

# Combustion Appliance Safety Testing

## Heating Systems for Energy Auditors and Inspectors

### Learning Objectives

By attending this session, participants will understand:

- The basic principles of combustion, distribution, and venting and be able to recognize safety-related problems.
- The health and safety issues related to combustion equipment.
- The basics of visual and diagnostic combustion appliance safety and efficiency inspection.
- The test procedures for vented and non-vented appliances.
- The relationship between combustion safety problems and poorly designed or non-code compliant vent systems.
- Worst-case combustion appliance zone testing.

### Key Terminology

Air free

Ambient air

As measured

Backdrafting

Baffle

Barometric damper

Breech

British Thermal Unit (BTU)

Carbon Dioxide (CO<sub>2</sub>)

Carbon Monoxide (CO)

Combustion analyzer

Combustion Appliance Zone (CAZ)

Combustion efficiency

Condensing furnace

Digital probe thermometer

Dilution air opening

DOE Hot Climate Initiative

Draft

Draft diverter

Draft gauge

Draft hood

Draft reversal

Flame impingement

Health and Safety (H&S)

Inches of Water Column (IWC)

Inspection mirror

Liquefied Petroleum Gas (LPG)

Make-up air

National Fire Protection Association (NFPA)

Natural gas

NFPA 54, National Fuel Gas Code

Oxygen (O<sub>2</sub>)

Parts per million (ppm)	Smoke tester
Pascals (Pa)	Spillage
Primary air	Steady-state efficiency
Propane	U.S. Department of Energy (DOE)
Secondary air	Worst-case combustion appliance zone testing

## Supplemental Materials

### Handouts & Resources

Applicable sections of NFPA 54: National Fuel Gas Code.

Combustion Analysis Quick Sheet.

DeKieffer, Rob. "Combustion Safety Checks: How Not to Kill Your Clients." *Home Energy* Mar./Apr. 1995. [www.homeenergy.org](http://www.homeenergy.org).

DOE. EERE. "Combustion Equipment Fact Sheet." Oct. 2000.

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DOE. WAP. Midwest Regional Field Office. *Midwest Weatherization Best Practices Field Guide* May 2007, pp. 37-56. [www.karg.com/pdf/Midwest\\_Wx\\_Best\\_Practices\\_May\\_2007.pdf](http://www.karg.com/pdf/Midwest_Wx_Best_Practices_May_2007.pdf).

EPA. "EPA Carbon Monoxide Fact Sheet." Oct. 1996. [www.epa.gov/iaq/pubs/coftsht.html#CO%20Poisoning%20Symptoms](http://www.epa.gov/iaq/pubs/coftsht.html#CO%20Poisoning%20Symptoms).

Indiana Community Action Association. "INCAP Daily Safety Test-Out Procedure Checklist." June 2005. Download from field guide at [www.incap.org](http://www.incap.org).

Karg, Rick. "CO Testing for the Real World." *Home Energy* Jan./Feb. 2002. [www.homeenergy.org](http://www.homeenergy.org).

Kilcoyne, Scott, and Bill Van der Meer. "Confined Space Combustion Appliance Zones and the Code." *Weatherization Training Center Technical Update* 1.6. Weatherization Training Center at Pennsylvania College of Technology. October 2005. [www.pct.edu/wtc/articles.htm](http://www.pct.edu/wtc/articles.htm).

Moffatt, Sebastian. "Backdrafting Causes and Cures." *Home Energy* May 1991, pp. 30-35. [www.homeenergy.org](http://www.homeenergy.org).

OSHA. "Carbon Monoxide Fact Sheet." 2002. [www.osha.gov/OshDoc/data\\_General\\_Facts/carbonmonoxide-factsheet.pdf](http://www.osha.gov/OshDoc/data_General_Facts/carbonmonoxide-factsheet.pdf).

OSHA. "Carbon Monoxide Poisoning QuickCard™." 2005. [www.osha.gov/pls/publications/publication.athruz?pType=Types&pID=6](http://www.osha.gov/pls/publications/publication.athruz?pType=Types&pID=6).

Worst-case CAZ Depressurization Step-by-Step Handout.

## **Classroom Props & Activities**

### **Tools:**

- Mirror and flashlight.
- Gas leak detector and soap solution.
- Combustion analyzer.
- CO detector.
- Draft gauge.
- Smoke tester (oil).
- Digital manometer and hose.
- Digital probe thermometer.

Note: Demonstrate diagnostic tests with the most up-to-date equipment possible.

### **Miscellaneous:**

- Oil burner.
- Barometric damper (oil).
- Thermostat.
- Various vent materials.

**Gas leak detection** – Demonstrate the sensitivity of the gas leak detector by drawing a thick line on a piece of paper with a permanent marker. Then show that the detector goes off as it approaches the line.

**Combustion analyzer** – Demonstrate the functions of a combustion analyzer.

**Combustion air** – Calculate the required volume in a combustion appliance zone to provide sufficient combustion air for a furnace and water heater totaling 120,000 BTUH input; 50 ft<sup>3</sup> of volume must be provided for every 1,000 BTUH of appliance input.

$$\text{BTU input: } 120,000 \div 1,000 = 120$$

$$120 \times 50 \text{ ft}^3 = 6,000 \text{ ft}^3$$

## **Hands-on Props & Activities**

**Combustion appliances:** Set up several used appliances so you can perform diagnostic tests on them. Non-operating appliances can be used to identify components and problems. Include:

- Vented and unvented space heater.
- Atmospheric furnace.
- Atmospheric water heater.
- Gas cook stove.

**Combustion appliances for inspection and testing** – Point out the components of the appliances and have students identify them. Have students work in groups to inspect wiring and fans, look for cracked or corroded heat exchangers, and identify proper vent materials. Test for fuel leaks, safety shut-off, draft, free oxygen (combustion air), CO, cracked heat exchangers, and combustion efficiency.

**Field trip:** If a house with working combustion appliances is available, take the class on a field trip. Conduct all appropriate tests, including the spillage test, draft test, CO test, and worst-case CAZ test, with as much student involvement as possible.

## **Class Overview**

Introduce the concepts of combustion safety with the classroom presentation. Refer to the DOE “Combustion Appliance Safety & Efficiency Testing” document when discussing proper testing locations for CO and draft on various appliances. Break up the presentation by demonstrating various combustion inspection tools.

Incorporate the hands-on props and activities listed above. Ensure that each student has a chance to perform the full range of safety tests at least once, using the full range of tools.