Bringing Weatherization to the ADOH

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AZ Governor's office of energy policy

Foundation for Senior Living

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Rehab + Weatherization Here is what we will cover:

- The list of WAP measures to be installed
- How each of these measures work
- Where can you find energy auditors?
- Standards, Standards, ...oh and codes.

The "List" Your auditor will look for

- Air Barrier / Thermal Barrier
- Windows
- Roofing
- Room Pressure Balancing
- HVAC Systems
- Static Pressures
- Duct Leakage
- AC Sizing
- Duct design
- Ventilation
- Appliances
- Hot Water Systems
- Lighting
- CAZ testing

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The Spirit of this is change

- Energy is not 'driving' the rehab
- You are just doing what you already do.
- When certain criteria are met, certain measures will be taken.

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How do all of these measures work?

That would be best described by explaining some basic building science:

- What does an Energy Auditor do?
- How Pressure Diagnostics works
- AC and the Duct System
- IAQ, Safety

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A House is a *System!*

A system derives it's characteristics from the ***interactions*** *of is* ***essential*** *parts and* ***none*** *of those parts taken separately.*

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A House is a system

- A house is made up individual parts.
- We keep adding more and more parts.
  - During design and retrofit
- For it to operate properly, all of the parts must work together.
- It is important to understand and determine the potential **impact** of these parts.

Never assume, test and verify!
Test in, test during work, test out!

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House as a system

- Health & Safety
- Durability
- Comfort
- Affordable

Never do anything to save energy that has a negative impact on health, safety, durability or comfort.

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Lighting:

- Change out light bulbs with CFL's or LED lighting.

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A. Using a meter

- There are many types of meters but they all do the same thing.
- The longer a meter is on, the more accurate the numbers will be.
- Often used on Refrigerators and freezers, DVR's. Anything that is not fully running all the time.
- Refrigerators should be monitored a *Minimum* of 2 hours.

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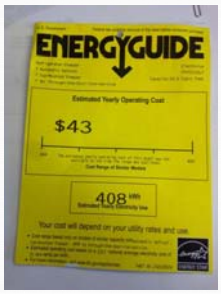
Energy Guide: Is it cheaper?



Once you know what the current appliance is consuming, you can compare a similar but more efficient appliance and determine if it is worth it to change it out.

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The "List"

- Air Barrier / Thermal Barrier
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- Room Pressure Balancing
- HVAC Systems
- Static Pressures
- Duct Leakage
- AC Sizing
- Duct design
- Ventilation
- ~~Appliances~~ *Use energy star appliance*
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- ~~Lighting~~ *Use CFL's or LED*
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How does Heat get in?

- And what do we do to stop it?

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Sunshine on my shoulder … gives me sunburn

- Sun is the original source of energy
- Where does that energy go?
- Where is last summer's sun energy?
  - The sun's energy is not destroyed
  - It is moved from place to place
    - Heats surfaces
      - Roads, roofs, parking lots, buildings
  - And changes form
    - Electromagnetic energy to chemical energy from photosynthesis

Thermodynamics

- What are some of the things we do to control the movement of heat in and out and around a building?
  - Slow it
    - Insulation
    - Radiant barriers
  - Block it
    - Air barriers
    - Shading
  - Store it and use it
    - Water heating, PV solar
  - Move it
    - Air conditioning

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Types of Heat Flow

- Conduction
- Convection
- Radiation

(KD32)

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IECC 2009 Window U Values

FRAME TYPE	SINGLE PANE	DOUBLE PANE	SKYLIGHT Single	SKYLIGHT Double
Metal	1.20	0.80	2.00	1.30
Metal with Thermal Break	1.10	0.65	1.90	1.10
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05
Glazed Block	0.60			

IECC 2009 SHGC Values

SINGLE GLAZED		DOUBLE GLAZED		GLAZED BLOCK
Clear	Tinted	Clear	Tinted	
0.8	0.7	0.7	0.6	0.6

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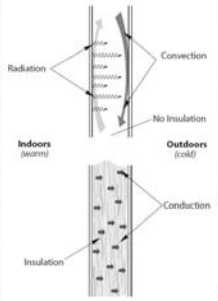
Effect of Insulation



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The most important part…

- Insulation must be installed without:
  - Gaps
  - Voids
  - Compressions
  - Air intrusion
  - Misalignment.
- *Insulation must be 100% continuous and in contact with an air barrier 100% of the time.*

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Quality vs. Quantity

Insulation Performance

(Slowing heat flow)

- The approach to insulation has always been that more is better. At some point, this is wrong!
- The key to controlling conduction is not how much insulation (R-value) is installed, but how well the envelope slows heat flow.

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Source: Copied with permission from *BPI Analyst Certification – Types of Heat Flow*

Quality vs. Quantity

Heat Flow/R-Value

Sq. Ft x Delta T x U-value = Heat Flow

- 1000 x 20 x 0.5 (none) = 10,000 Btus per hour
- 1000 x 20 x 0.1 (R-10) = 2,000 Btus per hour
- 1000 x 20 x 0.05 (R-20) = 1,000 Btus per hour
- 1000 x 20 x 0.033 (R-30) = 660 Btus per hour
- 1000 x 20 x 0.025 (R-40) = 500 Btus per hour

With each R-10 increase, the reduction in heat flow is reduced, from **8,000 Btus for the initial R-10** to only 160 Btus for the R-30 to R-40 increase.

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Quality vs. Quantity

R-Value vs. P-Value

Designed heat flow vs. real heat flow

100% R30

.033 (R30) x 1000 x 20 = 660 BTUs

95% R30 - 5% uninsulated

.033 (R30) x 950 x 20 = 627 BTUs

.5 (none) x 50 x 20 = 500 BTUs

1127 BTUs

- Total BTUs ***(same as a R16)***
- Small defects can have a large impact, today's complex home design is tough on the insulators.

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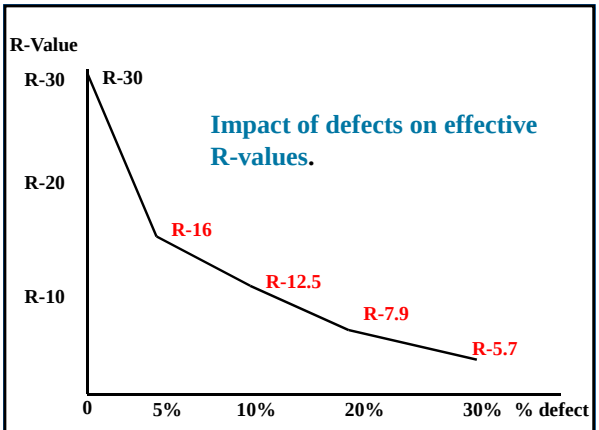

Impact of defects on effective R-values.

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Quality vs. Quantity

In our work we need to ask more questions.

- What is the ***Effective*** R-value?
- Has the insulation transferred its resistance to the envelope?
- If not, how can the thermal resistance of the envelope be improved?

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Uninsulated attic hatch is hot (white)

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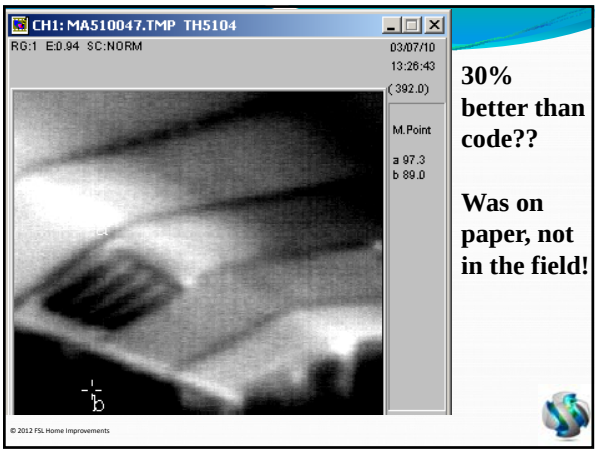

30% better than code??

Was on paper, not in the field!

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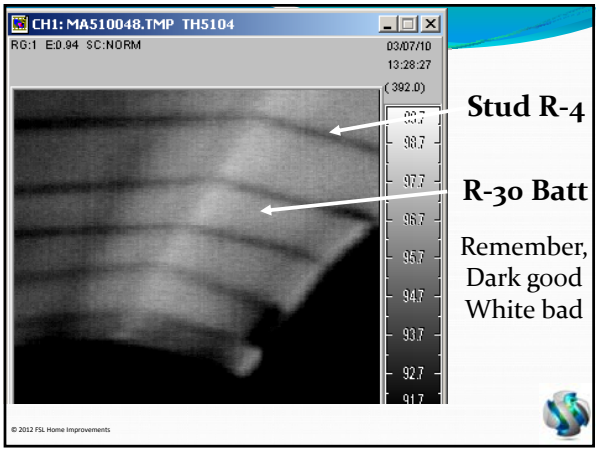

Stud R-4

R-30 Batt

Remember, Dark good White bad

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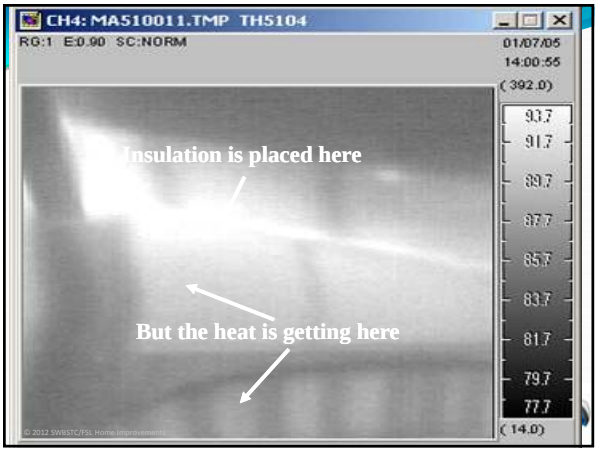

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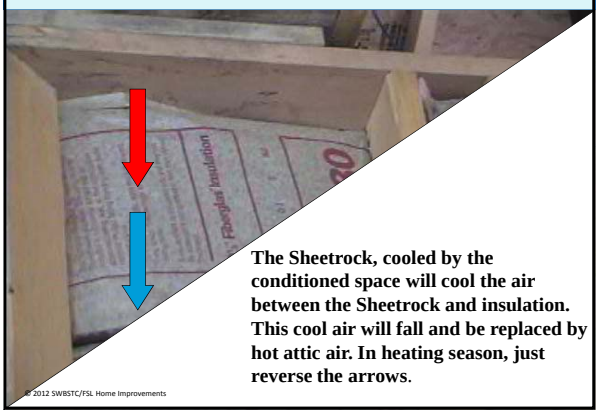
Knee-wall insulation attached to the back of the stud.



The Sheetrock, cooled by the conditioned space will cool the air between the Sheetrock and insulation. This cool air will fall and be replaced by hot attic air. In heating season, just reverse the arrows.

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Knee-wall insulation attached to the back of the stud.

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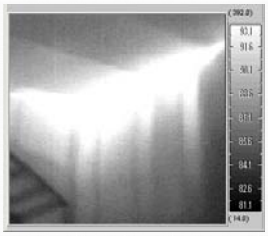
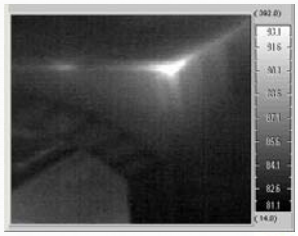
Insulation Problems

No air barrier

Air barrier and insulation aligned





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No air barrier, suspended insulation

Air barrier and insulation aligned

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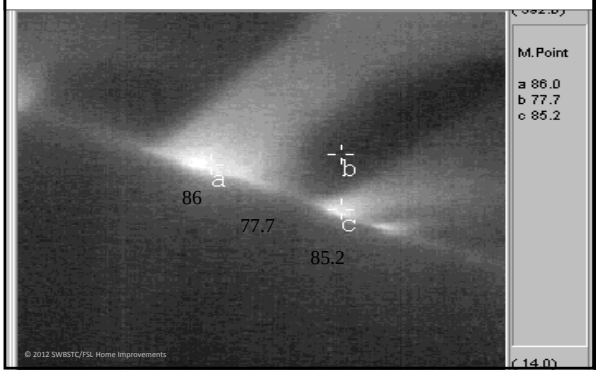
Wind intrusion



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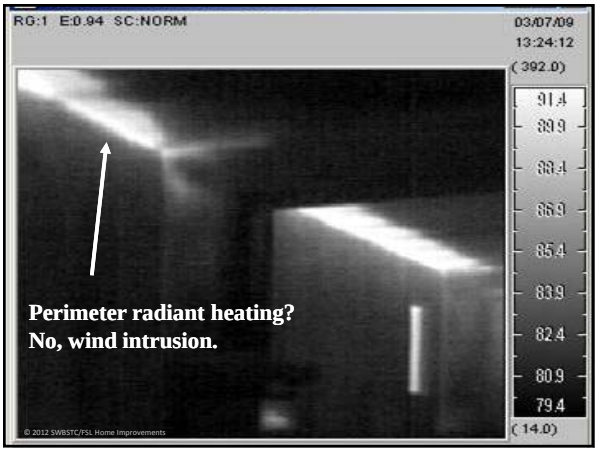

Perimeter radiant heating?
No, wind intrusion.

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2009 IECC Insulation Values. Climate Zone 2

ZONE	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE[i]	FLOOR *R*-VALUE	BASEMENT[c] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c] WALL *R*-VALUE
2	30	13	4/6	13	0	0	0

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How Pressure Diagnostics Work

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Manometers

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Pressure Diagnostics

- Air flow is the largest factor in a home that impacts health, durability, comfort and energy use.
  - Combustion safety (reversing the flow on vents)
  - Pollutants (both bring them in and getting them out)
  - Infiltration, both holes and pressures
  - Duct leakage
  - HVAC air flow
  - Insulation performance

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Topics

- Some basic terms and concepts
- Review of tools
  - Pressure gauge
  - Blower Door
  - Duct Blaster

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Diagnostic Terms

- CFM – Cubic feet per minute
- CFM50/CFM25– The CFM air flow at a test pressure.
- Pascal (Pa)- Unit of pressure.
- With Reference To (WRT) – The reference point for a pressure test.
- CO – Carbon Monoxide
- PPM – Parts per million of Carbon Monoxide
- Passive return system – Jump ducts, High Low, pass-thru vents

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Fans

- Air handler - 1000's of CFM.
- Dryers - 200+ CFM
- Range hoods and other kitchen exhaust are getting bigger and bigger – 100 to 1000 CFM
- Bathroom fan 25-50 CFM average
- Others?

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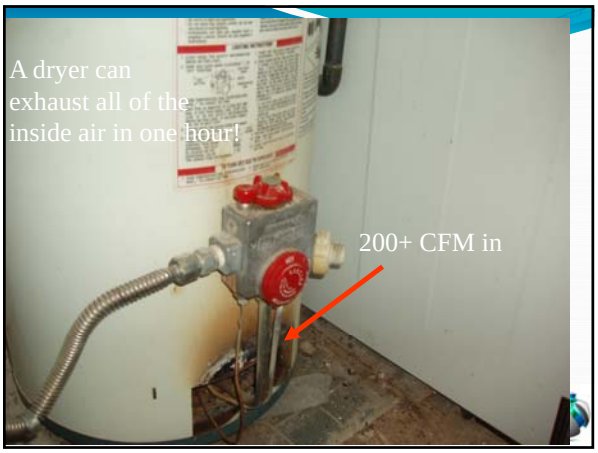
Family with five kids,
how long is this fan on each day?



Doors and insulation performance

- What doors in your home account for the most heating and cooling costs?
  - Front and back doors
  - Patio doors
  - Doggie doors
  - Interior doors

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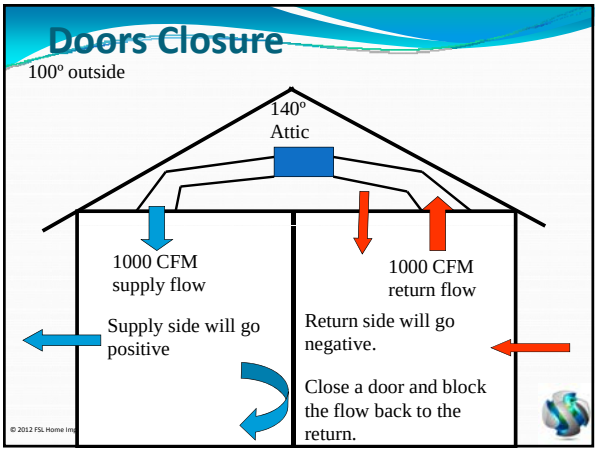
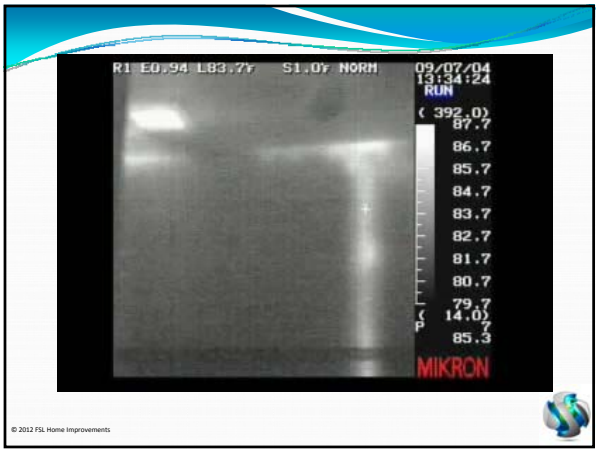
Doors Closure





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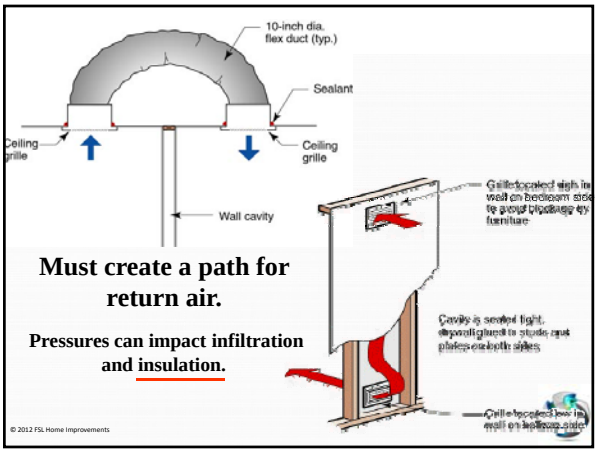

Must create a path for return air.

Pressures can impact infiltration and insulation.

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CAZ Test

- CAZ tests will alert you to:
  - the potential of back drafting combustion appliances.
  - the potential for flame roll out of a combustion appliances.
  - the potential to draw in fumes from the garage.

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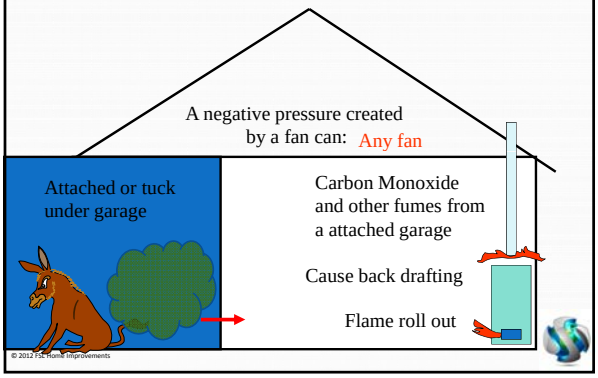
CAZ Test



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Blower Door Tests

- Initial Blower Door Test (CFM50)
- Pressure Pan tests (testing the ducts)
- Zonal Tests (Where are the pressure barriers?)

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Zonal Pressures

- Using the Blower Door CFM50 test, the pressure boundary of a home can be determined.
- The pressure boundary of the home is made up of the surfaces that are designed to control air flow (keep inside in & outside out).
- This can be used to insure that the pressure boundary and thermal boundary are aligned.

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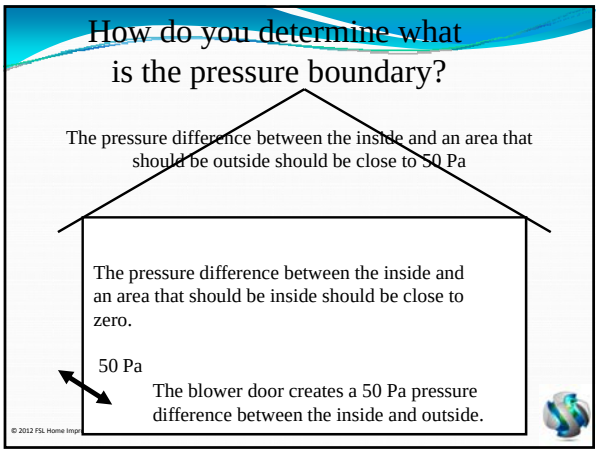

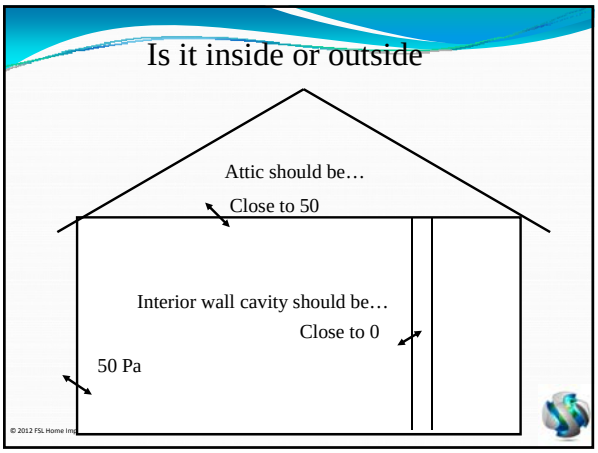

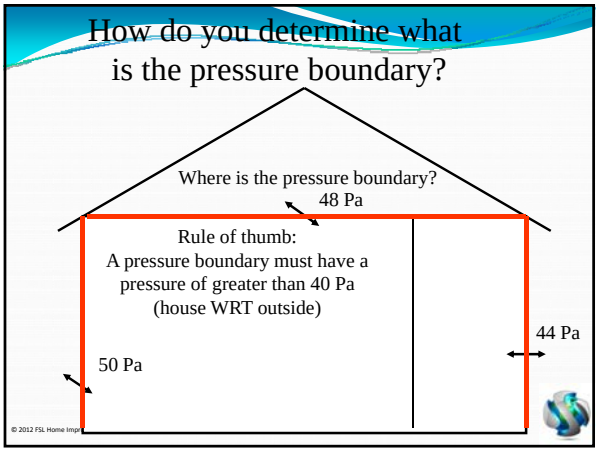

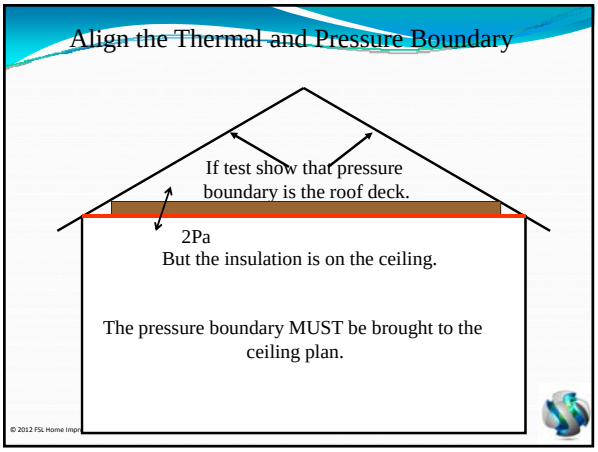

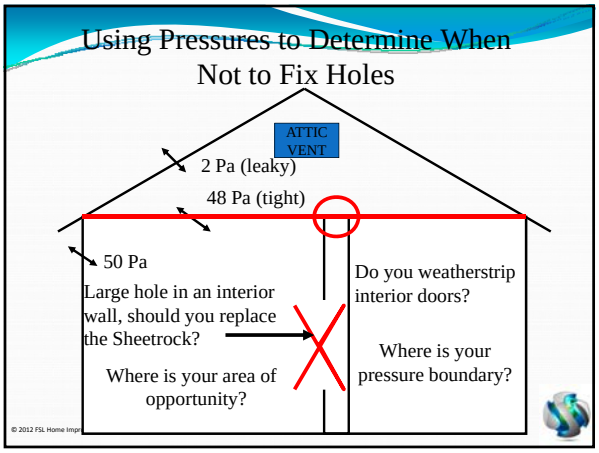

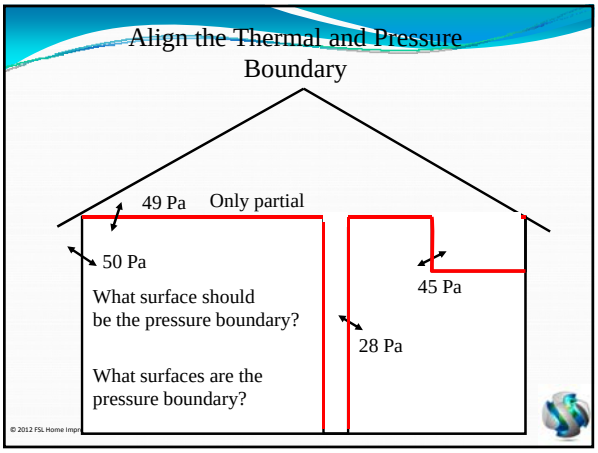

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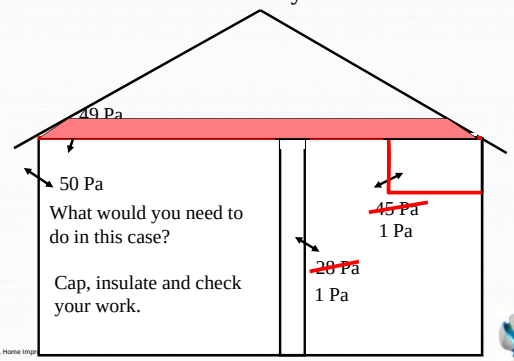
Align the Thermal and Pressure Boundary



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What does a CFM50 value tell you about the house?

- CFM50 is like a 20 mile per hour wind blowing on all sides of the house.
  - From this value you can **estimate** the natural leakage of a home (see appendix E in the BD manual).
- The CFM50 value can give you a good indication of the total size of all the holes in a home.
  - A tenth (remove the last digit) of the CFM50 number is about equal to the square inches of holes in the house. 1500 CFM50 = about 150 sq. inches of holes.

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Using the blower door to test ducts

- Pressure Pan
- Subtraction method
- Smoke

Remember, our goal is not to determine the amount of duct leakage present, but to get the system as leak free as possible.

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Pressure Pan Test Rules of Thumb

- In **MOST** cases a reading of less the 1 Pa indicates a fairly leak free duct system.
- In some cases you can get low readings even on a system with leaks.
- Reading of over 1 Pa indicate a leaky system. High reading always means leaks.
- If there are two or more registers located very close together, treat them as one by using tape/pan on all.

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Infiltration

Present value of 100 CFM50 reduction in infiltration.

Climate zone 1= $160
Climate zone 2 = $40
Climate zone 3 = $90
Climate zone 4 = $40
Climate zone 5 = $90
Climate zone 6 = $40

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Duct Leakage

Present value of 100 CFM50 reduction in duct leakage.
Cooling values only apply if AC is present.

Heating	Cooling
Climate zone 1= $800	Climate zone 1= $10
Climate zone 2 = $90	Climate zone 2= $450
Climate zone 3 = $345	Climate zone 3= $80
Climate zone 4 = $950	Climate zone 4= $300
Climate zone 5 = $385	Climate zone 5= $100
Climate zone 6 = $50	Climate zone 6= $870

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- ~~Roofing~~ *Reflect the heat and use Radiant barrier sheathing*
- ~~Room Pressure Balancing~~ *Control ALL the air*
- HVAC Systems
- Static Pressures
- ~~Duct Leakage~~ *This will save the most energy and increase comfort*
- AC Sizing
- Duct design
- ~~Ventilation~~ *Make sure it is clean safe air*
- ~~Appliances~~ *Use energy star appliance*
- Hot Water Systems
- ~~Lighting~~ *Use CFL's or LED*
- ~~CAZ testing~~ *Do no harm!*

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Measuring Static Pressures

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- When you measure system's static pressure, you can discover a list of duct defects that cause poor system performance.
- By measuring actual operating conditions, you'll be able to offer real solutions to many existing comfort problems that are overlooked by your competitors.

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- By *understanding* static pressures you quickly begin to see that equipment capacity and efficiency is actually controlled by the duct work.
- In terms of comfort and efficiency, a well designed and balanced duct system is far more valuable than the equipment itself.

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System Airflow Capacities

- We measure static pressure to interpret airflow in a system.
- It works similar to blood pressure, the higher the pressure on the heart, the less blood it can move.
- With fans, the higher the static pressure in the system, the less air it can move.

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- Most manufacturers' engineering manuals rate airflow in furnaces, fan coils, and air handlers based on Total External Static Pressure (TESP).
- A typical furnace is designed to operate at a maximum of .50-in. w.c.
- If there is more than .50-in. of Total External Static Pressure, the fan is unable to move the required 400 CFM per ton.

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Measuring Static Pressure #4

Measuring External Static Pressure

- If ESP is too high, the airflow might be blocked or the ductwork might be too small or restricted.
- If ESP is too low, the ductwork might be very leaky or the fan might be dirty or damaged.
- Typical ESP totals are around 0.5 IWC or 125 Pa with an air conditioning coil and filter.
- Typical ESP totals are around 0.25 IWC or 62 Pa without an air conditioning coil and filter.

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- HVAC Systems
- ~~Static Pressures~~ *These should be measured after all sealing or change out*
- ~~Duct Leakage~~ *This will save the most energy and increase comfort*
- AC Sizing
- Duct design
- ~~Ventilation~~ *Make sure it is clean safe air*
- ~~Appliances~~ *Use energy star appliance*
- Hot Water Systems
- ~~Lighting~~ *Use CFL's or LED*
- ~~CAZ testing~~ *Do no harm!*

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AC and Duct Sizing and design

- A lot of our homes already have oversized AC systems.
- A lot of these energy measures we do cause them to be further oversized.
- Oversized AC units have two main issues:
- High operating costs because of cycling,
- Higher Relative humidity because of Cycling

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Changing out AC systems

- Whenever an AC System is changed out the contractor needs to complete a 'Manual J' for that equipment based on any weatherization measures you will be implementing.
- When sizing up or down, the existing duct system will probably no longer work. Your contractor should then run a 'Manual D' to ensure a proper duct design for the new equipment.

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- ~~Room Pressure Balancing~~ *Control ALL the air*
- ~~HVAC Systems~~ *Manual J*
- ~~Static Pressures~~ *These should be measured after all sealing or change out*
- ~~Duct Leakage~~ *This will save the most energy and increase comfort*
- ~~AC Sizing~~ *We make houses require smaller systems. Be aware of that.*
- ~~Duct design~~ *Manual D*
- ~~Ventilation~~ *Make sure it is clean safe air*
- ~~Appliances~~ *Use energy star appliance*
- Hot Water Systems
- ~~Lighting~~ *Use CFL's or LED*
- ~~CAZ testing~~ *Do no harm!*

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Hot Water systems:

- Water heaters should be set to deliver 120°F
- Shower heads should use no more than 1.5 gallons per minute
- Low flow aerators should be installed in all faucets.
- When changing out an electric water heater in a garage, if the home has 4 or more occupants you need to install a Heat Pump Hybrid water heater.

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The "List"

- ~~Air Barrier~~ / ~~Thermal Barrier~~ *Use the right insulation in the right places*
- ~~Windows~~ *Use Low E windows when you are replacing windows*
- ~~Roofing~~ *Reflect the heat, use Radiant barrier sheathing*
- ~~Room Pressure Balancing~~ *Control ALL the air*
- ~~HVAC Systems~~ *Manual J*
- ~~Static Pressures~~ *These should be measured after all sealing or change out*
- ~~Duct Leakage~~ *This will save the most energy and increase comfort*
- ~~AC Sizing~~ *We make houses require smaller systems. Be aware of that.*
- ~~Duct design~~ *Manual D*
- ~~Ventilation~~ *Make sure it is clean safe air*
- ~~Appliances~~ *Use energy star appliance*
- ~~Hot Water Systems~~ *Go Hybrid when you can.*
- ~~Lighting~~ *Use CFL's or LED*
- ~~CAZ testing~~ *Do no harm!*

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Standards, standards, standards

- Your energy auditor follows BPI/BA standards.
- Energy efficient installs follow the "Standardized work specifications" standards
- Insulation & windows follow IECC 2009 Standards
- Ventilation follows ASHRAE 62.2-2010 Standards
- Appliances follow Energy Star Standards
- And we all have to follow Code!
- IECC 2009 http://publicecodes.cyberregs.com/icod/iecc/2009/index.htm

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Where do you find a good auditor?

- www.azhomeperformance.com
- www.bpi.org
- Any local weatherization agency
- Ask me.
- We have included contact info and these links on your thumb drives.

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Thank you!