


## Home Performance Diagnostics with the House of Pressure (Part 2)

Pressure diagnostics help determine:

- How leaky a house is
- Pressure boundary of a house
- Communication by air leakage between zones inside the building shell
- Presence of duct leakage (pressure pan testing)
- Dominant duct leakage
- Room pressure imbalances (pressure balancing a forced air distribution system)
- Worst-case depressurization of the combustion appliance zone
- Worst-case draft of combustion appliances



### Types of Pressure Diagnostics

Tests commonly performed in a house depressurized by a **blower door**:

- Blower door test
- Zonal pressure diagnostics
- Pressure pan testing

Tests commonly performed **under normal operating conditions** (using existing air handler and exhaust fans):

- Combustion appliance zone pressure
- Dominant duct leakage
- Worst-case draft




### Examples of Pressure Testing Using a Blower Door

- Air leakage testing
- Zonal testing
- Pressure pan testing

### Intro Questions

- How many are Doing Zonal Pressure Diagnostics
- Where are you testing Zonal Pressures
  - Attic, Garages, Crawlspace, Wall/Floor Cavities...
- How are you testing
  - Direct Pressure
  - Charts
  - Calculators
- How many are Doing Pressure Pan Testing

### Zone Testing

- What are Zones?
  - Spaces that might be better connected to *Inside or Outside*
- Zone Types
  - Primary
  - Secondary

## ZONE TYPES

can you tell what determines type?

Primary Zones	Secondary Zones
Attic	Cantilevers
Basement	Floor Cavity b/w Floors
Garage	Soffits
Crawlspace	Porch Ceiling
Attached Porch	Interior Wall

## Zone Types

- Primary Zones
  - Are zones that have an opening in one of the surfaces
    - House to Zone or Zone to Outside
    - This is an advantage for testing
- Secondary Zones
  - Do not have an access in either surface
    - Only Direct Pressure measurements can be taken

## Levels of Zone Testing

- Level 1 – Direct Pressure Measurement
- Level 2 – Charts and Graphs
- Level 3 – ZPD Calculators

### This Class

- Level 1 (Pressure Only)
  - Is the zone more *indoors* or more *outdoors*?
- Level 2
  - zone with an opening
  - Can calculate square inches leakage of both barriers
  - Can calculate the leakage through the zone (available CFM50 reduction)

## *Level 1 Zonal Pressures*

## Use your Blower Door more

- The Blower Door can estimate total amount of amount air leakage, but when performing ZPD with the Blower Door we can find out:
  - Where the air barrier (PRESSURE BOUNDARY) is so we can determine where to air seal
  - If the Pressure Boundary and insulation (THERMAL BOUNDARY) line up
  - How big are holes in the Pressure Boundary
  - How much CFM Reduction we can expect by sealing holes in the Pressure Boundary

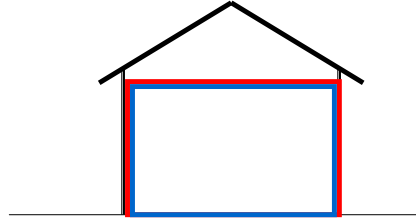
## Pressure and Thermal Boundaries

The **Pressure Boundary** is the air block between Conditioned indoor air and Unconditioned outdoor air

The **Thermal Boundary** is the insulation between Conditioned indoor air and Unconditioned outdoor air

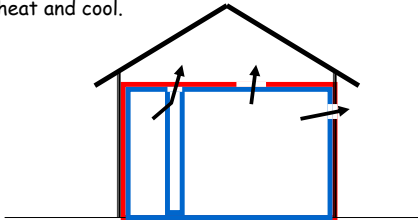
## Pressure and Thermal Boundaries

- The **Pressure Boundary** and **Thermal Boundary** must be together and continuous.



## Pressure and Thermal Boundaries

- If the boundaries are misaligned or If there are holes, voids or gaps this will make the building difficult to heat and cool.



### Benefits of Doing Zonals

#### Zonal Pressure Diagnostics Can:

- Give us an idea of how well connected two spaces are by air leakage
- Help determine the location of primary and secondary air barriers within the building shell
- Help us make decisions about how to align the air barrier and thermal boundary of a home
- Be a good check for air sealing work



Testing a chimney chase

### Measuring Zonal Pressures

With the blower door at -50 pascals, we can measure the pressure difference between different zones inside the building enclosure.



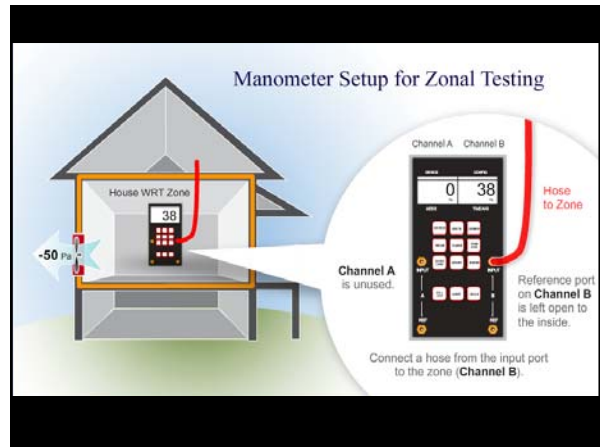
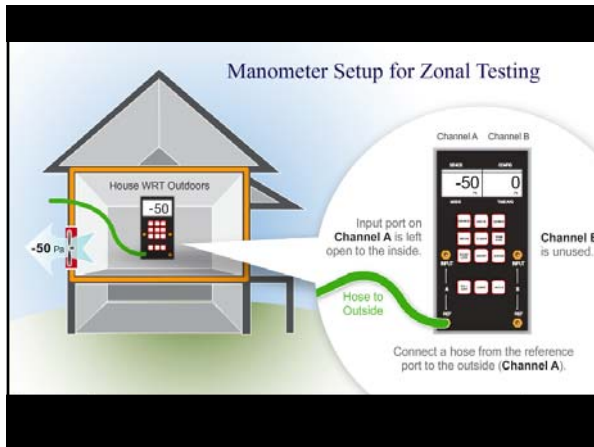
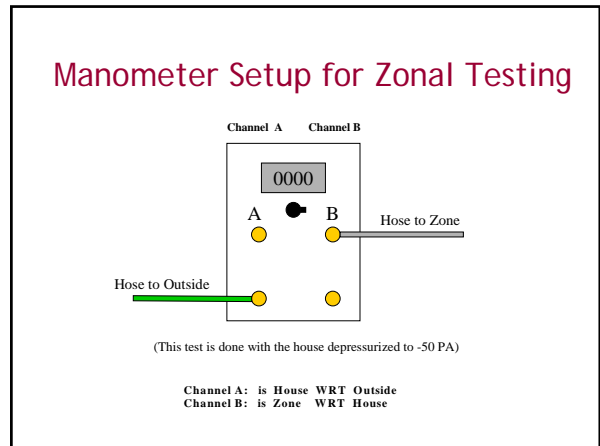
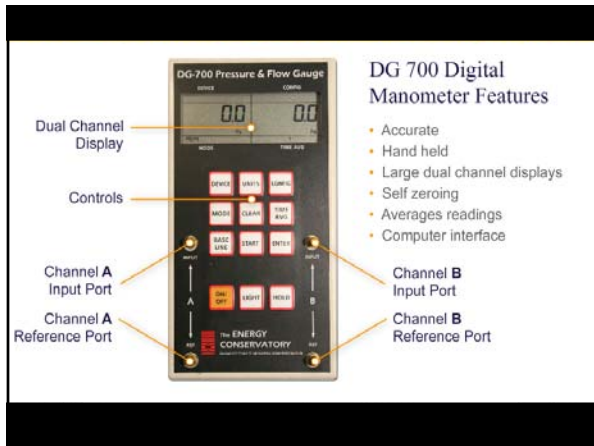
### What Do We Measure?

Not total pressure, but **pressure differences** between one space and another

#### Always one space with reference to (WRT) another:

- House WRT outside
- Attic WRT house
- Porch roof cavity WRT outside





## Zonal Testing

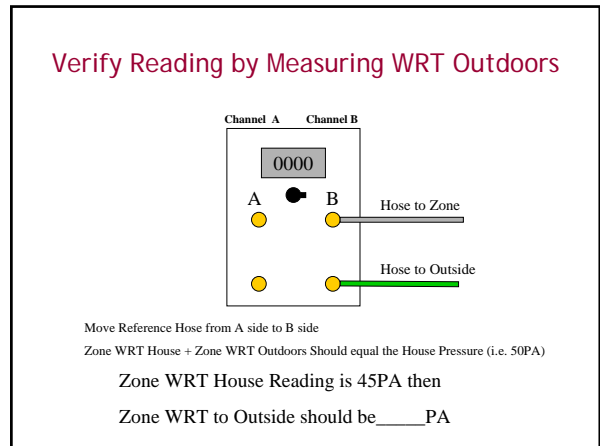
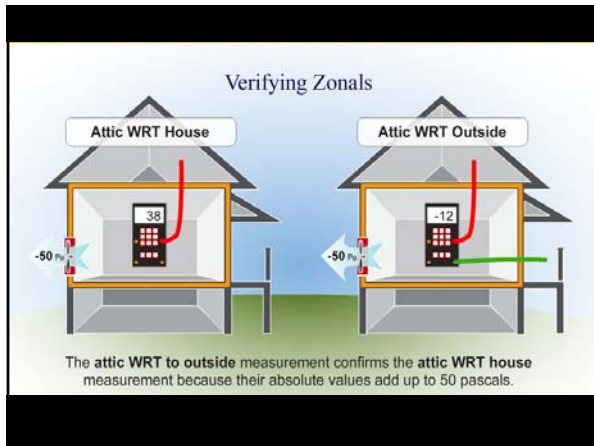
This test is used to determine which areas of the House are INSIDE and which areas are OUTSIDE Pressure (Air) Boundary

ZONAL TEST RETURN CHASE

## Outside Zones and Inside Zones

We want Zones Outside the House (Unheated Areas) to be closer to 50PA with reference to the House

We want Zones Inside the House (Heated Areas) be closer to 0PA with reference to the House



- ### WRT With Reference To
- Zone WRT House = 40PA
  - Zone WRT Outside = \_\_\_\_PA
  
  - Zone WRT House = 15PA
  - Zone WRT Outside = \_\_\_\_PA
  
  - Zone WRT House = 25PA
  - Zone WRT Outside \_\_\_\_\_PA

- ### Outside Zones and Inside Zones
- |  |   |
|--|---|
| <p>Unheated zones <b>OUTSIDE</b> the house should be closer to <b>50 pascals</b>.</p> <p><b>Outside Zones (Unheated)</b></p> <ul style="list-style-type: none"> <li>• Attics</li> <li>• Garage</li> <li>• Porches (sometimes)</li> <li>• Crawlspace (sometimes)</li> <li>• Basement (sometimes)</li> </ul> | <p>Heated zones <b>INSIDE</b> the house should be closer to <b>0 pascals</b>.</p> <p><b>Inside Zones (Heated)</b></p> <ul style="list-style-type: none"> <li>• Interior walls</li> <li>• Floors between stories</li> <li>• Porches (sometimes)</li> <li>• Crawlspace (sometimes)</li> <li>• Basement (sometimes)</li> </ul> |
|--|---|

Are the zones where they are supposed to be??

If the zones are **NOT** where they are supposed to be, we need to seal holes between Inside and Outside. (*wasting money and Energy*)

By sealing the holes we stop Air Leakage by making a **PRESSURE BOUNDARY**

**Pressure Boundary** (Air Block between Inside and Outside)

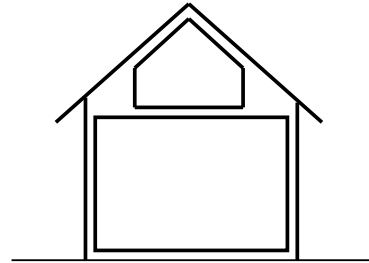


## Zonal Pressure Testing

- By dividing the building into zones you can then see if the [Pressure Boundaries](#) and the [Thermal Boundaries \(Insulation\)](#) line up



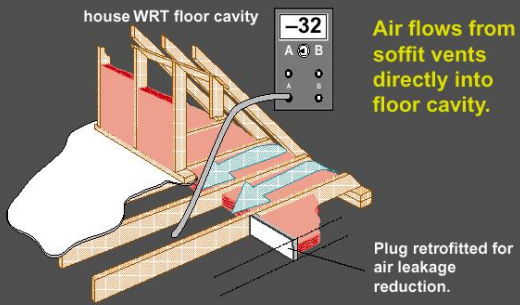
Kneewall Attic



Unsealed/Uninsulated

## Ventilated kneewall attic

*Air-leakage conduit to second floor cavity*



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One-and-a-Half Story Cape Cod

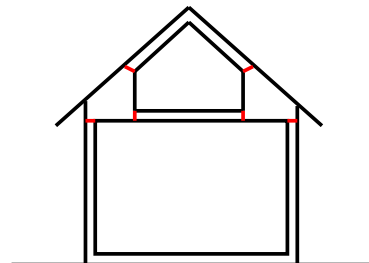
Heated first and second floor rooms over a heated basement

- Air Sealed
- Insulated

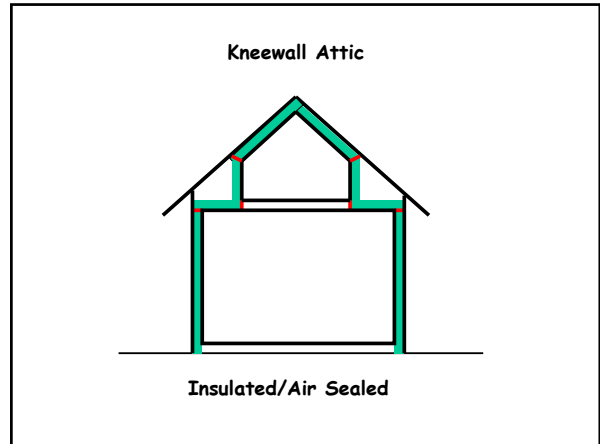
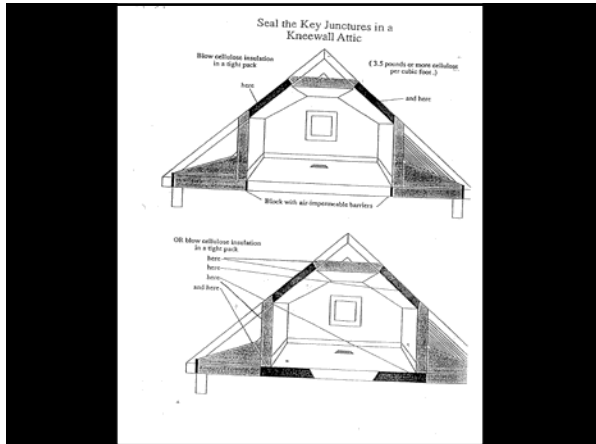


Snow melting because of bypasses in attic kneewall

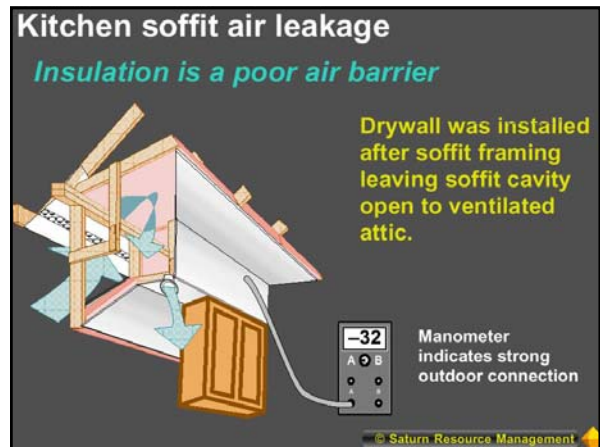
Kneewall Attic



Air Sealed/Uninsulated



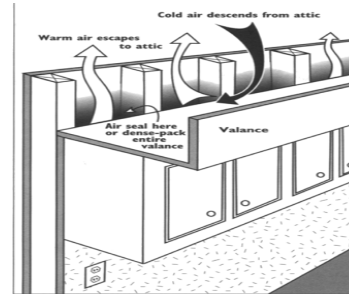
- ## Interconnection
- Depressurize house to 50 Pa
  - Measure pressure to one zone
  - Open a door to the other zone, readjust blower door to read 50 again
  - If the zones are connected, the pressure in the first zone will change, If not, it won't



### Kitchen Soffit and Base Cabinet were open to attic

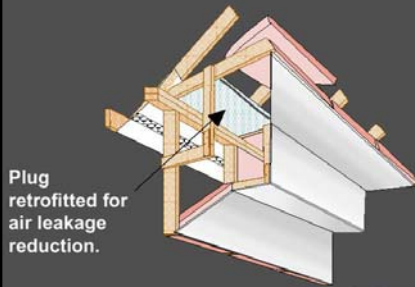


### Soffit Open to Attic



### Kitchen soffit air-leakage retrofit

Sealing the top of this cavity reduces air leakage and convection.

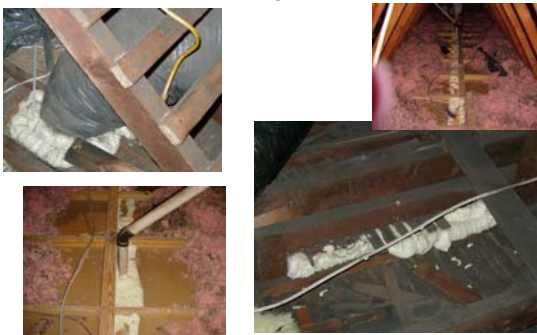


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### Common By-Passes

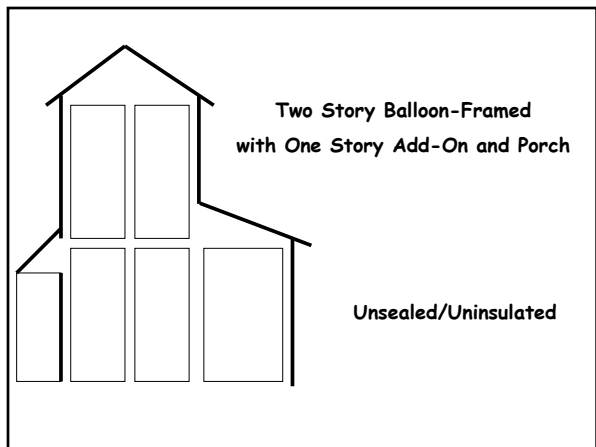
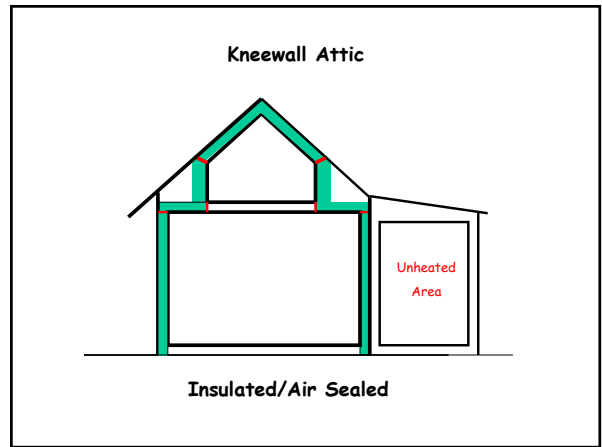
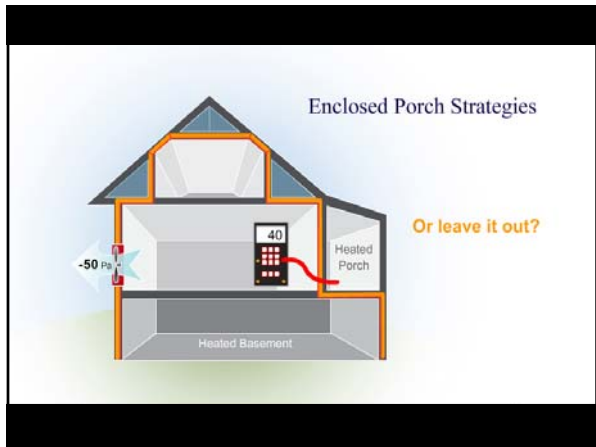
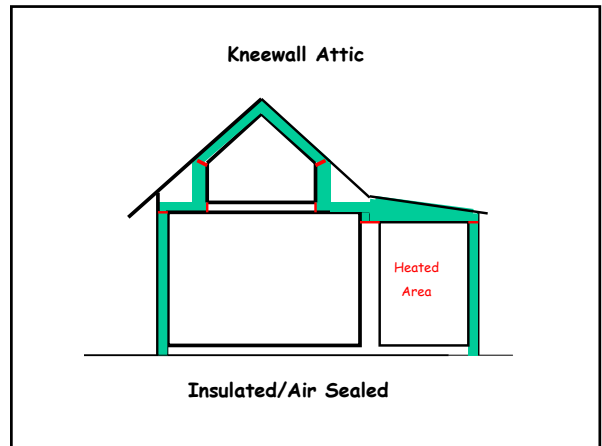
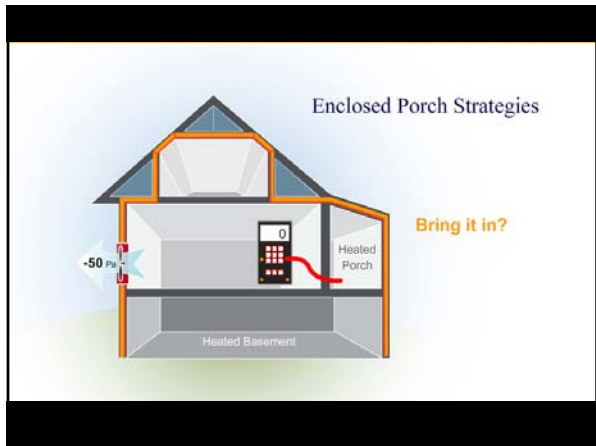


### Sealed By-Passes



### Using Pressure Pan to do Zonal Test





EXERCISE:  
Air Seal a Typical Turn-of-the-Century Triple Decker

Unsealed/Uninsulated two-story balloon-framed with one-story addition and unheated porch over unheated basement

Calculate

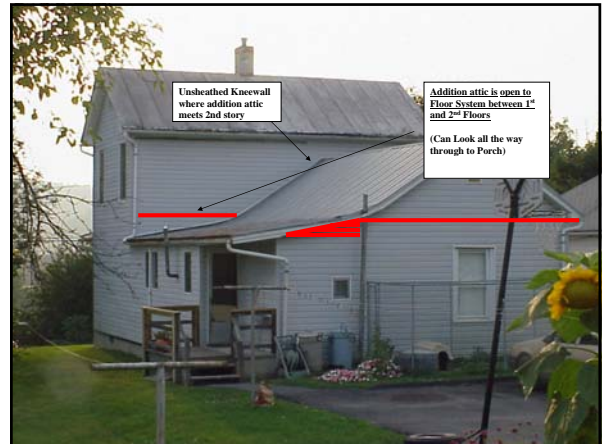
Click on any of the leak regions to seal and unseal the leakers and then click "Calculate" to view the resulting manometer readings.

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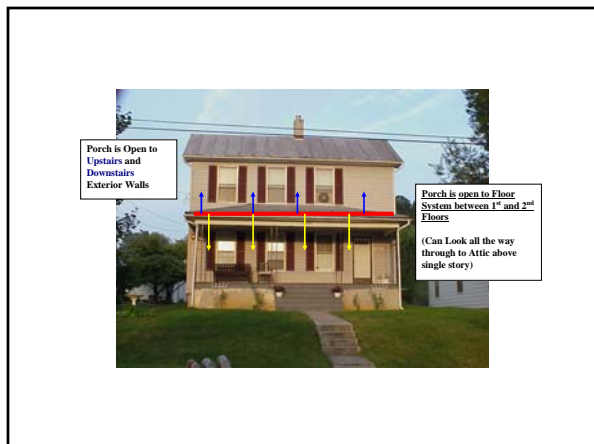
**2-level attic in split-level or tri-level homes**  
*Common wall is a possible air-leakage conduit*

Air leaks between ventilated attic and uninsulated interior wall cavity

Plug retrofitted for air leakage reduction.

Manometer indicates outdoor connection.

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**Zone Connections (Manometer Outdoors)**

Porch WRT Outdoors = -20 Pa

- Porch roof cavity is open to exterior wall cavities
- The goal is for the zone WRT outdoors to be close to 0 pascals.

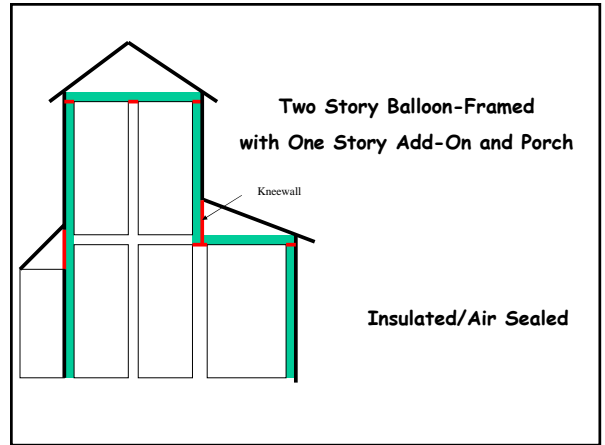
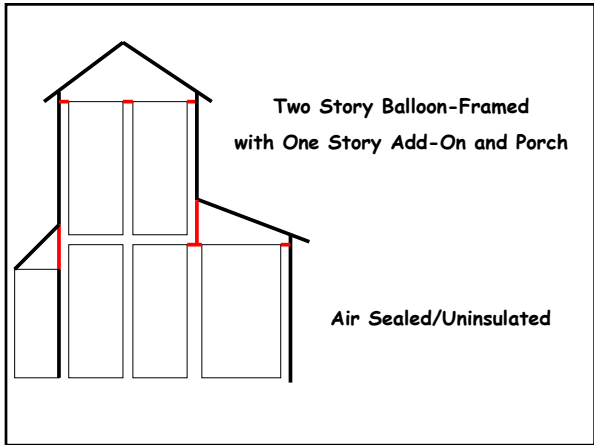


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Click on any of the leak regions to seal and unseal the leaks and then click "Calculate" to view the resulting manometer readings.



**An Effective Air Barrier, Defined**

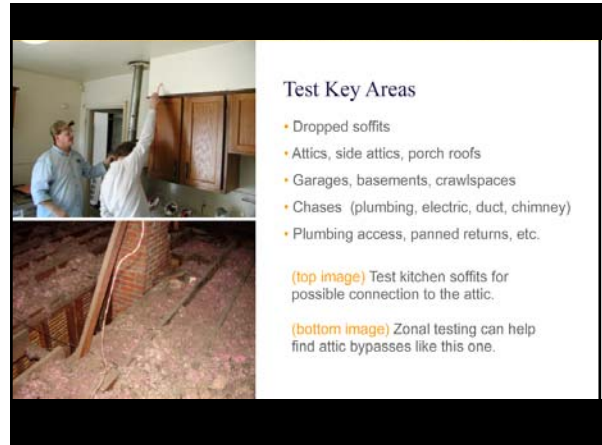
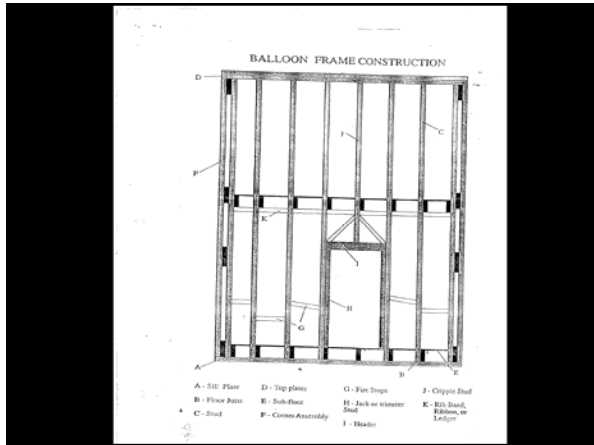
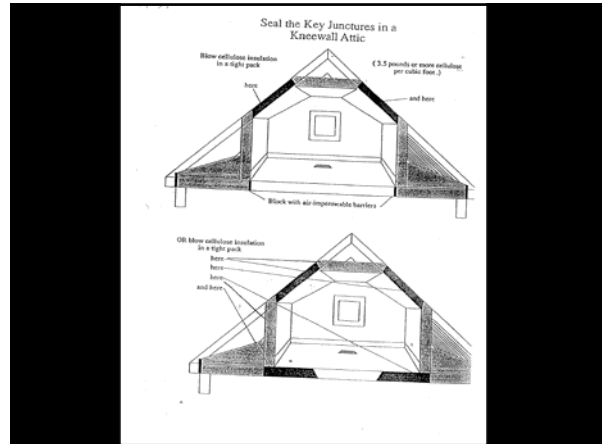
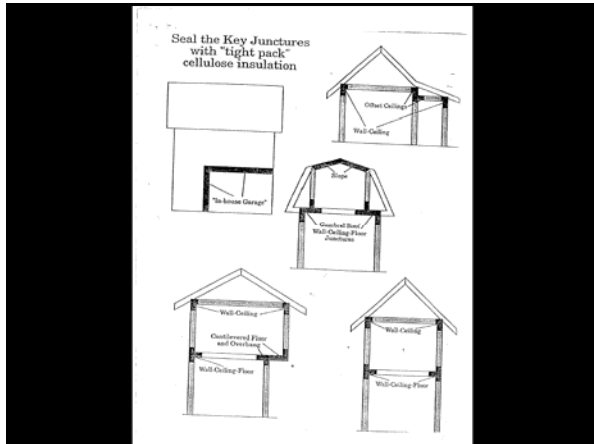
Two-story balloon-framed with one-story addition and unheated porch over unheated basement

Air Sealed  
 Uninsulated

Attic Bypass Examples

This is a view of an attic space called the "Attic Bypass". The roof of this space is not pitched, so that the numbered dimensions fit one story.

1. Install flashing around chimney, using metal flashing and high temperature sealant
2. Block around gable-end vent stack with an air barrier
3. Block open interior wall cavities with air barrier
4. Block open exterior wall cavities with air barrier
5. Block the open joist cavities under the kneewall with air barrier
6. Use floorboards to install air barrier in joist cavities under the kneewall
7. Block the slope rafter cavities with an air barrier, and blow in cellulose insulation with a tight pack.



**Keep It Simple**

- Record basic pressure measurements
- Explain bad pressure readings (ex 10 attic)
- Should take very little time (Bdoor is all ready up)

CONCLUSIONS

Do "Zonals" to Make Useful Decisions

- Decide what's inside and what's outside.
- Determine Air Barrier & Thermal Boundaries.
- Decide where the Air Barrier & Thermal Boundary should be.
- Determine the duct location (inside or outside) and where ducts should be.
- Determine if the Air Barrier and Thermal Boundary line up.



## Where Should We Start?

- Look at House, tests, talk to client, fuel bills to understand house & how it should work
- Do the work and remeasure when think done
- Outside (Attic, Garage) Should be more outside (Closer 50)
- Inside (Interior wall, Chase) Should be more inside (Closer 0)
- Check zones with no change in right direction

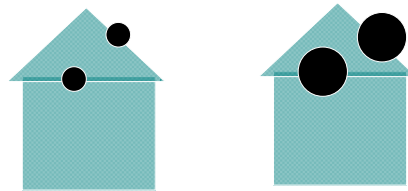
## Just a Tool

- Doesn't Replace Common Sense (Head,Eyes)
- Testing will help a lot in understanding complicated houses along with other observations
- If get a reading of 46 to 50 PA check Attic WRT to outside (should add to 50) May have a lot of venting (Make sure look)
- If unusual readings (Check hose for pinch, disconnect,plugged)

## Pressures and Leakage

### Attic Zonal Reading of 25pa

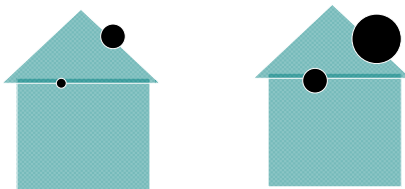
Means hole between Attic and House is Same size as Hole Between Attic and Outdoors



## Pressures and Leakage

### Attic Zonal Reading of 48pa

Means hole between Attic and House is 1/8<sup>th</sup> size of Hole Between Attic and Outdoors



## Pressures and Leakage

Zone Pressures		Relative Size of Leaks	
Zone-House	Zone-Out	Zone-House	Zone-Out
12	38	2	1
25	25	1	1
37	13	1/2	1
41	9	1/3	1
45	5	1/4	1
48	2	1/8	1
49	1	1/13	1

## Pressure Pan Test

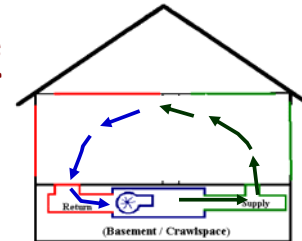
This test is done with the Blower Door depressurizing the house and is used to give a general idea of where leak sites are in ductwork by measuring the pressure at each supply and return register throughout the house.



## What is Ductwork?

Ductwork circulates heated or cooled air inside the home.

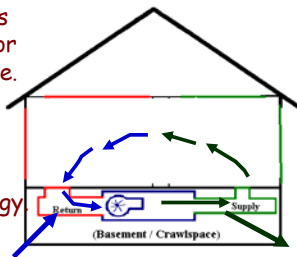
Ductwork should be sealed so that there are no leaks.



## Why Do Pressure Pan Testing?

If there are Duct Leaks you are losing **heated** or **cooled** air to the outside.

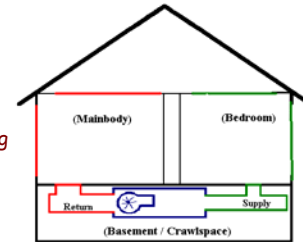
This makes the house uncomfortable, and wastes Money and Energy



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## All Holes are Not Created Equal

Duct leakage can also create **positive** and **negative** pressures on the building by delivering and taking air from the wrong places.



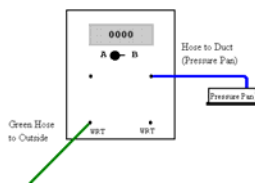
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## Manometer Setup for Pressure Pan



Pressure Pan Testing

Channel A Channel B



Channel A: is House WRT Outside  
Channel B: is Duct WRT House

## Pressure Pan Results

Pressure Pan Test ( Duct WRT House)									
Location	Before	After	Location	Before	After	Location	Before	After	
1 Living Room	4.2	0.5	8	RETURN	15.9	0.8	15		
2 Dining Room	6.2	0.4	9			16			
3 Kitchen	8.3	0.5	10			17			
4 Bathroom	6.0	0.8	11			18			
5 Bedroom 1	4.2	0.5	12			19			
6 Bedroom 2	4.7	0.4	13			20			
7 Bedroom 3	3.2	0.2	14			21			

## Duct Leakage With the Pressure Pan

- Since ductwork circulates inside air we should get a pressure pan reading near 0.
- The Higher the reading, the leakier the Duct in that vicinity.
- If we get a reading higher than 1.0 we want to seal the duct with Mastic (not duct tape)

## Quality Control

- This test can be performed after Duct Sealing is done as measure of Quality Control.
- Lets crew know how well the duct was sealed and if anything was missed.



## Things to Know When Using Pressure Pan

- Remove Furnace Filters
- Make sure registers in conditioned areas are **open**
- Make sure registers in semi and unconditioned areas are **sealed off** (*garages, shop, etc.*)
- Temporarily seal outside combustion air inlets or ventilation system connections which are hard ducted into the duct system

## More Stuff to Know

Take Zonal Pressure readings in duct locations

- If zone reading only 12pa then highest reading possible even if duct is disconnected would be 12pa
- Can either adjust or open zone to outdoors so that zone will be near 50pa
- If basement is considered outside the conditioned living space, close the basement door to the house, open a window or door in the basement, and seal all basement supply and return registers
- In crawlspace houses, open crawlspace door or vents

## Duct Blaster



## Duct Blaster

- A Duct Blaster is fan similar to the Blower Door.
- It can be used for Blower Door testing on Smaller Homes and can move about 1500cfm.
- The Duct Blaster will estimate the Total Duct System Leakage in cfm.

## Duct Blaster Setup

- Duct Blaster is usually installed at the Return grill or at the Air Handler
- Seal off all Supply Registers and Return Grills with Duct Mask or Masking Tape
- The Duct Blaster can be used to Pressurize or Depressurize duct system typically to +25 or -25 pa

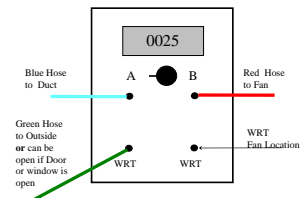
## Leakage Standards

- Pre and Post tests can be done to determine duct sealing effectiveness
- Standards for tightness on new homes are 3% of floor area or 5% of system air flow
- Retrofit standards will be higher and will depend on accessibility to seal ducts

## Diagnostic Testing

- Smoke may be injected with a Fog Machine while ducts are being pressurized to visualize leaks.
- You can also use your hand or a smoke puffer to locate leaks during a Duct Blaster test.
- Duct Leakage to the Outside can be determined by Pressurizing house with Blower Door so that leakage to interior is eliminated.

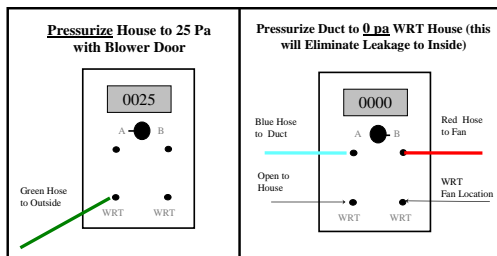
## Manometer Setup for Duct Blaster



(Get Duct Pressure 25 PA on Channel A)

(Then Flip to Channel B to read Fan Flow)

## Duct Leakage to Outside



Gauge 1 **Pressurize House 25 PA** with Blower Door (May have to re-adjust once Duct Blaster is on)

Gauge 2 **Pressurize Duct 0 PA** on Channel A, (Flip to Channel B to read Fan Flow on Duct Blaster)