



Combustion Testing Procedures

To ensure safe and efficient burner operation, all residential, commercial and industrial space and process heating equipment must be properly tested for:

- Carbon monoxide
- Smoke (Fuel oil only)
- Excess air
- Stack temperature
- Draft

Oxygen, Carbon Monoxide and Stack Temperature

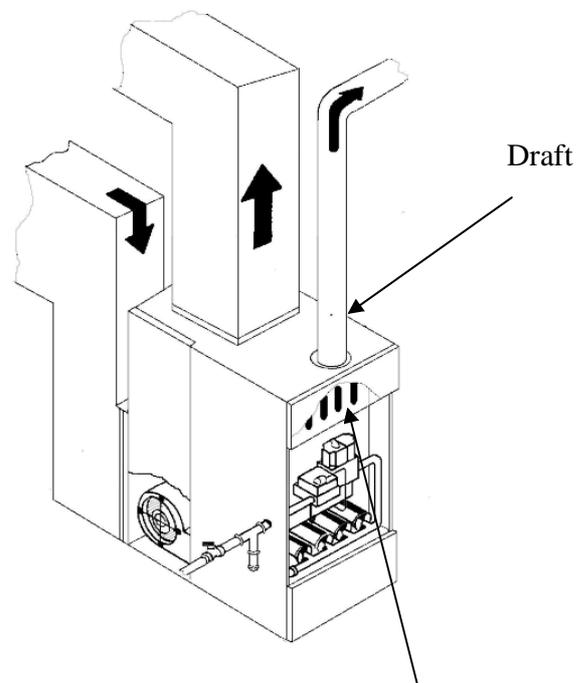
The measurement for gases and temperature should be taken at the same point. Typically, this is done by selecting a sample location 'upstream' from the draft diverter/hood, barometric control or any other opening, which allows room air to enter and dilute flue gases in the stack. In larger installations it may also be necessary to extract a number of samples from inside the flue to determine the area of greatest flue gas concentration. Another common practice is to take the flue gas sample from the 'Hot Spot' or the area with the highest temperature.

Make sure that the sample point is before any draft diverter/hood or barometric damper so that the flue gasses are not diluted and the stack temperature has not been decreased by surrounding air used to balance the draft.

The sample point should also be as close to the breach area as possible, again, to obtain an accurate stack temperature. This may also provide a more accurate O₂ reading should air be entering the flue gas stream through joints in sheet metal vent connectors.

When testing **atmospheric, forced air heating equipment** with a clamshell or sectional heat exchanger design, test each of the exhaust ports at the top of the heat exchanger. The probe should be inserted back into each of the exhaust ports to obtain a flue gas sample, before any dilution air is mixed in.

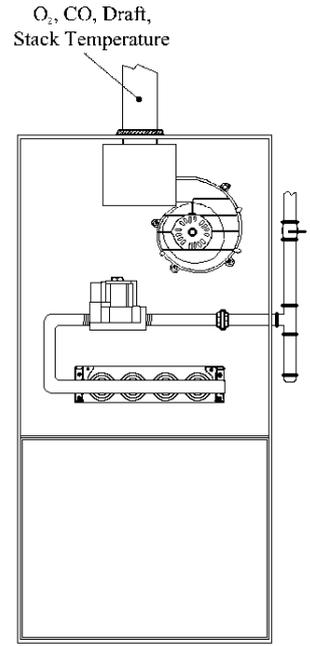
Draft tests should be taken from a hole drilled in the stack downstream from the draft hood.



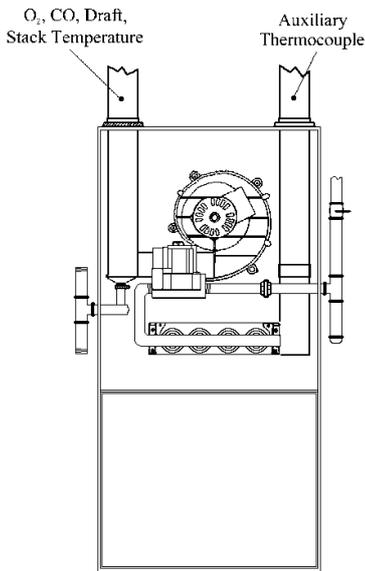
Verify Proper
Combustion:

- O₂
- CO Air Free
- Stack Temp

Combustion and draft testing fan assist, furnaces/boilers should be done through a hole drilled in the vent immediately above the inducer fan.



80% Fan Assist Furnace/Boiler



90% Condensing Furnace/Boiler

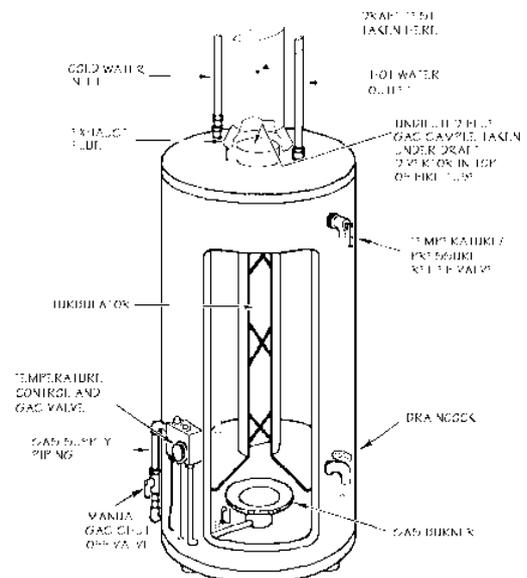
Condensing furnaces/boilers can be tested through a hole drilled in the plastic vent pipe (when allowed by the manufacturer or 'local authority of jurisdiction) or taken from the exhaust termination.

In order to obtain an accurate Steady State Efficiency reading, an auxiliary thermocouple must be inserted in the combustion air intake so that a true net stack temperature is used in the calculation.

It is important to remember that the vent system on these units operates under a positive pressure. As a result, any holes in the vent need to be sealed.

Domestic hot water heaters with the 'bell' shaped draft diverter on top can be accurately tested by attaching a section of copper tubing to the probe or using a flexible probe which is then inserted directly into the top of the fire tube below the diverter.

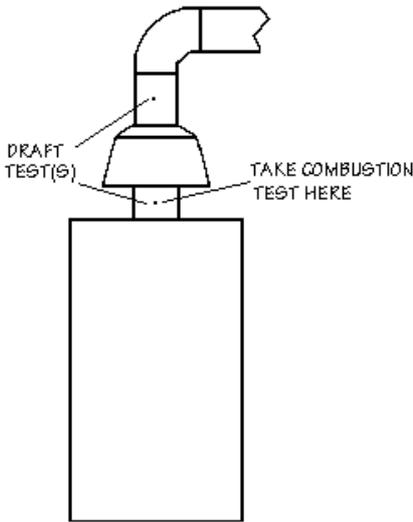
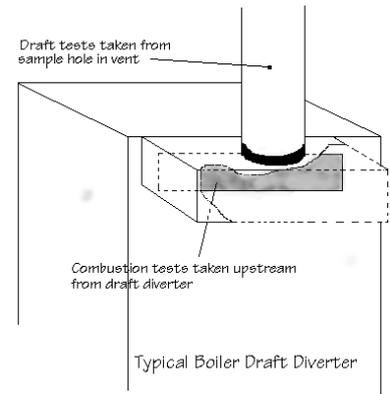
Another common practice is to insert the probe in the hole drilled for the draft test, direct it down and push it below the level of the draft hood.



Gas Fired Domestic Hot Water Tank

When testing boilers with a draft diverter mounted on the back of the equipment, flue gas samples should be taken by passing the probe from one side to the other, again upstream (toward the burner) from the opening into the draft diverter.

Draft tests should be taken from a hole drilled in the vent connector immediately above the diverter.



Typical Atmospheric Boiler cabinet.

Boilers, which have a ‘bell’ shaped draft diverter directly on top, should be tested directly below the diverter through a hole drilled in the vent connector.

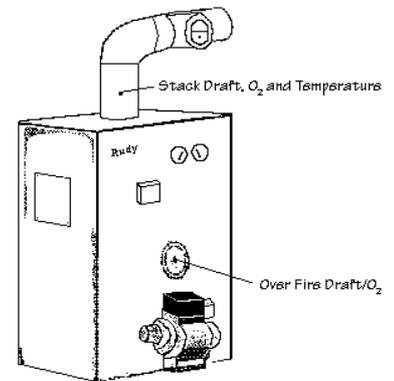
Should draft tests below the diverter measure insufficient draft levels, an additional test should be performed above the diverter to determine if the reason for insufficient draft is related to a chimney problem or a draft hood problem.

It is also a good idea to test any areas with openings that provide a path for combustion air to be introduced to the flame. These areas provide a path where flue gases can potentially be exhausted.

With forced air systems this area is generally limited to immediately in front of the burners while many styles of boilers allow secondary combustion air to also be drawn in from all around the base of the

Gas and oil fired power burners should be tested up stream from the barometric, as close to the breech area as possible.

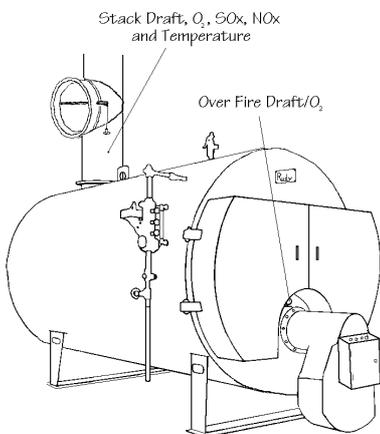
While stack draft may be an important measurement, fuel oil and gas fired power burners require draft control over the fire to maintain a proper and controlled intake of combustion air.



Comparing stack and overfire O₂ can verify that leakage between boiler sections, access door, etc is minimal and the combustion test results are accurate.

Use caution when taking over fire O₂ readings. Do not expose thermocouple or sampling assembly to excess temperatures longer than necessary.

When testing (primarily commercial/industrial) equipment with modulating or multiple firing rates, it is critical that tests are performed throughout the entire firing range. Failing to test throughout the entire cycle of burner operation may not identify a particular point at which O₂ readings are outside the manufacturer’s specifications or excess levels of CO are produced.



Acceptable Combustion Test Results

It is very important to consult with the manufacturer or their literature to determine acceptable ranges of O₂, CO air free, Stack Temperature, Steady State Efficiency, Smoke and Draft. Requirements for NO, NO₂ and SO₂ emissions (if any exist) vary from local to local.

The following ranges are generally considered acceptable for residential/commercial/industrial units; *always check with the appliance manufacturer of specific recommendations*, particularly when testing 90% residential equipment as recommended test results vary considerably from manufacturer to manufacturer, particularly on 2 stage firing rates.

Residential/Light Commercial Gas Fired Equipment

Combustion Readings	Atmospheric Furnaces, Boilers and Hot Water Tanks	80%, Fan Assist Furnaces, Boilers and Hot Water Tanks	90%, Condensing Furnaces, Boilers and Hot Water Tanks
Oxygen (O ₂)	6% to 9%	6% to 9%	4% to 9%
Stack Temperature (°F)	450° to 550° or 270° + air or water temp	325° to 450° or 170° + air or water temp	90° to 120°
Draft in Water Column Inches (WC'')	-.02 WC'' to -.04 WC'' in the stack	-.02 WC'' to -.04 WC'' in the stack	PMI
Carbon Monoxide in Parts Per Million (ppm) Air Free	<50ppm (Goal)	<50ppm (Goal)	<50ppm PMI
	>100ppm (Excessive)	>100ppm (Excessive)	>100ppm (Excessive)

Oil Fired Power Burners

Combustion Readings	Residential Furnaces, Boilers and Hot Water Tanks	Commercial Boilers
Oxygen (O ₂)	5% to 7%	4% to 6%
Stack Temperature (°F)	450° to 500°	325° to 425°
Draft in Water Column Inches (WC'')	-.01 WC'' Overfire or PMI*	-.01 WC'' Overfire or PMI
Carbon Monoxide in Parts Per Million (ppm) Air Free	<50 ppm (Goal)	<100ppm (Goal)
	>100ppm (Excessive)	>200ppm (Excessive)
Smoke	Zero or PMI	Zero or PMI

Commercial Gas Fired Power Burners

Combustion Readings	Low Fire (Light Off)	High Fire
Oxygen (O ₂)	6% to 9%	3% to 6%
Stack Temperature (°F) <small>These are recommendations, always check with the manufacturer.</small>	Atmospheric boiler	270° + water/steam temp
	2 or 3 pass power burner	170° + water/steam temp
	4 pass power burner	100° + water/steam temp
Draft in Water Column Inches (WC'') *	-.01 WC'' Over fire or PMI	-.01 WC'' Over fire or PMI
Carbon Monoxide in Parts Per Million (ppm) Air Free	<100ppm (Goal)	<100ppm (Goal)
	>300 - 400ppm (Excessive)	>200ppm (Excessive)

* Positive over fire pressure power burner recommended settings vary widely, consult the manufacturer.

**Modern Combustion
Test Instruments can:**

Measure:

- O₂
- CO
- Pressure
- Temperature

Calculate:

- CO₂
- Excess Air
- CO Air Free
- Steady State Efficiency (SSE)

Customizable
Printing Capabilities

Heating Specialties 412-576-1350	
DATE:	2/14/2011
TIME:	9:48 AM
FUEL:	(F1) Natural Gas
EFFICIENCY	79.7%
EXCESS AIR	43.7%
STACK TEMP	428° F
PRIMARY TEMP	67° F
DELTA TEMP	361° F
O2	6.7%
CO2	8.0%
CO	12 ppm
CO AIR FREE	18 ppm
Draft	-0.03 WC
COMMENTS:	

Can be used for:

- Residential and light duty commercial use
- Measuring flue gas and ambient Carbon Monoxide (up to 4,000ppm)
- Insuring sufficient draft
- Checking natural and LP gas pressures
- Verifying sufficient air flow by measuring External Static Duct Pressures (ESP)
- Testing high limit and pressure switches
- Measuring static pressure drop across coils and filters
- Measuring temperature drop/rise
- Checking for cracked heat exchangers
- Verifying sufficient combustion and make up air
- Diagnosing building pressures
- Evaluating existing equipment for cost effective replacement
- Insuring equipment is operating as designed and engineered under actual operating conditions
- Reduce nuisance lockouts and callbacks
- Finding more work!!

Printing copies of the test results:

- Reduces liability
- Develops a burner performance history to enhance preventive maintenance efforts
- Impresses homeowners and facility managers to increase 'word of mouth' referrals
- Provides a hard copy of any hazardous condition that may exist
- Helps grow your business!!

For additional information or technical support regarding combustion or carbon monoxide testing issues, feel free to contact Rudy at:

Cell 412-576-1350

rudy@hbbpro.com