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Building Performance Diagnostic Tools 101

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The Blower Door

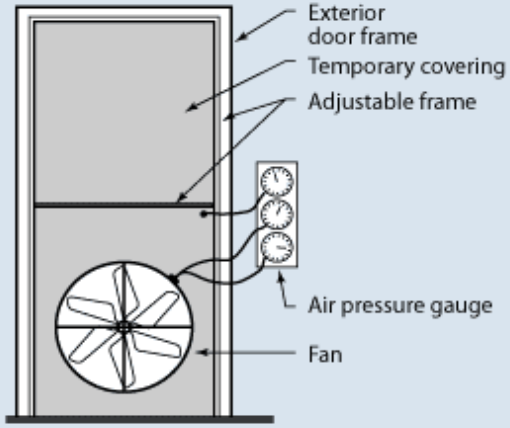
Blower Doors

Blower Doors

- A diagnostic tool
- Measures pressure and air flow

Diagnostic Tools

Testing the airtightness of a home using a special fan called a blower door can help to ensure that air sealing work is effective. Often, energy efficiency incentive programs, such as the DOE/ EPA ENERGY STAR Program, require a blower door test (usually performed in less than an hour) to confirm the tightness of the house.

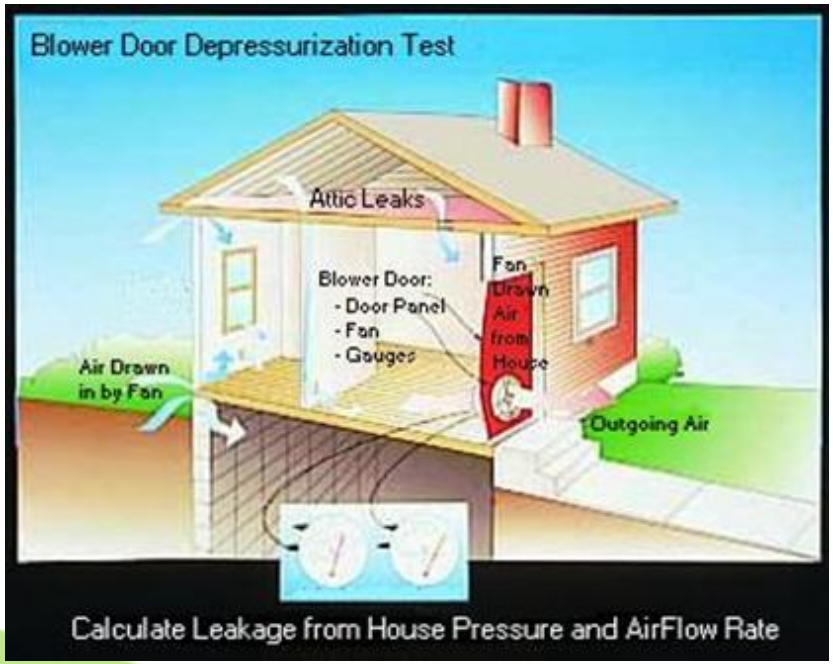


Blower Door Testing

Blower Door Testing
is used to quantify and locate air leakage by using a calibrated fan or fans to depressurize a building.

Goals of Air Leakage Testing

- Measure building airtightness
- Compare to standards
- Locate air leaks
- Reduce air leaks



Blower Door Basics

- Natural driving forces
  - Pressure differences are too small to measure reliably
- Blower door
  - Exaggerates pressure differences so they can be measured reliably and the results are repeatable

Blower Door Basics

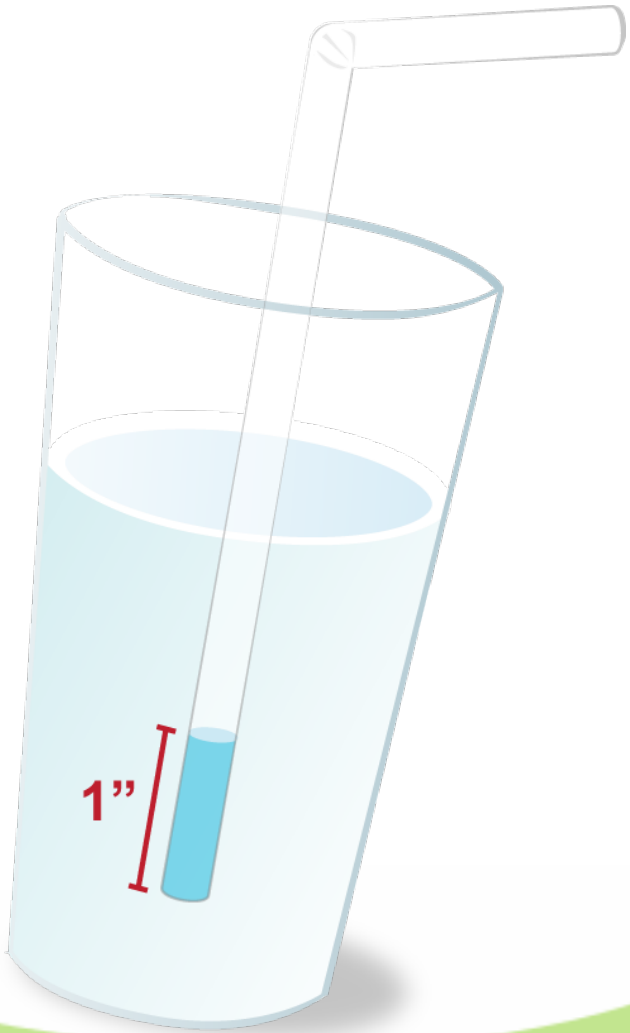
- Air leakage measured by the blower door is proportional to the size of the holes in the building between inside and outside.
- Can conduct blower tests before and after air-sealing work to determine the effectiveness of the work.
- Can use blower door testing to tell us which buildings have the most potential for energy savings through air sealing.

Blower Door Basics

- We don’t measure total pressure, but the pressure difference between one space and another
- Always one pressure with reference to (WRT) another
- Sometimes we measure pressures under controlled, artificial conditions, sometimes under normal operating conditions

Blower Door Basics

- **1 Pascal** = weight of one Post-It note
- **248 Pascals** = 1 inch water column (American standard)
- **1” water column** = pressure required to suck 1” of water up a straw



Blower Door Setup

- Prepare the buildings
  - Set building up for heating or cooling mode
    - Exterior Windows and doors closed
    - Vents closed and registers open.
  - Turn off combustion appliances
    - Set to Pilot or;
    - Turn Off
  - Open interior doors
  - Survey for pollutants that may be disturbed.
    - Mold
    - Asbestos

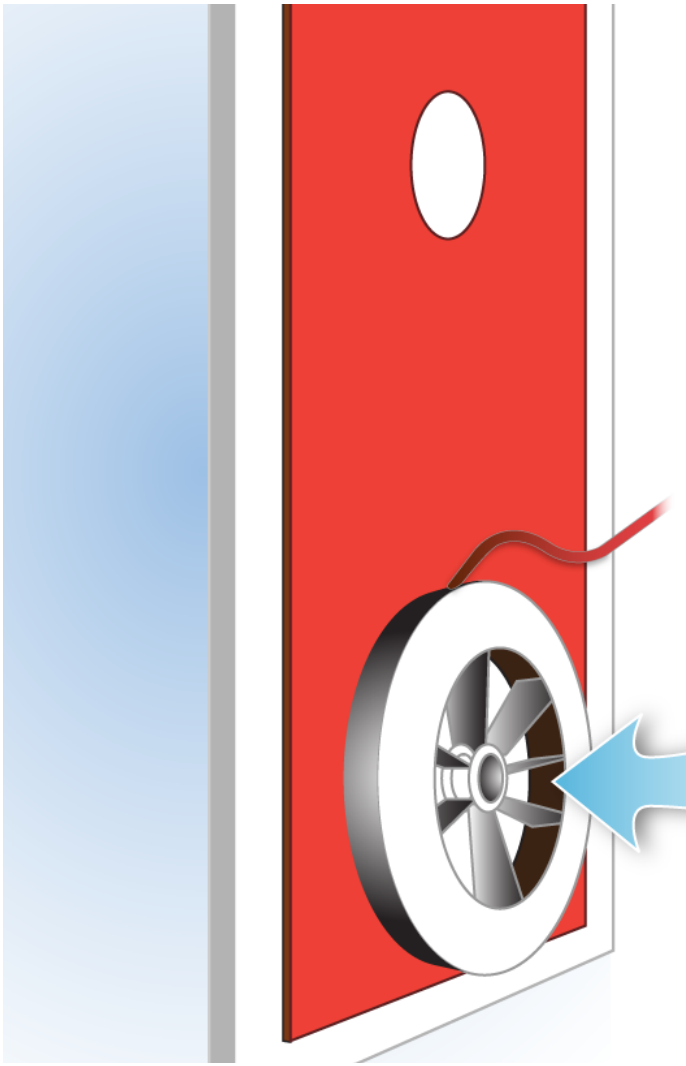
Blower Door Setup

- Install blower door frame, panel and fan in an exterior doorway
- Follow manufacturer's instructions for fan orientation and manometer setup

Blower Door Setup

- Things to know
  - Low-flow rings (for tighter buildings)
  - Check flow sensors
  - Hose to outside – end should be at least 5 feet on one side of fan or the other (not in front of fan)

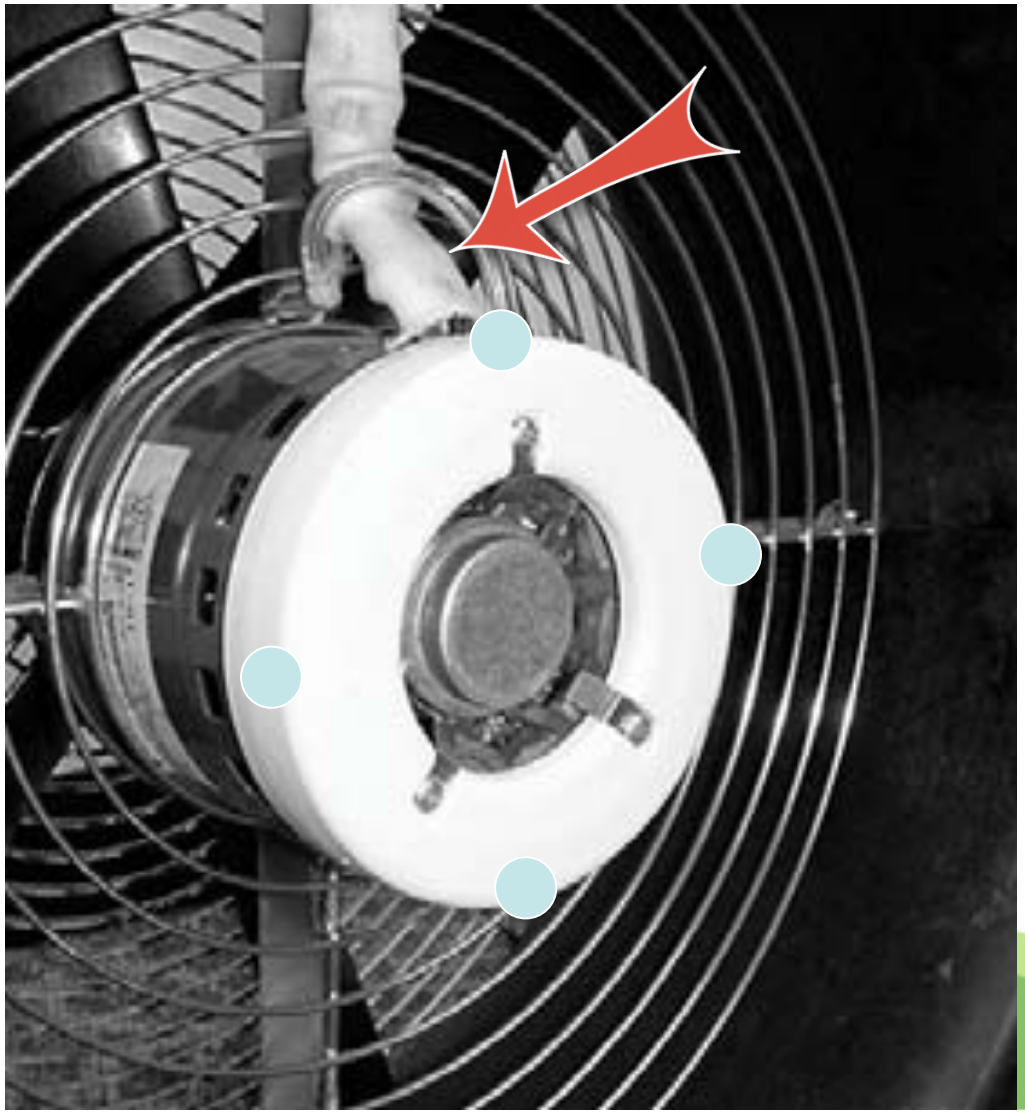
Blower Door Setup



- Air flow across the sensor in the hub of the fan causes air pressure.
- The manometer compares this fan pressure to the pressure inside the building and,
- Converts the pressure difference to a rate of air flow.

Direction of Air Flow

Blower Door Setup

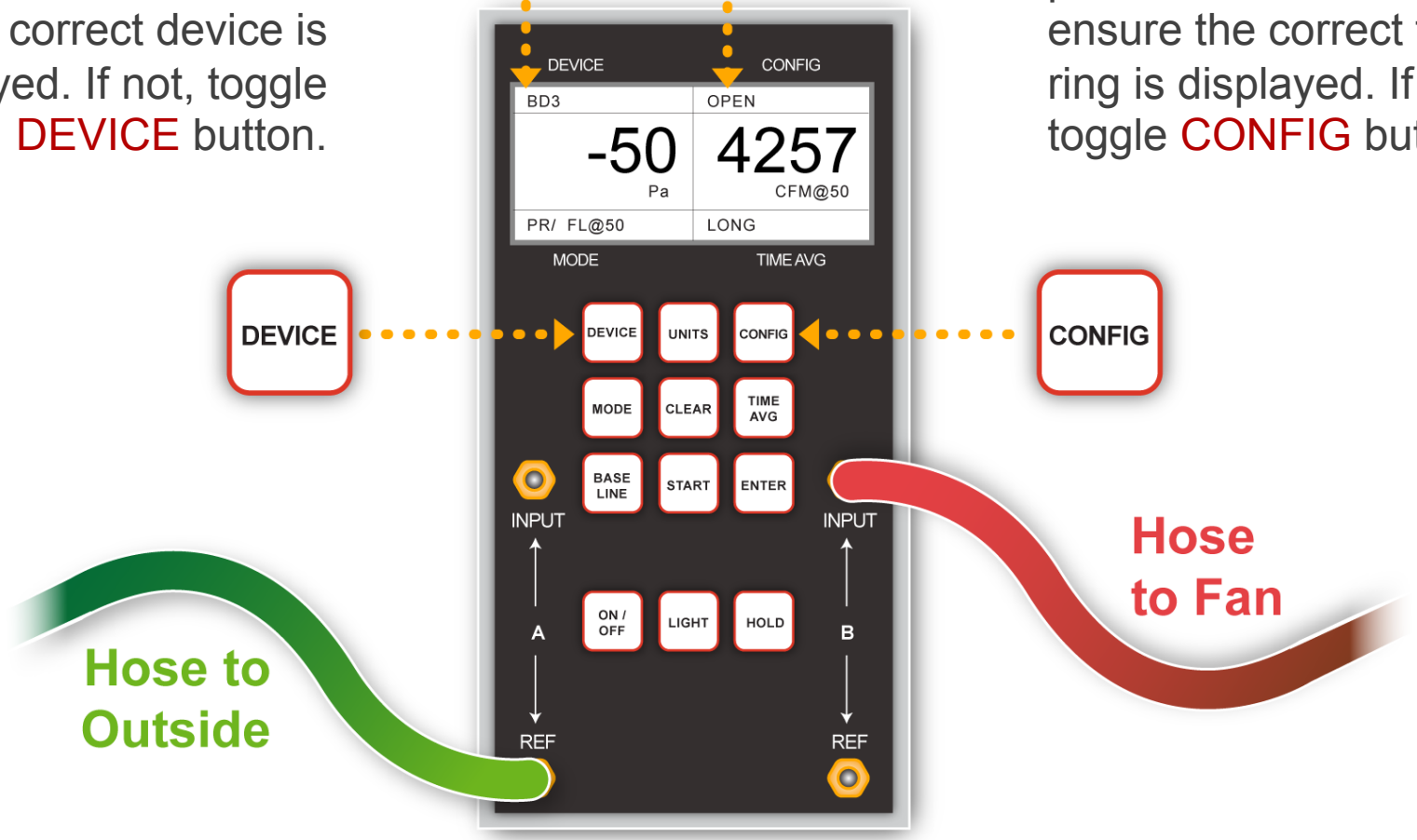


The flow sensor is just a plastic ring with four holes in the outer circumference. An airtight tunnel inside the sensor connects the holes to the hose coming out of the sensor. This hose connects to a tap mounted on the top of the fan. When you set up the blower door, you connect a hose from this tap to the manometer.

Blower Door Setup

Check upper left portion of screen to ensure correct device is displayed. If not, toggle DEVICE button.

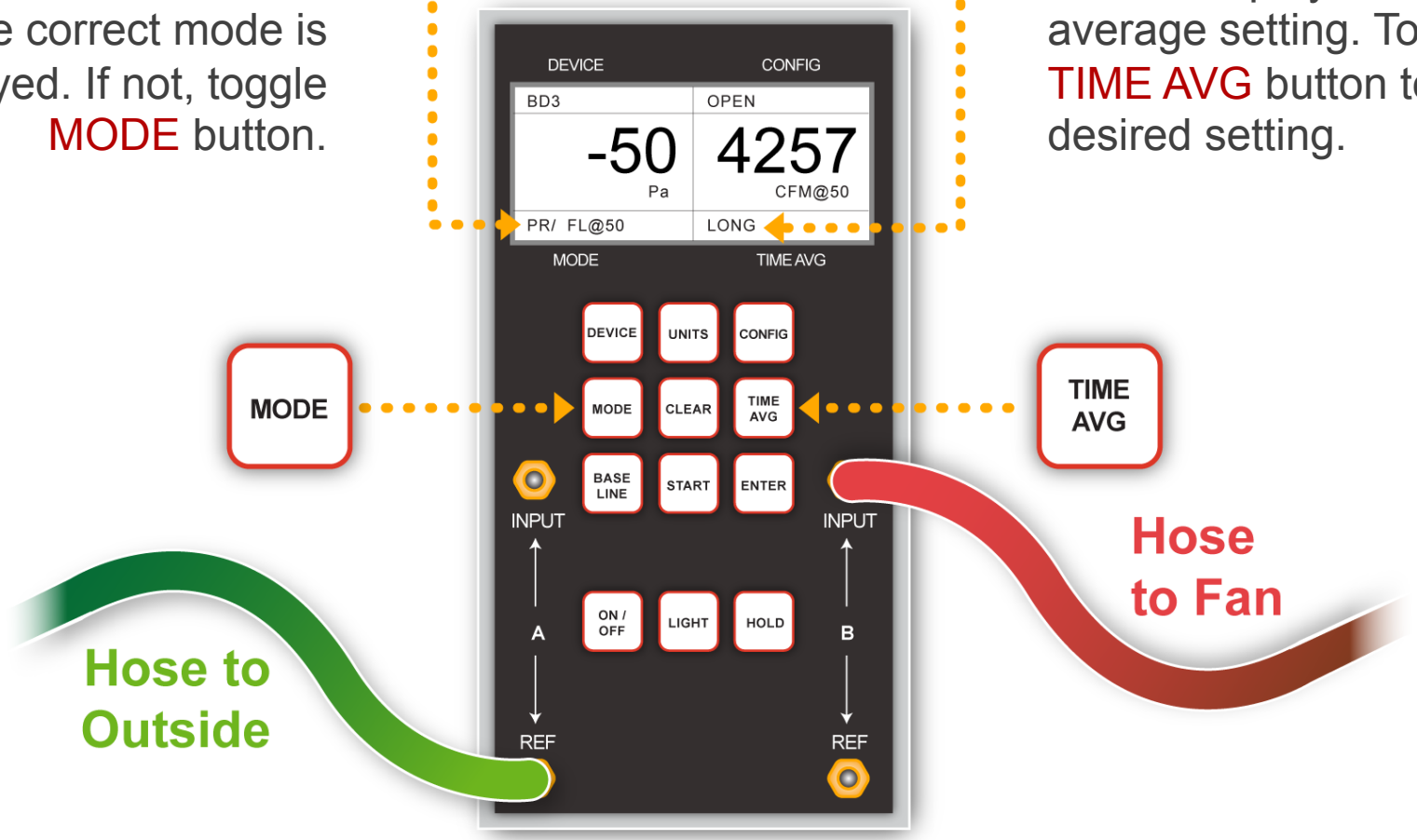
Check upper right portion of screen to ensure the correct flow ring is displayed. If not, toggle CONFIG button.



Blower Door Setup

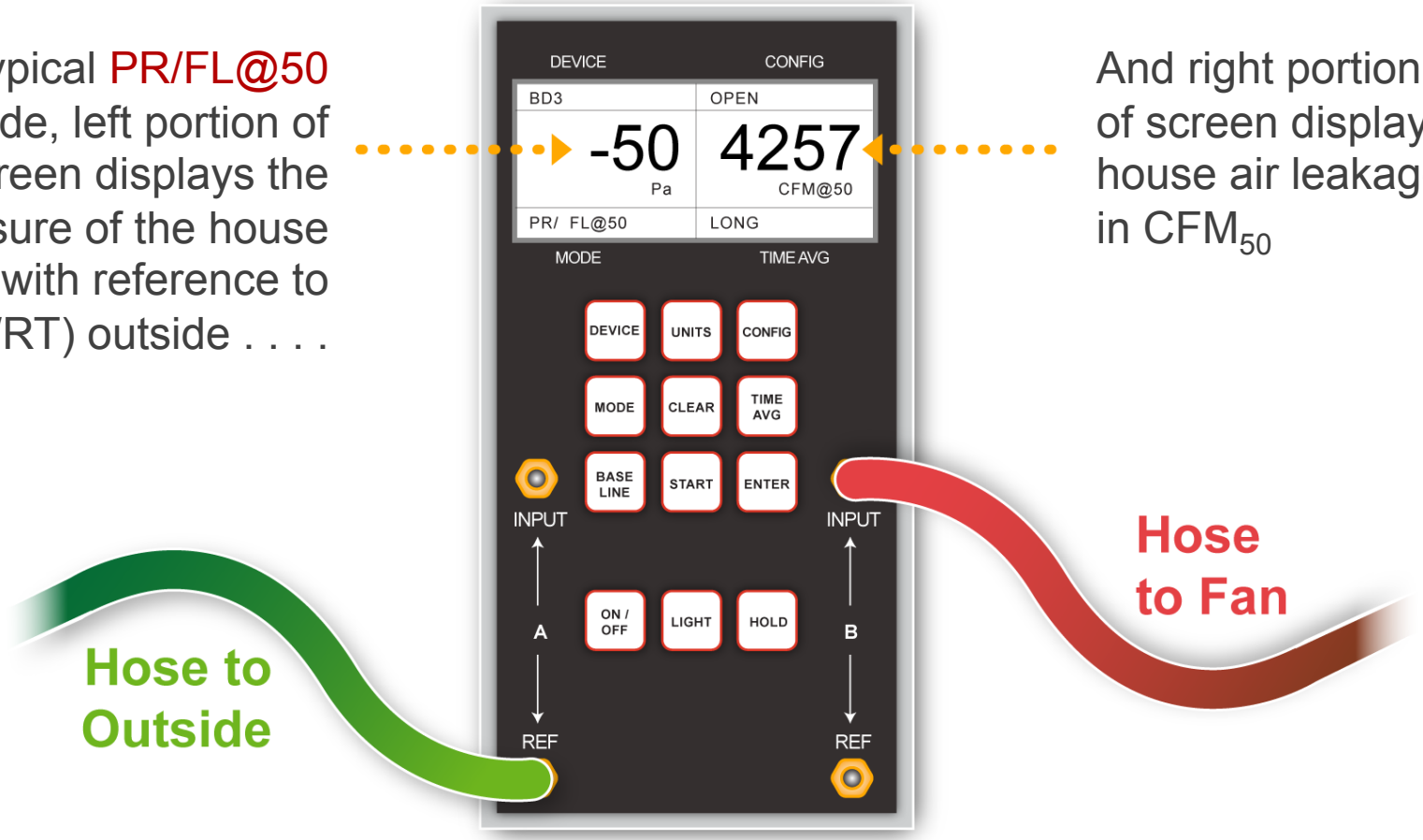
Check lower left portion of screen to ensure correct mode is displayed. If not, toggle MODE button.

Lower right portion of screen displays time average setting. Toggle TIME AVG button to desired setting.



Blower Door Setup

In typical PR/FL@50 mode, left portion of screen displays the pressure of the house with reference to (WRT) outside . . . .

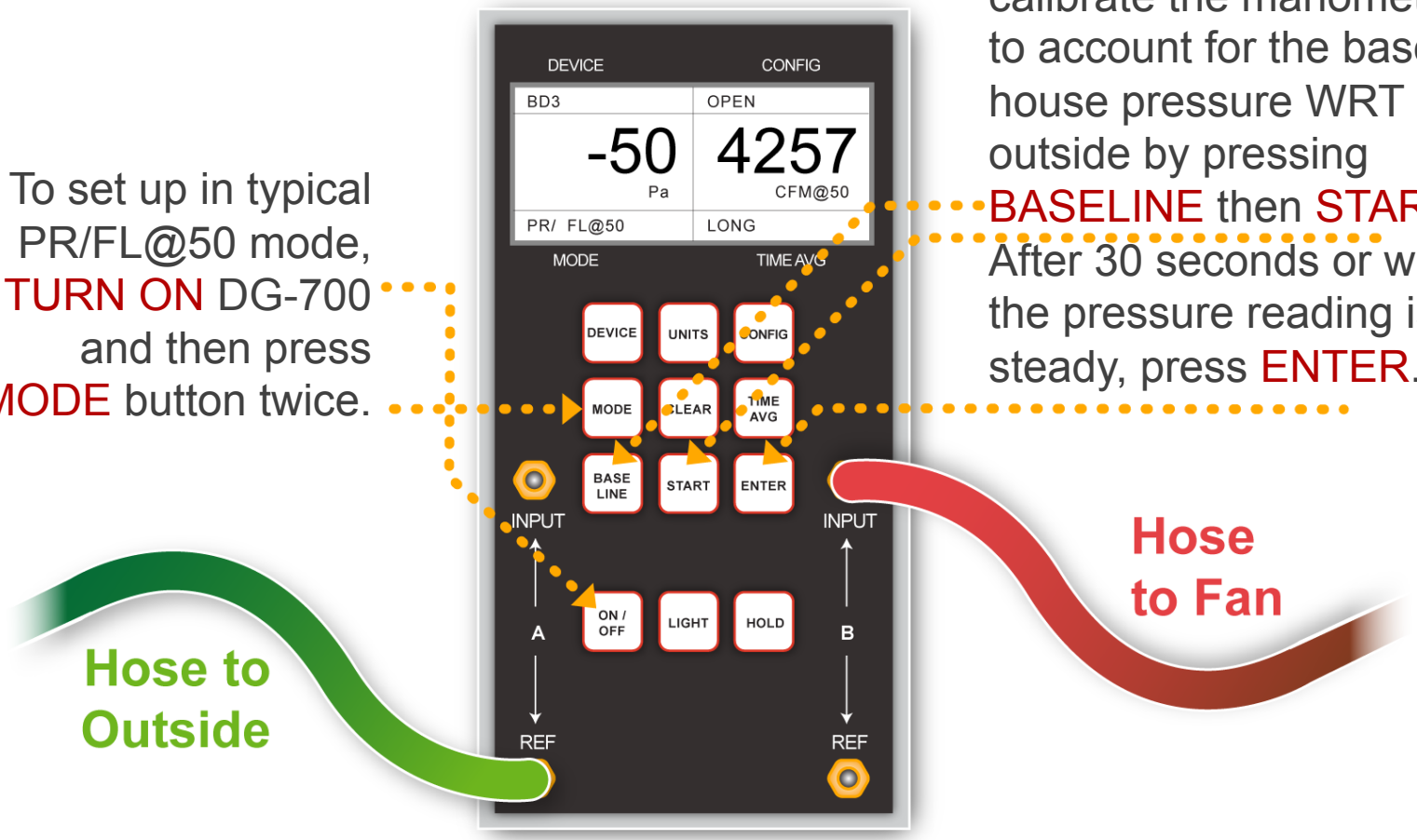


And right portion of screen displays house air leakage in CFM_{50}

Blower Door Setup

To set up in typical PR/FL@50 mode, TURN ON DG-700 and then press MODE button twice.

Then, with fan cover on, calibrate the manometer to account for the baseline house pressure WRT outside by pressing BASELINE then START. After 30 seconds or when the pressure reading is steady, press ENTER.



Blower Door Test

- Turn blower door on and slowly increase speed to achieve a pressure difference between the building WRT outside of **-50 or -75 Pascals** (**Channel A**)
- Read air infiltration rate in CFM”s/50pa or 75pa on **Channel B**

Multifamily Blower Door Testing

- Considerations
  - It is important to distinguish between high-rise buildings and the low-rise stock; the latter often resembles single units stacked one on top of the other.

Multifamily Blower Door Testing

- Considerations
  - Low-rise apartments often have tight inner skins, and building cavities included between apartments and into the attic are inaccessible. Such cavities provide opportunities for convective loops to occur, and they can act like unconditioned spaces.

Multifamily Blower Door Testing

- Considerations
  - The pressure barrier often consists of the attic floor and the exterior walls.
  - Special areas that need attention are overhangs, cantilevers, and ducts.

Multifamily Blower Door Testing

When to use a blower door

Shared outside entrance but low rise and few units

Shared outside entrance but low rise, few units – blower door.

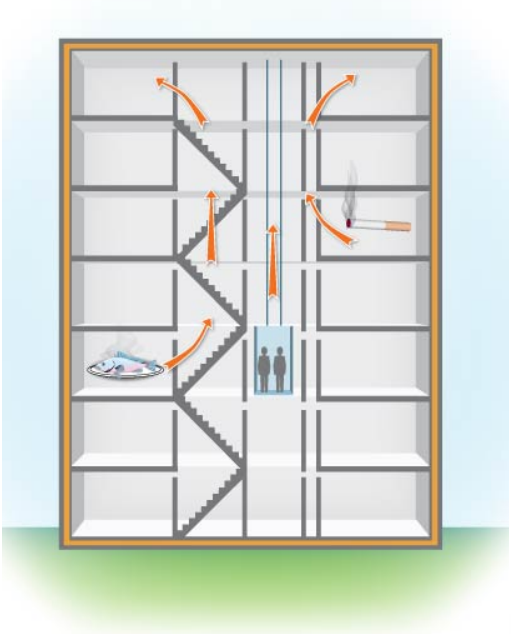
Multifamily Blower Door Testing

When not to use a blower door

Multifamily Blower Door Testing

Best Scenario

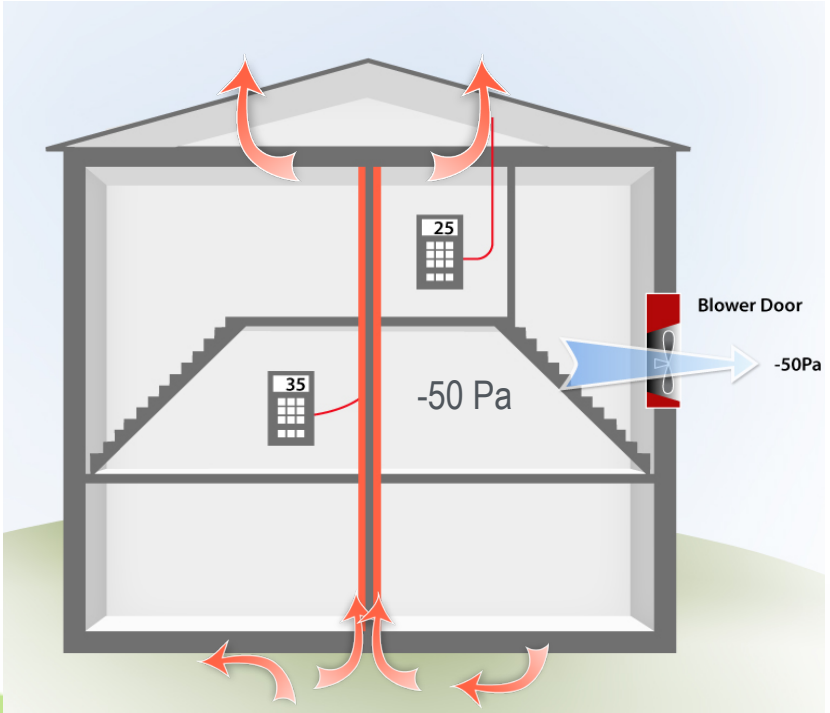
- Easier for occupants to control their own climate
- Easier to size HVAC
- Minimizes noise and smells from adjacent units



Multifamily Blower Door Testing

Unsealed & Uninsulated

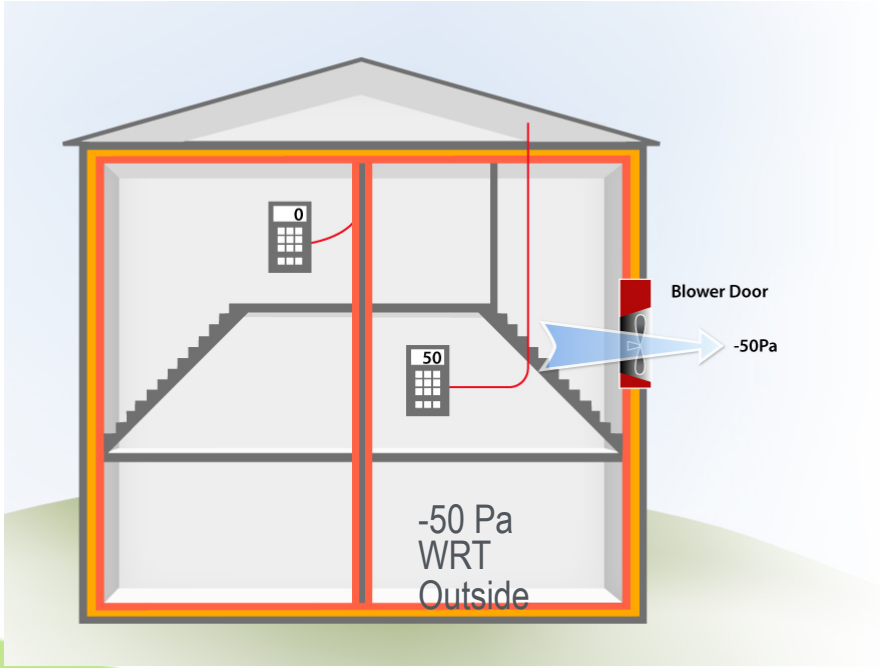
2-story apartment unit with a 1-story unit underneath – There is no real isolation of the individual units.



Multifamily Blower Door Testing

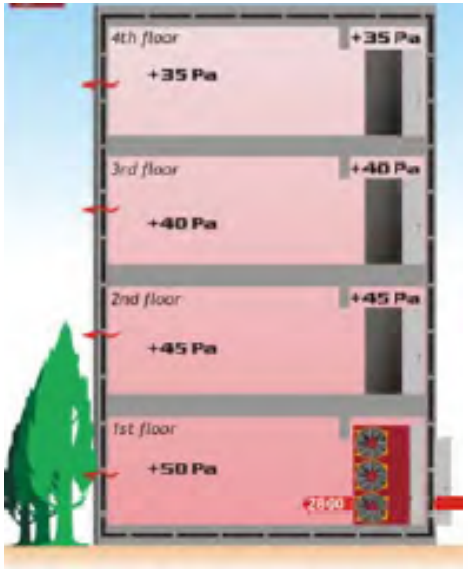
Sealed & Insulated

Air-sealed/insulated 2-story apartment unit with air barrier and insulation in alignment.



Multifamily Blower Door Testing Problems

Pressure Drops from Floor to Floor

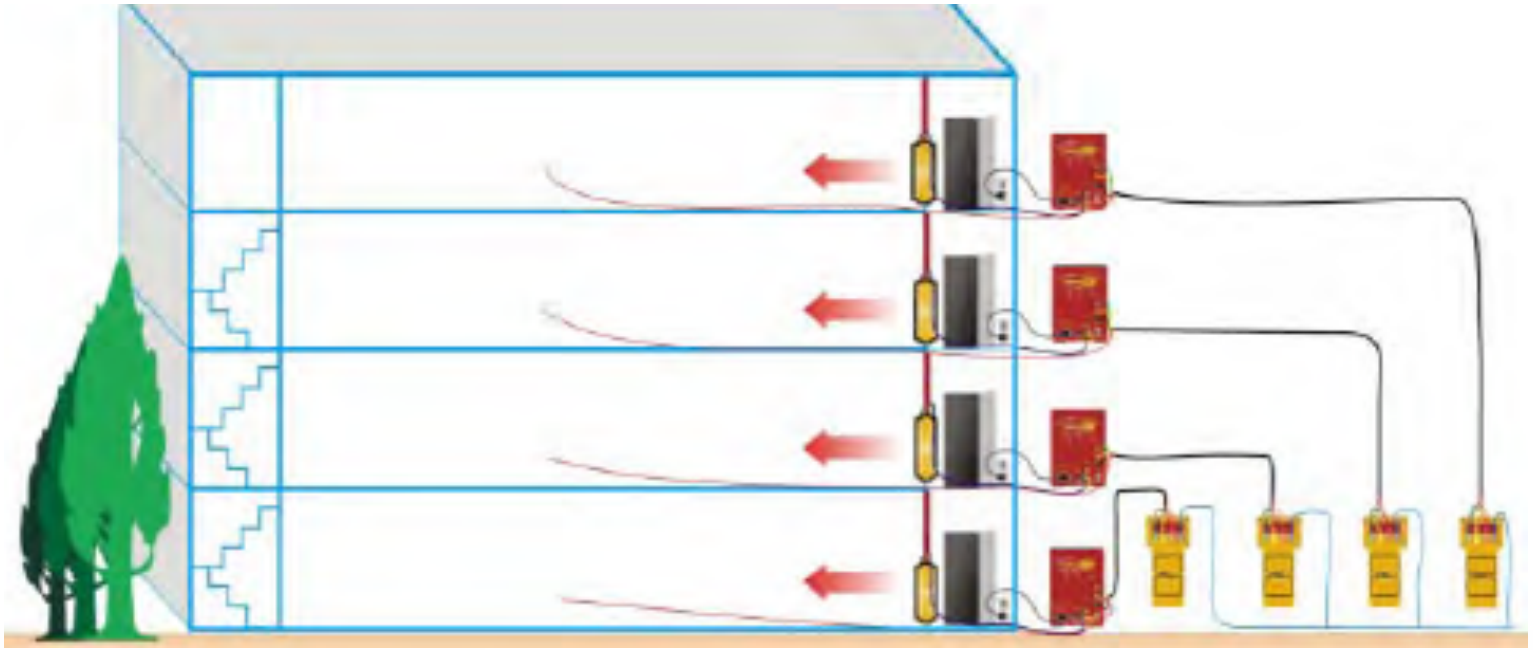


Multifamily Blower Door Testing Problems

Tough to Control Fans in Multiple Locations

Multifamily Blower Door Testing Problems

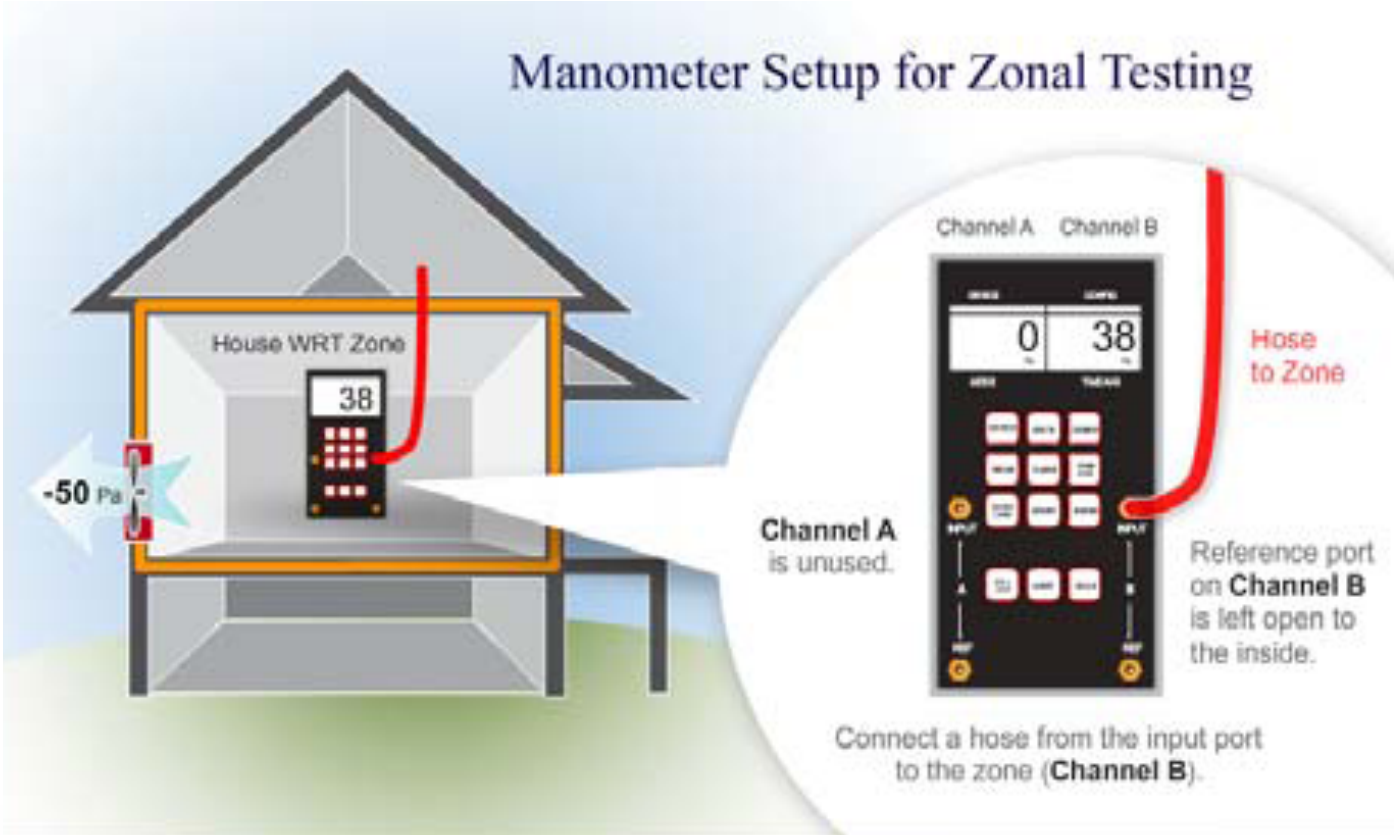
Where to Measure Building Pressure



Zonal Pressure Testing

- Helps determine location of air barrier
- Tests for connectivity between the building and intermediate zones such as:
  - Wall Cavities
  - Floor Cavities
  - Dropped Soffits and Ceilings
  - Attics and Crawl Spaces

Zonal Pressure Testing



Summary

- The blower door is a controlled driving force used to quantify air leakage
- Air leakage is measured in Cubic Feet per Minute (CFM) at a pressure difference of 50 or 75 Pascals with reference to (WRT) another space
- Minimum Ventilation Rates (MVR) assure adequate fresh air
- Air Changes per Hour (ACH) relate air leakage to building size
- Blower door readings can be converted to air leakage under natural conditions, total size of opening, and ACH

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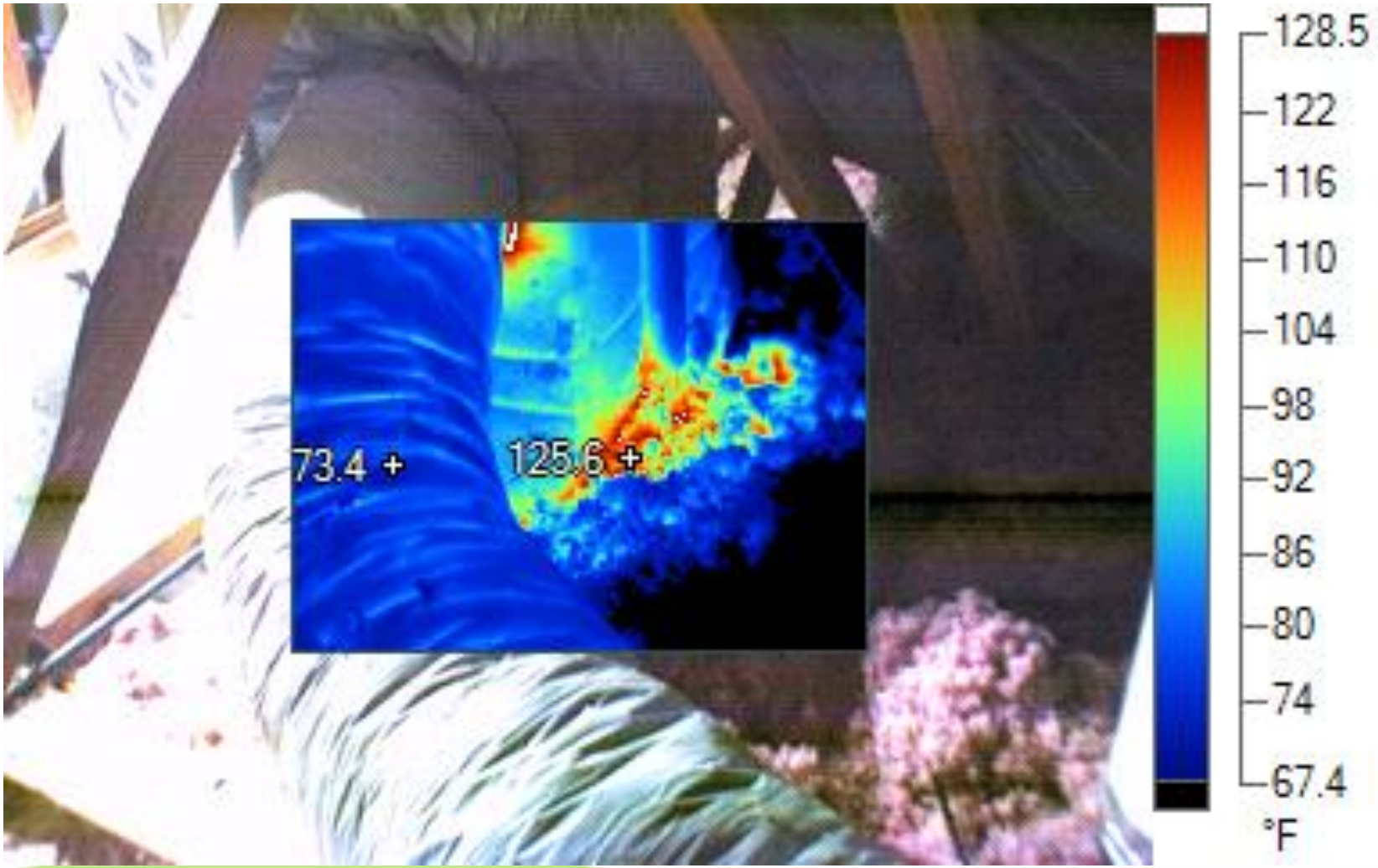
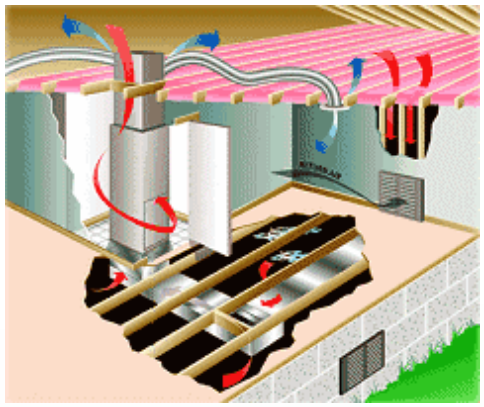
The Duct Blaster


73.4 +
125.6 +
128.5
122
116
110
104
98
92
86
80
74
67.4
°F

Duct Leakage Testing

- Why is duct leakage important?
  - Major source of energy waste
  - Can account for as much as 25% or more of the total building's energy loss
  - Single largest cause of performance and comfort problems

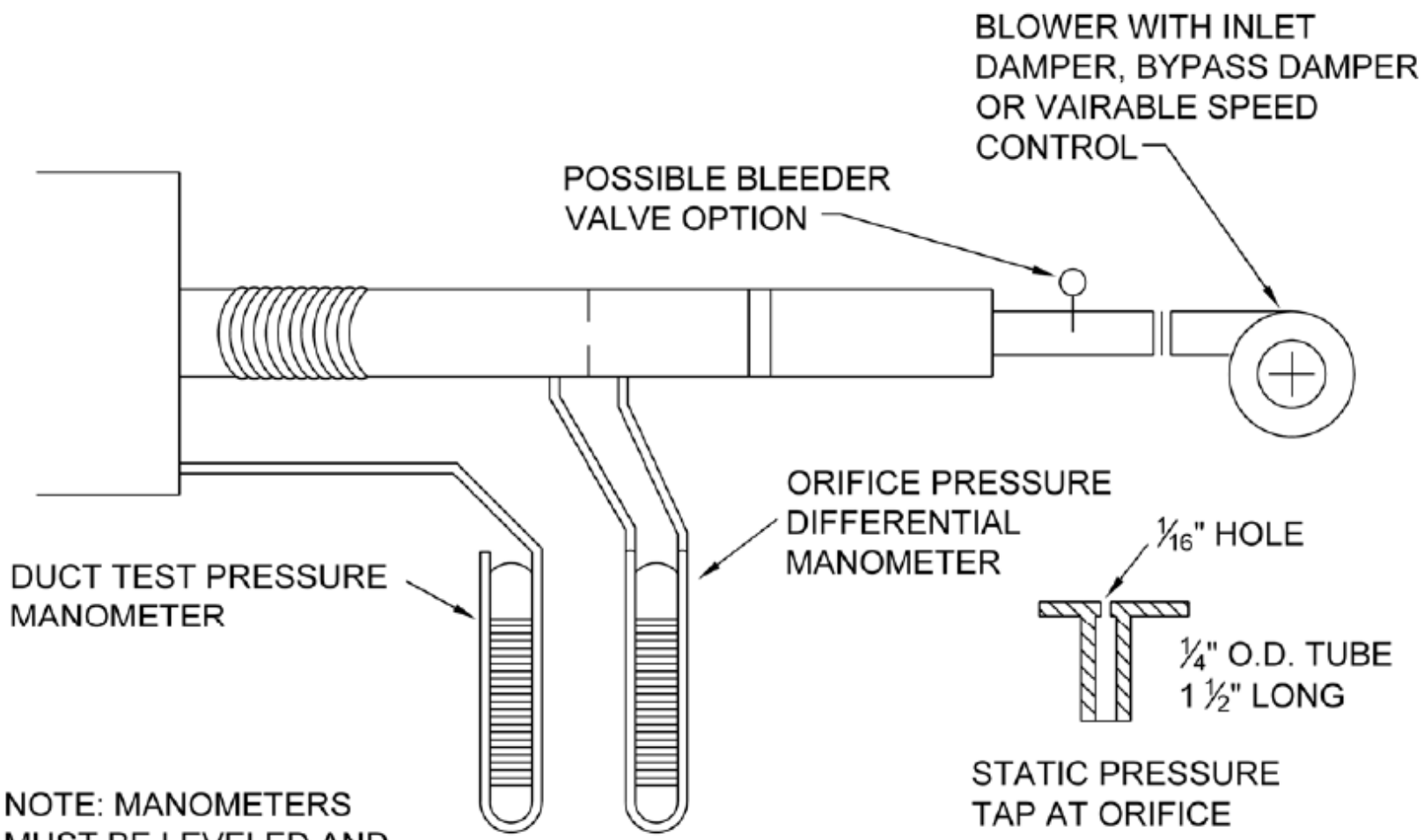


Duct Leakage Factors

- The factors that determine how much a given duct leaks
  - Type of construction (seam choice)
  - The amount of seams and joints
  - Static pressure
  - Openings and penetrations
  - Sealant
  - Workmanship

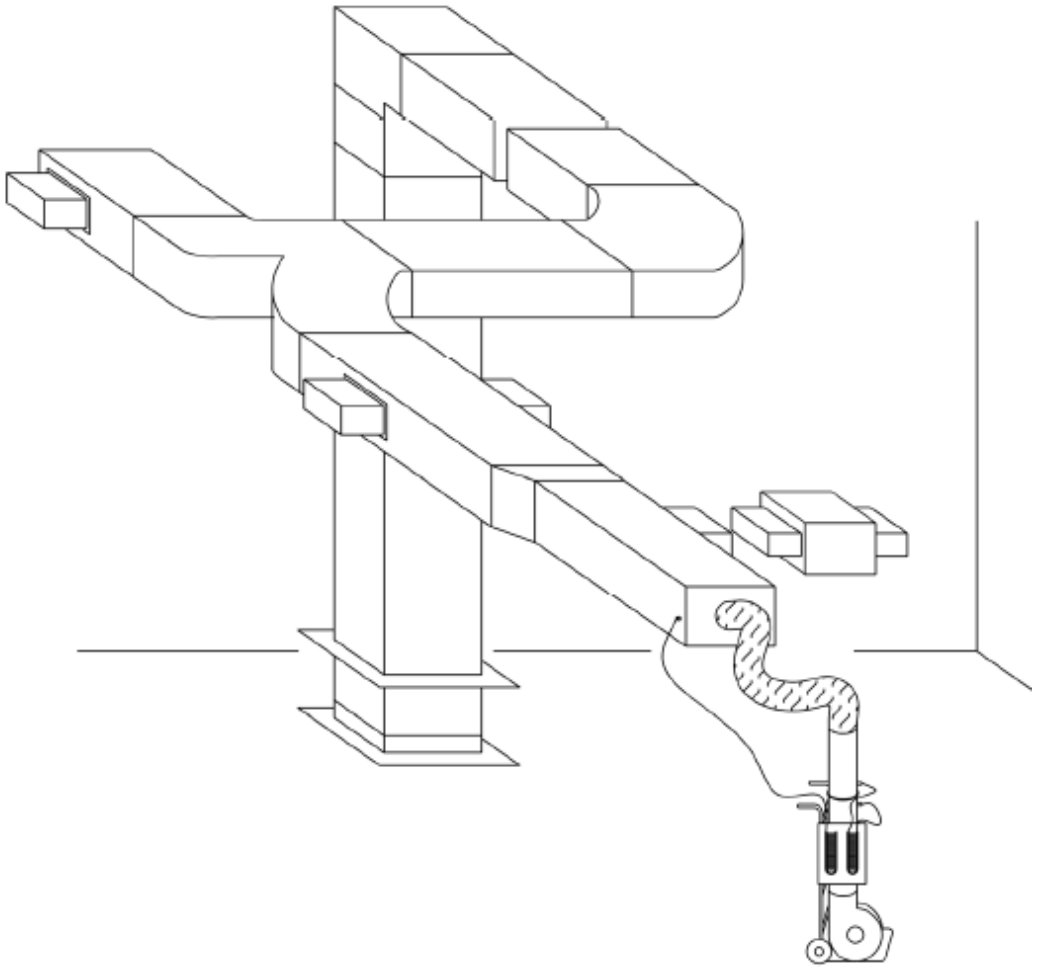
Testing Apparatus

- Testing apparatus consists of:
  - Air flow measuring device (orifices tube)
  - Flow producing unit (fan)
  - Pressure indicating device (manometer)
  - Accessories to connect the apparatus to the system (tubes, flex hoses)
  - Optional items (smoke generating device)



TYPICAL LAYOUT

Testing Layout



Testing Equipment

Testing Procedures

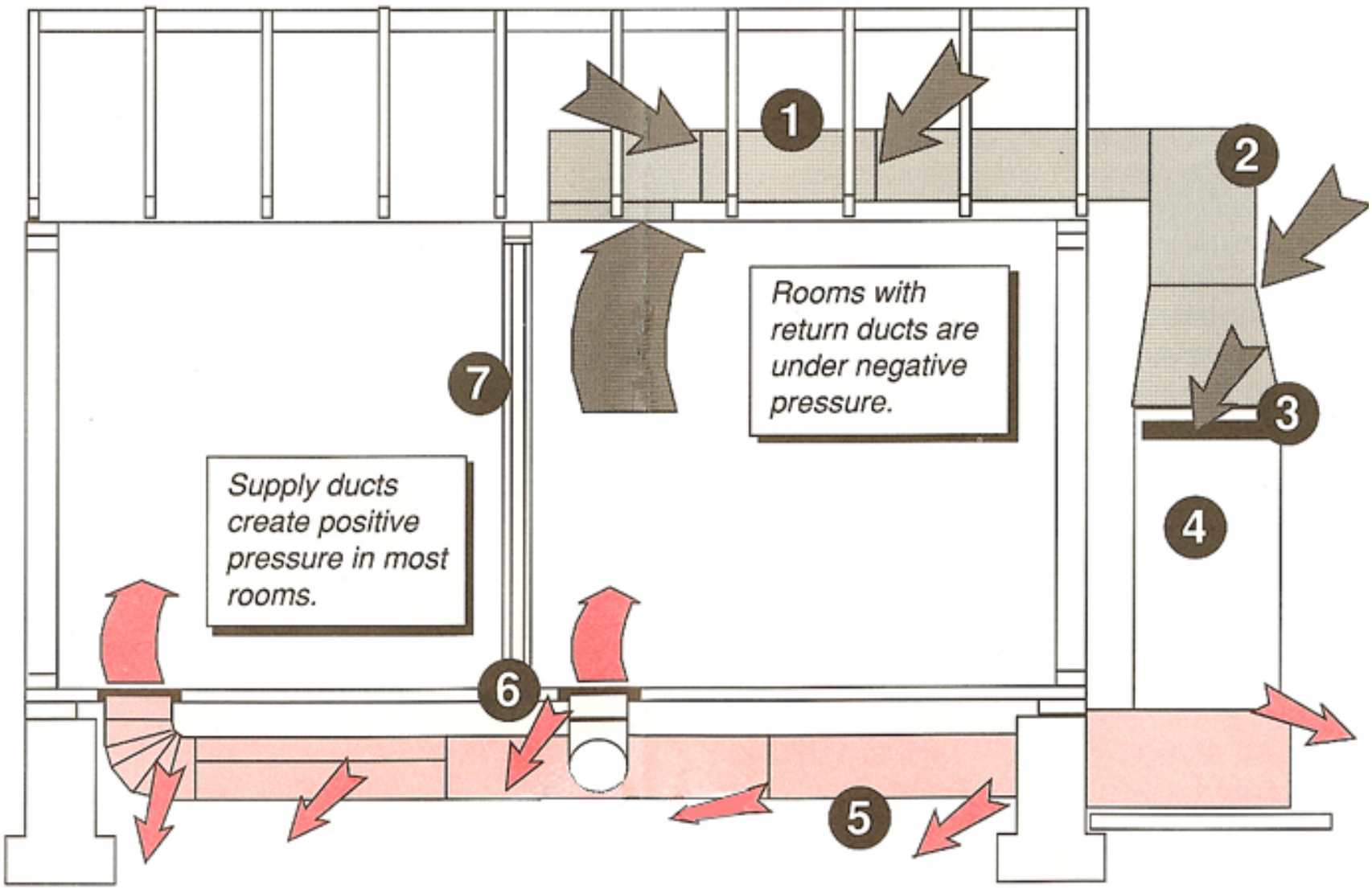
1. Attach the Duct Blaster fan to the air distribution system at a return grille, a supply plenum, or the blower compartment on the air handling unit.
2. Temporarily seal off all the registers and grilles. Then turn on the Duct Blaster fan and apply test pressure.

Testing Procedures

3. The Duct Blaster system measures the airflow needed to create the test pressure.
4. This airflow rate is our duct leakage measurement.
5. Compare the duct leakage reading with a recognized standard.

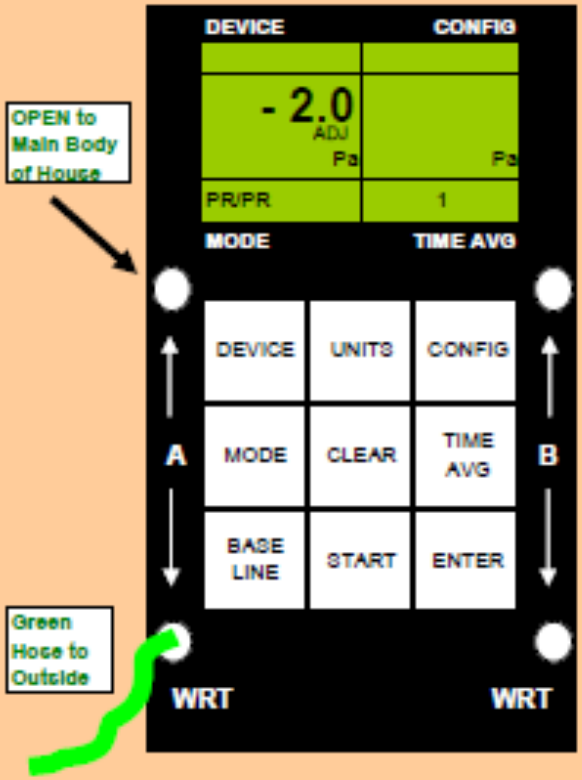
Dominate Duct Leakage

- Can be determined by:
  - Using a manometer
  - Turning on the air handler
  - Measure pressure difference WRT the outside when fan comes on


1
2
3
4
5
6
7
Rooms with return ducts are under negative pressure.
Supply ducts create positive pressure in most rooms.

THESE TESTS ARE DONE WITH ONLY AIR HANDLER ON

Dominant Duct Leak Test



Setup House in Winter Mode
OPEN Interior Doors

Setup Channel A to Measure House WRT Outside

1. **Connect** Hoses to Manometer
2. Turn Manometer **On.**
3. Press **BASELINE** Button **1 time.**
4. Press **START** Button **1 time.**
5. **Wait** until number is **steady**, then press **ENTER** Button **1 time.**
6. Turn Air Handler Fan **On**
   Measure Pressure Difference when fan comes on
7. **May need to repeat a few times to get better number**

- Negative Pressure	Dominant Supply Leaks
+ Positive Pressure	Dominant Return Leaks
No Pressure Change	Tight Ducts, Equal Leaks, or House to Leaky to Hold Pressure

Duct-Induced Room Pressure (DIRP)

- An improperly balanced air-handling system can cause problems with:
  - Comfort
  - Building durability
  - Indoor air quality (IAQ)
  - Increased air leakage through the building shell

Testing for DIRP

- Set up house for winter/summer conditions
- Turn Air handler fan on
- Close all interior doors
- Using the manometer;
  - Place a hose from input tap on the manometer under one of the closed doors
  - Place a hose on reference tap connected to outdoors

Estimating Pressure Relief

- Determine the area:
  - Slowly open door until pressure drops to within ± 3 pascals
  - Estimate the area of the opening in the door
- Provide pressure relief by:
  - Undercutting the doors
  - Installing transfer grills
  - Installing jumper ducts

Pressure Pan Testing

Qualitative testing to *estimate* excessive duct leakage

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Diagnostic Testing

Tools for Draft and Combustion Safety Testing

What is Draft?

- **Draft** is a current of air which occurs in a vent or chimney when hot combustion by-products move through a vent or chimney and out of the building
- Combustion by-products must be hotter than the outside air in order for draft to occur
- Outside air temperature affects how rapidly combustion by-products move up the vent or chimney and out of the building

Spillage and Backdraft

- Spillage is temporary backdrafting
  - Combustion by-products flow into the home
  - It typically happens from a cold start when the flue temperature is at or near outdoor temperature
  - It should stop after the appliance warms up (1 minute)
- Backdrafting is <u>continuous</u> spillage

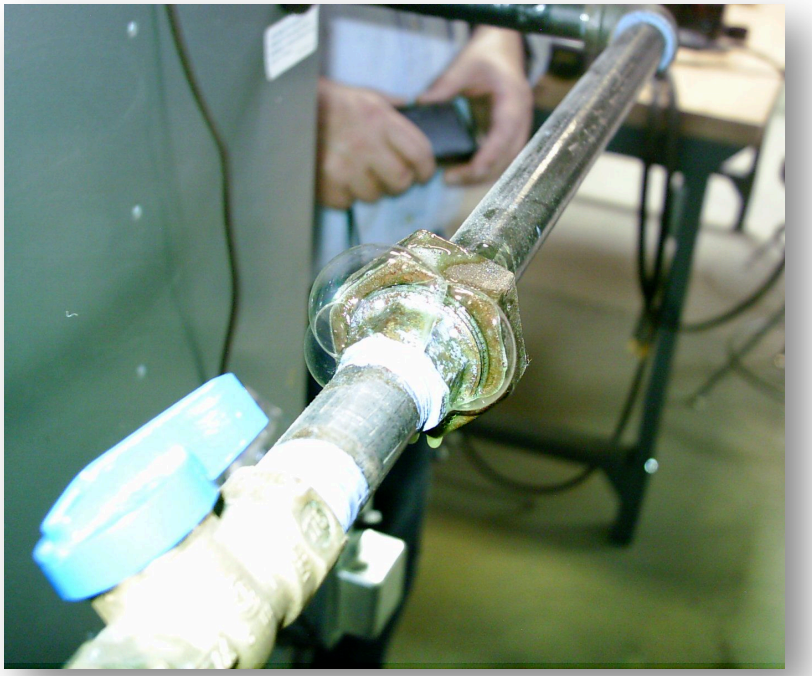
Combustion Safety

- The building is a system.
- When we air seal and insulate, we change how the building operates.
- We need to inspect and test to make sure the building is safe when we leave.
- Making the building tighter could;
  - Make existing problems worse and/or
  - Create new problems.

Combustion Safety Testing

- What do we test for on combustion appliances?
  - Fuel Leaks
  - Correct Operation of Appliances
  - Ensure Proper Combustion Air
  - Worse Case Draft
  - Carbon Monoxide Output
  - Combustion Efficiency

The Fuel Leak Detector



Combustion Gas Analyzer

- Bacharach Fyrite

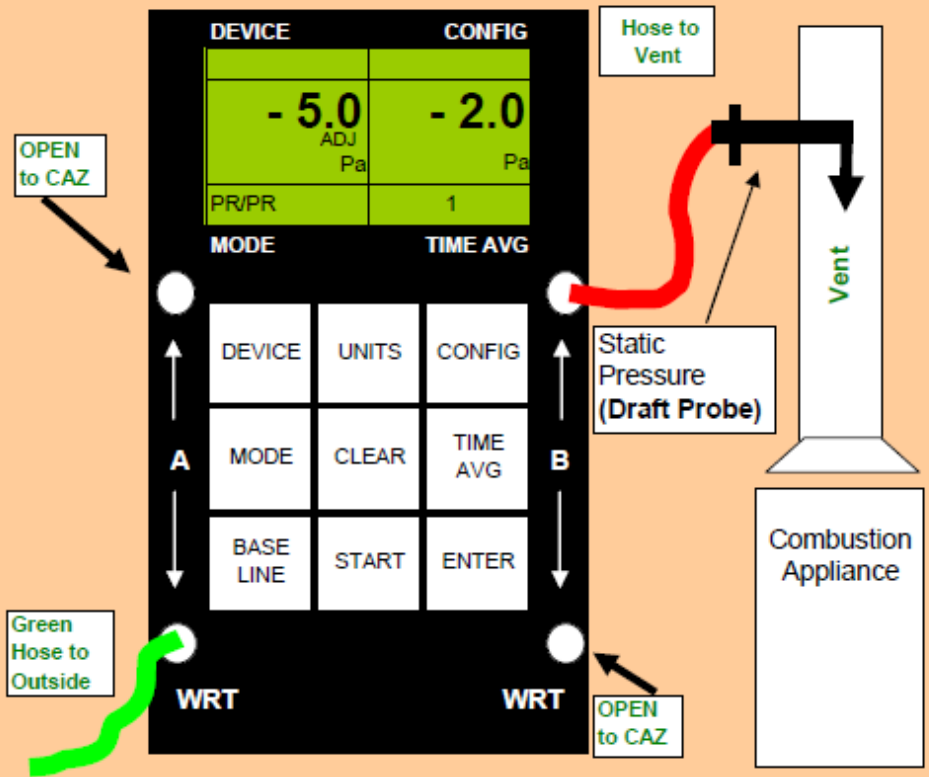
The Manometer

COMBUSTION APPLIANCE ZONE AND WORST CASE DRAFT TESTING

with DG-700 Digital Manometer

House Should be in Winter Mode with Blower Door Fan Covered
Setup Hoses to Measure:
CAZ with reference to Outside on Channel A and
Vent with reference to CAZ on Channel B (based on your location)

You are in CAZ



1. **Connect** Hoses to Manometer
2. Turn Manometer **on**.
3. Press **BASELINE** Button **1 time**.
4. Press **START** Button **1 time**.
5. **Wait** until number is **steady**, then press **ENTER** Button **1 time**.
6. Follow BPI Procedure to Determine Worst Case Depressurization **for each CAZ**
7. **Recreate Worst Case Depressurization and Perform Worst Case Draft Test on each Appliance starting with the smallest BTU.**
8. You may press the **TIME AVG** Button until it says **LONG**. Record reading when it becomes steady. Press **START** Button once to restart TIME AVG as necessary.

Simple Devices

- Our eyes, a strong light and an inspection mirror
  - On heat exchangers.

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Building Performance Diagnostic Tools

Tools for Measuring

Air Flow

ASHRAE 62.1

- ANSI/ASHRAE Standard 62.1-2007, (***Ventilation for Acceptable Indoor Air Quality)*** sets forth minimum ventilation rates for typical spaces.
- Its goal is to provide acceptable indoor air quality for human occupants and “to minimize the potential for adverse health effects.”

ASHRAE 62.2

- ANSI/ASHRAE Standard 62.2-2010 (***Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings)***
- Applies to spaces intended for human occupancy within single-family houses and multi-family structures of three stories or fewer above grade, including manufactured and modular houses.

ASHRAE 62.2

- Calculate Continuous Ventilation Needed
  - Multiply Greatest of Bedrooms + 1 or;
  - Number of People X 7.5cfm. Then;
  - Calculate 1cfm per 100 sq.ft. and add to above.
- Example:
  - 1800SF three bedroom home
  - 4 X 7.5 + 18 = 48cfm continuous

The Balometer

- Sometimes called the capture hood

Anemometer

- Small Vane

Anemometer

- Large Vane

Exhaust Fan Flow Meter

- Energy Conservatory

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Building Performance Diagnostic Tools

The Infrared Camera

Definitions

- **Thermal Imager** – camera-like device capable of detecting, displaying and recording thermal patterns across the surface of an object.

Definitions

- **Radiometer**– electronic device that converts infrared energy emitted by an object surface into a temperature value.

Definitions

- **Imaging Radiometer**– thermal imager capable of measuring temperature.

Thermal Imaging vs. Night Vision

- Thermal imagers detect infrared radiation or heat
  - Can be used in complete darkness or daylight
  - Completely passive
- Night Vision magnifies ambient light
  - Can only be used in darkness
  - Certain models require infrared illuminators

Thermal Imaging vs. Night Vision

Applying Thermography

- Uses
  - Preventive/Predictive Maintenance
  - Condition Assessment
  - Condition Monitoring
  - Quality Assurance
  - Forensics
  - Surveillance
  - Medical/Veterinary

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THE END