

# UNDERSTANDING ENERGY AUDITS



Foundation for  
Senior Living

*Thirty Years of Care by Design*

## THE SCIENCE BEHIND CONSTRUCTION

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**City of Phoenix**

# WHAT IS AN ENERGY AUDIT?



An Energy Audit consists of a set of visual and diagnostic tests to assess how much energy a home uses and to evaluate what measures can be taken to make a home more energy efficient.



An energy audit should also include the assessment of the health and safety components, the durability of the structure and comfort levels of the occupant(s).



# What's the purpose? Why do we do this?



- ▶ Identify Hazards
- ▶ Assess Waste
- ▶ Record Appliance/Mechanical Data
- ▶ Determine Scope of Work
- ▶ Quality Assurance

# The “List” auditors 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

# How do all of these measures work?

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

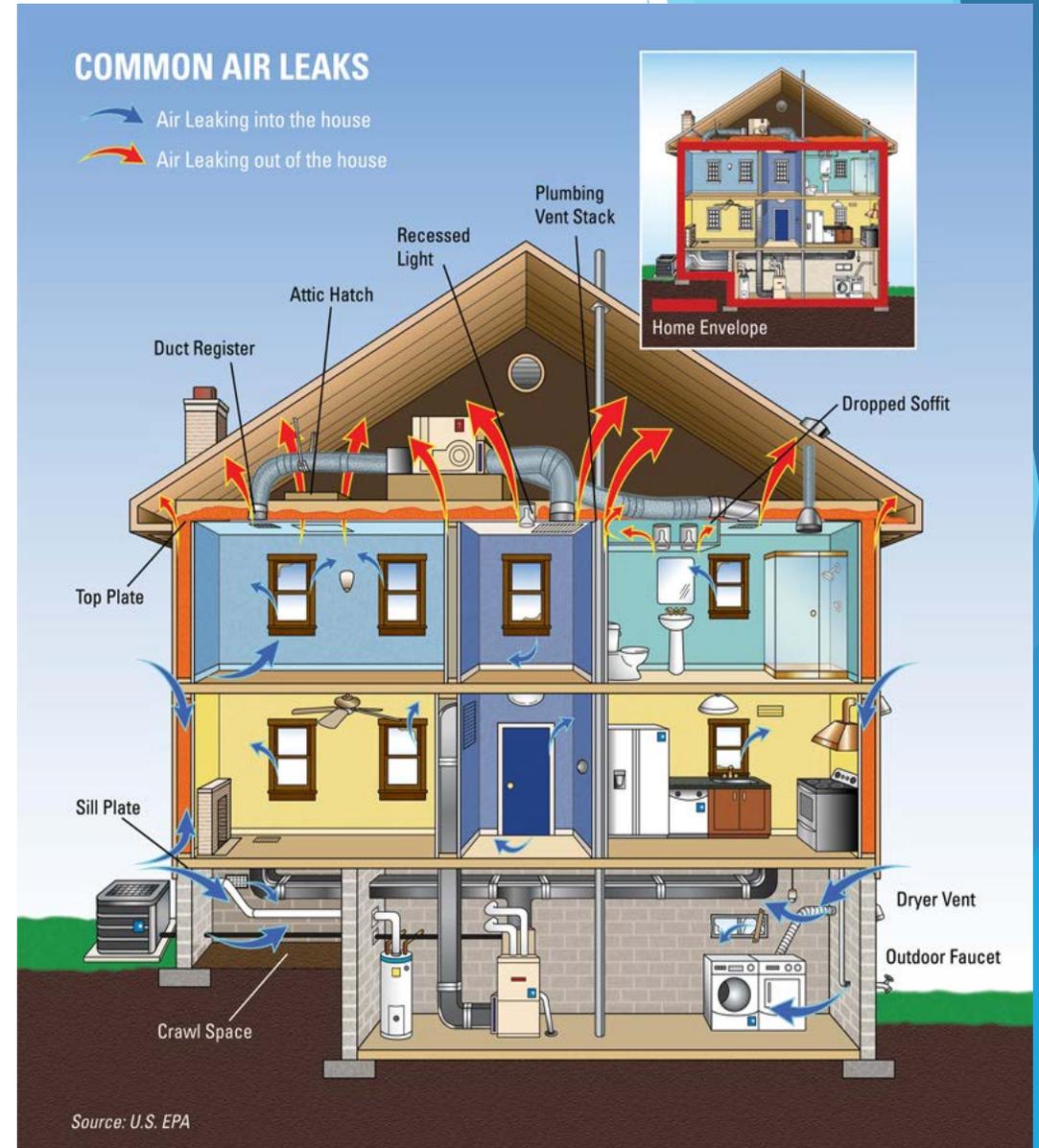
- ▶ What does an Energy Auditor do?
- ▶ How Pressure Diagnostics work?
- ▶ AC and the Duct System
- ▶ IAQ, Safety

# A House is a System!

*A system derives its characteristics from the interactions of its essential parts and none of those parts taken separately.*

# THE "SYSTEMS" WE LIVE IN...

- A house is made up of 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.



.....and add some more parts...



Oh heck, just keep on building.....



# 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.

# Client/household assessment

- ▶ Number of Occupants
- ▶ Lifestyle
- ▶ Occupant Health Concerns
- ▶ Pets
- ▶ Pests



# Lighting:

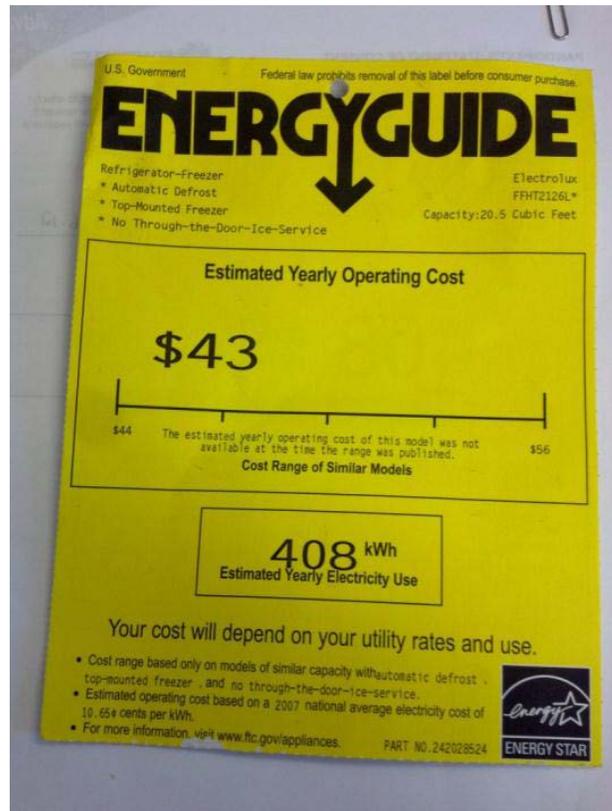
- ▶ Change out light bulbs with CFL's or LED lighting.

# 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.

# 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.

# The “List”

- ▶ Air Barrier / Thermal Barrier
- ▶ Windows
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- ▶ AC Sizing
- ▶ Duct design
- ▶ Ventilation
- ▶ ~~Appliances~~ *Use energy star appliance*
- ▶ Hot Water Systems
- ▶ ~~Lighting~~ *Use CFL's or LED*
- ▶ CAZ testing

# How does Heat get in?

- ▶ And what do we do to stop it?

# 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

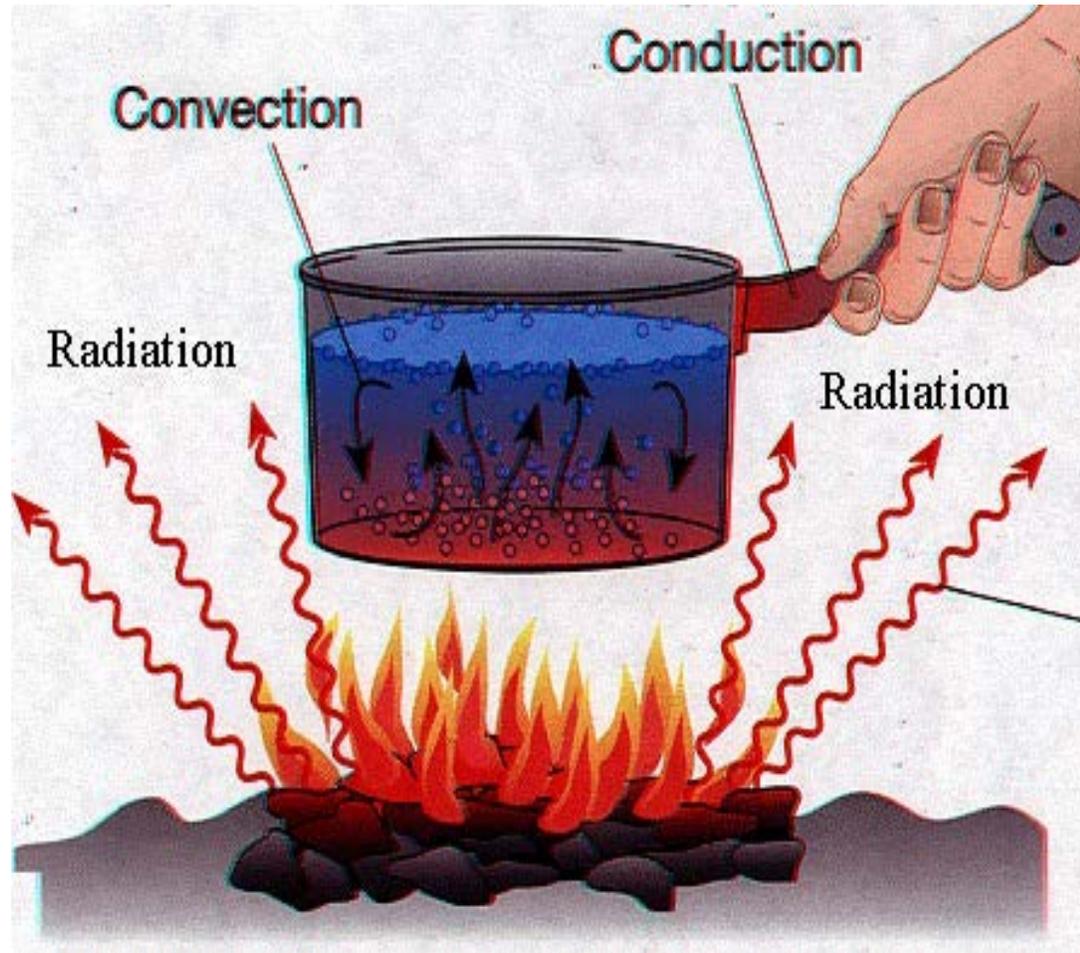


# Thermodynamics

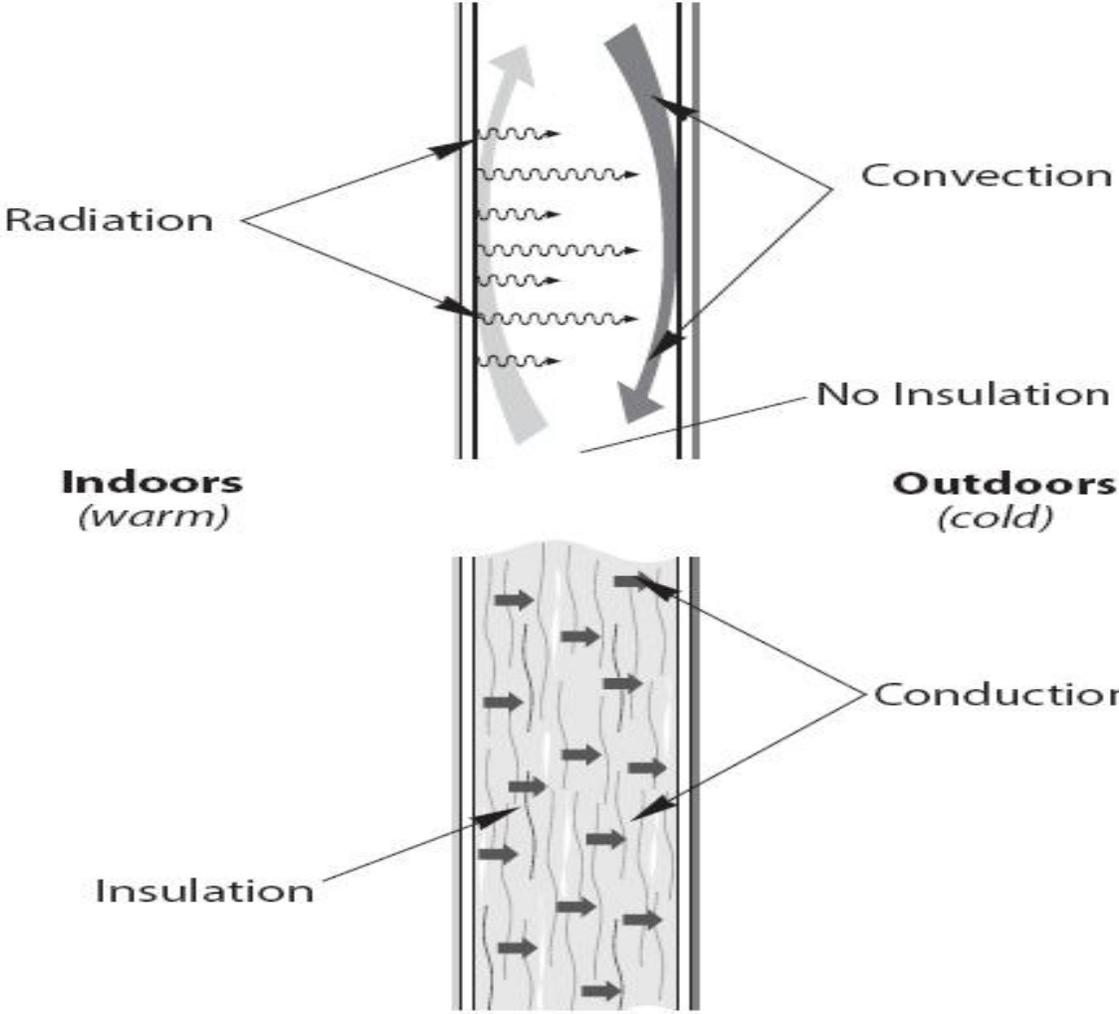
- ▶ What are some of the things we do to control the movement of heat in and out and around a building?
- ▶ Slow it
  - Insulation
  - Radiant barriers
- ▶ Block it
  - Air barriers
  - Shading
- ▶ Store it and use it
  - Water heating, PV solar
- ▶ Move it
  - Air conditioning

# Types of Heat Flow

- ▶ Conduction
- ▶ Convection
- ▶ Radiation



# Effect of Insulation



# 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.*

# 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.

# Quality vs. Quantity

## Heat Flow/R-Value

$$\text{Sq. Ft} \times \text{Delta T} \times \text{U-value} = \text{Heat Flow}$$

- $1000 \times 20 \times 0.5$  (none) = 10,000 Btus per hour
- $1000 \times 20 \times 0.1$  (R-10) = 2,000 Btus per hour
- $1000 \times 20 \times 0.05$  (R-20) = 1,000 Btus per hour
- $1000 \times 20 \times 0.033$  (R-30) = 660 Btus per hour
- $1000 \times 20 \times 0.025$  (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.

R-Value

R-30

R-30

Impact of defects on effective R-values.

R-20

R-16

R-10

R-12.5

R-7.9

R-5.7

0

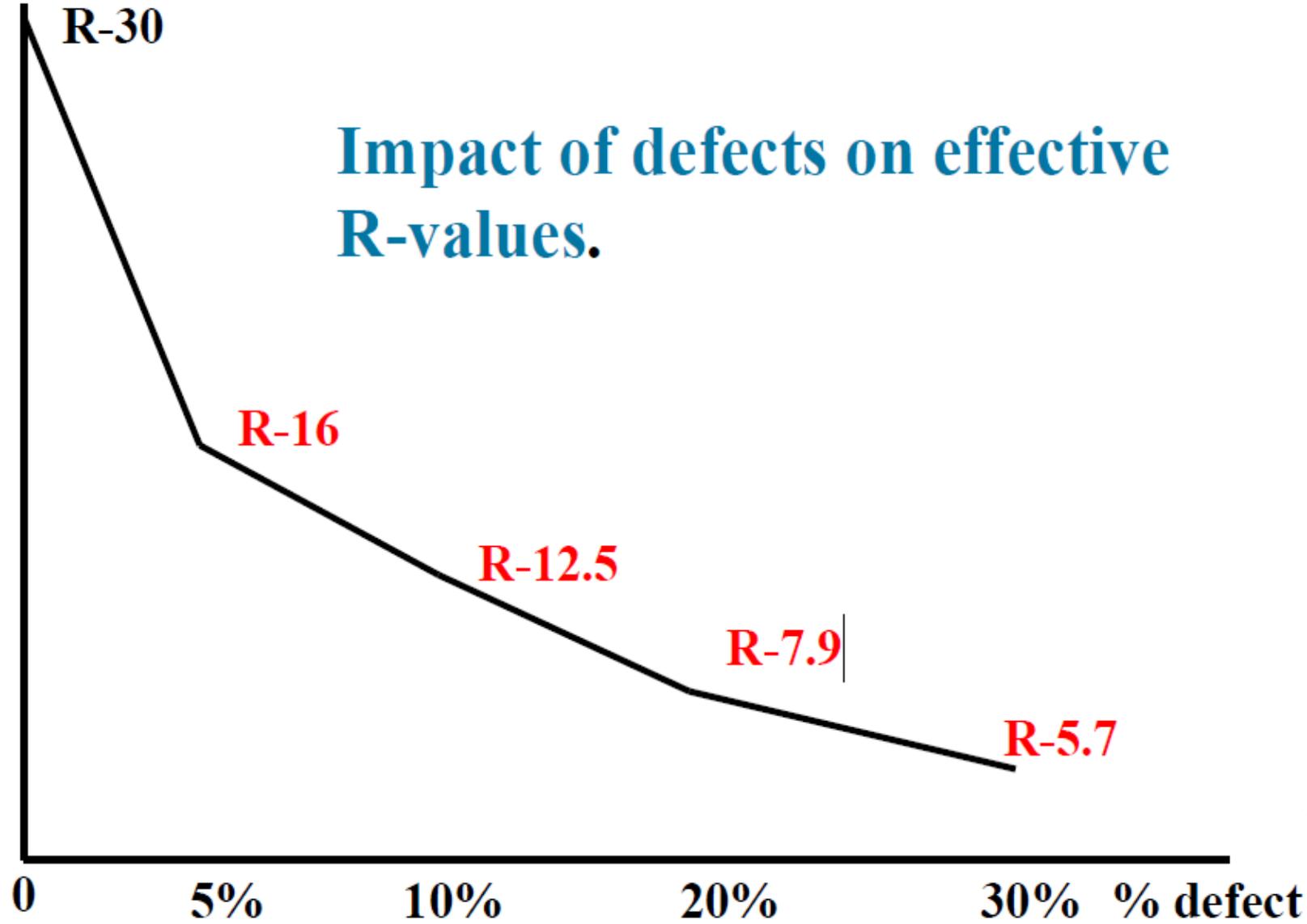
5%

10%

20%

30%

% defect



## 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?

# Attic Hatch/Access





**Uninsulated attic hatch is hot (white)**



**30%  
better than  
code??**

**Was on  
paper, not  
in the field!**

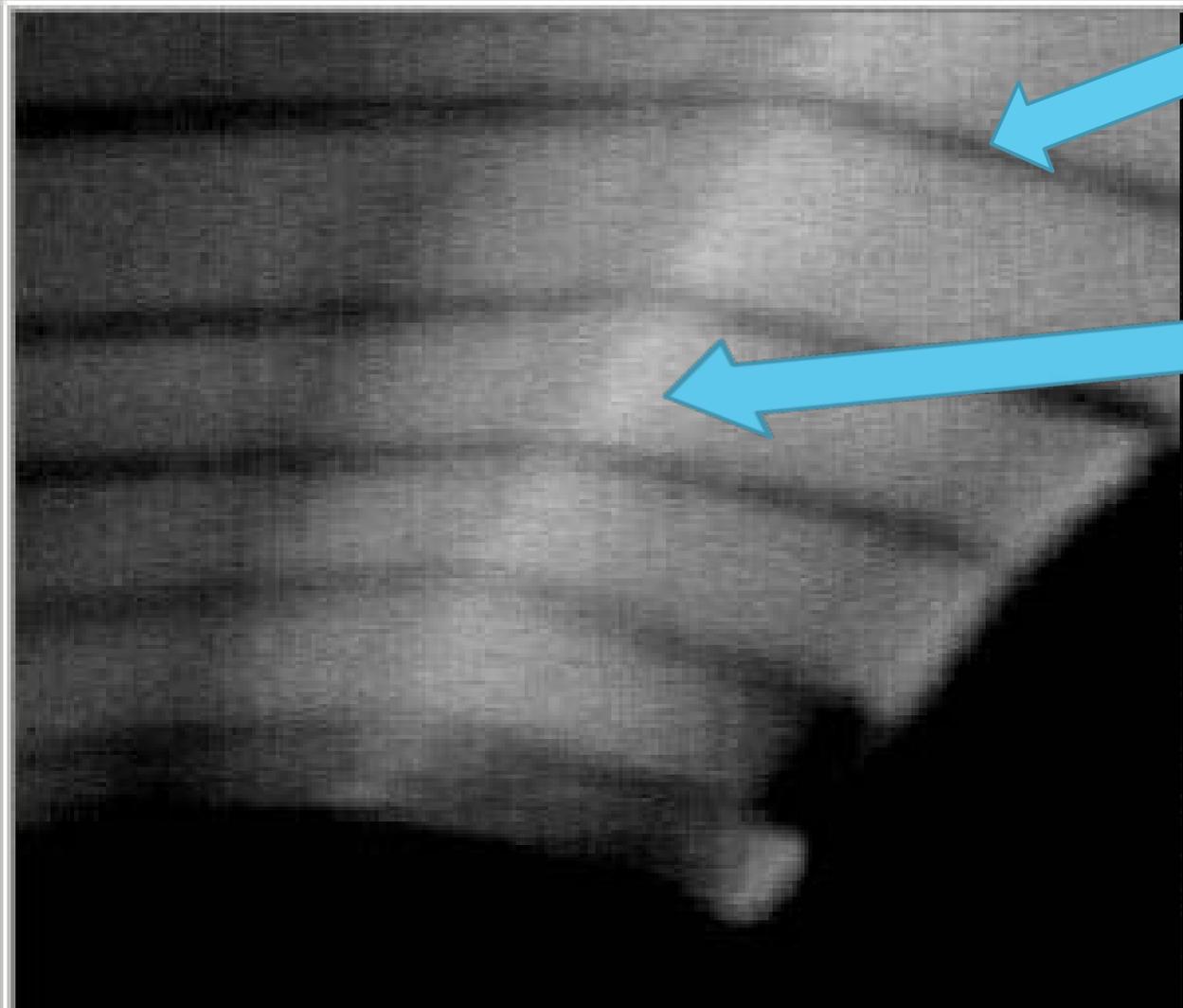
CH1: MA510048.TMP TH5104

RG:1 E:0.94 SC:NORM

03/07/10

13:28:27

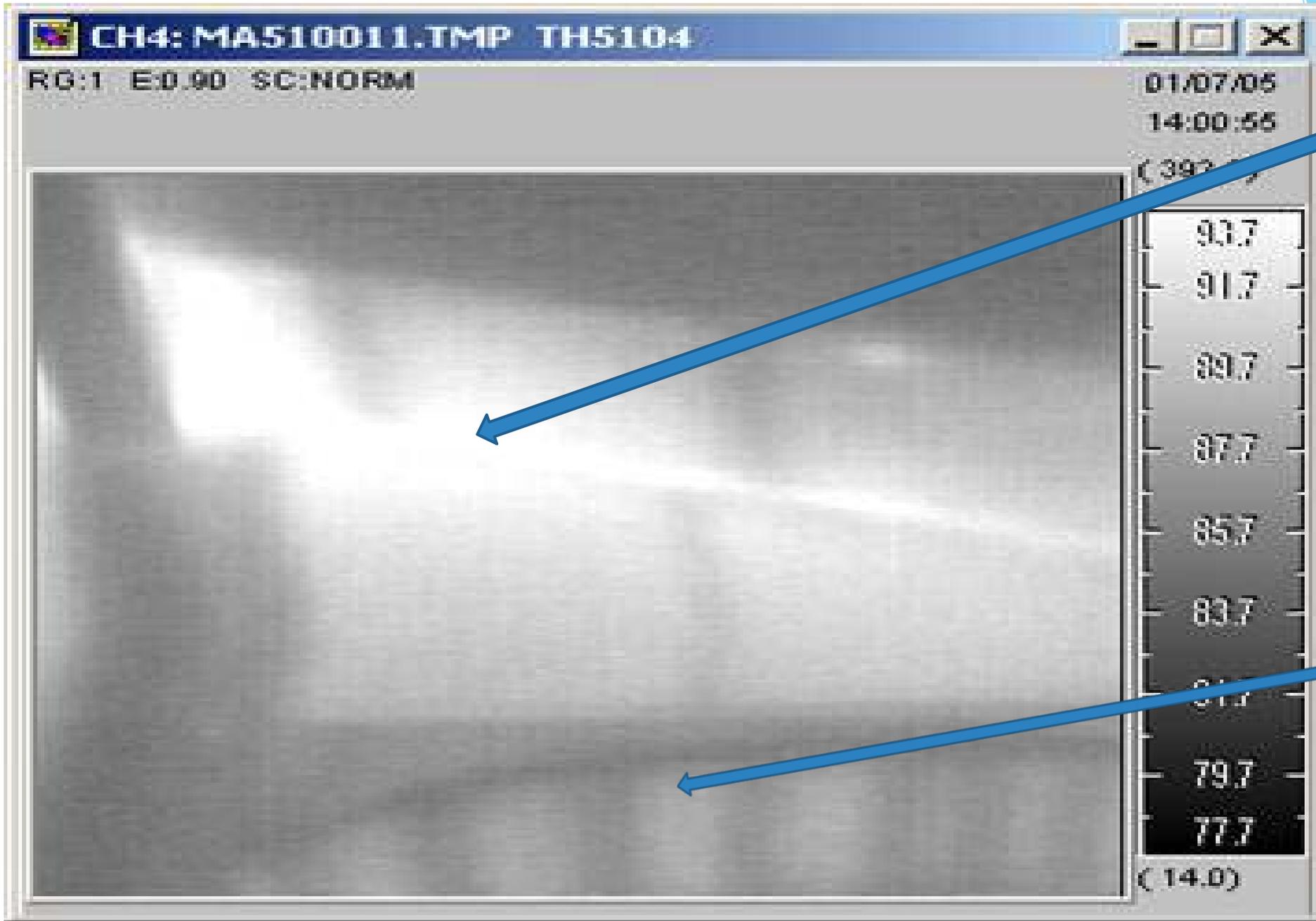
(392.0)



99.7  
98.7  
97.7  
96.7  
95.7  
94.7  
93.7  
92.7  
91.7

**Stud  
R-4**

**R-30 Batt**  
Remember,  
Dark good  
White bad



Insulation is placed here...

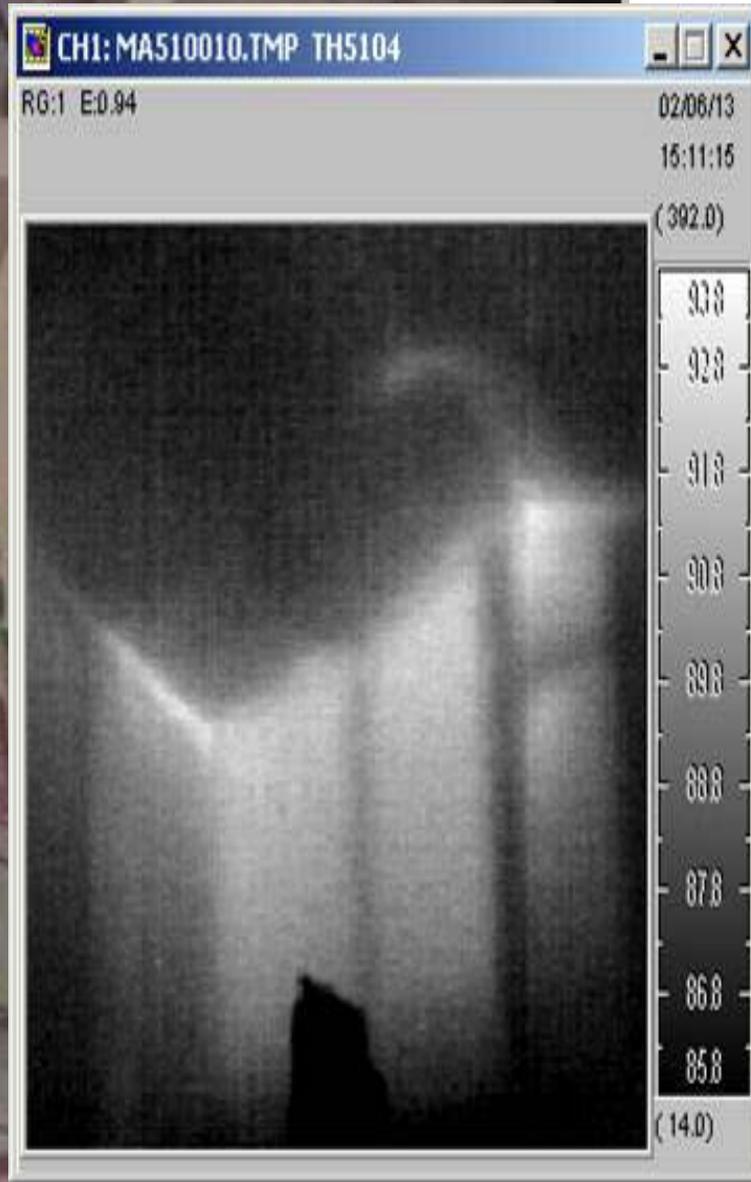
But the heat is getting here...

## 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.**

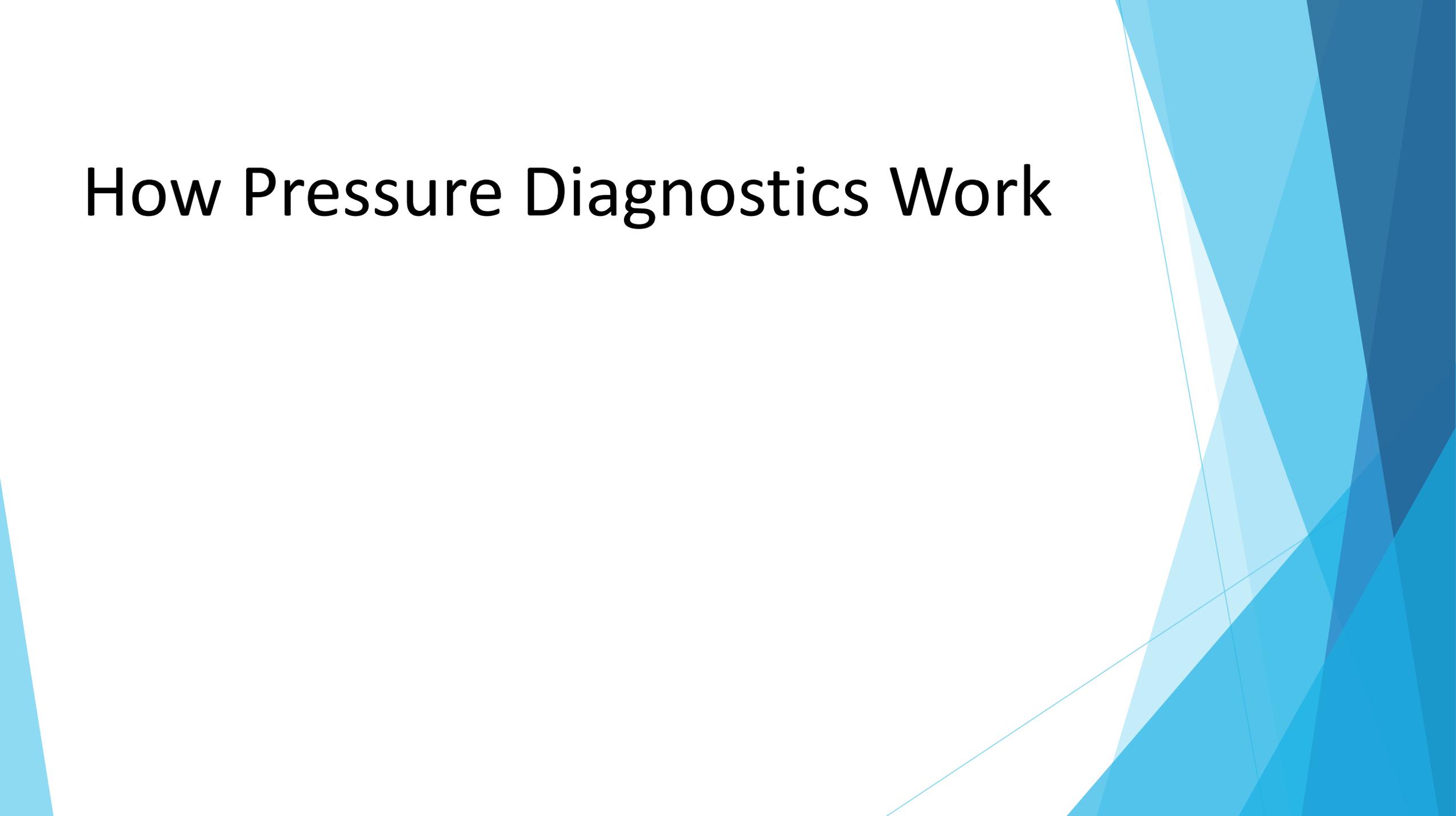


Heat  
flowing  
from  
hot to  
cold

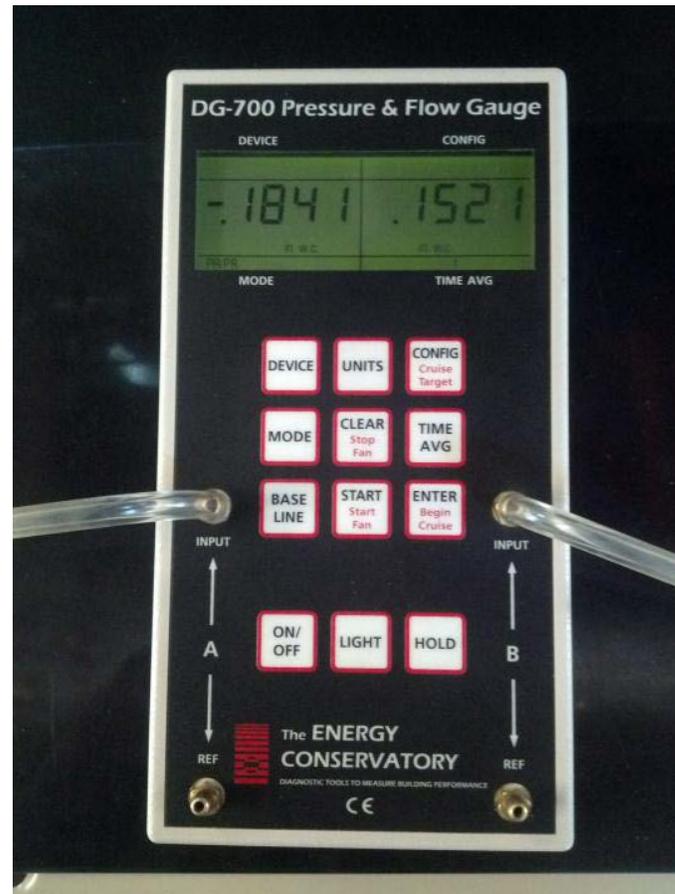
# The “List”

- ▶ Air Barrier / ~~Thermal Barrier~~ *Use the right insulation in the right places*
- ▶ ~~Windows~~ *Use Low E windows if you are replacing windows*
- ▶ ~~Roofing~~ *Reflect the heat, use Radiant barrier sheathing*
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- ▶ Ventilation
- ▶ ~~Appliances~~ *Use energy star appliance*
- ▶ Hot Water Systems
- ▶ ~~Lighting~~ *Use CFL's or LED*
- ▶ CAZ testing

# How Pressure Diagnostics Work

The background of the slide features abstract, overlapping geometric shapes in various shades of blue, ranging from light sky blue to dark navy blue. These shapes are primarily located on the right side of the slide, creating a modern, technical aesthetic.

# Manometers



# 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

# Topics

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

# Diagnostic Terms

- ▶ **CFM –Cubic feet per minute**
- ▶ **CFM<sub>50</sub>/CFM<sub>25</sub>–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**

# Fans

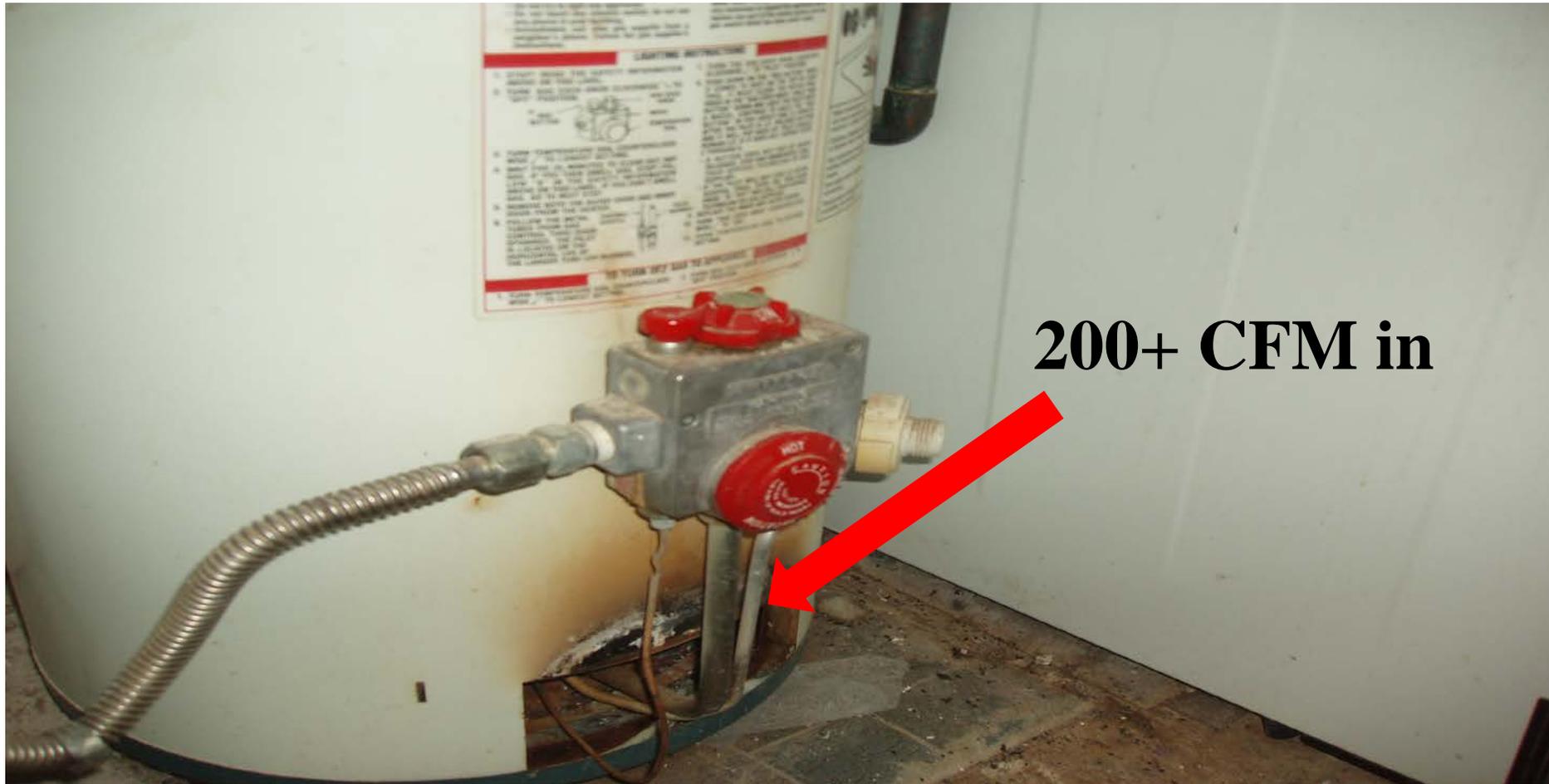
- ▶ Air handler -1000's of CFM.
- ▶ Dryers -200+ CFM
- ▶ Range hoods and other kitchen exhaust are getting bigger and bigger -100 to 1000 CFM
- ▶ Bathroom fan 25-50 CFM average
- ▶ Others?



200+ CFM out

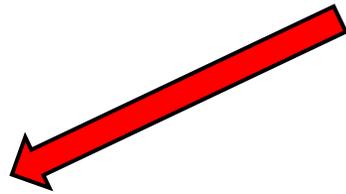
Family with five kids,  
how long is this fan on each day?

**A dryer can exhaust all of the inside air in one hour!**



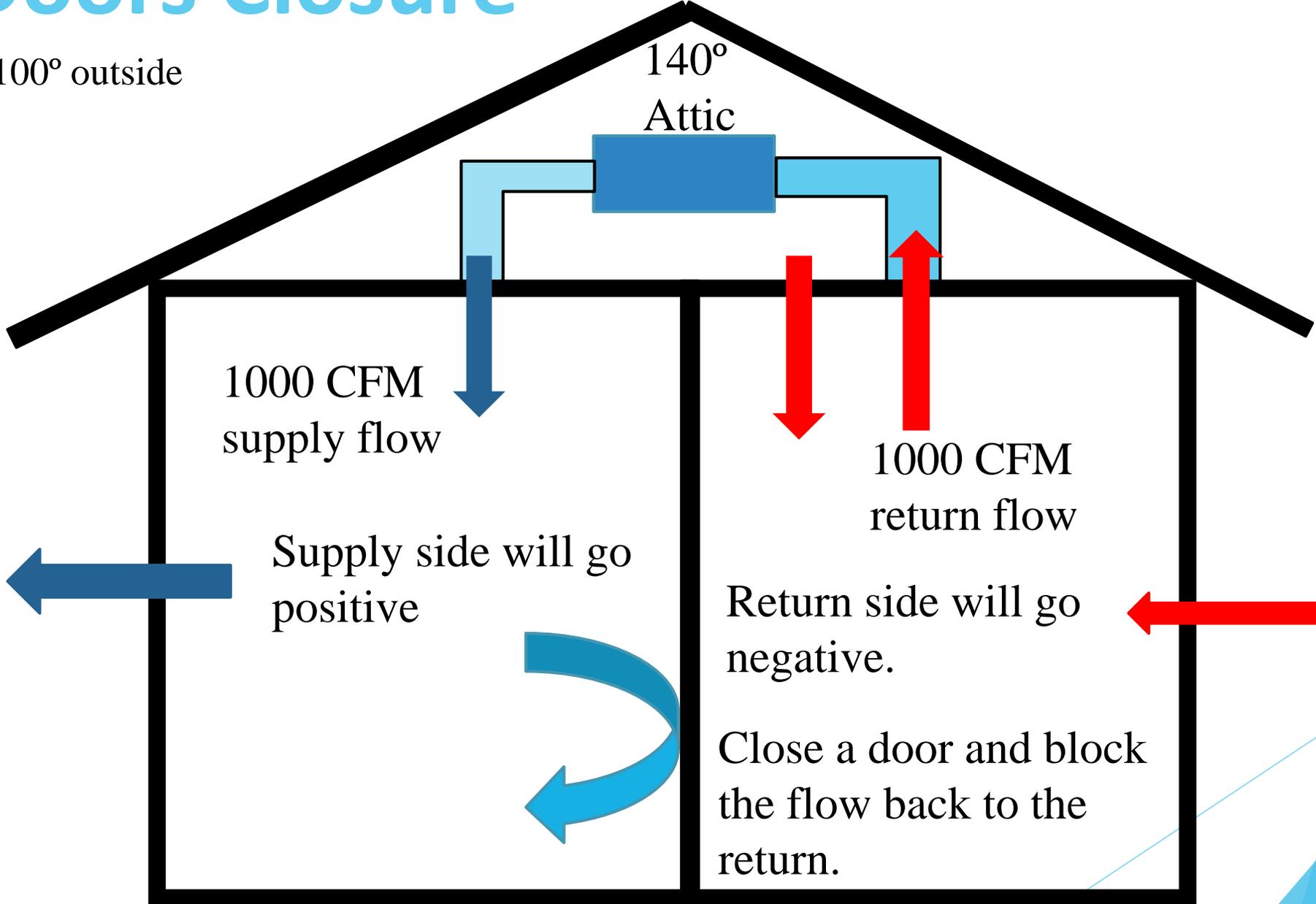
# Doors and insulation performance

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



# Doors Closure

100° outside



# 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.



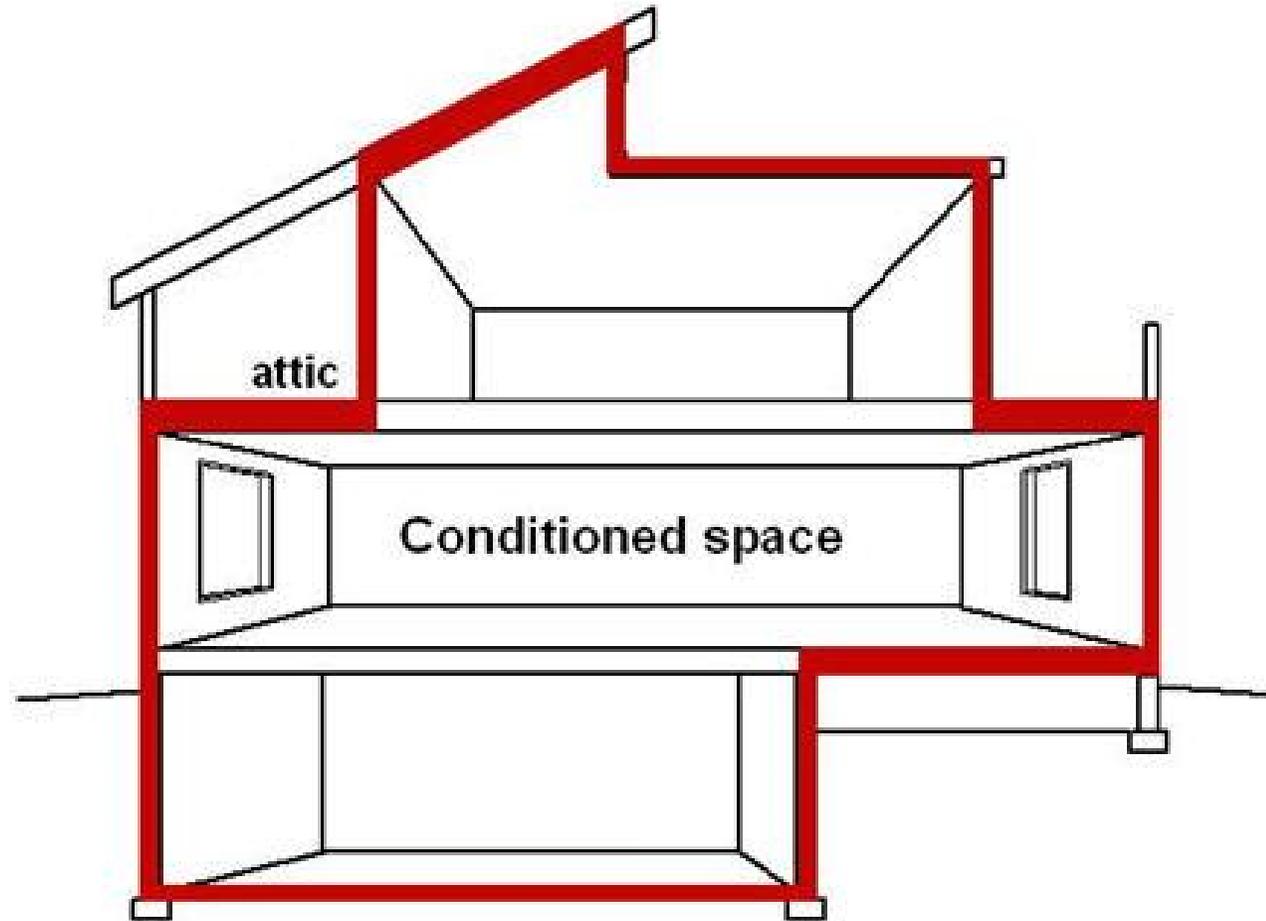
# Blower Door Tests

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

# Zonal Pressures

- ▶ Using the Blower Door CFM<sub>50</sub> 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.

# Align the Thermal and Pressure Boundary



# 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.**

# Using the blower door to test ducts

- ▶ Pressure Pan
- ▶ Subtraction method
- ▶ Smoke

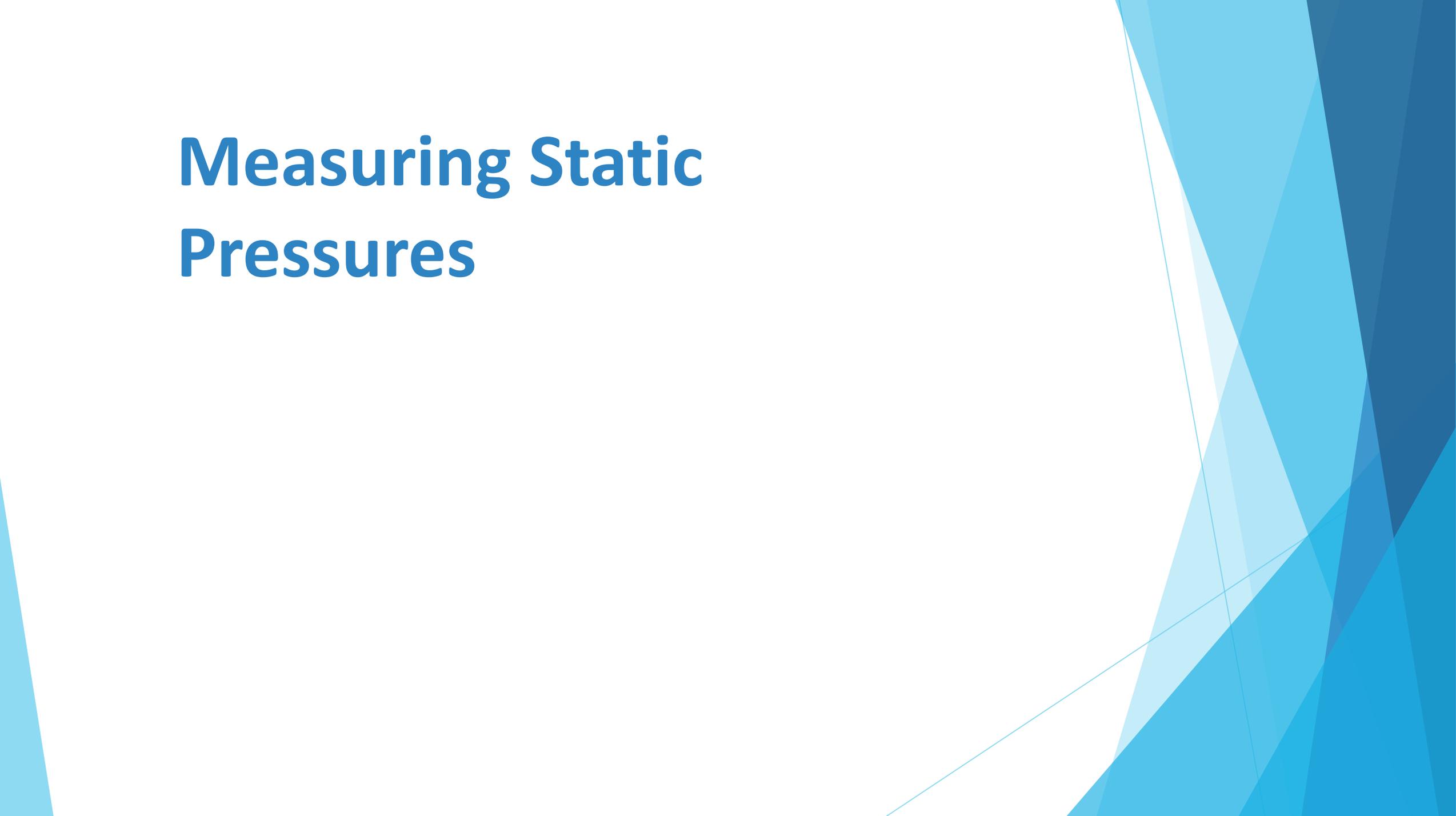
**Remember, our goal is not to determine the amount of duct leakage present, but to get the system as leak free as possible.**



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- ▶ ~~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!

# Measuring Static Pressures

The background features abstract, overlapping geometric shapes in various shades of blue, ranging from light sky blue to deep navy blue. These shapes are primarily located on the right side of the slide, creating a modern, layered effect.

- ▶ 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 most in the construction industry.



- ▶ 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.



# 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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# 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



# 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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- ▶ ~~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
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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.

# HYBRID



# 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!

# Standards, standards, standards

- ▶ Your energy auditor follows all BPI standards.
- ▶ Energy efficient installs follow the “SWS” (Standardized work specifications) Insulation & windows follow IECC 2012 Standards
- ▶ Ventilation follows ASHRAE 62.2-2013 Standards
- ▶ Appliances follow Energy Star Standards
- ▶ And we all have to follow Code!
- ▶ IECC 2012/2015

# Where do you find a good auditor?

- ▶ **[www.azhomeperformance.com](http://www.azhomeperformance.com)**
- ▶ [www.bpi.org](http://www.bpi.org)
- ▶ Any local weatherization agency
- ▶ Ask us.

# THANK YOU!!



Peace Out

