2012 Energy Codes: Performance Standards for Air Sealing and Duct Leakage

Presented by:
Peter Harding
Home Energy Technologies

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Construction Institute

Outline

- Energy Codes
  - 2009, 2012 & 2015 IECC codes
  - Mandatory requirements
  - Prescriptive compliance options
  - Performance compliance options
- Ventilation Requirements
- Envelope Sealing Requirements
- Duct Sealing Requirements

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Compliance Options for 2009 & 2012 IECC/IRC

Mandatory Provisions

- Labeling
- Air sealing
- Duct leakage
- Programmable thermostats
- Building cavities
- Equipment sizing
- Lighting
- Ventilation (2012)
- Pipe insulation (2012)

Prescriptive Path Option

Prescriptive Envelope Specs
Or
Total UA Alternative (REScheck)
Plus
Specific Insulation, Fenestration and Lighting Provisions

or

Performance Path Option

Simulated Cost Performance Alternative

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Compliance Options for 2015 IECC

Mandatory Provisions

- Labeling
- Air sealing
- Duct leakage
- Programmable thermostats
- Building cavities
- Equipment sizing
- Lighting
- Ventilation (2012)
- Pipe insulation (2012)

Prescriptive Path Option

Prescriptive Envelope Specs
Or
Total UA Alternative (REScheck)
Plus
Specific Insulation, Fenestration and Lighting Provisions

or

Performance Path Option

Simulated Cost Performance Alternative

or

Energy Rating Index Alternative
(ERI ≤ 55 in CZ5, ≤ 54 in CZ6)

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Performance-based Alternatives

- Simulated Performance Alternative (2009, 2012 & 2015 IECC)
  - Compares projected heating and cooling energy use of proposed design to same home configured to prescriptive requirements
  - Allows credit for better than code air leakage or duct leakage
- Energy Rating Index Compliance Alternative (2015 IECC)
  - Compares projected energy use of rated home to same home configured to 2006 code requirements
  - Includes all energy uses
    - Heating & cooling
    - Water heating
    - Lighting, appliances, miscellaneous loads

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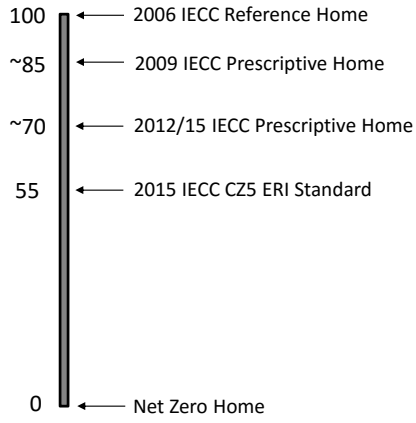
ERI Scale

The ER Index is identical to the HERS Index



- ERI expressed on a 0-100 scale of relative energy usage
- 2015 IECC Standard for CZ5
  - ERI ≤ 55
- Mandatory requirements
  - Thermal envelope ≥ 2009 IECC requirement
  - Air leakage
  - Pipe insulation

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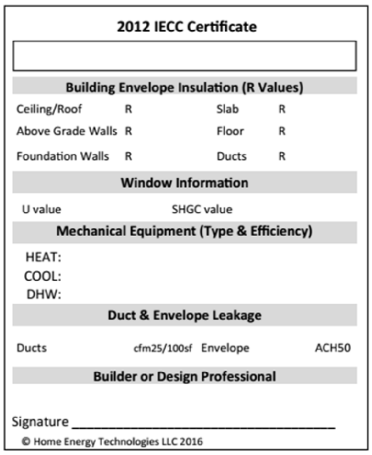
Labeling - Mandatory



2012 IECC Certificate

Building Envelope Insulation (R Values)

Ceiling/Roof	R	Slab	R
Above Grade Walls	R	Floor	R
Foundation Walls	R	Ducts	R

Window Information

U value SHGC value

Mechanical Equipment (Type & Efficiency)

HEAT:
COOL:
DHW:

Duct & Envelope Leakage

Ducts cfm25/100sf Envelope ACH50

Builder or Design Professional

Signature _____

- 2009 IECC requires
  - A permanent certificate posted on or in the electrical distribution panel
  - Completed by the builder or registered design professional
  - List predominant R-values, fenestration U and SHGC values, and types and efficiencies of heating, cooling and water heating equipment
- 2012 IECC additional requirements
  - Air leakage test results
  - Duct leakage test results

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Prescriptive Insulation for CZ5

Component	2009 IECC	2012/2015 IECC
Fenestration U-factor	0.35	**0.32**
Ceiling	38	**49**
Framed wall	20 or 13+5	20 or 13+5
Basement/crawl wall	10/13	**15/19**
Frame floor	30	30
Slab R & depth	10, 2’	10, 2’

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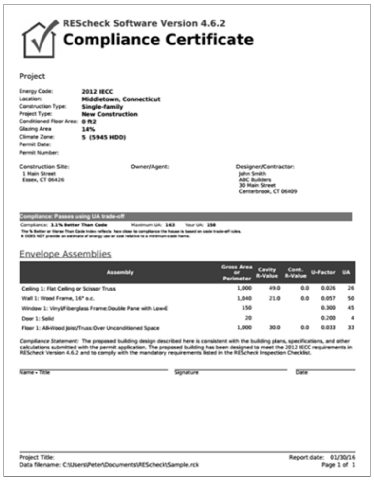
Prescriptive Total UA Alternative



REScheck Software Version 4.6.2

Compliance Certificate

Project

Energy Code: 2012 IECC
Location: Middletown, Connecticut
Construction Type: Single-family
Project Type: New Construction
Conditioned Floor Area: 0 ft2
Glazing Area: 14%
Climate Zone: 5 (5945 HDD)
Permit Date:
Permit Number:

Construction Site: 1 Main Street Essex, CT 06426
Owner/Agent:
Designer/Contractor: John Smith ABC Builders 30 Main Street Centerbrook, CT 06409

Compliance: Passes using UA trade-off

Compliance: 3.1% Better Than Code Maximum UA: 163 Your UA: 158

The % Better or Worse Than Code Index reflects how close to compliance the house is based on each trade-off rules. It DOES NOT provide an estimate of energy use or cost relative to a minimum code home.

Envelope Assemblies

Assembly	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	U-Factor	UA
Ceiling 1: Flat Ceiling or Scissor Truss	1,000	49.0	0.0	0.026	26
Wall 1: Wood Frame, 16" o.c.	1,040	21.0	0.0	0.057	59
Window 1: Vinyl/Fiberglass Frame:Double Pane with Low-E	150			0.300	45
Door 1: Solid	20			0.200	4
Floor 1: Allvirtual Joist/Truss:Over Unconditioned Space	1,000	30.0	0.0	0.033	33

Compliance Statement: The proposed building design described here is consistent with the building plans, specifications, and other calculations submitted with the permit application. The proposed building has been designed to meet the 2012 IECC requirements in REScheck Version 4.6.2 and to comply with the mandatory requirements listed in the REScheck Inspection Checklist.

Name - Title Signature Date

Project Title: Report date: 01/30/16
Data Filename: C:\Users\Peter\Documents\REScheck\Sample.rck Page 1 of 1

- REScheck allows builders to trade-off envelope insulation values
  - e.g. better windows for lower R-values in other assemblies
- Only applies to insulation requirements
  - No mechanical equipment trade-offs

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HVAC - Mandatory

	2009 IECC	2012/2015 IECC
Load & sizing calculations	Manuals J & S (by reference to Section M of the 2009 IRC)	Manuals J & S
Mechanical ventilation	Not required	Mandatory
Duct insulation	R8 for supply ducts in unconditioned attics. R6 in other unconditioned spaces	R8 for supply & return ducts in unconditioned attics (2015 IECC). R6 in other unconditioned spaces
Building cavities	Building framing cavities shall not be used as supply ducts	Building framing cavities shall not be used as supply or return ducts
Programmable thermostats	Required for all forced-air systems	
Duct leakage	Testing required unless system is located completely inside the conditioned space	

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Pipe Insulation - Mandatory

Recirculating Systems
- Automatic control or readily-accessible switch
- R3 insulation

R3 Hot water pipe insulation
- Piping >3/4" diameter
- From water heater to
  - Distribution manifold
  - Kitchen outlets
- Buried or under-slab piping
- Piping outside the conditioned space
- Pipe runs exceeding prescribed length
  - E.g. ½" pipe over 20'

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Lighting (except low-voltage lighting)

A minimum of 75% of the lamps in permanently installed fixtures shall be high-efficacy lamps (50% in 2009 IECC)

Or

A minimum of 75% of the permanently installed lighting fixtures shall contain only high-efficacy lamps

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Ventilation - Mandatory

The building shall be provided with a mechanical ventilation system per the IRC

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

DWELLING UNIT FLOOR AREA (square feet)	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

e.g. A 4-bedroom 2,500 sf home must have 75 cfm of continuous mechanical ventilation

Intermittent systems providing the equivalent ventilation rate over a four-hour period are acceptable

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Ventilation System Types

- Exhaust only
  - Often combined with local exhaust
- Supply only
  - Often combined with ducted heating/cooling systems
- Balanced systems
  - Standalone or combined with ducted heating/cooling system

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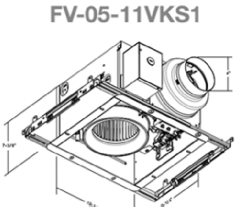
Exhaust-only ventilation



Two commonly installed options:
1. Controller in unit
2. Separate controller

Advantages
- Lowest cost
- Uses local exhaust equipment

Disadvantages
- No control over makeup air sources
- No heat recovery

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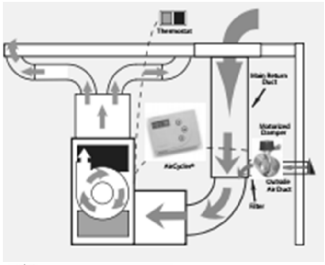
Supply-only ventilation



Two system components
- Fresh air intake duct with mechanical damper
- Ventilation controller
  - Opens damper for set minutes per hour
  - Cycles air handler if insufficient heating/cooling run time

Advantages
- Known air source
- Filtered, conditioned air

Disadvantages
- High energy use in fan-only mode
  - IECC mandates ECM blower motors in supply-only systems

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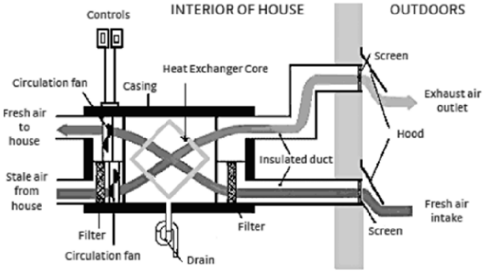
Balanced ventilation



Balanced supply and exhaust airflows
- HRV - Heat transfer only
- ERV – Heat & moisture transfer

Advantages
- Neutral pressure effect on home
- Controlled source
- Heat/moisture recovery

Disadvantages
- Highest initial cost

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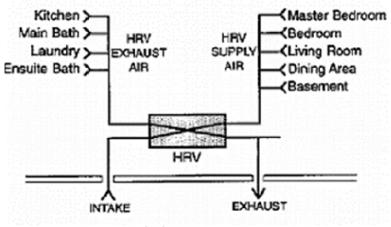
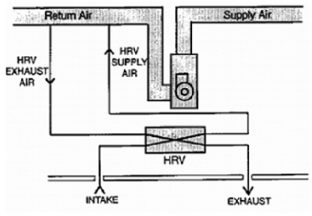
HRV/ERV Installation

Three installation options
- Standalone – dedicated exhaust and supply ducts
  - Best ventilation, most expensive installation
- Hybrid – dedicated exhaust, supply through heating/cooling ducts
  - Reasonably effective
- Integrated system – exhaust & supply from heating/cooling ducts
  - Lowest cost installation, requires air handler fan operation



Standalone System



Integrated System

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Other Ventilation Requirements

- Exhaust openings must terminate >3’ from operable and inoperable openings and >10’ from mechanical air intakes
- Whole house ventilation systems must be provided with controls that enable manual override
- Kitchen range hoods >400 cfm capacity must have automatically-controlled makeup air with a means of closure (2009 IRC)

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Air Sealing - Mandatory

2009 IECC	2012/2015 IECC
Air sealing mandatory	Air sealing mandatory
Verification by	*Verification by*
Tested Leakage ≤ 7 ACH50	Tested Leakage ≤ 3 ACH50
OR	**AND**
Completed Inspection Checklist (Table 402.4.2)	Completed Inspection Checklist (Table 402.4.1.1)

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Benefits of Envelope Sealing

- Energy efficiency
  - Low cost/high impact measures
  - Principal improvement measures used in existing home weatherization programs
- Comfort
  - Reduced thermal stratification, drafts, hot/cold spots
- Air quality
  - Reduced infiltration from garages, basements, crawl spaces, etc.
- Initial cost
  - Smaller, simpler mechanical systems

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Table R402.4.1.1

TABLE R402.4.1.1
AIR BARRIER AND INSULATION INSTALLATION

COMPONENT	CRITERIA[a]
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.

a. In addition, inspection of log walls shall be in accordance with the provisions of ICC-400.

- A great builders guide!
  - If Table 402.4.1.1 is followed builders should not have difficulty in meeting the < 3 ACH50 requirement

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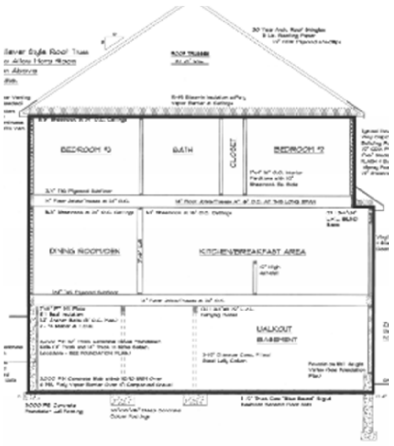
Red-Line Drawing



A <u>continuous</u> air barrier shall be installed in the <u>building envelope</u>

<u>Breaks</u> or <u>joints</u> in the air barrier shall be sealed

- Connections are always the weak point

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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.
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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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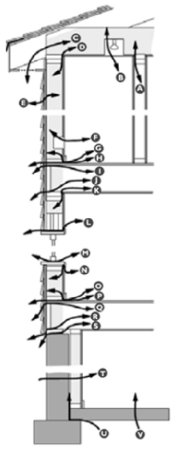
Critical Air Leakage Points



Joint	ACH50
Top plate to attic	0.29 to 1.60
Duct boots	0.13 to 0.26
Recessed lights	0.15 to 0.31
Band joists	0.37 to 0.42
Garage-house common wall	0.14 to 0.26
Sheathing to plate	0.04 to 0.38
Window/door framing to sheathing	0.02 to 0.10
Bottom plate to subfloor	0 to 0.11

Source: Owens Corning *Just How Airtight are Your Homes?*

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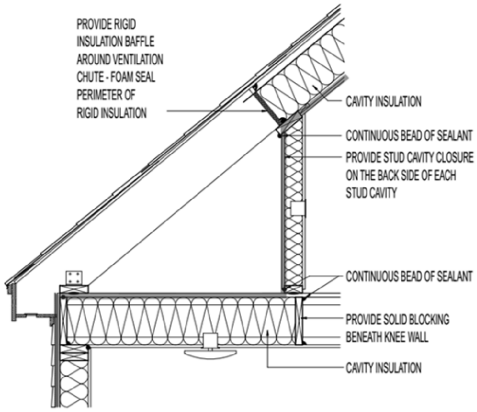
Knee wall sealing



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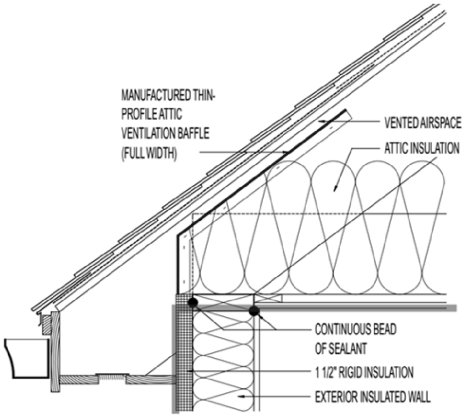
Eave vents



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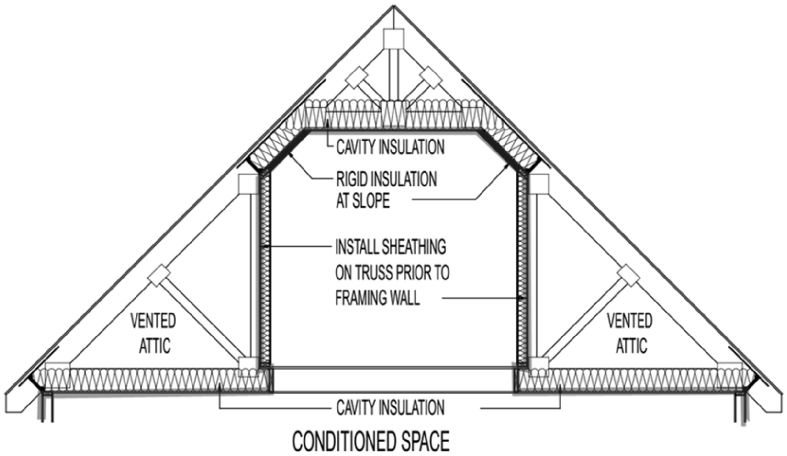
Attic rooms



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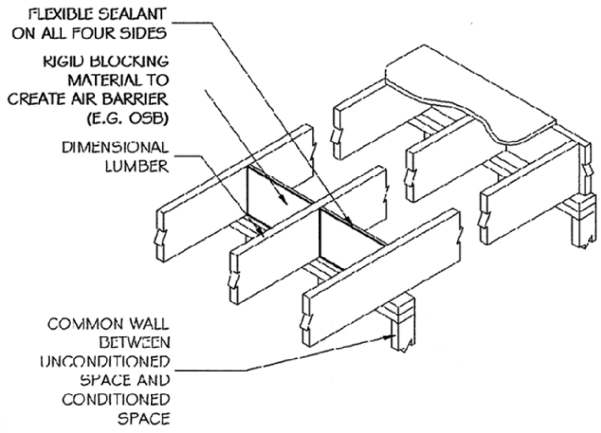
Floor/ceiling blocking & sealing



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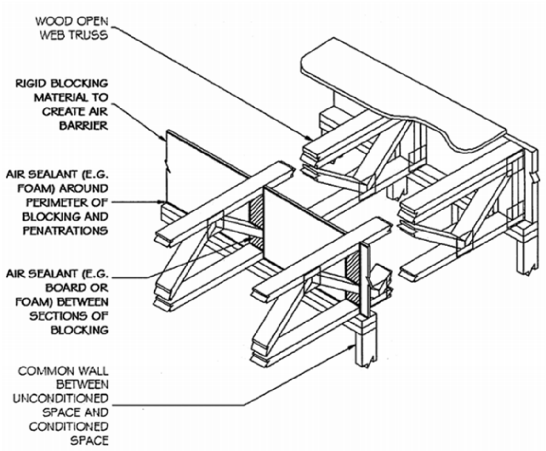
Floor/ceiling truss blocking



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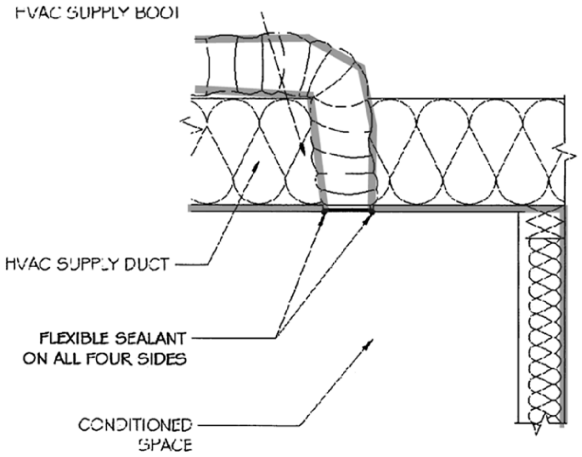
Duct boots



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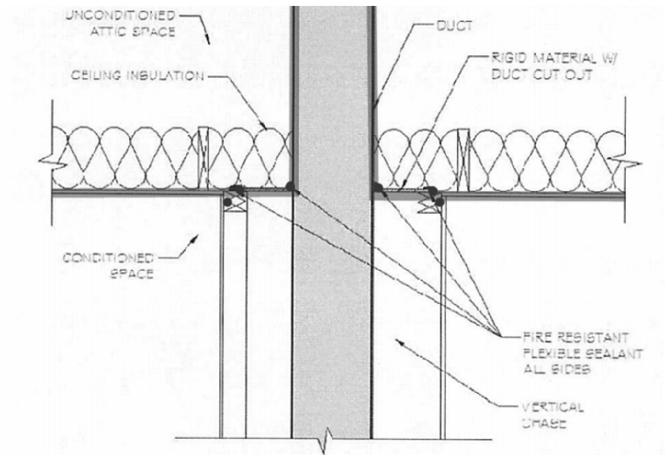
Duct chases



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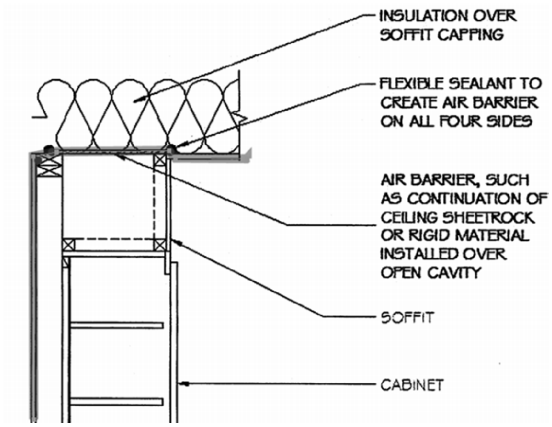
Soffits



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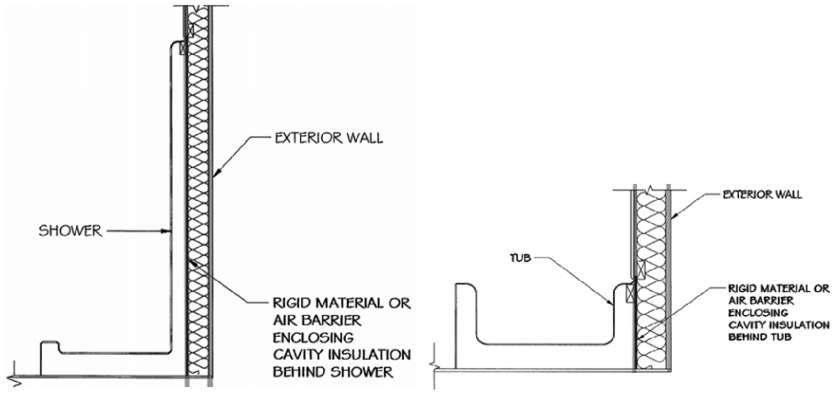
Showers & tubs



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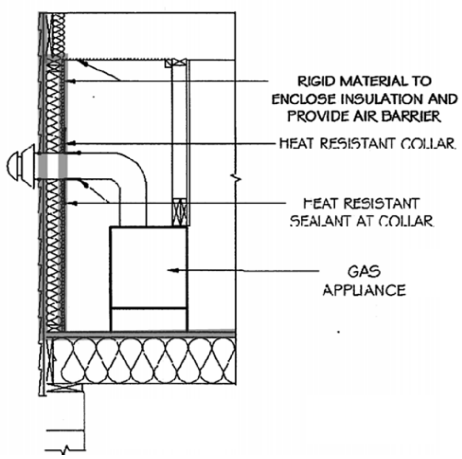
Gas fireplaces



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Blower Door Testing - Equipment

Rings are installed as necessary to ensure adequate air flow for accurate flow readings

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Manometer

Manometer measures pressure differences

- Left channel: Between inside house and the outside
- Right channel: Measures fan pressure
  - Automatically converted to CFM of air flow based on ring size used

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Blower Door Testing - Timing

- Code states:
  - "Testing shall occur after rough-in and after installation of penetrations in the building envelope, including penetrations for utilities, plumbing, electrical, ventilation and combustion appliances"
- In practice
  - Test immediately before final CO
    - Duct boots sealed to air barrier
    - Attic hatch gasketed
    - Door & window seals in place

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Test preparation

2009 IECC Section 402.4.2.1 requires that

1. Exterior windows and doors, fireplace and stove doors shall be closed but not sealed
2. Dampers shall be closed, but not sealed, including exhaust, intake, makeup air, backdraft and flue dampers
3. Interior doors shall be open
4. Exterior openings for continuous ventilation systems and heat recovery systems shall be closed and sealed
5. Heating, cooling and ventilation system(s) shall be turned off
6. HVAC ducts shall not be sealed; and
7. Supply and return registers shall not be sealed

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Test protocol

RESNET Standard Section 802.5 Procedure for Conducting a One-Point Depressurization Air Tightness Test

1. With fan sealed, measure baseline inside/outside pressure differential and set in manometer
2. Unseal fan, turn on and increase exhaust flow until inside/outside pressure differential equals 50 Pascals
3. Record fan flow in CFM from manometer (minimum 10 second average), inside & outside temperatures, fan and manometer model and serial numbers
4. Calculate corrected CFM50 value if inside/outside $\Delta T > 30$ degrees

While fan is running it is good practice to show builder any notable sources of air infiltration

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Interpretation

$$ACH50 = \frac{CFM50 \times 60}{\text{Volume of Enclosure}}$$

- ACH50 is the number of complete air exchanges the home would experience in one hour with a 50 Pascal inside/outside pressure differential
- Volume may be calculated from (conditioned floor area) x (average ceiling height)
  - Includes all volume within the thermal envelope, e.g. insulated basements and crawlspaces, sealed attics

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Benchmarks

ACH50	CFM/sf*	ELA (sq. in.)	Example
15+	2.0+	150	Older homes, balloon framed
10	1.3	100	Recent code-built homes
7	0.93	70	2009 IECC standard
4	0.53	40	ENERGY STAR v3 prescriptive standard
3	0.4	30	2012 &2015 IECC standard
0.6	0.08	6	Passive House standard
0.05	0.007	0.5	Claimed record (Dillingham, Alaska)

* 8′ ceiling height

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ACH50 and ACHn

The natural rate of air exchange (ACHn) can be estimated from the ACH50 results:

$$ACHn = ACH50 / n$$

In Connecticut, for a normally exposed, 2-story building n=14.8 so

7 ACH50 = (7/14.8) ACHn **= 0.47 ACHn**

and

3 ACH50 = (3/14.8) ACHn **= 0.20 ACHn**

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Testing challenges

- Additions
  - Generally impossible to isolate old and new construction in one building
- Multi-family units
  - Most infiltration is from adjacent units and common spaces
  - Compartmentalization is critical. Demising building assemblies must be airsealed to exterior wall standards

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What if I fail?

Blower door may identify specific problem areas

Treat drywall as the air barrier

- Seal duct boots and recessed lights
- Seal baseboard and trim
- Seal electrical outlets & plumbing penetrations
- Seal top plate-attic joints

Insulate the basement to bring it inside the conditioned volume

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Duct Leakage - Mandatory

2009 IECC	2012 IECC
Post Construction DLO ≤ 8 CFM25/100SF or TDL ≤ 12 CFM25/100 SF Or **Rough In** TDL ≤6 CFM25/100 SF including air handler or TDL ≤ 4 CFM25/100SF excluding air handler	**Post Construction** TDL ≤4 CFM/100SF Or **Rough In** TDL ≤ 4 CFM/100 SF including air handler or TDL ≤ 3 CFM25/100SF excluding air handler
Duct leakage testing not required if air handler and all ductwork are inside the conditioned space	

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Leakage Test Types

- Duct testing is done at 25 Pascals (0.1” wc), similar to normal operating pressure
- Total Duct Leakage
  - All leakage from the duct system regardless of whether the loss is to conditioned or unconditioned space
- Leakage to Outside
  - That part of total duct leakage that is outside the conditioned space

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Duct Leakage Testing - Equipment

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Test Preparation

- Turn off HVAC systems
- Turn off fans, ventilation systems
- Remove filters
- Open windows, doors, access panels to outside of unconditioned spaces where ducts are run
- Seal supply registers and return grills
  - Rough-in: Seal boots with duct sealing tape
  - Post-Construction: Seal registers with register sealing tape
- Connect Duct Blaster to
  - Major return closest to air handler, or
  - Air handler cabinet, or
  - Duct plenum (Rough-in test if air handler not installed)
- Insert test probe to measure duct system pressure
  - Largest supply register close to air handler
  - Main supply trunk line

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Test Protocol – Total Duct Leakage Test

- Open at least one door or window between building and outside
- Turn on fan. Increase speed until pressure in duct system is +25 Pascals with respect to the building
- Record fan flow CFM reading, fan and manometer model and serial numbers

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Test Protocol – Leakage to Outside Test

- Ensure all doors and windows to outside are closed
- Reverse direction of blower door fan (installed as for blower door test) so that building will be pressurized rather than depressurized
- Turn on blower door fan. Increase speed to make building pressure +25 Pascals with respect to outside
  - Pressure in duct system will be negative with respect to the building if there is any leakage outside the conditioned space
- Turn on and increase Duct Blaster fan speed to blow air into duct system until the pressure in the duct system is equal to the building pressure (zero pressure differential)
- Record fan flow CFM, fan and manometer model and serial numbers

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Interpretation

Duct leakage test result is normalized for building size by dividing by the Conditioned Floor Area:

$$\text{Leakage/100 sf CFA} = \frac{\text{CFM25 Leakage Test Result}}{\text{Conditioned Floor Area}}$$

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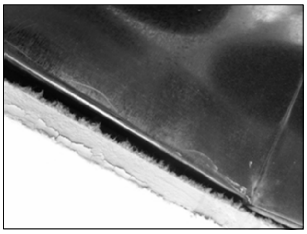
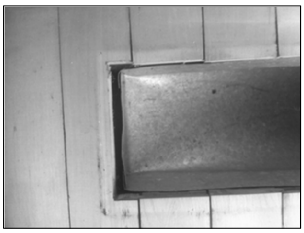
Failures





The vast majority of failures are due to the contractor's failure to seal the duct boots to the building thermal/pressure envelope allowing leakage into unconditioned spaces. Fortunately this is (usually) easy to correct

Less common problems are due to:
- Toe kick ducts not connected
- Buried ducts
- Disconnected fittings
- Unsealed connections

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Recommendations

- Keep all ducts and air handlers in conditioned space
- Test ducts at rough-in
  - Problems easier to find and fix
  - Sealing boots during installation keeps duct systems clean
  - OK for code compliance, ENERGY STAR still requires post construction testing
- Use mastic!
- Ensure boots are sealed to floor or drywall
  - Ensure cabinet installer aware of proper toe kick duct installation requirements

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Recap

- Duct and Envelope Tightness standards account for the majority of the energy efficiency gains in the 2009 and 2012 IECC
  - 2009 Standards: A learning opportunity
  - 2012 Standards: The bar is raised
- Reducing Duct and Envelope Leakage is the most cost effective energy efficiency improvement in most homes
  - Success requires paying attention to details, not expensive upgrades

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Incentives for Duct & Envelope Tightness Testing


2016 RESIDENTIAL
NEW CONSTRUCTION DUCT AND ENVELOPE TESTING REBATE

The CT Energy Efficiency Fund offers a $300 incentive for homes that meet the 2009 IECC Duct & Envelope tightness standards.

Testing must be performed by a qualified verifier. Applications and information may be obtained at www.EnergizeCT.com.

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Questions?

Peter Harding
peter@homeenergytechnologies.com

Home Energy Technologies LLC
(877) 800-6440
www.homeenergytechnologies.com