Building Science - Weatherization for Pros

Exploring how to make homes healthier, safer, and more efficient
Introductions
Agenda

Unhealthy homes
Inefficient Homes
Building Science
Heat Transfer
Air Movement
Water
Construction Solutions
Definitions
Health and Safety

**Health and Safety**

**Toxic Mold**
Plumbing leaks and any source of moisture can cause toxic mold. Diseases associated with toxic mold are leukemia, broncy, esophagus, and liver cancer.

**Dust**
Dust is a harmful indoor allergen that contains particles of dust mites, chemicals, outdoor minerals, insect parts, dander, fungi, and bacteria. Inhaling dust can trigger allergies and asthma.

**Viruses**
Viruses in the home can be caused by fungus in mattresses and pillows, parasites, indoor pests, and a variety of microorganisms that are found in homes.

**Dust Mites**
Dust mite waste triggers asthma. Dust mites are found in 90% of all homes. 47% of all bedding in North America contains enough dust mite allergen to trigger allergies.

**Dander**
Cat and dog dander is a leading allergen that triggers asthma. Dander is found in carpets, beds, and every place in the home that is visited by these two popular pets.

**Asian Ladybugs**
Found mostly in the Northeastern states. Ladybugs hibernate inside of structures. When disturbed, ladybugs emit a yellowish secretion that triggers allergic asthma.

**Carbon Monoxide**
Carbon monoxide is a poisonous gas that is caused by clogged fireplaces and faulty heating systems. The odorless gas causes nausea, dizziness, headaches, and over exposure can be lethal.

**Radon**
Radon is an odorless gas that is found in 1 in 15 homes across the U.S. It enters a home from the ground through a crack in the foundation or floor and the deadly gas is the second leading cause of lung cancer in America. Radon causes 20,000 deaths each year.

**Asbestos/Hazardous Materials**
Asbestos and other hazardous materials like pesticides, fiberglass, and other chemical based products can pollute the indoor environment. Spores and chemical fumes can cause severe illness.

**Carbon Dioxide**
Poor ventilation creates 50% of indoor pollution. Stagnant air production and over exposure can be lethal.

**Rats & Mice**
Rats and mice can live up to 12 months without eating protein in their usual diet, and become harmful allergens in the ventilation system. Throughout the home, allergen triggers can be found.

**Lead**
Many older homes were painted over with lead paint in 1978. One in ten children suffer from lead poisoning.

**Bacteria**
A variety of serious infections caused by bacteria. Polluted water distribution systems, fungi in mattresses, and anyplace where mold is found.

**Pollens**
Plants and trees release pollen that gets into the home through open windows and doors. Pollen causes headaches, fever, and triggers allergies and asthma.

**Fungi**
There are many different kinds of fungi in a home. Some are in mattresses and pillows and feed on dust mite waste. Fungi can live beneath carpets, in garbage piles, water drains, air ducts, where mildew or high humidity creates moisture. Inhalation can trigger allergies and will cause or worsen illnesses.

**Fungus**
Fungi can live beneath carpets, in garbage piles, water drains, air ducts, where mildew or high humidity creates moisture. Inhalation can trigger allergies and will cause or worsen illnesses.

**Cookroaches**
Like mice and rats, cockroaches can also live for long periods of time in a home without being discovered. Their waste and dusty skin is a harmful allergen that also triggers asthma.
Inefficient Homes
Building Science

Heat (Hot moves to cold)
Air (High pressure moves to low pressure)
Water (Wet moves to dry)
Heat Transfer

Heat flows due to:
- Conduction
- Convection
- Radiation

Hot

Cold
Heat Transfer and Energy Flows

**IN THE SUMMER...**
1. Sun radiates heat to the roof
2. Roof radiates heat to the ceiling
3. Heat is conducted through the ceiling and radiated into the home

**IN THE WINTER...**
1. Convection causes warm air to rise
2. Heat is conducted from the warm air to the ceiling
3. Heat is conducted through the ceiling to the attic air
4. Convection causes warm air to rise and the heat is lost
Air Movement

Stack
Wind
Mechanical

Note: Air barriers are not the same as vapor barriers
Wind creates pressure on one side of home and suction on the other side, just like an airplane wing. Open windows on the downside and air will flow out of window.
Heat Recovery Ventilator (HRV)

HRV exhausts stale, moist air to outside and transfers heat to fresh ventilation air from outside. Fresh air can be ducted into furnace return duct or into home directly.
Common air leaks into an attic

Warm and moist interior air pushes into the attic through any opening.

Gaps in Drywall

Wiring

Plumbing Vents

Trap Door

Around Chimney

Electrical Boxes, Lights, Fans

© Tom Felza Mr. Fix-It Inc.
Water/Moisture Movement

Bulk water
Capillary water
Vapor diffusion
Air leakage

The famous Canadian building scientist, Mark Bomberg, is known for, among many things, this quote:

“Our buildings get wet during the winter but don’t rot till the summer.”

He was speaking in the context of adding central air conditioning to homes in cold climates; without the AC they were getting wet in the winter and drying out in the summer. Add AC, and the reduced drying sends the assemblies over the moisture management cliff.
Construction Techniques
Advanced Framing

Traditional Framing Method

DiM: Advanced Framing Reduces thermal bridging.
Advanced Framing

- Foam sheathing
- Insulated header
- 2x2 nailer added to outside and flush to the exterior of window opening to provide nailing surface for siding and window trim
Roofs are bombarded with heat, so insulation should be extra thick.

Walls are relatively skinny, so insulation should have as much R-value per inch as possible.

Regardless of insulation type or placement, building assemblies should be designed so that they can dry to the outside, inside, or both.

Foundations sit in stable temperatures, but constant moisture. Insulation should be nearly waterproof.
## Climate Zones

<table>
<thead>
<tr>
<th>Zone</th>
<th>Uninsulated Attic</th>
<th>Existing 3–4 Inches of Insulation</th>
<th>Floor</th>
<th>Zone 1 Includes Hawai‘i, Guam, Puerto Rico, and the Virgin Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R30 to R49</td>
<td>R25 to R30</td>
<td>R13</td>
<td>All of Alaska in Zone 7 except for the following Boroughs in Zone 8:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bethel, Dillingham, Fairbanks N. Star, Nome, North Slope, Northwest Arctic, Southeast Fairbanks, Wade Hampton, Yukon–Koyukak,</td>
</tr>
</tbody>
</table>
# Types of Insulation and Corresponding R-Values

<table>
<thead>
<tr>
<th>Insulation Type</th>
<th>R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiberglass or rock wool batts</td>
<td>2.8 – 4.0/inch</td>
</tr>
<tr>
<td>Blown cellulose</td>
<td>3.0 – 4.0/inch</td>
</tr>
<tr>
<td>Beadboard foam insulation</td>
<td>3.9 – 4.3/inch</td>
</tr>
<tr>
<td>Pink/blue board</td>
<td>5.0/inch</td>
</tr>
<tr>
<td>Polyurethane spray foam</td>
<td>6.2 – 7.0/inch</td>
</tr>
<tr>
<td>Icynene foam</td>
<td>3.6/inch</td>
</tr>
<tr>
<td>Concrete block</td>
<td>0.1375/inch</td>
</tr>
</tbody>
</table>
Airtightness

Measured:
Air Changes per Hour (ACH)
CFM per square foot area
Estimated Leakage Area (ELA)
Airtightness

Requirements:

International Residential Code (IRC) require 7 ACH50,

Energy Star has required 5 ACH50 and their new 2011 version 3.0 has a climate zone specific requirement:

Infiltration rates shall be less than or equal to the following values:
- 6 ACH50 in CZs 1,2
- 5 ACH50 in CZs 3,4
- 4 ACH50 in CZs 5,6,7
- 3 ACH50 in CZ 8

And the Energy & Environmental Builder's Alliance (EEBA) requires less than 0.25 cfm of leakage per square foot of building surface area (including floor) @ 50 Pa.
leakage areas
Air Barrier

Caulk all joints
Tape seams (European flashing tape)
Spray foam cracks
Cover holes
If the roof deck isn’t insulated with spray foam, do the following:

- Seal the tops of light fixtures that penetrate the envelope.
- Seal at all wire, pipe, and duct penetrations that go from the top floor to the unconditioned attic spaces.
- Seal attic hatches or stairs with air-sealing products or weatherstripping.

3. The third line of defense is to seal the interior of the envelope with open-cell spray foam, 10 in. thick in the walls, 14 in. thick in the roof.

2. The second line of defense is a layer of 1-in. XPS rigid foam applied to the exterior.

- Use two layers of sill sealer between the top of the foundation and the bottom of the sill plate.

1. The first line of defense is to tape all exterior sheathing joints. When using OSB or plywood, always use Grace Vycor or 3M shielding tapes and the recommended primers. *Apply construction adhesive between the rim joist and the exterior sheathing, and between the sheathing and the frame, especially around all openings.*

- Systems like ZipWall have their own sheathing tape and don’t require additional primers.
Water and Vapor Barrier

Complete air barrier

Consider the direction of water vapor travel in all seasons

All materials to dry out

Reduce condensation points

Eliminate sheathing
Resources

Framing
  ◦ http://energy.gov/energysaver/advanced-house-framing

Marvelous Marvels Video
Tools

Blower door
IR Camera
Experience and continual reassessment