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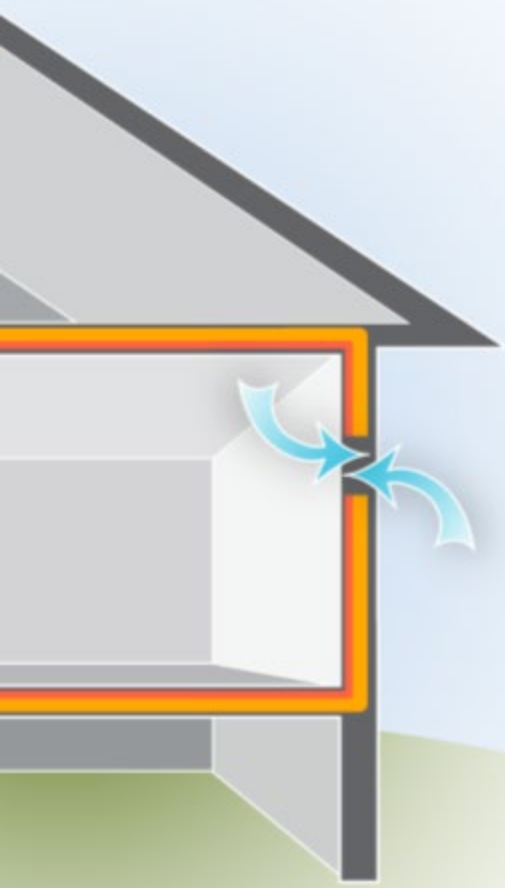
# BLOWER DOOR GUIDED AIR SEALING

BUREAU
Community Action and Economic Opportunity

# LEARNING OBJECTIVES

- Discuss basic principles of air leakage.
- Explain air barrier concepts and how a blower door is used to locate deficiencies
- Identify typical construction details that lead to compromised pressure boundaries.

# AIR LEAKAGE

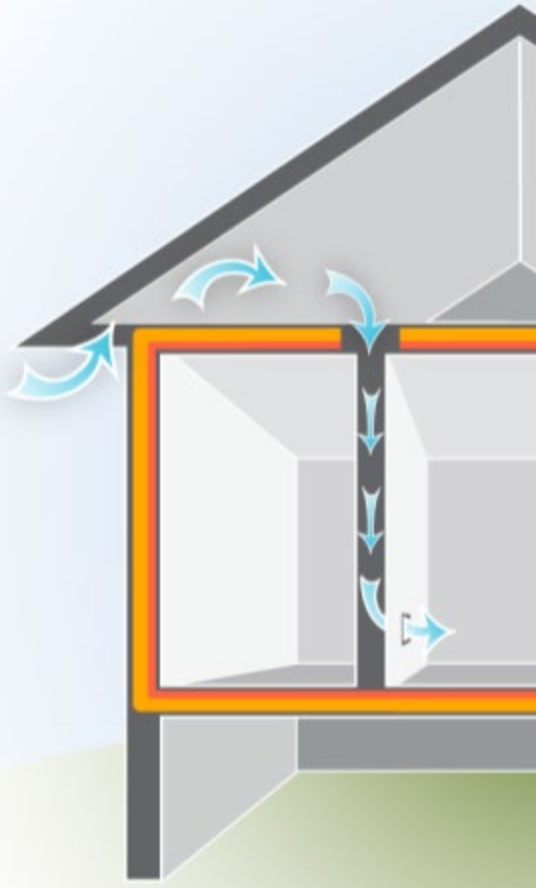


## Direct Leakage

occurs at direct openings to the outdoors. Leakage enters or exits the building envelope directly at this location.

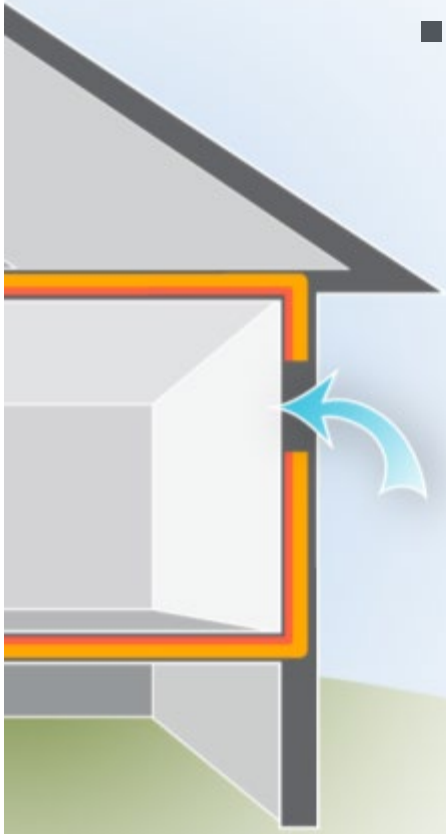
## Indirect Leakage

Leakage enters at one location, moves through building cavities, and exits at a different location.

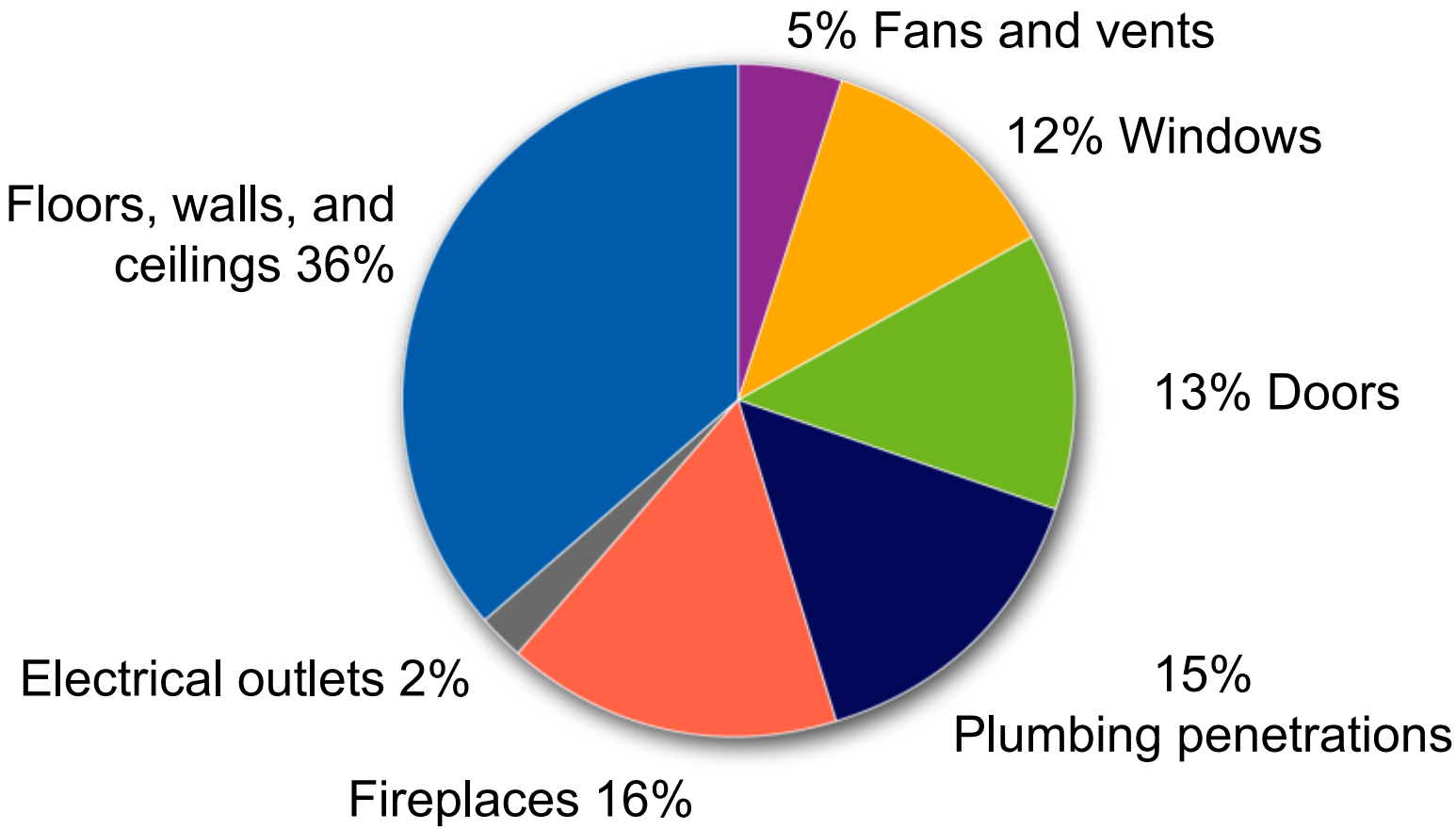


# Air Leakage requires:

- A hole.
- Pressure difference across that hole.
  - The bigger the hole or higher the pressure difference, the more airflow.
  - To reduce airflow, we can reduce the size of the hole or lower the pressure difference.



# PRIMARY AIR INFILTRATION SITES



# SHELL AIR-LEAKAGE FUNDAMENTALS

Controlling shell air leakage is the main goal of weatherization. The decisions you make about sealing affect a building throughout its lifespan.

- Air leakage accounts for a significant percentage of a building's heat loss

- Air leakage through insulated assemblies reduces the R-value of insulation

- Air leakage moves moisture in and out of the house

- Air leakage causes house pressures that can interfere with the venting of combustion appliances

Blower Door guided air sealing is used to quantify and locate air leakage

# NECESSARY EQUIPMENT


# Measuring Building Air Leakage

- Air leakage measured by the blower door is proportional to the size of the holes in the house between inside and outside
- Conduct blower tests before, in-progress, and after air-sealing to determine the effectiveness of our work
- Conduct blower door testing to tell us which houses have the more potential for energy savings through air sealing

# Measuring Pressure & Airflow

- 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

# MEASURING BUILDING AIR LEAKAGE

## Natural driving forces

Pressure differences too small to measure reliably

## Blower door

Exaggerates pressure differences so they can be measured reliably, and the results are repeatable

Exaggerated air leakage measured with the blower door gives us an idea of the amount of air leakage that would occur under natural conditions

# Blower Door Setup

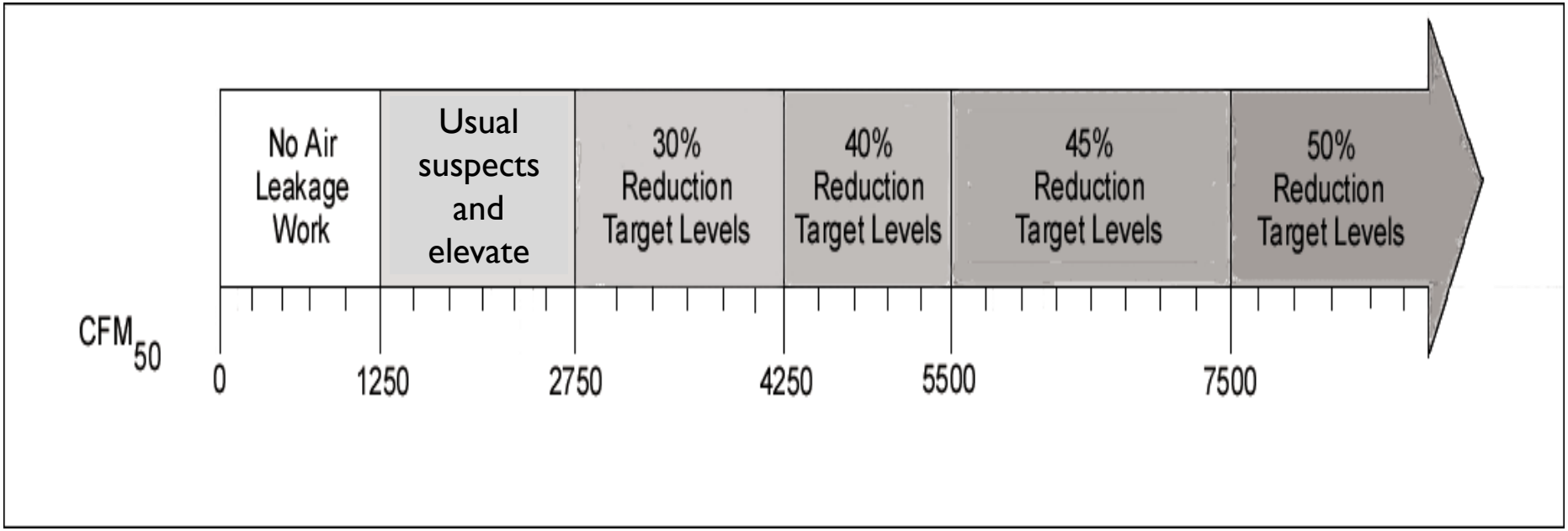
- Put the house in winter mode
- Turn off HVAC systems and gas water heaters
- wood stoves / fireplace inactive, close dampers, remove ashes or cover with wet newspaper
- Be aware of possible dangerous contaminants
  - Vermiculite
  - Lead dust
  - Friable asbestos

# APPROXIMATE LEAKAGE AREA


- Divide $CFM_{50}$ by 10
- *For example:*

  5,000 $CFM_{50}$/10
- = **500 sq. in.**

# TARGET REDUCTION




4500 CFM50 x 0.6 = 2700 CFM50

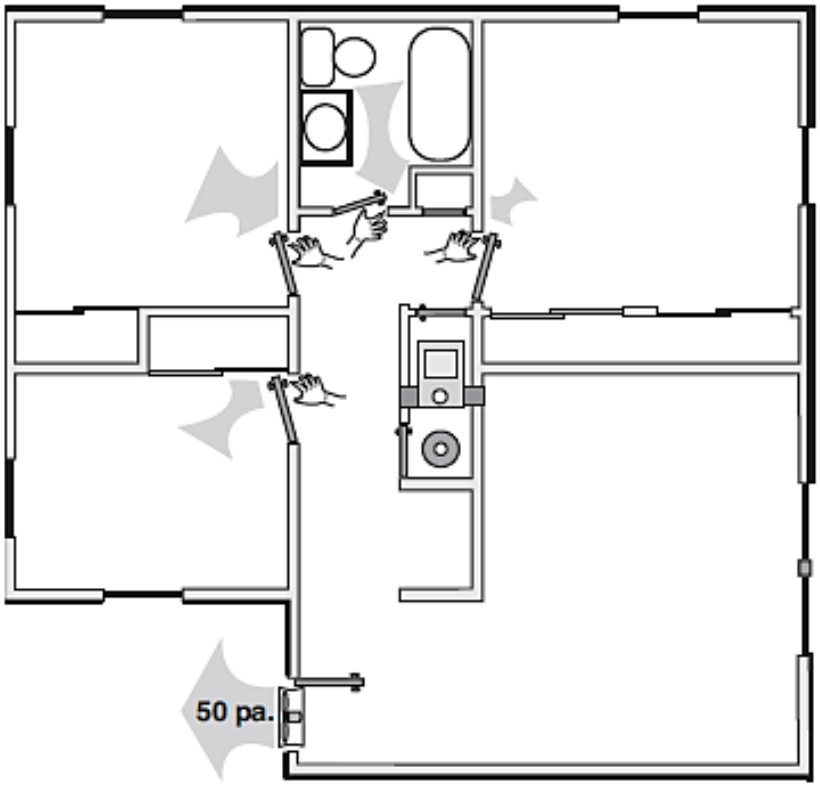
# Simple Pressure Tests

Blower door tests give us valuable information about the relative leakiness of rooms or sections of the home.

***Feeling zone air leakage**:* Close an interior door partially so that there is a one-inch gap between the door and door jamb. Feel the airflow along the length of that crack, and compare that airflow intensity with other rooms / zones of the home

***Room pressure difference**:* Check the pressure difference between a closed room or zone and the main body of a home. Larger pressure differences indicate larger air leakage

***Room airflow difference**:* Measure the house CFM50 with all interior doors open. Close the door to a single room and note the difference in the CFM50 reading. The difference is the approximate leakage through that room's air barrier.




**Interior door test:** Feeling airflow with your hand at the crack of an interior door gives a rough indication of the air leakage coming from the outdoors through that room.

# TESTING AIR BARRIERS

Leaks in air barriers cause energy and moisture problems in many homes. Air-barrier leak-testing avoids unnecessary visual inspection and unnecessary air sealing in hard-to-reach areas.

**Determine relative leakiness.**

The higher the pressure the smaller the hole.

**Prioritize air sealing activities.**

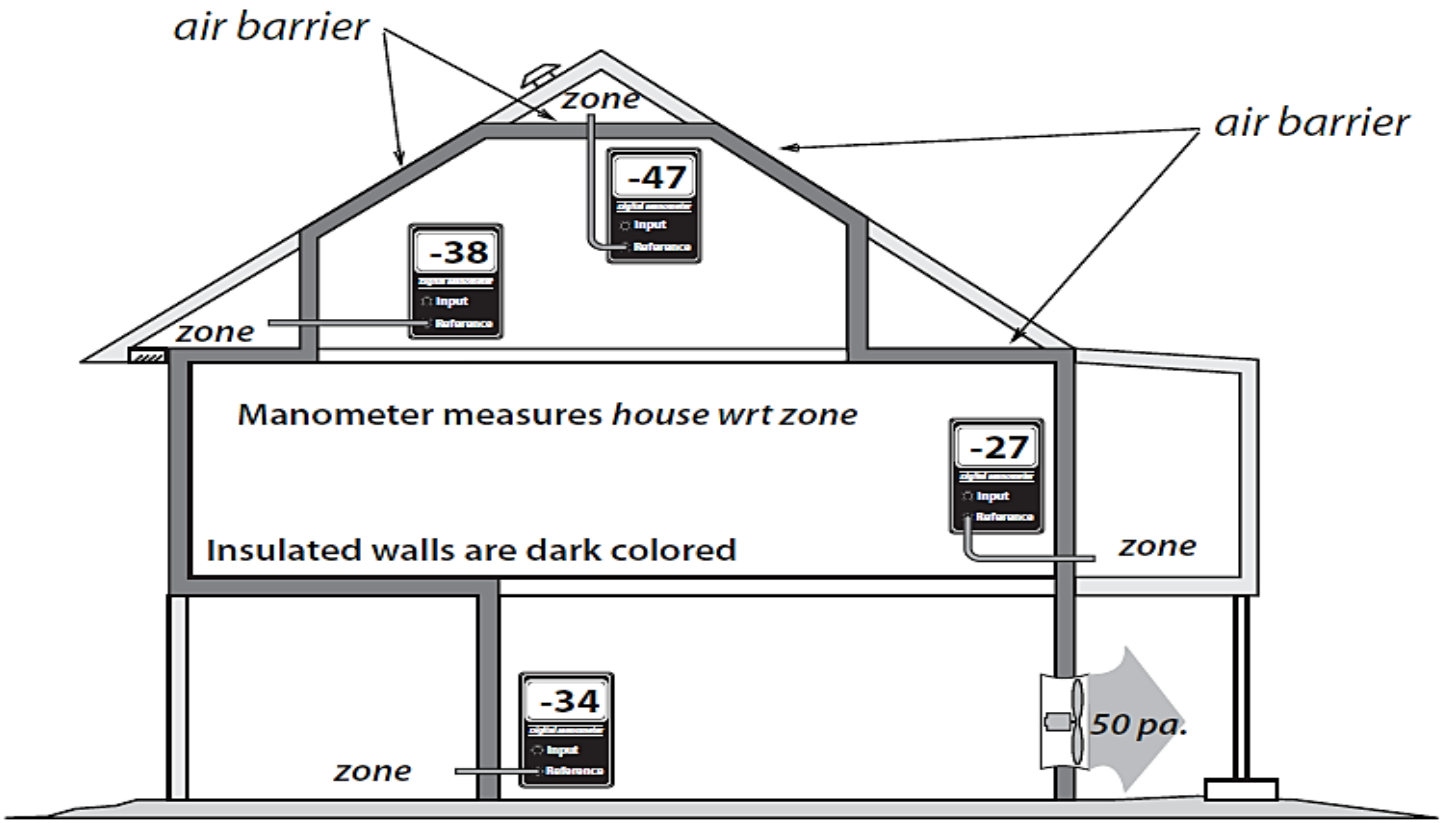
Quickly determine which are the leakiest zones.

**Evaluate completed air sealing measures.**

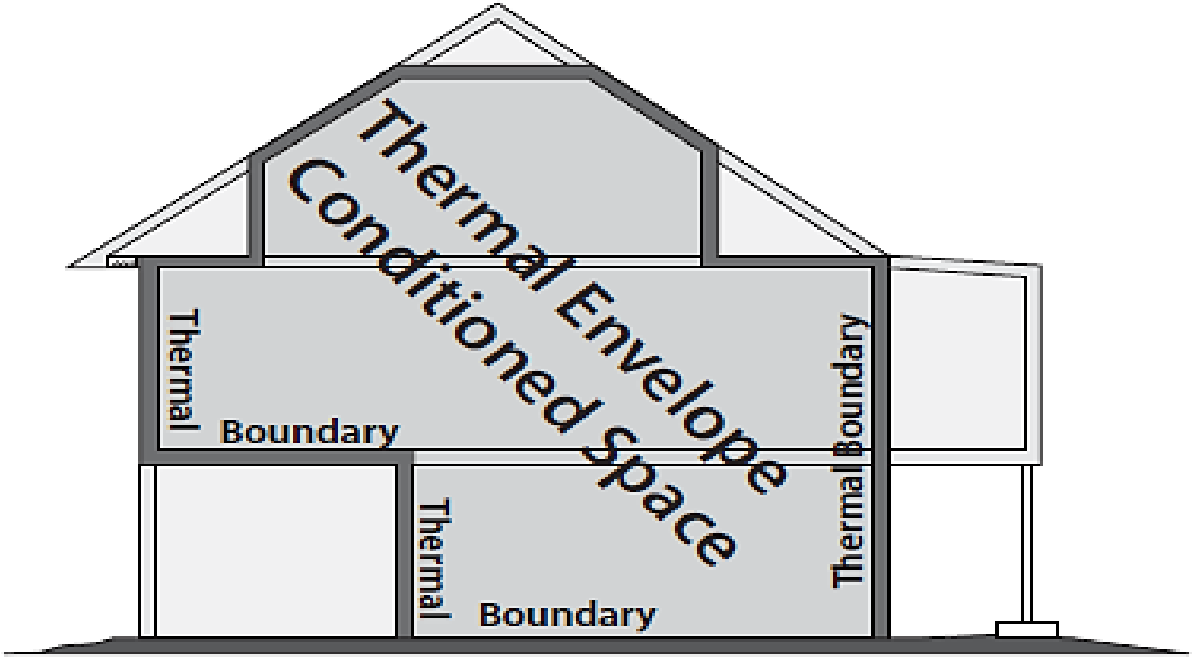
Know if your air sealing work is complete.

- Evaluate the airtightness of portions of a building's air barrier, especially floors and ceilings.
- Decide which of two possible air barriers to air seal; for example, the floor versus foundation walls.
- Determine whether building cavities like porch roofs, floor cavities, and overhangs are conduits for air leakage.
- Estimate the air leakage in CFM50 through an air barrier, then estimate what is necessary to seal the leaks.

Measuring  pressure differences between the house and its intermediate zones

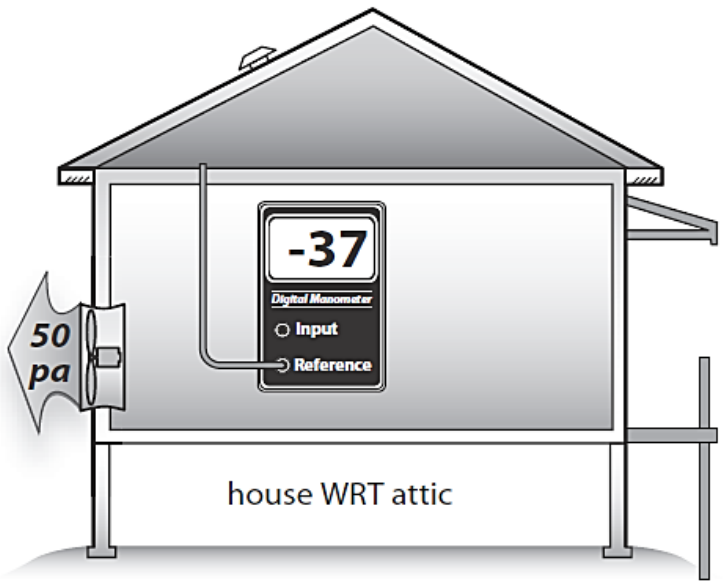


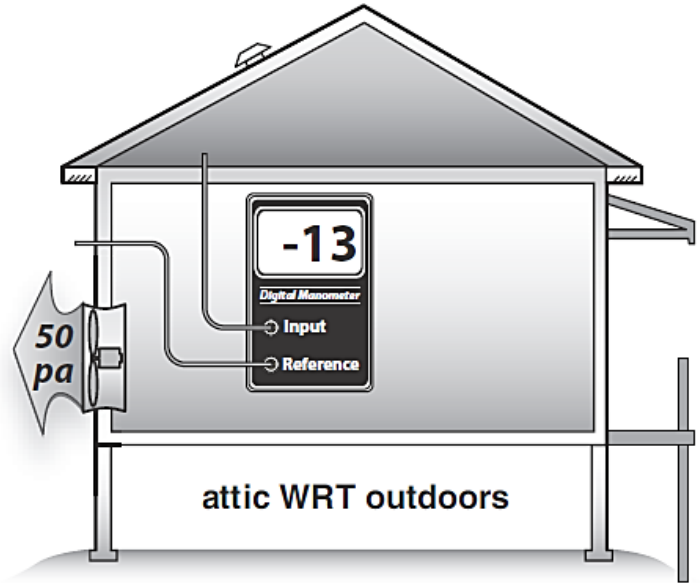

**Pressure-testing building zones:** Measuring the pressure difference across the assumed thermal boundary (*house wrt zone*) tells you whether the air barrier and insulation are aligned. If the manometer reads close to –50 pascals, the air barrier and insulation are aligned and the tested zones are well-connected to outdoors.




## Air-Barrier Test Results

Air-barrier tests provide a range of information from simple clues about which parts of a building leak the most, to specific estimates of the airflow and hole size through a particular air barrier.




**House-to-attic pressure:** This commonly used measurement is convenient because it requires only one hose.

**Attic-to-outdoors pressure:** This measurement confirms the first because the two add up to –50 pascals.

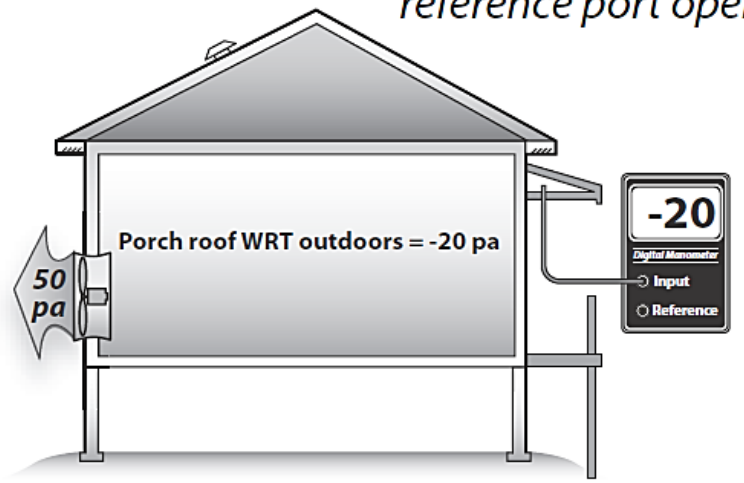
- Achieving a 50 pascal attic to house is the goal for every house

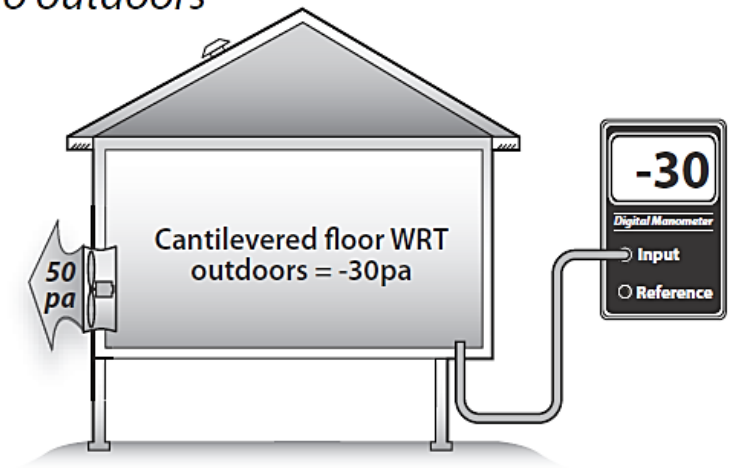
- Readings of 0 to 25 mean that the roof is tighter than the ceiling. If the roof is well-ventilated, the ceiling has even more leakage area than the roof ’s vent area.

- Readings around 25 indicate that the roof and ceiling are equally airtight or leaky.

- Need a general idea of the amount of roof venting to properly interpret readings

*These examples assume that the manometer is outdoors with the reference port open to outdoors*



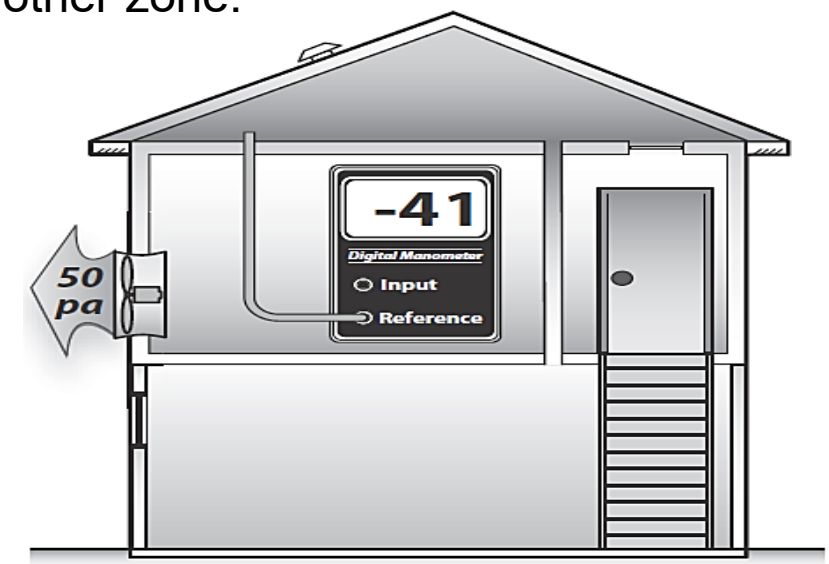



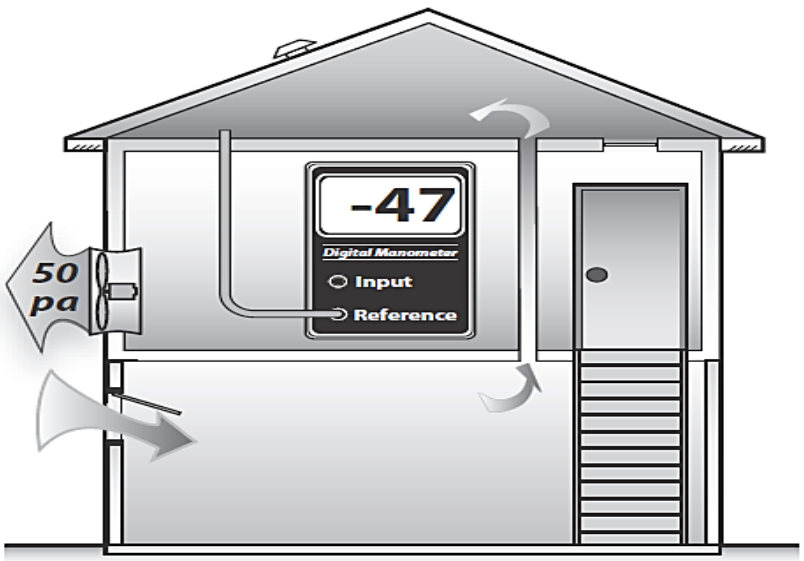

**Porch roof test:** If the porch roof were outdoors, the manometer would read near 0 pascals. We hope that the porch roof is outdoors because it is outside the insulation. We find, however, that it is partially indoors, indicating that it may harbor significant air leaks through the thermal boundary.

**Cantilevered floor test:** We hope to find the cantilevered floor to be indoors. A reading of –50 pascals would indicate that it is completely indoors. A reading less negative than –50 pascals is measured here, indicating that the floor cavity is partially connected to outdoors.

# Testing Zone Connectedness

Sometimes it's useful to determine whether two zones are connected by a large air leak. Measuring the house-to-zone pressure during a blower door test, before and then after opening the other zone to the outdoors, can establish whether the two zones are connected by a large air leak. You can also open an interior door to one of the zones and check for pressure changes in the other zone.




**Zone connectedness:** The attic measures closer to outdoors after the basement window is opened, indicating that the attic and basement are connected by a large bypass.

# Pressure Testing rooms to main body

- Measure pressure deference in specific parts of the house with Blower Door running.
- Helps to quickly identify dominant house leaks.
- Defines scope of work air sealing measure

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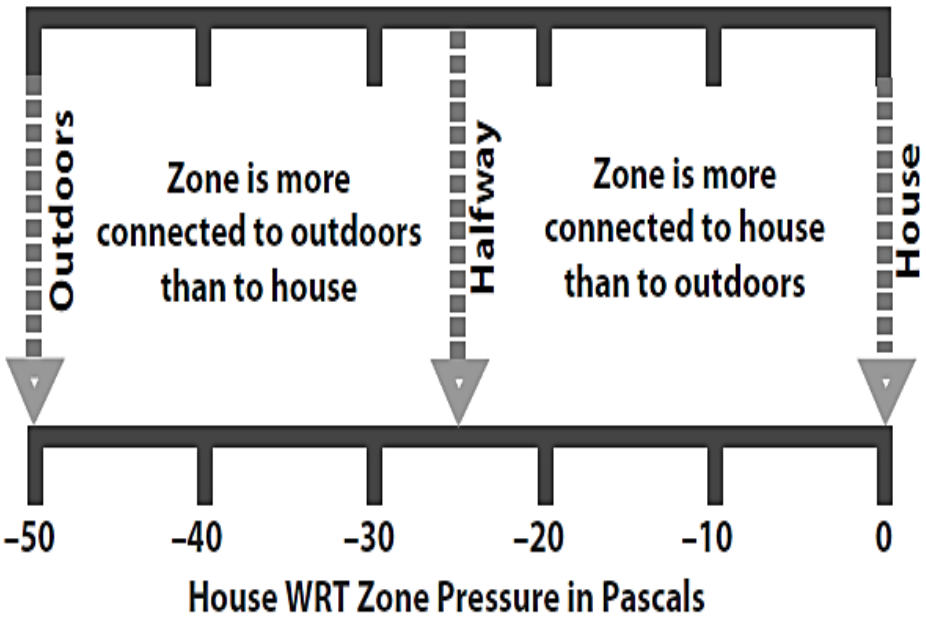
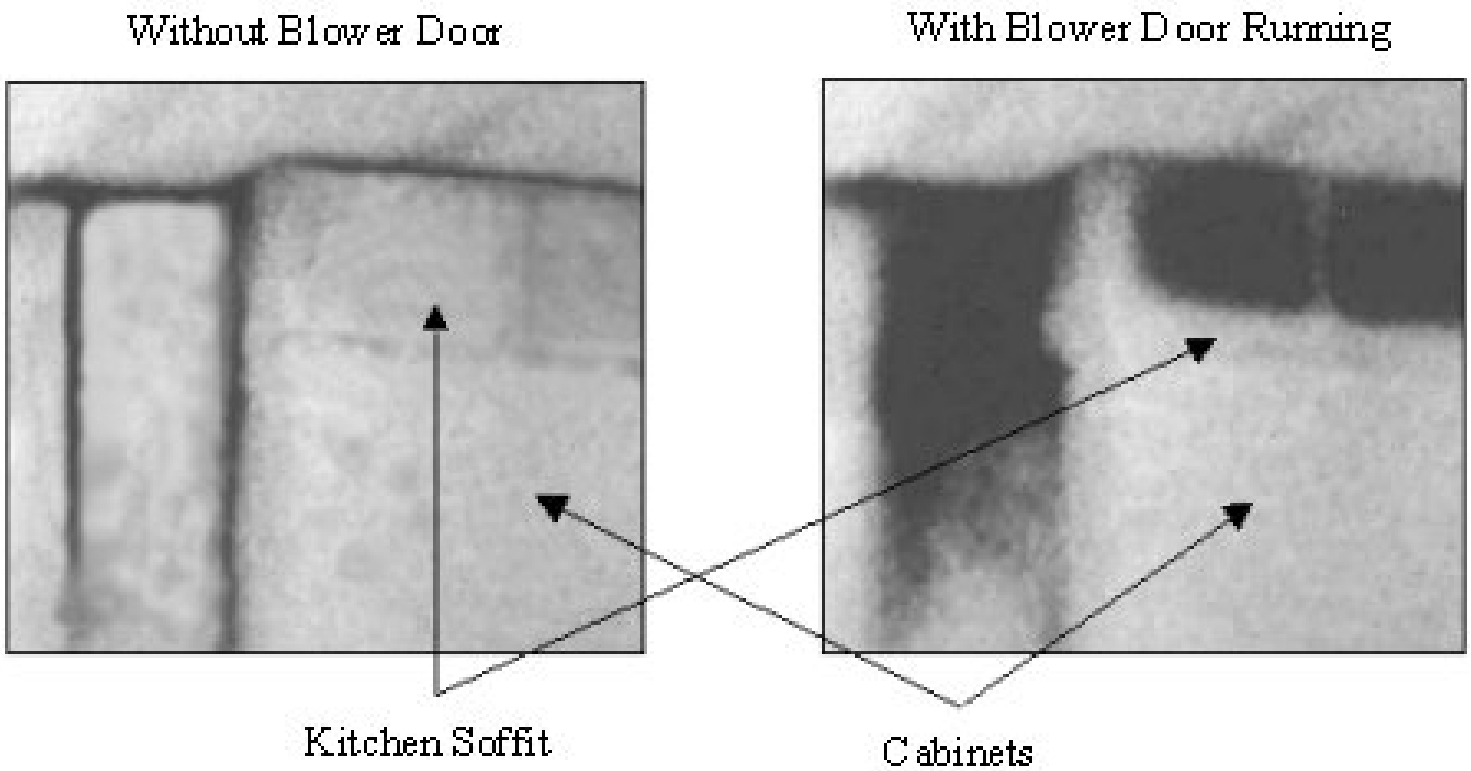
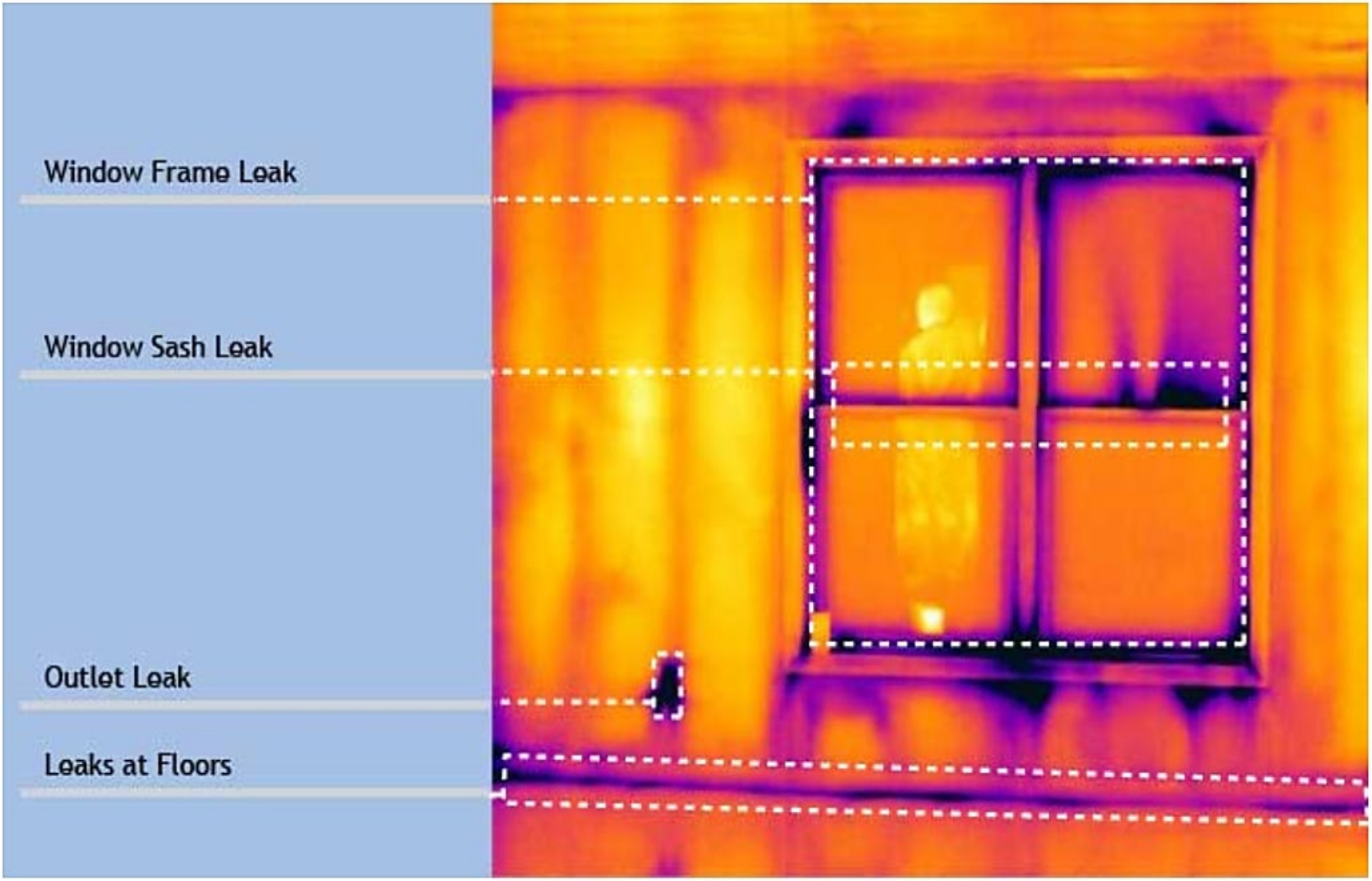
**Interpreting house-to-zone pressure:** The greater the negative number the better the air barrier is performing.



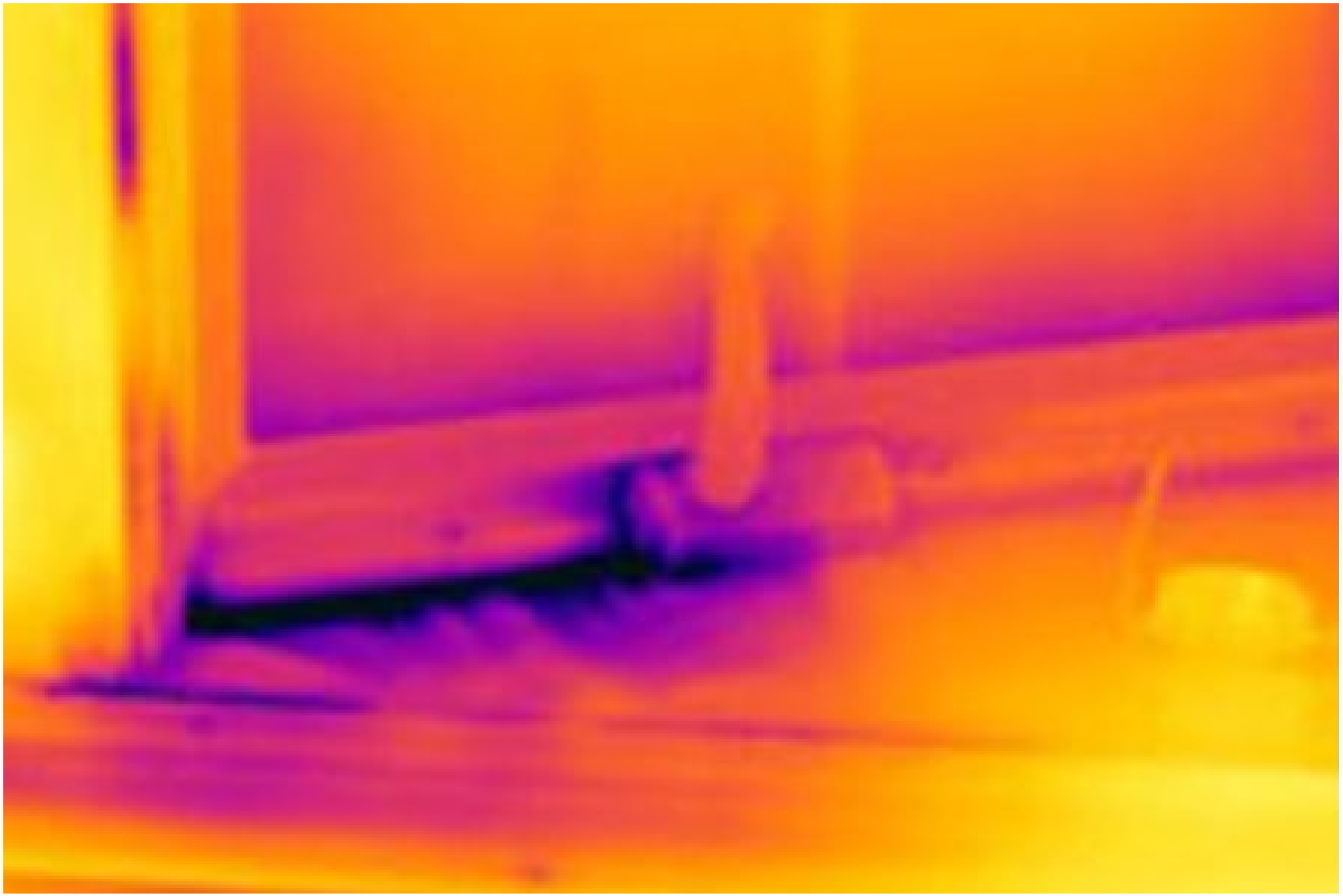
# Air Leakage Path investigation

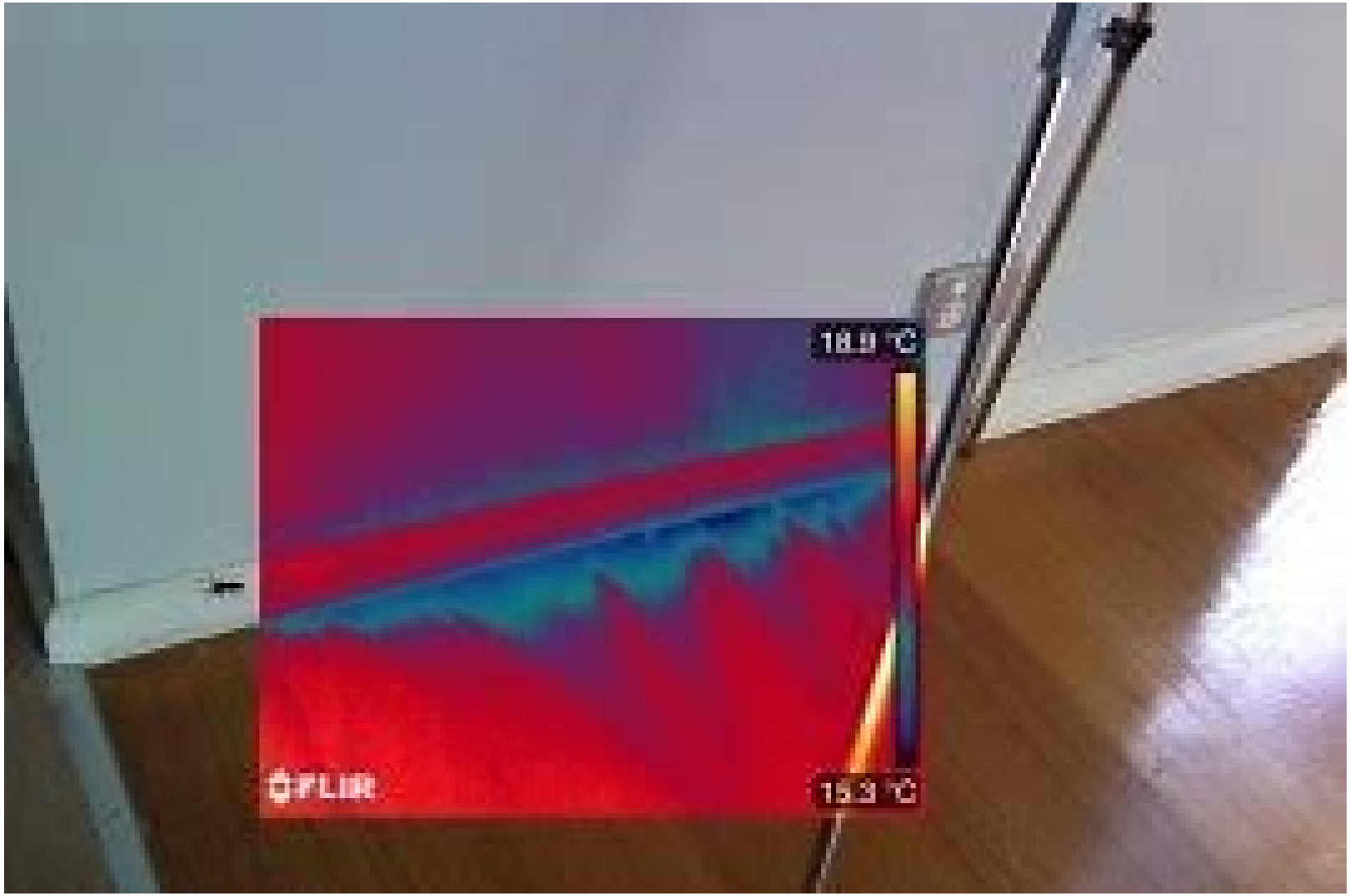
- Blower Door with an Infrared Camera
- View wall before Blower Door Test
- View wall with Blower Door running




Window Frame Leak
Window Sash Leak
Outlet Leak
Leaks at Floors


Spot 1 13.6 °C
Spot 2 16.5
17.2 °C
13.6 °C
FLIR




18.3 °C
15.3 °C
FLIR

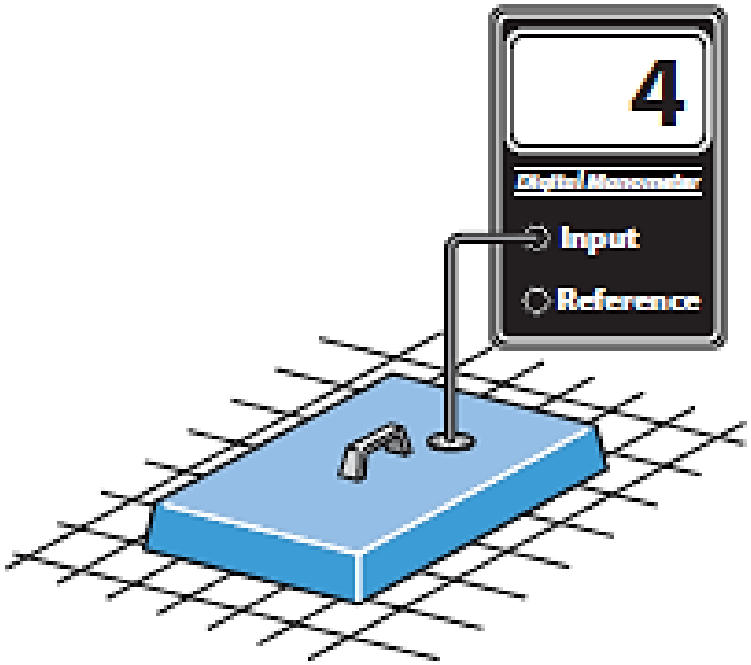
# Duct Leakage Diagnostics

Pressure Pan test to determine if duct work is connected to the outside.

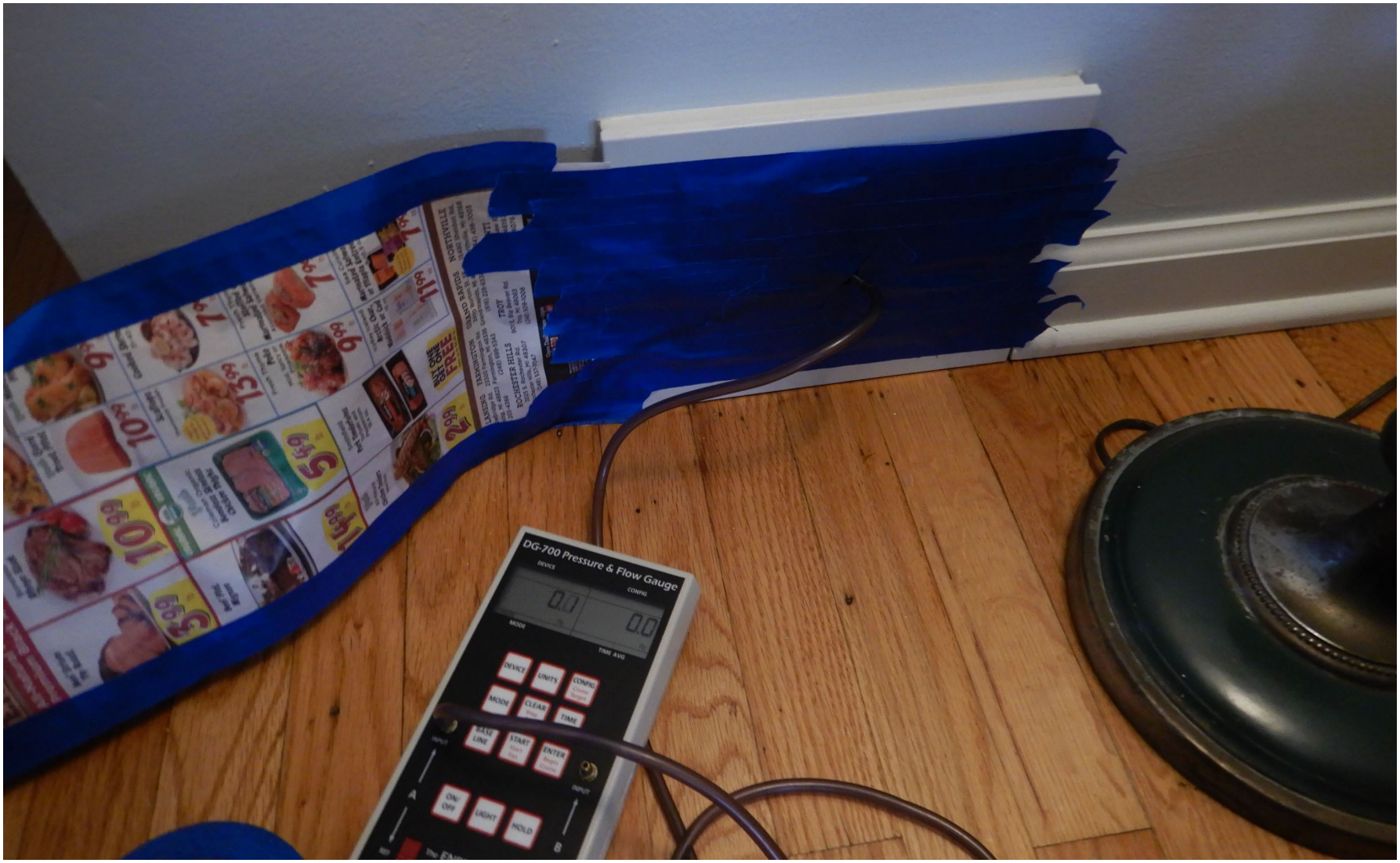
# Pressure Pan Testing

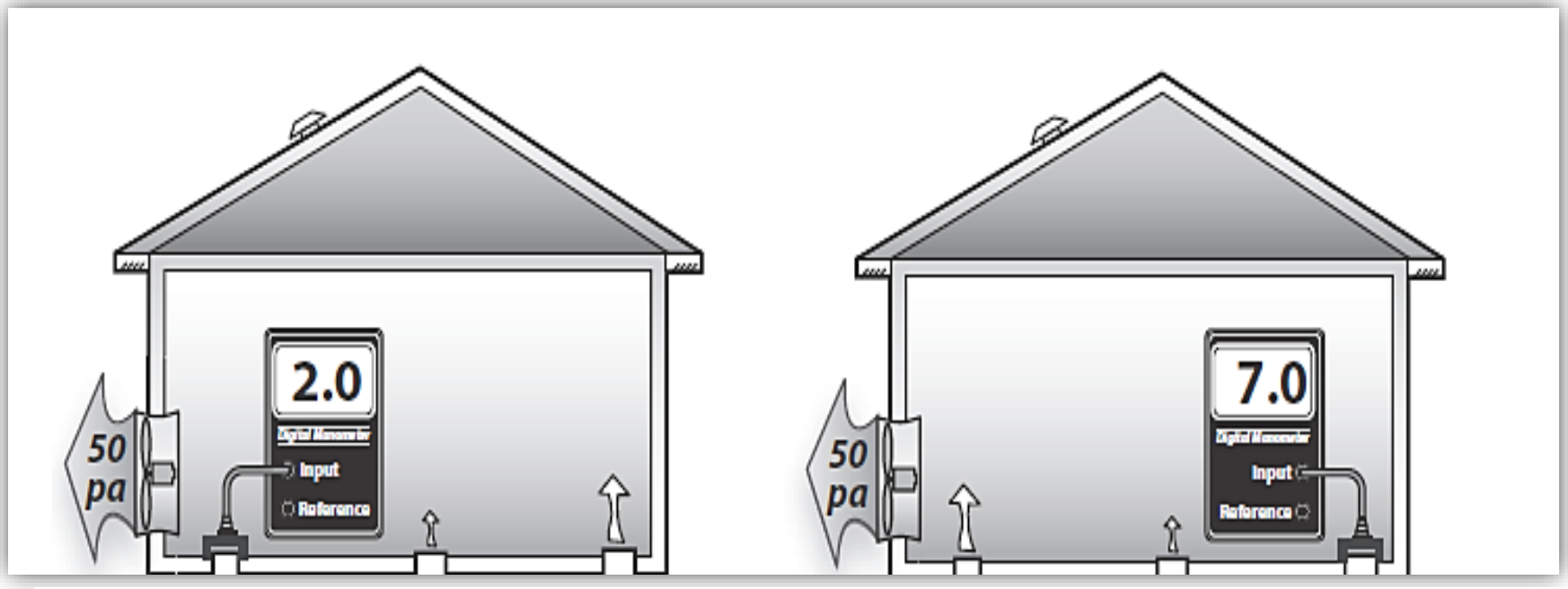
Pressure pan tests can identify leaky or disconnected ducts located in intermediate zones. Pressure pan measurements are taken at supply and return registers while using the blower door to depressurize the house to -50 pascals.

**A pressure pan:** Blocks a single register and measures the air pressure behind it during a blower door test. The magnitude of that pressure is an indicator of duct leakage.




DG-700 Pressure & Flow Gauge


DG-700 Pressure & Flow Gauge
DEVICE
CONFIG
MODE
TIME AVG
DEVICE
UNITS
CONFIG
MODE
CLEAR
TIME
BASE LINE
START
ENTER
ON/ OFF
LIGHT
HOLD
INPUT
A
B



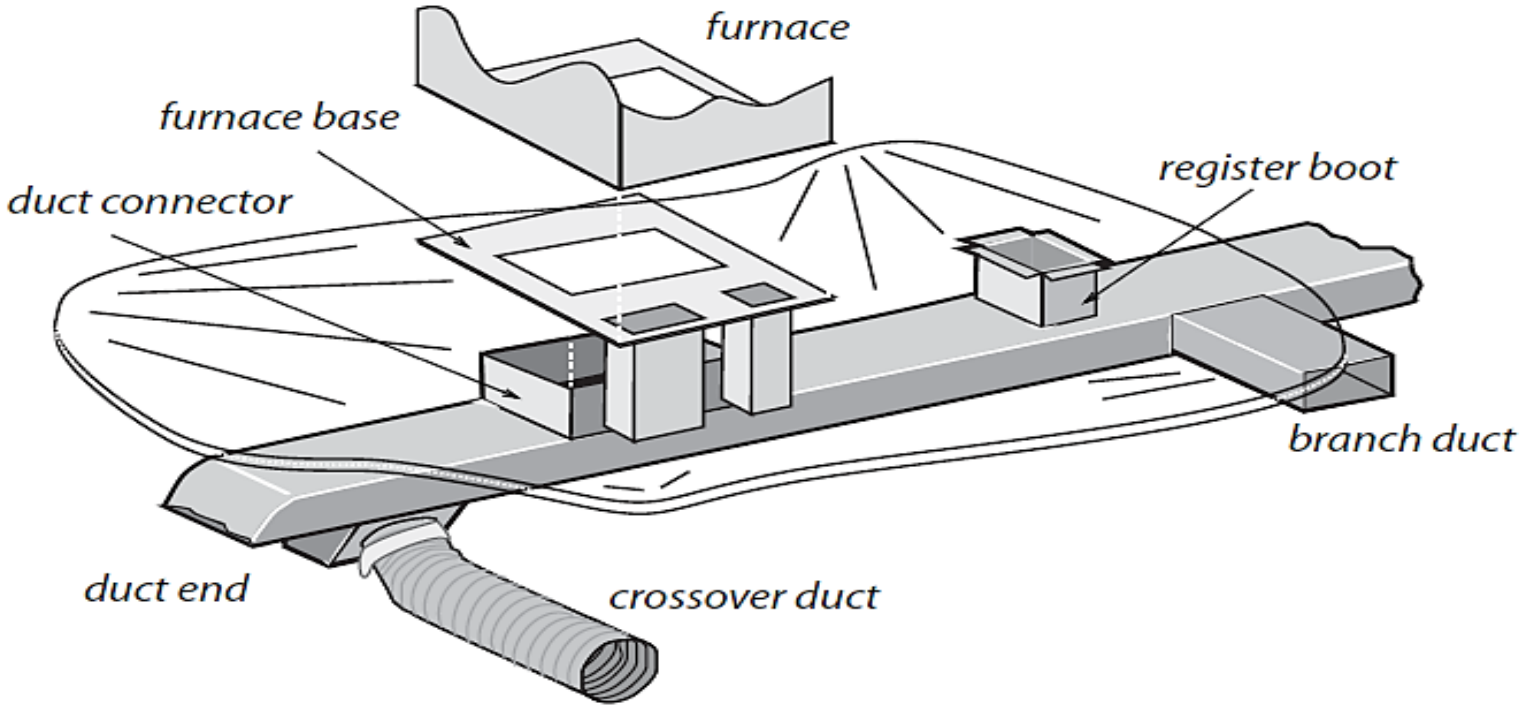

**Pressure pan test:** A pressure pan reading of 2 indicates moderate duct air leakage in the supply ducts.

**Problem register:** A pressure pan reading of 7 pascals indicates major air leakage near the tested register.

# Mobile Home Air Sealing

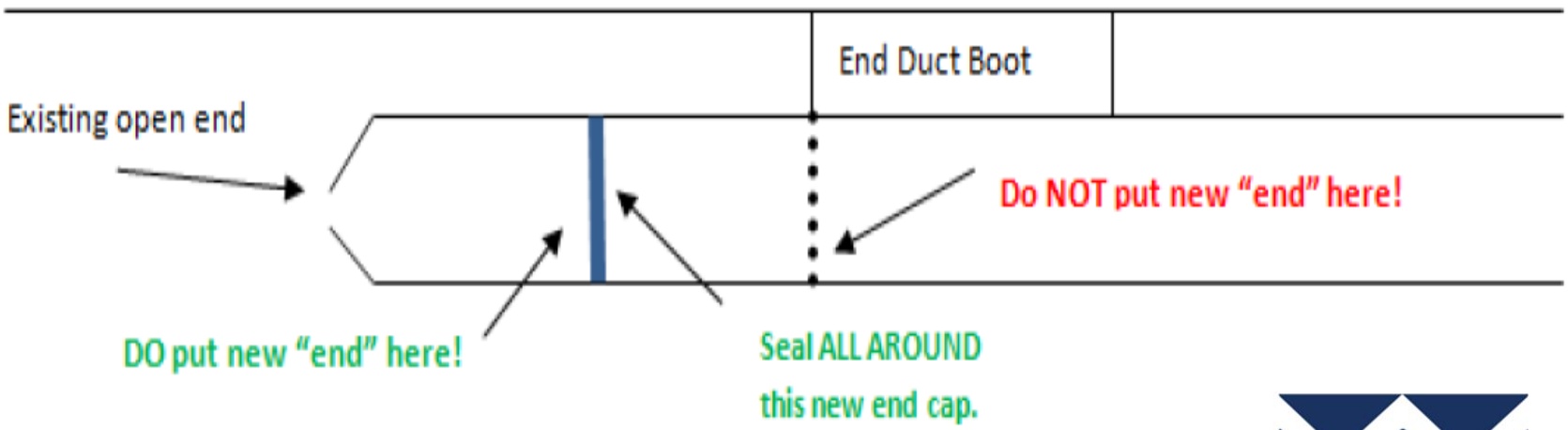
Table 11-1: Air Leakage Locations & Typical $CFM_{50}$ Reduction

| Air Sealing Procedure | Typical $CFM_{50}$ Reduction |
|---|---|
| Patching large air leaks in the floor, walls and ceiling | 200–900 |
| Sealing floor cavity used as return-air plenum | 300–900 |
| Sealing leaky water-heater closet | 200–600 |
| Sealing leaky supply ducts | 100–500 |
| Installing tight interior storm windows | 100–250 |
| Caulking and weatherstripping | 50–150 |




**Mobile home ducts:** Mobile home ducts leak at their ends and joints — especially at the joints beneath the furnace. The furnace base attaches the furnace to the duct connector. Leaks occur where the duct connector meets the main duct and where it meets the furnace. Branch ducts are rare, but easy to find, because their supply register isn't in line with the others. Crossover ducts are found only in double-wide and triple-wide homes.

When sealing end runs in MOHO trunk lines pay attention to placement as to not create a static pressure issue.

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# Unique Construction Details

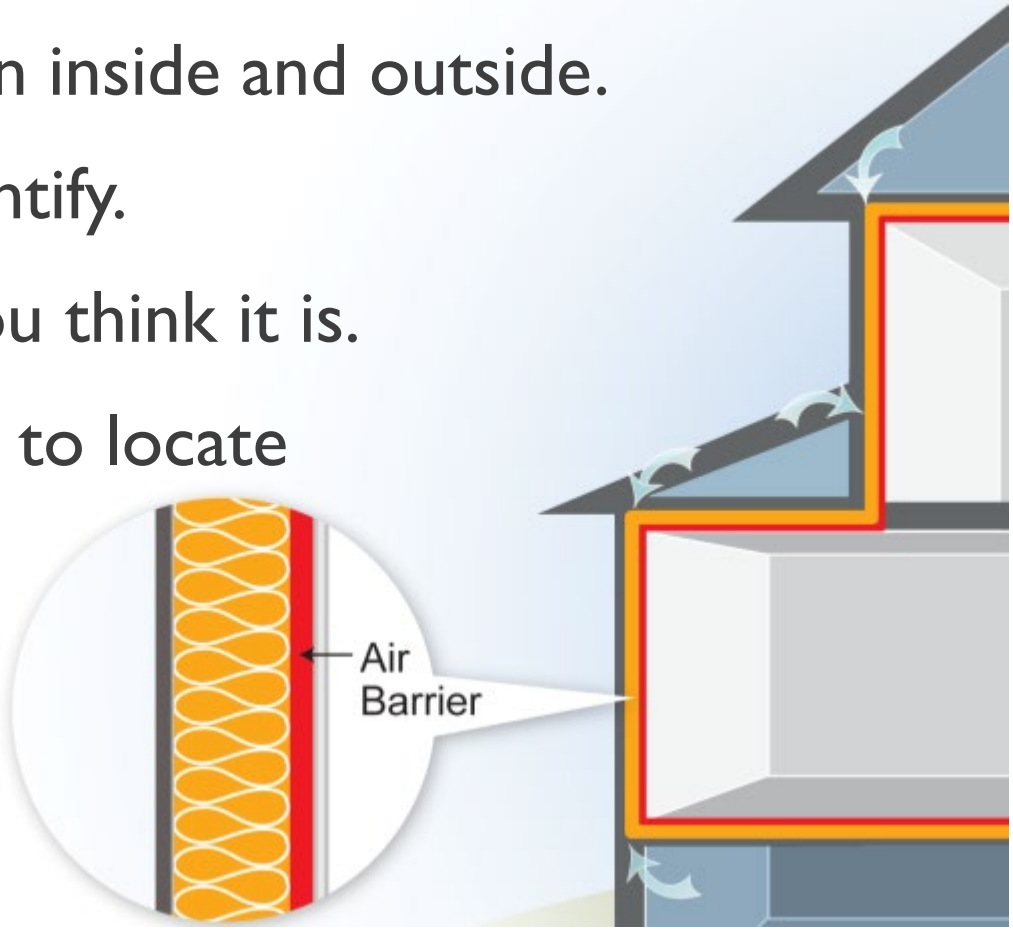
Other construction details can result in gaps in pressure and thermal barriers.

- Changes in ceiling height
- Knee-wall attics
- Walk-up attics
- Dropped soffits
  - Above kitchen cabinets
  - In bathrooms
  - Above vanities
  - Above built-ins
  - At duct chases/bulkheads

# IDENTIFYING & AIR SEALING THE ENVELOPE

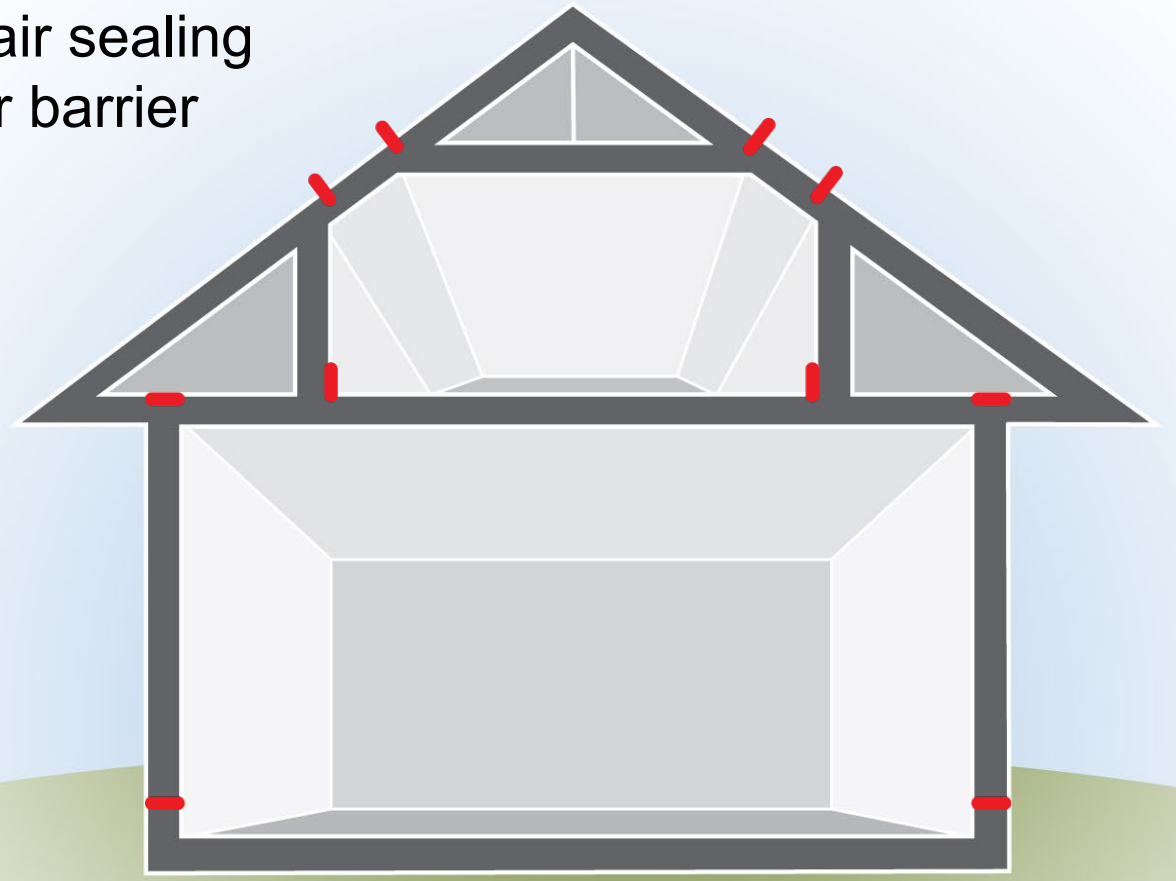
## AIR BARRIER

- Limits air flow between inside and outside.
- Is more difficult to identify.
- Is not always where you think it is.
- A blower door is used to locate the air barrier.

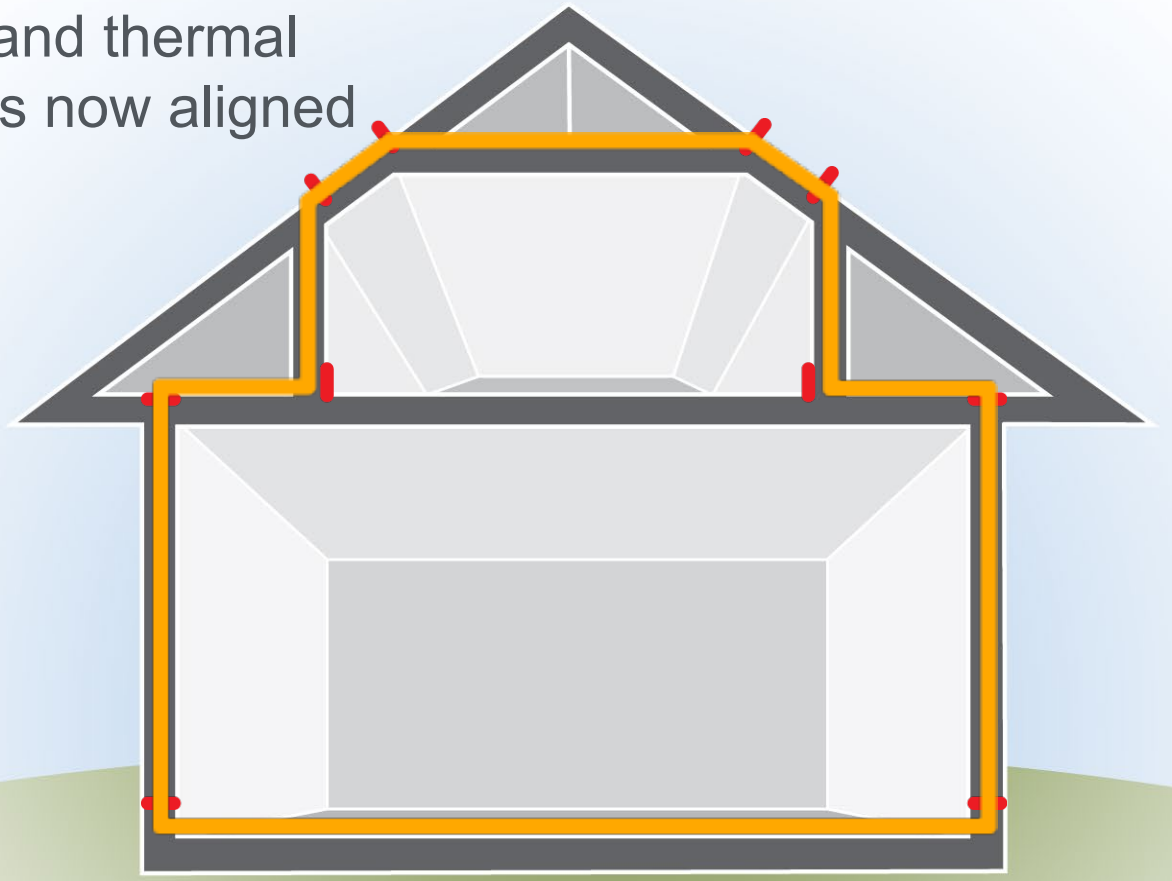


# WHERE IS THE AIR BARRIER?

Targeted air sealing defines air barrier



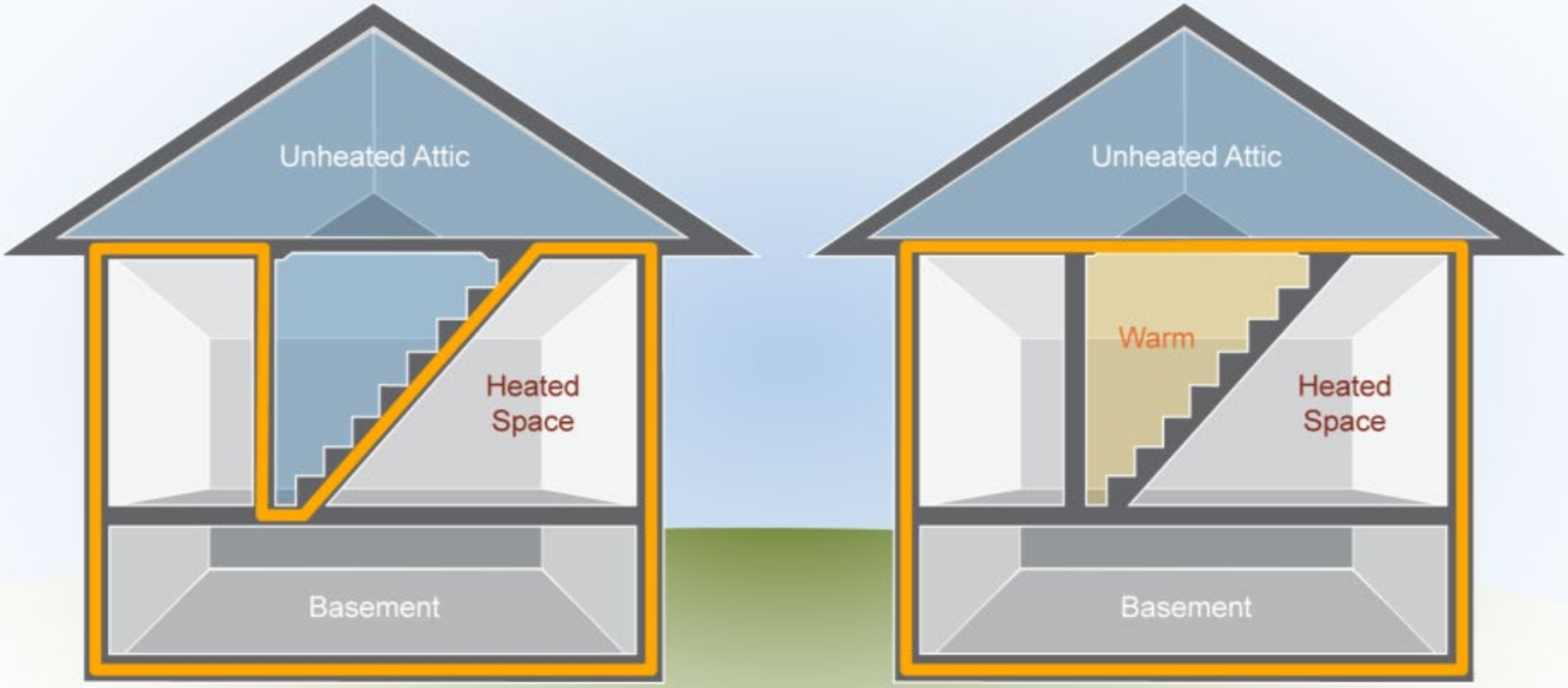
Pressure and thermal boundaries now aligned



*Graphic developed for the US DOE WAP Standardized Curricula*

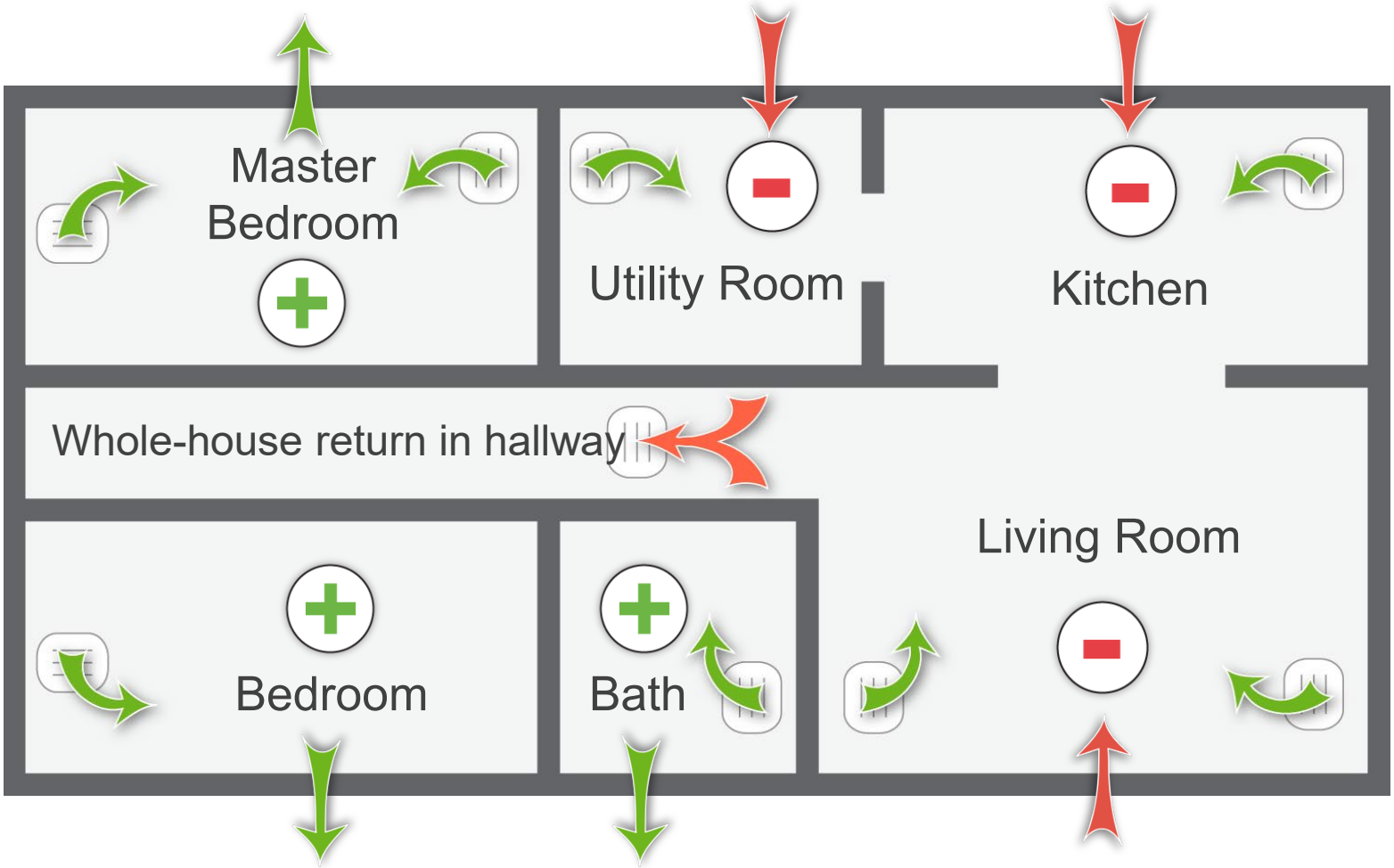
# WALK-UP ATTICS

Where Is the Pressure Boundary?
Where Should It Be?



# Cause and Effect

## Room Pressure Imbalances



- When we do a bang-up job of air sealing it is crucial to test for spillage on combustion appliances.

- Always verifying that we didn't eliminate any driving forces that were allowing these appliances to draft properly cannot be overlooked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