IECC
Real World Application

Presented by Robby Schwarz

About EnergyLogic

Berthoud, Colorado-based EnergyLogic is a software and building consulting company that has provided expert resources, education and support to new home builders and energy raters involved in the construction of high-performance homes since 2006.
Our Plan

- Intro
- What is a Rating?
- Diagnostic Testing
- Air Barrier and Insulation Installation Table
- Ventilation and HVAC

Change is Hard ... Change is Good... Change can be Made Easier

Expectation
**2018 IECC Definition: R105.4 Approved Inspection Agencies**

The *code official* is authorized to accept reports of third-party inspection agencies not affiliated with the *building* design or construction, provided that such agencies are *approved* as to qualifications and reliability relevant to the *building* components and systems that they are inspecting.
What Are a Rater’s Responsibilities?

- Different types of ratings, different responsibilities
- HERS minimum rated features vs. code mandatory
- HERS Index and HERC vs. ERI and ERI Report
  - Cost compliance report, UA compliance report
- Testing/inspection for code vs. for a HERS Ratings
  - Insulation / air barrier
  - Blower door
  - Duct leakage

What Is a Rating?

- Methodology for evaluating a house
  - Provides
    - Alignment
    - Uniformity
    - Consistency
  - May also...
    - Assess performance
    - Demonstrate compliance
    - Offer certification
- Index score
- Energy code
- ENERGY STAR®
- LEED®
- Other program
- Warranty
- Audit
**Asset Rating**

RESNET® HERS Rating
- Minimum rated features
- Not a pass / fail evaluation

Minimum rated features of a home include:
- Building envelope features
- Water heating
- Space heating and cooling systems
- Passive solar
- Solar domestic water heating
- Appliances
- One-site power production

**RESNET Insulation Grading**

Modeling guidance for derating the R-value of insulation:
- When it is possible to inspect insulation as installed (i.e., new construction), inspectors shall rate the installation as “Grade I, II, or III” according to the following guidelines.

<table>
<thead>
<tr>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Grade 1" /></td>
<td><img src="image2" alt="Grade 2" /></td>
<td><img src="image3" alt="Grade 3" /></td>
</tr>
</tbody>
</table>
Air Sealing and Insulation

N1101.13 (R303.2)

• Materials, systems and equipment shall be installed in accordance with the manufacturer's instructions and the International Building Code or the International Residential Code, as applicable.

• For insulation only Grade 1 installation meets the intent of the IECC.

Program Rating

- Certification/labeling Rating
  - Minimum rated features
  - Pass / fail evaluation

ENERGY STAR v3

- HERS Index target
- Thermal enclosure checklist
- Rater HVAC checklist
- HVAC design report
- HVAC commissioning report
- Builder water management checklist
- Footnote requirements
**R403.3.3 Duct Testing (Mandatory).**

Leakage testing required when *any portion* of ductwork is in unconditioned space

- Attic
- Unconditioned crawl space
- Isolated mechanical room with natural draft appliance
- Floor over garage?
- Exterior wall?

**ENERGY STAR Requires Duct Testing Regardless of the Location of the Duct**

*Total Duct Leakage*  
*Duct Leakage to Outside*

*Must be tested when using the performance path of code*
**Code Rating**

Compliance rating
- Minimum rated features
- Pass / fail evaluation

**Mandatory requirements:**
- Compliance modeling
  - UA compliance
  - Cost compliance
  - EIR compliance
- Insulation installation
- Air barriers
- Air leakage 3/5ACH
- Duct leakage 4%
- High-efficacy lighting

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**Items Listed in This Table Are Mandatory and Sometimes Not Clear**

**Definitions**

**Building Thermal Envelope**
The basement walls, exterior walls, floor, roof, and any other building element that enclose the conditioned space. This boundary also includes the boundary between conditioned space and any exempt or unconditioned space.
Energy Code Inspection

Fundamental Questions

<table>
<thead>
<tr>
<th>Is It There?</th>
<th>Does It Work?</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
</tbody>
</table>
Code Compliance Paths

- Prescriptive Path
- UA Compliance Path
- Simulated Performance Path
- Energy Rating Index Path

Code Ensures a Solid Thermal Envelope
What / Where Is the Thermal Envelope?

- Control and predictability:
  - Air Flow
  - Moisture Flow
  - Thermal Flow

Two Functions of an Air Barrier

- Interior vs. exterior air barrier
- At its simplest form:
  - Interior drywall
  - Exterior sheathing
    - House wrap?
    - Drainage plane
- Function
  - Enclosing insulation
    - 6 sided encapsulation
  - Thermal control
  - Air control
  - Moisture control
Can a House Be Too Tight?

NO!

- Wrong question
- Control air flow
- In order to control the air

Real question...
- Can houses be under-ventilated?

YES!

Build tight and ventilate right!

Code and Adopted Proven Building Science

Control and predictability

- Air flow
- Thermal flow
- Moisture flow
R402.4.1.2 Testing
(Mandatory)

• The building or dwelling unit shall be tested and verified as having an air leakage rate not exceeding:
  • 5 ACH@50 in climate zones 1 and 2
  • 3 ACH@50 in climate zones 3 through 8
• Testing shall be conducted by an approved third-party
• Reporting

Air Leakage Testing

• Air out = air in
• The principle behind the blower door
Air Leakage Report

Property: Blocktop
123 Fake St. CO 89001
Confirmed/Rating: Confirmed

Air Leakage

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blower Door Test</td>
<td>0.7</td>
</tr>
<tr>
<td>IAQ (Calculated)</td>
<td>81.3</td>
</tr>
</tbody>
</table>

Duct Leakage

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Duct Systems</td>
<td>5 Systems</td>
</tr>
<tr>
<td>Leaking to Ducts (DPH @ 25 Pa)</td>
<td>0.0</td>
</tr>
<tr>
<td>Leaking to Ducts (DPH @ 100 Pa)</td>
<td>0.0</td>
</tr>
<tr>
<td>Total Leaking</td>
<td>0.0</td>
</tr>
<tr>
<td>Test Type</td>
<td>Post-Construction</td>
</tr>
<tr>
<td>Leaking to Ducts (DPH @ 25 Pa)</td>
<td>0.0</td>
</tr>
<tr>
<td>Leaking to Ducts (DPH @ 100 Pa)</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Mechanical Ventilation

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test (DCHV)</td>
<td>52.8</td>
</tr>
<tr>
<td>Heat (kWh)</td>
<td>14.4</td>
</tr>
<tr>
<td>Fan (kWh)</td>
<td>15.9</td>
</tr>
<tr>
<td>Energy Efficiency %</td>
<td>88.0</td>
</tr>
<tr>
<td>Time of least micro every 5 min</td>
<td>30 min</td>
</tr>
<tr>
<td>Average Rate (CFH)</td>
<td>59.0</td>
</tr>
<tr>
<td>2013 ENERGY STAR Max Total Ventilation</td>
<td>82.1</td>
</tr>
</tbody>
</table>

Final Home Testing Results

Date: 5/13/2019
Prepared by: EnergyLogic

9191 E 52nd Dr
Denver, CO 80238

Supervisor: Jim Hinkle
Inspection: Majekta
Climate Zone: T-5 Dry
Floor Name: 1.00

Building Shell/Blower Door Test

<table>
<thead>
<tr>
<th>Test</th>
<th>Target</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blower Door Test</td>
<td>2,091.85 CPM</td>
<td>1,352 CPM</td>
</tr>
<tr>
<td>IAQ</td>
<td>0.00 CPM</td>
<td>0.00 CPM</td>
</tr>
<tr>
<td>House to Garage Connection</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>HVAC (C4) to Garage</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>House to CAT</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Building Shell/Insulation

Insulation installed to manufacturer's specifications Grade 1 | Insulation Type | R-Value |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2x6 walls</td>
<td>N/A</td>
<td>NA</td>
</tr>
<tr>
<td>2x4 walls</td>
<td>N/A</td>
<td>NA</td>
</tr>
<tr>
<td>2x4 walls</td>
<td>N/A</td>
<td>NA</td>
</tr>
</tbody>
</table>
Single Family vs. Attached Housing
Potential Alternative Language

• **R402.4.1.2 Testing.** The building or dwelling unit shall be tested and verified as having an air leakage rate not exceeding five air changes per hour or 0.30 cubic feet per minute (CFM) per square foot (ft²) of dwelling unit enclosure area in Climate Zones 1 and 2, and three air changes per hour or 0.24 CFM per (ft²) of dwelling unit enclosure area in Climate Zones 3 through 8. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals). Where required by the code official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope.

Exception:

• An air leakage rate not exceeding 0.30 cfm per ft² of the dwelling unit enclosure area shall be an accepted alternative in all climate zones for:
  • All attached/multifamily building dwelling units.
  • Buildings or dwelling units that are 1500 sqft or smaller.

402.4 Air Leakage and Air Barriers (Mandatory)

• **R402.4.1.1 Installation.** The components of the building thermal envelope as indicated in Table R402.4.1.1 shall be installed in accordance with the manufacturer’s instructions and the criteria indicated in Table R402.4.1.1, as applicable to the method of construction.

• **Building Thermal Envelope.** The basement walls, exterior walls, floors, ceiling, roofs and any other building element assemblies that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space.
### 2015/18 IECC Table

#### Table 2015/18 IECC Table

<table>
<thead>
<tr>
<th>Component</th>
<th>Required Components</th>
<th>Installation Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>A continuous or discrete surface or barrier for the heating and cooling systems.</td>
<td>Insulation Installation Category</td>
</tr>
<tr>
<td>Ceiling</td>
<td>The ceiling shall be insulated.</td>
<td>Insulation Installation Category</td>
</tr>
<tr>
<td>Walls</td>
<td>The walls shall be insulated.</td>
<td>Insulation Installation Category</td>
</tr>
<tr>
<td>Doors and windows</td>
<td>The doors and windows shall be insulated.</td>
<td>Insulation Installation Category</td>
</tr>
</tbody>
</table>

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**IECC**

INTERNATIONAL

ENERGY CONSERVATION

CODE

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[Image of the 2015/18 IECC Table]
R402.4 Air Leakage and Air Barriers
(Mandatory)

- The building thermal envelope shall be constructed to limit air leakage in accordance with the requirements of Sections R402.4.1 through R402.4.4.

- The components of the building thermal envelope as listed in Table R402.4.1.1 shall be installed in accordance with the manufacturer’s instructions and the criteria listed in Table R402.4.1.1.
Air Sealing and Insulation

2015 IECC R402.4

• The components of the thermal envelope as listed in Table R402.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria listed in table R402.4.1.1 as applicable to the method of construction.

Examples of Manufacturer's Instructions

• When insulating walls, place the insulation in the cavity and check to be sure it completely fills the cavity, top to bottom.
• Gently press the insulation at the sides into the framing cavity, usually about 3/4 inch, until the outside edge of the flange is flush with the face of the framing.
• Avoid gaps and “fish-mouths” between flanges and framing (Refer to Figure 3A).
• Remember, compressing insulation ... will result in some loss of R-value.
• Wherever insulation is installed in a building, it is very important that it fit snugly on all sides.
• When the wiring is in the center of the cavity, either a shallow cut in the insulation may be used to allow the wiring to pass through the insulation or it may be split lengthwise and the wiring sandwiched within.
• It is recommended that the insulation be pushed up to the subfloor.
• It is important also for the insulation to cover the top plate.
• Use baffles if necessary to keep the insulation from blocking the passage of air.
Insulation Installation Instructions

RESNET Standards Grade 1 Insulation Installation

- Installed according to manufacturer’s instructions
- Fills each cavity side-to-side and top-to-bottom
- No substantial gaps, voids, compressions, or obstructions
- Split or fitted tightly around wiring or obstructions in wall
- Occasional very small gaps are acceptable for “Grade I”
- Wall insulation shall be enclosed on all six sides
- Must be in substantial contact with the sheathing material.
- Inset stapling is neat (no buckling), and the batt is only compressed at the edges of each cavity, to the depth of the tab itself.

- Compression or incomplete fill amounting to 2% or less, if the empty spaces are less than 30% of the intended fill thickness, are acceptable for “Grade I”.
RESNET Standards: Grade I Insulation

Gray areas illustrate compression

Gray areas illustrate gaps & voids

Insulated sheathings enhance the cavity insulation and make it work better.
Insulation traps pockets of air. Stagnate air pockets create the R-value.

Air Barrier stops air movement, keeping stagnant air pocket. Now it works!

Controlling Thermal Flow

Most insulation is NOT an air barrier

Resists conduction

Does not resist air flow: That is the job of the air barrier

* An air barrier is any solid material that blocks air flow, including sealing at edges and seams.

What is the biggest insulation myth: Insulation stops the movement of air!
Terminology

• Mandatory requirements
  • Requirements that must be met by every building unless there is a specific exception in the code.

• Prescriptive requirements
  • Requirements that must be met by every building unless an approved tradeoff is utilized or unless there is a specific exception in the code.

• Performance approach
  • An overall performance requirement for the building that replaces the individual prescriptive requirements for building systems and components.

R402.2.1 Ceilings with Attic Spaces

• R-38 shall be deemed to satisfy the requirement for R-49 wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves.

• Tradeoff - SPP
**Theory of Ventilated Attic Insulation**

Baffle stops both 1&2. May need to use continuous baffles to stop ventilation air from bypassing baffles.

1. Wind-wash
2. Wind intrusion in the insulation

Ventilation air should only drop into the top of the insulation. The depth of the material is compensating for the inability to enclose it on all six sides.

**R402.2.3 Eave Baffle**

- For air permeable insulations in vented attics, a baffle shall be installed adjacent to soffit and eave vents.

- Baffles shall maintain an opening equal or greater than the size of the vent.

- The baffle shall extend over the top of the attic insulation.
Insulation Over the Top Plate:
ESv3: Baffle and Minimum R-21 in CZ-5

Vented or unvented?
That is the question!

Vaulted/Raftered Ceilings

Vented or unvented?
That is the question!
Vaulted/Raftered Ceilings

- Continuous baffled air space
- Sealed and separated from the insulation
Cathedralized Attic

Bring mechanical equipment and ductwork into conditioned space any way you can!

R402.2.10 Slab-On-Grade Floors

• Slab-on-grade floors with a floor surface less than 12 inches (305 mm) below grade shall be insulated in accordance with Table R402.1.2. The insulation shall extend downward from the top of the slab on the outside or inside of the foundation wall.

• Insulation located below grade shall be extended the distance provided in Table R402.1.2 by any combination of vertical insulation, insulation extending under the slab or insulation extending out from the building.

• Insulation extending away from the building shall be protected by pavement or by not less than 10 inches (254 mm) of soil.

• The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45-degree (0.79 rad) angle away from the exterior wall. Slab-edge insulation is not required in jurisdictions designated by the code official as having a very heavy termite infestation.
Slab on Grade and Walkouts

R402.2.10 Slab-On-Grade Floors
Table 402.4.1.1
Component - General Air Barrier/Thermal Barrier

**Air Barrier Criteria**
- 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.

**Insulation Installation Criteria**
- Air-permeable insulation shall not be used as a sealing material.

<table>
<thead>
<tr>
<th>General requirements</th>
<th>A continuous air barrier shall be installed in the building envelope.</th>
<th>Air-permeable insulation shall not be used as a sealing material.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The exterior thermal envelope contains a continuous air barrier.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Breaks or joints in the air barrier shall be sealed.</td>
<td></td>
</tr>
</tbody>
</table>

**Section R202 General Definitions**

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

- Continuous air barrier
  - A combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.
5 Key Air Barriers Attributes

- **Continuity**: The most important element in 3D structures with many different components to ensure alignment between insulation and the air ABS.

- **Impermeability**: The ABS must be impermeable to air after installation.

- **Strength**: The ABS must be designed to transfer the full designed wind load, stop external or internal air movement into the assembly, and continue to be impermeable.

- **Durability**: The ABS must continue to be impermeable throughout its service life, or at the IECC says, “over the useful life of the building.”

- **Stiffness**: The ABS must be stiff enough so that irregularities in the building found at installation of the ABS do not change its permeance.

Air-Permeable Insulation Shall Not Be Used as a Sealing Material
**Insulation Take Away**

- Fully filled cavity
- Enclosed on six sides
  - Exception - insulation in a ventilated attic and rim joist
- Adjacent and contiguous to thermal boundary with fully aligned air barriers
- Limited gaps, voids, or compressions
- No thermal bypass
- Grade 1 installs
  - Heading toward blown products

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**Table 402.4.1.1**

**Component – Ceiling / Attic**

**Air Barrier Criteria**
- 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.

**Insulation Installation Criteria**
- The insulation in any dropped ceiling/soffit shall be aligned with the air barrier.
Dropped Ceiling / Soffit
Full Air Barrier Aligned with Insulation

Sequencing
1. Air barrier to bottom cord of rafter!
2. Air barrier to exterior wall!
3. Over framing for dropped ceiling!
4. Brings drop into conditioned space!
Ceiling Access Openings

Insulated hatch that is heavy enough to create a seal on weather stripping. Recommend MDF or SIP hatches.

Attic Access
Table 402.4.1.1
Component - Walls

Air Barrier Criteria

• 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.
• Knee walls shall be sealed.

Insulation Installation Criteria

• Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance of R3 per inch minimum.
• Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.

<table>
<thead>
<tr>
<th>Walls</th>
<th>Insulation Installation Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>The junction of the foundation and sill plate shall be sealed.</td>
<td>Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance of R3 per inch minimum.</td>
</tr>
<tr>
<td>The junction of the top plate and top of exterior walls shall be sealed.</td>
<td>Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.</td>
</tr>
<tr>
<td>Knee walls shall be sealed.</td>
<td></td>
</tr>
</tbody>
</table>

Junction Of Foundation and Sill Plate Is Sealed

What Is Sill Seal Meant To Do?

Capillary Break
The Junction of the Top Plate and Top of Exterior Walls Shall Be Sealed

Attic Knee Walls
### Attic Knee Walls

![Images of attic knee walls]

### Doing It Right

Sequencing
1. Top plate
2. Bottom plate
3. Side Studs
4. Attic side sheathing
5. Interior drywall is the sixth side
**Small Attic Knee Walls**

**Knee walls 1’ or Less**

The installed depth of the insulation must be at the height of the knee wall in order to forego knee wall backing. The installed insulation angle should not exceed 45 degrees to ensure that the mounded insulation provides a minimum acceptable insulation depth over the corner of such structures and to ensure that it will not slide off. The depth of the insulation as illustrated by the two red arrows shall be equal hence ensuring at least R-38 over the outside edge of the knee wall.

Bottom plate of knee wall (top plate of wall below) should be separate walls and/or separated by blocking.
Knee wall greater than 1’

For short knee walls and for raised ceilings that are ≥ 1’ and or are taller than the ceiling below, the best practice is to install a full attic side air barrier and six sided enclosed cavity insulation. The air barrier should extend above the raised ceiling, to act as an insulation dam, to ensure that the higher insulation does not fall off the top plate onto the insulation below.

For Knee walls greater than 1’

Bottom plat of knee wall (top plate of wall below) needed to be separate walls and/or separated by blocking.

Small Knee Wall Done Right
**Corners and Headers Shall Be Insulated**

- Wood backer
- Drywall clip

**Interior Wall Meets Exterior Wall**

- Ladder Blocking
- Continuous 2x6 Behind 2x4
Other Wall Assemblies

- Exterior thermal envelope insulation for framed walls shall be installed in substantial **contact and continuous alignment** with the air barrier.
Chase: Where Is the Thermal Envelope?

Outside Chase is inside Inside

Chase: Where Is the Thermal Envelope?

Outside Chase is within Inside
Chase: Where Is the Thermal Envelope?

Table 402.4.1.1
Component – Windows, Skylights, and Doors

Air Barrier Criteria

- The space between window/door jambs and framing and skylights and framing shall be sealed.

Insulation Installation Criteria

| Windows, skylights and doors | The space between window/door jambs and framing and skylights and framing shall be sealed. |
Openings Between Window/Door Jams Sealed

Table 402.4.1.1
Component – Rim Joists

Air Barrier Criteria

- Rim joists shall include the air barrier.

Insulation Installation Criteria

- Rim joists shall be insulated.

| Rim Joists | Rim Joists shall include the air barrier | Rim Joists shall be insulated | Box Sill |