"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**

Building Envelope:
The Driving Forces

- wind
- heat
- humidity
- rain
- water

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.

**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)
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

High to Extreme 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...

- FROM WARM to COLD
- FROM MORE to LESS
So...

In a hot, humid climate, moisture moves from outside (warmer, higher RH) to inside (A/C cooler, dryer)

Relative Humidity (RH)

Amount of $\text{H}_2\text{O}$ in air

\[ \frac{\text{Amount of } \text{H}_2\text{O} \text{ in air}}{\text{Amount of } \text{H}_2\text{O} \text{ air can hold at that temperature}} \]

Humid air + cold surface = condensation
Northern Walls in the South

Warm, wet climate
+ 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>≤ 0.1</td>
<td>1</td>
<td>Vapor barrier</td>
</tr>
<tr>
<td>&gt; 0.1 ≤ 1.0</td>
<td>2</td>
<td>Vapor retarder</td>
</tr>
<tr>
<td>&gt; 1.0 ≤ 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>
Hot, Humid Climate Assembly

Low permeability          High permeability

Dries to the inside

All-climate Solution

- in summer, foam board provides exterior vapor barrier
- in winter, foam board interior is not cold enough for condensation within wall cavity

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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 energy efficient homes

- Vapor barrier under slab or subfloor
- Bath, kitchen exhaust fans (low noise)
- Right sized A/C *(bigger is NOT better)*
- Choose A/C with SHF < .75
  - min. 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
Healthy Housing Principle

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**

**Quiet fans + proper duct installation = effective exhaust**

- **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

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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?

Duct Leaks and Negative Pressure

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
Unvented Attic System

**Advantages**

- No HVAC losses to outside, so
  - Saves energy, money
  - Prevents negative pressure
  - Stops entry of humid air
- Enables smaller A/C
  - Offsets higher cost of system
- No need to air seal ceiling
  - No need for ICAT cans, detailing, etc.
- No attic, soffit vents
  - No wind driven water risk
- 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, no air leaks to outside**
  – Need sealed blocking at roof-wall junction
  – Vents, leaks in humid climate = moisture entry = condensation on cold ducts = mold + wet ceiling

• **Semi-conditioned space**
  – Don’t isolate from living space
  – A/C attic in hot, humid climate

• **NO combustion equipment**
  – Except direct vent, sealed combustion type
  – IAQ and moisture hazard

• **Proper installation, curing, safety**
  – Trained workers, with PPE
  – No occupants until cured

---

Unvented Attic System

Requirements & Recommendations

• **Ignition barrier** (code)
  – ES report approved product
  – Or, intumescent coating,
  – Or, thermal barrier covering (gypsum)

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

• **Heat tolerant, cool roofing**
  – Metal, tile, slate
  – Lighter color, high quality shingles
  – Energy Star “cool roofing” best

• **Open cell lower risk in La.**
  – Closed cell with adhesive membrane, adds structural racking resistance

• **R-value: Recommend > R 20 in La.**
  – No insulation on attic floor, no radiant barrier

---

(Images and diagrams illustrate the concepts discussed.)
High Performance Home

HVAC Recommendations

- For unvented attic:
  - Heat pump or sealed combustion gas
  - A/C supply + return in hot, 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, EMC A/C
  - Best: Whole house high-efficiency dehumidifier or ventilating dehumidifier

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
- Floods hardy system
- Adds strength
**Closed Cell Foam Under Raised Floor**

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

### Spray Foam Recommendations

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

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**For more information:**

- [BuildingAmerica.gov](http://BuildingAmerica.gov)  
  - Solution Center
- [BuildingScience.com](http://BuildingScience.com)  
  - Building guides by climate zone  
  - Articles on many topics
- [fsec.ucf.edu](http://fsec.ucf.edu)  
  - Florida Solar Energy Center research, info, training
- [dnr.louisiana.gov.energy](http://dnr.louisiana.gov.energy)  
  - Residential Energy Programs  
  - Louisiana Builders Guide
Questions?

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