Ducts in Conditioned Space . . . Well Sort Of
Session Description

High performance goals and code are pushing ductwork into conditioned space. This is achievable through several approaches but some require redesign.

The Building America program has been researching options to better deal with ducts in vented attics. This session will review the history of this research as well as the advantages and disadvantages of these systems compared to alternative strategies.

While the practice of burying ducts is not new, prescriptive code language is. The 2018 IECC details a prescriptive path for the use of buried ducts with fibrous insulation in vented attics for all climate zones. The code change has the potential to provide a vented attic design that is highly energy efficient but at lower cost than alternatives.
Learning objectives

• Review research conducted on ductwork in conditioned space

• Summarize code changes, energy modeling and implications

• Illustrate how to implement best practices

• Demonstrate energy and cost benefits
Why Buried Ducts?

• Ductwork thermal losses can range from 10-45%
• Interior ducts locations may impact cost, aesthetics and envelope loads
Ducts in Unvented Attic

- Allow flexibility with HVAC design
- Minimize design integration
- Typically more expensive
- May increase enclosure loads

2015 IRC Sections R806.5 Unvented Attic Assemblies

R316 FOAM PLASTIC control these assemblies
Ducts in Dropped Soffit

- Low-cost in simple plans
- Longer “throws” may be required
- Requires architectural integration
Ducts in Trusses

- Simple installation and design flexibility
- Cost-effective
- Cooling is less effective from floor registers
Ducts in Modified Trusses

- Work well in narrow plans
- Moderate cost-increase
- Sealing the air-barrier is critical
- Design integration required
What Are Buried Ducts?

- Low cost, high-performance duct strategy
- Very high R-values
Research Timeline

- **1998**
  - SWA: insulation enhanced ducts
  - R-30 attic suspended ducts
  - Phoenix, AZ

- **2000**
  - SWA: buried ducts
  - Southern CA
  - Beazer Homes
  - First buried R4.2 + R19

- **2002**
  - SWA: buried ducts
  - Southern CA
  - Beazer Homes

- **2003**
  - SWA: buried ducts
  - Southern CA
  - Beazer Homes
  - Sought to do drop hallway ceilings, but architect was not interested.
  - The science of buried ducts began + testing

- **2005** revisions to Title 24 Alternative Compliance Path incorporates buried ducts

- **2006**
  - SWA: Buried Duct Research
  - Finite element analysis model was developed
  - SWA ASHRAE paper: effective R-value of buried ducts and defining partial, fully, & deeply buried

- **2007**

- **2008**

- **2009**

- **2010**

- **2012**

- **2014**

- **2016**

- **2018**

© Steven Winter Associates, Inc. 2017
Buried/Encapsulated Ducts

Buried Ducts

Encapsulated Ducts

Buried & Encapsulated
SWA: hot/humid climate
- Knew R-6 buried duct would condense.
- Modeling suggested it would condense on side of duct @ ~11am. Monitoring confirmed this.
- Melbourne, FL

SWA: retrofit
- Foamed over suspended ducts
- Foamed, buried ducts
- Effective, but required significant oversight during installation.
- Jacksonville, FL

SWA: new construction
- Outlook Construction
- Working on technique of foamed over, buried ducts
- Cartersville, GA

2009 IRC prescriptively allows foamed ducts
Research Timeline

Owens Corning Science & Tech Center
- ASHRAE paper: thermal and moisture performance of buried ducts

HIRL: MD case study
- Double R-8 branch ducts with ~2" insulation mounded over the ducts

HIRL: NJ case study
- R-8 ducts with R-30 mounded over the ducts

FSEC: hot/humid climate
- Buried ducts
- Condensation during mid-summer
- Cocoa, FL

HIRL: humid climate
- R-8 ducts with R-30 mounded over the ducts
- Effective, but needs quality control
- Lady’s Island, SC

2018 IECC prescriptive language for buried ducts
Buried Duct Classification

Buried Duct Schematic
Buried Duct Classification

Buried & Encapsulated Duct Schematic

Ducts with R-8 insulation encapsulated in 1.5 in of ccSPF

Deeply-buried

Fully-buried

Partially-buried

Truss lower chords
Effective R-values

- R-value metrics:
  - Nominal – listed values for duct insulation
  - Effective – heat loss/gain from duct to attic
- Buried duct effective R-values calculated using FEA

Heat flux magnitude through a hung duct, and an encapsulated and fully-buried 8-in diameter duct
# Effective R-values

<table>
<thead>
<tr>
<th>Duct Configuration</th>
<th>R-4.2 Ducts</th>
<th>R-6 Ducts</th>
<th>R-8 Ducts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hung ducts encapsulated in 1.5” of ccSPF</td>
<td>11.3</td>
<td>12.0</td>
<td>12.7</td>
</tr>
<tr>
<td>Partially-buried</td>
<td>8.1</td>
<td>10.2</td>
<td>12.3</td>
</tr>
<tr>
<td>Fully-buried</td>
<td>12.0</td>
<td>14.1</td>
<td>16.2</td>
</tr>
<tr>
<td>Deeply-buried</td>
<td>20.7</td>
<td>22.1</td>
<td>23.5</td>
</tr>
<tr>
<td>Encapsulated in 1.5” of ccSPF and partially-buried</td>
<td>18.4</td>
<td>19.7</td>
<td>21.0</td>
</tr>
<tr>
<td>Encapsulated in 1.5” of ccSPF and fully-buried</td>
<td>22.6</td>
<td>23.8</td>
<td>25.0</td>
</tr>
<tr>
<td>Encapsulated in 1.5” of ccSPF and deeply-buried</td>
<td>29.6</td>
<td>30.3</td>
<td>31.1</td>
</tr>
</tbody>
</table>
BEDs Implementation

Ducts deeply buried under loose-fill insulation

Ducts with R-8 insulation encapsulated in 1.5 in of ccSPF running above the truss chords

Flex duct with R-8 insulation encapsulated in 1.5 in of ccSPF

Duct-boot connection over ceiling supply register encapsulated in 1.5 in of ccSPF

Gyp. board ceiling

Truss lower chords
Low-Profile - Compact Design

• Before ceiling drywall

• After ceiling drywall
Mastic seal ducts and TEST

- Test total duct leakage
  target \( \leq 3 \text{ cfm} \)25 per 100 ft2 of conditioned space
Apply 1 ½” minimum ccSPF

- ccSPF applied prior to ceiling gypsum board
Apply 1 ½” minimum ccSPF

- ccSPF applied after ceiling gypsum board
Quality Control - Retrofit

Exposed underside of duct jacket

Well-sealed ductwork

Exposed underside of duct jacket
Loose-fill insulation

- Insulation must be ASTM classified as “mineral-fiber”, and must cover the ccSPF by a minimum of 1 ½” (cellulose doesn’t qualify)
- Some foams are exempt from this requirement
Code Compliance

2015 IRC requires that spray foam insulation applied to the exterior of ductwork (Section M1601.3) in attics (Section R316.5.3) meet several requirements:

- Flame spread index less than 25
- Smoke-developed index less than 450
- No attic storage or occupancy
- Spray foam protected by ignition barrier (1 ½” mineral fiber)
  - Or meets R316.6 (no ignition barrier required)
Bringing Housing Innovations to Market

BUILDING AMERICA SOLUTION CENTER
BASC.ENERGY.GOV

Building best practices at your fingertips.

www.buildingamerica.gov
2018 Code Details

Ducts may be partially or fully buried under attic insulation.

1. Duct Insulation:
   - Minimum of R-8 for supply and return ducts; however...
   - CZ’s 1A, 2A, 3A require R-13 for buried supply ducts

2. Ceiling Insulation:
   - Above and below duct should total R-19, not including duct R-value

---

Figure 2. Example partially buried duct (left), buried duct across the truss bottom truss chord (middle), and buried duct on the ceiling (right).

---

1. General requirements/duct insulation:
   - Follow general requirements and duct insulation described previously

2. Air Handler Location:
   - Within the conditioned space

3. Duct Leakage:
   - Rough-in or post-construction total system leakage to outside of 1.5 cfm/100 sf CFA

4. Ceiling Insulation:
   - Insulation R-value against and above the duct $\geq$ ceiling R-value – duct R-value
Performance Path or ERI Compliance

• The 2018 code, as described, enables reduced energy usage options that can be claimed toward compliance when using the Performance Path or the Energy Rating Index

• Based on installation, this includes:
  – A deeply buried R-8 duct can use an R-25 exposed duct when performance modeling
  – A duct system that is covered with sufficient insulation and leaks less than 1.5 cfm/100ft² may model the ducts in conditioned space.

Credit: Craig Drumheller, Director- Construction Codes and Standards NAHB
Implementing Buried Ducts

Duct layout with the intention to bury
Buried Duct Done Right

Sealed – Insulated - Buried
Done Right… Sort Of
Not Done Right . . . At All
Our Approach

• While ccSPF is not specifically needed, we think it provides a more robust solution in terms of condensation control when implementing buried ducts. Again, it too must be done right.

• Without the use of ccSPF, providing R-13 at supply boots can be challenging.
In Summary

• Research shows that bringing ducts “inside” increases efficiency

• Code is catching up; the prescriptive practice in 2018 IECC can be implemented in all climate zones

• Success is in the details; ductwork needs to be well sealed & insulated

• Determining duct locations during design allows for the most flexibility with execution
Thank You

Questions?

Karla Butterfield
Senior Sustainability Consultant
LEED AP, BD+C Homes · LEED Green Rater · HERS Rate · NGBS Master Verifier · PHIUS+ Rater & MF Verifier
203-857-0200 x303
kbutterfield@swinter.com