

# Do No Harm: Combustion Safety

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Presented by

Rich Moore / Invisible Energy / Denver, CO

## 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

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## Introduction

- Who are you?
  - HERS Raters?
  - Weatherization Technicians?
  - Home Performance Contractors?
  - Home Improvement Contractors?
- Is there any HERS Software that includes combustion safety testing?
- Why do you feel the need for this testing?

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## Combustion-How It Works

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

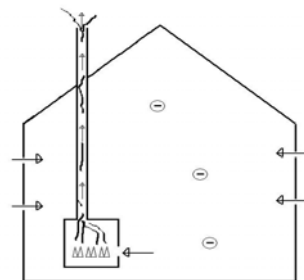
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Finish this sentence...

- The house is a...

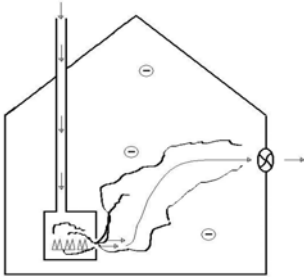
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## Systems Thinking-Before



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## Systems Thinking-After



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## 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

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## 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

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## 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.

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## 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.

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## Ignition Sources

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



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## Draft / Venting

- All combustion appliances create combustion byproducts. These must be removed from the living space to the outside via a venting system (chimney, metal or plastic vent, etc.).
- Draft:
  - 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.

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## 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)

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## Drafting

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

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## 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.

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## 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.

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## 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)



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## Open or Closed? High Efficiency?



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

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## Category IV Furnaces



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

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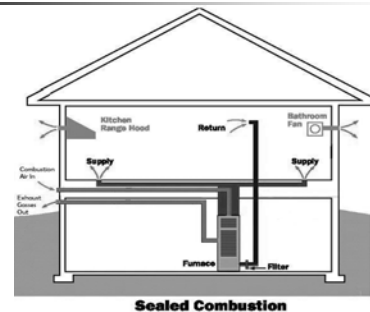
## Closed Combustion Appliance

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



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## Closed Combustion Appliance



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## Fix Venting Problems



Combustion spillage

Learn to observe!



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?

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## 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?

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## 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)

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## 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

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## Pressure Problems

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

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## 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.

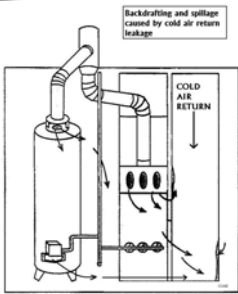
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## Ductwork

- 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

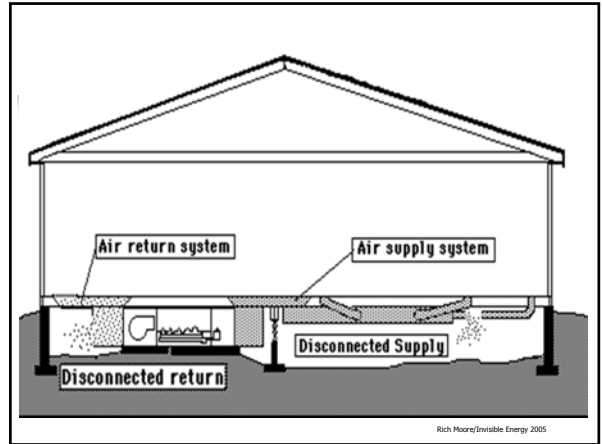
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## Effect of Duct Leakage On Open Combustion Appliances

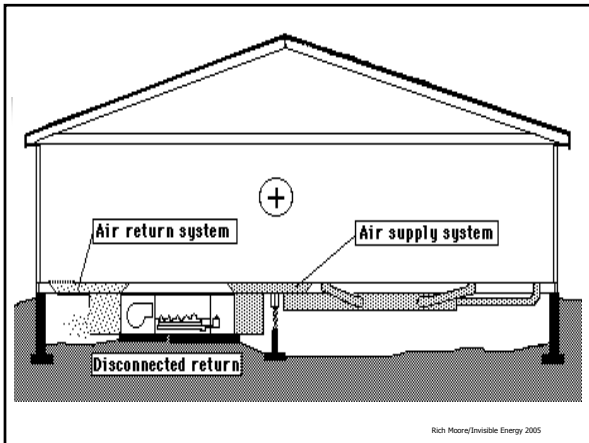


- The leaky cold air return on this furnace can draw combustion products down the flue and into the ductwork, for delivery into the living space.
- In addition, it robs the appliances of necessary combustion air, possibly leading to CO production.

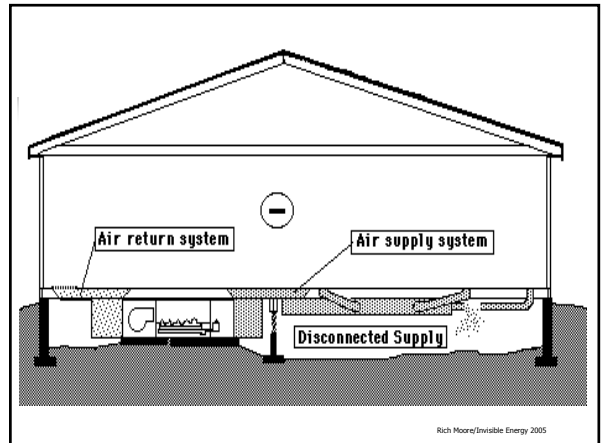
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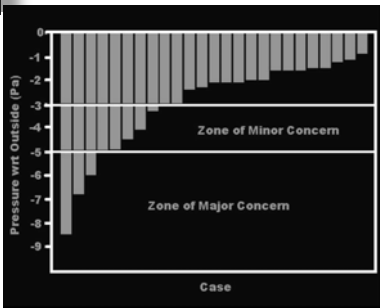


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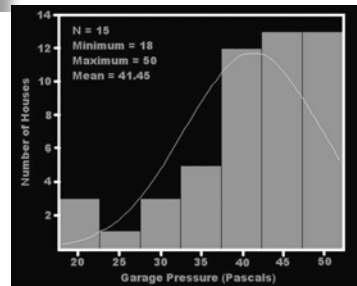
## Combustion Appliance Zone Pressures



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

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## 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

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## 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

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## 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

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## Equipment



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## And...

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

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