ENERAC POCKET 100
COMBUSTION ANALYZER

INSTRUCTION MANUAL

REVISION 3

CHAPTER 1
INTRODUCTION

A. UNPACKING THE INSTRUMENT

Every ENERAC™ POCKET 100 includes the following:

1. One ENERAC model 100 hand-held analyzer.
2. One probe consisting of a 10" section of Inconel tubing, 10' section of flexible hose and one water-trap with silica gel desiccant and disposable filter.
3. One battery charger for charging the batteries or AC use.
4. One small screwdriver for zeroing the unit.
5. One instruction manual.
6. One plastic ABS carrying case.

B. FUNDAMENTALS

The ENERAC POCKET 100 is designed as a rugged and reliable service tool to assist the boiler operator in getting maximum performance out of his boiler or furnace. This device is the smallest and most easily portable combustion analyzer, yet it offers more features than many other analyzers that are up to ten times larger in size and bulk.

The instrument measures three key boiler parameters:

1. Stack temperature
2. Oxygen
3. Carbon monoxide.

It computes three important stack parameters:

1. Carbon dioxide
2. Combustion efficiency
3. Carbon monoxide to carbon dioxide (CO/CO_2) ratio.

Basic operation is as follows:

Turn the instrument on, insert the probe in the stack, and read desired parameters on the display.

C. IMPORTANT ADVICE.

Most stack gases are hot, full of moisture, corrosive and laden with particles of soot. To make sure that your instrument will give you a long time of trouble free performance, please observe the following recommendations.

1. Never use the instrument without the condensation trap inserted between the probe and the unit.
2. Replace the disposable filter as soon as it becomes noticeably discolored.
3. Replace the desiccant when it turns pink-white.
4. Do not expose the probe tip to open flame.
5. Do not rest the hose of the stack probe on a hot boiler surface.
6. Allow the probe tip to cool off before packing the probe.
7. At the end of a measurement remove the water collected from the condensation trap and shake the hose vigorously to drain any remaining moisture from it.

CHAPTER 2
BASIC INSTRUMENT OPERATION

A. INSTRUMENT START-UP

1. Open the instrument case and remove the analyzer and the probe. If the case temperature is less than 40 degrees Fahrenheit, wait a few minutes for the unit to warm up. This way you avoid excess condensation inside the unit.

Connect the stack probe to the instrument as follows:

2. Plug the thermocouple end of the probe to the miniature jack that is located on the left side of the instrument below the heading "STACK PROBE INPUTS". Push the hose end of the probe to its mating gas fitting. Make sure the fittings are locked tight to avoid any leaks.

3. Turn the unit on. Observe the instrument display. If no digits appear, it is an indication that the batteries are depleted and need recharging. (You can still operate the instrument on AC using the battery charger, if you first charge the batteries for a few minutes).

4. Wait approximately 40 seconds for the unit to warm up and the sensor outputs to settle to their normal values.

5. Zero the instrument as follows:

    a. Push the SIDE SELECTOR SWITCH (horizontal slide switch) to the right and the DISPLAY SELECTOR SWITCH to the bottom (CO-TEMP position). Use the small screwdriver, if necessary, and rotate the “TEMP ZERO” potentiometer so that the display reads zero (net temperature).
    b. Push the DISPLAY SELECTOR SWITCH to the top (CO2-OXY position). Adjust the "OXY (20.9%)" potentiometer for a reading of 20.9% on the display, if necessary.
    c. Push the SIDE SELECTOR SWITCH to the left and the DISPLAY SELECTOR SWITCH to the bottom. Adjust the "CO (ZERO)" potentiometer, if necessary, for a zero readout on the display. (This adjustment must be carried out in a clean environment, since carbon monoxide levels as high as 5 PPM are common).

You are now ready to carry out stack measurements.

B. PERFORMING STACK MEASUREMENTS.

WARNING: If the display over-ranges when reading stack temperature, or carbon monoxide, remove the probe immediately to avoid damage to the instrument! The display is indicating an over-range when the most significant digit is ONE and the remaining digits are BLANKED!

1. Set the FUEL SELECTOR SWITCH to the type of fuel used in the boiler.
2. Insert the probe in the stack.

CAUTION: Do not expose the probe tip to direct flame because you may damage the thermocouple tip. Insert the probe at least 12" below any air dampers or diverters. Make sure there are no air leaks in the stack below the probe location, otherwise you may get erroneous oxygen readings.

3. Monitor the stack temperature first to make sure it is reasonably steady and that the boiler has reached steady-state conditions.
4. Use the SIDE SELECTOR SWITCH and the DISPLAY SELECTOR SWITCH to monitor the remaining stack parameters.
5. Make any required adjustments to the boiler following the manufacturer's recommendations.

C. SHUTTING DOWN THE INSTRUMENT.

1. Remove the probe from the stack and shake it vigorously to get rid of any water accumulated. Hold the hose vertically and let any water drain into the water trap. DO NOT TOUCH THE HOT TIP OF THE PROBE.
2. Remove the water-trap and drain all water accumulated. Check the color of the desiccant and replace, if necessary.
3. Allow the unit to run for two minutes aspirating air to purge any remaining moisture from the system.
4. Turn the unit off. Plug in the battery charger to give the batteries a fresh charge.

CHAPTER 4
INSTRUMENT FEATURES

To read the desired stack parameter (i.e. temperature, oxygen etc.) push the SIDE SELECTOR SWITCH to the left or to the right and then the DISPLAY SELECTOR SWITCH up or down, as required.

A. MEASURED PARAMETERS
The ENERAC model 100 measures directly the following three parameters:

1. NET STACK TEMPERATURE. Stack temperature is measured by means of a type K thermocouple. The hot junction of the thermocouple is located at the tip of the probe. The cold junction is located at the instrument temperature jack. The display reads the difference (net) between the two temperatures. (To obtain the stack temperature, add the room temperature to the display readout). Temperature limit is 2000 °F, with a 1 °F resolution. Units exported outside the US display the stack temperature in degrees Celsius.

CAUTION: If the stack temperature exceeds 2000 F the thermocouple will be damaged permanently and a new probe will be needed.

2. OXYGEN. The oxygen level (in % by volume) is measured by means of a sealed electrochemical sensor. Sensor life is approximately one year. Two-year sensors are available on special request. The principle of operation is as follows: Oxygen that is present in the stack gases diffuses into the sensor and reacts with a lead anode producing a current. The sensor output is linearized by the instrument's electronics to produce a display readout in the range 0-25% with 0.1% resolution. None of the common stack gases cross-interfere with the oxygen sensor.

3. CARBON MONOXIDE. Carbon monoxide is also measure by means of a sealed electrochemical sensor. Sensor life is approximately two years. The carbon monoxide gas diffuses through a tiny hole on the face of the sensor. It reacts with oxygen present inside the cell to form carbon dioxide. The reaction produces an electric current proportional to the concentration of the gas. Carbon monoxide measurement range is 0-2000 PPM (parts per million) with a 1 PPM resolution. (1000 PPM = 0.1% concentration by volume).

CAUTION: If the concentration of carbon monoxide in the stack exceeds 4000 PPM, it will cause the sensor to saturate and malfunction temporarily. Exposure of the sensors to CO levels in excess of 1% (10000 PPM) will require turning the unit off for 24 hours to allow the CO sensor to recover from saturation. The Carbon monoxide sensor shows no cross-interference to most common gases found in the stack with the exception of hydrogen. Its cross interference to hydrogen is approximately 30%.

B. COMPUTED PARAMETERS

The instrument computes the following stack parameters, based on the sensor inputs and fuel selected:

1. CARBON DIOXIDE. Carbon dioxide is computed in the range of 0-20% with a 0.1% resolution. The carbon dioxide computation is based on the measured oxygen level and the fuel selected.

2. COMBUSTION EFFICIENCY. Computation of the combustion efficiency is based on the heat loss method. The heat content of the escaping stack gases is measured and subtracted from 100%. The factors affecting combustion efficiency are the following:

   a. Stack temperature. Higher temperature means lower efficiency.
   b. Oxygen (or CO_2). Higher oxygen means lower efficiency.
   c. Fuel selected.
   d. Carbon monoxide. High values may indicate operation under fuel rich conditions or improper burner combustion. Maximum efficiency is achieved by reducing the oxygen level until the carbon monoxide level (and/or smoke & combustibles) rises to the maximum permissible level for that boiler. Safety requires that boilers be operated with some excess air.

3. CARBON MONOXIDE TO CARBON DIOXIDE RATIO. The instrument computes this ratio in the range 0-1000 ((PPM CO / % CO_2) / 10). This is a quick and useful diagnostic tool to that allows non- sophisticated personnel to determine if a boiler is operating correctly or maintenance should be called for a further check. Generally a low CO/CO_2 ratio indicates proper performance and a high ratio indicates poor performance. Establish what is the largest acceptable value of this ratio for your application and then use it determine when maintenance is required.

C. FUEL SELECTION

The FUEL SELECTOR SWITCH is located in the center of the instrument and offers a selection of one of the following three typical fuels:

1. OIL. The representative values for oil are 19000 btu/lb and an ultimate CO_2 value of 16%. This corresponds to an average between a #2 oil and a #6 oil. (Efficiency readings will be about 0.2% high for #2 oil and 0.2% low for #6 oil).

2. GAS. The representative values for gas (natural gas) are 21900 btu/lb and an ultimate CO_2 value of 12%.

3. COAL. The representative values for this typical coal are 11500 btu/lb and an ultimate CO_2 of 20%. Since coal parameters vary greatly depending on the type of coal used, the efficiency and CO_2 computations may be approximate only, for a particular application.

CHAPTER 4
INSTRUMENT DESCRIPTION

A. POWER REQUIREMENTS

The instrument is powered by six "AA" size rechargeable Nickel-Cadmium batteries. Battery life is estimated at 10 hours. When the batteries are depleted the LCD display will go blank. Use the AC charger/adaptor supplied with the unit to recharge the batteries. An overnight recharge will restore the batteries to full charge. The AC charger can also be used to power the unit on a continuous basis. Do not use any other charger except the one supplied with the unit. Export units have a special charger to connect to 220 Volt mains.

B. GAS FLOW DESCRIPTION

During operation a small sample (approximately 1500 ml/min) of the stack gases is drawn by means of an electric pump located inside the instrument. The gases pass first through a 10" long 5/16" OD Inconel tube that is typically insert close to the middle of the stack cross-section and can withstand temperatures up to 2000 °F. The Inconel tube is attached to an aluminum handle whose function is to cool the gases and provide a grip. An Inconel sheathed thermocouple is also located inside the Inconel tube. The gas is then drawn through a 10 ft. long braided latex hose, where most of the moisture is condensed. Longer lengths of hose are available on request. Keep in mind that for every additional 10 ft. of hose instrument response slows down by about 30 seconds. A condensation trap is located at the end of the hose. This consists of a plastic cylinder that is divided into two compartments. The first compartment is designed to trap the moisture that has already condensed in the hose section. The second compartment is filled with a desiccant (preferably Silica gel), which removes the remaining water vapor and prevents further condensation inside the instrument. The Silica gel is dyed blue. As water vapor accumulates it turns pink first and then pink-white when it is finally saturated with moisture. Immediately after the water-trap there is a disposable filter, whose function it to remove the soot particles that are carried by the gas. The filter should be replaced when it becomes noticeably discolored. The gas enters the instrument and passes through a small electric pump. The pump is capable of extracting gas from stacks with up to 20" of water negative draft. Following the pump the gas passes through a small gray container that houses the oxygen sensor and then through the carbon monoxide housing and is finally exhausted through the small opening on the side of the instrument.

CHAPTER 5
MAINTENANCE

A. MAINTENANCE OF THE CONDENSATION TRAP

The water-trap is made of two compartments. The first compartment is intended to catch all moisture that has condensed in the probe. The second compartment is filled with a desiccant material (#44 silica gel) that will adsorb the remaining water vapor in the stack gas. The desiccant is colored deep blue when dry. As it absorbs moisture its color changes progressively to dark pink and eventually to pale pink when it is completely used up. There is sufficient desiccant material in the trap for approximately four hours of continuous operation. When the desiccant is used-up it must be replaced, otherwise moisture will eventually penetrate through the filter and will be deposited on the surface of the sensors. This may cause erratic or low readings. Used-up desiccant material can be reactivated by heating it at 300-400 °F in a clean atmosphere for about one hour until it becomes blue again. Because of possible soot collection, however, it may be impractical to reactivate the desiccant more than two or three times. Extra desiccant material is available from the factory. It is supplied in one-pound containers. To replace the desiccant material, simply pull out the plastic plug (cap-plug) that is located at the bottom end of the water trap. Fill the silica gel compartment with new material and force the plastic plug back over the clear tube until an airtight seal is obtained. Liquid water that has accumulated in the first compartment can be removed by simply pulling out the cap-plug at the other end of the water trap, pouring out the liquid, and replacing the plug.

B. CHANGING THE DISPOSABLE FILTER

The disposable filter needs periodic replacement. It must be replaced if it becomes noticeably discolored, or if the pump fails to operate, indicating a blockage in the line. The disposable filter must always be connected so that the direction of flow is radially inwards (towards the center). This allows the operator to more easily notice discoloration of the filter and any moisture that penetrates through the water trap. To replace the filter, simply loosen the two clamps that secure it to the hose. Take a new filter and connect the two ends of the tubing to it, observing the correct direction of flow. Fasten the clamps.

C. REPLACING THE OXYGEN SENSOR

This is an infrequent procedure, since the oxygen sensor has a minimum life of a year. The oxygen sensor needs replacement when it is no longer possible to obtain a readout of 20.9% on the display, by adjusting the "OXY (20.9%)" potentiometer in ambient air. Before replacing the oxygen sensor make sure that a low oxygen reading is not due to condensation on the sensor's surface. To be sure, let the instrument run with fresh desiccant and aspirating ambient air for about three hours. If the sensor does not recover, then it must be replaced. To replace the oxygen sensor, remove the four screws that fasten the back of the case to the front. The oxygen sensor is located inside the small disposable gray plastic housing near the top of the instrument. Disconnect the two wires, then the two pieces of plastic tubing and pull the housing out. Dispose of it properly. Snap in a new sensor and connect the two wires and the pieces of plastic tubing. Make sure there is no kink in the hoses. Reassemble the case and wait 5 minutes for the sensor output to stabilize before calibrating.

D. REPLACING THE CARBON MONOXIDE SENSOR

This is a very infrequent procedure since the carbon monoxide sensor has an expected life of 1-2 years. The CO sensor needs replacement when it is no longer possible to calibrate the instrument using calibrated gas. To replace the sensor, remove the four screws that secure the base and expose the interior to the instrument. The sensor is the 1-1/2 inch round plastic disk that is attached to the back of the aluminum housing. Remove the screws that hold the sensor (the CO sensor contains sulfuric acid, exercise caution). Attach a new sensor to the housing. Remove the short between the sensor terminals and connect the wires to the sensor, observing the correct color code. Carefully, close the case, making sure that no wires or tubing are being pinched. Secure the case with the four screws.

E. INSTRUMENT CALIBRATION

There are three sensors in the instrument. The thermocouple requires normally no calibration during the life of the instrument. The oxygen sensor is normally span calibrated to 20.9% every time the unit is turned on.

The carbon monoxide sensor has been calibrated at the factory by using a calibrated gas that contains 200 PPM carbon monoxide in air. (However, any other calibration gas in the range of 50-500 PPM CO in air or nitrogen can be used, if available). The sensor possesses good stability and does not require frequent calibration. If it is desired to check the CO calibration of the instrument, connect the probe and turn on the instrument. Wait two minutes and carefully zero the instrument, making sure the air the instrument draws is clean and free of any smoke or exhausts. Feed the calibrated gas to the stack probe at a rate of approximately 1500 cc/min. Wait till the reading has stabilized. Make sure the area is well ventilated, or carry the calibration out under a fume hood, since carbon monoxide gas is highly toxic. Remove the small round black plastic cover to expose the adjustment labeled "CO (SPAN)" Using a small screwdriver, rotate the span adjustment potentiometer until the display indicates the correct reading. Replace the black plastic cap to avoid rotating this potentiometer accidentally. Shut off the gas, disconnect the probe, and wait 3 minutes until the reading goes back to zero.

CHAPTER 6
THE SIGNIFICANCE OF CO GAS

Carbon monoxide is a colorless, tasteless, odorless gas. It is slightly lighter than air. It is almost always found as a by-product of incomplete combustion. Carbon monoxide burns in air or oxygen to form carbon dioxide. The blue flame observed over a coal fire is carbon monoxide burning to carbon dioxide. Carbon monoxide is a direct and cumulative poison. It combines with the hemoglobin of the blood to form a relatively stable compound, carbony-hemoglobin, which makes the blood useless as an oxygen carrier. When about one third of the hemoglobin was combined, the victim dies. The gas is one of the most treacherous poisons because of its odorless character and insidious action. A concentration of 100 PPM of carbon monoxide in air produces symptoms of poisoning while a concentration of 1500 PPM (0.15%) will cause death in thirty minutes. The permissible levels for work areas, as specified by OSHA, are 50 PPM on a time weighted 8-hour day with a maximum allowable concentration of 400 PPM. Carbon monoxide in the home may come from a leaky furnace or red-hot kitchen stoves or heaters when the draft is closed. In the workplace, it is often the result of operation of internal combustion engines, where exhaust may contain from 1% to 8% (80,000 PPM) carbon monoxide, due to incomplete combustion. It has been estimated that a 20 horsepower engine produces one cubic foot/minute of the gas. In a small closed area, such as a garage, the atmosphere becomes deadly in 5 minutes if the engine is left running. A person breathing this atmosphere becomes helpless before realizing the danger. Even outdoors, in crowded city streets, the carbon monoxide concentration may approach the danger level. Since carbon monoxide is the product of incomplete combustion in a furnace, it becomes an excellent mechanism for reducing the excess air until incomplete combustion begins to take place. For most well functioning industrial burners or furnaces, a carbon monoxide concentration in the range of 100-200 PPM usually coincides the maximum boiler efficiency and therefore maximum fuel savings.

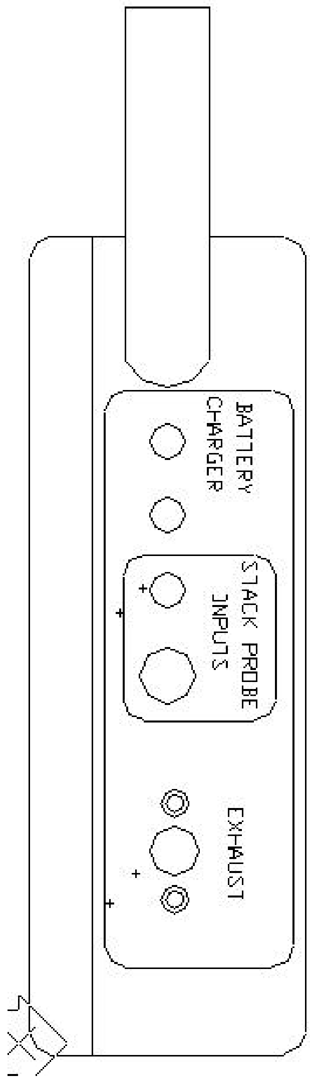
APPENDIX A

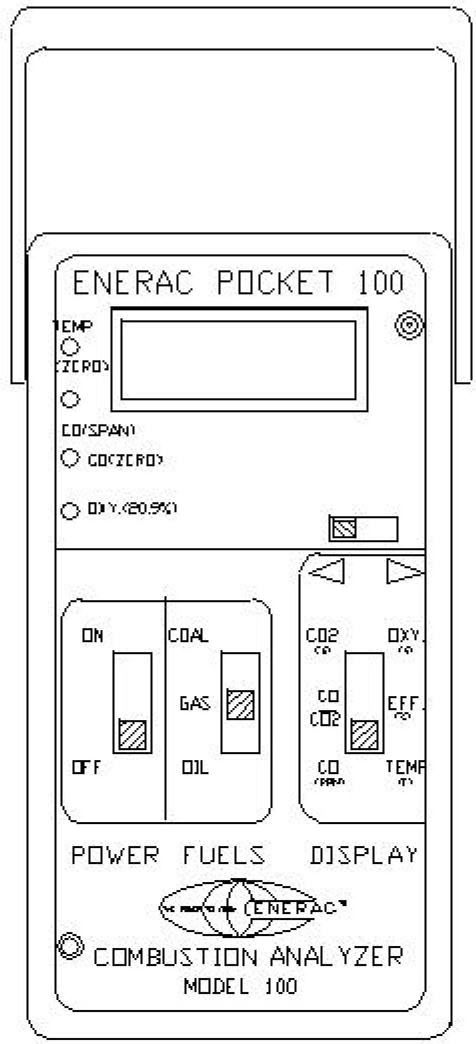
SYSTEM SPECIFICATIONS

Size:	5.9" x 3.1" x 1.9" plus handle
Weight:	2 lbs
Probe:	10" Inconel (5/16" OD) with 6 ft. black latex hose, condensation trap, desiccant and filter.
Power:	Six AA rechargeable Ni-Cd batteries (8-hour continuous operation, typically. 120 VAC operation using battery charger.
Display:	1/2" high, 3 1/2 digit LCD
Operating Temperature:	-10 to +40 degrees Celsius
Operating Humidity:	5% to 95% RH, non-condensing
Maximum Stack Temperature:	2000 °F

Measured parameters	
Temperature sensor:	Type K thermocouple, reads net temperature. Range: 0-2000 °F Resolution: 1 °F Accuracy: 5% of reading Response time: 90 seconds to 90% of final reading
Oxygen sensor:	Sealed electrochemical cell. Life 1 year. Range: 0-25.0% Resolution 0.1% Accuracy: 0.2% Response time: 45 seconds to 90% of final reading
Carbon Monoxide sensor:	Sealed electrochemical cell. Life 2 years. Range: 0-2000 PPM Resolution: 1 PPM Accuracy: 5% of reading Response time: Less than 120 sec. for 90% of final reading. Interference: Negligible cross-interference (<2%) from methane, sulfur dioxide, oxides of nitrogen. Hydrogen cross interference 30%

Computed parameters	
Carbon Dioxide	Range: 0-20% Resolution: 0.1% Accuracy: 0.3% on fuel indicated
Combustion Efficiency	Range: 0-100% Resolution: 0.1% Accuracy: 3% of reading
CO/CO_2 Ratio ((PPM / %) / 10)	Range: 0-1999 Resolution: 1 unit Accuracy: 10% (5%< CO_2 <20%, 10 PPM< CO <2000 PPM)


BATTERY CHARGER
STACK PROBE INPUTS
EXHAUST


ENERAC POCKET 100
TEMP
(ZERO)
CO(SPAN)
CO(ZERO)
OXY.(20.9%)
ON
OFF
COAL
GAS
OIL
CO2
OXY.
CO
CO2
EFF.
CO
TEMP
POWER
FUELS
DISPLAY
ENERAC
COMBUSTION ANALYZER
MODEL 100