Basic B.S.
(building science)
insights for
Spray Foam, HVAC
and Moisture

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Director, LaHouse Resource Center
“When the blind leads the blind...

get out of the way.”

Anonymous 1st Grade Student
A House is a System of *dynamic*, interacting systems...

- Thermal Envelope System ↔ Air Barrier System
- HVAC System ↔ Moisture Control System
- Plumbing System ↔ Electrical System

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Building Envelope:
The Driving Forces

Image Courtesy: Southface Institute
How Heat Flows

Conduction

• The transfer of heat through solid objects.

• Insulation, multiple layers of glass in windows, reduce conduction.
How Heat Flows

Radiation

• Movement of radiant energy *across empty space* from warmer to cooler objects.

• Examples:
  – Sunshine (solar heat) heats roof deck and brick veneer.
  – Hot roof deck radiates to attic floor; brick veneer to wall.
  – Solar and radiant heat from pavement passes through clear glass, heats floor.
How Heat Flows

Convection

• The flow of heat by currents of air.

• As air warms, it rises; as it cools, it gets heavier and sinks.

• Air flow into a home is *infiltration*;

• Outward flow is called *exfiltration*.

• *Air leakage* is both.
Typical Air Bypasses (Leaks) largely *to the attic and crawl space*
Where is the boundary of the conditioned space?

The thermal (insulation) and air barrier boundaries must be in direct contact.
An ice chest full of holes won’t keep your beer cold.

A house thermal blanket full of gaps and thin spots will need a lot more ice.
A Continuous Air Barrier
Why so important?

- Saves energy
- Saves money
- Controls air quality
- Increases comfort
- Reduces moisture into building cavities
Climate Zones
Rainfall
Keeping It Dry
Rain and Moisture Management

Wet happens...
but can it dry???
Moisture Dynamics

Liquid water flows downward, except when it doesn’t

Gravity

Adhesion

Wind

Wicking (capillary action)

Hydrostatic pressure
Water Vapor Moves by:

Air transport

Diffusion through materials
Moisture Flows...

WARM MORE COLD less
So....

Which way does it flow?
Which is wetter?
Which is warmer?

a. Outside air
b. Inside air
So....

Which way does it flow?

Cold, dry outside
Cozy inside

Hot, humid outside
Cool, dry A/C inside
Relative Humidity (RH)

Amount of H₂O in air

Amount of H₂O air can hold at that temperature

Humid air + cold surface = condensation
Recipe for lawyer wealth

Warm, wet weather
+ cool A/C
+ vinyl wallpaper
= mold
## Water Vapor Permeability

<table>
<thead>
<tr>
<th>Perm Rating</th>
<th>Class</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \leq 0.1 )</td>
<td>1</td>
<td>Vapor barrier</td>
</tr>
<tr>
<td>( &gt; 0.1 \leq 1.0 )</td>
<td>2</td>
<td>Vapor retarder</td>
</tr>
<tr>
<td>( &gt; 1.0 \leq 10 )</td>
<td>3</td>
<td>Semi-permeable vapor retarder</td>
</tr>
<tr>
<td>( &gt; 10 )</td>
<td>4</td>
<td>Vapor permeable</td>
</tr>
</tbody>
</table>
Mixed Climate Assembly

Vented cladding

High permeability

Dries in both directions
Warm, Humid Climate Assembly

Low permeability  High permeability

Dries to the inside
All-Climate High-Performance Solution

- **in summer**, foam board provides exterior vapor barrier
- **in winter**, foam board interior not cold enough for condensation within wall cavity
Indoor Air Quality Goal
RH 40-60%

In leaky homes, A/C runs long = big bills, but good dehumidification.
In tight, efficient homes, little temp. load, but humidity load remains.
Indoor Humidity Control

extra important in warm climate energy-efficient homes

- Moisture protected (dry) foundation or subfloor
- Rain and moisture managed walls and roof
- Bath, kitchen exhaust fans (low noise)
- Right sized A/C (bigger is NOT better)
  - with SHF < .75 (25% dehumidification)
- If not enough, add dehumidifier
Oversized A/C - Bad Idea

- Cost more to buy
- Cost more to operate – less efficient
- Shorter life
- Less comfort – poor dehumidification
Sizing: The Wrong and Right Ways

- By floor area and convenience
  - Old rule of thumb for standard homes = 1 ton/500 sq.ft.
  - One duct size fits all

- By Manual J and Manual D
  - Load for energy-efficient home = 1 ton/800-1000 sq.ft.
  - Designed duct system
Proper Ventilation

1. **Combustion Ventilation**
supply and exhaust; direct vent sealed combustion when indoors.

2. **Local Exhaust Ventilation**
to remove moisture, odors, other contaminants at the source.

3. **Fresh Air Ventilation**
to reduce indoor contaminants by dilution.

4. **Control of Airflow**
to filter air, distribute air, minimize energy and manage humidity.

**Build tight, vent right**
with controlled, filtered fresh air.
Keep it Properly Ventilated

Energy Star, Quiet Exhaust Fan
- < 0.3 sone at 80 cfm
- Moisture sensor or timer control

High Performance Hood
- < .3 sone at normal speed
- Extends over all burners

Correct Duct Installation
- Min. and smooth curves
- Larger, smooth duct
How much ventilation?

The old, the new, and the future

Ventilation Standards

7.5 cfm/person (# BRs + 1)

plus

1-3 cfm/100 sq. ft. of conditioned area

Example: 2000 sq. ft. 3 BR house = 50-90 cfm depending upon…..

Are leaky houses with “natural ventilation” and exhaust-only systems the best strategy?
Is this good or bad ventilation?

Why?

Courtesy of Building Science Corporation

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Avoid negative pressure in the south!

Infiltration of warm, humid air:
- into walls
- through chases
- to cool interiors
  can cause
  - hidden condensation
  - mold
  - backdrafting

Behind vinyl wallpaper

Best Practice – Aim for a slight positive pressure.
Air Handler and Duct Locations

1. **BEST** – In conditioned living space
   - Ducts in furr downs, below sealed ceiling
   - Air handler in closet

2. **Good** – In unvented attic
   - Insulation at roof, not ceiling and air sealed
   - Attic is then semi-conditioned space

3. **Good** – Super sealed in vented attic
   - Mastic, not duct tape + R-8 insulation
   - Return duct, not leaky plenum
   - Air tight ceiling
Vented vs. Unvented Attic

Figure 1. Diagram of Roof/attic thermal processes in vented and sealed attics.
Unvented Attic System

**Advantages**

- No HVAC losses to outside, so
  - Saves energy, money
  - Prevents negative pressure
  - Reduces forced air leakage
- Enables smaller A/C
  - Offsets higher cost of insulation system
- No need to air seal ceiling
  - No need for ICAT cans, detailing, etc.
- No attic, soffit vents
  - No wind driven water risk
- Closed-cell adds wind resistance
- Can deck attic floor, no insulation
- Clean, comfortable attic space

**But...**
Unvented Attic System

Requirements & Recommendations

• **Air-impermeable insulation** (spray foam) under roof decking (code)
  - Or, rigid foam above roof decking
  - To prevent winter condensation at ridge

• **NO vents**
  - Need sealed blocking at roof-wall junction
  - Vents or leaks in humid climate = moisture entry = condensation on cold ducts = mold + wet ceiling

• **Semi-conditioned space**
  - Don’t isolate from living space
  - Need slight A/C supply + return in warm climate for attic humidity control

• **NO combustion equipment**
  - *Except* direct vent, sealed combustion type
  - Critical IAQ and moisture hazard!

• **Proper installation, curing, safety**
  - Trained workers, right conditions
  - No occupants until cured
Unvented Attic System

Requirements & Recommendations

- **Ignition barrier (code)**
  - ES report approved product
  - Or, intumescent coating, gypsum, etc. covering

- **Low perm underlayment**
  - Synthetic felt or adhesive membrane
  - Stops vapor drive into decking to prevent swelling and buckling

- **Heat tolerant or cool roofing**
  - Metal, tile, slate, concrete
  - Light or “cool color”, high quality shingles

- **Only closed cell in cold climates**

- **Open cell in warm, rainy gulf region**
  - OK with indoor humidity control
  - More forgiving of roof leak, vapor drive

- **R-value higher than in walls** *(R 20-30 in La.)*
  - No insulation on attic floor
  - No radiant barrier under roof
**High Performance Home**

**HVAC Recommendations**

- **For unvented attic:**
  - Heat pump or sealed combustion gas
  - A/C supply + return in warm, humid climate

- **Right sized A/C**
  - Manual J sizing, Manual D duct design

- **Controlled ventilation**
  - Fresh air inlet at clean air location
  - Filter in convenient location
  - Auto flow control damper
  - Design to meet ventilation standard, but set timer for less in humid climate

- **Dehumidification options:**
  - **Good:** Two A/C units, divide load
  - **Better:** 2-speed A/C + portable Energy Star dehumidifier w/ drain
  - **Better:** Variable capacity compressor A/C
  - **Best:** Whole house high-efficiency dehumidifier or ventilating dehumidifier

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Supplemental Dehumidification in Warm-Humid Climates

By Armin Rudd  2013
Spray Foam in Walls

Ideal solution for band between floors
- Insulates and air seals in 1 step

Open cell – fill wall cavity
- Moves with building
- Still need to caulk plates

Closed cell – partial fill
- Flood hardy system
- Adds strength

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Insulating Raised Floors in Hot, Humid Climates

Research Findings on Moisture Management
**Closed Cell Foam Under Raised Floor**

- 2 in. for R-13
- If skirted crawl, coat joists

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**CRAWL SPACE/FLOOD ZONE: VENTED CRAWL SPACE WITH ‘FLOOD VENTS’**

U.S. Environmental Protection Agency’s "Indoor air PLUS" new homes labeling program <www.epa.gov/indoorairplus>, see Technical Guidance-Moisture Control; Illustrations- Dennis Livingston, Community Resources.
## In Summary

### Spray Foam Recommendations

<table>
<thead>
<tr>
<th>Location</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unvented Attic</strong></td>
<td>No vents, so no gas (except direct vent, sealed combustion only)</td>
</tr>
<tr>
<td></td>
<td><strong>Supply A/C</strong> in warm, humid climate</td>
</tr>
<tr>
<td></td>
<td><strong>Low perm underlayment</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Light color shingles, metal or tile</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Closed cell in cold climates</strong>, OK in any</td>
</tr>
<tr>
<td></td>
<td><strong>Open cell</strong> in rainy, hot climate</td>
</tr>
<tr>
<td><strong>Vented to Unvented Attic Conversion (existing homes)</strong></td>
<td><strong>All the above</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Seal airtight, test with blower door</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Remove attic floor insulation</strong></td>
</tr>
<tr>
<td><strong>Vented Attic</strong></td>
<td><strong>Airtight ceiling</strong> – can use foam</td>
</tr>
<tr>
<td></td>
<td><strong>Mastic sealed ducts + leakage test</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Radiant barrier</strong> if A/C, ducts in attic in south</td>
</tr>
<tr>
<td><strong>Walls</strong></td>
<td><strong>Either open or closed OK</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Still caulk plates</strong></td>
</tr>
<tr>
<td><strong>Raised Floors</strong></td>
<td><strong>Closed cell only</strong></td>
</tr>
<tr>
<td></td>
<td><strong>If skirted, coat joists</strong></td>
</tr>
</tbody>
</table>

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For more information:

• BuildingAmerica.gov
  – Solution Center

• BuildingScience.com
  – Building guides by climate zone
  – Articles on many topics

• fsec.ucf.edu
  – Florida Solar Energy Center research, info, training
Showcase of Solutions

- 4 high performance building systems
- 4 HP foundation systems
- 10 types of windows, doors
- 3 HVAC systems
- 5 attic treatments
- 5 moisture mngt. sytems
- Fortified for safer living
- DOE Building America
- Energy Star
- Healthy Home / IAQ
- Green Building
- Universal Design