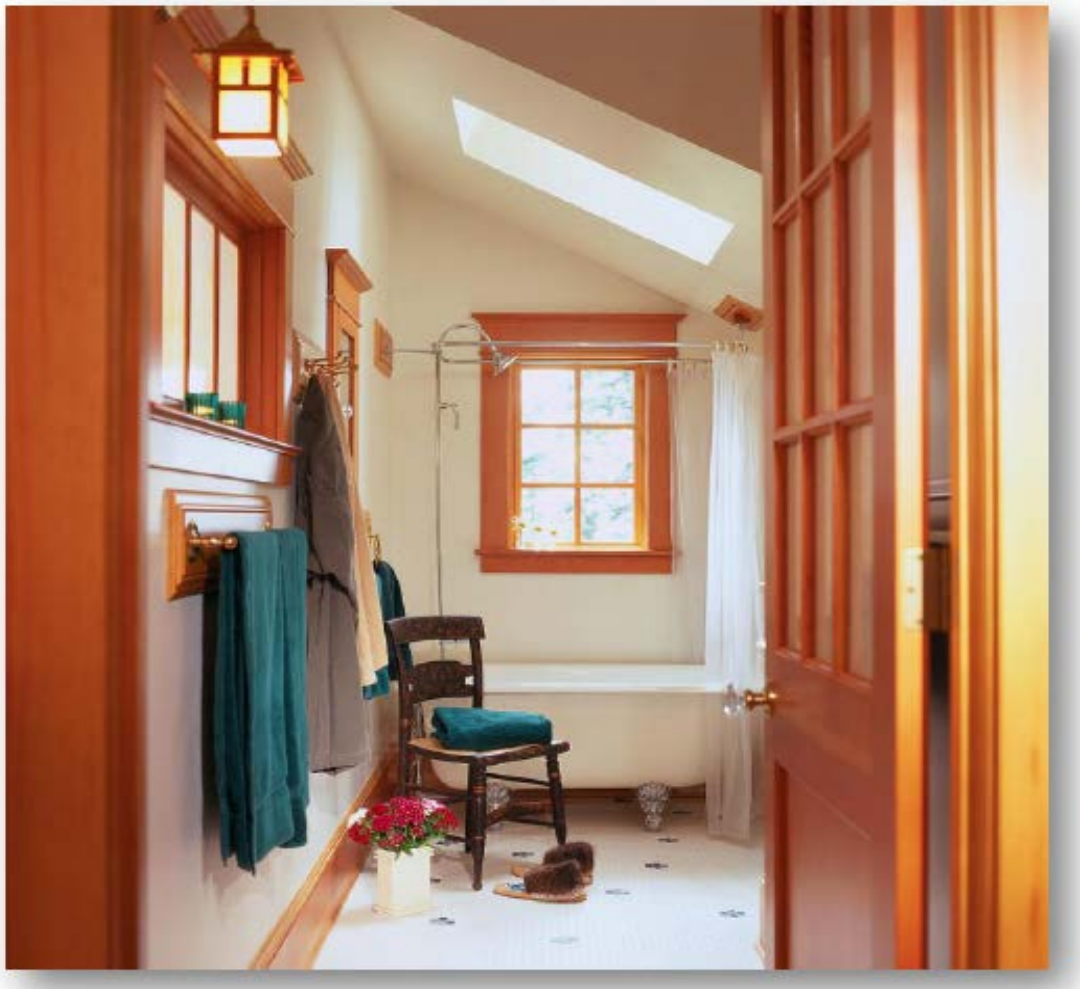
Source: www.nfrc.org



Skylights

R402.1.1

from 0.60 U-Factor to 0.55



Source: USDOE Building Energy Codes University

R402.1.1 Table of R-Values and U-Factors

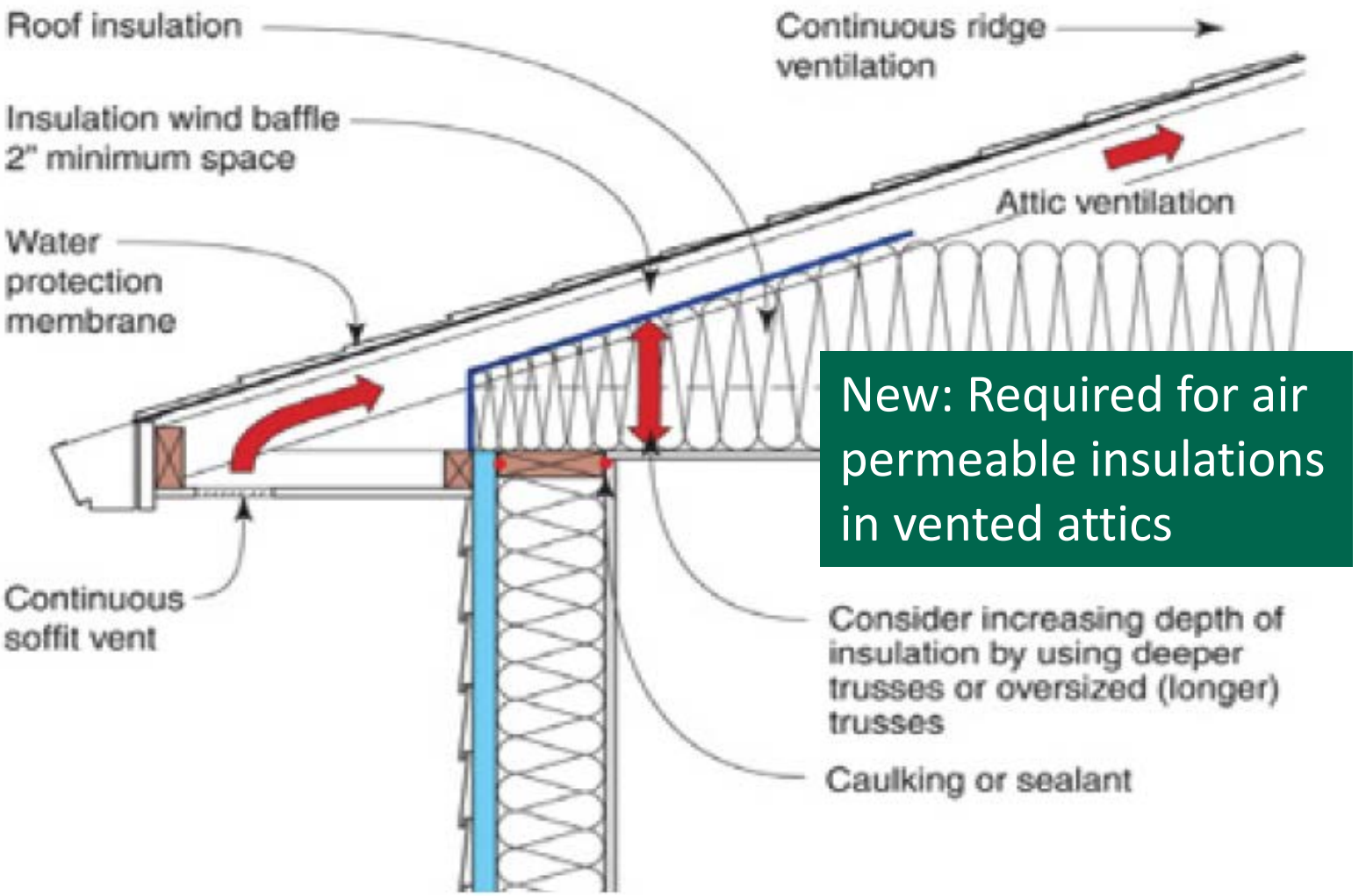
Insulation and Fenestration Requirements by Component

CLIMATE ZONE	FENESTRATION *U*- FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c] WALL R-VALUE
6	0.32	0.55	NR	49	21 or 13+5[h]	15/20	30[g]	15/19	10, 4 ft	15/19

R-38 if full height insulation over exterior walls.

Eave Baffles Required

R402.2.3



New: Required for air permeable insulations in vented attics

Source: USDOE Building Technologies Program, Introduction to Building Systems Performance: Houses That Work II

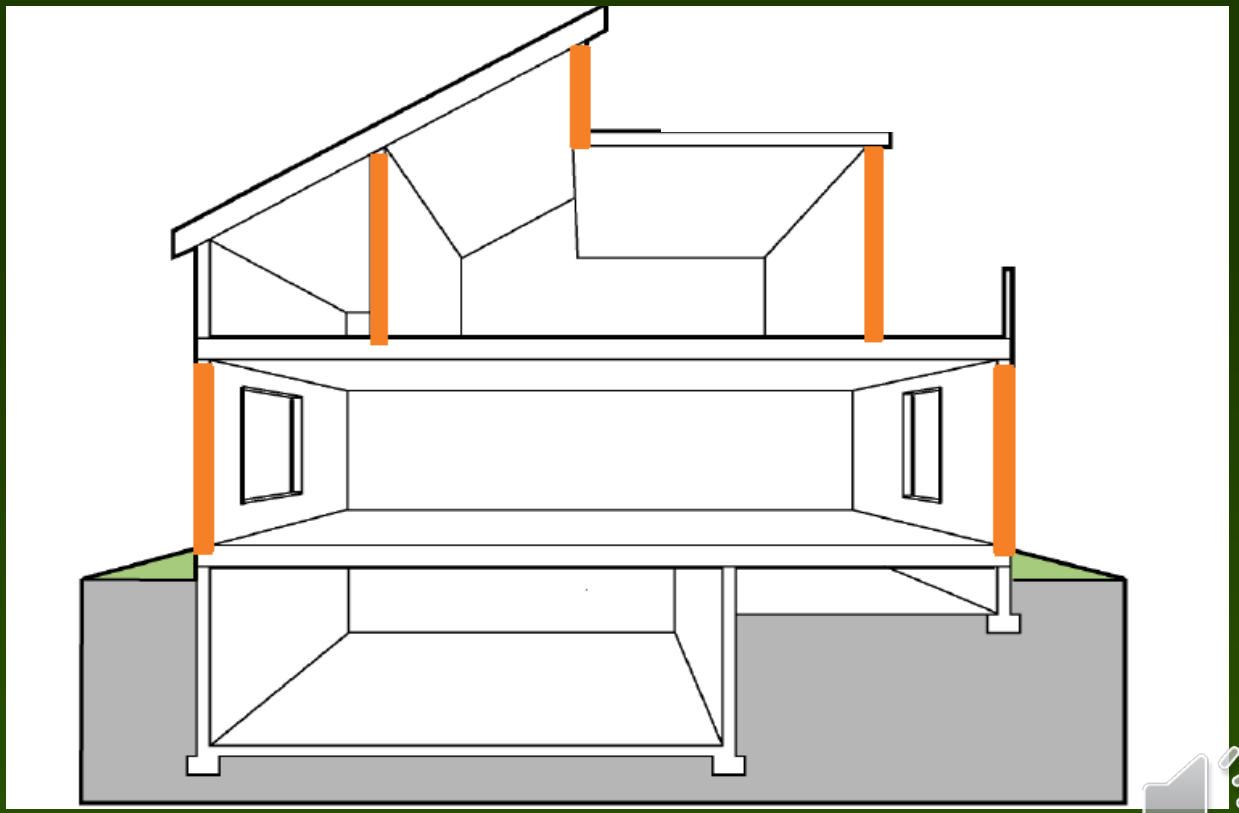
Wood Frame Wall R-Value

R402.1.1

From R21 or R13+R5 R-Value to No Change

2012 IECC ~~R20+R5 or R13+R10~~

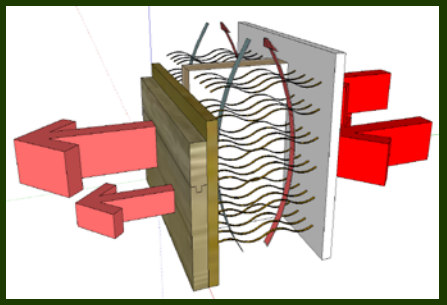
- Exterior above-grade walls
- Attic kneewalls
- Skylight shaft walls
- Perimeter joists
- Garage walls *(shared with conditioned space)*



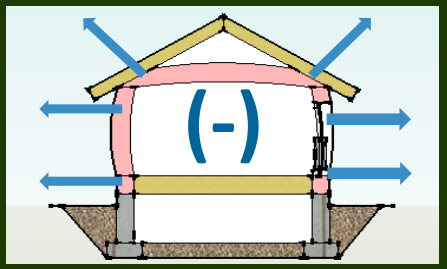
Do you think the installations shown in the photos below comply with the energy code?

Understanding Wall Control Functions

Heat

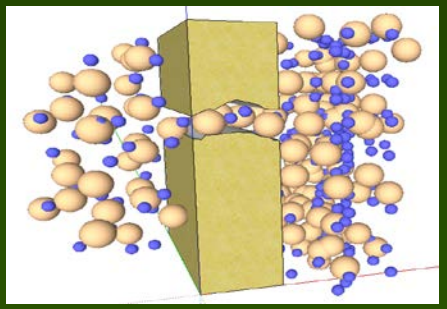


Air



Liquid Water

Water Vapor



Exterior Wall Design Challenges

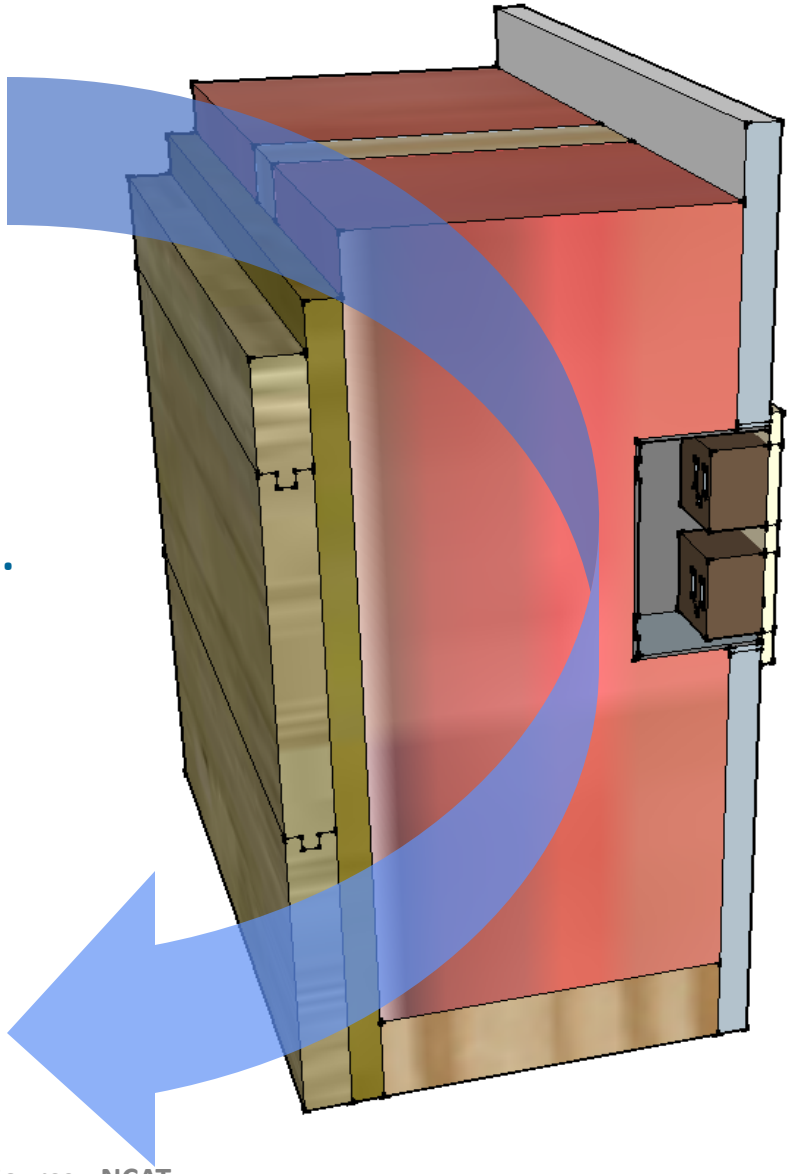
Problem #1:

Wind Washing

Applicable only to air permeable insulation.

Solution:

Exterior Air Barrier



Source - NCAT

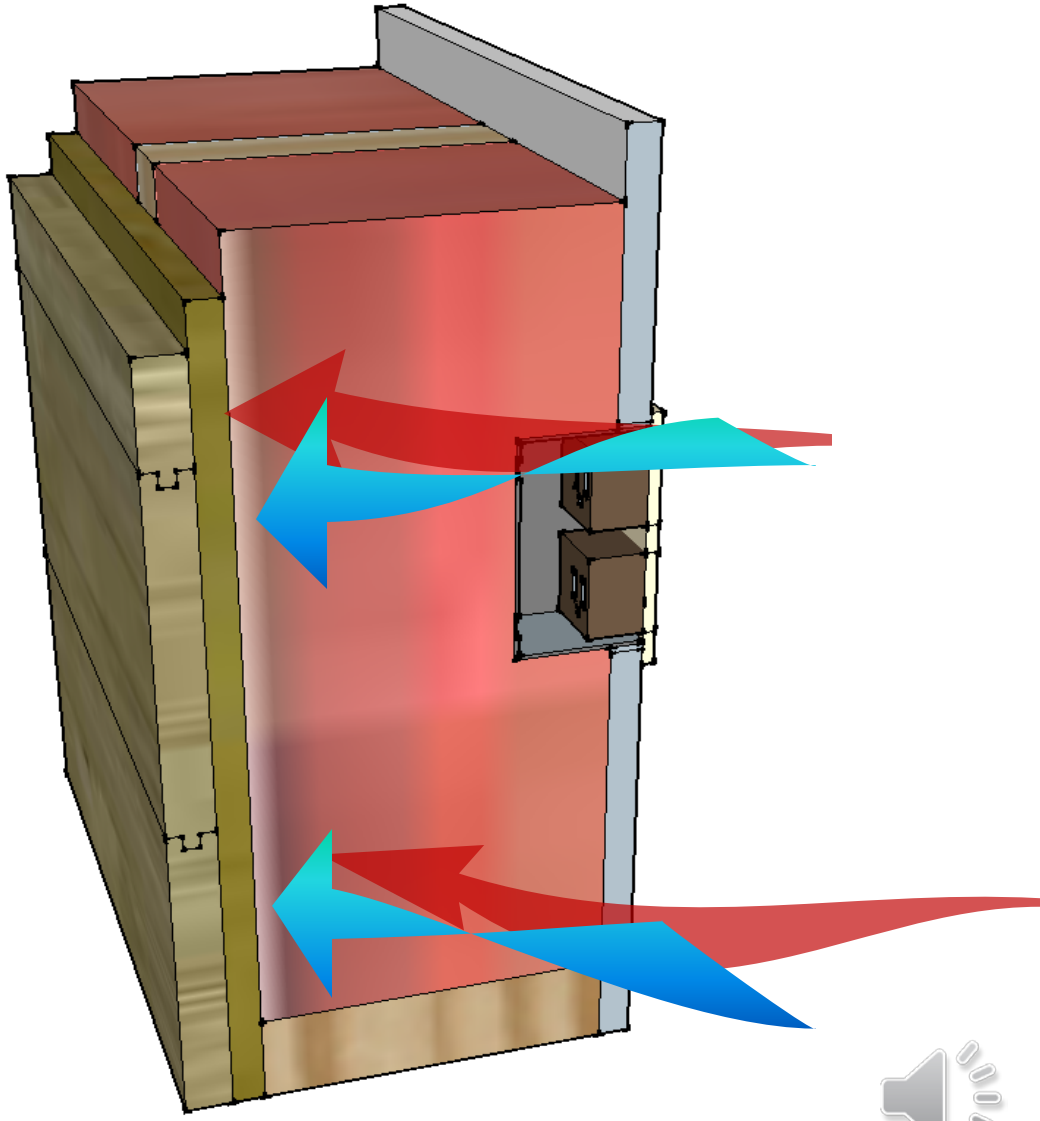
Exterior Wall Design Challenges

Problem #2:

Air (Vapor) Leakage into Wall Cavity

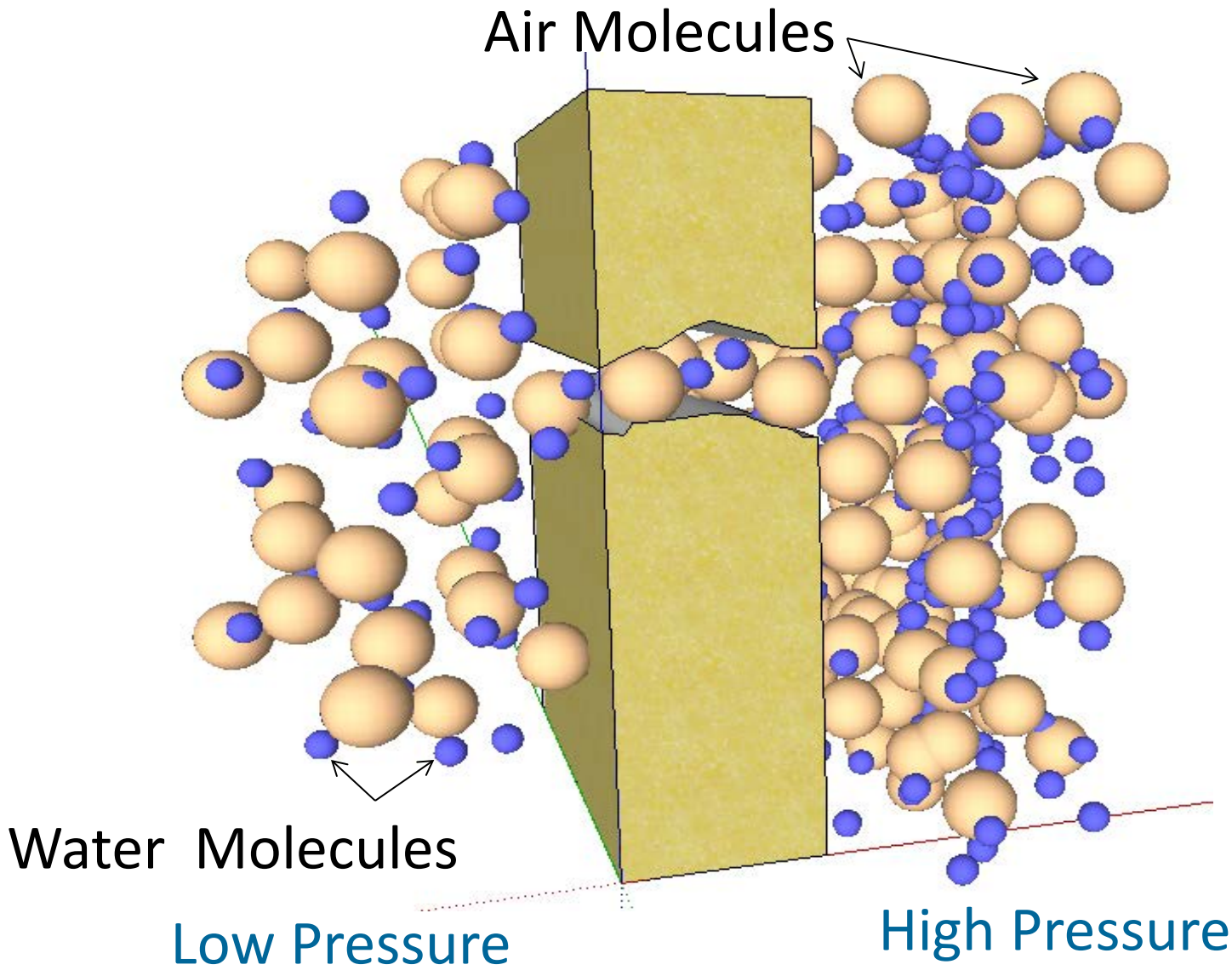
Solution:

Interior Air Barrier



Source - NCAT

Air and Vapor Migration



Source - **NCAT**

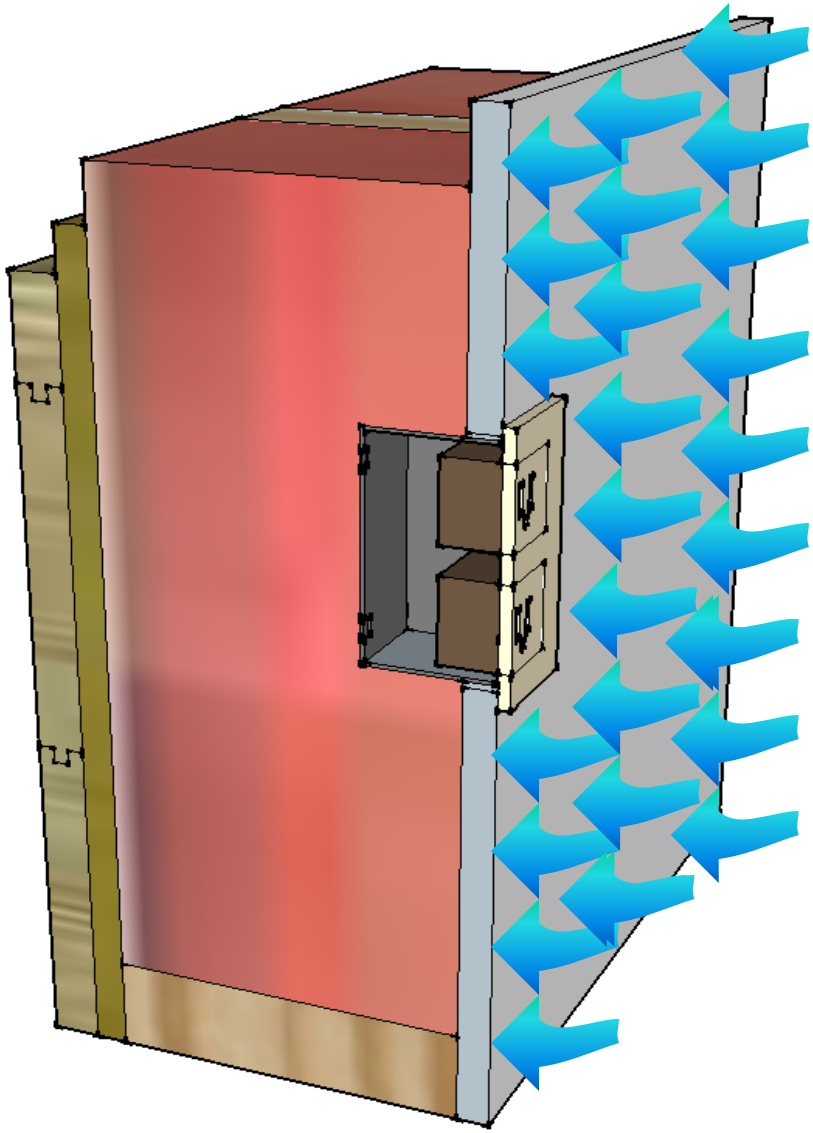
Exterior Wall Design Challenges

Problem #3:

Vapor Diffusion

Solution:

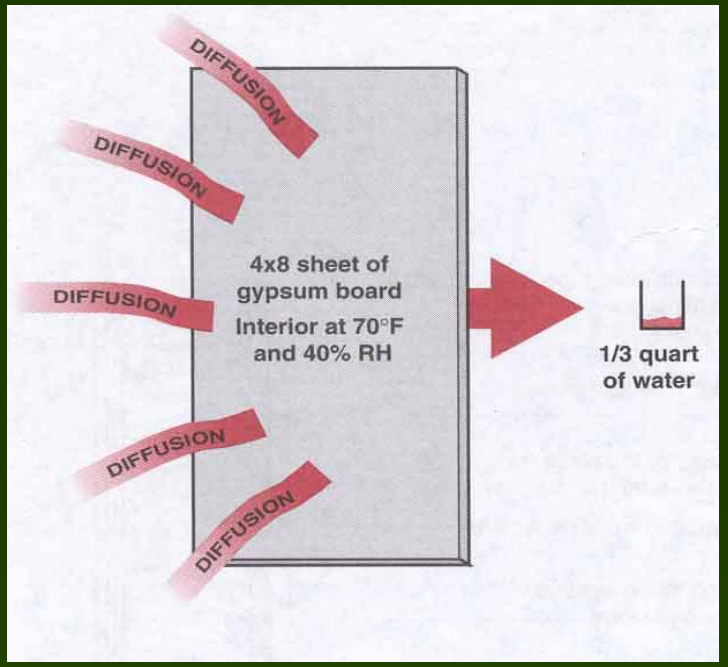
Interior Vapor Retarder

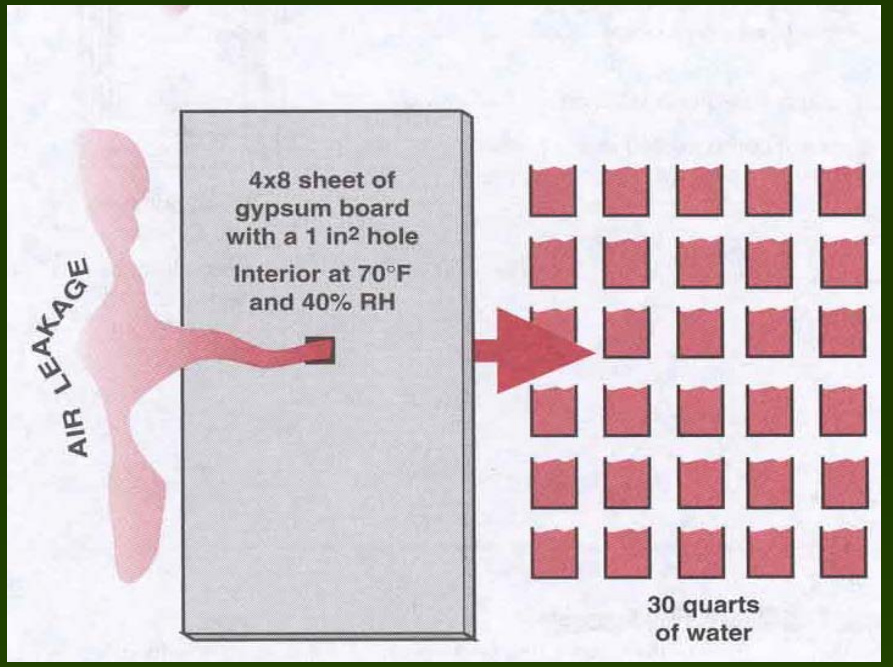


Source - **NCAT**

Vapor Diffusion vs. Air Transport

Air movement is typically far more important than vapor diffusion.





Water vapor moves in two ways

- Vapor Diffusion (movement through solid material)
- Air Transport (the more important)

Source: USDOE Building Technologies Program, Whole-House Energy Savings in Cold and Very Cold Climates

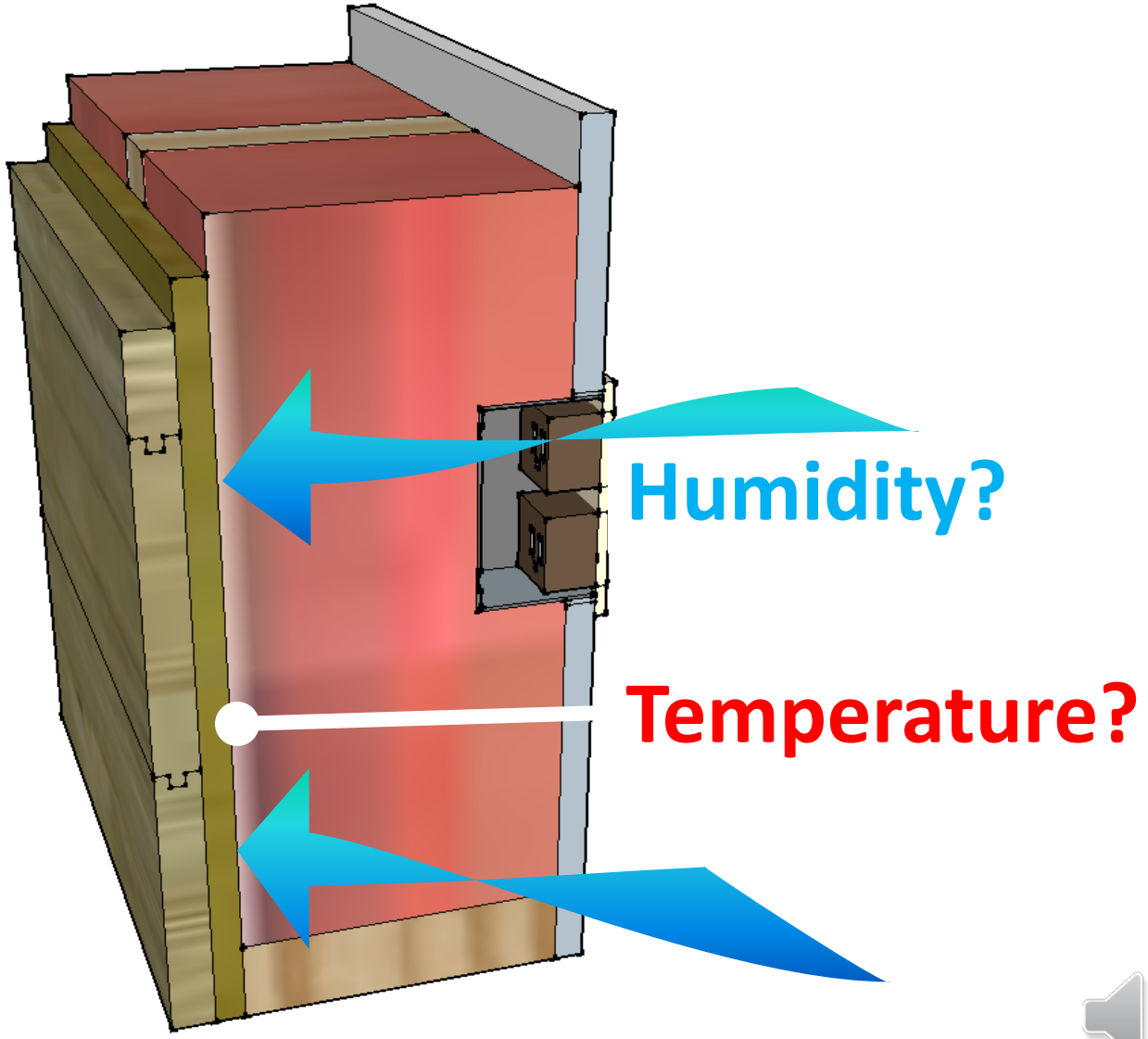
Exterior Wall Design Challenges

Problem #4:

Condensation Surface Temperature

Solution:

Insulate Condensation Surface



Source - **NCAT**

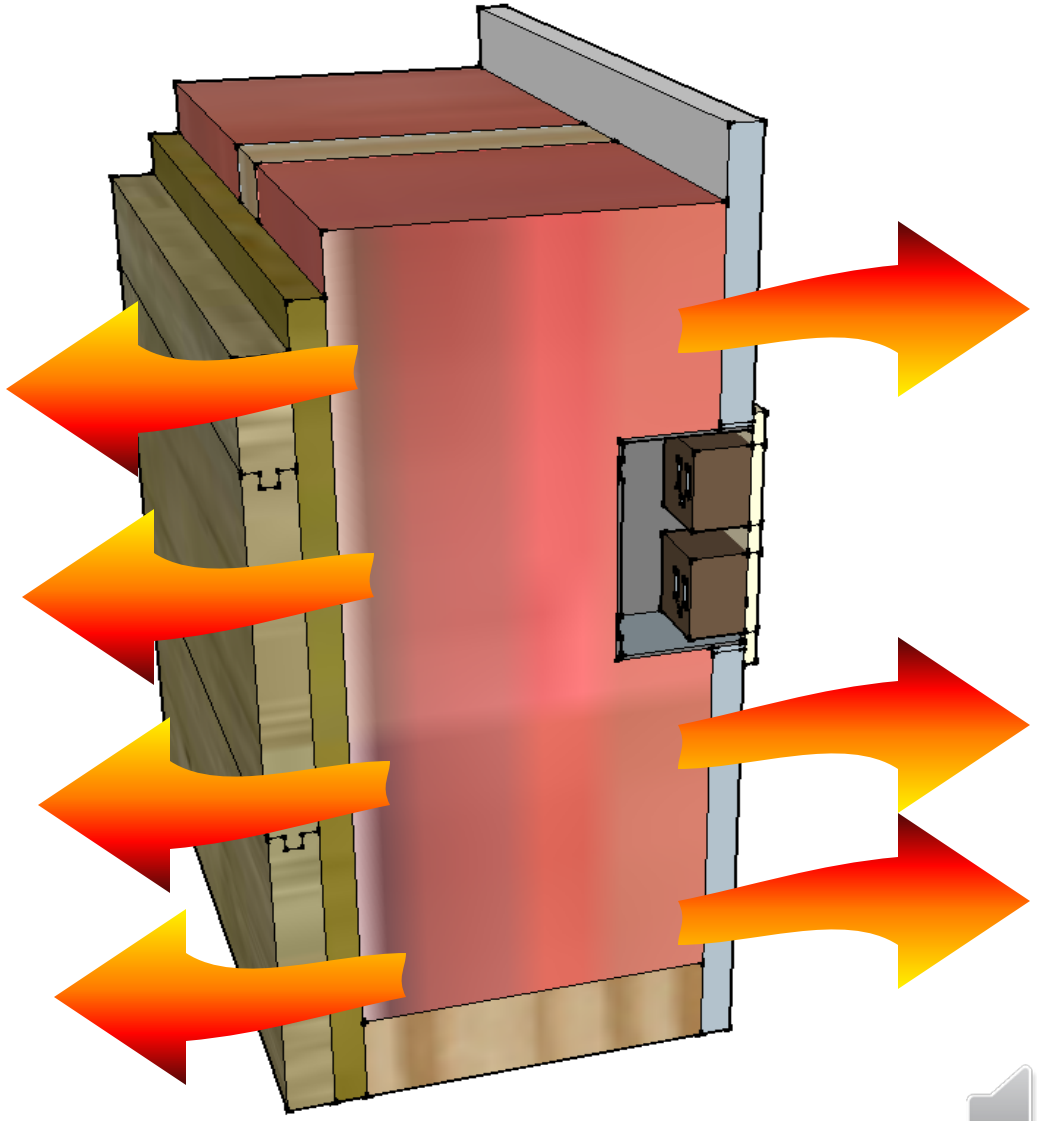
Exterior Wall Design Challenges

Problem #5:

Drying Strategy

Solution:

Class I Vapor Retarder on Only One Side of Wall



Source - **NCAT**

Air Barrier vs. Vapor Retarder

AIR BARRIER. Material(s) assembled and joined together to provide a barrier to air leakage through **and into** the building envelope. An air barrier may be a single material or a combination of materials.

VAPOR RETARDER CLASS. A measure of the ability of a material or assembly to limit the amount of moisture that passes through that material or assembly. Vapor retarder class shall be defined using the desiccant method with Procedure A of ASTM E 96 as follows:

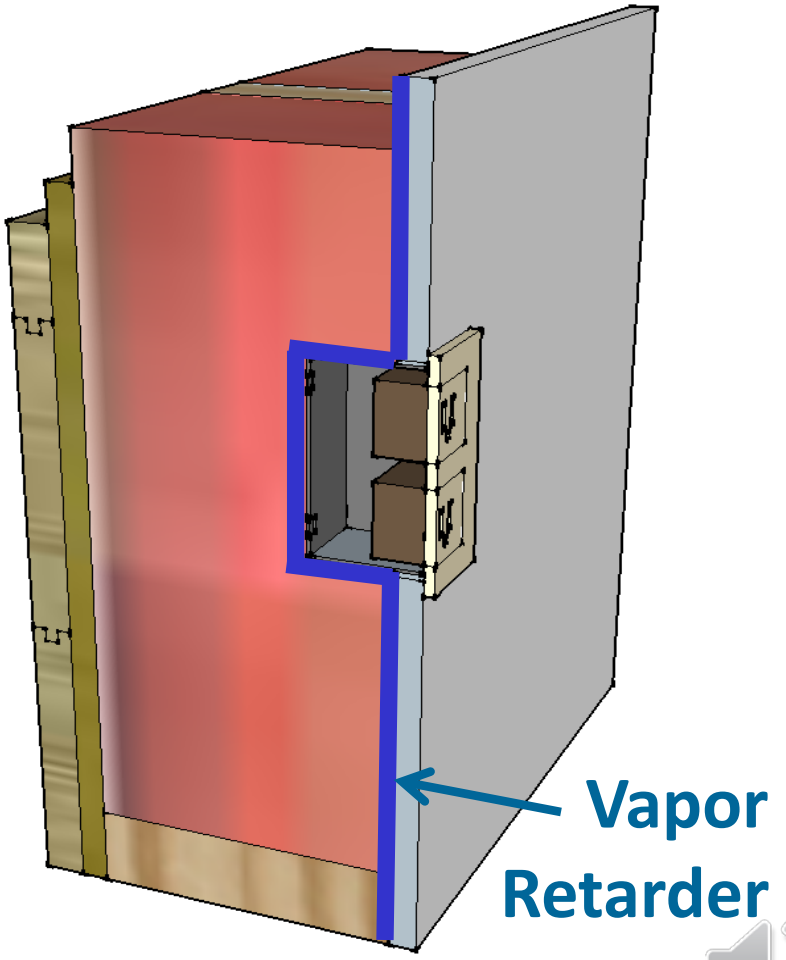
- Class I: 0.1 perm or less
- Class II: 0.1 < perm ≤ 1.0 perm
- Class III: 1.0 < perm ≤ 10 perm

Class I or II vapor retarder at warm side of wall required.

Exception: Basement Walls and any portion of below grade walls.

Class III is allowed for:

- Vented cladding
- Continuous Insulation
  - R-7.5 for 2x4 wall
  - R11.25 for 2x6 wall



Source - NCAT

Vapor Retarders

IRC R702

Class	Definition	Examples
I	0.1 perm or less	Sheet polyethyl-ene, sheet metal, non-perforated aluminum foil
II	Greater than 0.1 perm to less than 1.0 perm	Kraft-faced fiberglass batts or low-perm paint
III	Greater than 1.0 perm to less than 10 perm	Latex or enamel paint

Impermeable (vapor barrier)

Semi-impermeable

Semi-permeable

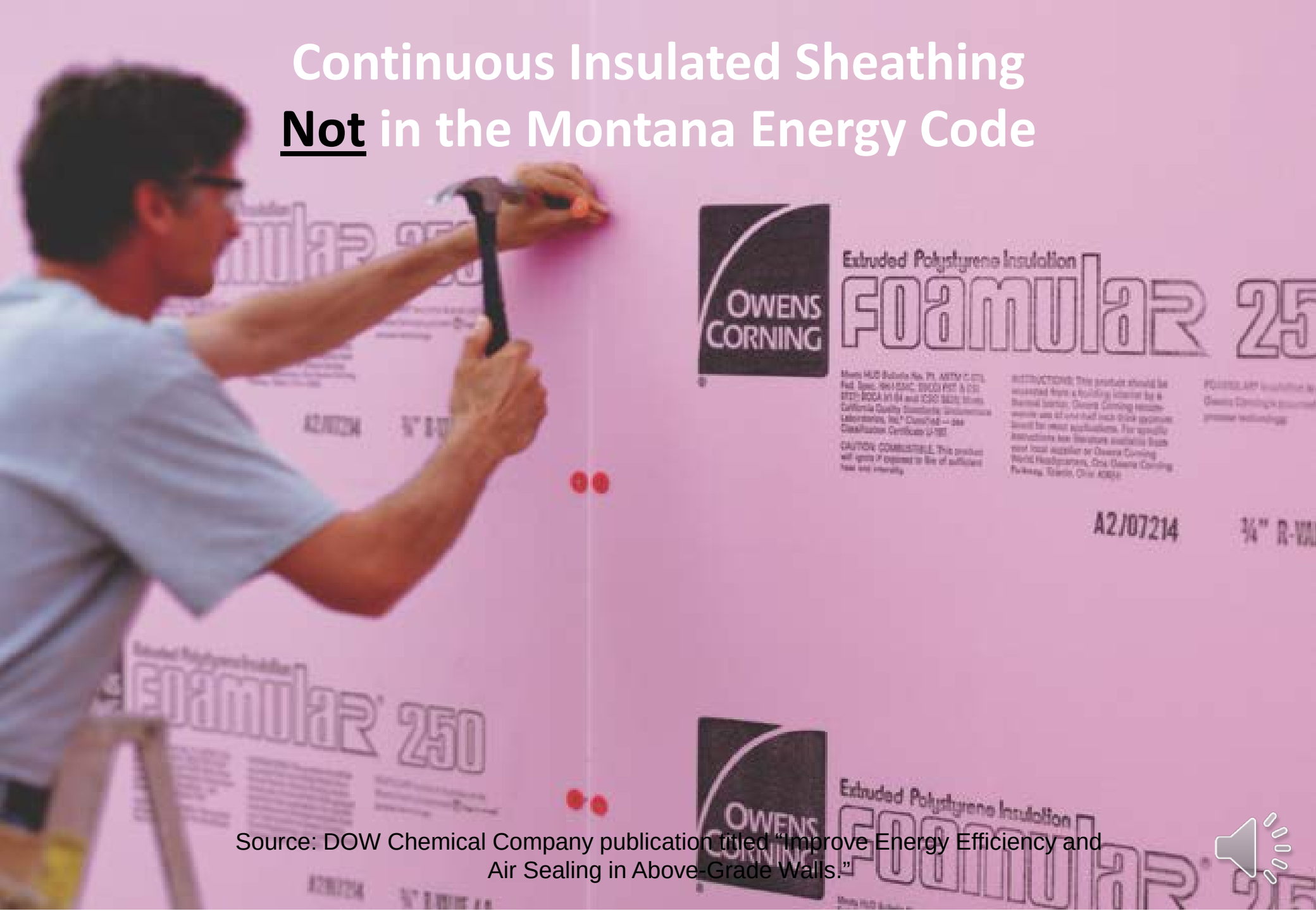
Source: USDOE Building Technologies Program, Whole-House Energy Savings in Cold and Very Cold Climates

Why Insulated Sheathing?

Exterior Insulated Sheathing = **Thermal Break + Insulation + Air Barrier**

Continuous Insulated Sheathing

Not in the Montana Energy Code



Source: DOW Chemical Company publication titled "Improve Energy Efficiency and Air Sealing in Above-Grade Walls."

Mass Walls

R402.2.5

Concrete block

Concrete

ICF

Masonry Cavity

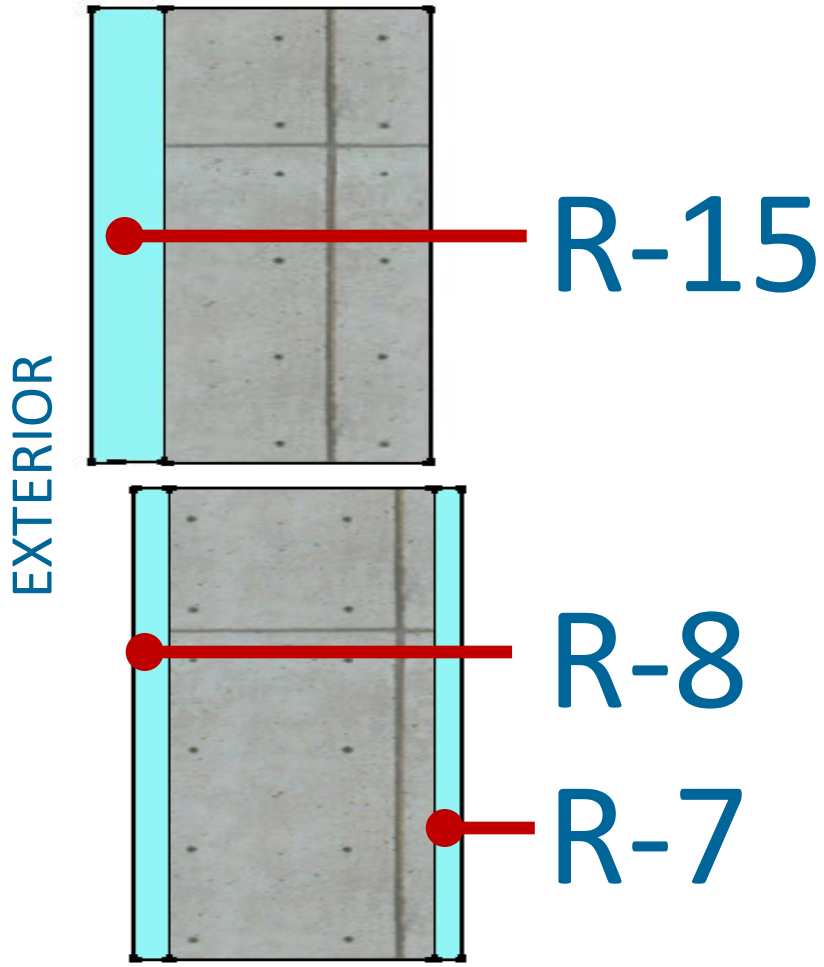
Brick

Earth

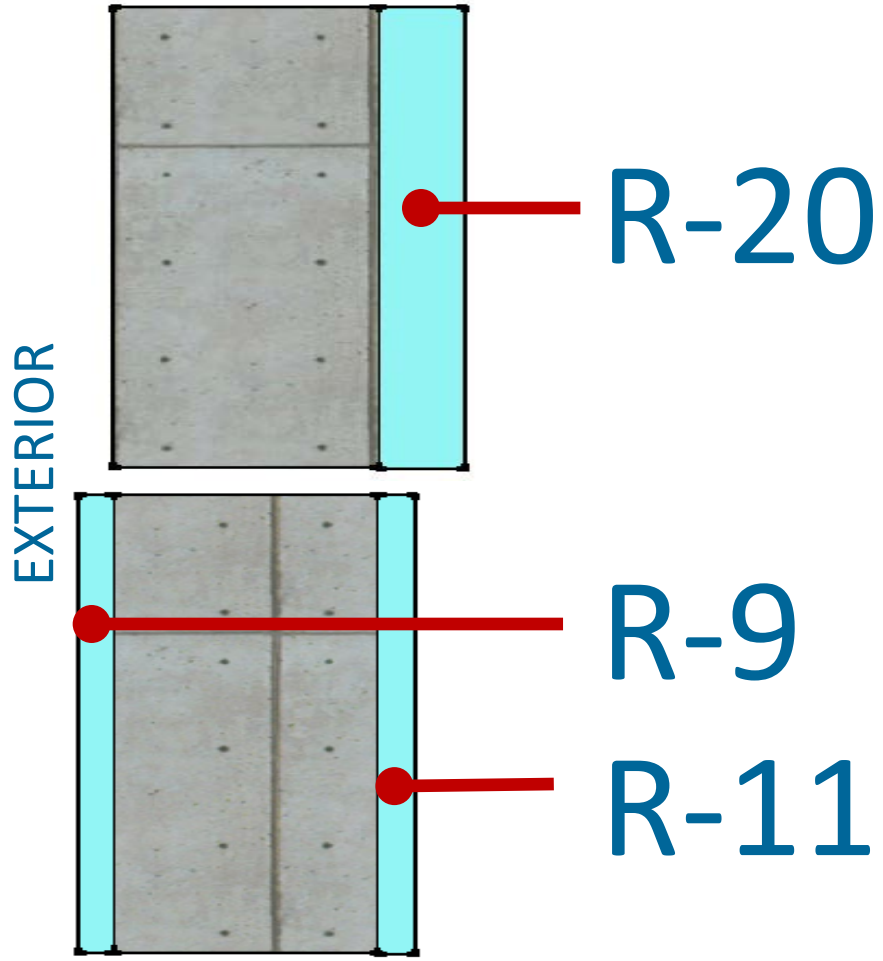
Solid Timber/Logs

Mass Walls

R402.2.5



R-15 If More Than Half of Insulation on the Exterior



R-20 More Than Half of Insulation on the Interior

Source - NCAT

Steel-Frame Walls

R402.2.6

Steel-Frame Ceiling, Wall and Floor Insulation (R-Value)

Wood Frame	Steel Truss Ceilings					
R-49	R-38 + 5					
	Steel Frame Wall 16" o.c.					
R-21	R-38 + 5	R-13 + 9.5	R-15 + 9.1	R-19 + 8.4	R-21 + 8.1	R-25 + 7.7
	Steel Framed Wall, 24" O.C					
R-21	R-0 + 14.6	R-13 + 8.3	R-15 + 7.7	R-19 + 6.9	R-21 + 6.5	R-25 + 5.9

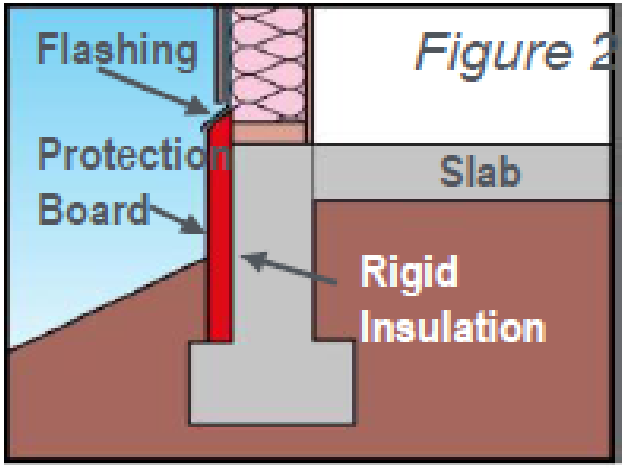
R402.1.1 Table of R-Values and U-Factors

Insulation and Fenestration Requirements by Component

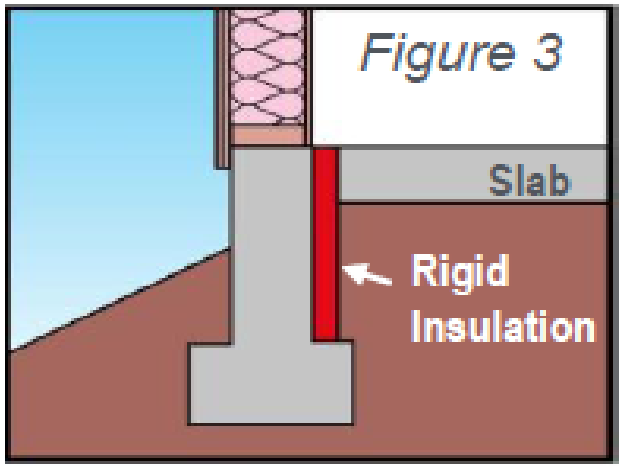
CLIMATE ZONE	FENESTRATION *U*- FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c] WALL R-VALUE
6	0.32	0.55	NR	49	21 or 13+5[h]	15/20	30[g]	15/19	10, 4 ft	15/19

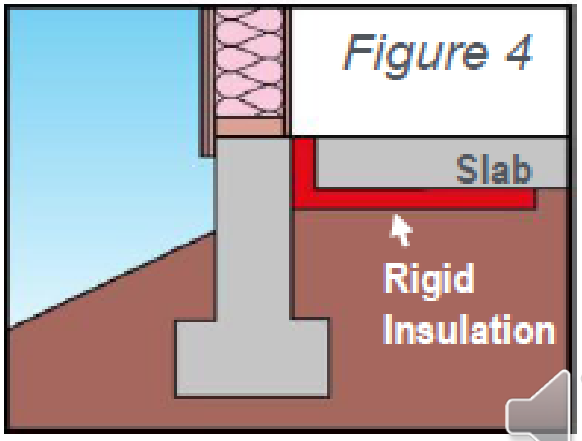
Slab Insulation

R402.2.9



R-10 for 4’ Vertical or Horizontal
Add R-5 if the slab has radiant heat

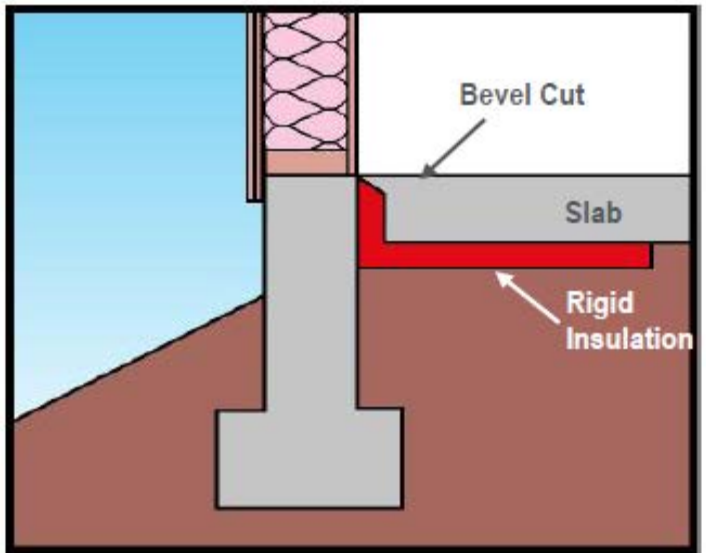




Source: USDOE Building Energy Codes University

Slab Insulation

R402.2.9



Source: USDOE Building Energy Codes University

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6	0.32	0.55	NR	49	21 or 13+5[h]	15/20	30[g]	15/19	10, 4 ft	15/19

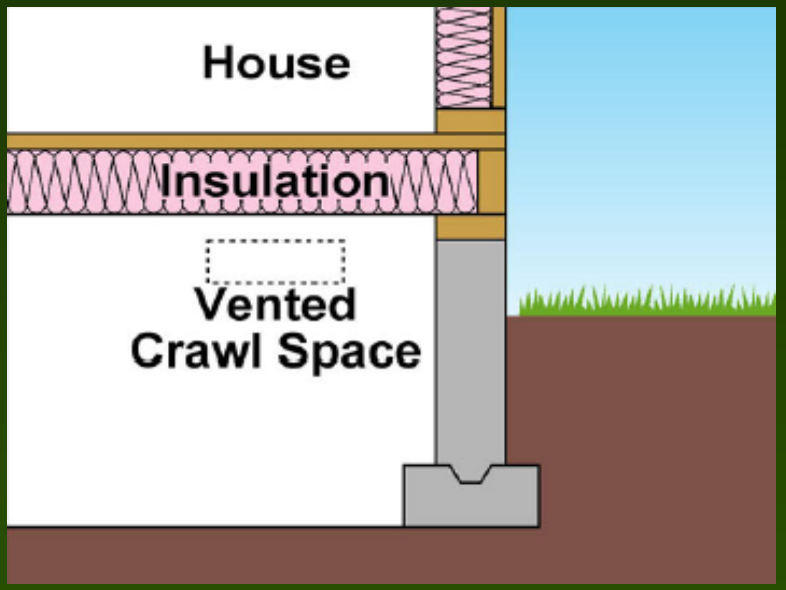
Unvented Crawlspace Wall

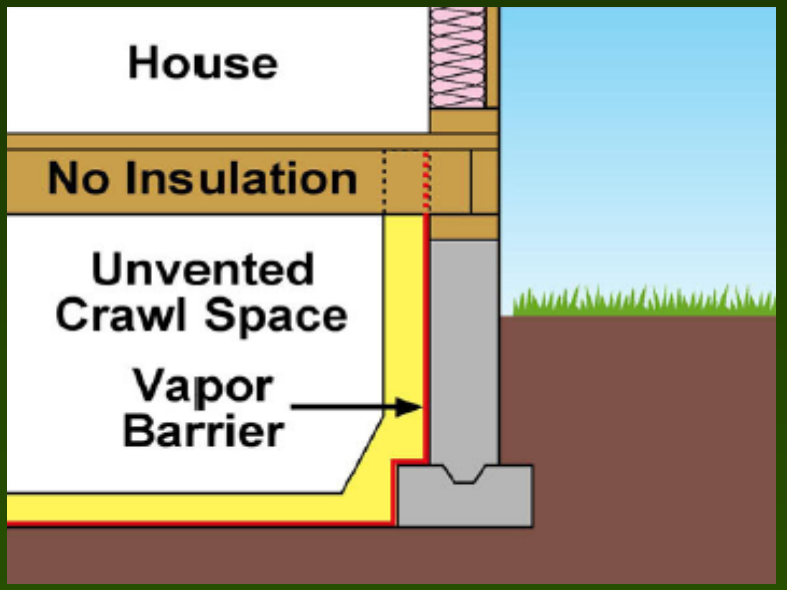
R402.1.1

From R10 / R19 to R15 / R19

(Continuous / Cavity)

- Must choose to insulate either floor or walls
- Either mechanically vented or minimally conditioned (*IRC)*
- Continuous Class I vapor retarder at exposed earth





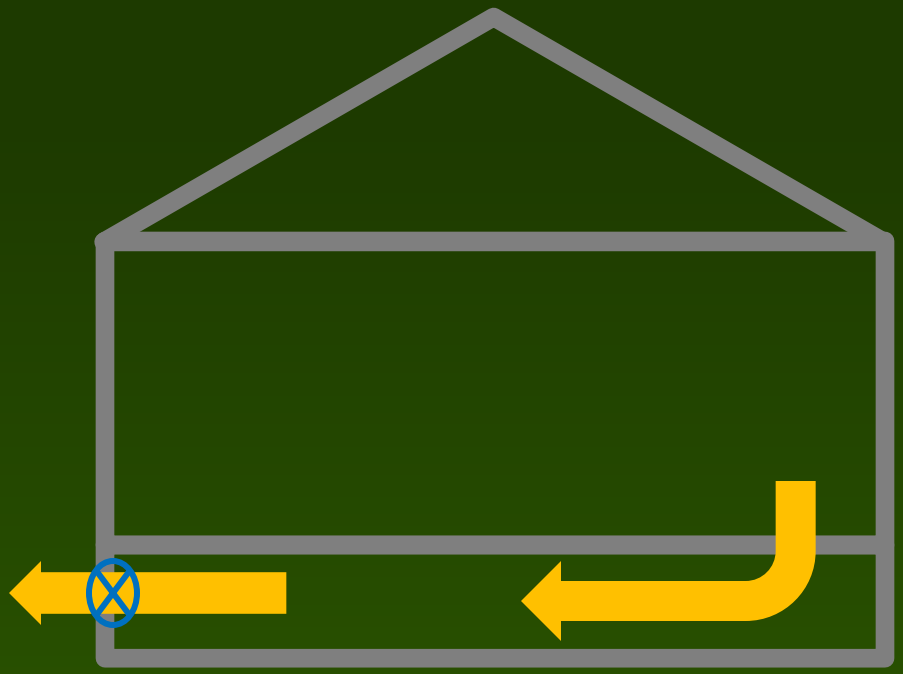
Source: USDOE Building Energy Codes University

Unvented Crawlspaces – Two Design Options

IRC R408.3

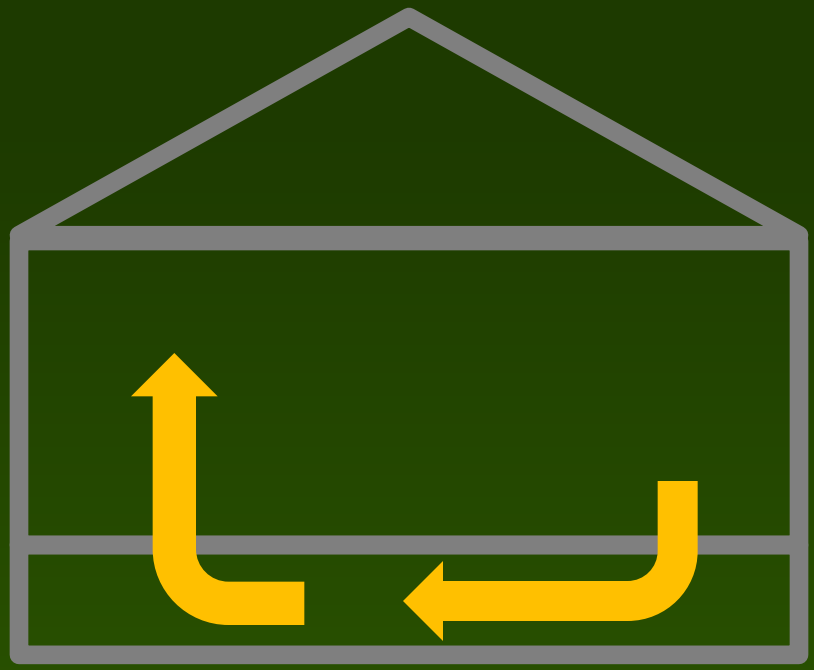
Continuous **Exhaust** to Exterior

- 1 CFM/50 SF Crawlspace Area
- Air Pathway from Common Area



Conditioned Air Supply

- 1 CFM/50 SF Crawlspace Area
- Air Pathway to Common Area



Source - NCAT

IRC R408.3

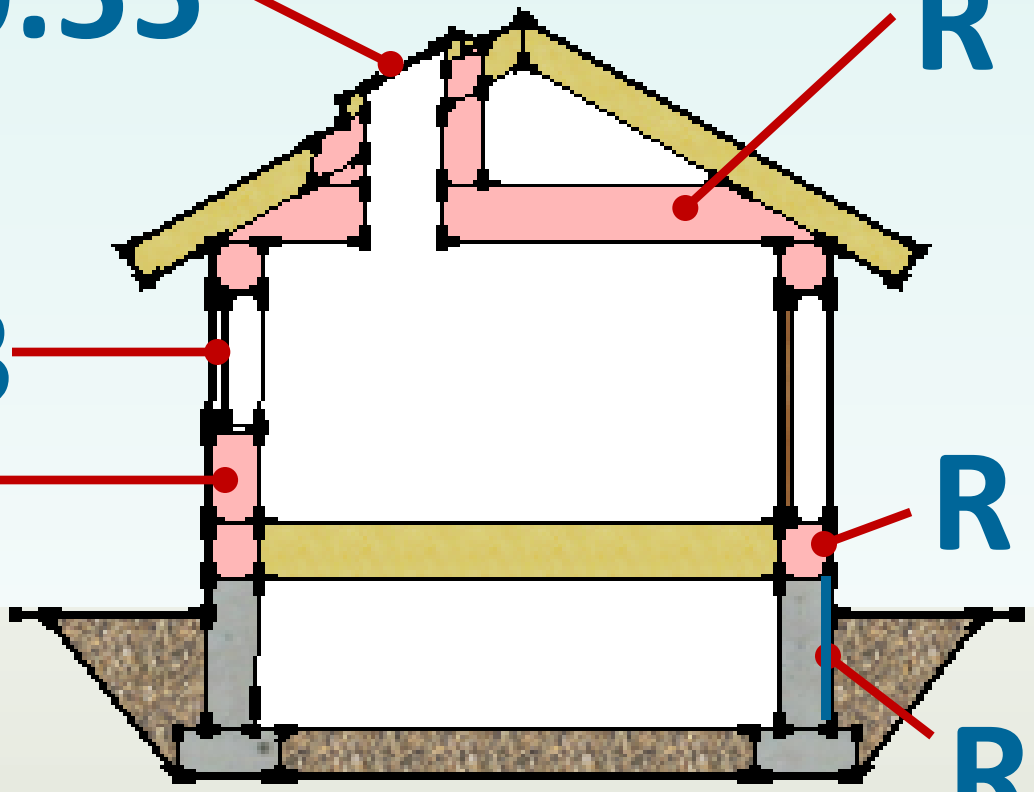
Unvented Crawlspaces

Cherry Peacock, UM
Mark Noon, Kingdom Builders
Russ Hellum, Energetechs

Class I Vapor Retarder at Exposed Earth

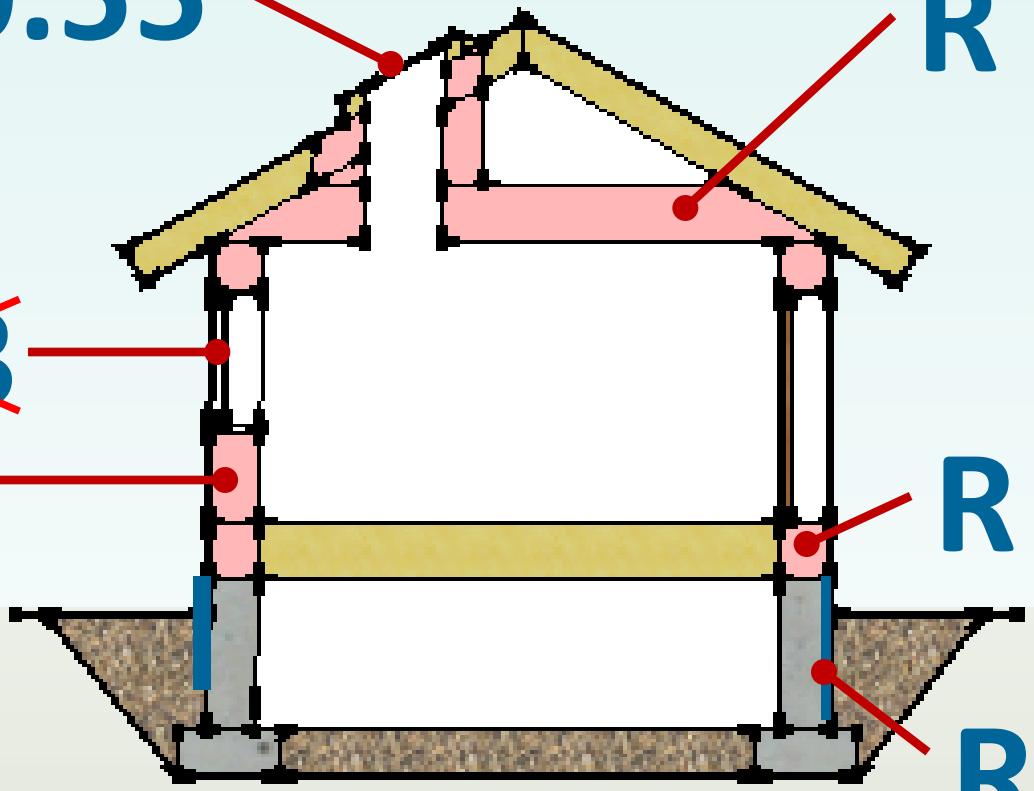
- 6” overlap sealed or taped
- Extend 6” up stem wall attached and sealed

Do the characteristics shown comply with the energy code?



Source - NCAT

Do the characteristics shown comply with the energy code?



U = 0.55

R = ~~38~~

U = ~~0.33~~

R = 21

R = 21

R = ~~10~~

Source - NCAT

Do the characteristics shown comply with the energy code?

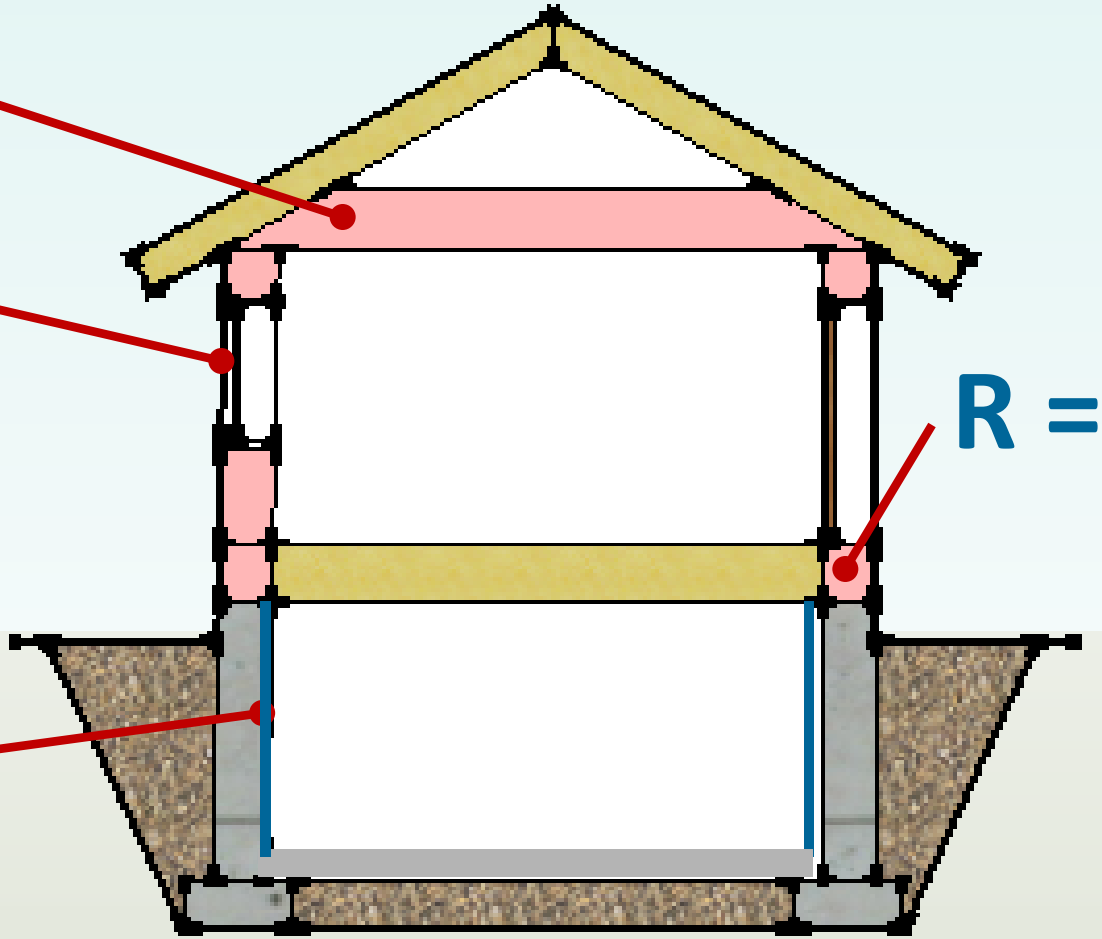
R = 49

Windows

100 SF U-0.33

100 SF U-0.30

R = 21



R = 15

Continuous

Source - NCAT

Do the characteristics shown comply with the energy code?

R = 49

Windows

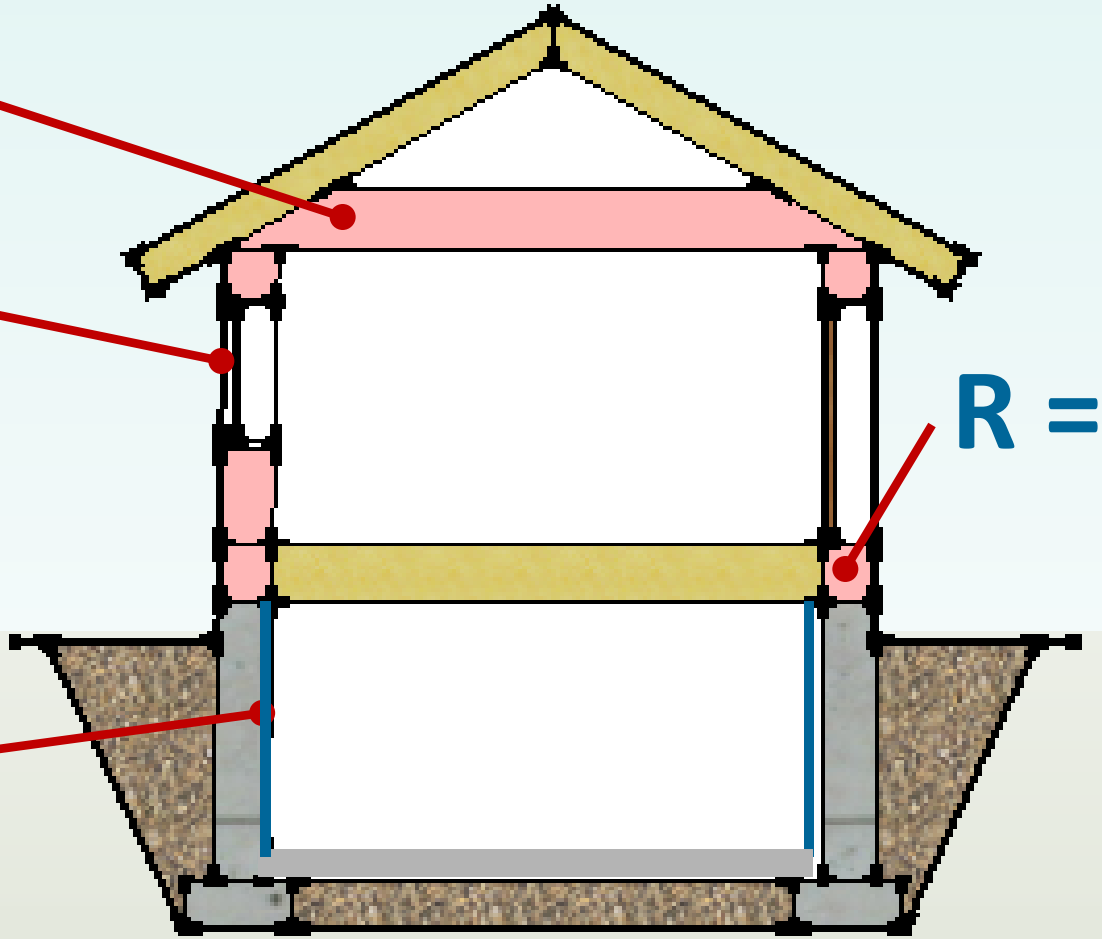
100 SF U-0.33

100 SF U-0.30

R = 21

R = 15

Continuous



Source - NCAT

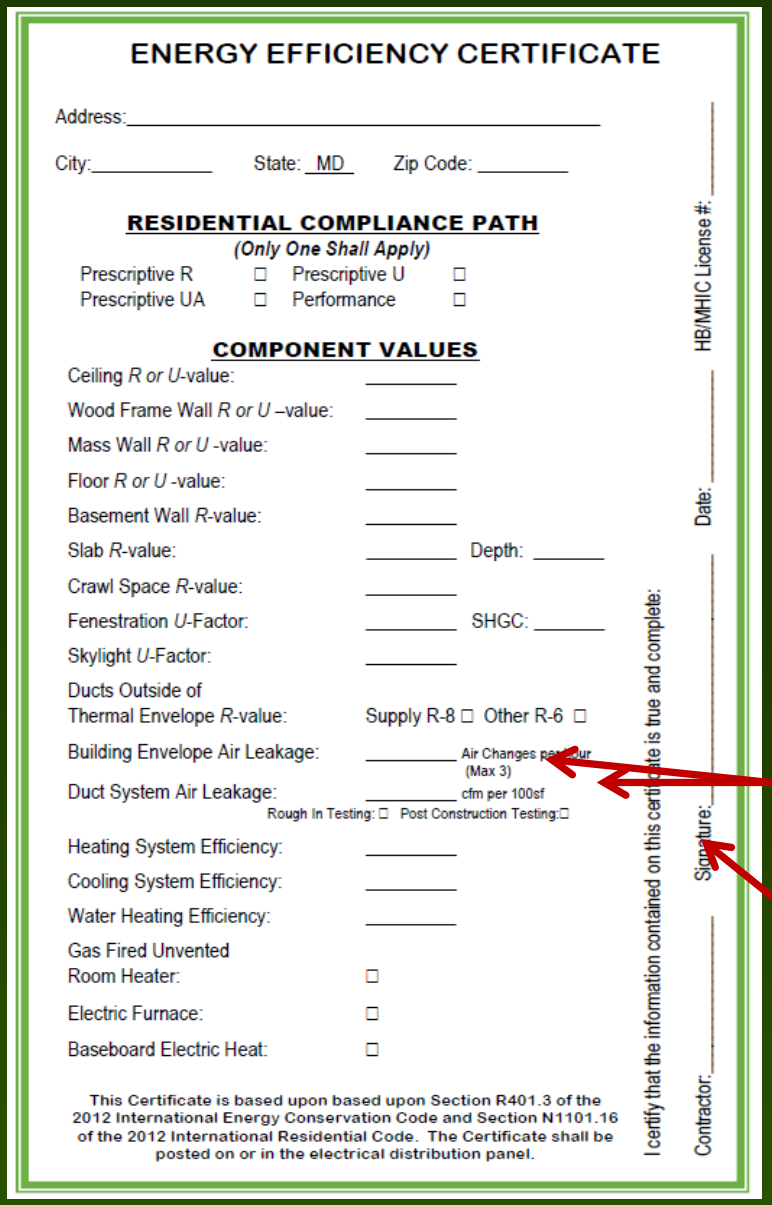
Example Mandatory Provisions

R401.2

IECC Mandatory Provisions	
Applies to all performance paths. Can not be traded off.	
Certificate	**R401.3**
Air Leakage (Testing & Visual Checklist)	**R402.4**
Controls for Heating and Cooling System	**R403.1**
Duct Sealing	**R403.2**
No Building Cavities as Ducts	**R403.2.3**
Mechanical System Pipe Insulation	**R403.3**
Mechanical Ventilation Required	**R403.5**
Equipment Sizing (ACCA Manuals S & J)	**R403.6**
Lighting Minimum Requirements	**R404.1**

Certificate (Mandatory)

R401.3



ENERGY EFFICIENCY CERTIFICATE

Address:_____

City:_____ State: MD Zip Code: _____

RESIDENTIAL COMPLIANCE PATH

(Only One Shall Apply)

Prescriptive R ☐ Prescriptive U ☐
Prescriptive UA ☐ Performance ☐

COMPONENT VALUES

Ceiling *R or U*-value: _____
Wood Frame Wall *R or U* –value: _____
Mass Wall *R or U* -value: _____
Floor *R or U* -value: _____
Basement Wall *R*-value: _____
Slab *R*-value: _____ Depth: _____
Crawl Space *R*-value: _____
Fenestration *U*-Factor: _____ SHGC: _____
Skylight *U*-Factor: _____
Ducts Outside of Thermal Envelope *R*-value: Supply R-8 ☐ Other R-6 ☐
Building Envelope Air Leakage: _____ Air Changes per Hour (Max 3)
Duct System Air Leakage: _____ cfm per 100sf
Rough In Testing: ☐ Post Construction Testing:☐
Heating System Efficiency: _____
Cooling System Efficiency: _____
Water Heating Efficiency: _____
Gas Fired Unvented Room Heater: ☐
Electric Furnace: ☐
Baseboard Electric Heat: ☐

This Certificate is based upon based upon Section R401.3 of the 2012 International Energy Conservation Code and Section N1101.16 of the 2012 International Residential Code. The Certificate shall be posted on or in the electrical distribution panel.

I certify that the information contained on this certificate is true and complete:

HB/MHIC License #: _____
Date: _____
Signature: _____
Contractor: _____

Place on electrical panel.

- R-Values
- U-Factors & SHGC
- Envelope Air Leakage
- Space Conditioning Efficiencies
- Duct Tightness Test
- Building Tightness Test
- Duct R-Values
- Builder Signature

Air Leakage (Mandatory)

R402.4

Thermal envelope must comply with both:

Testing (402.4.1.2)

Air Barrier and Insulation Installation (Table R402.4.1)

+

COMPONENT	CRITERIA*
Air barrier and thermal barrier	A continuous air barrier shall be installed in the building envelope. Exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed. Air-permeable insulation shall not be used as a sealing material.
Ceiling/attic	The air barrier in any dropped ceiling/soffit shall be aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop down stair or knee wall doors to unconditioned attic spaces shall be sealed.
Walls	Corners and headers shall be insulated and the junction of the foundation and sill plate shall be sealed. The junction of the top plate and top of exterior walls shall be sealed. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier. Knee walls shall be sealed.
Windows, skylights and doors	The space between window/door jambs and framing and skylights and framing shall be sealed.
Rim joists	Rim joists shall be insulated and include the air barrier.
Floors (including above-garage and cantilevered floors)	Insulation shall be installed to maintain permanent contact with underside of subfloor decking. The air barrier shall be installed at any exposed edge of insulation.
Crawl space walls	Where provided in lieu of floor insulation, insulation shall be permanently attached to the crawlspace walls. Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.
Shafts, penetrations	Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed.
Narrow cavities	Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled by insulation that on installation readily conforms to the available cavity space.
Garage separation	Air sealing shall be provided between the garage and conditioned spaces.
Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be air tight, IC rated, and sealed to the drywall.
Plumbing and wiring	Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation that on installation readily conforms to available space shall extend behind piping and wiring.
Shower/tub on exterior wall	Exterior walls adjacent to showers and tubs shall be insulated and the air barrier installed separating them from the showers and tubs.
Electrical/phone box on exterior walls	The air barrier shall be installed behind electrical or communication boxes or air sealed boxes shall be installed.
HVAC register boots	HVAC register boots that penetrate building thermal envelope shall be sealed to the sub-floor or drywall.
Fireplace	An air barrier shall be installed on fireplace walls. Fireplaces shall have gasketed doors.

"Where required by the code official, testing shall be conducted by an *approved* ~~third~~ party."

Air Barrier and Insulation Installation

Table R402.4.1.1

	COMPONENT
1	Air barrier and thermal barrier
2	Ceiling/attic
3	Walls
4	Windows, skylights and doors
5	Rim joists
6	Floors (including above-garage and cantilevered floors)
7	Crawl space walls
8	Shafts, penetrations
9	Narrow cavities
10	Garage separation
11	Recessed lighting
12	Plumbing and wiring
13	Shower/tub on exterior wall
14	Electrical/phone box on exterior walls
15	HVAC register boots
16	Fireplace

16 Installation Components

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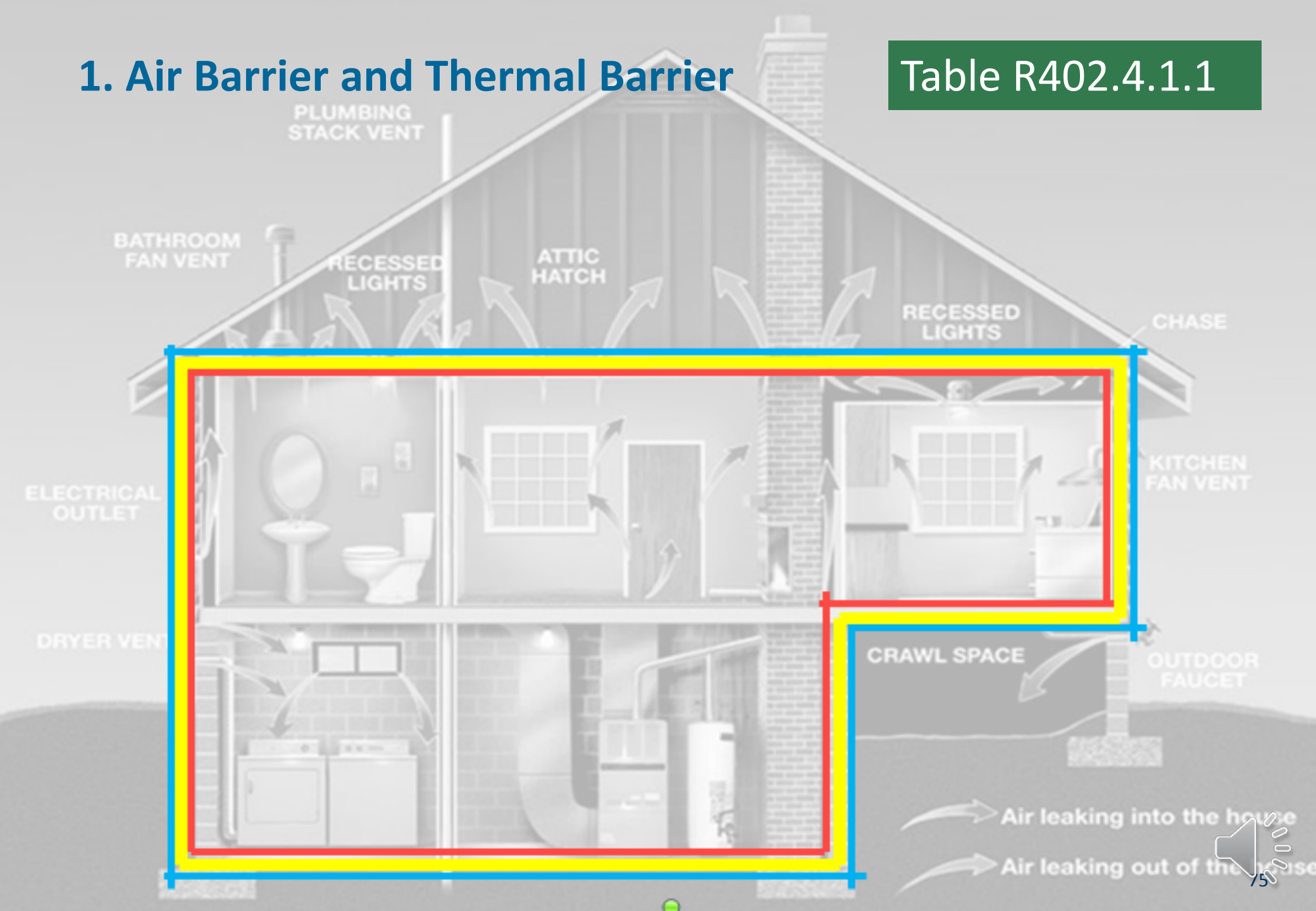
1. Air Barrier and Thermal Barrier

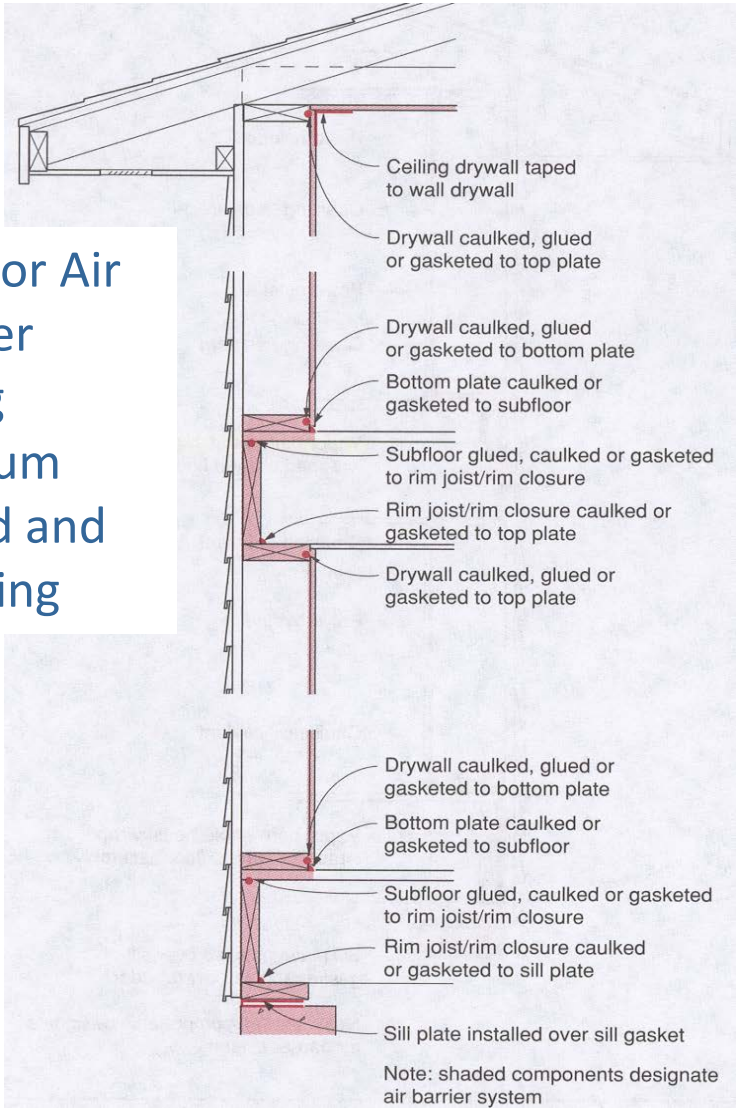
Table R402.4.1.1



1. Air Barrier and Thermal Barrier

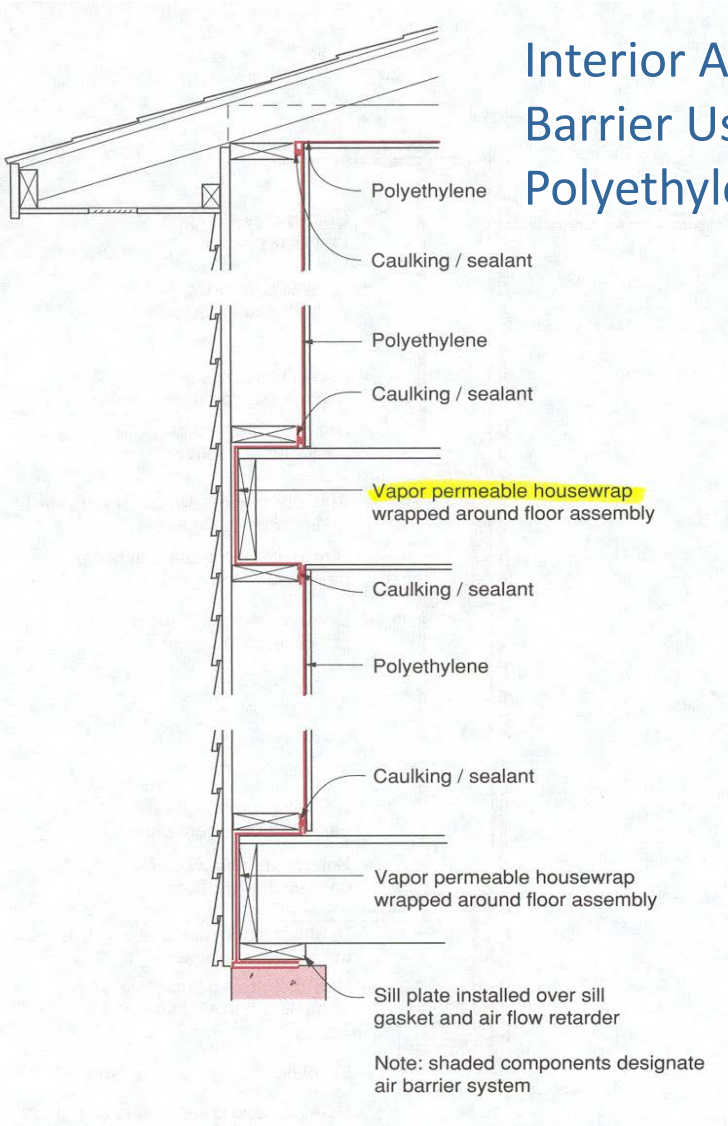
Table R402.4.1.1

Interior Air Barrier Using Gypsum Board and Framing



Source - Builder's Guide to CC

Interior Air Barrier Using Polyethylene

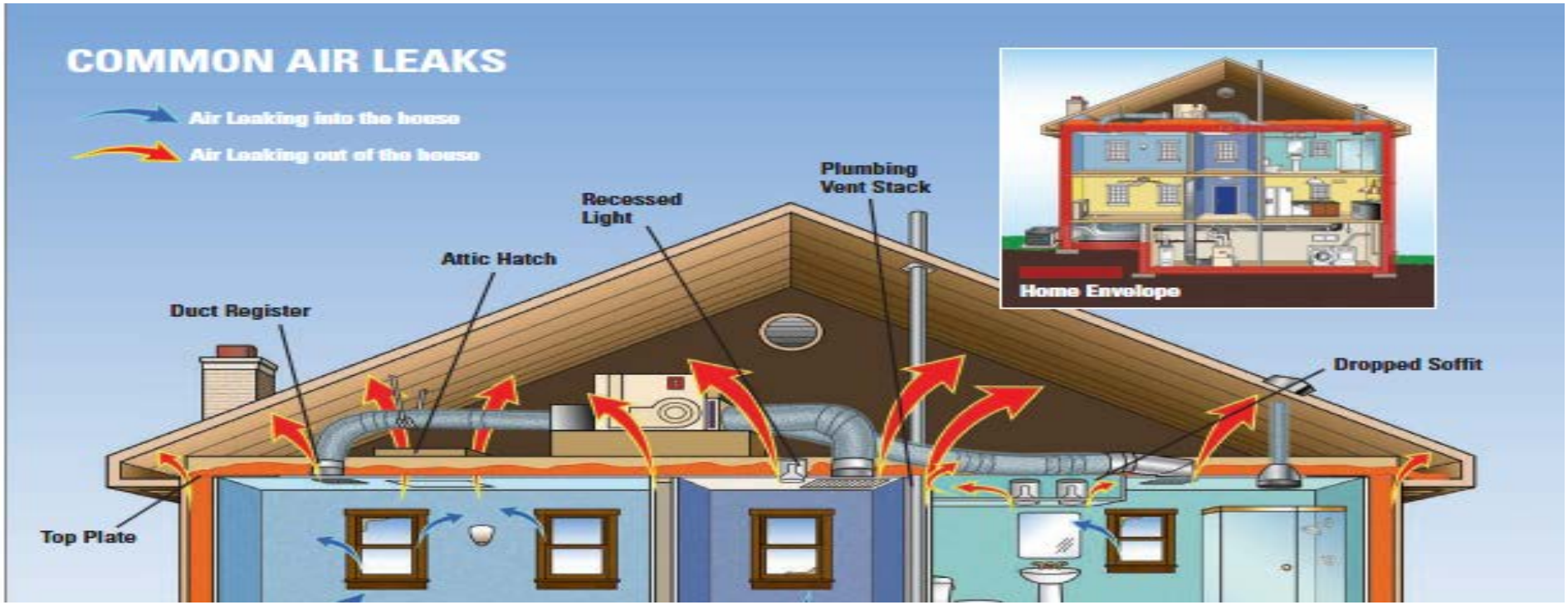


Source - Builder's Guide to CC

DU PONT
Tyvek
HomeWrap
National Lumber
800-370-WOOD

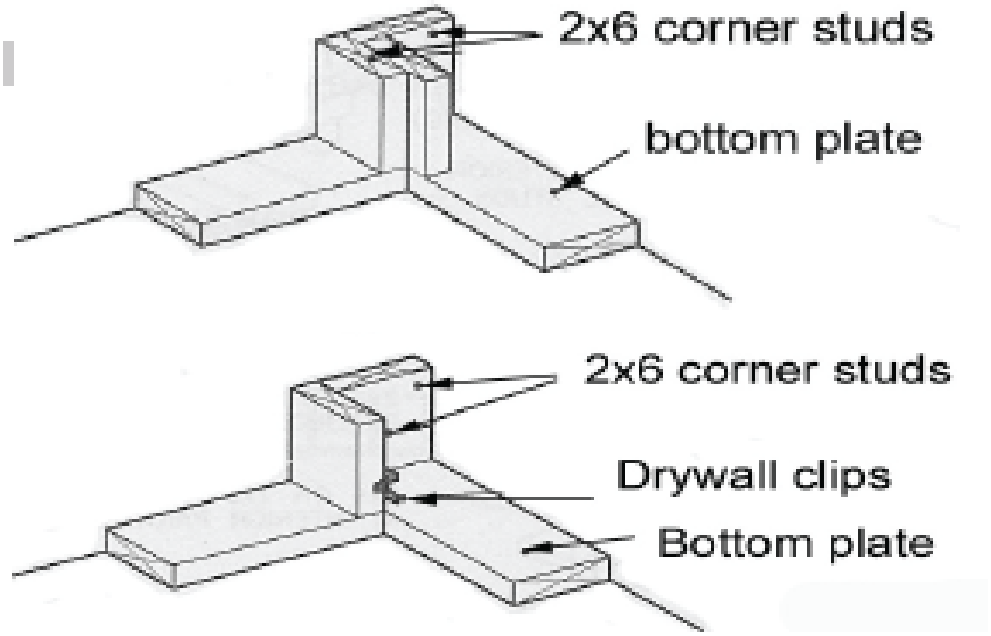
2. Ceiling/attic

Table R402.4.1.1

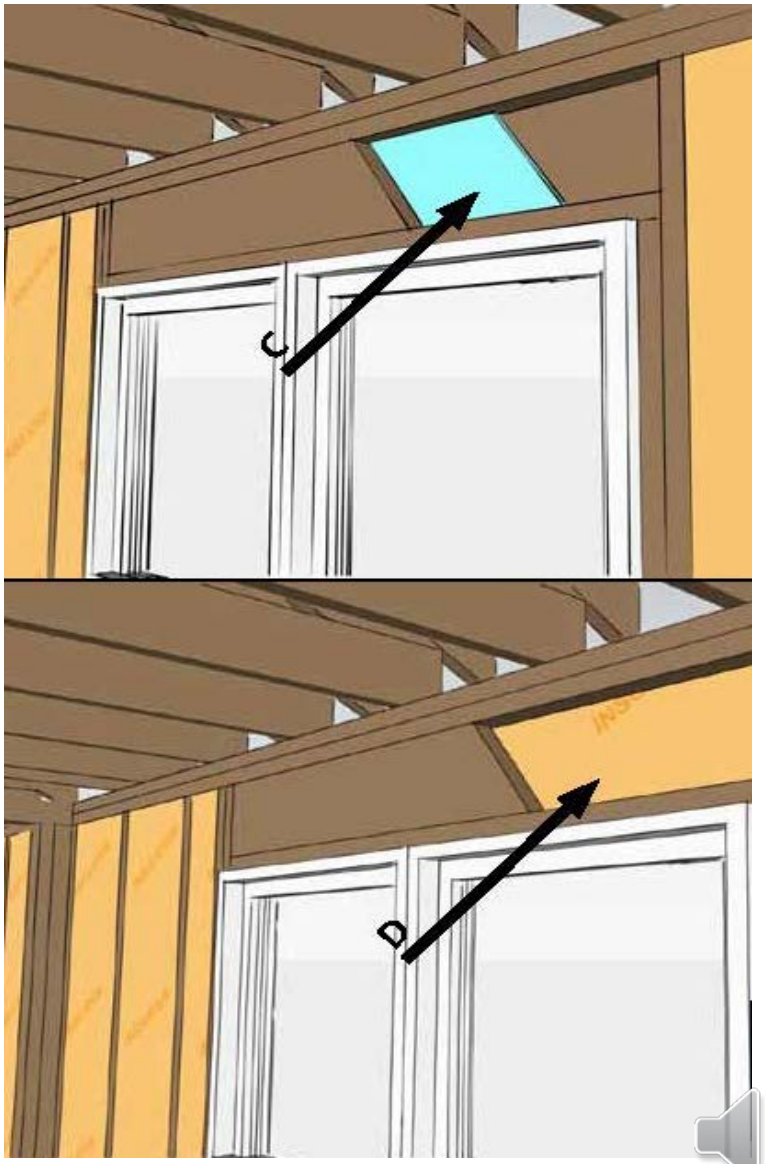


3. Walls

Table R402.4.1.1



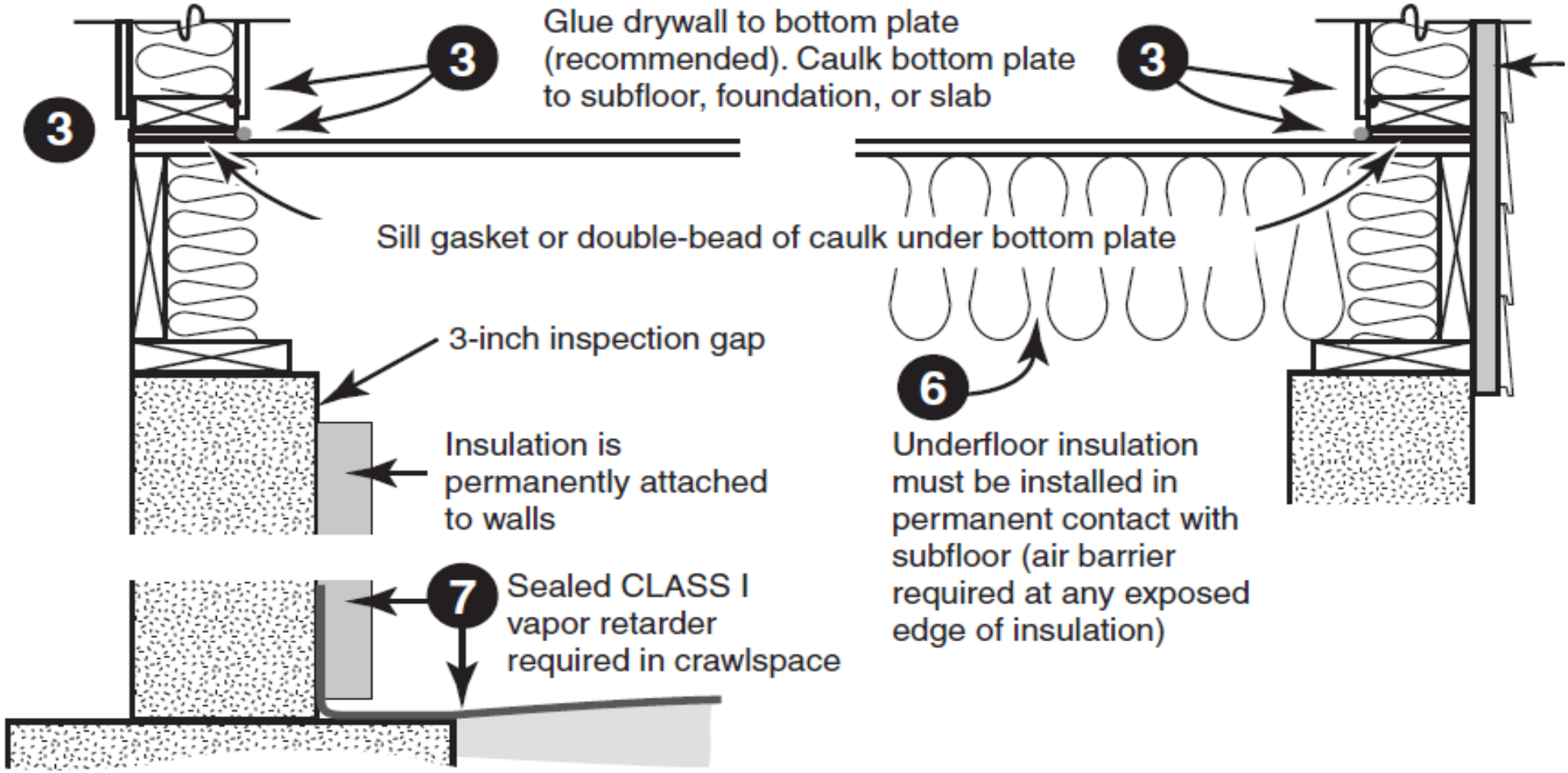
Source: ENERGY STAR New Homes



Source: ENERGY STAR New Homes

3. Walls

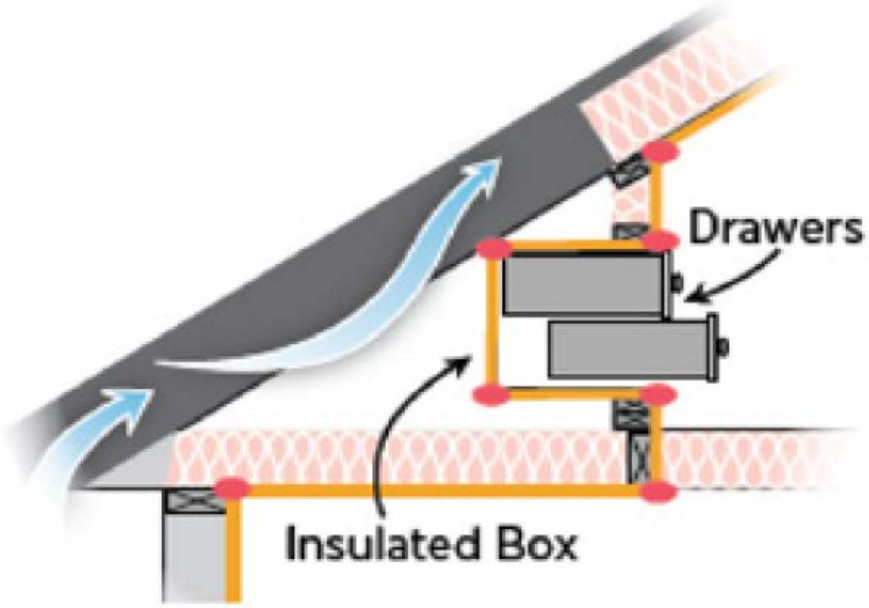
Table R402.4.1.1



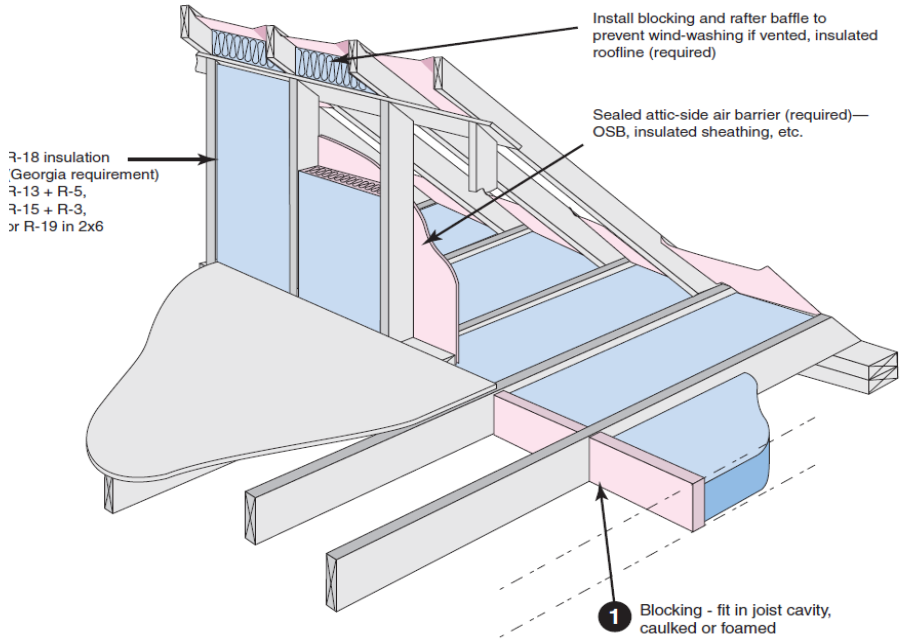
Appendix 2009 IECC

3. Walls

Table R402.4.1.1



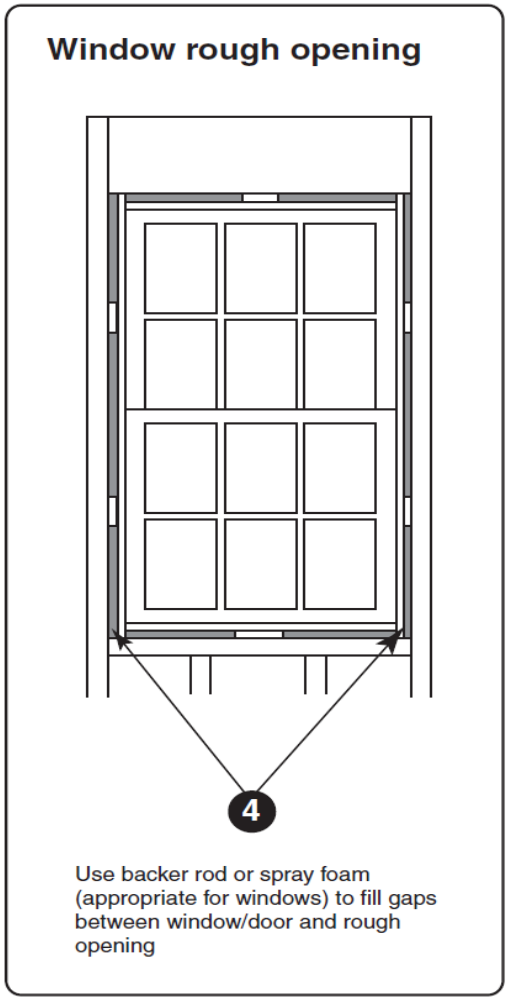
Air sealing key points *continued*



Appendix 2009 IECC

4. Windows, Skylights, and Doors

Table R402.4.1.1



Appendix 2009 IECC

Source: USDOE Building Energy Codes University

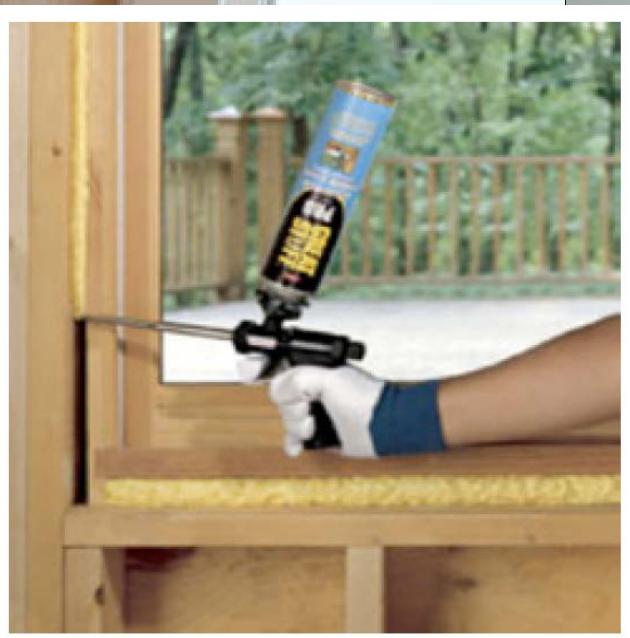


Image: Sprayfoam.com

Source: ENERGY STAR New Homes

5. Rim Joists

Table R402.4.1.1

5. Rim Joists

Table R402.4.1.1

6. Floors

Table R402.4.1.1

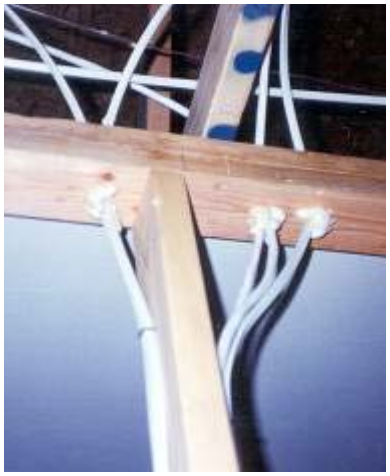
7. Crawl Space Walls

Table R402.4.1.1

8. Shafts, Penetrations

Table R402.4.1.1

Source: USDOE Building Energy Codes University



Source: USDOE Building Technologies Program, Whole-House Energy Savings in Cold and Very Cold Climates

9. Narrow Cavities

Table R402.4.1.1

10. Garage Separation

Table R402.4.1.1

Source: ENERGY STAR New Homes

11. Recessed Lighting

Table R402.4.1.1

Source: ENERGY STAR New Homes

12. Plumbing and Wiring

Table R402.4.1.1

Does Not Comply with Code

13. Shower/Tub on Exterior Wall

Table R402.4.1.1

Source: ENERGY STAR New Homes

Source: ENERGY STAR New Homes

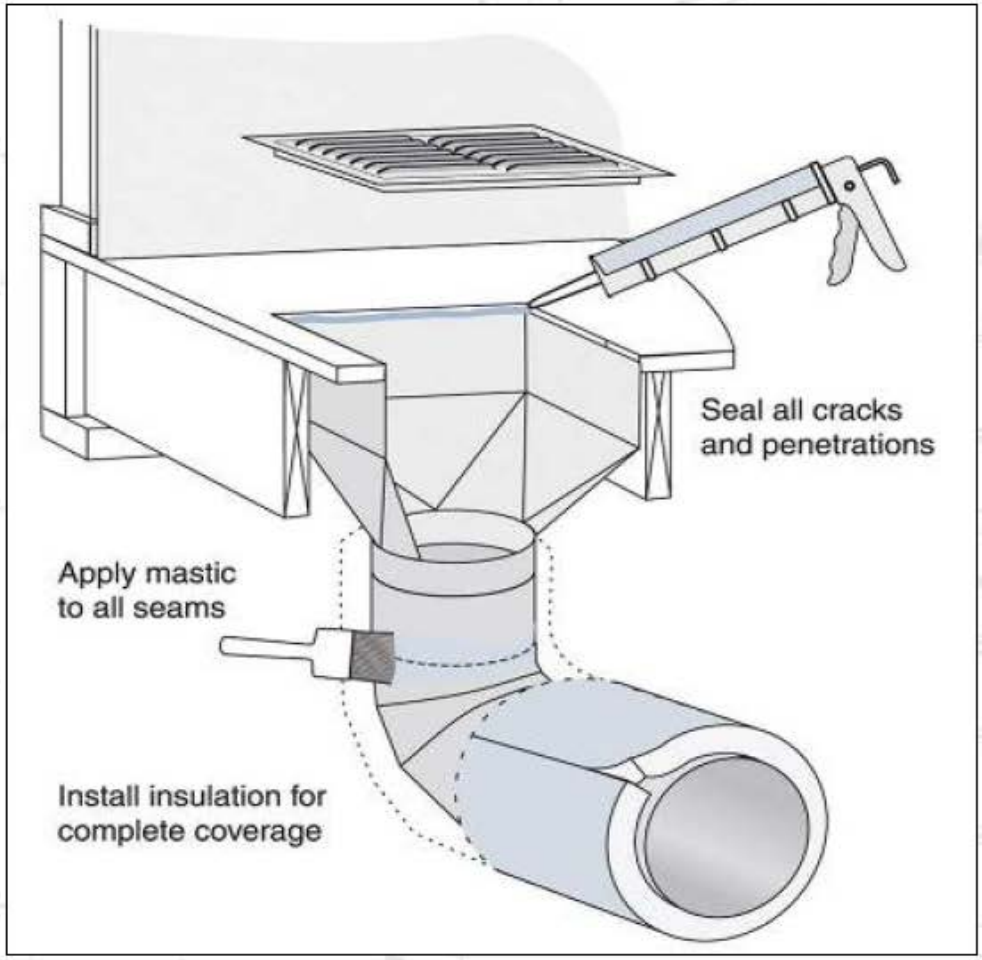
14. Electrical/Phone Box

Table R402.4.1.1

Source: USDOE Building Energy Codes University

15. HVAC Register Boots

Table R402.4.1.1



DUCT BOOTS & SEAMS
SEALED WITH MASTIC

Source: ENERGY STAR New Homes

16. Fireplace

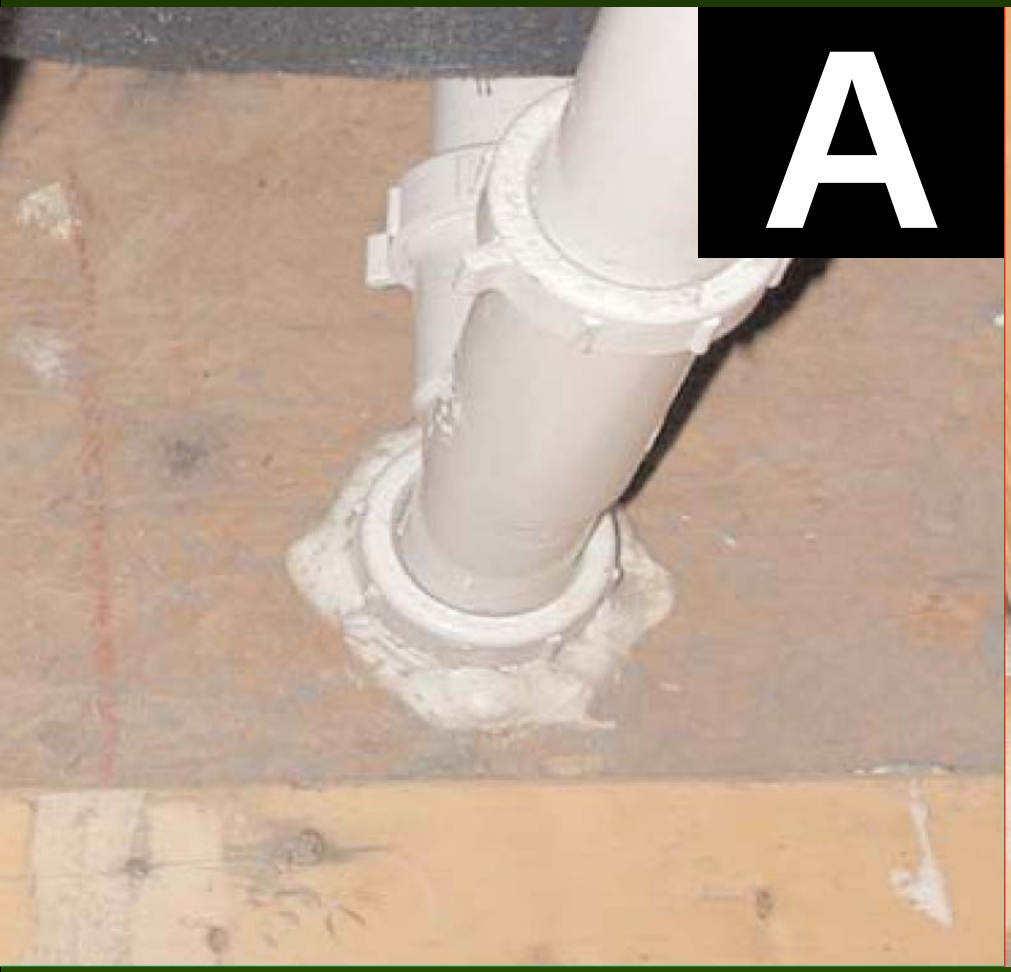
Table R402.4.1.1

Source: ENERGY STAR New Homes

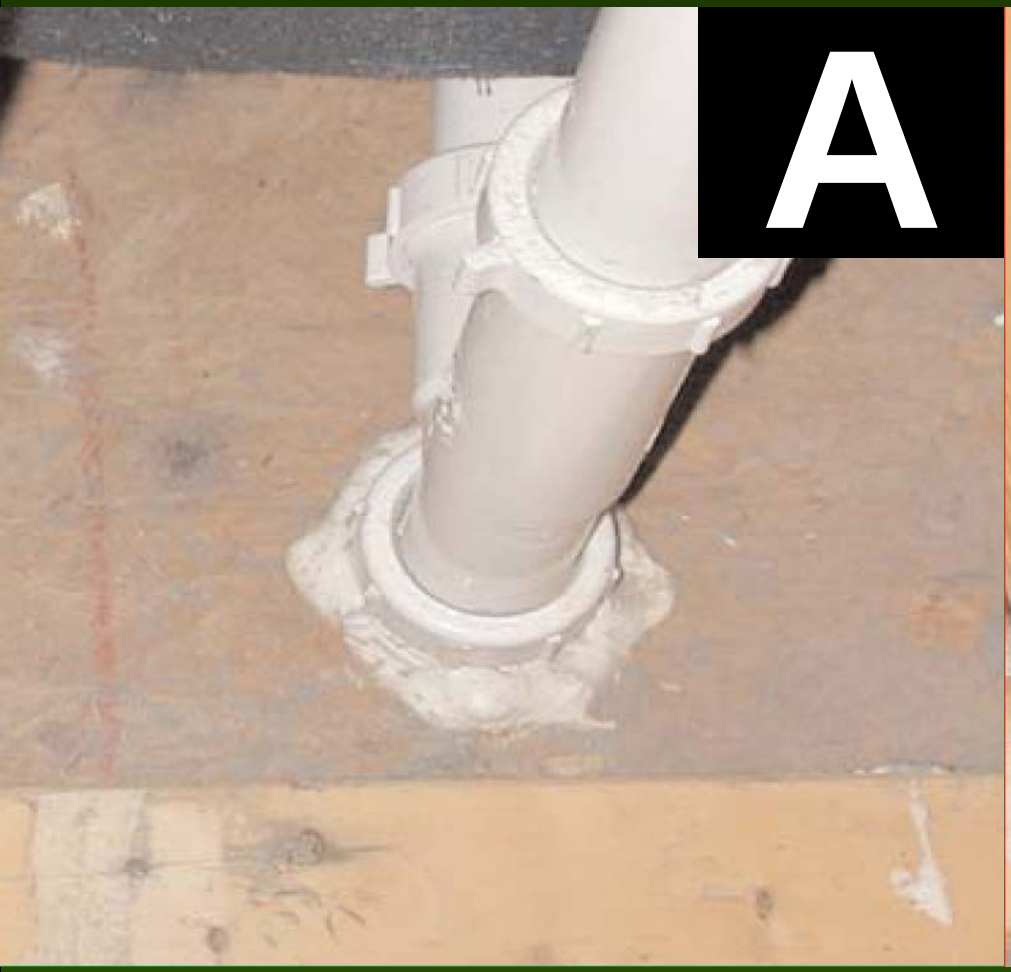
Which sealing installation complies with the energy code?

Which sealing installation complies with the energy code?

Which sealing installation complies with the energy code?



Which sealing installation complies with the energy code?



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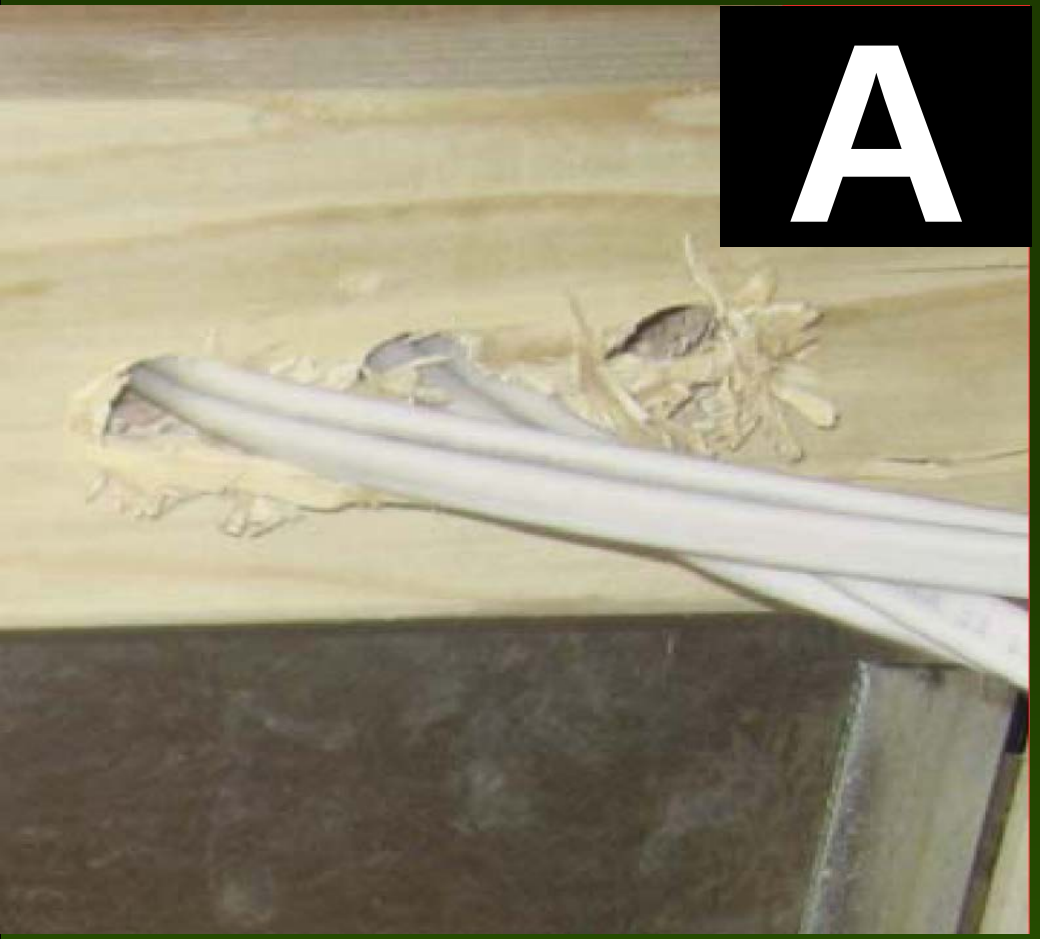
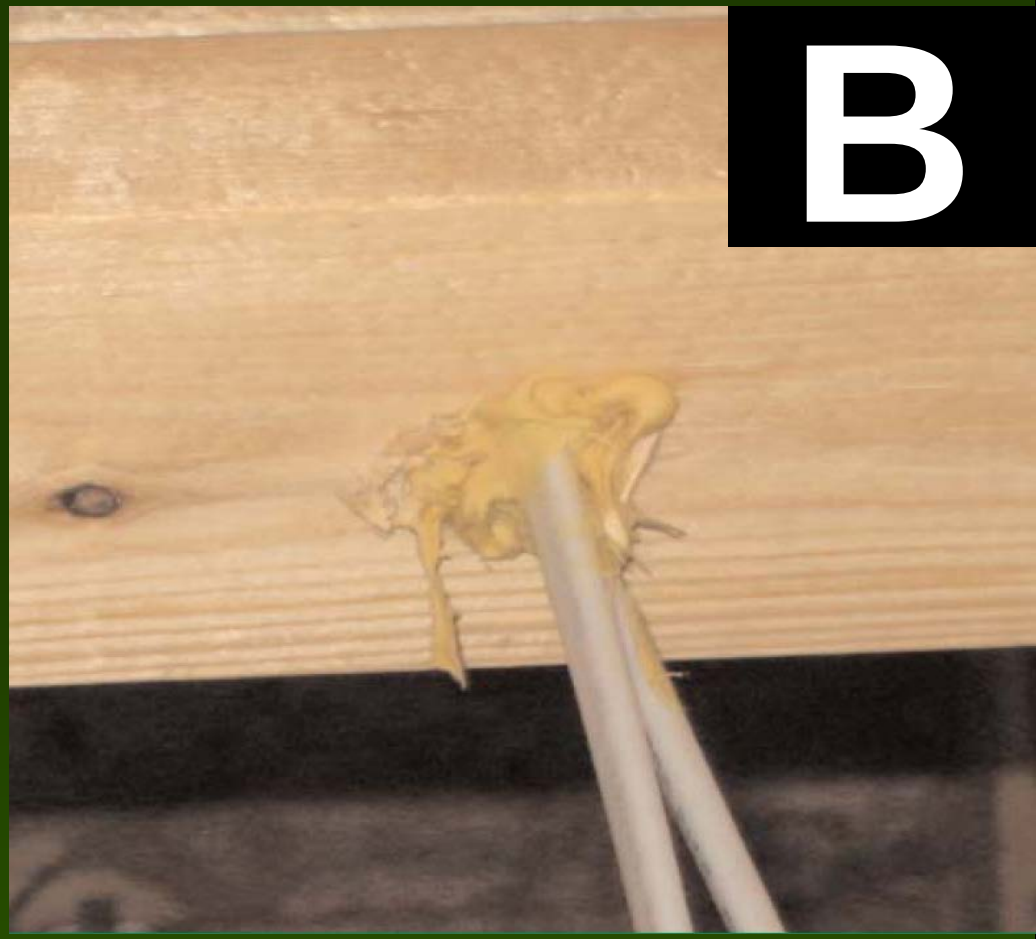
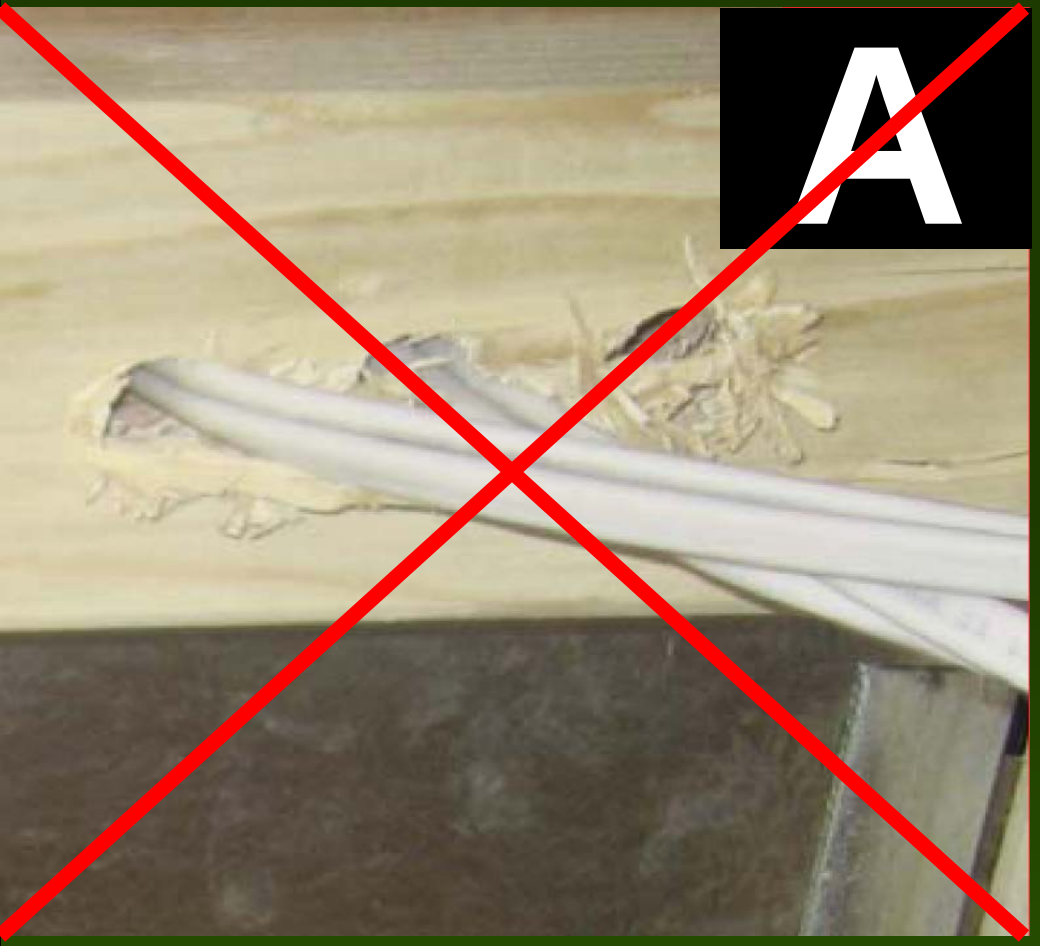
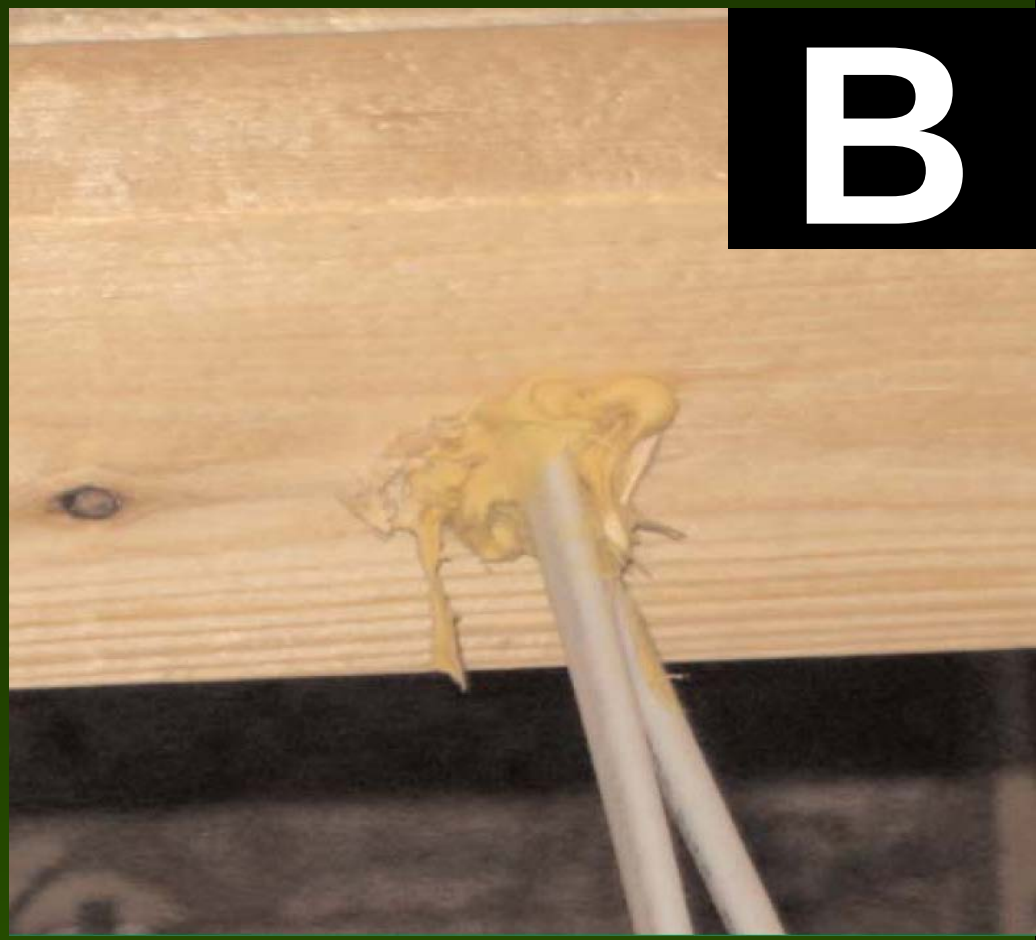




Which sealing installation complies with the energy code?

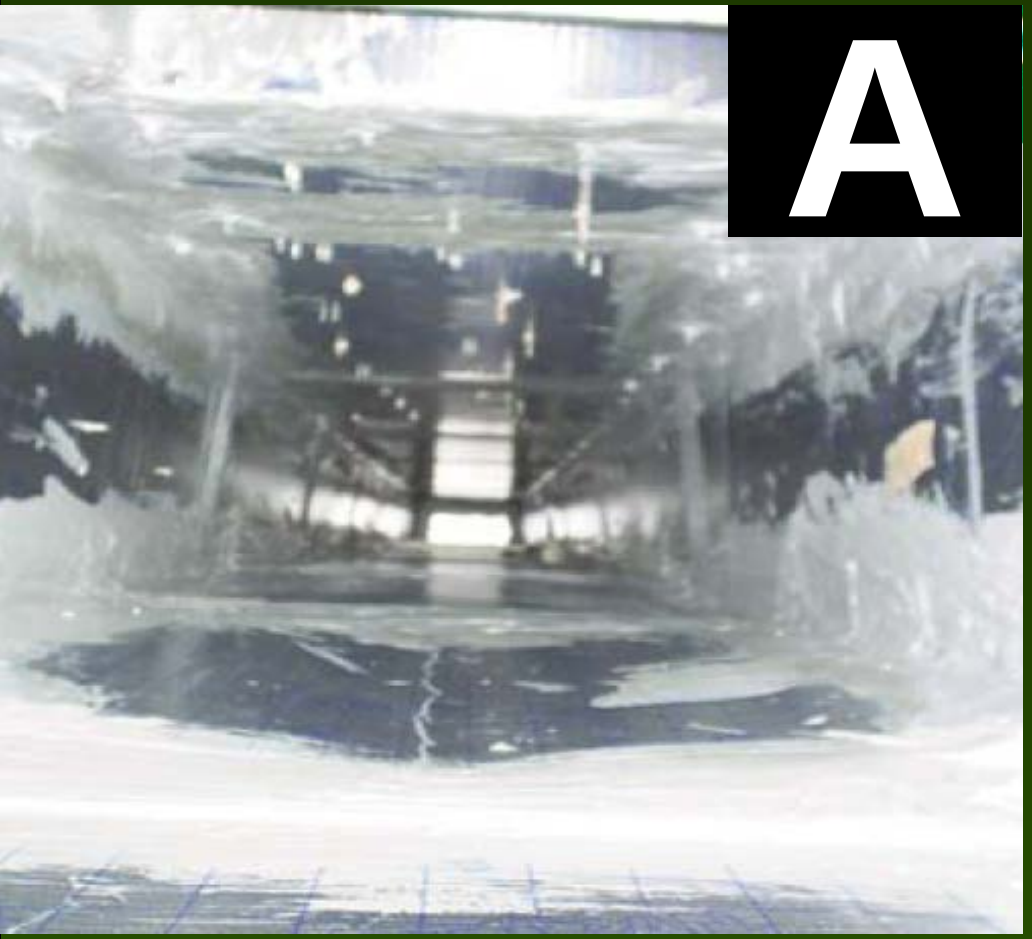




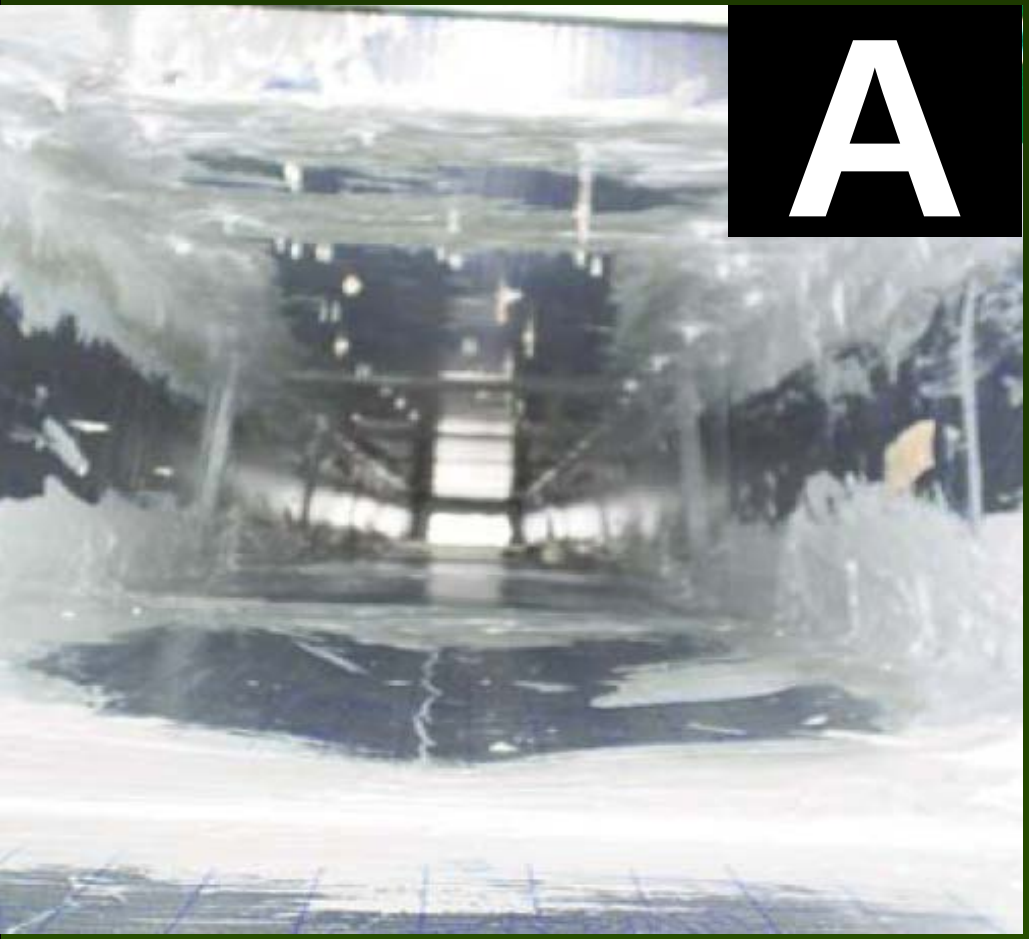
Which complies with the Air Barrier and Insulation Installation Table?

Which complies with the Air Barrier and Insulation Installation Table?

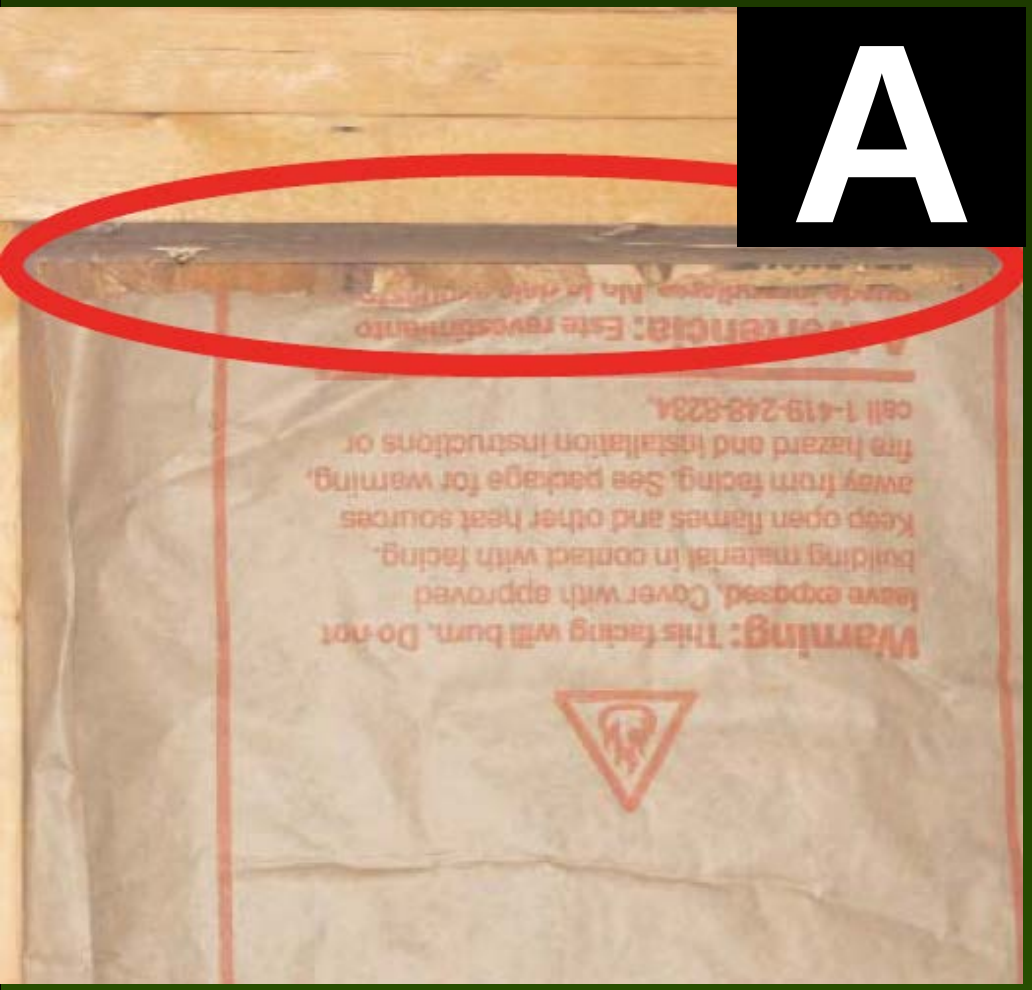
Which supply duct installation complies with the energy code?



Which supply duct installation complies with the energy code?



Which installation complies with the energy code?



Which installation complies with the energy code?

Which installation complies with the energy code?

Which installation complies with the energy code?

Which eave installation complies with the energy code?

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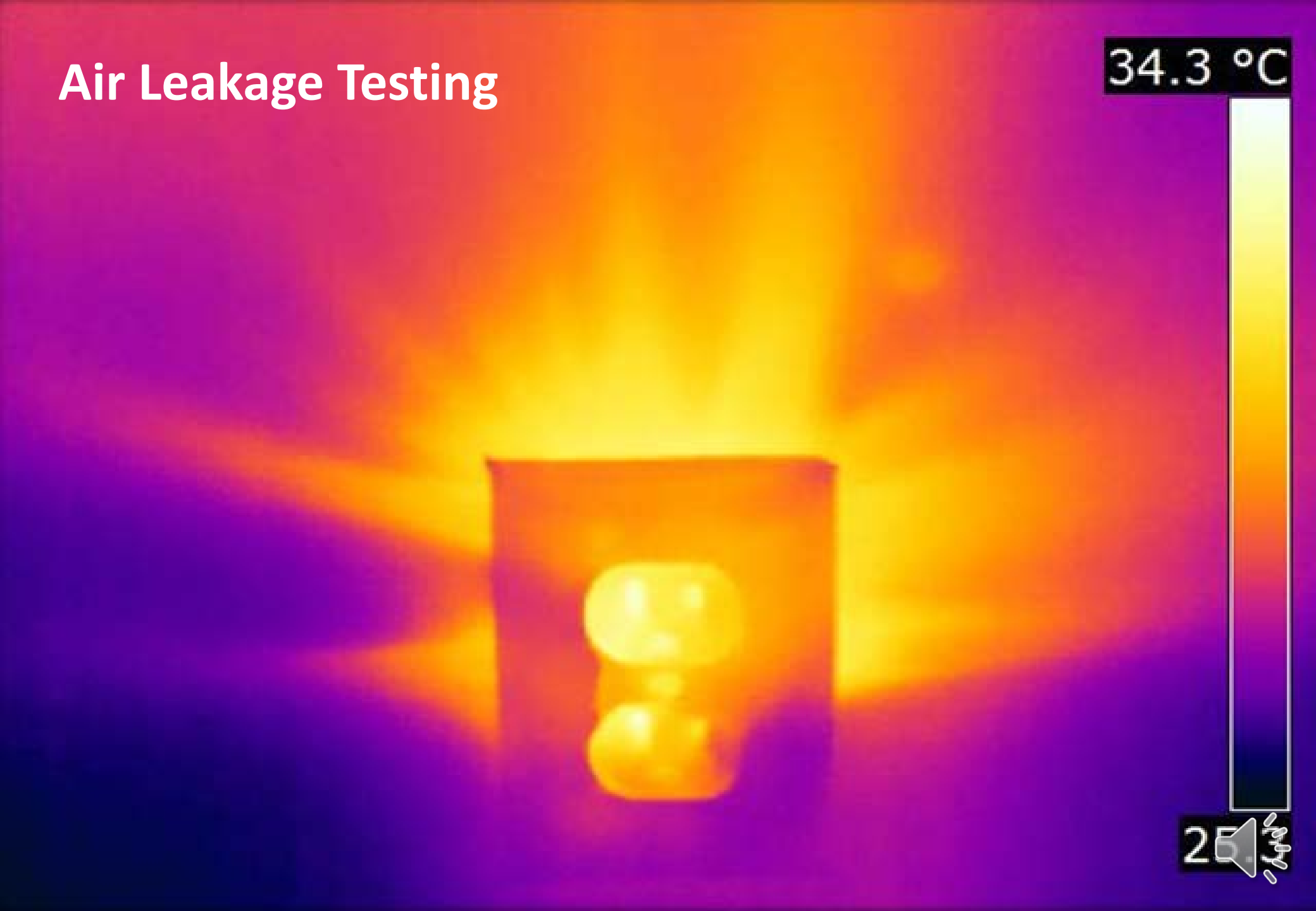
Air Leakage Testing



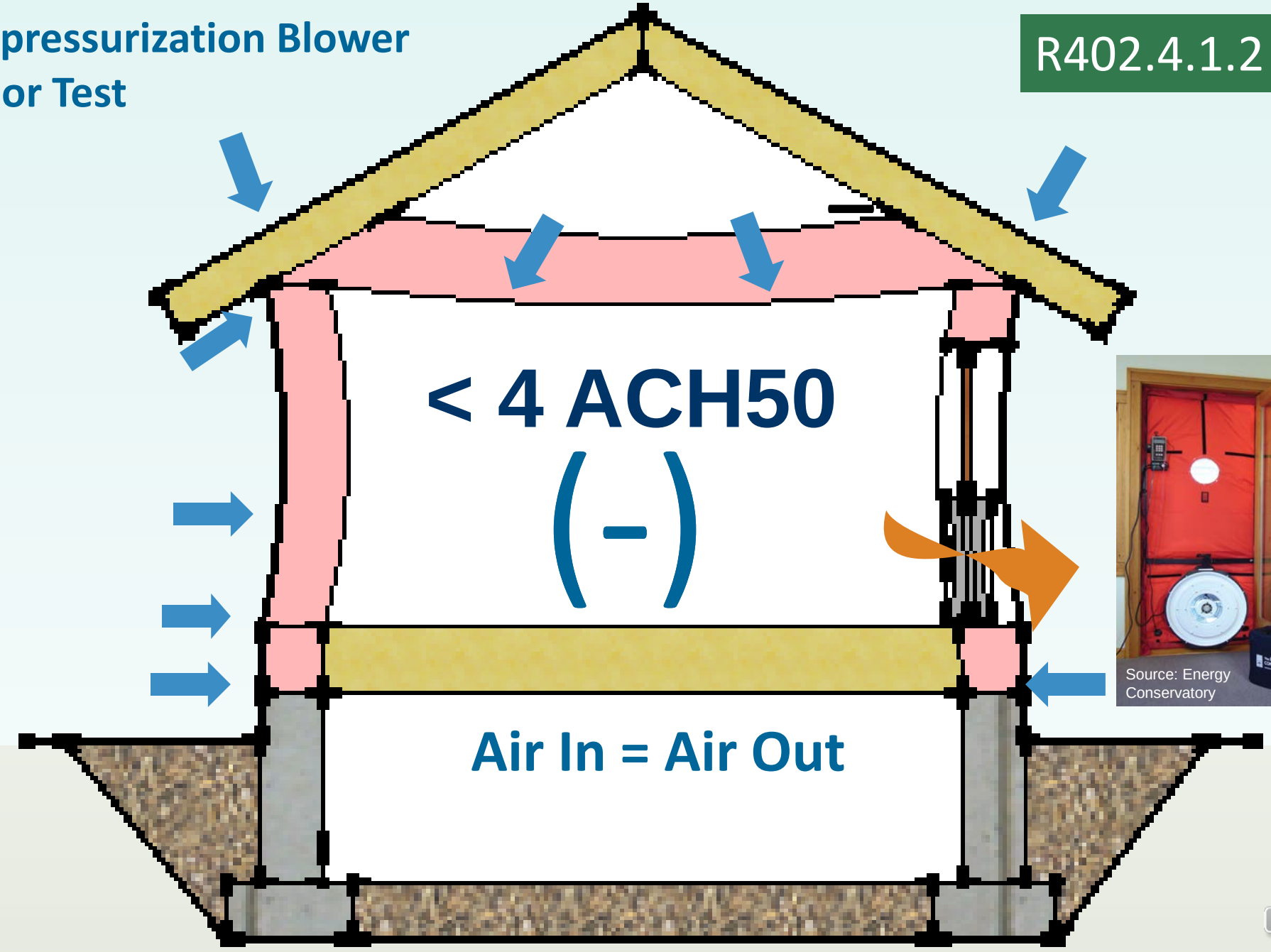
Typical House Tightness Levels

	ACH50	CFM 2000 SF
Older Homes	10+	>2600
Typical New Home ~2000	7	1800
2009 IECC Tightness Limit Zone 6	7	1800
Previous MT State Energy Code	4	1050
New MT State Energy Code	4	1050
Energy Star Homes	4	1050
Idaho New Homes 2013	3.6	930
2012 IECC Tightness Limit Zone 6	3	800

Example based on 2,000 Ft^2 house with n = 14.5.

Depressurization Blower Door Test

R402.4.1.2

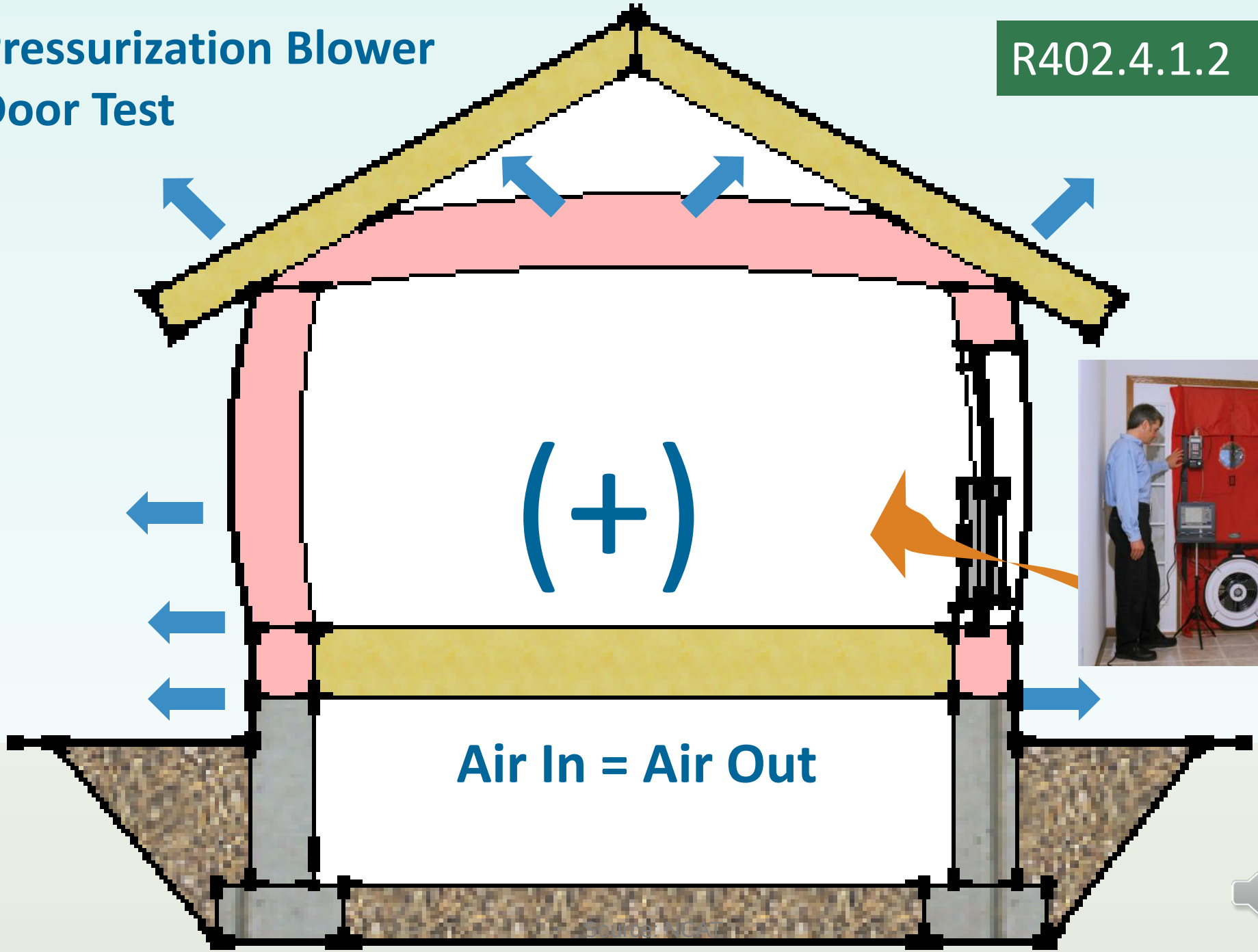


Source: Energy Conservatory

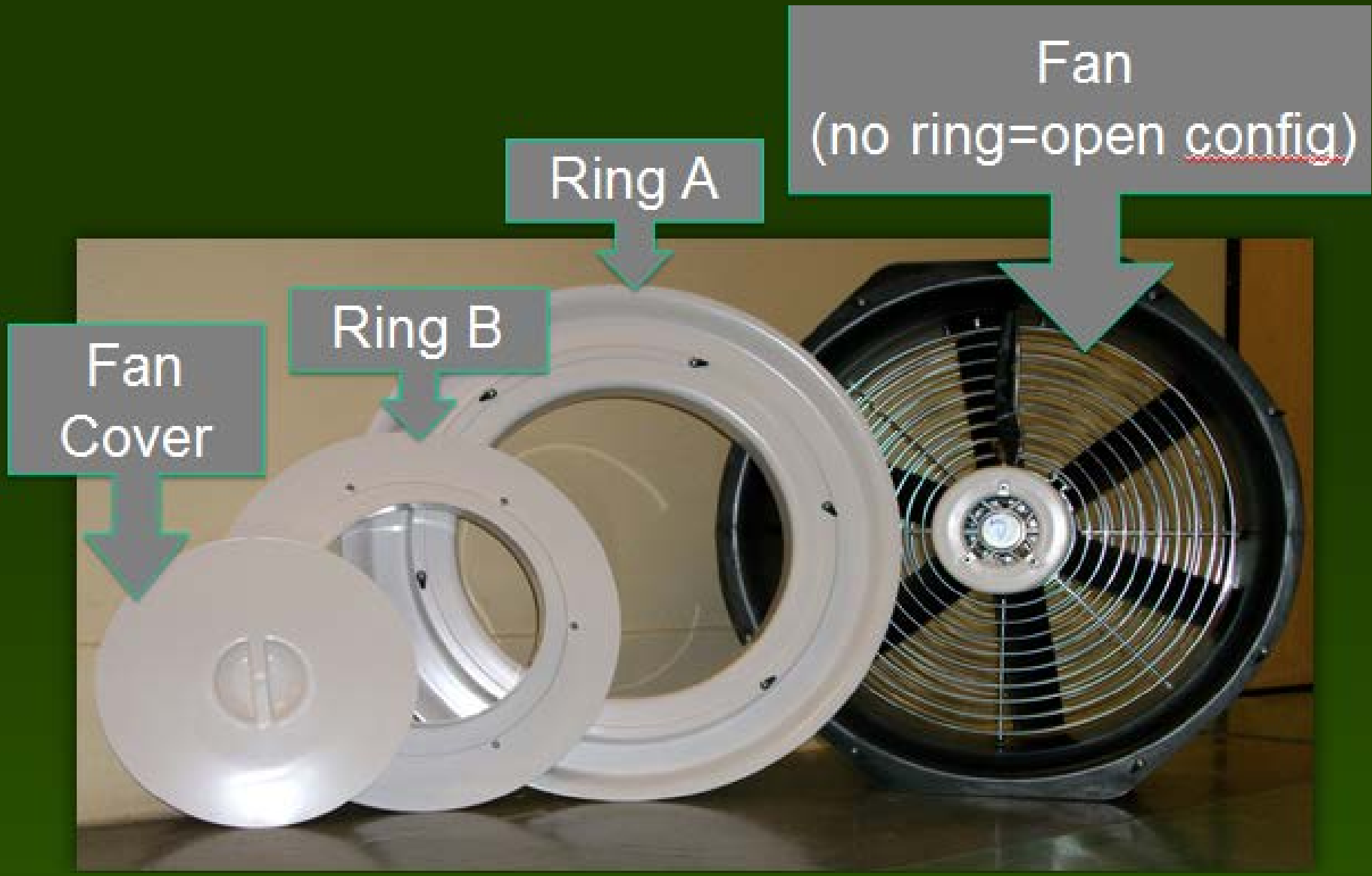
Source: NCAT

Pressurization Blower Door Test

R402.4.1.2



The Blower Door Parts - Rings



The Blower Door – The Skin

The Measurement

Blower Door Test
Depressurizing a House

BD3	A1
-50 Pa	1200 CFM
PR/ FL	1

STEPS

1. Install blower door with fan exhausting air from house. Rings must be to the inside of the house.

2. Connect hoses as shown.

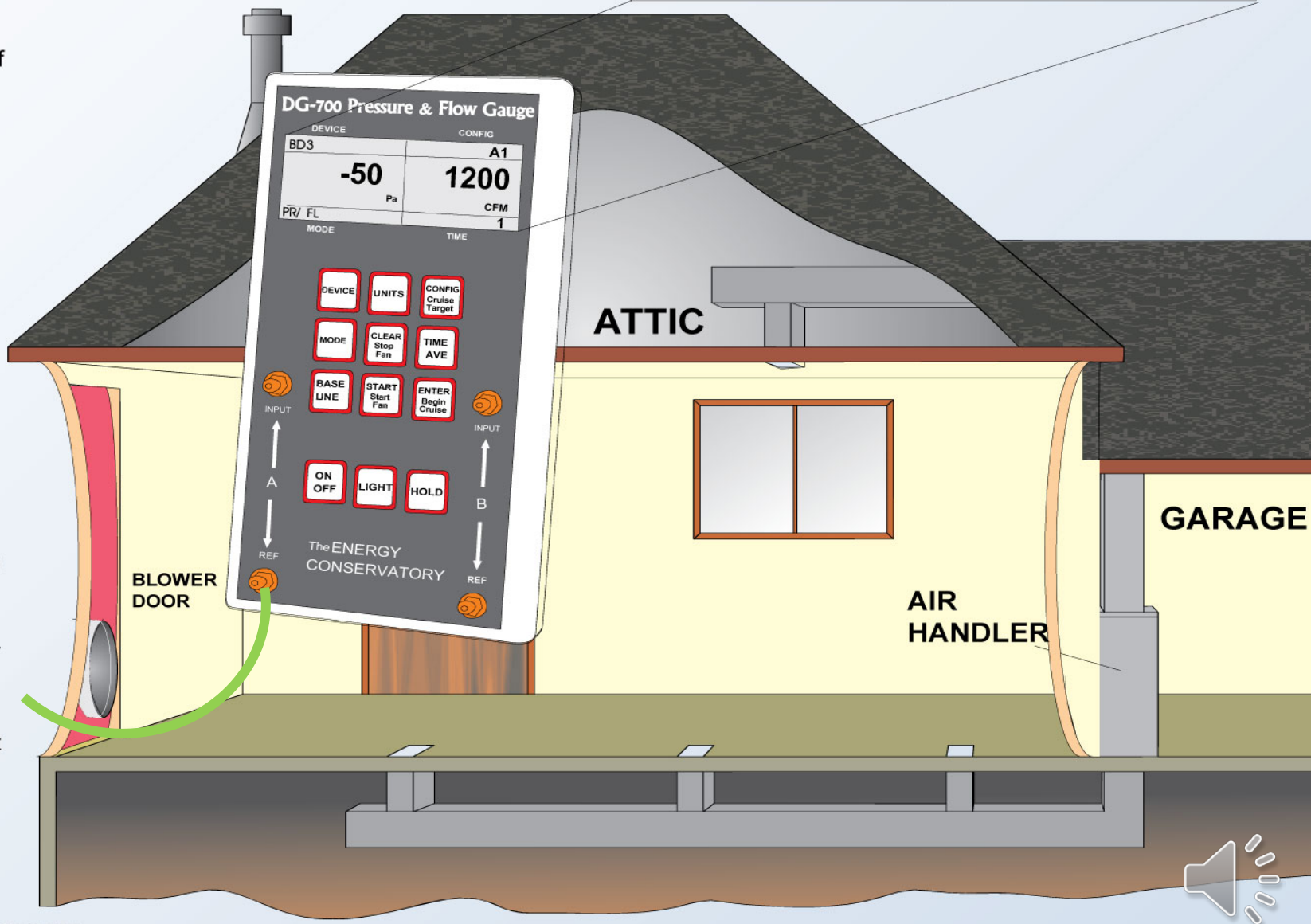
3. Manometer MODE should read PR/FL, CONFIG should reflect ring used (open, A, B, or C), and DEVICE should reflect BD3.

4. Open all interior doors. Close all exterior doors and windows.

5. Turn OFF airhandler, dryer, all fans and combustion equipment.

6. Turn on blower door, depressurize house to -50 Pascals (side A reading), +/- 0.5 Pa. (hint: canvas should be bulging inward). Use the smallest ring possible to get to -50 Pa. If you have to change the ring, be sure to reflect that in the manometer CONFIG setting.

7. Record reading on side B. This is your house cfm leakage at 50 Pa.



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Blower Door Math

To calculate air changes per hour at 50 Pa:

$$ACH_{50} = \frac{CFM_{50} \times 60}{\text{House Volume}}$$

House volume is cubic feet enclosed by the conditioned space boundary including exterior walls.

R403.2.2

PLUG, don't paint!
THICK AS A NICKEL

Duct Tightness Testing

R403.2.2

Postconstruction Test

Total Leakage or Leakage to the Outside

<= 4 cfm/100 SF (at 25 PA)

Former leakage to outside limit was 8 cfm/100 SF

Former total leakage limit was 12 cfm/100 SF

Rough-in Test

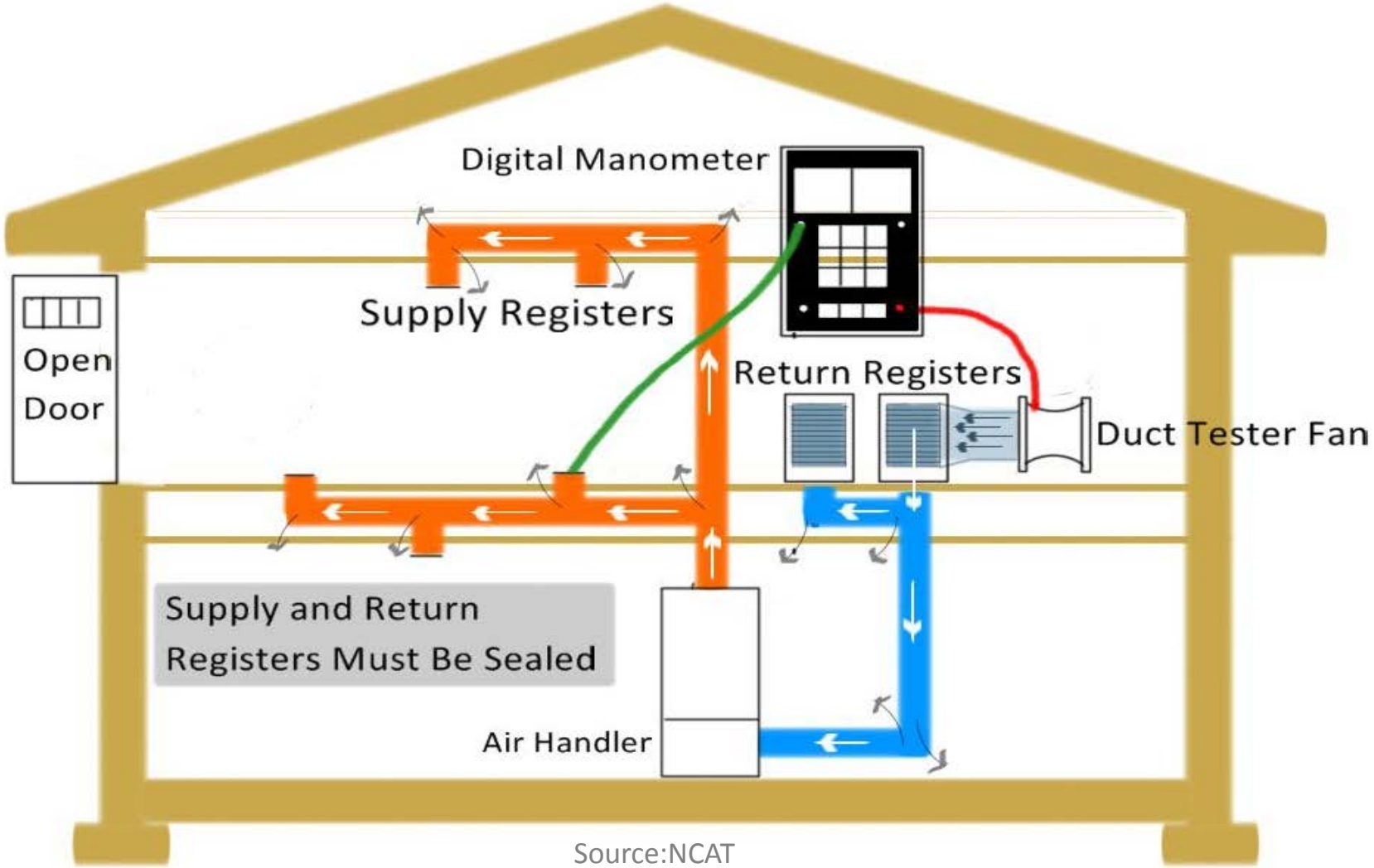
Total Leakage

<= 4 cfm/100 SF (at 25 PA)

Former total leakage limit was 6 cfm/100 SF

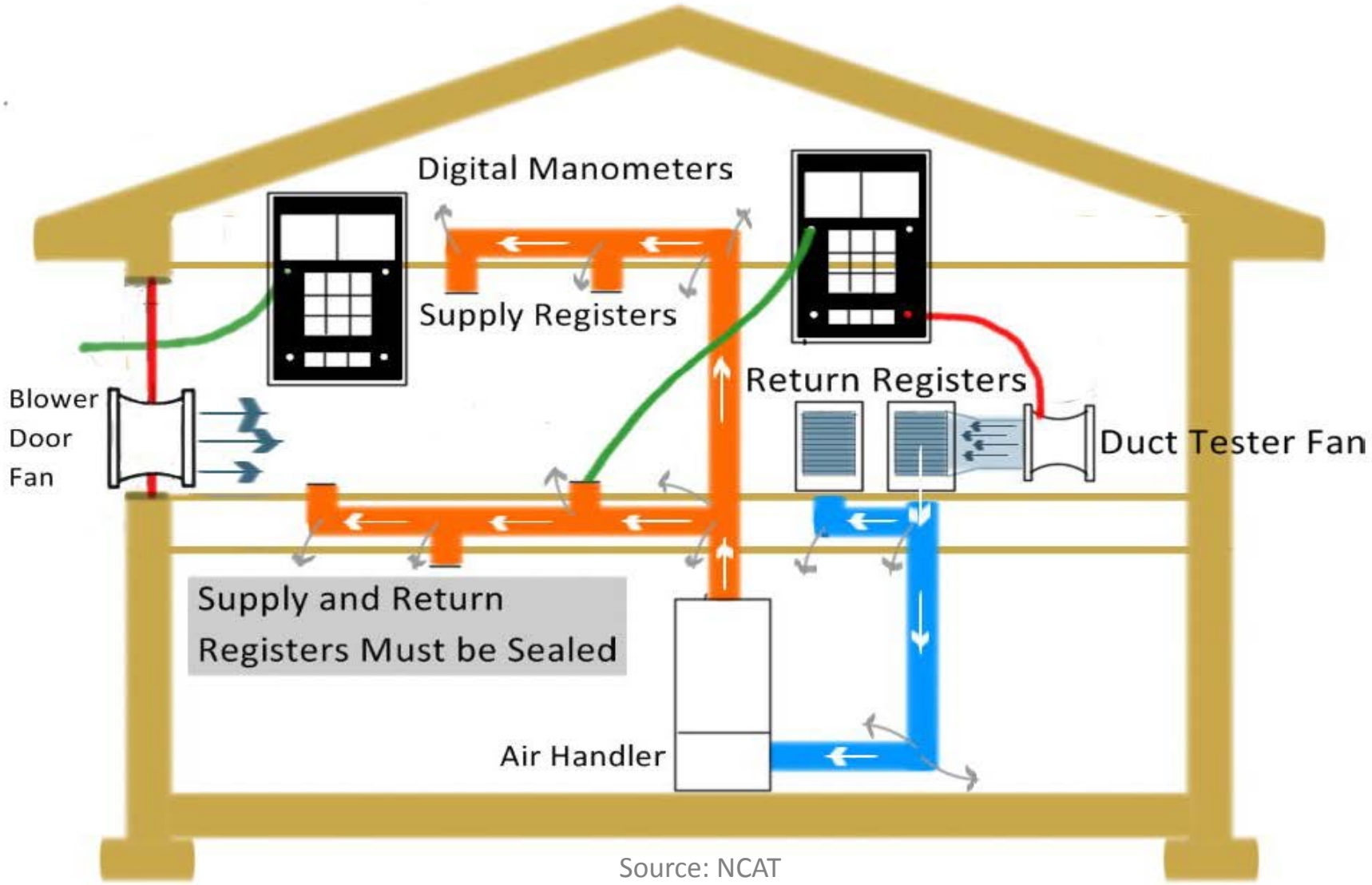
Testing not required if ducts and air handler entirely within building thermal envelope.

Total Duct Leakage Test



Source:NCAT

Duct Leakage to the Outside



Source: NCAT

Duct Tightness Testing

Source: USDOE Building Energy Codes University

Duct Tightness Testing

The Never Connected and the Disconnected

Source: PTCS

Building Cavities as Return Ducts (Mandatory) R403.2.3

2012 IECC prohibits use of building cavities for either supply or return.

Montana amendments allow use of building cavities for returns.

Source: USDOE Building Energy Codes University

Service Hot Water Systems

R403.4.2

R-3 Insulation on:

- Piping > ¾ in. nominal diameter
- Piping serving more than one dwelling unit
- ~~Piping from the water heater to kitchen outlets~~
- Piping located outside the conditioned space
- Piping from the water heater to a distribution manifold
- Piping under a floor slab
- Buried piping
- Supply and return piping in recirculating systems other than demand recirculation systems
- ~~Piping with run lengths > maximum run lengths for nominal pipe diameter in Table R403.4.2~~

~~All remaining piping to be at least R-3 or meet run length requirements in Table R403.4.2~~

IRC R303.4

Whole house mechanical ventilation mandatory when house is tighter than 5 ACH50.

"Build it tight and ventilate it right"

Mechanical Ventilation Fan Efficacy R403.5.1

Whole-house mechanical ventilation system fans to meet efficacy in Table R403.5.1

Exception When fans are integral to tested and listed HVAC equipment, powered by electronically commutated motor

TABLE R403.5.1 MECHANICAL VENTILATION SYSTEM FAN EFFICACY			
FAN LOCATION	AIR FLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)	AIR FLOW RATE MAXIMUM (CFM)
Range hoods	Any	2.8 cfm/watt	Any
In-line fan	Any	2.8 cfm/watt	Any
Bathroom, utility room	10	1.4 cfm/watt	< 90
Bathroom, utility room	90	2.8 cfm/watt	Any

Continuous Mechanical Ventilation

IRC M1507.3.3

TABLE M1507.3.3(1)
CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

	NUMBER OF BEDROOMS				
DWELLING UNIT FLOOR AREA (square feet)	**0-1**	**2-3**	**4-5**	**6-7**	**> 7**
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 - 3,000	45	60	75	90	105
3,001 - 4,500	60	75	90	105	120
4,501 - 6,000	75	90	105	120	135
6,001 - 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

Continuous Mechanical Ventilation

IRC M1507.3.3

TABLE M1507.3.3(1)
CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

	NUMBER OF BEDROOMS				
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	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 - 3,000	45	60	75	90	105
3,001 - 4,500	60	75	90	105	120
4,501 - 6,000	75	90	105	120	135
6,001 - 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

Intermittent Mechanical Ventilation

IRC M1507.3.3

TABLE M1507.3.3(2)
Intermittent Whole-House Mechancial Ventilation Rate Factors

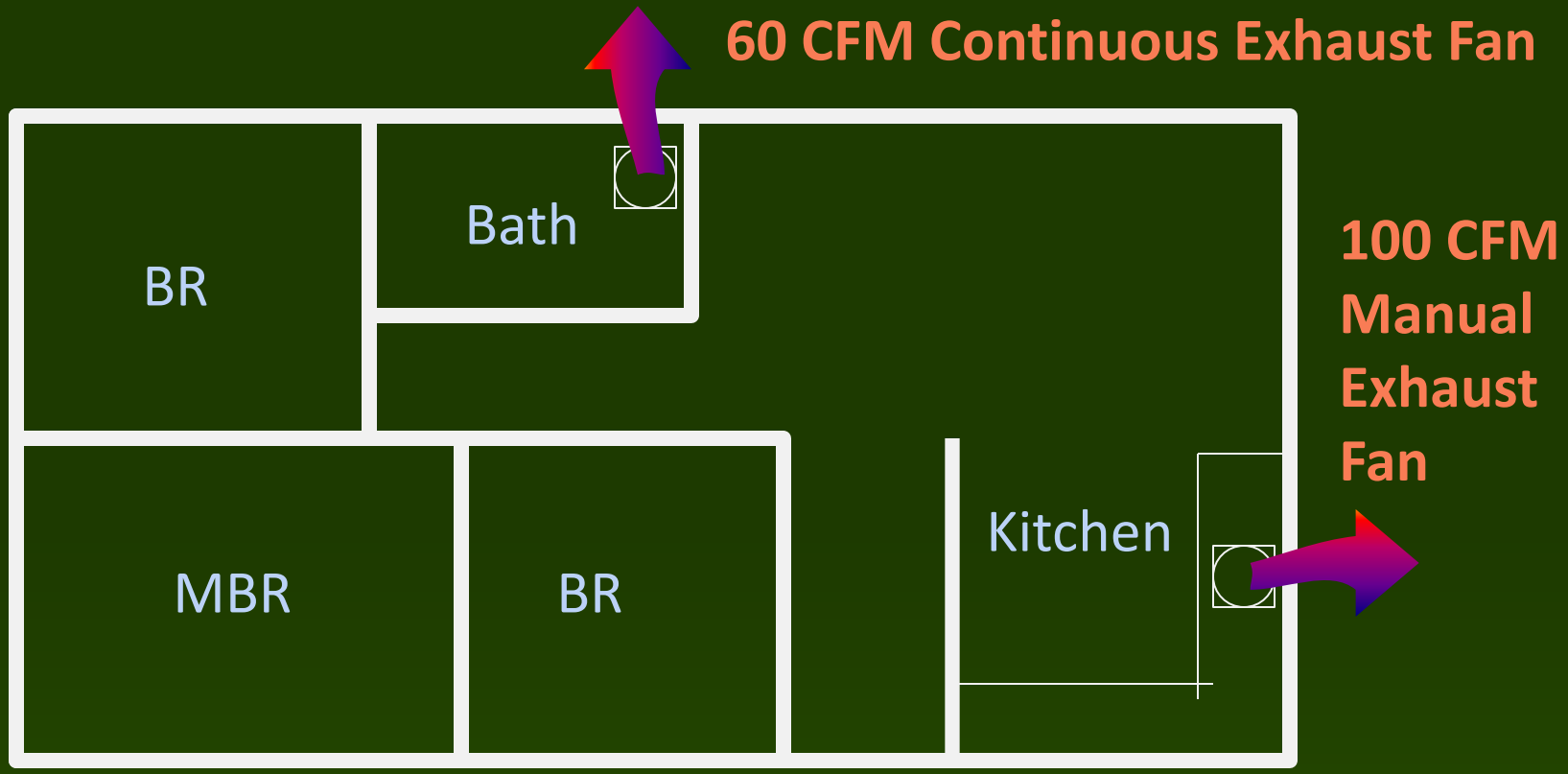
Run-Time Percent in Each 4-Hour Segment	25%	33%	50%	66%	75%	100%
Factor	4	3	2	1.5	1.3	1.0

Local Exhaust

IRC M1507.3.3

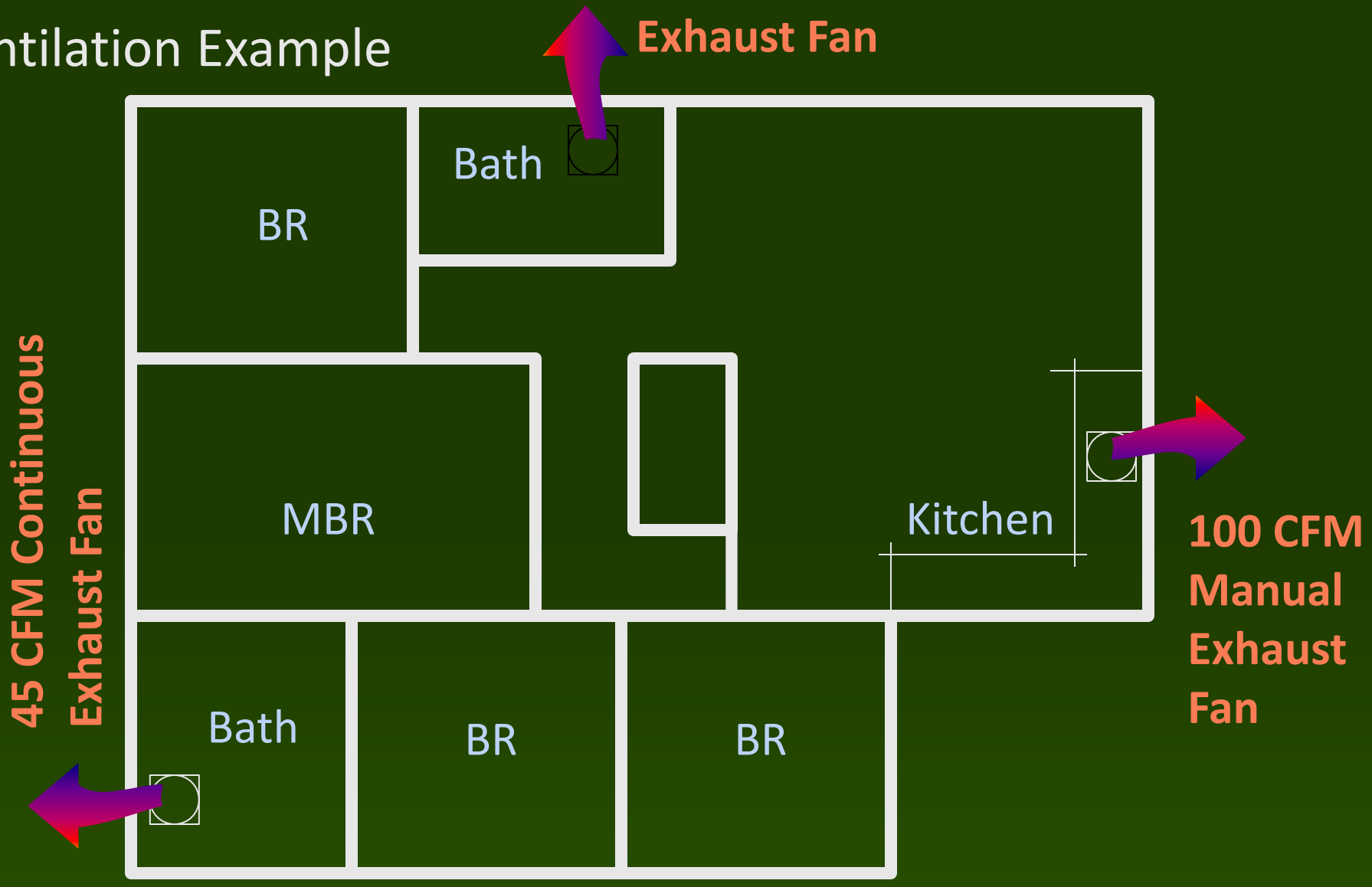
Table M1507.4 Minimum Rquired Local Exhaust Rates for One- and Two-Family Dwellings	
Area to Be Exhausted	**Exhaust Rates**
Kitchens	**100 cfm intermittent or 25 cfm continuous**
Bathrooms-Toilet Rooms	**Mechanical exhaust capacity of 50 cfm intermittent or 20 cfm continuous**

Whole House Ventilation Example



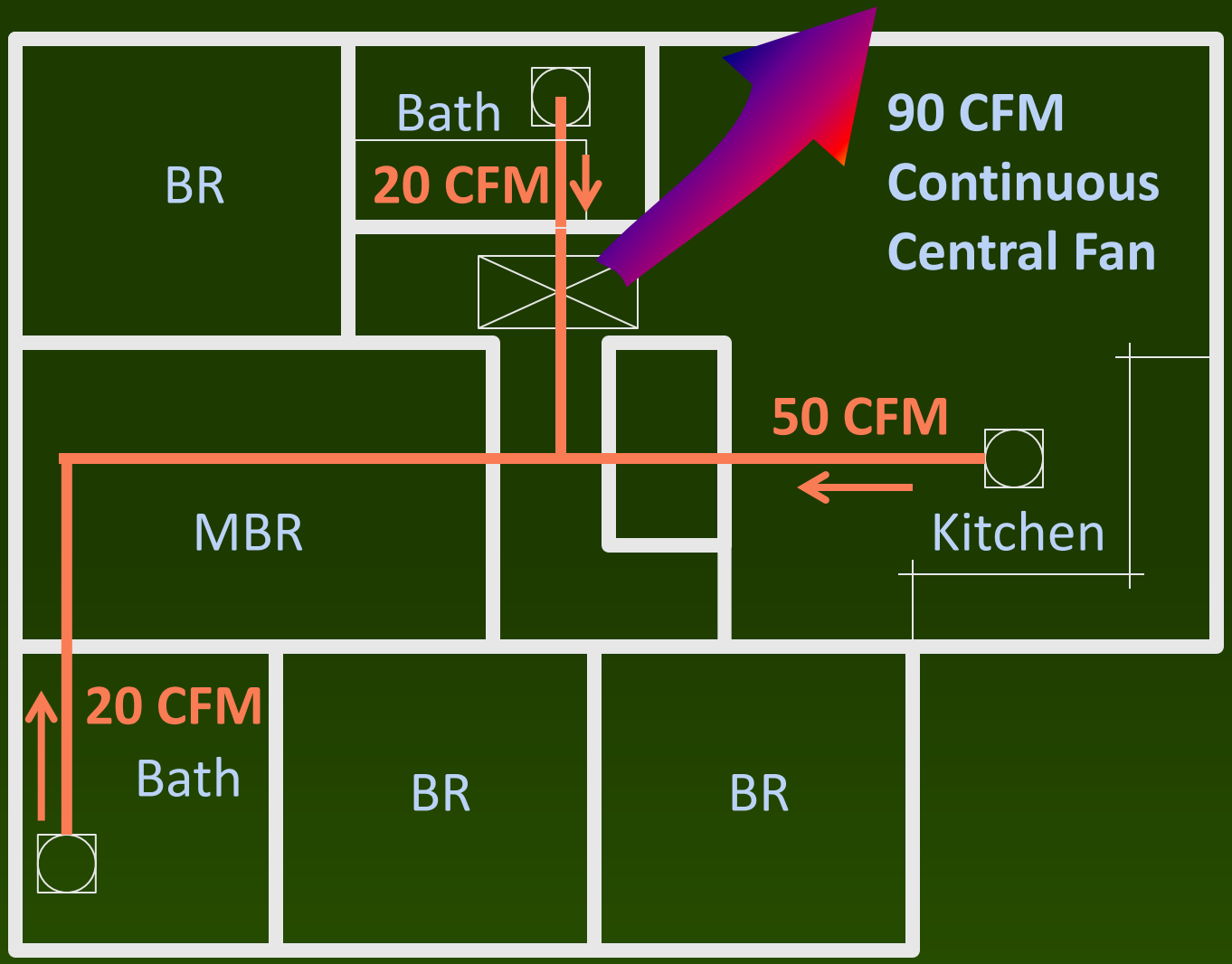
3BR, 2000 SF House = 60 CFM Needed

Whole House Ventilation Example



4BR, 3600 SF House = 90 CFM Needed

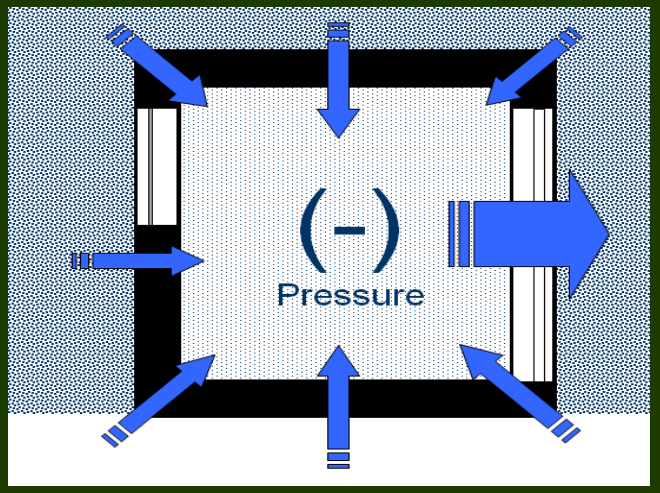
Whole House Ventilation Example



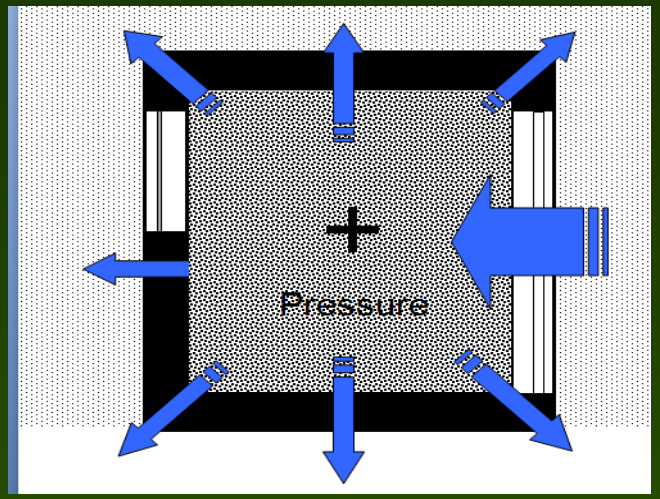
4BR, 3600 SF House = 90 CFM Needed

Mechanical Ventilation Strategies

Exhaust Only



Supply Only

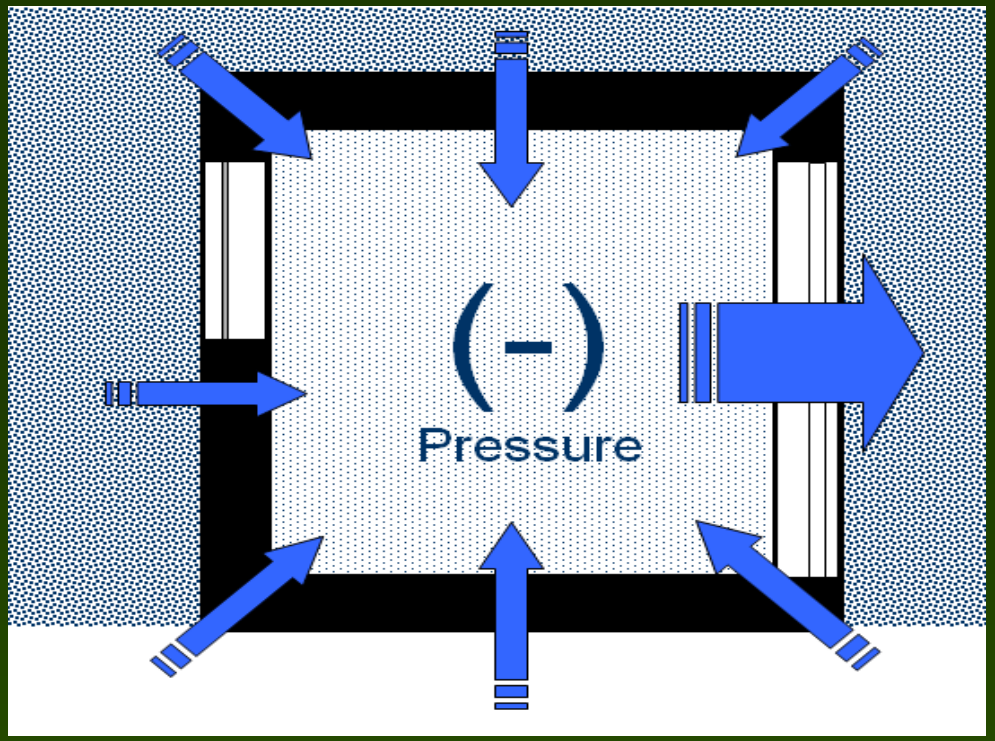


Balanced without Heat Recovery

Balanced with Heat Recovery

Mechanical Ventilation Strategies

Exhaust Only

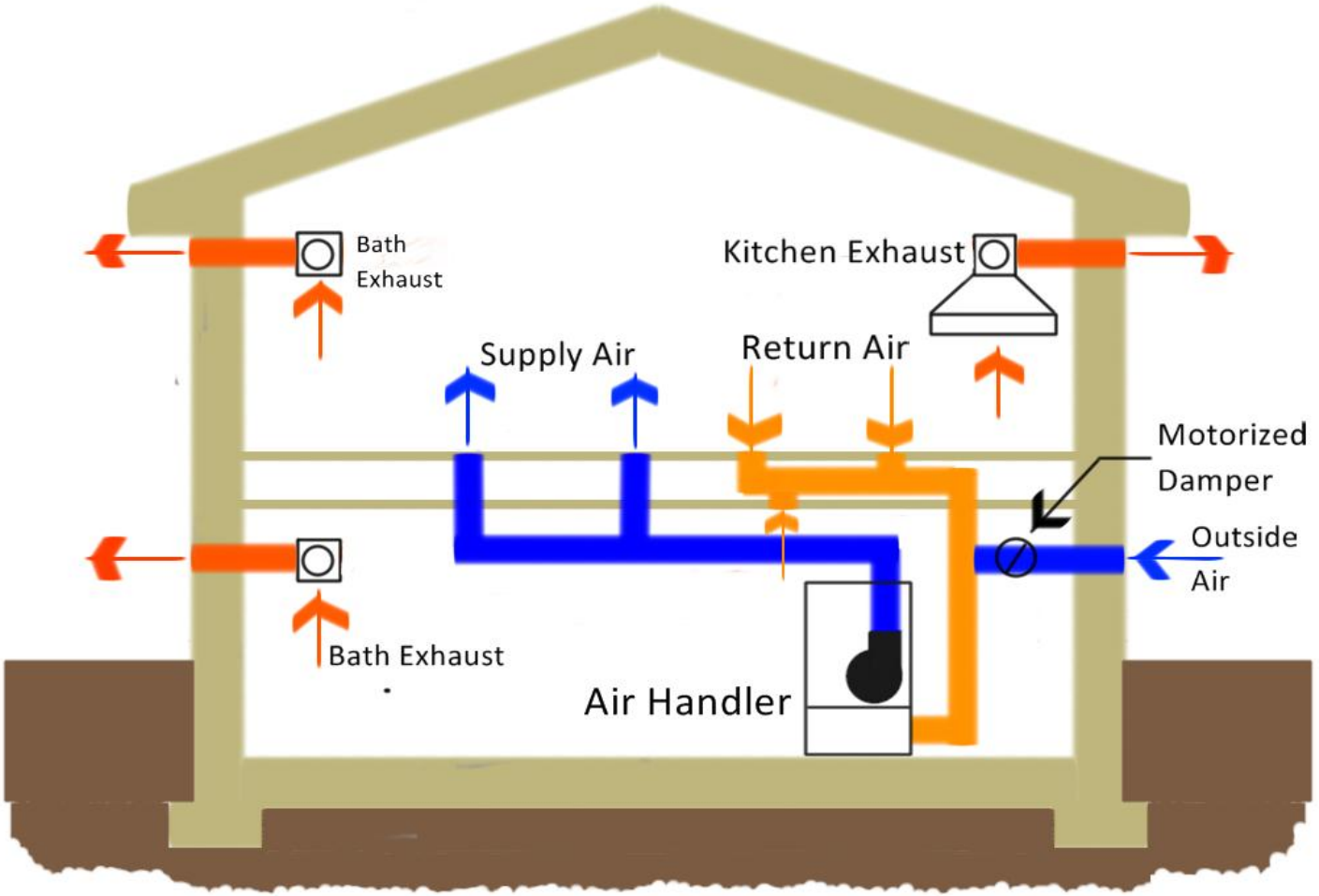


A simple controller for intermittent use of mechanical ventilation systems.

Benefits of Balanced Mechanical Ventilation Systems

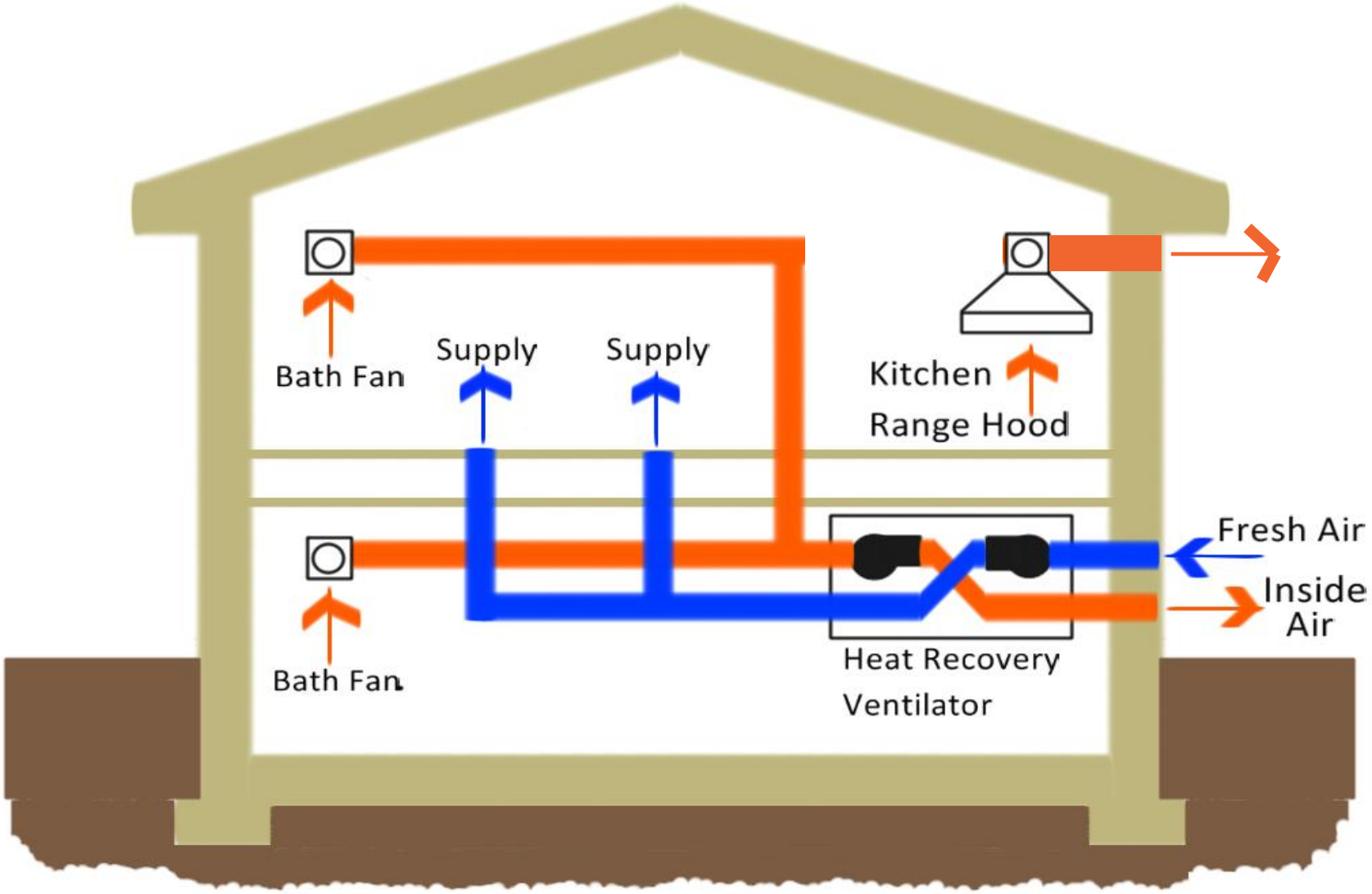
1. **Avoids problems of creating positive and negative pressures**
2. **More likely to actually provide design air quantities**
3. **Provides air through planned pathways which can improve air quality**
4. **Many systems provide options for heat recovery**

Central Balanced Exhaust without Heat Recovery

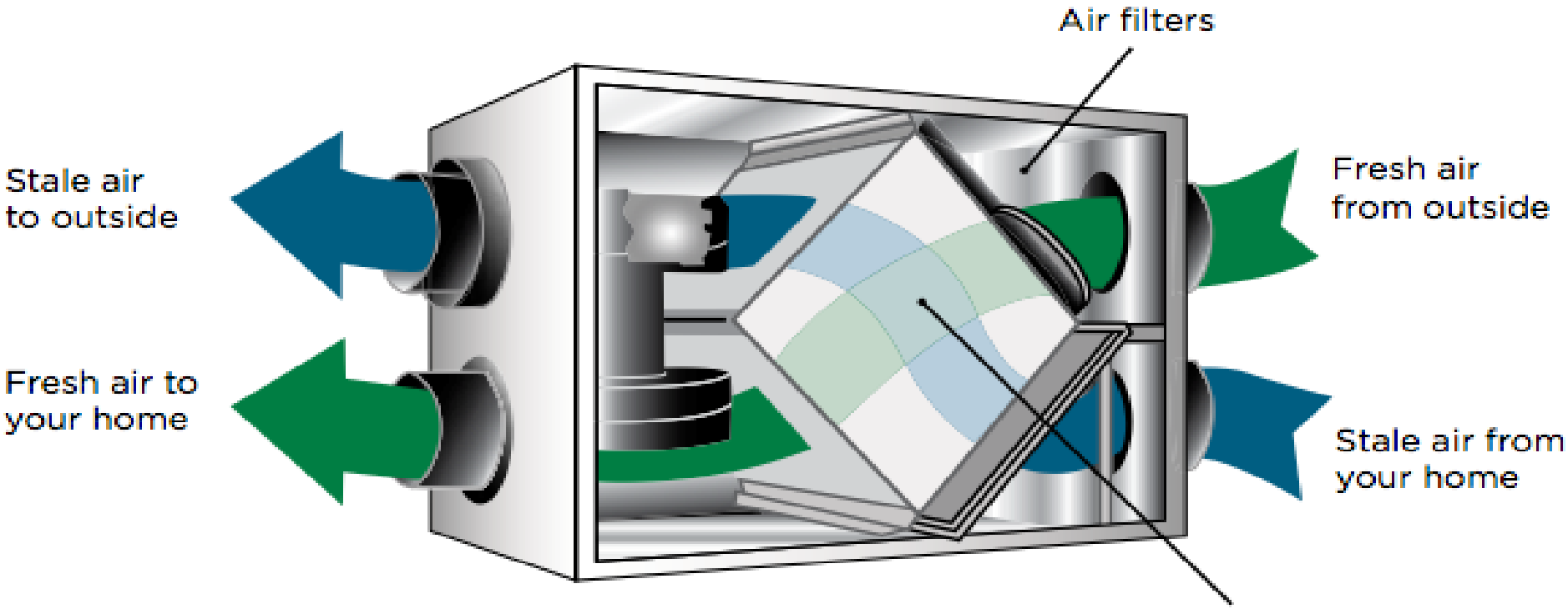


Balanced ventilation system with fresh air intake integrated with air handler and exhaust fan(s).

Central Balanced Exhaust with Heat Recovery



Heat Recovery Ventilator (HRV)



Recovery core where the warm inside air transfers its heat to the cool incoming fresh air

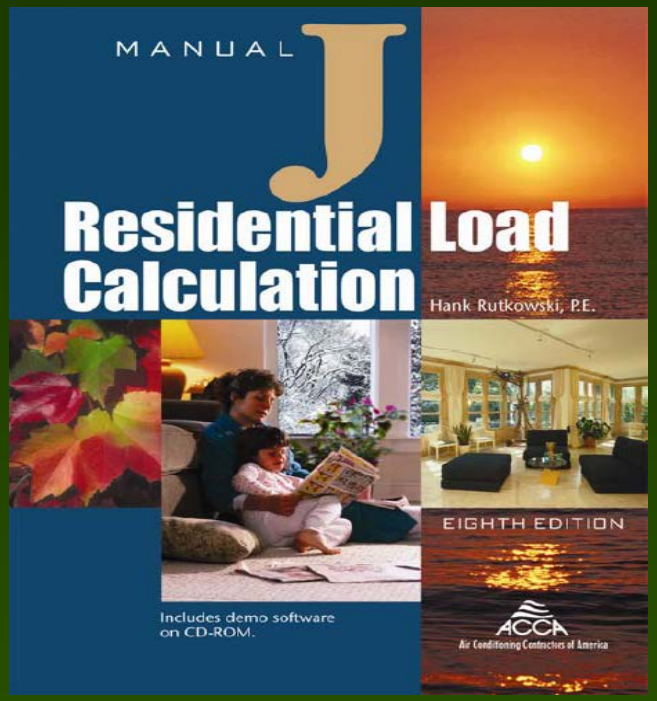
Equipment Sizing (Mandatory)

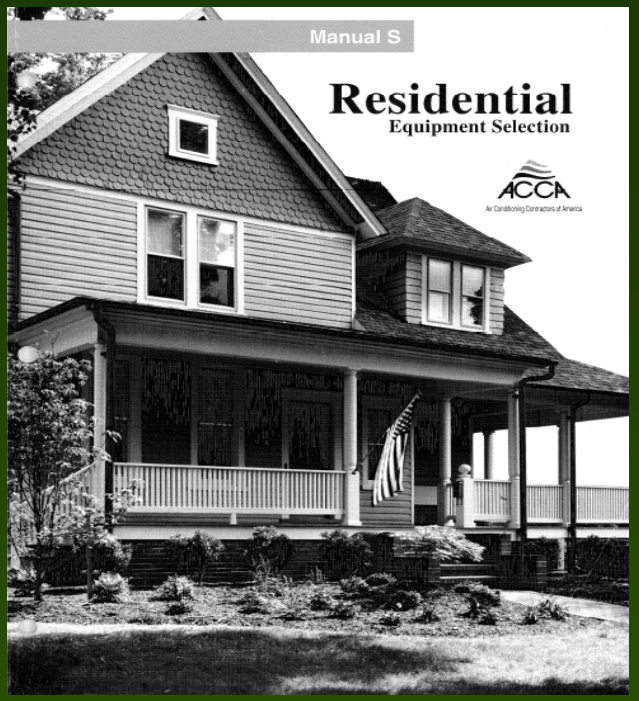
R403.6

Heating and Cooling Equipment

- Based on loads calculated per **ACCA Manual J**
- Sized according to **ACCA Manual S**

(or other approved calculation methodology)





Lighting (Mandatory)

R404.1

75% High Efficacy either:

1. **Lamps or**
2. **Permanently Installed Fixtures**

High Efficacy Lamps

1. Compact Fluorescent Lamps (CFL)
2. T-8 or small Diameter Linear Fluorescent Lamps
3. Lamps that meet the minimum lumens/watt

Low-wattage do not count.

Interior and exterior count.

Lighting (Mandatory)

R404.1

High Efficacy Lamp Values

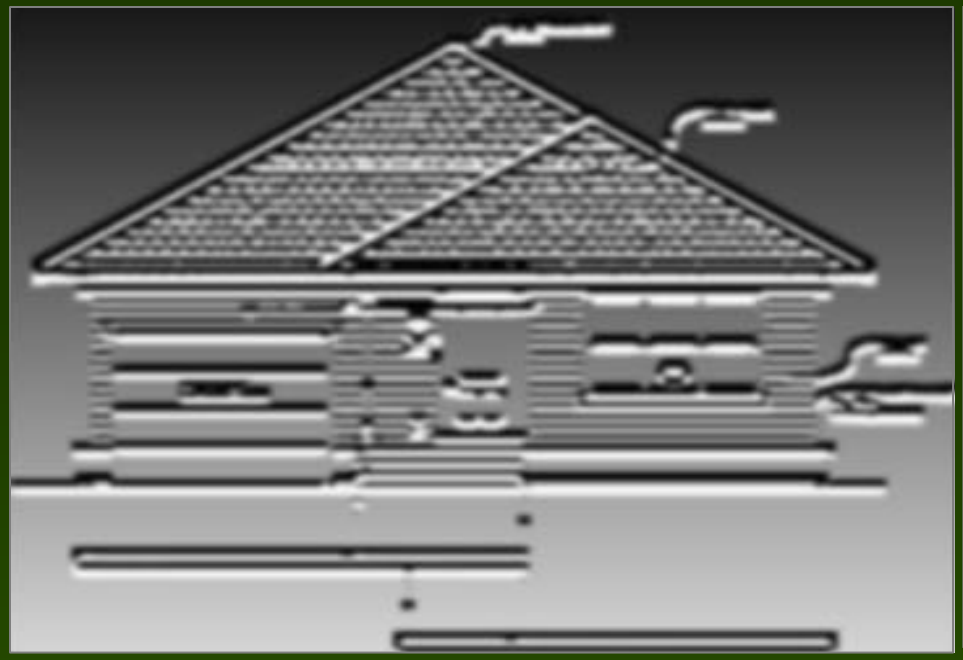
- 60 lumens per watt if over 40 W
- 50 lumens per watt if between 40 and 15 W
- 40 lumens per watt if 15 W less

Lamp Efficacy	
	Lum/Watt
Incandescent Tungsten Filament	7-18
Incandescent Tungsten Halogen	12-26
Linear Fluorescent	45-104
Compact Fluorescent	33-75
LED	70-140

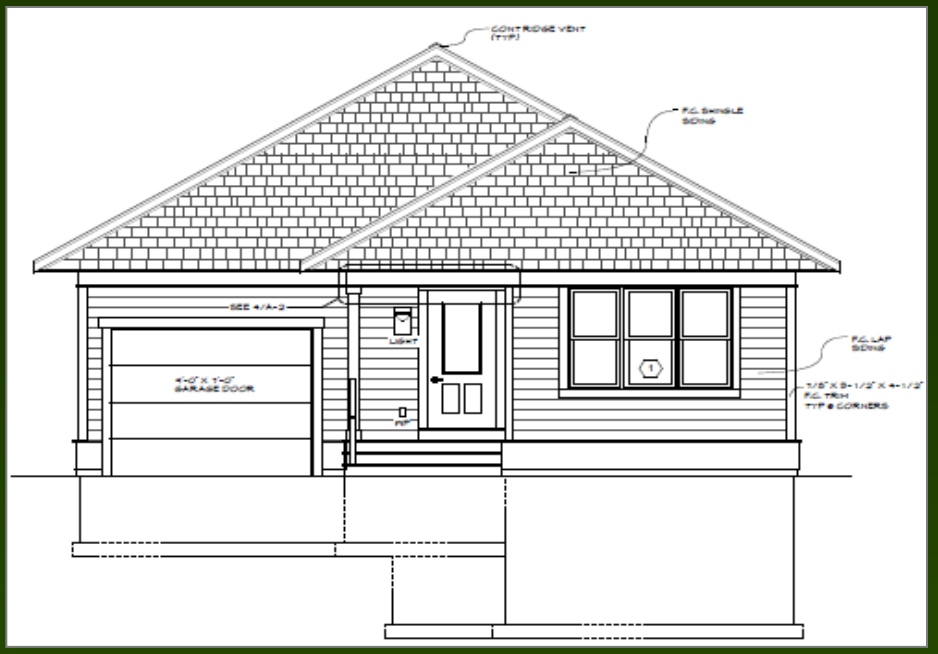
Performance Compliance

R405

Standard Reference Design



Proposed Design



"Geometric Twins"

Simulated Performance Alternative (Performance)

R405

Allows credit for:

- Exterior Shading
- Solar Heat Gain
- Innovative Framing Techniques
- Cool Roofing Systems
- Thermal Mass
- Solar Energy Systems
- Low Infiltration

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Montana Department of Environmental Quality

Credits

While the National Center for Appropriate Technology developed most of the graphics included in this presentation we would like to acknowledge the following as sources of particular photos or graphic images:

- USDOE Building Energy Codes Program - Energy Codes University
- USDOE Building America Program
- Northwest ENERGY STAR Homes Program funded by NEEA
- Performance Testing Comfort Systems (PTCS) maintained by BPA
- Ken Baker, K Energy
- Paul Tschida, Montana Department of Environmental Quality

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