Combustion Safety

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Energy & Design

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Goals of this session

- Recognize the need for combustion safety testing
  - Test In/Test Out
- Recognize the impact of energy improvements on combustion equipment
- Be familiar with testing protocols and equipment

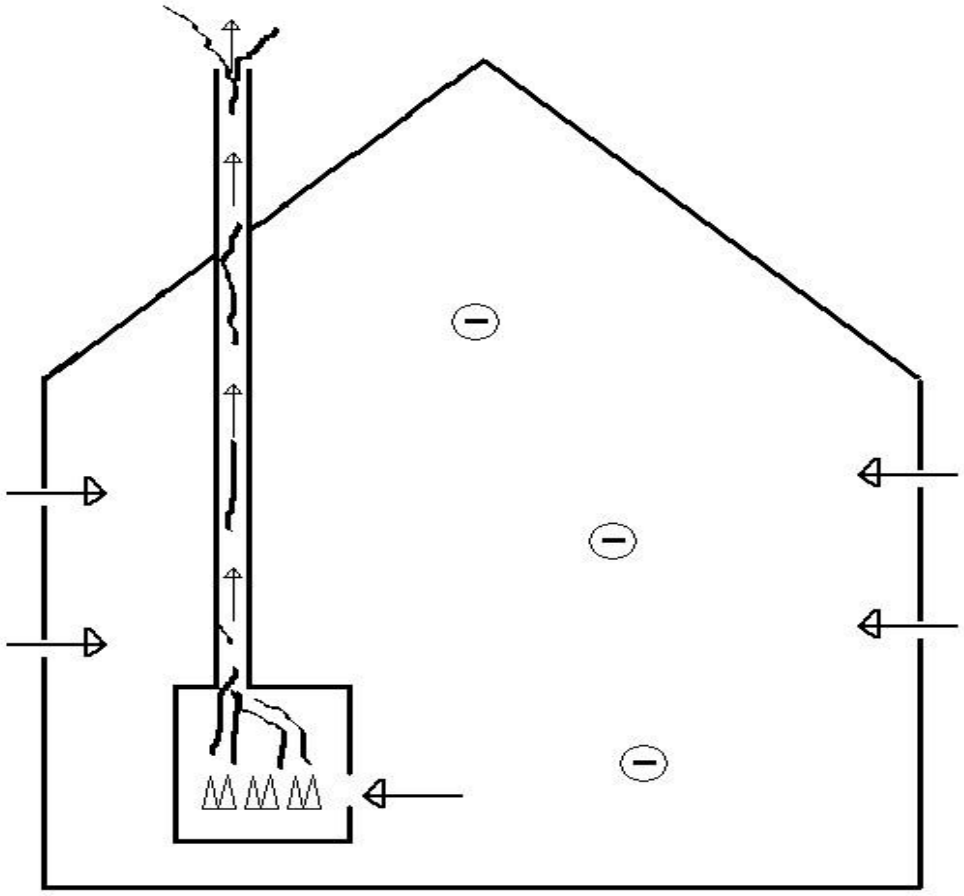
Introduction

- Who are you?
  - HERS Raters?
  - Weatherization Technicians?
  - Home Performance Contractors?
  - Home Improvement Contractors?
- Is anyone doing combustion safety testing?
  - What protocol?
- Why do you feel the need for this testing?

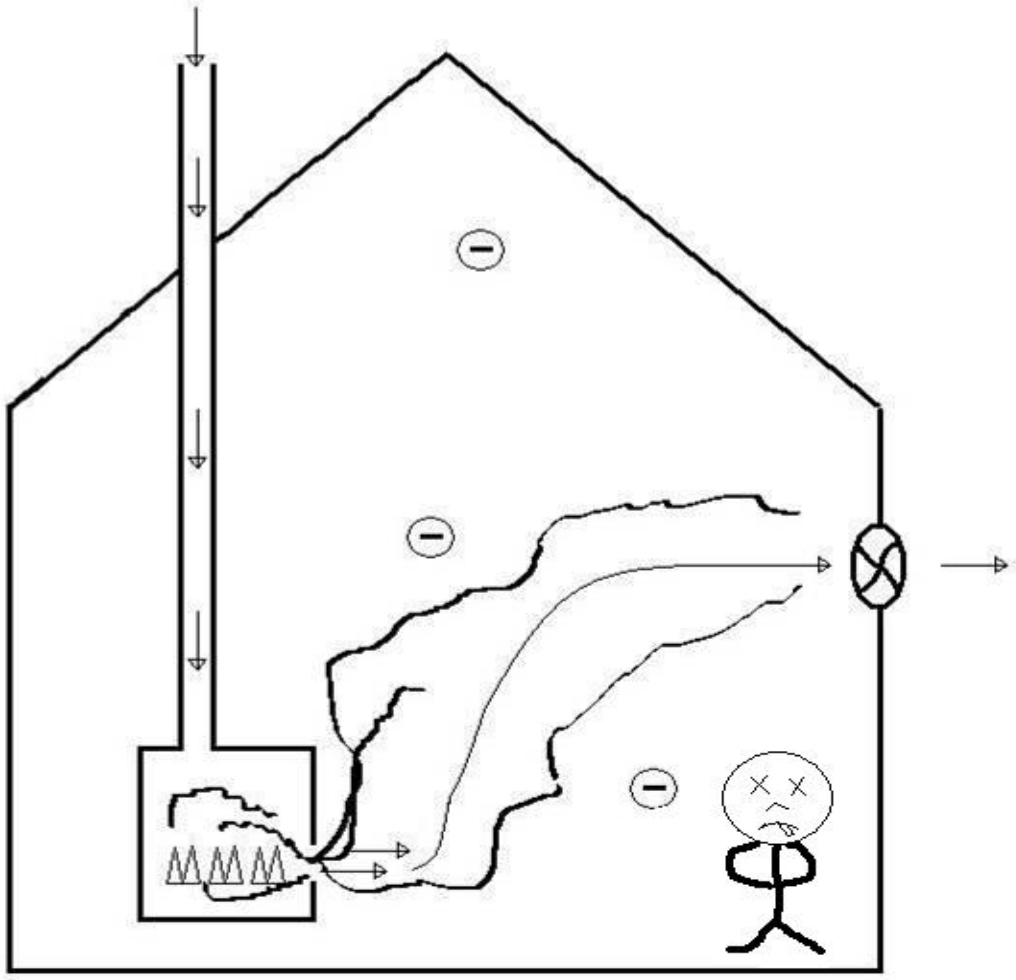
Finish this sentence...

- The house is a...

Systems Thinking-Before



Systems Thinking-After



Combustion-How It Works

- Combustion requires three things:
  - Fuel
  - Air
  - Ignition Source
- Combustion byproducts
  - Oxygen
  - Carbon Dioxide
  - Water
  - Nitrogen

Fuel-Natural Gas

- Comprised mainly of methane (81%)
- Lighter than air (specific gravity .65)
- BTU content/cu.ft. =700 to 1200
- Ignition temperature of 1100° to 1200°F
- Typical manifold pressure = 3.5” WC

Propane

- Comprised mainly of propane (95%)
- Heavier than air (specific gravity 1.53)
- BTU content/cu.ft. =2500 to 2700
- Ignition temperature of 920° to 1020°F
- Typical Manifold pressure = 11” WC

Air

- Combustion Air
  - Primary
  - Secondary
  - Dilution
  - Excess
- Natural gas appliances needs 10 cubic feet of combustion air for every 1 cubic foot of fuel.
- Propane appliances needs 25 cubic feet of combustion air for every 1 cubic feet of fuel.

Combustion Air Guidelines

- Uniform Mechanical Code Chapter 7:
  - “Two openings, with each opening having one square inch/4000 btu”
  - Other variations on this, depending on jurisdiction (local codes), equipment type and location.

Ignition Sources

- Standing Pilots
- Electronic
  - Spark Ignitors
  - Hot Surface Ignitors
- Others
  - Matches, candles...”manual” ignition!
  - (Not a good idea!)

Draft / Venting

- All combustion appliances create combustion byproducts. These must be removed to the outside via a venting system (masonry chimney, single or double wall metal pipe, or plastic vent, etc.).
- Drafting: (Positive or negative Pressure)
  - A current of warm exhaust gasses. This effect creates a slight negative pressure, carrying the gasses out of the home via a chimney or vent stack.

Open & Closed Combustion Appliances

- Open Combustion:
  - An appliance that gets its combustion air from the same area as the unit is located
    (you could reach in and touch the flame)
- Closed Combustion: (aka Sealed Combustion)
  - An appliance that gets its combustion air from the outdoors, piped directly to the unit's burner area
    (the combustion chamber is completely sealed and isolated from the zone it is located in)

Drafting

	Negative-pressure Venting	Positive-pressure Venting
Non-condensing	**I** Combustion Efficiency **83% or less** Use standard venting: masonry or Type B vent	**III** Combustion Efficiency **83% or less** Use only pressurizable vent as specified by manufacturer
Condensing	**II** Combustion Efficiency **over 83%** Use only special condensing-service vent as specified by manufacturer	**IV** Combustion Efficiency **over 83%** Use only pressurizable condensing-service vent as specified by manufacturer

American Gas Association Vent Categories

Most residential furnaces are either Category I (standard or mid-efficiency) or Category IV (high efficiency).

Please Note…

- IN NO CASE SHOULD ANY HOME IMPROVEMENTS BE MADE IF THERE ARE UNVENTED APPLANCES IN THE HOME.
- THIS INCLUDES FREE STANDING SPACE HEATERS AND COOKING APPLIANCES.

Open Combustion Appliance

These are both open combustion appliances. Air for combustion is drawn from the same area (zone) as the appliance. It is often house air.

Category I Furnaces

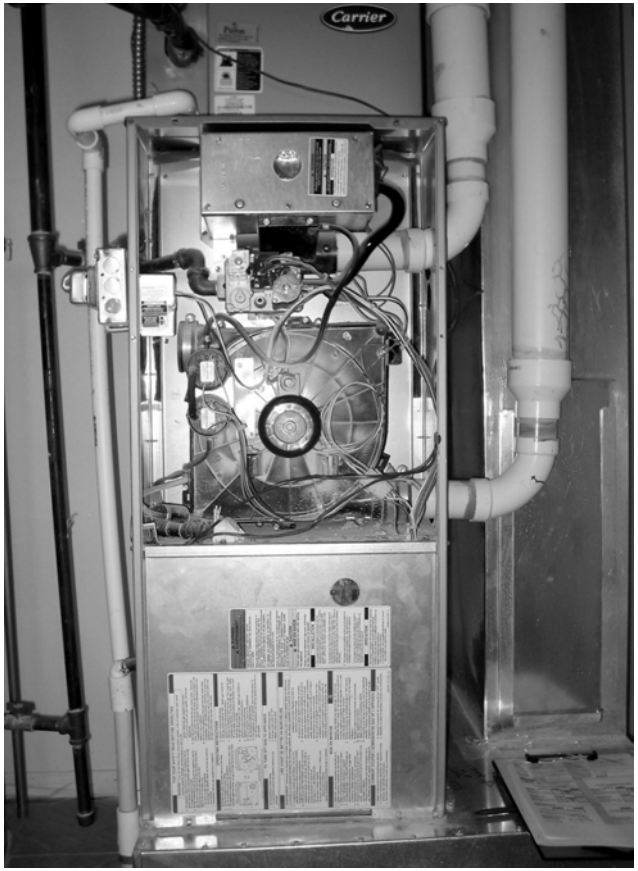
Each of these furnaces, though different AFUEs, are Category I appliances.

(The left unit is ~ 65%, the right is 80%. Each has negative pressure venting, non-condensing)

Open or Closed? High Efficiency?

- This is a Category I open combustion furnace. The combustion air source is house air, as it the hot water tank next to it.
- AFUE = 80%

Category IV Furnaces

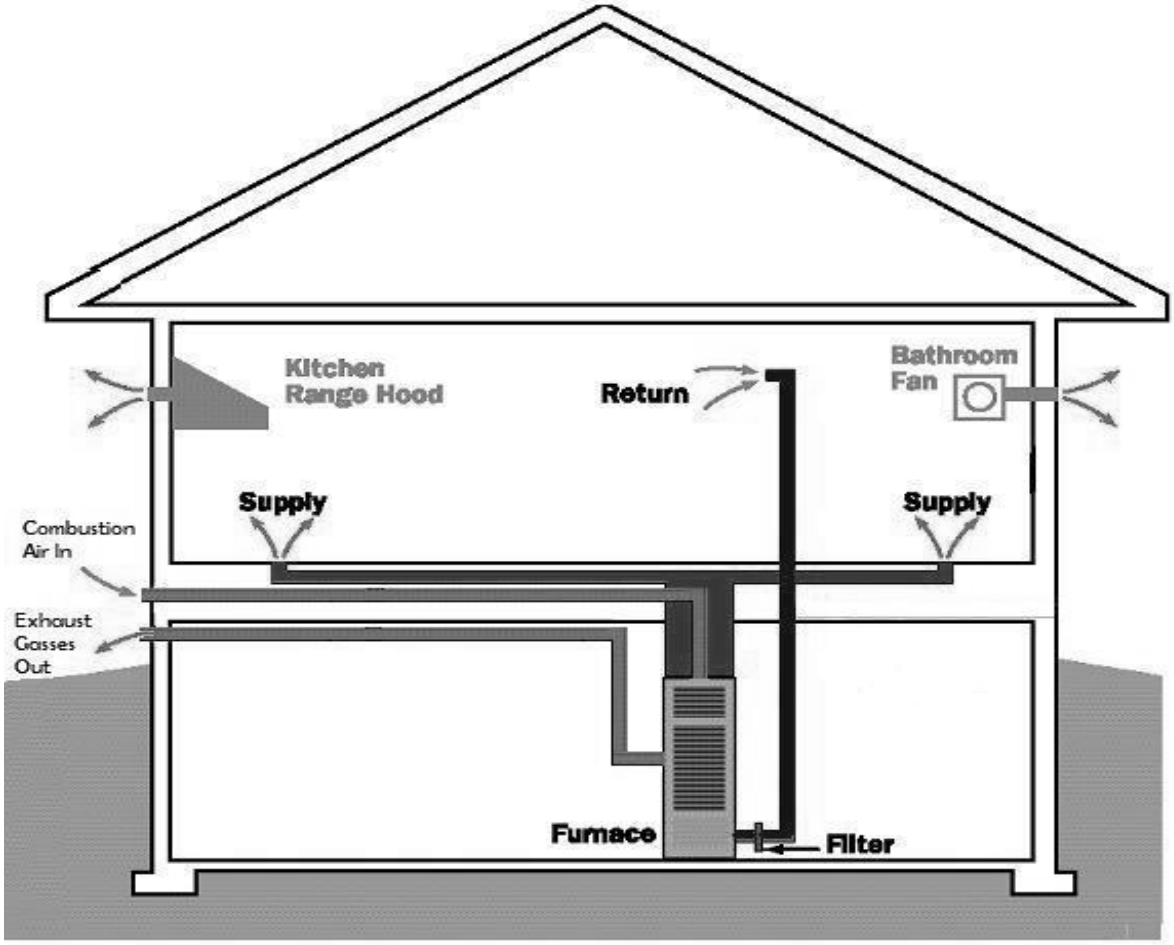


This 90+ AFUE (condensing) is a Category IV, with a positive pressure vent system

Closed Combustion Appliance

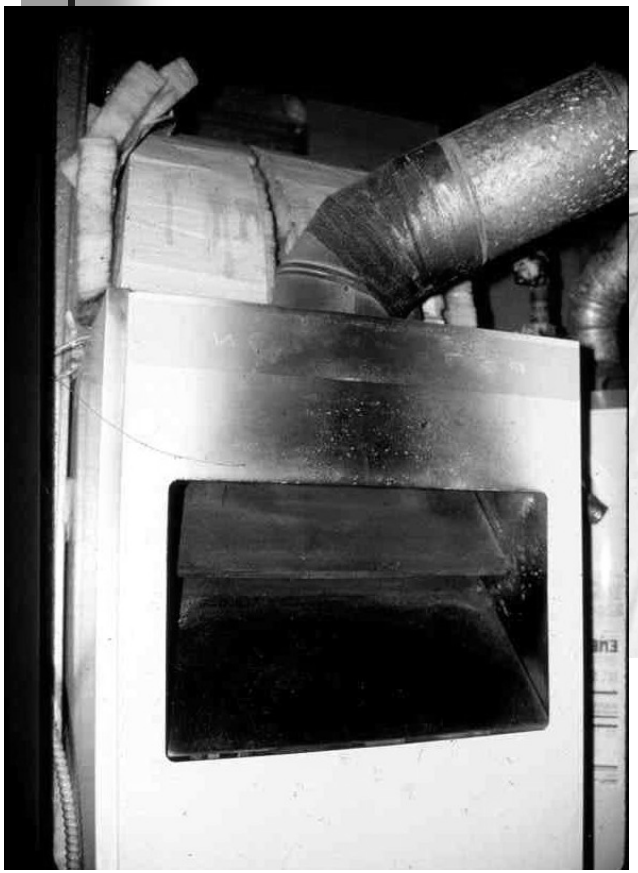
- Both the hot water heater and furnace shown here are closed combustion appliances. They each draw combustion air from outdoors, not the living space.

Closed Combustion Appliance



Sealed Combustion

Learn To Look!



Combustion spillage

This is from a new home!

Brother-in-law installation

What's wrong with these pictures?

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So What...

- If code is met, will the appliance work properly?
- If a new home has a CO, is everything OK?
- If the air changes are above .35 NACH, is there enough air for combustion?
- Can I tighten a house below .35 and have enough air for combustion?

How much air is needed

- Assuming 1000 btu/cubic foot of gas, then:
- A 100,000 btu furnace requires 1000 cubic feet of air for every hour it burns. (100,000 btu = 100 cubic feet of gas x 10 cubic feet of combustion air/ft = 1000 cubic feet of air)
- Where is this air coming from? How is combustion air allowed to the appliances?

How much air is present?

- 1000 square ft. home, 8’ ceilings = 8000 cubic ft. volume.
- Total appliances =160,000 btuh.
  - Furnace = 75,000 DHW = 40,000
  - Dryer = 25,000 Oven = 20,000
- Need 50 cubic feet/1000 btu
- Need 8000 cubic feet (enough is present)

Air Sealing

- What are some typical improvements made to reduce air leakage in the home?
  - Attics-top plates, open walls, drop ceilings, plumbing and electrical penetrations, etc.
  - Wall insulation (dense pack)
  - Basements
    - Rim joists. Wall penetrations, windows, etc.
  - Ductwork

Pressure Problems

- Know the impact of air sealing on combustion appliances:
  - Over-tightening a home
  - Exhaust appliances
    - fans, dryers, fireplaces
  - Duct Leakage

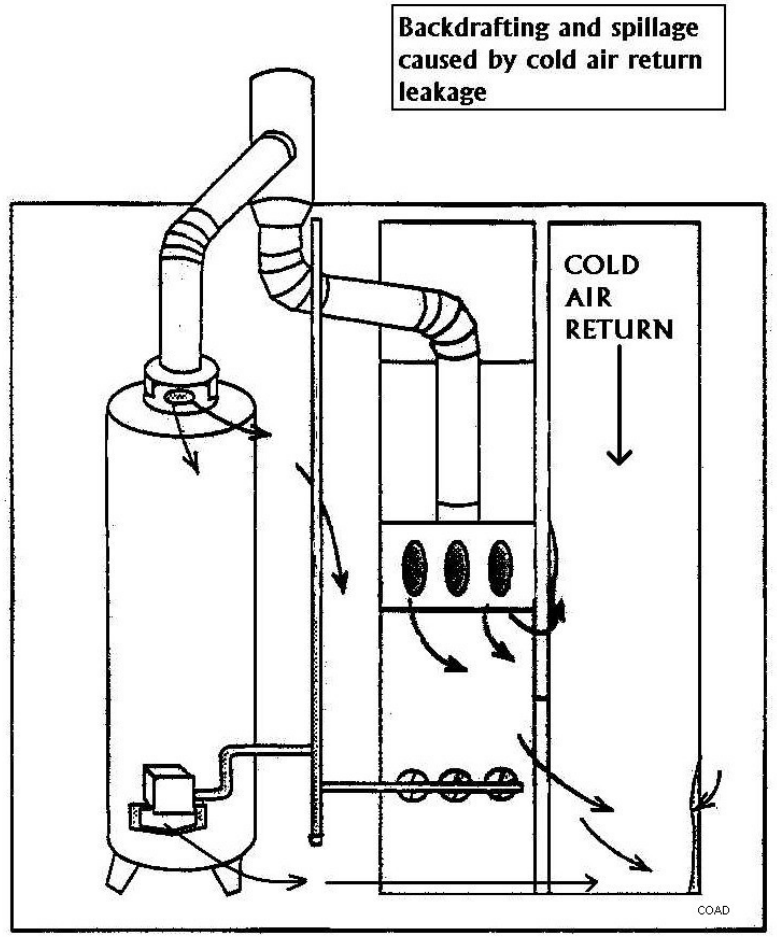
Pressure Problems

- A HOME MAY NOT HAVE HAD A PRESSURE PROBLEM *BEFORE* YOU BEGAN IMPROVEMENTS.
- THE EFFECTS OF TIGHTENING A HOME MAY CREATE ADVERSE CONDITIONS *AFTERWARDS.* (BACKDRAFTING, PRESSURE IMBALANCES, ETC.)
- Don’t assume anything. Test In, Test Out.

Ductwork

- The impact of leaky ductwork can never be emphasized enough.
- Sealing only supply ductwork can lead to catastrophic results, including backdrafting in the CAZ, or excessive positive pressure in the core of the home

Effect of Duct Leakage On Open Combustion Appliances



- The leaky cold air return on this furnace can draw combustion products down the flue and into the ductwork, for delivery into the living space.
- In addition, it robs the appliances of necessary combustion air, possibly leading to CO production.

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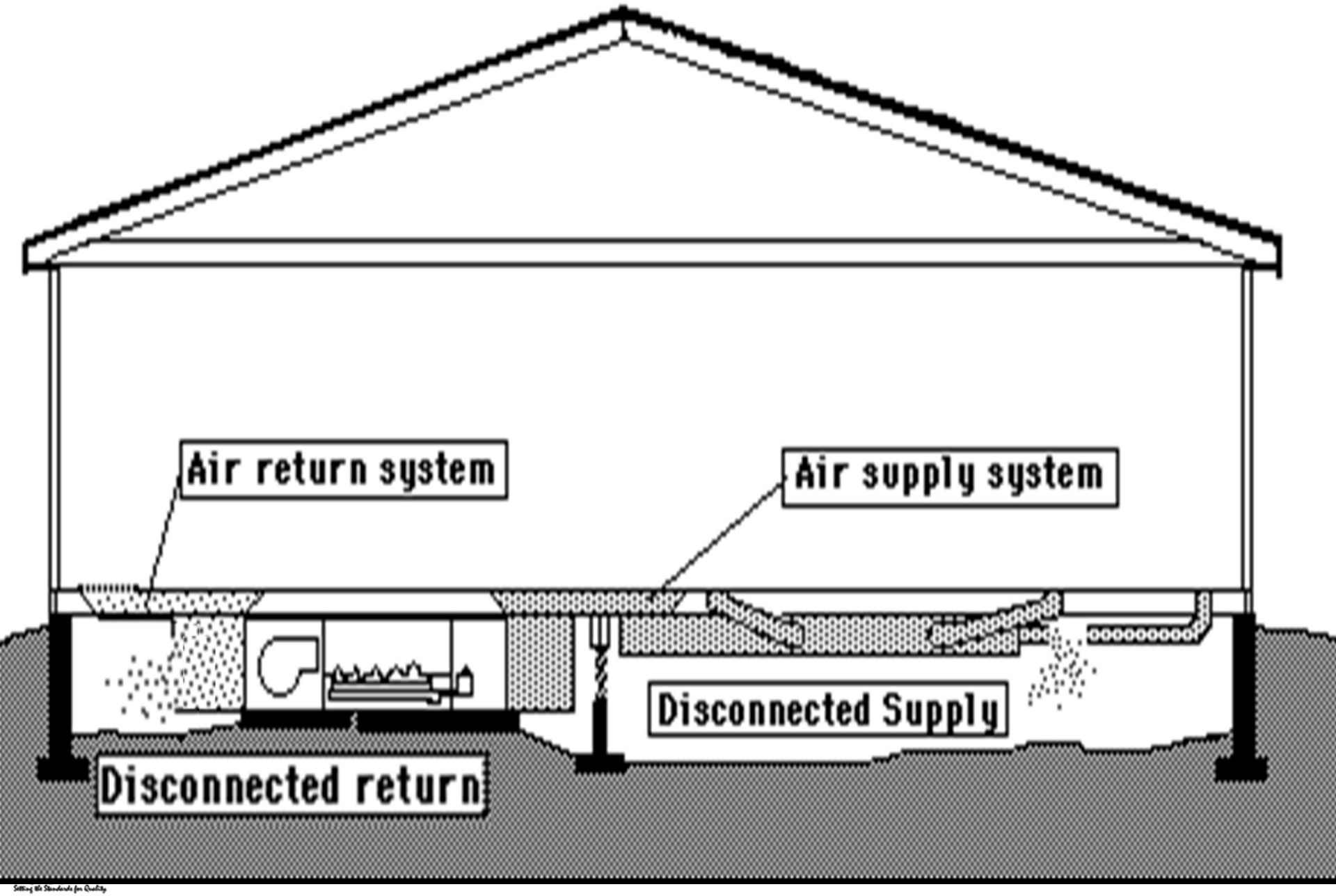
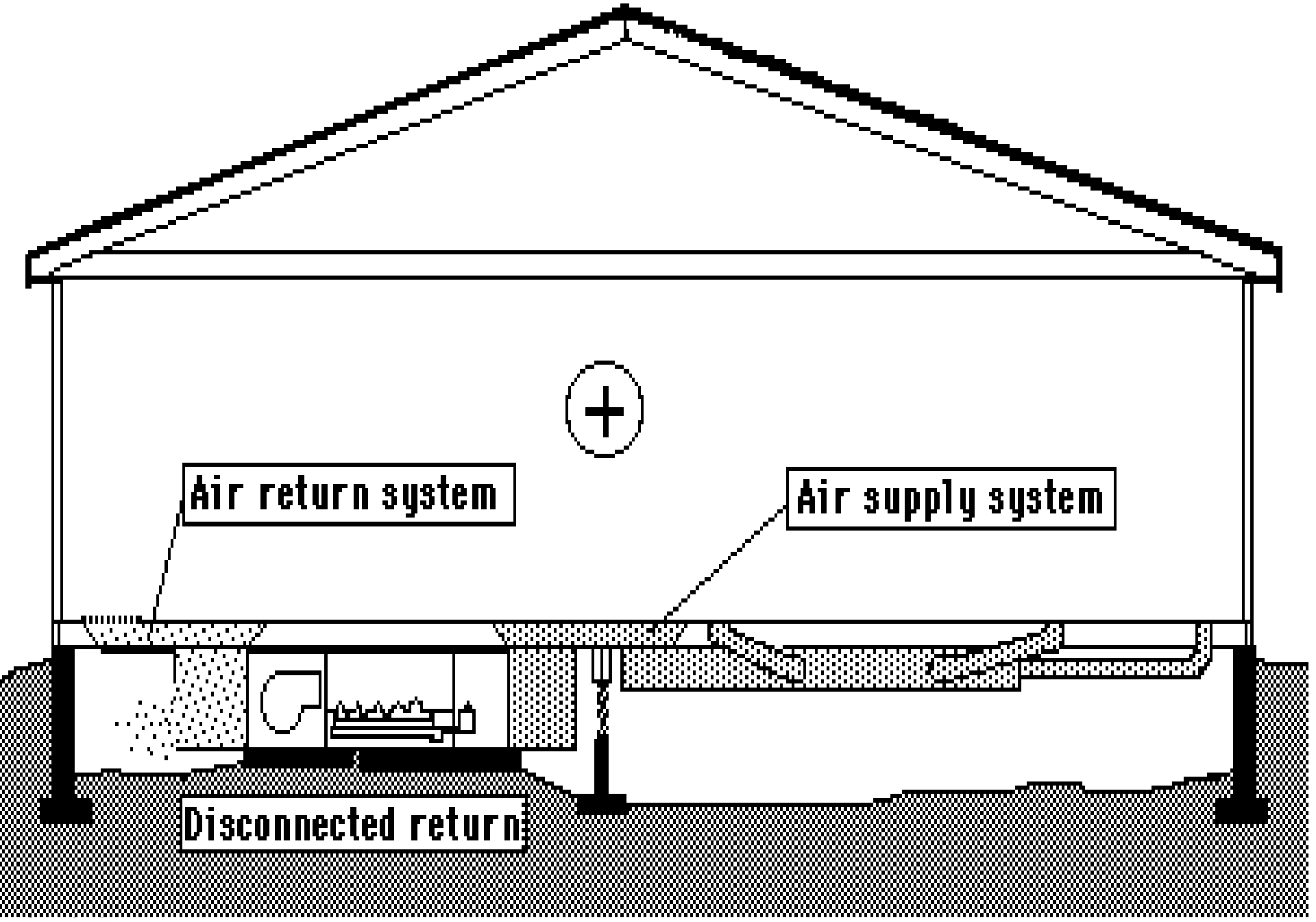
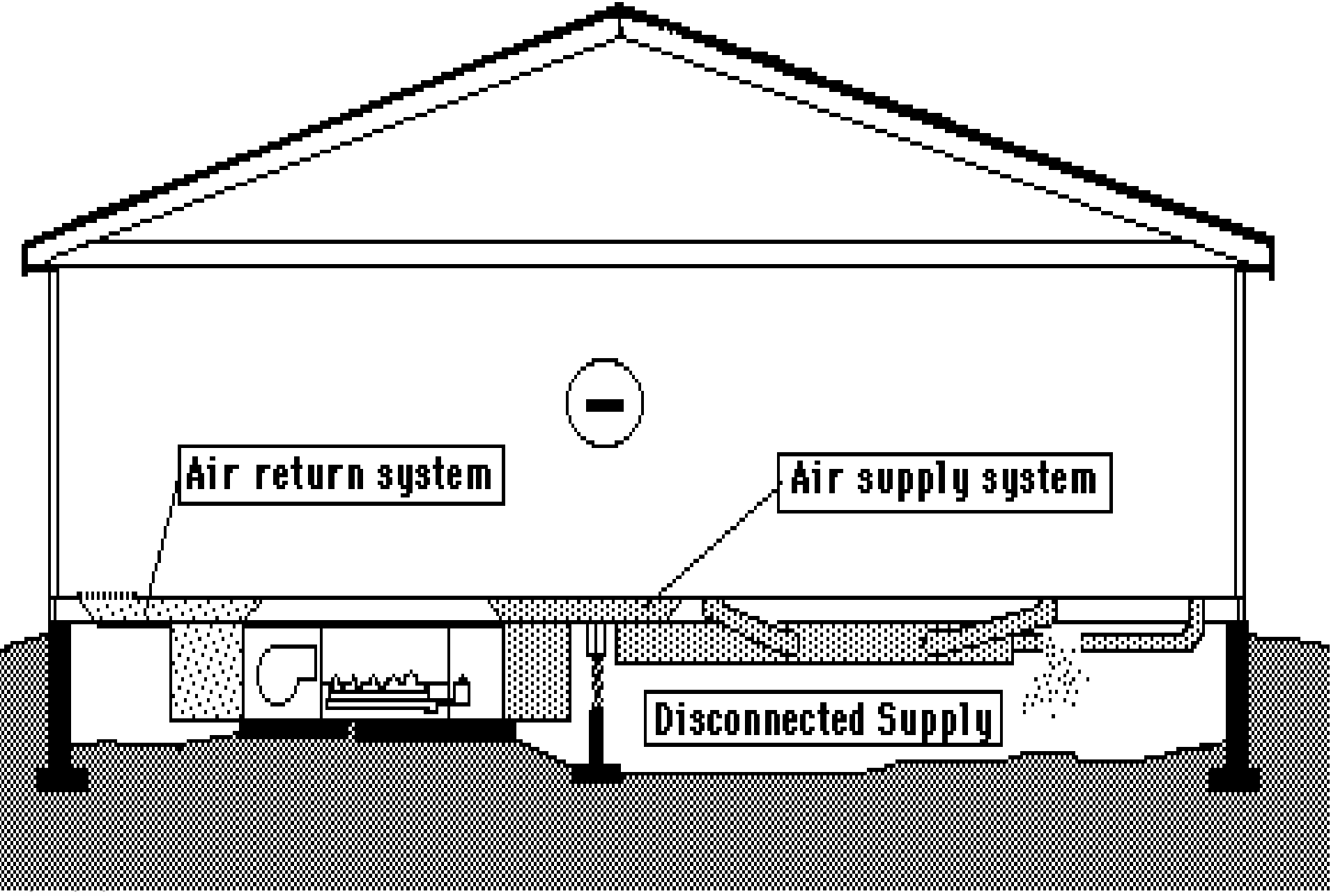
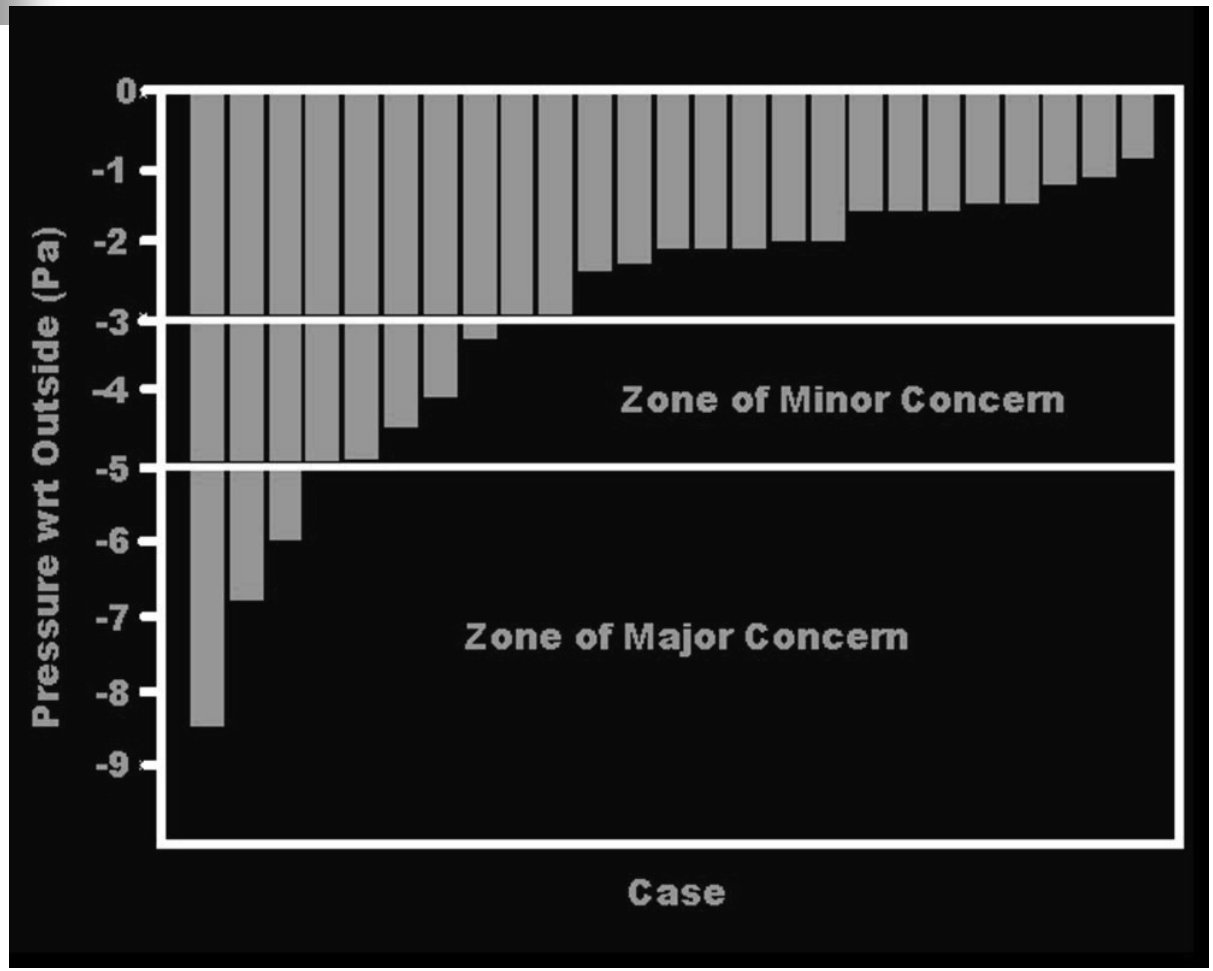

Air return system
Air supply system
Disconnected Supply
Disconnected return


Air return system
Air supply system
Disconnected return


Air return system
Air supply system
Disconnected Supply

Combustion Appliance Zone Pressures



Combustion appliance zone (CAZ) pressures may overcome the draft pressure needed to safely exhaust hot water tanks and furnaces. Typical draft pressures may be -5 pa or less.

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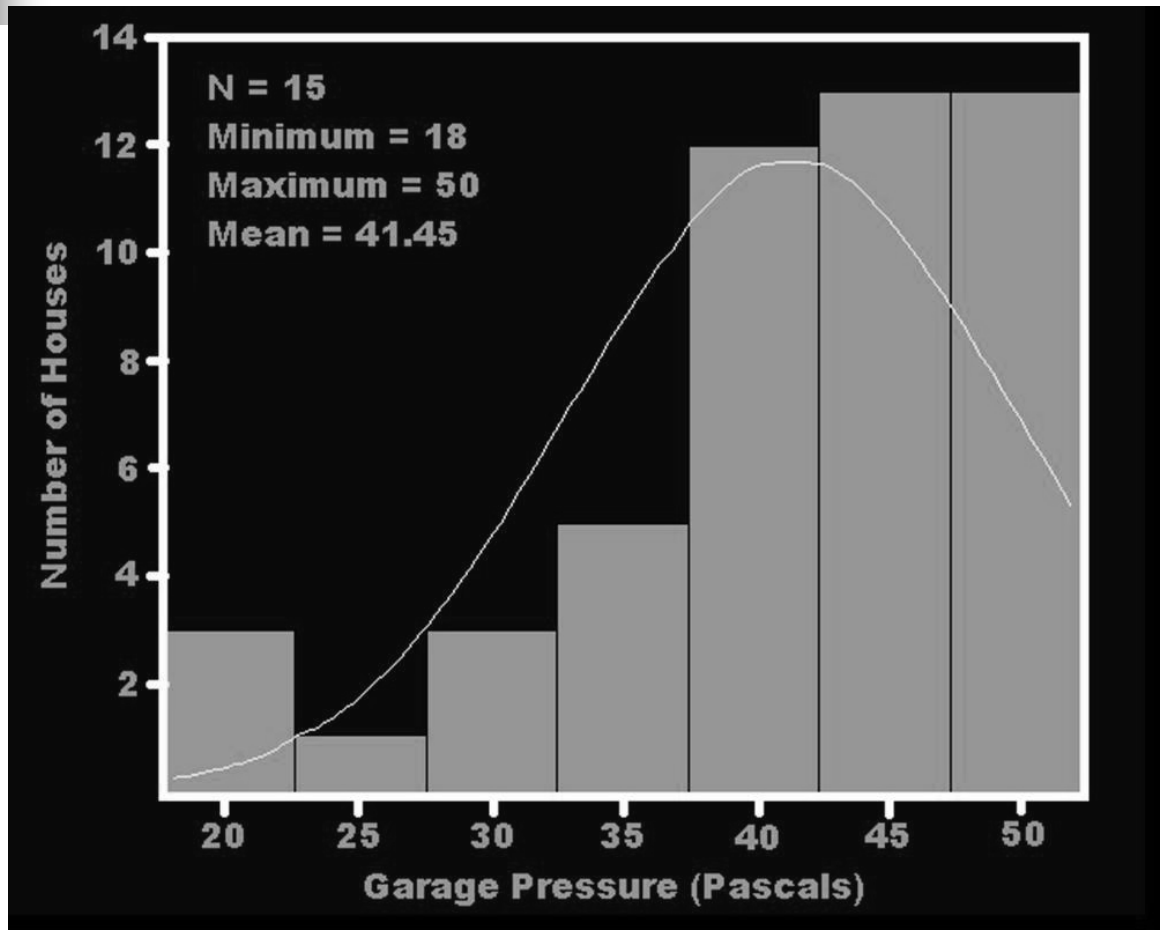
House to Garage Connections



If air sealing is performed throughout the home,
makeup air for appliances may now only be available via the house-garage connection.
Be careful!

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Carbon Monoxide

- An odorless, colorless, tasteless toxic gas that can be lethal at high concentrations.
  - Low level poisoning contributes to health problems.
  - Has distinct odor when combined with byproducts of incomplete combustion.
  - Is caused by *incomplete* combustion

Carbon Monoxide

Myth or Fact?

All furnaces and hot water tanks always produce Carbon Monoxide

Myth!

Properly tuned equipment produces little or no measurable levels of CO

Testing

"You get what you inspect, not what you expect"

- Blower Door Testing
  - Location of leaks
  - Zone connections (house/garage, etc.)
- Combustion Safety Testing
  - Carbon Monoxide, Draft, Spillage, CAZ Pressure
- Duct Leakage Testing
  - Shows location and quantity of duct leakage

Combustion Safety Testing

- Measure temperature outside
- Measure base pressure
- Establish worst case, measure CAZ
- Measure CO/draft /spillage at worst case and if necessary again at natural conditions

Test Equipment

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Testing

- Check the venting systems to see that they are safe and intact.
  - Be sure the vent is cool to the touch
  - Hand check venting integrity
- Check for carbon in the heat exchanger, draft hood and gas vent(s) of all appliances being tested.
  - Another hand check
- Visually check for cracks in the heat exchanger.
- Drill test holes in the gas vent(s) of atmospheric drafting appliances.

Remember...

- Houses with central returns vs. returns in every room may change your door arrangement.
- Leaky ductwork can cause a zone to go positive, negative, or remain neutral.
- If there is an operable fireplace, it may be necessary to run a blower door at a low (~200 to 400 cfm or higher) flow in order to simulate its drafting.

Test Locations-65% Furnaces

The vent on this furnace should be drilled approximately 18” from the top of the draft hood. This hole is for testing the draft, not CO.

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Test Locations-80% Furnaces

The test hole on this furnace should be in the adaptor section above the combustion blower. Avoid drilling into double wall vent. This test hole is for measuring draft *and* CO.

Spillage tests are not usually taken on furnaces like this. (They do not have a draft hood, but sometimes a test can be done at the burner area.)

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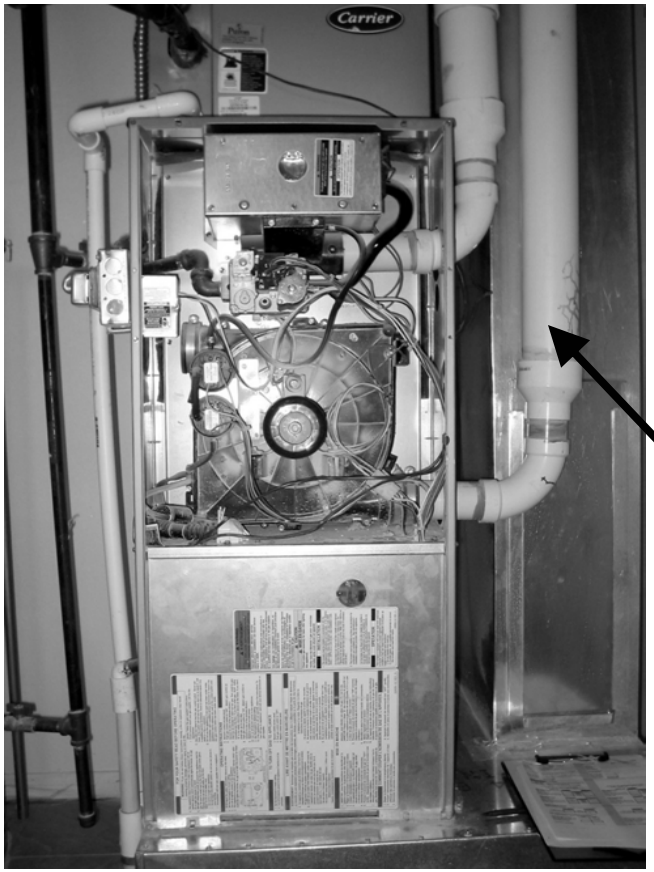
Test Locations-90+ Furnaces



- It is preferred that PVC venting not be drilled. Always try to test at the vent termination. Some manufacturer's will allow drilling of the vent pipe, however it must be completely sealed after testing is done, with approved material.
- CO only is measured on 90+ furnaces (positive pressure venting).

Test Locations-CO testing 65% Furnaces

This →

Not this →

- The top picture shows the correct location for CO measurement on a 65% efficiency unit. Do not measure CO in the vent pipe when a draft hood is present.
- One CO reading is taken at *every* port under the draft hood; one for each burner. The numbers are *not* averaged.

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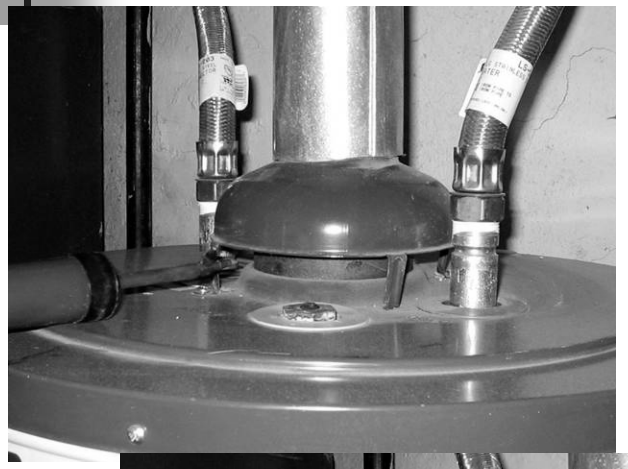
Test Locations-Spillage

- On a draft hood furnace, spillage is tested using smoke, matches, or a mirror, to check for the presence of combustion products.
  - If spillage is present, the CO_2 will extinguish a flame.
  - A mirror will fog over from the moisture content of the gasses.

Test Locations – Hot Water Tanks



- An atmospheric water heater is tested for spillage around the base of the draft hood, again using smoke, matches or a mirror.
  - CO is measured *inside* the draft hood, underneath it, before dilution air enters. There are two readings taken, one from each side of the baffle

And...

- Don’t get in over your head
- Know what you are doing
- Ask for help

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