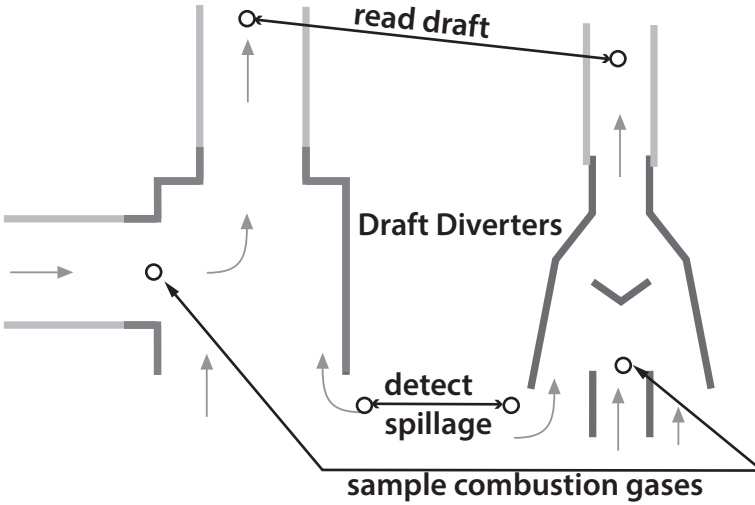
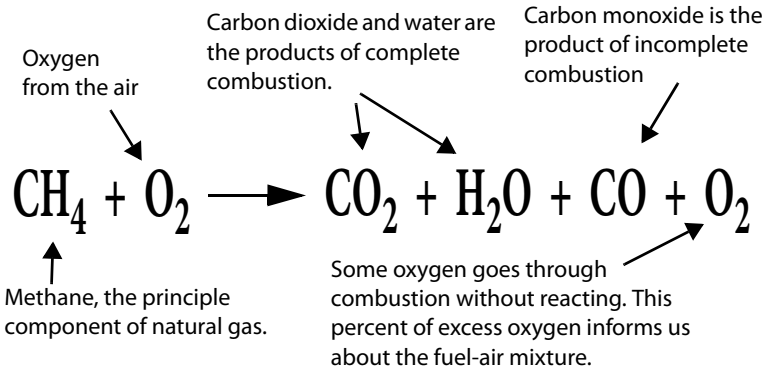


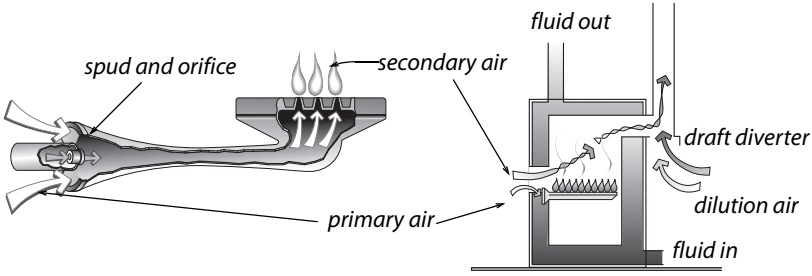
Testing locations: This illustration shows two draft diverters and the locations (circles) for draft testing, spillage detection, and sampling of combustion gases.

8.4 Electronic Combustion Analysis

The goal of a combustion analysis is to quickly analyze combustion safety and efficiency. When the combustion appliance reaches steady-state efficiency (SSE), you can measure its most critical combustion parameters. This information saves time and informs both service and installation adjustments.



Modern combustion analyzers measure O_2, CO, and flue-gas temperature. Some models also measure draft. Combustion analyzers also calculate combustion efficiency or steady-state efficiency (SSE), which are synonymous.



Natural-draft, open combustion gas burners: Combustion air comes from the indoors in open combustion appliances. These burners use the heat of the flame to pull combustion air into the burner. Dilution air, entering at the draft diverter, prevents overfire draft from becoming excessive.

70+ Furnace: Sample flue gases within the draft diverter inside each exhaust port.

80+ Furnace: Measure draft and sample flue gases in the vent connector above the furnace.

8.4.1 Critical Combustion-Testing Parameters

These furnace-testing parameters tell you how efficient and safe the furnace currently is and how much you might be able to improve efficiency. Use these measurements to analyze the combustion process.

Carbon monoxide (CO) (ppm): Poisonous gas indicates incomplete combustion. Modern combustion analyzers let you choose between an as-measured value or a calculated value that states the concentration of CO in theoretical **air-free** flue gases. Adjusting combustion to produce less than 100 ppm as measured or 200 ppm air-free is almost always possible with fuel-pressure adjustments, air adjustments, or burner maintenance.

Oxygen (percent): Indicates the percent of excess air and whether fuel-air mixture is within a safe and efficient range. Efficiency increases as oxygen decreases because excess air, indicated by the O_2 carries heat up the chimney. Percent O_2 may also indicate the cause of CO as either too little or too much

combustion air. Technicians used to measure CO_2, but O_2 is easier to measure, and you only need to measure one of these two gases.

Flue-gas temperature: Flue-gas temperature is directly related to furnace efficiency. Too high flue-gas temperature wastes energy and too-low flue-gas temperature causes corrosive condensation in the venting system.

Smoke number: For oil only, this measurement compares the stain made by flue gases with a numbered stain-darkness rating called smoke number. Smoke number should be 1 or lighter on a 1-to-10 smoke scale.

Draft: The pressure in the chimney or vent connector (chimney draft or breech draft). Also the pressure in the combustion chamber (over-fire draft), used primarily with oil power burners.

Table 8-4: Combustion Standards for Gas Furnaces and Boilers

Performance Indicator	SSE 70+	SSE 80+	SSE 90+
Carbon monoxide (CO) (ppm as measured/air-free)	<200 ppm/ 400 ppm	<200 ppm/ 400 ppm	<200 ppm/ 400 ppm
Stack temperature (°F)	350°–475°	325°–450°	<120°
Oxygen (%O2)	5–10%	4–9%	4–9%
Natural gas pressure inches water column (IWC)	3.2–4.2 IWC*	3.2–4.2 IWC*	3.2–4.2 IWC*
LP gas pressure	10–12 IWC	10–12 IWC	10–12 IWC
Steady-state efficiency (SSE) (%)	72–78%	78–82%	92–97%
Chimney draft (IWC, Pa.)	–0.020 IWC –5 Pa.	–0.020 IWC –5 Pa.	0.100–0.250 IWC +25–60 Pa.

* pmi = per manufacturer's instructions
Use these standards also for boilers except for temperature rise.
See "Minimum Oil Burner Combustion Standards" on page 323.

Table 8-5: Carbon Monoxide Causes and Solutions

Cause	Analysis & Solution
Flame smothered by combustion gases.	Chimney backdrafting from CAZ depressurization or chimney blockage.
Burner or pilot flame impinges.	Align burner or pilot burner. Reduce gas pressure if excessive.
Inadequate combustion air with too rich fuel-air mixture.	O_2 is <6%. Gas input is excessive or combustion air is lacking. Reduce gas or add combustion air.
Blower interferes with flame.	Inspect heat exchanger. Replace furnace or heat exchanger.
Primary air shutter closed.	Open primary air shutter.
Dirt and debris on burner.	Clean burners.
Excessive combustion air cooling flame.	O_2 is >10%. Increase gas pressure.