AIR SEALING AND INSULATING EXISTING HOMES

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Learning objectives

- Participants will be able to verbalize at least five important installation details necessary to achieve and maintain thermal performance in California attic and crawlspace assemblies.
- Participants will be able to list examples of materials that are appropriate for air, thermal, and vapor barriers.
- Participants will be able to verbalize what tools are necessary to diagnose existing thermal performance and how to use the same tools to guide installation quality.
- Participants will be able to describe one or more of the systematic effects (moisture, durability, air quality, and comfort) of choices related to the building envelope.
- Participants will be able to verbalize two important metrics for successful thermal performance that exceed code and program standards.
Could you heat your house with this?

1500 Watts = 5118 BTUS

Targeting comfortable homes with low heating cooling cost on a square foot basis.
California performance building enclosure targets

<table>
<thead>
<tr>
<th>Measureable Targets</th>
<th>New Construction</th>
<th>Retrofit Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACH$_{50}$</td>
<td>1 ACH$_{50}$ or less</td>
<td>3 ACH$_{50}$</td>
</tr>
<tr>
<td>CFM$_{50}$ reduction</td>
<td>Not Applicable</td>
<td>50% minimum</td>
</tr>
<tr>
<td>Leakage to garage, vented attic, crawlspace</td>
<td>0 measurable</td>
<td>As close to 0 as possible</td>
</tr>
<tr>
<td>Duct leakage, ducts outside building air barrier.</td>
<td>Less than 10 CFM$_{25}$ +test at normal system operation pressure.</td>
<td>Less than 10 CFM$_{25}$ +test at normal system operation pressure</td>
</tr>
<tr>
<td>Distribution: delivered energy</td>
<td>90% or &gt; measured BTU delivered</td>
<td>85% or &gt; measured BTU delivered</td>
</tr>
<tr>
<td>BTU/hr per sqft</td>
<td>5BTU/hr or less</td>
<td>10BTU/hr or less</td>
</tr>
<tr>
<td>Annual heating (cooling) Kwh/TDD</td>
<td>1Kwh/HDD or less</td>
<td>3 kwh/HDD or less</td>
</tr>
<tr>
<td>Interior Relative Humidity (climate specific)</td>
<td>45%RH +/− 5%</td>
<td>45%RH +/− 5%</td>
</tr>
<tr>
<td>IEQ: Carbon Monoxide</td>
<td>0 measurable</td>
<td>0 measurable</td>
</tr>
<tr>
<td>IEQ: Radon</td>
<td>Less than 2 Picocuries/liter</td>
<td>Less than 2 Picocuries/liter</td>
</tr>
</tbody>
</table>

These design targets were developed for a 900-8000 HDD, 500-2000 CDD
Analyze Bills after a year

Energy Docs Home Performance: Redding 1971 PG&E Home Retrofit
Before and After Utility Costs from Actual Utility Bills

Annual Results:
76% SAVINGS
$9,963.00 SAVED
REDEFINE COST EFFECTIVE

LOVE OUR HOME!!! There just aren't enough good words to express what Energy Docs has done for us! For the first time since owning this home we have a PG&E bill that is less than $1500, even less than $300!!! and for the first time in 12 years our son has made it through his first December without a trip to the hospital because our air quality is so much better! This project has improved our lives in more ways than we could have imagined. Thank You So Much

Unlike · Comment · Tuesday at 9:42pm

You like this.

Effective means real world results, energy is just one.
Enclosure Goals

- Save energy
- Control
- Net Zero
- Load shifting
- Indoor Air Quality
- Wild fire resistance
- Load shifting
- Moisture balance
- Passive survivability
- Simplicity
- Durability
Tools of the Trade:
Blower Door
Tools of the Trade: Blower Door to commission your work

- Pressure test assemblies prior to insulation
- Smoke, and tactile testing for leakage, (in the attic, main body, crawlspace)
- IR can be used with induced delta T, changing the location of resistance heaters.
AIR LEAKAGE RATES AND PATH

ACH50

Other
Garage
Attic

AIR LEAKAGE RATES AND PATH

ACH50

Other
Garage
Attic

43%

10%

47%
GRAPH FROM:

Ventilation and Indoor Air Quality in New California Homes with Gas Appliances and Mechanical Ventilation

Primary Author(s): Wanyu R. Chan, Yang-Seon Kim, Brennan D. Less, Brett C. Singer, Iain S. Walker

70 homes built between 2011 and 2017
Combustion Safety: Non-negotiable
(Unless you get rid of all the combustion appliances)

You change the pressure you are responsible for the consequences

Sealed combustion appliances are compatible with tight envelopes, open combustion are not.
Moisture Balance: non-negotiable

When you tighten a building you are responsible for the moisture balance and air changes.
Data log your work to find Patterns, Compare different spaces.
infrared
What will we start to expect of our insulation performance when every one has infrared?
PRIORITIZE YOUR AIR SEALING
Prioritize your Air Sealing Efforts

High $\Delta T$ & High $\Delta P$

High Leaks (energy, durability, air quality)
Low Leaks (durability, air quality, energy)
Attached Garage (air quality, energy)
Winter cold air top plate infiltration

Summer warm air top plate infiltration

0.3 to 0.7 CFM50/ft
0.3 to 1.6 ACH50
Top plate visible from attic
Evaluating Air Sealing and Insulation Materials

Will the material provide a durable air tight surface, is it time tested?

Is it easy to ensure that the material is installed and performs well?

Does the material need to be resistant to moisture, wildfire, pests?

What is the most appropriate material for a given surface?

Does the assembly require a high R value per inch to achieve the goal?

Will the material need to manage vapor diffusion?

How will the choice of material impact dew point (out-silation?)

Does the material work with the construction schedule?

Does the material choice have any code implications?
Single Part Gun Foam
Single Part Gun Foam
Dry wall Gasket
2 part Spray Foam (flash)
Acrylic Building Tapes
Duct Mastic
Liquid Applied Sealants
Define the problem, then fix it

Problem: Side stapled kraft faced batts create a path for air movement, gap must be eliminated, you choose how.

Attic air can move between the sheet rock and insulation.

Air - Thermal boundary mis-alignment
Air moving between batts and sheet rock
Re-think access

Outside to Outside

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64.1 +

81.5 +
Custom exterior access
Attic Access hatch

[Images and diagrams related to attic access hatch]
Recessed light Fixtures

9.1 CFM50/light
0.3 to 0.5 ACH50
TYPE NON-IC — Recessed luminaires that are NOT suitable for installation in direct contact with combustible materials or thermal insulation, including insulation installed over the top of the luminaire that entraps heat (Type Non-IC) are marked “DO NOT INSTALL INSULATION WITHIN 76 mm (3 in) OF ANY PART OF THE LUMINAIRE." (not intended for insulation contact) — a recessed luminaire designed for installation in a cavity that has minimum dimensions and spacing to thermal insulation and combustible material in compliance with the installation code. It is not intended to be in contact or covered with thermal insulation.
Type Non-IC
Type IC

Type IC (intended for insulation contact) — a recessed luminaire that is designed and identified for installation in a cavity filled with thermal insulation. The luminaire may be in direct contact with combustible materials and the insulation.
Are Can lights really a good idea for low energy homes?
Ultra Thin LED

Warning: Do not recommend installing these without building an enclosure.
Field applied enclosures
FIRE Sprinklers
Service Cavity
FIX ELECTRIC BEFORE INSULATION
Insulation to Reuse or Not?

Has the insulation been contaminated in any way?
Insulation to Reuse or Not?

Does the existing attic pitch allow for additional insulation over the existing insulation?
Blowing over insulation that is not in contact with the air barrier doesn’t work.
In the beginning the air barrier is inaccessible
Make the knee walls work as well as the ceiling

10” double wall
R Value per inch

R Value per inch for various insulation materials:
- Fiberglass loose fill
- Fiberglass batt standard density
- High density cellulose
- Denim batt
- High density cellulose
- Loose fill cellulose
- Low Density Urethane, Spray foam
- Mineral wool ridged board
- Polystyrene, expanded rigid board (EPS)
- Mineral wool batt
- Polystyrene, extruded rigid board (XPS)
- High density Urethane, Spray foam
- Poly-isocyanurate, rigid board

Note: The graph shows the R-value for 1 inch of each material.
Develop a RISK management plan
TWO PART FOAM

REQUIRES THE CORRECT:

- DENSITY
- MATERIAL TEMPERATURE
- SUBSTRATE TEMPERATURE
- SUBSTRATE MOISTURE CONTENT
- MAXIMUM LIFT PER PASS
- TIME FOR CURE BETWEEN LIFTS
- ELECTRICAL PREPERATION

HOUSE PREPERATION
### Effective R-values for Batt Insulation

<table>
<thead>
<tr>
<th>Measured Batt Thickness (inches)</th>
<th>&quot;Good&quot; Effective R-value (2.5 per inch)</th>
<th>&quot;Fair&quot; Effective R-value (1.8 per inch)</th>
<th>&quot;Poor&quot; Effective R-value (0.7 per inch)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
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<td>20</td>
<td>8</td>
</tr>
<tr>
<td>12</td>
<td>30</td>
<td>22</td>
<td>8.8</td>
</tr>
</tbody>
</table>

1. Measure the insulation thickness.
2. Determine the condition of the installation using the following criteria:
   - **Good** – No gaps or other imperfections
   - **Fair** – Gaps over 2.5% of the insulated area. (This equals 3/8 inch space along a 14.5 inch batt.)
   - **Poor** – Gaps over 5% of the insulated area. (This equals ¼ inch space along a 14.5 inch batt.)
3. Look up the effective R-value of the installed insulation using the condition and measured inches.

*Derived from ASHRAE document “Heat Transmission Coefficients for Walls, Roofs, Ceilings, and Floors” 1996
Insulation Density Test

Cylinder of a known diameter + weight = density
Insulation Density

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84.4 +


85.3 +
Goal: attic dry, durable, isolated
No Baffles/poor baffles

No insulation over the top of the exterior wall

Wind washed insulation
Airtight Baffles
Vents designed to minimize ember intrusion
Freeze blocks
Attic Knee Walls

105°F

DELTA T=35°F

70°F

140°F

DELTA T=70°F
Attic Knee Walls
Attic Knee Walls
BUILD A DOUBLE WALL

Insulate to enough density to prevent settling
INSULATION DAMN ABOVE KNEE WALL
Insulation Damns

Insulation dams for:
✓ Adjacent unconditioned porch
✓ Adjacent unconditioned garage
✓ Ceiling height changes.
CONTINUOUS ATTIC SIDE AIR BARRIER OVER KNEE WALL
SKYLIGHT WELLS ARE KNEEWALLS
T&G board ceilings
T&G board ceilings
SURVEY SAYS PLEASE TAKE A COUPLE MINUTES TO COMPLETE YOUR CLASS EVALUATION NOW.
Attic bypass
Has any one seen the architect?
Soffits Problem and Opportunity
Goal for soffits: simplify the air barrier
Interstitial Cavities
Stairwell
Fire place chimneys
COMBUSTIBLE CLEARANCE REQUIRED

B Vent requires a 1 inch clearance

Single wall vent requires a 6” clearance
Use KD steal duct and screws to maintain combustion clearances.
So we spend all this time and effort

And the Cable Guy comes along?
Cat walks
Insulated shell surface area

\[ Q = U \times A \times \Delta T \]
\[ Q_{hr} = \frac{(A \times \text{Delta } T)}{R} \]

\( Q_{hr} = \frac{(800\text{ft}^2 \times 70^\circ\text{F})}{R} \)

\( Q_{hr} = \frac{(56,000\text{btu/hr})}{R^2} \)

\( Q_{hr} = 28,000\text{btu/hr} \)

\( \text{Area} = 2000\text{ft}^2 \times 0.4 = 800\text{ft}^2 \)

\( \text{Delta } T = 140^\circ\text{F} - 70^\circ\text{F} = 70^\circ\text{F} \)
Difference in conductive loss

Typical over sized gas furnace
Example 100,000 BTU/hr

Delta T across ceiling = 58°F

32°F

90°F

60°F

Right sized heating system
Example 24,000 BTU/hr

Delta T across ceiling = 38°F

32°F

70°F

68°F
To learn about high performance ducted systems

Optimizing Residential Forced Air HVAC systems

A Balance Point Home Performance Class by Dan Perunko
WE HAVE GOT TO BURY DUCTS, EVEN THE BIG ONES
Exterior intake and exhaust penetrations and HVAC ducts planned and installed so envelope tightness and insulation levels are maintained.
whole house fans
If you have to have a “hole” house fan. Make it airtight and insulate it.
Low voltage transformers.
Exhausting Problems
Making exhaust fans work
Exhaust dampers
Ventilation non-Negotiable

- Ventilation isn’t a replacement for source control
- Fans have to move more air to do work
- Decide where your “fresh” air will come from and how filtered it is
Air Quality Monitors

"Ultra Low Level" Carbon Monoxide Health Monitor
MODEL PG-2017
To learn more ventilation systems

Balanced Ventilation for better health, comfort and energy efficiency

A Balance Point Home Performance Class by Dan Perunko
Loose fill insulation
Vaults

What not to do
Vaulted ceiling no attic

Outside

- Shallow rafters and/or low interior ceiling.
- Simple roof lines
- Low pitch roof
- Roof near end of service life.
- Architectural interior ceiling.
- Less thermal bridging, greater airtightness.
Vaulted ceiling no attic
Outside
To learn more about fixing crawlspaces

Retrofitting Crawlspace for Health, Comfort, and Energy Efficiency

A Balance Point Home Performance Class by Gavin Healy
Walls outside

- Ineffective exterior cladding / water management.
- Shallow interior wall cavity
- Excessive framing factor
- Steal framing
- Newer interior finishes
- Upgrading windows or siding.
- Less thermal bridging, greater airtightness.
- Two story/ raised floor
- Cantilevered windows
Walls outside
Walls inside

- Exterior weather barrier/flashing works.
- Thick studs.
- Space for furring.
- Remodeling anyway.
- Electric upgrade
- No existing drywall/plaster
- Changing wall framing
- Architectural/historic restrictions.
- No eves
Walls inside
Walls inside
Cantilevers
Slab edge

- Building moisture characteristics
- Wood destroying pests
- Slab edge depth
- Existing wood to earth clearance.
- Site grade.
Make decisions based on tested performance data, not manufactures claims

“FTC Rattles Windows Over Energy Savings Claims: Five window marketers, including Serious Windows, have agreed to stop making deceptive claims about energy savings”
Posted on Mar 20 2012 by Richard Defendorf
www.greenbuildingadvisors.com

Federal Trade Commission Law 460, Labeling and Advertising of Home Insulation
3295 CFM\textsubscript{50} PRE/POST 1403 CFM\textsubscript{50}

Pre retrofit drop ceiling | Post retrofit drop ceiling
PRE/POST

0.42 $\text{ACH}_{\text{nat}}$

.18 $\text{ACH}_{\text{nat}}$

Pre retrofit recessed light fixture

Post retrofit recessed light fixture
Things that make it difficult to get it right

- Poor Access
- Difficult Working Conditions
- Low Pay
- Construction Schedule
- Wrong Priorities
- Poor Preparation
- Lack of Training
- Wrong Training
- Modeling Software
- Energy Code
- Specifications
- Certifications
- Trade Conflicts
- Budget
- Belief That Better Is Possible
How cost effective is typically installed poorly performing insulation, with no air barrier?
What is the return on investment of happy customers?
Many “professionals” rarely adjust their work or recommendations based on measured results from their own projects. They just assume it works as intended.

- Learn from your current project to make the next project better.
- Test don’t guess.
- Set your own internal targets.