Energy Code for Residential Buildings:
What You Really Need to Know

Performance Systems Development (PSD)

2015 IECC

Training materials were prepared with support funding from the Pennsylvania Department of Environmental Protection and the US Department of Energy's State Energy Program.

POLL #1

How would you rate your understanding of the residential provisions of the IECC?

a. I am new to the IECC
b. I have passed a certification exam, but that's about it
c. I have a pretty good working knowledge of the IECC, but could use a refresher
d. I have an excellent working knowledge of the IECC

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Introduction

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AGENDA

- Summary of code changes
- Prioritizing your attention
- Envelope air sealing
- Air leakage testing
- Insulation installation
- Mechanical ventilation
- Duct sealing and testing
- Service hot water
- Lighting
- Alternative compliance paths
- Pennsylvania Alternative

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LEARNING OBJECTIVES

After attending this session, students will be able to…

1. Describe important changes that occurred between the 2009 and 2015 IECC Residential Provisions.
2. Identify key air barrier details necessary to meet code and obtain 5 ACH50.
3. Determine compliance with mechanical systems including duct leakage and whole-house ventilation requirements.
4. Understand when to collect and how to review blower door and duct leakage testing documentation.

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BENEFITS OF ENERGY CODE COMPLIANCE AND ENFORCEMENT

- Improved comfort
- Better durability (when done right)
- Reduced energy costs
- Reduced greenhouse gas emissions
- Improved resilience

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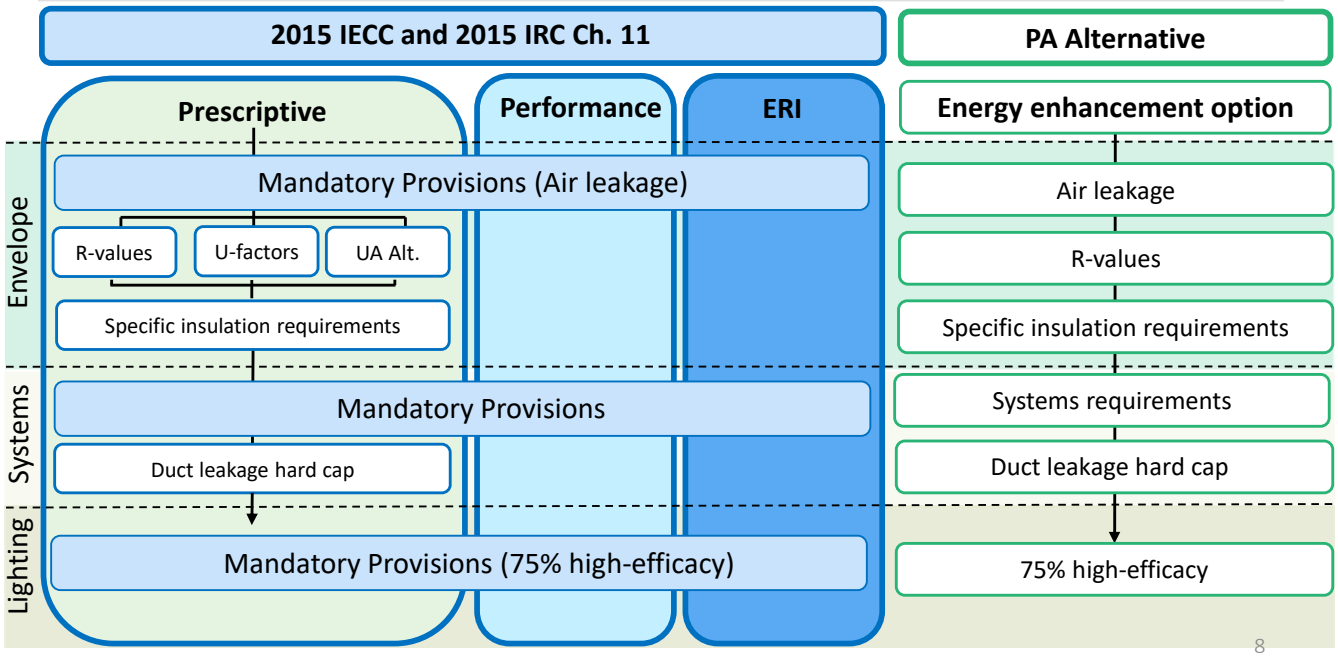
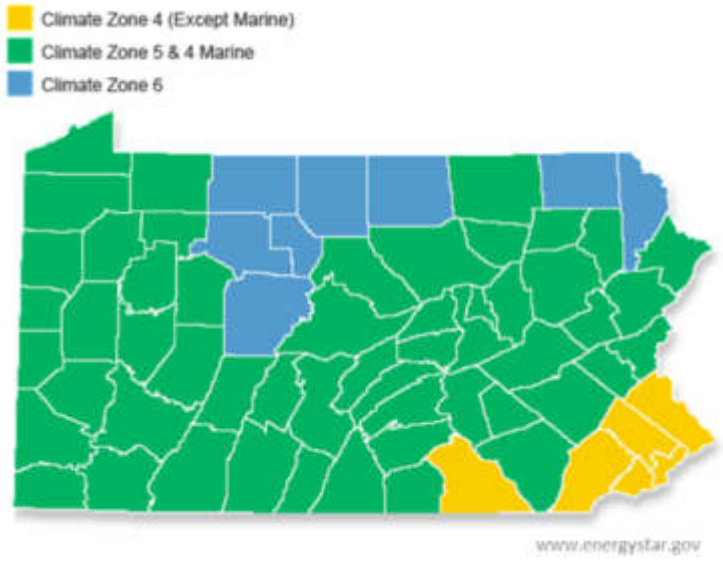
RESIDENTIAL ENERGY CODE COMPLIANCE PATHS



PENNSYLVANIA CLIMATE ZONES (NO CHANGE)



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POLL #2

What climate zone(s) do you work in? Choose all that apply.

a. Climate zone 4A
b. Climate zone 5A
c. Climate zone 6A
d. Other (I do work outside Pennsylvania)

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Summary of Changes
2009 IECC to 2015 IECC

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2009 TO 2015 IECC – SUMMARY OF CHANGES

All Climate Zones

- Mandatory blower door testing
- Whole-house mechanical ventilation (IRC+IECC)
- Reduced maximum duct leakage rates and no "leakage to outdoors" option
- 75% high-efficacy lighting
- New compliance path option – Energy Rating Index (ERI) Compliance Alternative

Pennsylvania amendment

- Footnote j: R-18 insulation shall be acceptable in place of R-20, provided that…
  - The wall framing factor is 20% or less or
  - Exterior walls have 24" stud spacing

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2009 TO 2015 IECC – SUMMARY OF CHANGES – INSULATION AND FENESTRATION

Climate Zone 4

	2009 IECC	2015 IECC
Windows	U-0.35	U-0.35
Skylights	U-0.60	**U-0.55**
Window SHGC	No requirement	**0.40**
Ceilings	R-38	**R-49[1]**
Wood-frame walls	13	**20[2] or 13+5**
Mass walls	5/10	**8/13**
Basement walls	R-10/13	R-10/13
Crawlspace walls	R-10/13	R-10/13

1. PA-Alt allows R-38
2. Pennsylvania Amendment allows R-18 with advanced framing

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2009 TO 2015 IECC – SUMMARY OF CHANGES – INSULATION AND FENESTRATION

Climate Zone 5

	2009 IECC	2015 IECC
Windows	U-0.35	**U-0.32**
Skylights	U-0.60	**U-0.55**
Window SHGC	NR	NR
Ceilings	R-38	**R-49**
Wood-frame walls	R-20 or 13+5	R-20[1] or 13+5
Mass walls	R-10/17	R-10/17
Basement walls	R-10/13	**R-15/19[2]**
Crawlspace walls	R-10/13	**R-15/19**

1. Pennsylvania Amendment allows R-18 with advanced framing
2. PA-Alt allows 10/13

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2009 TO 2015 IECC – SUMMARY OF CHANGES – INSULATION AND FENESTRATION

Climate Zone 6

	2009 IECC	2015 IECC
Windows	U-0.35	**U-0.32**
Skylights	U-0.60	**U-0.55**
Window SHGC	NR	NR
Ceilings	R-38	**R-49**
Wood-frame walls	R-20 or 13+5	**R-20[1]+5 or 13+10 or 18+6.5[2]**
Mass walls	R-10/17	R-10/17
Basement walls	R-10/13	R-15/19
Crawlspace walls	R-10/13	**R-15/19**

1. Pennsylvania Amendment allows R-18 with advanced framing
2. The R-18+6.5 option is a Pennsylvania-specific amendment

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Prioritizing Your Attention

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ENERGY EFFICIENCY PRIORITIES

USDOE Energy Efficiency Field Studies

- Building envelope air sealing
- Insulation installation quality
- Duct leakage
- Lighting (?)

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ENERGY EFFICIENCY PRIORITIES

Pennsylvania findings

Compared to a 2009 IECC baseline

Table ES.1. Estimated Annual Statewide Savings Potential in Pennsylvania

Measure	Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)	Total State Emissions Reduction (MT CO2e)
Duct Leakage	86,553	1,360,493	6,363
Exterior Wall Insulation	54,594	798,031	3,710
Foundation Insulation	17,711	175,611	802
Lighting	4,868	365,254	1,760
TOTAL	**163,726 MMBtu**	**$2,699,388**	**12,635 MT CO2e**

Source: Pennsylvania Residential Energy Code Field Study: Baseline Report (May 2017)

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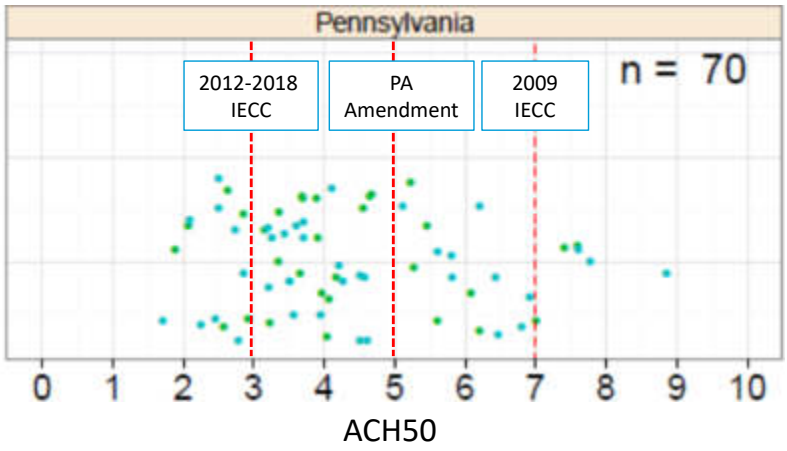
2015 ENERGY CODE FIELD STUDY – ENVELOPE AIR LEAKAGE

Better



Worse

- 70 sample homes
- 5 homes (7%) failed the 2009 IECC limit
- 20 homes (30%) would have failed the current PA limit
- 55 homes (79%) would have failed the unamended 2015 IECC

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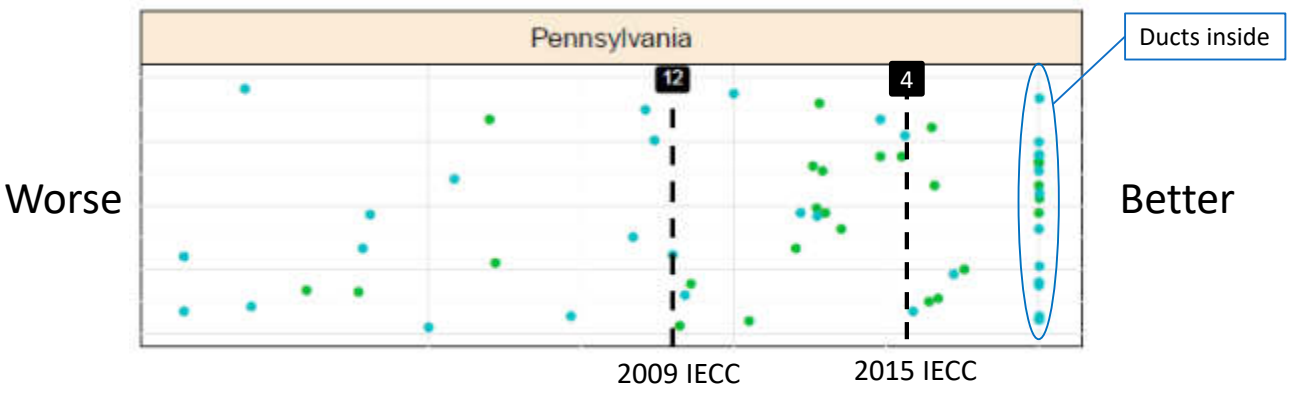
2015 ENERGY CODE FIELD STUDY – DUCT LEAKAGE



- 52 sample homes
- 26 homes (50%) failed the 2009 IECC limit
- 44 homes (85%) would have failed the 2015 IECC limit

2015 ENERGY CODE FIELD STUDY – INSULATION INSTALLATION QUALITY

Table 3.4. Wall U-Factor, including Wall Insulation Installation Quality

Climate Zone	CZ4	CZ5	Statewide
Number	28	34	62
Range	0.082 to 0.043	0.105 to 0.020	0.105 to 0.020
Average	0.080	0.072	0.076
Assembly U-Factor (expected)	0.082	0.057	0.082 in CZ4 and 0.057 in CZ5
Rate	13 of 28 (46%)	1 of 34 (3%)	14 of 62 (23%)

- All of the observations in Climate Zone 4 met or exceeded the prescriptive code R-values
- In Climate Zone 5, not quite half did
- Two-thirds of the observations had moderate to substantial defects

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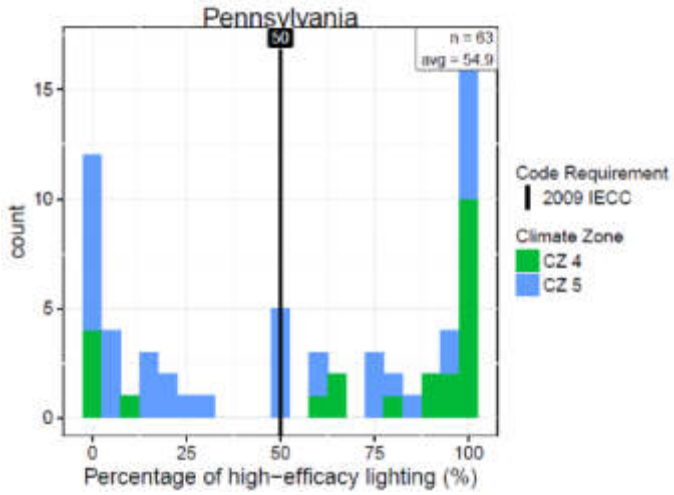
2015 ENERGY CODE FIELD STUDY – HIGH-EFFICACY LIGHTING

Worse



Better

- 63 sample homes
- 23 homes (38%) did not have the code-required 50% high-efficacy lamps

POLL #3

According to a 2015 field study, the greatest energy savings potential in PA is with improving compliance with _____.

a. Window U-factors
b. Ceiling insulation R-values
c. Wall insulation installation
d. Duct sealing/testing

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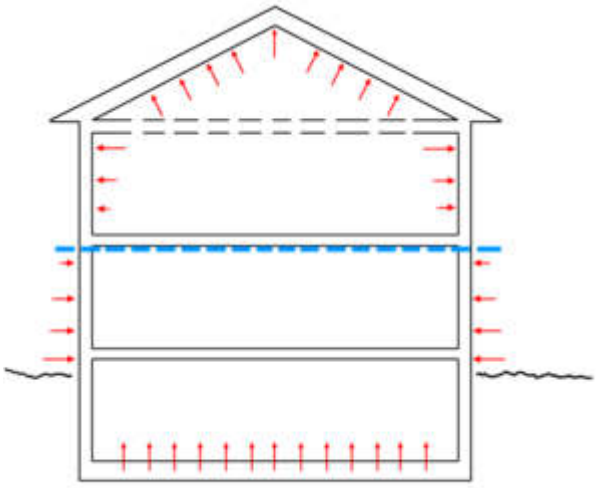
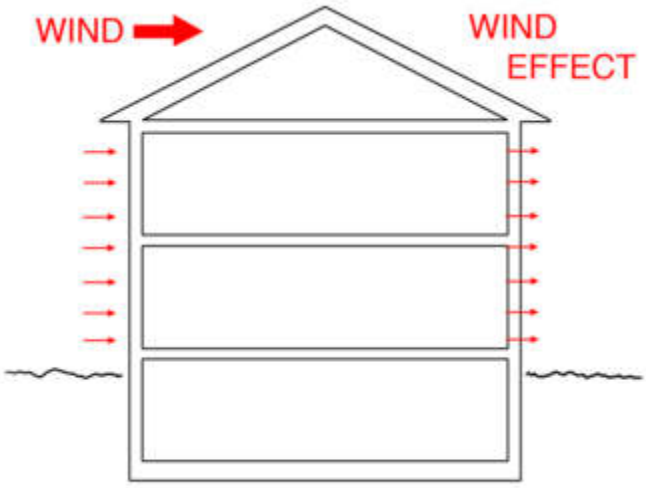
Envelope Air Sealing

ENVELOPE AIR LEAKAGE DRIVERS

Stack effect



Wind



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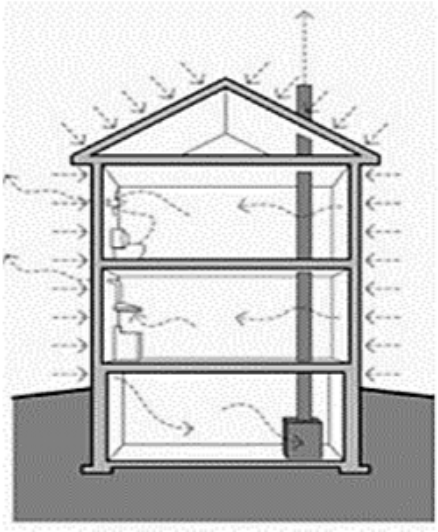
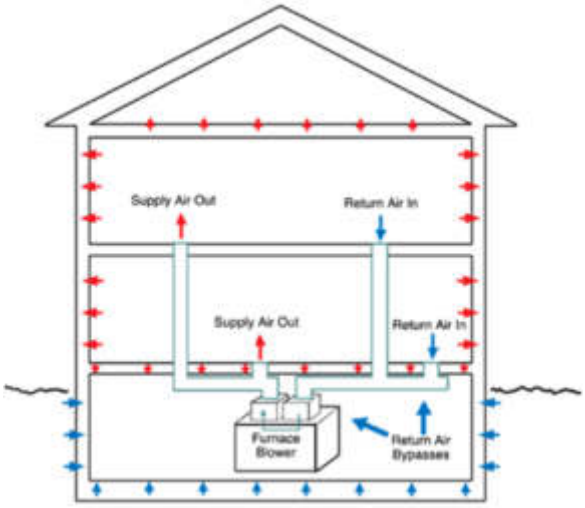
ENVELOPE AIR LEAKAGE DRIVERS

Ventilation and vented appliances



Unbalanced duct leakage



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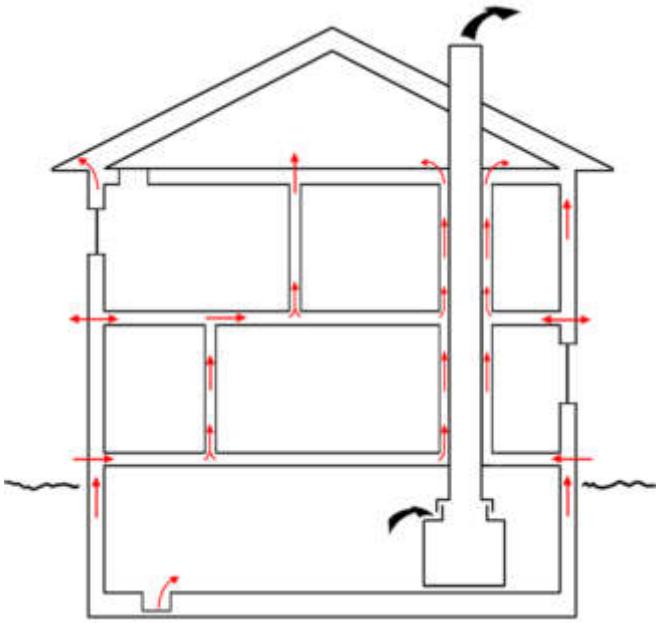
AIR LEAKAGE PATHWAYS



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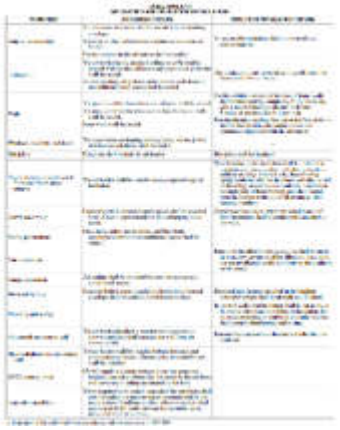
AIR SEALING REQUIREMENTS IN THE CODE

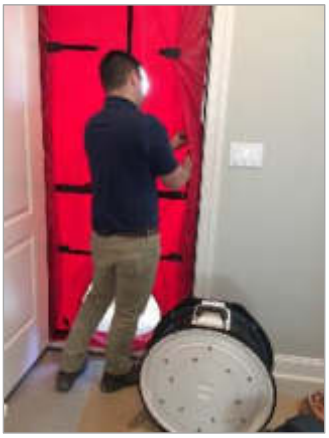
Air Barrier and Insulation Installation Criteria



2009 IECC
"Or"

2015 IECC
"And"

Blower door test



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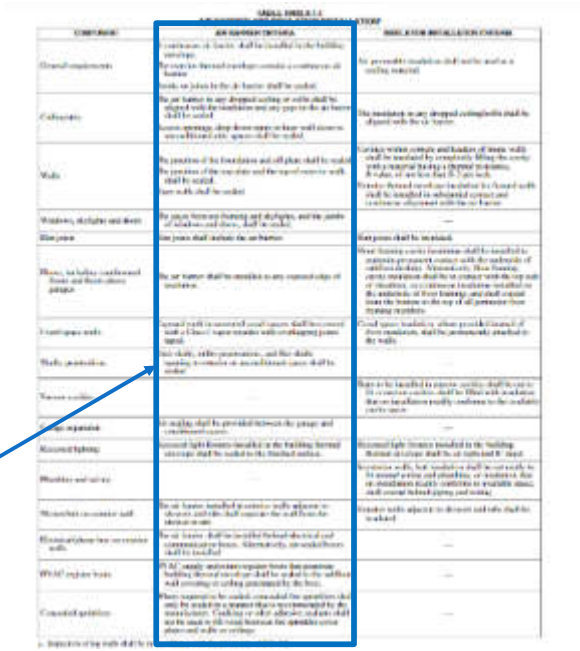
BUILDING THERMAL ENVELOPE – INSTALLATION

Section R402.4.1.1: The components of the building thermal envelope shall be installed in accordance with *manufacturer's instructions* and the criteria listed in *Table 402.4.1.1*

Air barrier criteria



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	Air barrier material (C402.5.1.2.1)	Min. Thickness
1	Plywood	3/8”
2	Oriented strand board (OSB)	3/8”
3	Extruded polystyrene (XPS)	1/2”
4	Foil-back polyisocyanurate	1/2”
5	Closed-cell spray foam	1 ½”
6	Open-cell spray foam	4 ½”
7	Gypsum board (exterior or interior)	1/2”
8	Cement board	1/2”
9	Built-up roofing membrane	--
10	Modified bituminous roof membrane	--
11	Fully adhered single-ply roof membrane	--
12	Portland cement/sand parge or gypsum plaster	--
13	Cast-in-place and pre-cast concrete	--
14	Fully grouted concrete block masonry	--
15	Sheet steel or aluminum	--
16	Clay or shale masonry units	--

From Commercial Code, for reference only

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GENERAL REQUIREMENTS

GENERAL REQUIREMENTS
☐ Breaks or joints in the air barrier shall be sealed.
☐ Air-permeable insulation shall not be used as a sealing material.
☐ A continuous air barrier shall be installed in the building envelope.
☐ The exterior thermal envelope contains a continuous air barrier.

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CEILING/ATTIC PLANE

☐	**Ceiling/attic**	• The insulation in any dropped ceiling/soffit shall be aligned with the air barrier.

CAD details *Courtesy of the Department of Energy's Building America Solution Center (http://basc.energy.gov)*

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CEILING/ATTIC – SOFFIT SPACES

The air barrier in any dropped ceiling/soffit shall be aligned with the insulation and any gaps in the air barrier shall be sealed.

Courtesy of the Department of Energy's Building America Solution Center (http://basc.energy.gov)

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WALLS – GENERAL

1. Tape or caulk exterior sheathing or install house wrap as an air barrier
2. Seal drywall to the top and bottom plates
3. Seal bottom plate to subfloor
4. Seal band joist to subfloor and plates

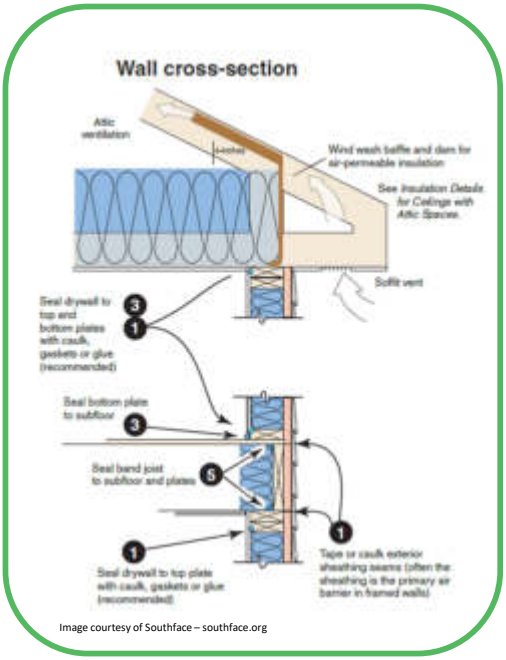

Image courtesy of Southface – southface.org

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PARTY WALLS

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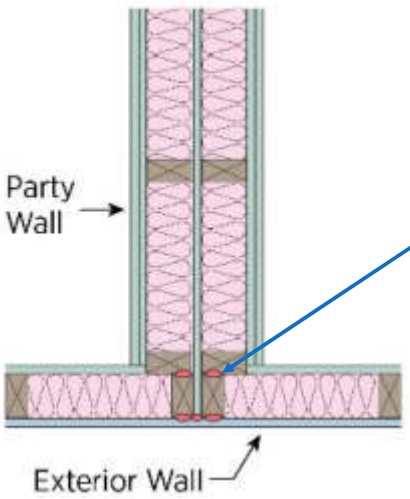
PARTY WALLS



- Use fire-rated sealants
- Seal drywall to top plates and bottom plates
- Caulk partition wall studs to exterior wall studs

Source: *Air sealing multi-family party walls,* Building America Solutions Center

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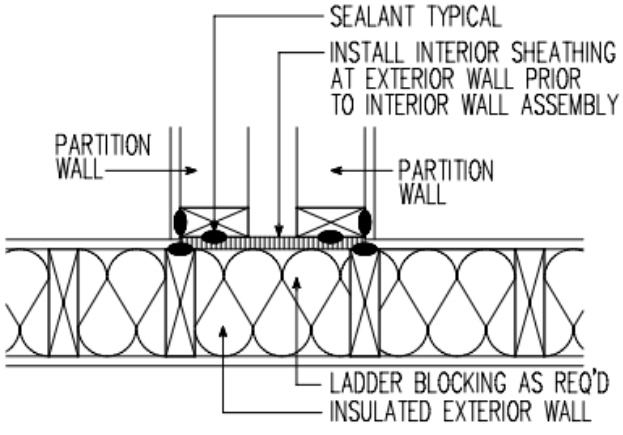
PARTY WALLS



Courtesy of the Department of Energy's Building America Solution Center (http://basc.energy.gov)

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PARTITION WALLS

Courtesy of the Department of Energy's Building America Solution Center (http://basc.energy.gov)

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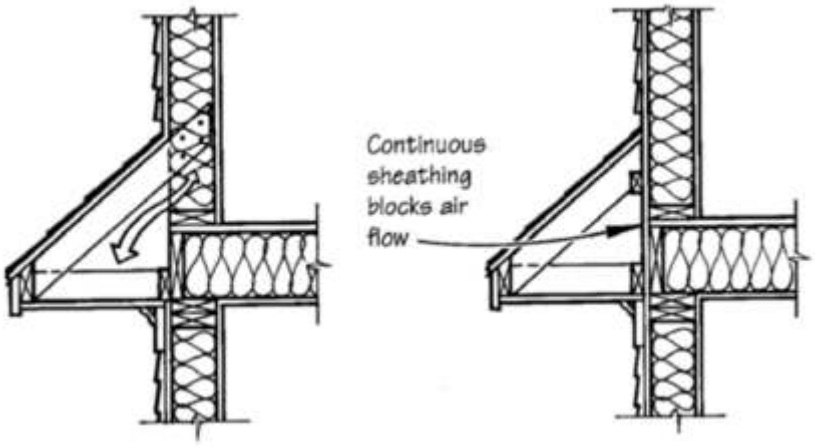
AIR-PERMEABLE INSULATION



Install an air barrier at porch roofs

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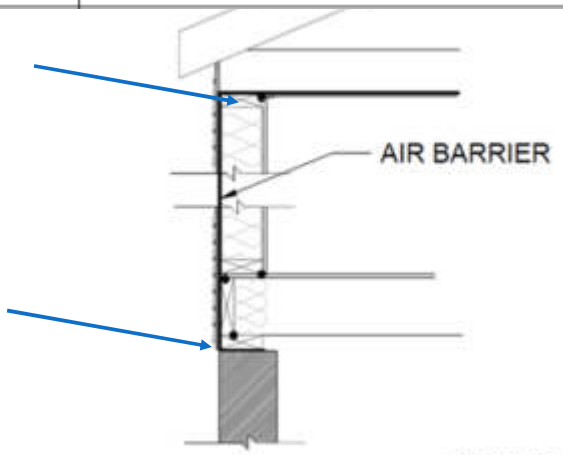
WALLS AIR BARRIER

☐	**Walls**	• The junction of the foundation and sill plate shall be sealed. • The junction of the top plate and the top of exterior walls shall be sealed. • Knee walls shall be sealed. • Walls are framed to allow the corner to be insulated or continuous insulation is/will be installed.



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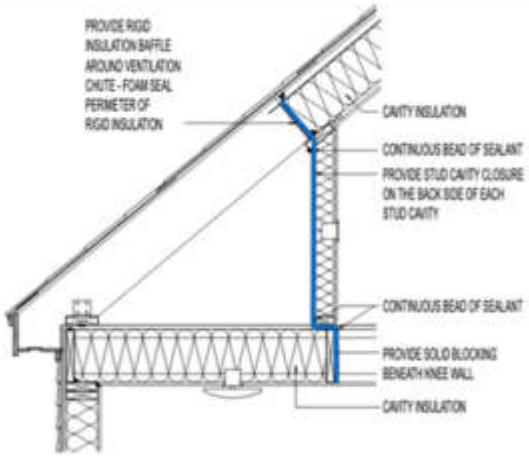
KNEE WALLS

☐	**Walls**	• The junction of the foundation and sill plate shall be sealed. • The junction of the top plate and the top of exterior walls shall be sealed. • Knee walls shall be sealed. • Walls are framed to allow the corner to be insulated or continuous insulation is/will be installed.



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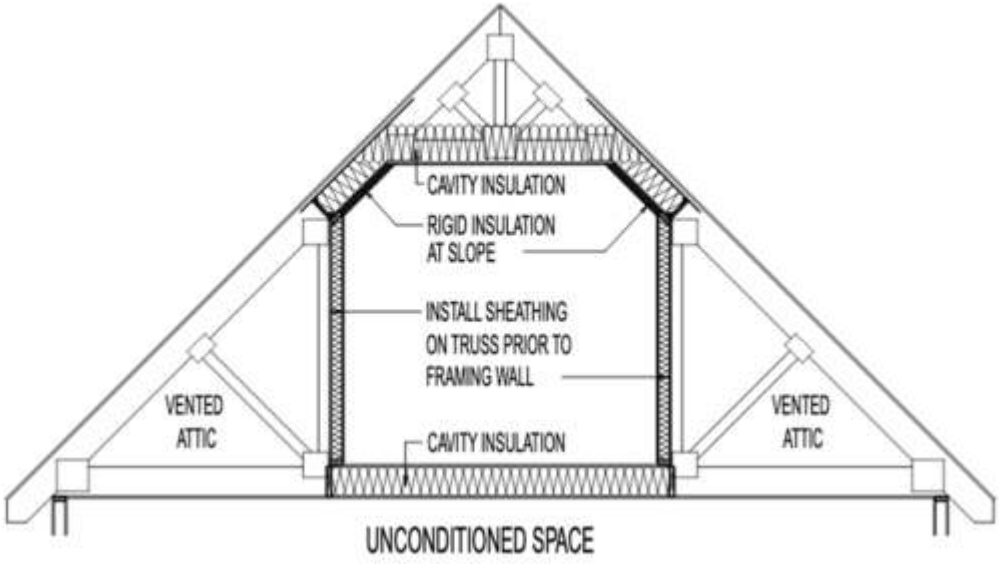
KNEE WALLS – BONUS ROOM OVER GARAGE



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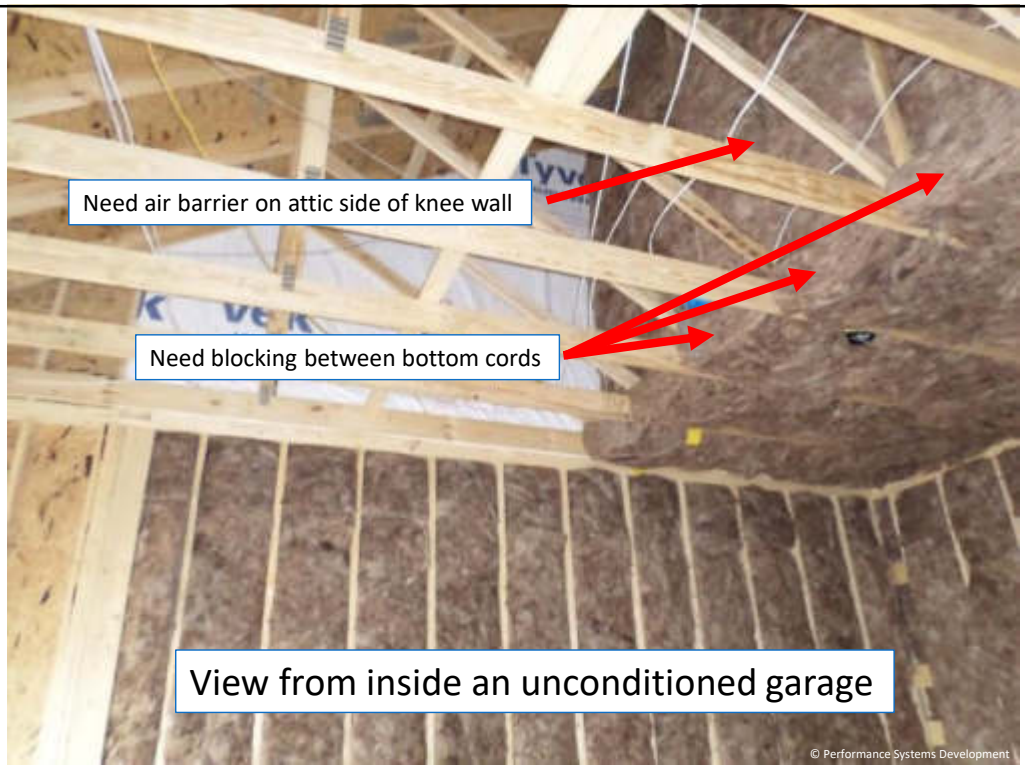

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KNEE WALLS

Courtesy of the Department of Energy's Building America Solution Center (http://basc.energy.gov)

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WALLS – FRAMED TO ALLOW INSULATION

☐	**Walls**	• The junction of the foundation and sill plate shall be sealed. • The junction of the top plate and the top of exterior walls shall be sealed. • Knee walls shall be sealed. • Walls are framed to allow the corner to be insulated or continuous insulation is/will be installed.

WINDOWS & DOORS

☐	**Windows, skylights and doors**	• The space between window/door jambs and framing, and skylights and framing shall be sealed.

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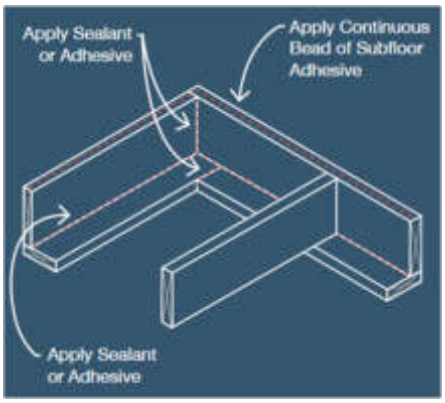
RIM JOISTS

☐	**Rim joists**	• Rim joists shall include the air barrier.



Priority Air Sealing Locations for New Homes, Insulation Institute.

Courtesy of the Department of Energy's Building America Solution Center (http://basc.energy.gov)

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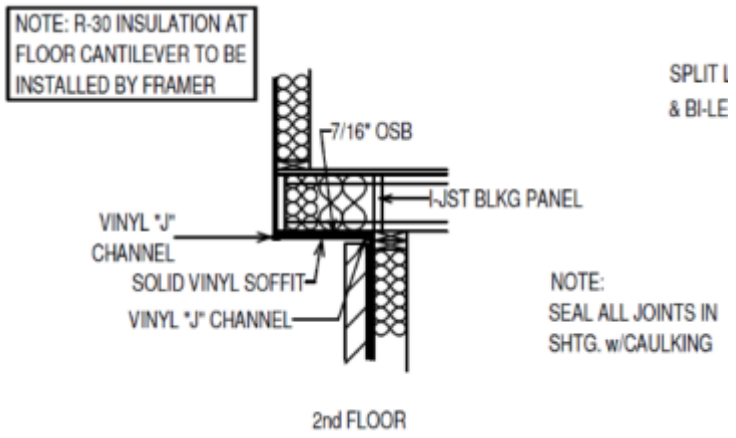
FLOORS

☐	**Floors (including above garage and cantilevered floors)**	• The air barrier shall be installed at any exposed edge of insulation.



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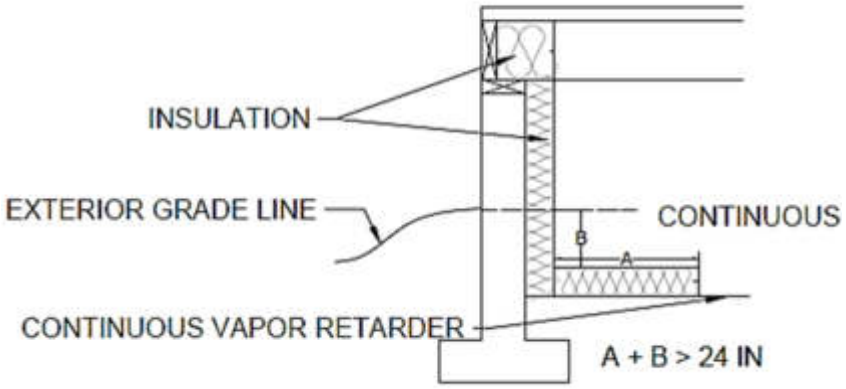
FLOORS

Air barriers are installed at any exposed edge of insulation

Room over garage

(UNVENTED) CRAWL SPACE WALLS

☐	**Crawl space walls**	• Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.



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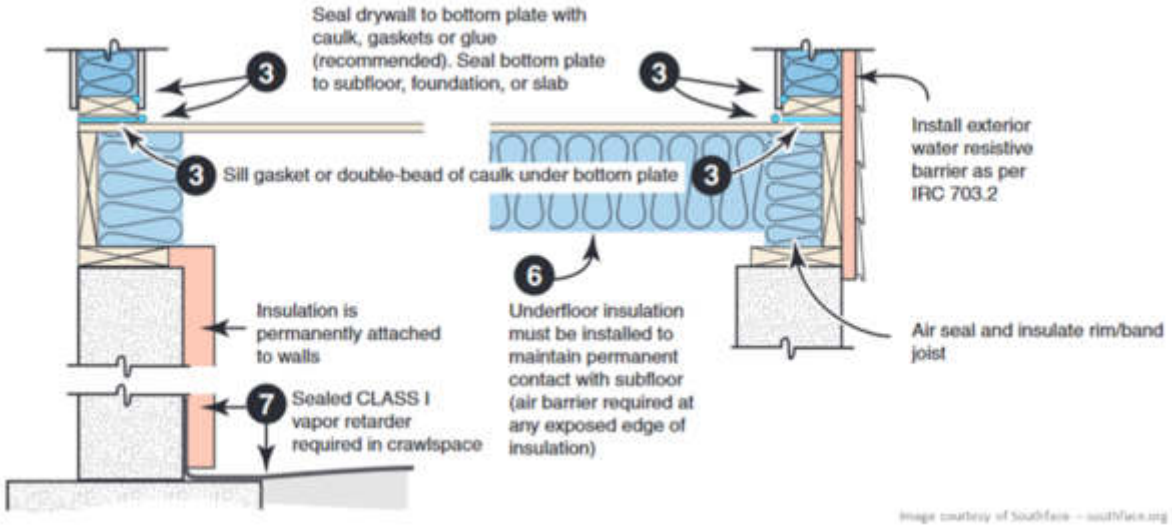
CRAWL SPACES



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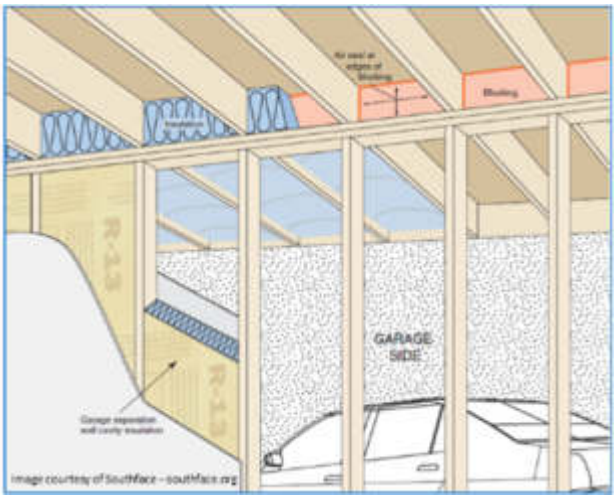
GARAGE SEPARATION

☐	**Garage separation**	• Air sealing shall be provided between the garage and conditioned spaces.



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GARAGE SEPARATION

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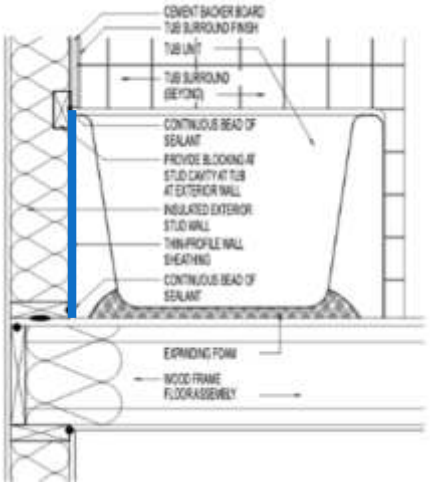
SHOWER/TUB ON EXTERIOR WALL

☐	**Shower/tub on exterior wall**	• Exterior walls adjacent to showers and tubs shall be insulated • The air barrier installed at exterior walls adjacent showers and tubs shall separate them from the showers and tubs.



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SHOWER/TUB ON EXTERIOR WALL

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SHOWER/TUB ON EXTERIOR WALL

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ELECTRICAL/PHONE BOXES ON EXTERIOR WALLS

☐	**Electrical/phone box on exterior walls**	• The air barrier shall be installed behind electrical or communication boxes or air-sealed boxes shall be installed.

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SHAFTS & PENETRATIONS

☐	**Shafts, penetrations**	• Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed.

Southface.org

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HVAC REGISTER BOOTS

☐	**HVAC register boots**	• HVAC register boots that penetrate building thermal envelope shall be sealed to the subfloor or drywall.

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RECESSED LIGHTING

☐	**Recessed lighting**	• Recessed light fixtures installed in the building thermal envelope shall be sealed to the drywall.

61

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ATTIC ACCESS HATCH

☐	**Ceiling/Attic**	• Access openings, drop down stairs or knee wall doors to unconditioned attic spaces shall be sealed.

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ATTIC ACCESS HATCH

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Training materials were prepared with support funding from the Pennsylvania Department of Environmental Protection and the US Department of Energy's State Energy Program.

POLL #4

Which of the following is NOT an air barrier installation requirement of the IECC?

a. Air barriers separate tubs/showers from exterior walls
b. Continuous insulation is installed on all exterior walls
c. Insulation in a soffit is aligned with an air barrier
d. Attic hatches are sealed

64

Envelope Air Leakage Testing

Training materials were prepared with support funding from the Pennsylvania Department of Environmental Protection and the US Department of Energy's State Energy Program.

AIR LEAKAGE TESTING

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AIR LEAKAGE (BLOWER DOOR) TESTING

Fan and Rings

Door and Frame

Digital Manometer

67

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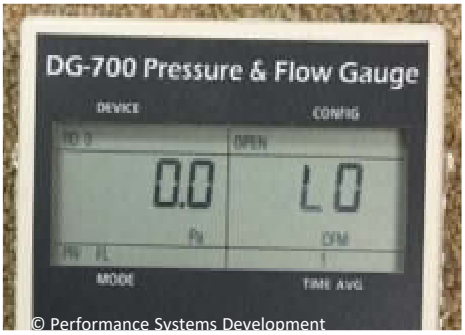
AIR LEAKAGE (BLOWER DOOR) TESTING



68

AIR LEAKAGE (BLOWER DOOR) TESTING

Video demonstration

69

Training materials were prepared with support funding from the Pennsylvania Department of Environmental Protection and the US Department of Energy's State Energy Program.

AIR BARRIER AND INSULATION INSTALLATION CHECKLIST (OVERVIEW)

- Checklist for code official inspectors or third-party energy inspectors

Note: R402.4.1.1. Where required by the code official, an *approved* **third party** shall inspect all components and verify compliance

70

ENVELOPE TESTING VERIFICATION FORM

RESIDENTIAL DUCT & ENVELOPE TESTING (DET) FORM

House Address:_____ **Permit #:**_____ **Date:**_____

Permit holder:_____ **Phone:** _____

I Building Envelope Air Leakage (mandatory):

Blower door test (Mandatory)

Test Result:

Fan Flow at 50 Pascals = _____ CFM50 Total Conditioned Volume = _____ ft³

ACH50 = CFM50 x 60 / Volume = _____ ACH50*

Testing company:_____ Phone: _____

Tester Name (print):_____ Signature: _____ Date: _____

BPI or HERS certification number: BPI no: _____ HERS Rater no: _____ HERS RFI no: _____

*For Simulated Performance Alternative and Energy Rating Index Paths, value must match 2015 IECC Energy Cost Report or 2015 Final RRI Report

71

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AIR LEAKAGE AND EXISTING BUILDINGS

- Additions
  - Must meet **R402.4 Air leakage requirements** (like new construction)
- Alterations
  - Building envelope assemblies part of the alteration shall comply with requirements for new construction
    - Meet **R402.4 Air leakage requirements**
  - Without requiring unaltered portions to comply
- Changes in space conditioning
  - Any unconditioned or low-energy space converted to a conditioned space needs to be brought to full compliance with the code by:
    - Meeting all prescriptive and mandatory provisions
    - Using the Simulated Performance Alternative (110% energy cost of reference home OK)
- Changes in occupancy from anything to Group R
  - Must comply like new construction – prescriptive air sealing and blower door test

72

POLL #5

What are the two pieces of information you need to know to determine if a home passes the blower door test at 5 ACH50 or less?

a. Blower door test result in CFM50 and volume of conditioned space
b. Equivalent leakage area and volume of conditioned space
c. Blower door test result in CFM50 and envelope surface area
d. Tracer gas test result and conditioned floor area

73

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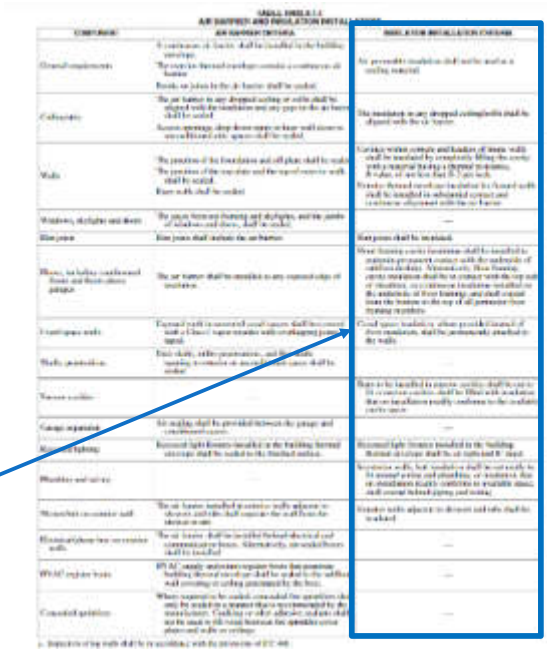
Insulation Installation

BUILDING THERMAL ENVELOPE – INSTALLATION

Section R402.4.1.1: The components of the building thermal envelope shall be installed in accordance with *manufacturer's instructions* and the criteria listed in *Table 402.4.1.1*

Insulation installation criteria



75

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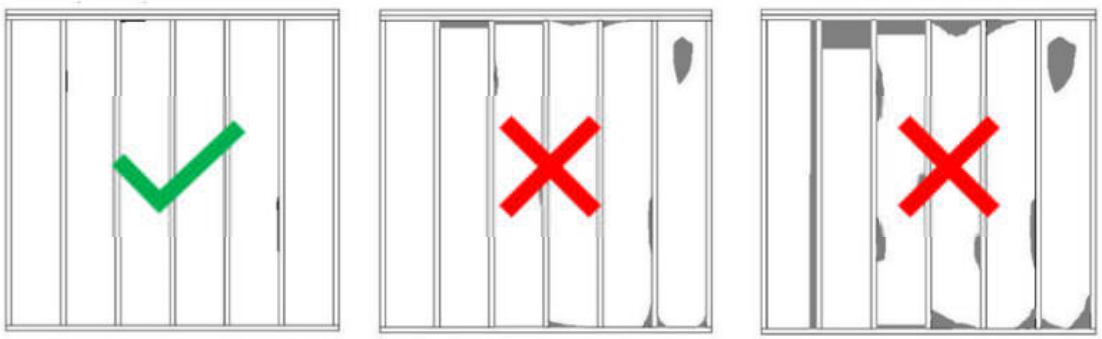
INSULATION INSTALLATION CRITERIA



Grade I: Almost no gaps | Grade II: Up to 2% | Grade III: 2% - 5%

Section R402.4.1.1: The components of the building thermal envelope shall be installed in accordance with *manufacturer's instructions* and the criteria listed in *Table 402.4.1.1*

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INSULATION INSTALLATION CRITERIA – INSULATED CORNERS & HEADERS

☐	**Walls**	• Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance of R-3 per inch minimum. • Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.

77

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INSULATION INSTALLATION CRITERIA – INSULATED CORNERS & HEADERS

78

INSULATION INSTALLATION CRITERIA

☐	**Walls**	• Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance of R-3 per inch minimum. • Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.

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INSULATION INSTALLATION CRITERIA

☐	**Rim joists**	• Rim joists shall be insulated.

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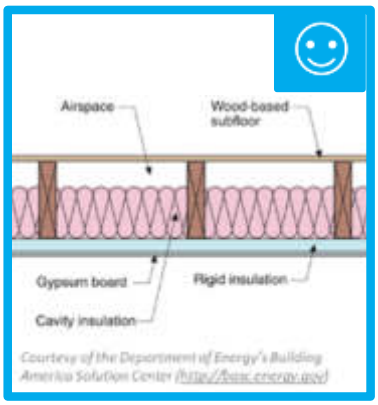
INSULATION INSTALLATION CRITERIA

☐	**Floors (including above garage and cantilevered floors)**	• Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of subfloor decking, or floor framing cavity insulation shall be permitted to be in contact with the top side of sheathing, or continuous insulation installed on the underside of floor framing and extends from the bottom to the top of all perimeter floor framing members.



81

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INSULATION INSTALLATION CRITERIA

☐	**Crawl space walls**	• Where provided instead of floor insulation, insulation shall be permanently attached to the crawlspace walls.

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INSULATION INSTALLATION CRITERIA

☐	**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.

83

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INSULATION INSTALLATION CRITERIA

☐	**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.

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INSULATION R-VALUES

	Walls (including rim/band joists)
☐	Cavity insulation is R-20 or greater[2] or a combination of cavity and continuous insulation is installed with R-13 or greater cavity + R-5 or greater continuous.[3]
	Windows and skylights
☐	Window and door U-factors are 0.32 or below and skylight U-factors are 0.55 or below.[3]
	Floors
☐	Floor insulation is R-30 or greater.[3]
	(Unvented) Crawl space walls
☐	R-15 or greater continuous insulation or R-19 or greater cavity insulation is installed[5]
	Ceilings
☐	Insulation R-value is R-49 or greater.[5] (A minimum of R-38 insulation is allowed if the full height of uncompressed insulation extends over the top of the walls.)

From checklist for Climate Zone 5 – Prescriptive

85

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AIR BARRIER AND INSULATION INSTALLATION CHECKLIST (REMINDER)

- Checklist for code official inspectors or third-party energy inspectors

Note: R402.4.1.1. Where required by the code official, an *approved* **third party** shall inspect all components and verify compliance

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INSULATION AND EXISTING BUILDINGS

- Additions
  - Meet insulation R-values and installation requirements for new construction
- Alterations
  - Exceptions for exposed cavities (fill the cavity)
- Changes in space conditioning
  - Brought into full compliance – R-values and installation requirements for new construction
- Changes in occupancy from anything to Group R
  - Brought into full compliance – R-values and installation requirements for new construction

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POLL #6

True or False. Per the IECC, a code official may require a builder to hire an approved third party to inspect the components of the Air Barrier and Insulation Installation Criteria and verify compliance.

a. True
b. False

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Whole-house Mechanical Ventilation

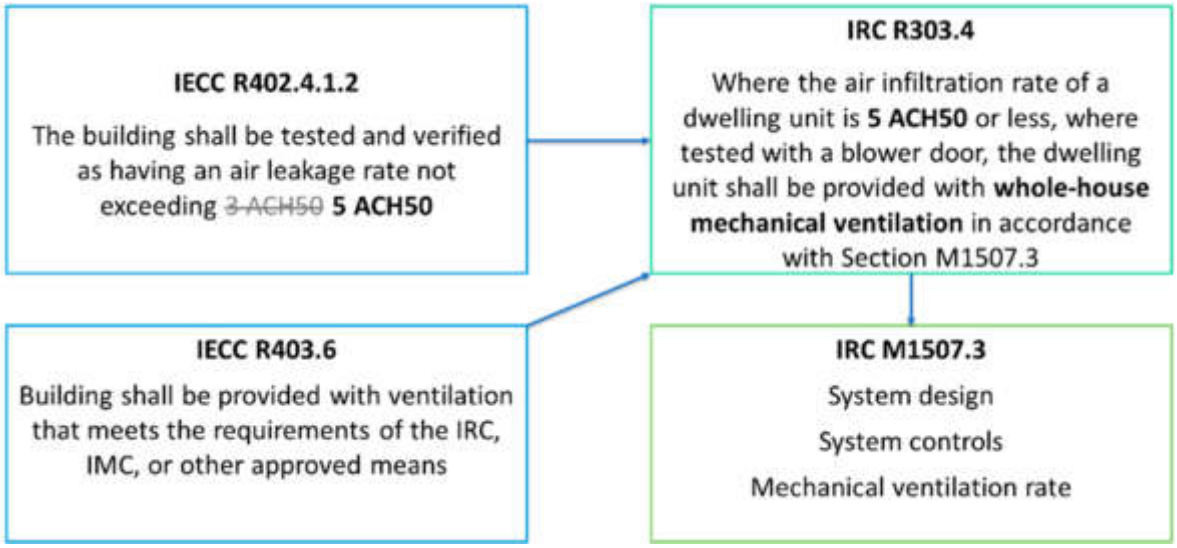
Training materials were prepared with support funding from the Pennsylvania Department of Environmental Protection and the US Department of Energy's State Energy Program.

BUILD TIGHT VENTILATE RIGHT

Uncontrolled air leakage	Tight house with mechanical ventilation
▪ Wastes energy and money ▪ Poses condensation risks ▪ Results in inconsistent/unreliable rates of incoming "fresh" air ▪ Source of incoming air cannot be controlled (may be polluted) ▪ Creates uncomfortable drafts	▪ Conditioning entering fresh air + fan energy costs less than uncontrolled air leakage ▪ Has reduced condensation risks ▪ Results in consistent/reliable rates of fresh air ▪ Can control source of incoming air, ability to filter ▪ Results in improved comfort

90

WHOLE-HOUSE MECHANICAL VENTILATION IN THE CODE



91

Training materials were prepared with support funding from the Pennsylvania Department of Environmental Protection and the US Department of Energy's State Energy Program.

WHOLE-HOUSE MECHANICAL VENTILATION – IRC REQUIREMENTS

System design

- The system shall consist of:
  - One or more **supply or exhaust** fans, or a **combination** and associated ducts and controls

IRC M1507.3.1

System controls

- System shall be provided with controls that enable **manual override**

IRC M1507.3.2

Mechanical ventilation rate

- System shall provide outdoor air at a continuous rate per Table M1507.3.3(1) or intermittently per Table M1507.3.3(2)

IRC M1507.3.3

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WHOLE-HOUSE MECHANICAL VENTILATION – IRC REQUIREMENTS

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

DWELLING UNIT FLOOR AREA (ft^2)	NUMBER OF BEDROOMS				
	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

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WHOLE-HOUSE MECHANICAL VENTILATION – IRC REQUIREMENTS

Exception: System may operate intermittently if

- Controls enable operation for at least 25% of every 4 hours
- Ventilation rate is multiplied by an adjustment factor per Table M1507.3.3(2)

TABLE M1507.3.3(2)[a,b]
CONTINUOUS WHOLE-HOUSE VENTILATIONSYSTEM
AIRFLOW RATE REQUIREMENTS

RUN-TIME PERCENTAGE IN EACH 4-HOUR SEGMENT	25%	33%	50%	66%	75%	100%
Factor[a]	4	3	2	1.5	1.3	1.0

a. For ventilation run time values between those given, the factors are permitted to be interpolated
b. Extrapolation beyond the table is permitted

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WHOLE-HOUSE MECHANICAL VENTILATION – IECC REQUIREMENTS

Mechanical ventilation system fan shall meet the efficacy requirements of Table R403.6.1

TABLE R403.6.1
WHOLE-HOUSE MECHANICAL VENTILATION FAN EFFICACY

Fan Location	Air Flow Rate Minimum (CFM)	Minimum Efficacy (CFM/WATT)[a]	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

a. When tested in accordance with HVI Standard 916 (Home Ventilation Institute Airflow Test Procedure)

Exception: Where whole-house mechanical ventilation fans are integral to HVAC equipment they shall be powered by an electronically commutated motor (ECM)

95

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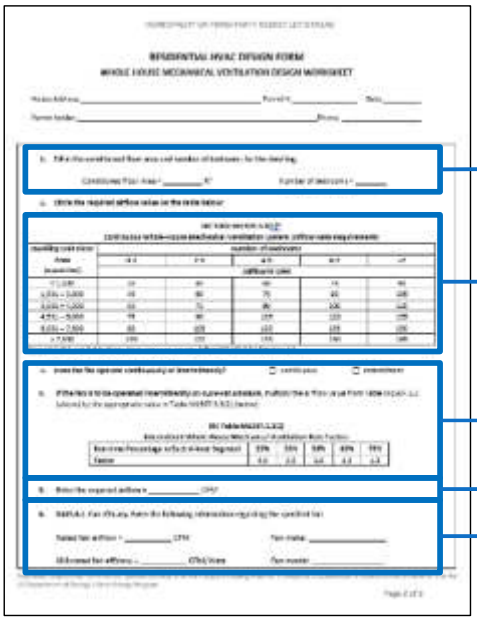
WHOLE-HOUSE MECHANICAL VENTILATION – DESIGN WORKSHEET



Inputs:

- Conditioned floor area and number of bedrooms
- Minimum ventilation rate (continuous)
- Ventilation rate adjustment (if intermittent)
- Ventilation rate – final answer
- Fan efficacy information

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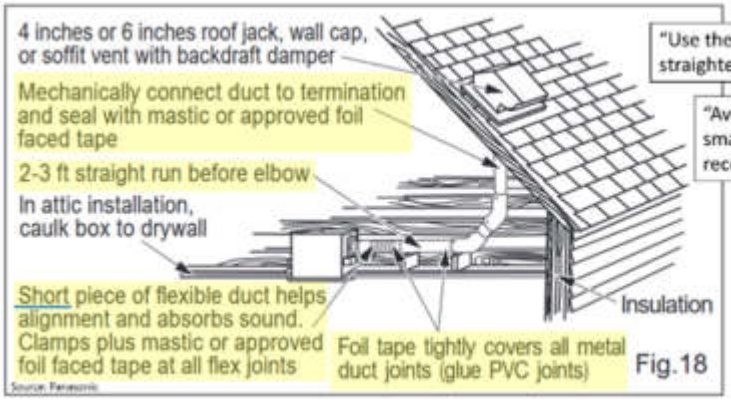
WHOLE-HOUSE MECHANICAL VENTILATION – INSTALLATION & INSPECTION



1) Automatically controlled continuous or intermittent ventilation fan is present
2) Ducting and termination installed properly

Improper installation

97

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WHOLE-HOUSE MECHANICAL VENTILATION AND EXISTING BUILDINGS

- Additions and alterations
  - IRC requires whole-house mechanical ventilation for dwelling units tested at ≤ 5 ACH50
    - No blower door test for most additions and alterations → no whole-house mechanical ventilation requirement
- Changes in space conditioning
  - Interpretation:
    - Alteration that impacts none of, or only a portion of, the thermal envelope → No blower door test, no mechanical ventilation requirement
    - Whole-house renovation – all of the thermal envelope is part of the alteration, must comply like new construction → blower door test and mechanical ventilation
- Changes in occupancy to R-use
  - Must be brought into full compliance (5 ACH50), blower door test required, mechanical ventilation *required*

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POLL #7

Requirements relating to whole-house mechanical ventilation are found in which of the following code chapters?

a. IRC Chapter 3. Building Planning
b. IRC Chapter 15. Exhaust Systems
c. IECC Chapter 4 [RE]. Residential Energy Efficiency
d. All of the above

99

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Duct Leakage

DUCT SEALING IN THE IRC

M1601.4

Longitudinal and transverse joints, seams and connections as specified in:

SMACNA HVAC Duct Construction Standards – Metal and Flexible

NAIMA Fibrous Glass Duct Construction Standards

Joints, longitudinal and transverse seams, and connections in ductwork shall be ***securely fastened and sealed***

Tapes, mastics, and fasteners comply with UL 181

- Fiberglass ducts: UL 181 A
- Metallic and flex ducts: UL 181 B

101

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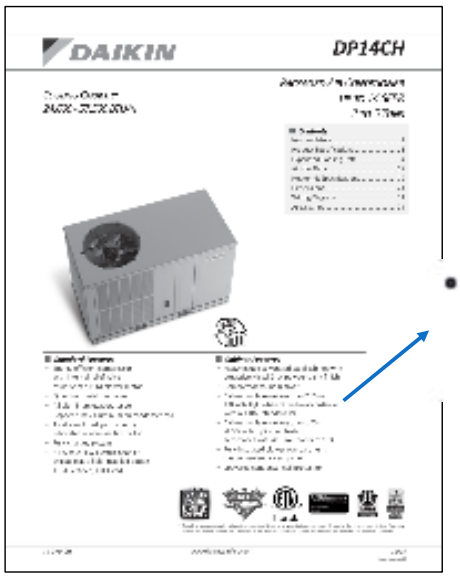
AIRTIGHT AIR HANDLER

R403.3.2.1



Air handlers shall have an air leakage rate no more than 2% of the design flow rate when tested per ASHRAE 193.

- Cabinet air leakage less than 2.0% at 1.0 inch H_2O when tested in accordance with ASHRAE standard 193

102

DUCT TESTING

R403.3.3 Duct *Testing* (Mandatory)
(Applies to all projects)

- Ducts shall be pressure tested to determine air leakage during rough-in OR post-construction.
- A written report of the results of the test shall be signed by the party conducting the test and provided to the building official.

EXCEPTION:
Air handler and **all** ducts are located entirely within the building thermal envelope

R403.3.4 Duct *Leakage* (Prescriptive)
(Prescriptive path only, including RES*check*)

- Total duct leakage shall not exceed:
  - Rough-in test
    - With air handler: 4 cfm per 100 ft^2
    - Without air handler: 3 cfm per 100 ft^2
- Post-construction test
  - 4 cfm per 100 ft^2 conditioned floor area

Prescriptive leakage limits **do not** apply when using:
- Simulated Performance Alternative
- Energy Rating Index Alternative

103

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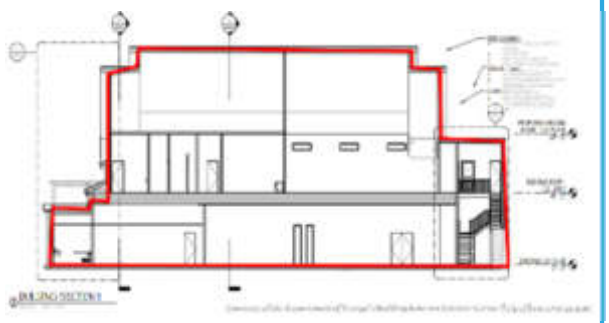
DUCT TESTING – DETERMINING WHEN IT'S REQUIRED

1. Identify the thermal envelope (R105.2.1 0 …shall be represented on the construction drawings
2. Notify applicant/subcontractors when testing is required
3. Provide/obtain blank DET form
4. Obtain/submit completed DET form prior to CO



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DUCT AND ENVELOPE TESTING VERIFICATION FORM

II. Heating and Cooling System Duct Leakage

☐ I certify that all portions of the ducts are located entirely within the building thermal envelope. Testing is not required.

Owner or approved third party signature: _____ Date: _____

Total duct leakage test

Energy code compliance path: ☐ Prescriptive (including REScheck) ☐ Performance or Energy Rating Index

Type of test performed: ☐ Rough-in with air handler ☐ Rough-in without air handler ☐ Post construction

Test Result System 1:

Fan Flow at 25 Pascals (CFM25) _____ CFM Conditioned Floor Area (CFA) served by system = _____ ft²

CFM25 / CFA x 100 = _____ CFM/100 ft²

Test Result System 2 (if present):

Fan Flow at 25 Pascals (CFM25) _____ CFM Conditioned Floor Area (CFA) served by system = _____ ft²

CFM25 / CFA x 100 = _____ CFM/100 ft²

Testing company: _____ Phone: _____

Tester Name (print): _____ Signature: _____ Date: _____

BPI or HERS certification number: BPI no: _____ HERS Rater no: _____ HERS RFI no: _____

Qualified professionals may be found at:
http://pennenergycodes.com/det-directory-map/

- Certification that all ducts are inside
- Compliance path
- Type of test
- Tested leakage rate, floor area, and conversion
- Sign-off and tester info
- Locate a pro

105

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DUCT LEAKAGE AND EXISTING BUILDINGS

- Additions and Alterations shall comply with
  - **R403.3 Duct insulation and sealing**
    - **Exception:** Where ducts from an existing heating and cooling system are extended to an addition, duct systems with **less than 40 linear feet** in unconditioned space are not required to be tested.
- Changes in space conditioning
  - **R403.3 Duct insulation and sealing**, including testing (no exceptions)
- Changes in occupancy from anything to Group R
  - **R403.3 Duct insulation and sealing**, including testing (no exceptions)

106

POLL #8

Which of the following statements is FALSE regarding changes in duct leakage/testing requirements between the 2009 and 2015 IECC?

a. The test pressure for duct leakage testing remains at 25 pascals
b. The maximum leakage rate for a postconstruction total leakage test decreased from 12 cfm/100 sqft to 4 cfm/100 sqft
c. A “leakage to outdoors” test is no longer an option
d. The criteria for when duct leakage testing is required have changed

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Service Hot Water

PERFORMANCE SYSTEMS DEVELOPMENT | We Speak Building

SERVICE HOT WATER PIPE INSULATION

IECC 2015 Hot Water Pipe Insulation of R-3 required for
1) Piping ¾ inch nominal diameter and larger
2) Piping serving more than one dwelling unit
3) Piping located outside conditioned space
4) Piping from water heater to distribution manifold
5) Piping located under a floor slab
6) Buried in piping
7) Supply and Return piping in recirculation systems other than demand recirc.

Note: Pipe insulation is required if *any* of the above conditions apply

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SERVICE WATER HEATING AND EXISTING BUILDINGS

- All *new* hot water piping meeting the conditions of R403.5.3 (previous slide) must be insulated to R-3

110

Lighting

Training materials were prepared with support funding from the Pennsylvania Department of Environmental Protection and the US Department of Energy's State Energy Program.

ELECTRIC POWER AND LIGHTING

75% of lamps in permanent fixtures are high-efficacy

Or

75% of fixtures contain only high-efficacy lamps

EXISTING BUILDINGS

- Additions
  - New lighting systems shall comply with **R404.1 Electric power and lighting** (like new construction)
- Alterations
  - New lighting systems shall comply with **R404.1 Electric power and lighting** (like new construction)
    - **Exception:** Alterations that replace **less than 50% of the luminaires** in a space provided that such alterations **do not increase the installed interior lighting power**.
- Changes in space conditioning
  - New lighting systems shall comply with **R404.1 Electric power and lighting** (like new construction)
- Changes in occupancy to R-use
  - New lighting systems shall comply with **R404.1 Electric power and lighting** (like new construction)

113

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Simulated Performance Alternative

SIMULATED PERFORMANCE ALTERNATIVE

- Energy cost of the proposed home must be less than or equal to the reference home
- Preliminary 2015 IECC Performance Report required to obtain a permit
  - Building characteristics must match the plans
  - Uses *estimated* envelope and duct leakage values
- Use approved plans to perform inspections (like always)
- Final 2015 IECC Performance Report required to obtain a CO
  - Uses *tested* envelope and duct leakage values

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SIMULATED PERFORMANCE ALTERNATIVE AND EXISTING BUILDINGS

- Additions
  - Addition + existing building option
  - Energy use of proposed building ≤ reference building
- Alterations
  - Not applicable, except for changes in space conditioning
- Changes in space conditioning
  - Energy use of proposed building ≤ **110%** of reference building
- Changes in occupancy to R-use
  - Energy use of proposed building ≤ **110%** of reference building

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Energy Rating Index Compliance Alternative

Training materials were prepared with support funding from the Pennsylvania Department of Environmental Protection and the US Department of Energy's State Energy Program.

ENERGY RATING INDEX ALTERNATIVE

Pennsylvania amendment

Use Table R406.4 Max Energy Rating Index from 2018 IECC

- Climate Zone 4: Energy Rating Index must be ≤ 62
- Climate Zone 5 & 6: Energy Rating Index must be ≤ 61

The *lower* the ERI score the better!

Verification

- Preliminary 2015 IECC ERI Report required to obtain a permit
  - Building characteristics must match the plans
- Third-party energy professionals performs inspections and testing
- Final 2015 IECC ERI Report required to obtain a CO

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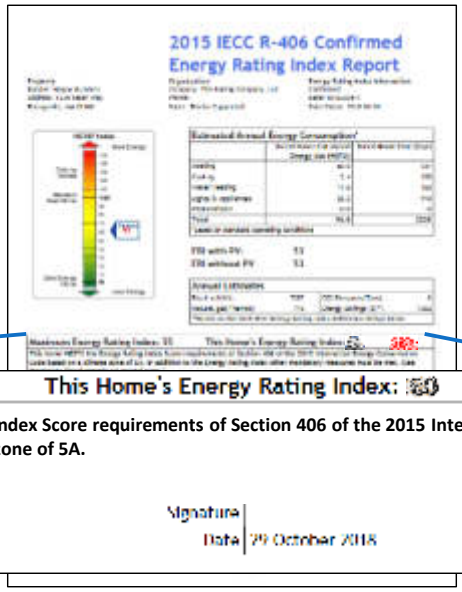
ENERGY RATING INDEX ALTERNATIVE

Note on ERI documentation:

- 2015 IECC max ERI: 54 or 55 in CZ 4-6
- PA amendment: 61 or 62 (from 2018 IECC)
- REM/Rate report may say "FAIL", but be OK for Pennsylvania
  - ERI must be ≤ 61 or 62
  - All other items, except air leakage must pass (next slide)


2015 IECC R-406 Confirmed
Energy Rating Index Report

Maximum Energy Rating Index: 55 This Home's Energy Rating Index: 58 FAIL

This home DOES NOT meet the Energy Rating Index Score requirements of Section 406 of the 2015 International Energy Conservation Code based on a climate zone of 5A.

Name Emelie Cuppernell Signature
Organization The Rating Company, LLC Date 29 October 2018

Ekotrope has PA-specific report

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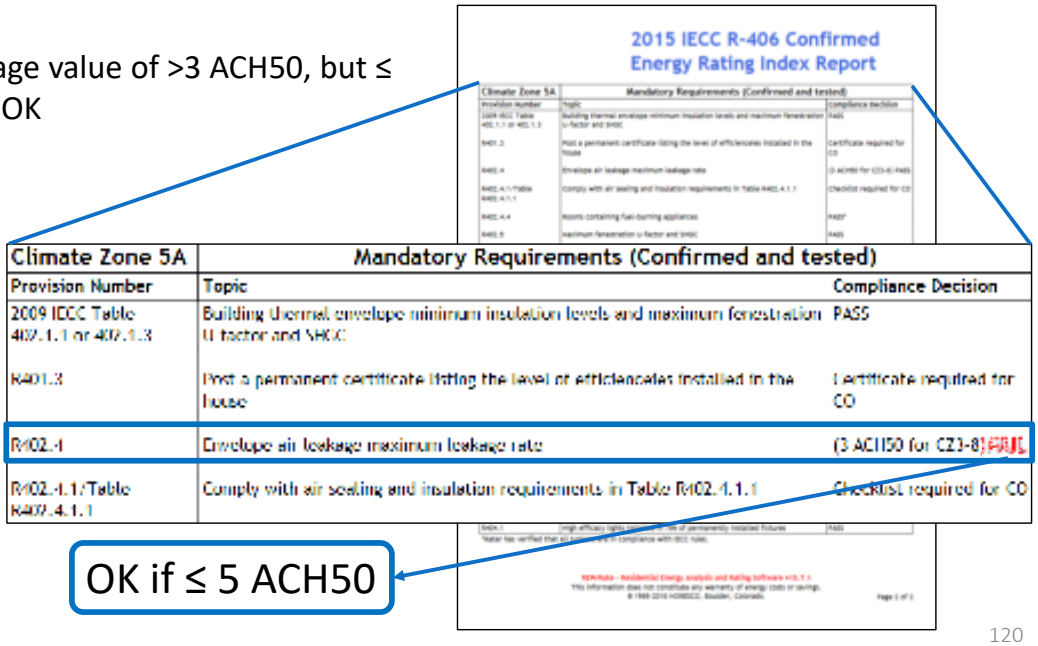
ENERGY RATING INDEX ALTERNATIVE

- An air leakage value of >3 ACH50, but ≤ 5 ACH50 is OK



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ENERGY RATING INDEX ALTERNATIVE AND EXISTING BUILDINGS

- Additions
  - Not applicable
- Alterations
  - Not applicable (but conceivable for whole-house renovations)
- Change of occupancy from anything to Group R
  - Optional path, treat like new construction

121

Training materials were prepared with support funding from the Pennsylvania Department of Environmental Protection and the US Department of Energy's State Energy Program.

Pennsylvania's Alternative Residential Energy Provisions (Pennsylvania Alternative)

THE PENNSYLVANIA ALTERNATIVE

- The PHRC developed Pennsylvania Alternative Residential Energy Provisions (PA-Alt) for consideration by DLI to meet their legislated mandate.
- The PA-Alt was developed with the intent of being:
  - Simpler to build to and easier to enforce;
  - More rational and flexible;
  - Focused on Pennsylvania in terms of climatic and other conditions; and,
  - Equivalent to the provisions of the International Energy Conservation Code (IECC).

Free download:
https://www.phrc.psu.edu/assets/docs/Publications/2018_Pennsylvania_Alternative_Energy_Provisions.pdf

123

Training materials were prepared with support funding from the Pennsylvania Department of Environmental Protection and the US Department of Energy's State Energy Program.

THE PENNSYLVANIA ALTERNATIVE

The basics

- Nearly identical to the 2015 IECC prescriptive path
- No RES*check* or performance paths
- Only includes Climate Zones (4-6)
- Must choose one Energy Enhancement Option
- Allows specific items to be less efficient than the IECC

Free download:
https://www.phrc.psu.edu/assets/docs/Publications/2018_Pennsylvania_Alternative_Energy_Provisions.pdf

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THE PENNSYLVANIA ALTERNATIVE – ENERGY ENHANCEMENT OPTIONS

Choose 1 Enhancement → **Get exceptions**

Option	Description		Minimum efficiency by climate zone		
			South (4)	Central (5)	North (6)
1	Ductless heat pumps		8.5 HSPF	8.5 HSPF	8.5 HSPF
2	All air ducts located inside the thermal envelope		Compliant	Compliant	Compliant
3	Solar photovoltaic system installed		1.4 kW	1.7 kW	3.4 kW
4	Geothermal or water source heat pump installed		Compliant	Compliant	Compliant
5	Improved efficiency air source heat pump installed		8.7 HSPF	9.0 HSPF	10.0 HSPF
6	Improved efficiency furnace installed		90 AFUE	90 AFUE	90 AFUE
7	Exterior continuous insulation		R20+10	R20+10	
8	Improved airtightness		3.0 ACH50	3.0 ACH50	3.0 ACH50
9	Improved efficiency windows		U-factor = 0.25	U-factor = 0.23	U-factor = 0.19
10	Package: Improved efficiency windows and higher attic R-value with raised heel truss[a]	Windows	U-factor = 0.27	U-factor = 0.25	U-factor = 0.25
		Attic	R-value = 60	R-value = 60	R-value = 60
11	Package: Improved efficiency windows and heat pump water heater	Windows	U-factor = 0.27	U-factor = 0.25	U-factor = 0.23
		Heat Pump Water Heater	Compliant	Compliant	Compliant

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THE PENNSYLVANIA ALTERNATIVE – EXCEPTIONS TO IECC REQUIREMENTS

	IECC w/ PA Amendments	PA-Alt
Ceilings with attic spaces in CZ4	R-49	R-38
Ceilings without attic spaces	R-30, limit 20% of ceiling area or 500 sqft	R-30, no limit on area
Attic hatches	Same R-value as surrounding surface	R-20 rigid foam, permanently attached
Wood-frame walls in CZ6	R-20+5 or 13+10 or 18+6.5	R-23 cavity-only
Basement walls in CZ5 and CZ6	R-15/19	R-10/13
Slab insulation	R-10 extending downward from the top of the slab	R-10, but ½" thermal break OK on slab edge

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THE PENNSYLVANIA ALTERNATIVE AND EXISTING BUILDINGS

- Not applicable

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POLL #9

Which of the following is a passing ERI score in Pennsylvania?

a. 60
b. 63
c. 65
d. 70

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Summary

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SUMMARY

- Better insulation R-values and fenestration U-factors
- Blower door test (every home)
- Whole-house mechanical ventilation (every home)
- Duct leakage test or all ducts inside
- Use forms/checklists – hand out with permits, approved plans, collect
  - Air Barrier And Insulation Installation Checklist
  - Duct & Envelope Testing Verification Form
  - Whole-house Mechanical Ventilation Design Worksheet

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