BUILDING CODE TRAINING

Residential Thermal Envelope – Air Sealing
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ABOUT SOUTHCORPSE

Building a Regenerative Economy, Responsible Resource Use & Social Equity Through a Healthy Built Environment for All
PRESENTERS

Joey Starr
Education

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ENERGY CODE RESOURCES

Online educational resources are available by visiting: www.southfaceonlinetraining.org

Technical assistance or training requests can be submitted to Georgia Energy Code Hotline at: energycodes@southface.org or 404-604-3598

Additional Resources
Georgia Energy Code: If you would like additional information on Georgia’s current energy code, please visit the Georgia Department of Community Affairs website at: www.dca.ga.gov/development/ConstructionCodes/programs/EnergyCodeTrainingWorkshops.asp

DOE Field Study: If you would like additional information on other DOE Field Studies and participating states, please visit the Building Energy Codes website here: https://www.energycodes.gov/compliance/energy-code-field-studies

Georgia Field Study: If you would like further information regarding the Georgia Energy Code Field Study, please visit our project webpage found at: www.seealliance.org

LEARNING OBJECTIVES

• Understand Georgia State Minimum Standard Energy Code air barrier requirements
• Learn thermal boundary requirements of the Georgia energy code
• Identify house air sealing key points
IMPORTANCE OF ENERGY CODES

Saves energy - Buildings consume 40% of energy in U.S.

Saves money - Energy costs continue to escalate and energy codes help keep money within local economy

Additional benefits:
• Increases comfort, health and durability of homes
• Increases value of homes in local community
• Reduces liability for builders and subcontractors
SCOPE OF RESIDENTIAL ENERGY CODE

- Heavy focus on building thermal envelope
  - Ceilings, walls, windows, floors, foundations
  - Sets insulation levels, window U-factors and SHGC
- Infiltration control (Mandatory)
  - Caulk and seal to prevent air leaks
  - Verify tight envelope with blower door AND visual inspection
- Ducts
  - No building cavities as ducts
  - Seal properly and insulate
  - Verify tight with duct pressurization test
- Hot water pipe insulation
- Lighting - high-efficacy bulbs required
- No appliance requirements
The Georgia Department of Community Affairs (DCA) used the 2015 IECC Code to develop the new code

**Georgia Amendments for Codes Effective January 1, 2020**
2015 GEORGIA RESIDENTIAL ENERGY CODE FIELD STUDY

8 Key Items:
• High-efficiency lighting
• **Envelope tightness (ACH50)**
• Duct leakage
• Exterior wall insulation
• Ceiling insulation
• Foundation insulation (floor / basement wall / slab)
• Window U-factor
• Window SHGC

63 observations of each key item minimum
Vertical red line indicates the IECC prescriptive code requirement of 7 ACH50 5 ACH

Key Takeaways
Only 3 results worse than the 2009 IECC code of 73 tests conducted

The average ACH50 for all homes tested was 4.9
DUCT AND ENVELOPE TIGHTNESS VERIFICATION

Third-party verifiers shall have one of the following minimum qualifications to conduct inspections or plan review for the energy efficiency provisions of residential buildings as defined by this code:

1. Accredited HERS Rater
2. ICC Residential Energy Inspector/Plans Examiner Certification
3. EarthCraft House Technical Advisor
4. Building Performance Institute (BPI) Analyst
5. Equivalent qualifications as approved by the local code official (Duct and Envelope Tightness Verifier)
ENVELOPE TIGHTNESS EXAMPLE

\[
\text{ACH}_{50} = \frac{\text{CFM}_{50} \times 60}{\text{Conditioned Volume}}
\]

Blower Door Test: 1000 CFM

House Volume: 9600 ft³

\[
\text{ACH}_{50} = \frac{(1000 \times 60)}{9600}
\]

\[
\text{ACH}_{50} = 6.25 \text{ FAIL}
\]
ENVELOPE TIGHTNESS EXAMPLE

\[ \text{ACH}_{50} = \frac{\text{CFM}_{50} \times 60}{\text{Conditioned Volume}} \]

Blower Door Test: 800 CFM<sub>50</sub>
House Volume: 9600 ft<sup>3</sup>
\[ \text{ACH}_{50} = \frac{(800 \times 60)}{(9600)} \]
\[ \text{ACH}_{50} = 5 \text{ PASS} \]
ENVELOPE TIGHTNESS EXAMPLE

\[
ACH_{50} = \frac{CFM_{50} \times 60}{\text{Conditioned Volume}}
\]

Blower Door Test: \textbf{1000 CFM}_{50}

House Volume: \textbf{12000 ft}^3

\[
ACH_{50} = \frac{(1000 \times 60)}{(12000)}
\]

\[
ACH_{50} = 5 \text{ PASS}
\]
A house is a system made up of interrelated parts:
- Space conditioning
- Ventilation
- Water heating & distribution
- Lighting & appliances
- The building thermal envelope

Building science represents a holistic view of a house and applies an understanding of the flow of: Heat, air and moisture
The building thermal envelope is the barrier that separates conditioned space from unconditioned space. The envelope should consist of a **continuous** thermal barrier (insulation) and an air barrier that are in contact.
CONDUCTION

• Heat moves through a material
• Insulation can slow down conduction
  • How well a material slows conduction is called resistance
  • Resistance is measured as R value or U value
THERMAL BARRIER

• Limits heat flow between inside and outside.
• Easy to identify by presence of insulation.
• The location of insulation in relation to other building components is critical to its effectiveness.
• Even small areas of missing insulation are very important.
• Voids of 7% can reduce effective R-value by almost 50%.
CONVECTION

- Air moves from areas of higher pressure to areas of lower pressure
- Natural and man-made forces that can create pressure differences cause air to flow
- Whenever air moves out of a home, an equal amount of air enters the home

Image courtesy of Building Science Corporation,
AIR BARRIER

• Limits airflow between inside and outside
• More difficult to identify
• Not always where you think it is
• Should be collocated with the thermal barrier
• Blower door is used to locate air barrier

Graphic developed for the US DOE WAP Standardized Curricula
Another reason to limit air flow in a home is to reduce moisture instruction. Even a small hole can allow a large amount of water into the building.
*Although these three homes look identical from the outside, each has defined the building thermal envelope differently*
a) **Conditioned space:** a cooled space, heated space, or indirectly conditioned space is defined as follows:

1. **Cooled space:** an enclosed space within a building that is cooled by a cooling system whose sensible output capacity exceeds 5 Btu/h·ft$^2$ of floor area.

2. **Heated space:** an enclosed space within a building that is heated by a heating system whose output capacity relative to the floor area is greater than or equal to 5 Btu/h·ft$^2$.

3. **Indirectly conditioned space:**
3. **Indirectly conditioned space:** an enclosed space within a building that is not a heated space or a cooled space, containing un-insulated ducts, or containing the heating equipment or which is heated or cooled indirectly by being connected to adjacent space(s), provided that air from heated or cooled spaces is transferred (naturally or mechanically) into the space.

Unvented Attic Assemblies meeting the requirements of the IRC are an approved indirectly conditioned space.
b) **Semi-heated space:** an enclosed space within a building that is heated by a heating system whose output capacity is greater than or equal to 3.4 Btu/h·ft² of floor area but is not a conditioned space.

c) **Unconditioned space:** an enclosed space within a building that is not a conditioned space or a semi-heated space. Crawl spaces, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces.
AIR BARRIER INSTALLATION

Residential Building Code Training
ATTIC HATCHES

Graphic courtesy of http://www.energysavers.gov
ATTIC HATCHES

Graphic courtesy of http://www.energysavers.gov
ATTIC DOORS

Vertical doors must have a minimum of R-5 and must be weatherstripped for air sealing.
AIR IMPERMEABLE INSULATION

Appendix RA
2015 IECC (2019 Georgia Energy Code)

Roofline Installed Insulation Options
Reference Table 402.1.1 and 402.1.6 in the Georgia Energy Code amendments to the 2015 IECC and Section 806.5 “unvented attic assemblies” in the Georgia Amendments to the 2012 IRC

Vaulted unvented attic – roofline air-impermeable insulation
(e.g., spray foam insulation)

Air impermeable insulation
(e.g., open- or closed-cell spray foam)

Air impermeable insulation
R-20 minimum if trade-offs are used (Georgia requirements)
SHOWER/TUB ON EXTERIOR WALL

Photo courtesy of Anthony Cox
SHOWER/TUB ON EXTERIOR WALL

Coordinate with your subcontractors so that insulation and air sealing details are not missed before it is too late!

Complete air barrier behind tub
PLUMBING AND WIRING

Install insulation and sealed air barrier behind tub (required)
CANTILEVERED FLOOR

Did not install blocking
(Just Covered Over With Insulation)
Cantilevered floor

The blocking above the bearing wall helps to define the home’s air barrier, so each piece of blocking needs to be sealed at the perimeter with caulk or canned spray foam. As long as both layers of rigid foam are installed with attention to airtightness, this type of cantilevered floor performs well.
GARAGE SEPARATION

Installed blocking but did not airseal
GARAGE SEPARATION

Penetrations Sealed
Framing Blocked and Sealed
Good!!!

Garage on Other Side of Wall
DUCT SHAFTS

Cap chases with rigid material and seal tight around ducts or flue pipes
DUCT SHAFTS

Sealed with foam

Chase capped with OSB material

Penetrations in Top Plate Sealed
PLUMBING AND WIRING PENETRATIONS

Penetrations opening to exterior or unconditioned space shall be sealed.

Use appropriate materials: caulking, foam, or mastic.
KNEE WALLS

Air permeable kneewall insulation needs to be encapsulated on all sides.

No blocking under kneewalls.
402.4.5 RECESSED LIGHTS

Standard Can Light

Airtight and IC Rated

- All recessed luminaires shall be labeled as having an air leakage rate not more than 2.0 cfm tested at 75 pa
- All recessed luminaires shall be sealed with a gasket or caulk between the housing and the interior wall or ceiling covering
SILL (BOTTOM) PLATE

Bottom Plate Sealed
(but batt installation fails!)
SILL (BOTTOM) PLATE

Dirty carpet on **exterior** wall indicates leak at wall sill plate

On **interior** wall indicates wall leaking to attic
R402.2.8 FLOORS

Floor insulation must maintain permanent contact with the subfloor.
FLOOR INSULATION

GOOD!

- Installed insulation is in complete contact with air barrier (subfloor)
- Insulation coverage is complete
- Insulation is slit around plumbing and wiring and securely fastened with minimal compression

BAD!

- Insulation is not installed in complete contact with air barrier (subfloor)
- Insulation coverage is incomplete due to obstructions (plumbing, electrical, ductwork, etc.)
- Insulation is compressed around plumbing and wiring and is not securely fastened
R402.2.11 CRAWLSPACE WALLS

- Air seal & insulate band area
- 3-inch view strip (removable is option)
- Insulation must be permanently fastened and extend to within 9” of the finished interior grade
- Complete plastic sealed to walls at least 6 inches up the stem wall
CRAWLSPACE WALLS

Southface suggestion: taped, hinged “plug” of rigid insulation board in gap
BAND JOISTS

• Must air seal and insulate rim/band area in basements & crawlspaces
• Pest control industry struggles with band area fully filled with spray foam
• Blocks inspection for pest control
• Air seal and then insulate with movable insulation product (batts, pillows, rigid board, etc.)
Do **not** use atmospherically vented appliances in closed crawlspaces or attics.
CRAWLSPACE VENTING

Satisfy IRC exception to vent requirement (IRC section R408.3)

Venting Exceptions:

• Continuous exhaust (radon)
• Direct condition crawlspace (supply)
• Direct condition (dehumidifier)
402.4.2 WOOD BURNING FIREPLACES

New wood-burning fireplaces shall have tight-fitting flue dampers or doors, and outdoor combustion air.
402.4.4 ROOMS CONTAINING FUEL-BURNING APPLIANCES

The appliances and combustion air opening shall be located outside the building thermal envelope or enclosed in a room, isolated from inside the thermal envelope. Direct vent appliances with both intake and exhaust pipes installed continuous to the outside are exempt.
Sealed combustion appliances do not need high/low vents because they get their air directly from the outdoors. Direct vent water heaters are exempt for the same reason.

*Keep people air and combustion air separate.*
HVAC REGISTER BOOTS

6 CFM per 100 sq ft
Total Leakage
## WHOLE-HOUSE MECHANICAL VENTILATION

<table>
<thead>
<tr>
<th>Ventilation Type</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exhaust Only</strong></td>
<td>• Easy to install</td>
<td>• Negative pressure may cause backdrafting</td>
</tr>
<tr>
<td>Air is exhausted from the house</td>
<td>• Simple method for spot ventilation</td>
<td>• Makeup air is from random sources</td>
</tr>
<tr>
<td>with a fan</td>
<td>• Inexpensive</td>
<td>• Removes heated or cooled air</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Supply Only</strong></td>
<td>• Does not interfere with combustion appliances</td>
<td>• Does not remove indoor air pollutants at their source</td>
</tr>
<tr>
<td>Air is supplied into the house</td>
<td>• Positive pressures inhibit pollutants from entering</td>
<td>• Brings in hot or cold air or moisture from the outside</td>
</tr>
<tr>
<td>with a fan</td>
<td>• Delivers to important locations</td>
<td>• Air circulation can feel drafty</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Furnace fan runs more often unless fan has an ECM (variable-speed motor)</td>
</tr>
<tr>
<td><strong>Balanced Air Exchange System</strong></td>
<td>• No combustion impact</td>
<td>• More complicated design considerations</td>
</tr>
<tr>
<td>Heat and energy recovery</td>
<td>• No induced infiltration/exfiltration</td>
<td>• Over ventilation unless the building is tight</td>
</tr>
<tr>
<td>ventilators supply and exhaust</td>
<td>• Can be regulated to optimize performance</td>
<td>• Cost</td>
</tr>
<tr>
<td>air</td>
<td>• Provides equal supply and exhaust air</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Recovers up to 80% of the energy in air exchanged</td>
<td></td>
</tr>
</tbody>
</table>
WHOLE-HOUSE MECHANICAL VENTILATION

Whole-house mechanical ventilation is required at 3 \( ACH_{50} \).
THANK YOU!

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