INSTRUCTION MANUAL

THE POWER TO KNOW

ENERAC

INTEGRATED EMISSIONS SYSTEM

MODEL 700

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ENERAC 700 MANUAL

EDITION 5

M700 FIRMWARE 3.0+
M700 HARDWARE >= H

TABLE OF CONTENTS

CHAPTER 1

FUNDAMENTALS

The ENERAC Model 700 Integrated Emissions System is an advanced hand-held analyzer designed to measure, record, and transmit its combustion and emissions parameters.

The Model 700 emissions analyzer consists of the sampling system, whose function is to extract, clean, and dry the sample, and the main unit, which analyzes the sample and displays the measurements.

It has been designed as a modular system:

- The base unit contains the sensors, pumps, electronics, and battery.
- The thermo-cooler (or water-trap) is attached to the side of the analyzer.
- The probe, thermocouple, and hose-assemblies are connected to complete the sampling system.

Standard analyzer capabilities include measuring ambient temperature, stack temperature, stack draft, and oxygen.

The available options are separated into three categories:

1. SAMPLE PROBES & CONDITIONING SYSTEMS

   A. Inconel probe (9" typical) with latex sampling-line and water-trap
   B. Inconel probe (9" typical) with Viton sampling-line and thermoelectric condenser.
   C. Stack-Velocity probe: Stainless-Steel S-type Pitot tube for stack velocity measurements (in feet/second) and stack gas flow-rate measurements (in cubic-feet/minute).

2. ANALYZER SENSORS

   A. Carbon Monoxide (CO) sensor - SEM type electrochemical sensor
   B. Nitric Oxide (NO) sensor - SEM type electrochemical sensor with on-board temperature monitoring
   C. Nitrogen Dioxide (NO_2) sensor - SEM type electrochemical sensor
   D. Sulfur Dioxide (SO_2) sensor - SEM type electrochemical sensor
   E. Hydrogen Sulfide (H_2S) sensor – Standard electrochemical sensor
   F. Ammonia (NH_3) sensor – Standard electrochemical sensor
   G. Carbon Monoxide / Carbon Dioxide / Hydrocarbons sensor bench – Non-dispersive-infrared (NDIR) sensors

3. ANALYZER OPTIONS

Standard Equipment

A. Internal storage capacity of 500 buffers
B. Integrated 2” thermal printer
C. Serial communications via USB or RS-232 connection
D. Custom-fuel programming

Optional Equipment

E. Additional pump and O_2 sensor for dual-range measurement and purging capability
F. Bluetooth wireless communications

The ENERAC Model 700 is the most advanced portable emissions analyzer. It uses the latest proprietary (SEM™) electrochemical sensors, and non-dispersive infrared (NDIR) technology to measure emissions.

The ENERAC Model 700 is an extremely versatile emissions measurement system that meets practically all emissions measurement requirements:

- Measuring stack temperature and oxygen concentration.

- Measuring the ambient temperature inside the analyzer where the sensors are located, as specified by the EPA methods CTM-030 and CTM-034.

- Measuring the emissions of carbon monoxide, oxides of nitrogen, and sulfur dioxide from stationary and mobile combustion sources by means of high-quality (SEM) electrochemical sensors.

- Measuring the oxide of nitrogen emissions in accordance with the EPA Provisional Reference Method (EMTIC CTM-022, CTM-030, & CTM-034) for portable NOX analyzers.

- Measuring, carbon monoxide, carbon dioxide, and gaseous hydrocarbons as propane using NDIR technology. The Model 700 meets EPA’s Reference Method 25B Appendix A 40CFR60 “Determination of Total Gaseous Organic Concentration Using a Non-dispersive Infrared Analyzer”.

- Computing the emission rates in parts-per-million (PPM), pounds-per-million-BTU, or grams-per-brake-horsepower-hour; mass-emissions measurement in pounds-per-hour for CO, NO_X, and SO_2, and in tons-per-day for CO_2, according to the EPA's 40CFR75 regulations for continuous emissions monitoring.

- Measuring the stack gas velocity and volumetric flow-rate, and computing emission rates according to the EPA Method 2, or Method 2C, Appendix A of 40CFR60.

The ENERAC Model 700 can assist the operator of a combustion source with the task of optimizing its performance and saving fuel. It can be used as a management tool to assist the plant manager with keeping records and controlling costs.

Basic instrument operation is as follows:

You insert the probe in the exhaust stack of an operating combustion source, such as a boiler, furnace, or combustion engine. A pump located inside the instrument draws a small sample of the stack gas. The sample is conditioned before entering the analyzer. A number of sensors analyze the contents of the stack gas. The analyzer can store data, print records, and connect to your computer using a USB or Bluetooth connection.

A. UNPACKING THE INSTRUMENT

The ENERAC Model 700 Integrated Emissions System includes:

1 The Model 700 Emissions Analyzer

2 A stack-probe

3 A sampling-line assembly

4 A sample-conditioning system: either a water-trap or a thermoelectric-condenser

5 A battery charger

6 An extra roll of thermal printer paper

7 PTFE membrane (For NDIR option only)

8 One extra disposable filter

B. PREPARING THE INSTRUMENT

1. Remove the instrument from its case and connect the thermoelectric condenser (or water-trap) and probe to the unit.

2. Make sure the instrument is in a clean-air, room-temperature environment and turn it on. If you have a problem with the display initializing, please RESET the unit. **The RESET switch is located next to the charger connector.**

3. *IF YOU HAVE THE INFRARED (NDIR) OPTION*, you must press **ENTER** to begin an autozero countdown. Allow instrument to warm up for 5 to 10 minutes before autozeroing.

4. *IF YOU DON'T HAVE THE INFRARED OPTION*, you may bypass the initial autozero, although it is recommended that you zero the instrument once before beginning your tests. Allow instrument to warm up for 5 to 10 min. before autozeroing. To bypass the autozero, press the **DISPLAY DATA** key.

5. After an autozero, if the status line of the display shows AUTOZERO COMPLETE, you are ready to use the instrument for your measurements. If at the end of the autozero countdown the display shows an error message for a particular sensor, see the troubleshooting table in section D of this chapter.

The instrument will measure correctly all sensors that do not show an error message.

6. The LOW RANGE mode is the default setting. If any parameter reads OVER on the display, you must withdraw the probe from the stack immediately to prevent sensor saturation.

DUAL RANGE OPTION

7. If you suspect HIGH concentrations of gases in your stack, or if your emissions sensors read OVER in the LOW RANGE, press the **PUMP** key to switch the instrument to its HIGH RANGE mode.

For CO, an auto-range setting is available. This enables the unit to switch automatically to high range when the CO concentration reaches a user determined threshold. This feature is explained in chapter 6.

EFF:	OVER%	CO:	0PPM
ST:	80°F	NO_X:	0PPM
OXY:	20.9%	NO:	0PPM
HC:	0PPM	NO_2:	0PPM
CO_2:	0.0%	SO_2:	0PPM
AIR:	OVER%	DFT:	0.0″
LOW RANGE			12:45:00

THE DATA SCREEN

C. IMPORTANT ADVICE

Most stack gases are hot, full of moisture, corrosive and laden with soot particles.

To make sure that your instrument will give you a long time of trouble-free performance, please observe the following recommendations.

1. Follow the instructions in this manual.

2. Never use the instrument without the disposable filter(s) located in line with the thermoelectric cooler or inside the water-trap. Operating the instrument without the filter may damage the pump and sensors. (This is a costly replacement!)

3. Prevent moisture from entering the analyzer. If the electrochemical sensors get wet they will not work until they can dry out. If the NDIR bench gets wet it will not read properly, and afterward, it may not autozero successfully. Once dried, typically overnight, the electrochemical sensors will usually recover. However, the NDIR optics will probably require cleaning at the factory.

4. Do not expose the probe tip to open flame.

5. Do not rest the stack probe's hose on a hot boiler surface.

6. Allow the probe tip to cool off and the instrument to aspirate air before packing the probe.

7. Always be sure to use single span gas mixtures preferably with balance nitrogen when calibrating the sensors. Do not use CO/NO, NO/NO_2, or SO_2/NO_2 span gas blends for calibration!

D. AUTOZERO ERRORS & BASIC TROUBLESHOOTING

AUTOZERO ERRORS		
Channel	**Possible Causes**	**Resolution**
CO NO NO2 SO2 O2 Combustibles	Sensor has been recently exposed to gas and has not returned to zero.	Wait 10 minutes, monitor sensor voltage, and re-zero.
	Battery was dead, sensor has destabilized.	Charge battery, wait a few hours for sensor to stabilize, and re-zero.
	Sensor cell is dead.	Call for a replacement.
Stack Temperature	Thermocouple is hot.	Probe tip should be cool.
Stack Draft	Thermo-electric cooler or water trap not connected.	Draft voltage will be high. Connect probe and re-zero or ignore draft readings.
	Filters are dirty.	Draft voltage will be low. Check filters.
	Hose is kinked, possibly Internally.	Draft voltage will be zero. Check for suction at end of probe.
Infrared CO-CO2-HC 00	No response from infrared system.	Autozero period must be at least 40 seconds. Zero the instrument again.
Infrared CO-CO2-HC XX	Infrared system is reporting error code XX.	Infrared system may need maintenance.

POWER-UP PROBLEMS		
Symptoms	**Possible Causes**	**Resolution**
Analyzer will not turn on (Screen is off).	Battery is dead.	Plug in the charger. Analyzer should turn on.
	Battery is not charging.	Check charger and jack.
	Internal initialization problem.	Reset the analyzer.
Analyzer turns on but screen has no text or is faded.	Internal initialization problem.	Reset the analyzer.
	Analyzer is overheating.	Unplug charger. Check fan. Turn off & on to reinitialize.

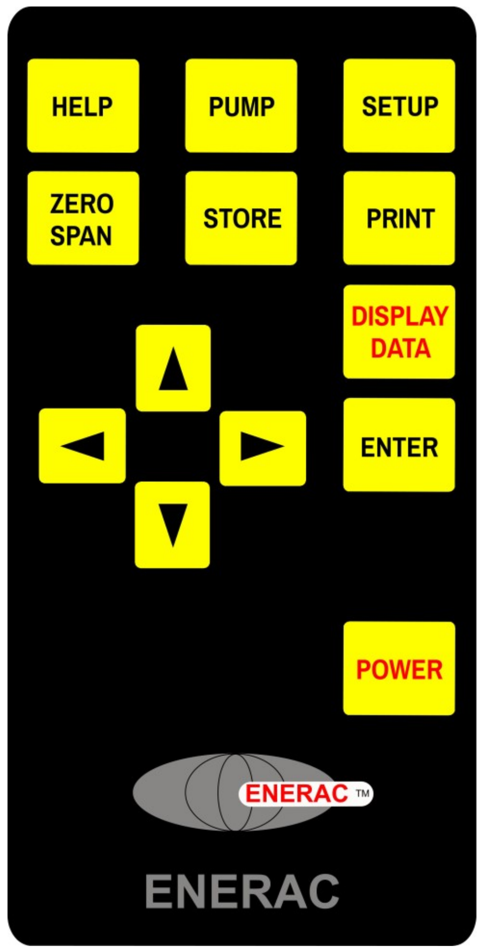
CHAPTER 2

BASIC INSTRUMENT OPERATION

THE INSTRUMENT KEYBOARD

The Model 700 is operated by the 13-button keyboard located on the front of the analyzer.

- The **POWER** key turns the unit on and off.
- The **DISPLAY DATA** key shows the currently measured parameters.
- Four keys will bring up a menu: **SETUP**, **ZERO/SPAN**, **STORE**, & **PRINT**.
- The menus are navigated with the **UP**, **DOWN**, **LEFT**, **RIGHT**, & **ENTER** keys.
- The **HELP** key provides a brief explanation of each menu's functions.
- The **PUMP** key controls the analyzer's measurement mode. There are four states:
    - LOW RANGE
    - HIGH RANGE (Dilution option)
    - PURGE
    - OFF



At the end of this manual is a useful chart which summarizes the keyboard operation of the analyzer.

INSTRUMENT OPERATION OVERVIEW

Follow the steps outlined below.

1. Attach the sample conditioning system and hose/probe assembly and turn the instrument on by pressing POWER key.

2. The instrument pump will immediately turn on and the ENERAC logo will appear.

3. Press the **DISPLAY DATA** key (**ENTER** for infrared equipped units) and check the unit's battery condition. The **DISPLAY DATA** key toggles between a small font and a large font screen. Select the small font screen.

Battery Full

Battery Empty

Battery Charger Connected

Fast-Charge Mode

EFF:	OVER%	CO:	0PPM
ST:	80°F	NOX:	0PPM
OXY:	20.9%	NO:	0PPM
HC:	0PPM	NO2:	0PPM
CO2:	0.0%	SO2:	0PPM
AIR:	OVER%	DFT:	0.0"
LOW RANGE		12:45:00	

NOTE: Depending on your analyzer's configuration, some of the entries in one or more of the displays shown here may be different or blank

The battery icon is displayed in the middle of the bottom line of the display. Its condition is marked by the shaded fraction of the icon. If the unit is powered by the battery charger, a small 'plug' icon will replace the battery icon.

When connecting the battery charger to the analyzer make sure that the 'plug' icon appears on the **DISPLAY DATA** screen. This ensures a proper power connection and charging of the batteries.

4. If you are using the analyzer for the first time, press the **SETUP** key to set the appropriate parameters (measurement units, fuel, etc.) for your application.

5. Use the **UP/DOWN** and **ENTER** keys to modify any parameter. See Chapter 6: Analyzer.

6. After making sure that the analyzer is drawing clean air at room temperature sample, press the **ZERO/SPAN** key.

```
JAN 1 '19   12:45:00
Fuel:    Natural Gas
Temperature Units: F
Measure Units:   PPM
Pressure Units: inWC
OxygenReference:TRUE
Pumps: AUTO RANGE
Dilute CO:   2000PPM
CO-IR Thresh:6000PPM
Cooler Duty: 50%
Thermal Eff:0.30
Display Contrast:24
Baudrate:  9.6 kbps
Velocity Units: FPS
Stack Size:5000 in²
Version: 3.09IV
Battery: 5.20 V
```

The line:

`Zero All Sensors`

will be highlighted.

Press the **ENTER** key to execute an auto zero cycle of all the sensors.

7. Following the end of the autozero period, all sensors should indicate zero reading with the exceptions of the oxygen sensor which should read 20.9% (the concentration of ambient air) and the stack temperature which should correspond approximately to the room temperature.

8. Insert the analyzer's probe into the stack or engine exhaust. Use the **DISPLAY DATA** key to read the stack parameters.

9. To obtain a printout of the data displayed, press the **PRINT** key.

   "Print Test Record"

   will be highlighted. Press the **ENTER** key.

10. To store the data displayed, press the **STORE** key.

    "Store Current Buffer"

    will be highlighted. Press the **ENTER** key.

11. When you are finished with your measurements, withdraw the probe from the stack. Allow the analyzer to draw ambient air for a few minutes, and for the probe to cool down, before packing the analyzer in it's carrying case.

CHAPTER 3

POWER REQUIREMENTS

Power is supplied by a battery pack consisting of four D-size Ni-MH rechargeable batteries. A 120 –240 Volt AC charger having a 9 Volt DC/ 2.5 A output is supplied with the instrument. The battery charger will charge the 9,000 mAH batteries in about six hours.

Battery life is approximately 4-6 hours of continuous operation. When the battery voltage drops to 4.0 volts, a "battery low" warning will appear on the display. A few minutes later the instrument will automatically turn off to preserve the remaining battery power for the sensor biases.

- *The CO, NO, and SO2 sensors need a tiny amount of electrical power even when the analyzer is off.*
- *Do not allow the batteries to discharge completely. When not in daily use, remember to charge your analyzer periodically.*
- *If the analyzer has been without power for a long time, you may need to wait a few hours after recharging the battery for the sensors to be restored.*

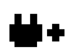
You can check the condition of the battery at any time:

1. Press the **DISPLAY DATA** key and observe the battery icon, located at the bottom of the display.

 Battery Full

 Battery Empty

 Battery Charger Connected

 Fast-Charge Mode

2. Press the **LEFT ARROW** and **RIGHT ARROW** keys together and observe the current battery voltage, listed as **BAT**. When the unit is operating on its batteries, the voltage displayed will vary from an initial 5.2–5.4 volts (fully charged), dropping slowly to 4.2 volts (batteries nearly discharged).

CHAPTER 4

SAMPLE EXTRACTION & CONDITIONING

The stack probe extracts the gas-sample and the conditioning system filters the sample and collects the water vapor.

The extraction probe is universal for all options and consists of 3/8" Inconel 600 high-temperature tubing, typically 12 inches in length. The probe tube is threaded at the stack-end to accept a sintered stainless-steel filter. A type-K inconel-sheathed thermocouple is located inside the probe tube. Maximum continuous temperature for the probe is 2,000 ºF. For stacks having a diameter larger than 24 inches, attach an inconel extension tube.

The sampling line connects to the probe and delivers the gas to the conditioning system. The hose may be made of Viton, Teflon, or EPDM. The integrated yellow wire is for connecting the thermocouple to the analyzer.

The ENERAC Model 700 can accommodate 2 types of available sample conditioning systems:

1. WATER TRAP

This is the least expensive conditioning system available. It is recommended for measurements of engine exhausts using the NDIR (infrared) option, where partial loss of NO_2 and SO_2 is not important, since the measurement of those gases is not typically required. It is also recommended as a low-cost option for combustion efficiency measurements.

- The water trap should be cleared of condensation after each use.

- The internal polypropylene filter should be replaced when it becomes noticeably discolored.

2. THERMOELECTRIC CONDENSER

The thermoelectrically-cooled condenser and trap, or 'thermo-cooler', is the standard option for the Model 700 emissions analyzer.

It is recommended for most applications where condensation removal without significant loss of the NO_2 and SO_2 fraction of the sample is required. NO_2 and SO_2 are gases that are highly soluble in water. The exhaust sample contains typically between 5% and 20% of water vapor, most of which will condense in the probe and sample line.

To prevent significant loss of NO_2 and SO_2 during transport of the sample from the probe to the analyzer, the following conditions must be satisfied:

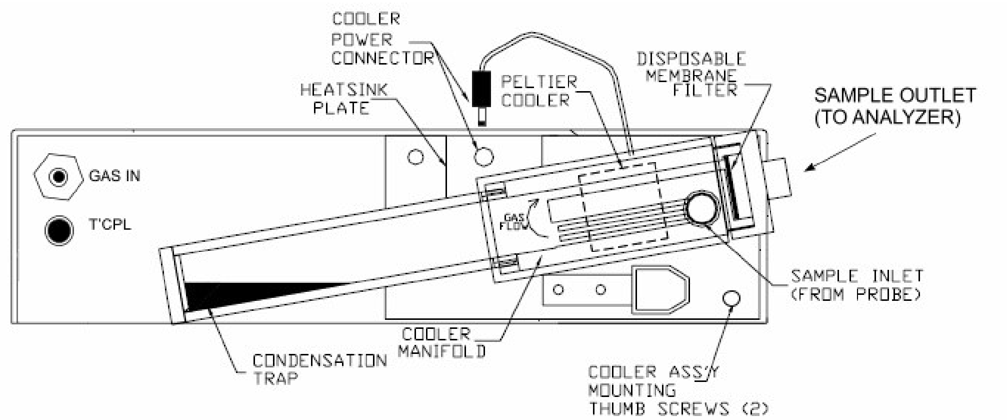
1. Rapid sample transport. This is accomplished by maintaining a high flow rate over a relatively small diameter sampling line.

2. Use of a sample line made from a highly hydrophobic material. A Teflon sample line limited to 15 ft. long is best.

3. Minimum contact of the gas sample with the water collection mechanism and also no additional condensation occurring following the thermo-cooler. This is accomplished by using a specially designed Peltier cooled manifold to separate the gas from the water.

THE STANDARD THERMOCOOLER

The following drawing shows the thermo-cooler mounted to the side of the 700.



The sample, consisting of gas and partially condensed water vapor, enters the drier through the “SAMPLE INLET”. It flows through multiple narrow chilled passages, where total separation of gas and vapor occurs. The dried sample makes a 180-degree turn, flowing upwards and exiting through the “SAMPLE OUTLET”, while condensed vapor is collected in the trap.

To maintain proper operation the analyzer must be held either in a face-up horizontal or an upright-vertical position. Do not turn the unit upside-down when there is water in the condensation trap!

The thermo-cooler will maintain the sample at a certain temperature below ambient temperature to ensure no further condensation inside the analyzer. You can control this temperature differential by adjusting the COOLER DUTY CYCLE, if necessary.

The following table shows the approximate relationship between duty cycle and temperature differential:

DUTY CYCLE	SAMPLE TEMP AMBIENT TEMP (°F)*
50%	-8
100%	-14

*At 75°F ambient.

The duty cycle of the thermoelectric cooler is set at the factory to 50% and can be adjusted on the SETUP MENU.

The thermo-cooler requires electrical power for operation. This is available from the analyzer through the dedicated electrical connector for the device. Operation of the thermo-cooler will reduce the analyzer's battery life. It is therefore recommended, but not necessary, to use the battery charger for longer operation.

The condensation trap will fill with water after 2 to 4 hours depending on the fuel used. To empty the condensation trap simply disconnect it from the manifold by unscrewing it. When replacing it, be careful to seat the O-ring properly.

The thermo-cooler is typically equipped with two filters:

1. A cylindrical filter for particulates
2. A disc-shaped filter for condensed water

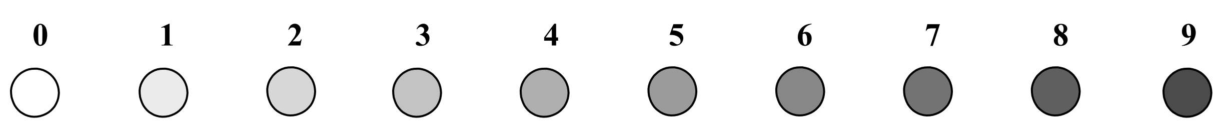
OPTIONAL PROBE ACCESSORIES

Sintered Hastelloy-X filter (10 microns)
The purpose of the filter is to block soot particles from entering the probe housing. The filter is reusable and can be cleaned in a detergent and by blowing air from inside out. Maximum filter temperature is 1900ºF.

Inconel probe extension
This tube screws into the end of the sample probe to extend its reach. This is needed if you cannot reach the center of your stack with the sample probe alone.

Smoke Test Adapter
The smoke test accessory is required to perform smoke tests (ASTM METHOD D2156). If you wish to take a measurement of the smoke using the smoke spot method, press and hold the PUMP key for 3 seconds. The pump will shut off, and the words "**PRESS ENTER FOR SMOKE**" will appear on the display. At this point, insert a piece of smoke paper into the cut-out in the smoke test adapter. To do this, first loosen the thumb-screw to make room for the paper. Once the paper is inserted, hand tighten the thumb-screw tightly to prevent an air leak.

Press ENTER key. The smoke test will begin. The display will read "**Smoke Test:**" and will count down from 85 seconds. The pump will be on and drawing a sample. At the end of the test the pump will stop again and the message "**SMOKE TEST COMPLETE**" will appear. Remove the smoke paper and tighten the thumbscrew to avoid any leaks. Push the ENTER key to continue with your measurements. Compare the paper's discoloration with the standard shades of grey on the smoke chart provided with the instrument. The number corresponding to the closest match is the smoke number.



CHAPTER 5

SENSORS

The great versatility of the ENERAC Model 700 Emissions system is partly due to the large number of sensors available within a single analyzer.

These sensors are primarily gas sensors and can be grouped into three categories based on their principle of operation:

1. Electrochemical (SEM) sensors
2. Infrared (NDIR) sensors
3. Temperature & pressure sensors

1. ELECTROCHEMICAL SENSORS

The ENERAC Model 700 employs proprietary SEM™ sensors specifically designed for harsh environmental conditions expected during stack and engine emissions measurements.

The SEM sensors are distinguished by their design. Each sensor consists of two sections: the sensor module, and the precision control module (PCM). The PCM sets the sensitivity of the sensor, and also contains filter material to remove the effect of any interfering gases present.

*PCM*s *are uniquely designed for each sensor type. Do not interchange a PCM designed for one gas type with a PCM made for another gas type!*

Electrochemical sensors produce an electrical current that is proportional to the detected gas.

These sensors measure the following emission gases:

A. Carbon monoxide (CO sensor)

This is a four-electrode sensor that measures simultaneously the carbon monoxide concentration and the interfering hydrogen concentration. The analyzer subtracts any hydrogen interference for an accurate CO measurement.

The carbon monoxide sensor is available in a number of different possible ranges. Sensor life is estimated at 2 years. Life of the filter is typically 1 year, but it depends on the amount of exposure to NO gas and frequency of use.

B. Nitric oxide sensor (NO sensor)

This is a proprietary four-electrode sealed electrochemical cell that contains a temperature sensor embedded within the sensor element. Its PCM is different from the other sensors in that it is made of aluminum, to allow efficient heat transfer. The NO sensor is temperature controlled by a thermoelectric Peltier element located where the sensor meets the manifold. The sensor temperature is maintained below 25 °C to limit unpredictable temperature-based baseline drifts, in accordance with the EPA's CTM-022 protocol requirements. This eliminates the requirement of repeated ambient temperature recordings, described in CTM-32 and CTM-24.

The sensor section contains a proprietary design consisting of four electrodes made of exclusively noble metals. It is available in a number of different ranges. Sensor life is estimated at 2 years.

The SEM™ NO sensor of the ENERAC Model 700 is superior to the typical electrochemical type sensor in accuracy, interference rejection, and its design for continuous operation. Its inboard disposable filter has an estimated life in excess of 100,000 PPM-hours against sulfur dioxide.

This sensor requires a constant bias voltage for proper operation. This voltage is present even when the instrument is turned off. It draws a small amount of current and will drain the batteries completely in about 10 months. For this reason, the unit should always be given a fresh charge once every 2-3 months.

C. Nitrogen dioxide sensor (NO_2 sensor)

The nitrogen dioxide sensor is available in a number of different possible ranges. There is no interference rejection filter media for it. It has a standard range of 0 to 500 PPM. Its life is estimated at 2 years.

D. Sulfur dioxide sensor (SO_2 sensor)

Standard SO_2 sensors will respond falsely to NO_2. A breakthrough in sensor design greatly reduces this interference.
The SEM™ SO_2 sensor of the ENERAC Model 700 is fabricated in a different manner from the typical electrochemical type sensor and is superior in accuracy, interference rejection and its design for continuous operation. Sensor life estimated at 2 years.

This sensor also requires a constant bias voltage for proper operation. This voltage is present even when the instrument is turned off. It draws a small amount of current and will drain the batteries completely in about 10 months. For this reason, the unit should always be given a fresh charge once every 2-3 months.

E. Oxygen sensor (O_2 sensor)

This is a standard two-electrode electrochemical cell. It has a silver cathode and a lead anode. Oxygen diffuses through a tiny hole and reacts with the lead anode. The reaction produces an electric current. The unit software linearizes the current vs. oxygen response. The cell becomes exhausted when all the lead is consumed. It takes about two years for this to happen.

DUAL RANGE OPTION FOR ELECTROCHEMICAL SENSORS

By means of an accurate dilution control system, the sensors are capable of measuring both low and high gas concentrations.

Electrochemical sensors typically have a range which is limited to at most three orders of magnitude. Thus, typically sensors with a range of 2,000 PPM should not even be exposed to higher concentrations, since one of the weaknesses of these sensors is saturation and erroneous readings if exposed to higher concentrations.

A number of applications, however, require the need for measuring both low and high gas concentrations as is the case of measurements upstream and downstream of a catalyst.

The Model 700 uses a second pump to draw dilution air that enables the analyzer to extend the range of the sensors by a factor of at least 3. It also allows purging of the sensors as required by the EPA CTM-034 method.

To obtain an accurate high range reading the Model 700 uses an additional oxygen sensor. By combining the readings of the sample oxygen sensor with the dilution oxygen sensor, an accurate calculation of the gas concentration for the high range is obtained.

Typically, the air pump has a flow rate of 2000 cc/min. The flow rate of the sample pump can be adjusted from 400 to 2000 cc/min by controlling the duty-cycle. The two oxygen sensors monitor the respective concentrations of oxygen and the processor calculates the dilution ratio.

When the analyzer operates in its low range, only the sample pump is on. When the analyzer operates in its high range, both pumps are on and the duty-cycle for the sample pump is automatically reduced. In the purge mode, only the air pump is on.

The optional NDIR sensor bench is not affected by the setting of the analyzer range.

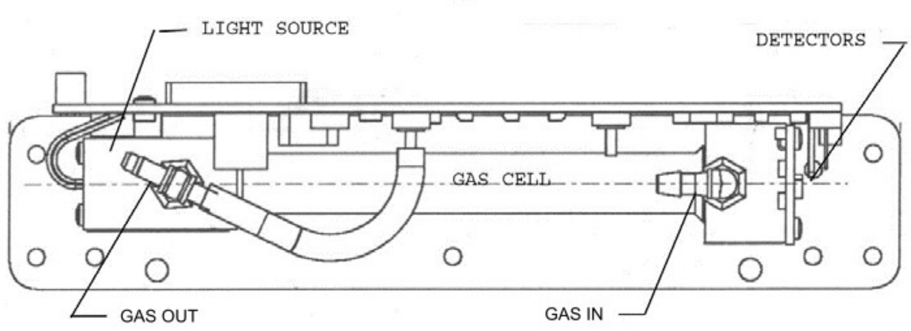
2. INFRARED (NDIR) SENSORS

The Model 700 emissions analyzer can be equipped with infrared sensor measurement capability for the measurement of three gases: carbon monoxide, carbon dioxide and hydrocarbons.
The infrared option has the following specifications:

GAS	RANGE	ACCURACY
CARBON MONOXIDE	0% - 10% 10% - 15%	3% relative 5% relative
CARBON DIOXIDE	0% - 16% 16% - 20%	3% relative 5% relative
HYDROCARBONS AS PROPANE	0 - 2000 PPM 2000 - 10,000 PPM 10,000 - 30,000 PPM	3% relative, (4 PPM max) 5% relative 8% relative

NDIR (non-dispersive infrared spectroscopy) relies on the way different gases absorb infrared radiation at varying frequencies, depending on the particular gas. The amount of radiation absorbed is used to calculate the concentration of the gas based on Beer's Law.

The figure below shows an outline of the NDIR assembly.



The light source is a pulsed incandescent bulb. There are four detectors, one for each gas, plus a reference detector. The detectors consist of pyroelectric elements equipped with narrow-band transmission filters; each filter is tuned to the absorption band of the target gas.

Life for the device is in excess of 5,000 hours, but care must be taken to prevent soot or water from entering the gas cell. It is possible in principle to clean the gas cell, but it is a costly and time-consuming operation.

NOTE: If the analyzer is equipped with the NDIR option, the analyzer must always enter an autozero each time it is turned on. Consequently, you must not turn on the analyzer and complete an autozero if the probe is currently connected to an engine or stack exhaust.

The NDIR bench is designed for operation primarily with measurements of engine exhausts, according to the California BAR 97 regulations.

The hydrocarbons sensor is tuned to the absorption band of propane. However, it will respond to other hydrocarbons with different sensitivity.

3. NON-GAS SENSORS

a. Ambient temperature sensor

   This is an IC sensor located inside the analyzer. The ambient temperature is displayed on the ZERO/SPAN screen. The instrument may be a few degrees warmer than its surroundings. This can be corrected for by adjusting the Ambient Temperature offset.

b. Stack Temperature sensor

   The thermocouple is located at the tip of the probe. It measures the stack temperature minus the ambient temperature. The thermocouple junction is a shielded, ungrounded, inconel sheathed, type K thermocouple with a capability of measuring temperatures from 0 to 2000 ºF. The instrument software linearizes the thermocouple output to improve the accuracy.

c. NO temperature-control sensor

   This is an IC sensor located inside the SEM NO sensor. Its purpose is to monitor the NO sensor temperature. It is used by the system microprocessor to regulate the NO sensor temperature.

d. Stack Draft / Stack Velocity sensor

   The draft sensor is a piezoelectric pressure sensor located inside the analyzer. Because of the pressure drop caused by sample flow through the sampling line and filters, the sensor zeroes itself every time an autozero is carried out. Consequently, you must not allow the filter to get clogged with soot as this would give an erroneous reading. For accurate draft measurements irrespective of filter condition, you may request a sampling line with an extra section of tubing for draft measurements.

If the analyzer is equipped with the velocity option, the standard pressure sensor is replaced by a more sensitive pressure sensor which converts low pressure readings to velocity. The pressure sensor is connected to the stack velocity probe via two dedicated hoses.

STACK VELOCITY (S-V) PROBE

A stack velocity probe, shown here, can be used to measure the stack gas flow velocity for mass-emissions measurements of the toxic gases (pounds/hour). It is an S-type Pitot tube.

Pitot Tube and Hose Assembly

The S-type Pitot tube consists of a pair of 3/16” diameter stainless steel tubes welded together and having their stack ends open and bent at a certain angle as required by the EPA specifications of 40CFR60 Appendix A, Method 2 for measuring stack gas velocities.

The Pitot tube detects the pressure differential between the lower tip and the upper tip, which is mathematically converted to gas velocity (in FPS) and gas flow-rate (in CFM). The Pitot tube assembly is connected to the internal pressure sensor by means of two flexible hoses connected to the velocity inputs on the side of the analyzer case.

NOTE: The Pitot tube must always be oriented with the open tips parallel to the direction of the stack gas flow!

CHAPTER 6

ANALYZER SETUP

The SETUP MENU allows the operator to change system parameters.

```
JAN 1 ’19   12:45:00
Fuel:    Natural Gas
Temperature Units: F
Measure Units:   PPM
Pressure Units: inWC
OxygenReference:TRUE
Pumps: AUTO RANGE
Dilute CO:   2000PPM
CO-IR Thresh:6000PPM
Cooler Duty: 50%
Thermal Eff:0.30
Display Contrast:24
Baudrate:  9.6 kbps
Velocity Units: FPS
Stack Size:5000 in²
--------------------
Version: 3.09IV
Battery: 5.20 V
```

Every parameter listed on the SETUP MENU screen can be changed as follows.

1. Use the **UP / DOWN** keys to move the cursor to the parameter you wish to change.
2. Press **ENTER** to select the parameter. The value will be highlighted. This indicates that you are in edit mode.
3. Use the **UP / DOWN** keys until the desired value of the selected parameter appears on the display.
4. Make sure to press **ENTER** after each value change.

A more detailed explanation of each parameter follows.

1) DATE & TIME: The analyzer’s internal clock is displayed in the format month-day-year, hour-minute-second. Hours are always displayed using a 24-hour clock.

2) FUEL: The fuel selection affects the following parameters: combustion efficiency, carbon dioxide calculation, and display of toxic gases in units other than PPM. The analyzer has the following seventeen fuels stored in its memory:

1) #2 OIL/DIESEL
2) #4 OIL
3) #6 OIL
4) KEROSENE
5) GASOLINE
6) GASOLINE-OXYG.
7) ANTHRACITE (COAL)
8) BITUMINOUS (COAL)
9) LIGNITE (COAL)
10) WOOD, 50% H_2O
11) WOOD, 00% H_2O
12) COKE OVEN GAS
13) BLAST FURNACE
14) SEWER GAS
15) NATURAL GAS
16) PROPANE
17) BUTANE

To select the desired fuel, press the **UP / DOWN** keys until the desired fuel appears, and then press **ENTER**.

3) TEMPERATURE UNITS: The **UP / DOWN** keys toggle between °F (Fahrenheit) and °C (Celsius). Stack temperature and ambient temperature will be displayed, printed, and saved in the selected units.

4) MEASURE UNITS: With the cursor on this line you can select any of the following units of measurement for the toxic gases (CO, NO, NO_2 & SO_2):

- PPM: Parts per million (volumetric)
- MGM: Milligrams per cubic meter
- #/B: Pounds (of pollutant) per million BTU of fuel
- GBH: Grams (of pollutant) per brake horsepower-hour

To choose the desired emission units, press the **UP / DOWN** keys until the proper units are displayed. Then confirm with the **ENTER** key.

If you select GBH (grams/brake horsepower-hour) as the desired units, you must set the value of the (engine) thermal efficiency also! You can obtain this figure from the engine's manufacturer specifications. It differs somewhat as a function of engine type and load factor. (Typically, it is a number between 0.25 and 0.35) The default value is 0.30. If the thermal efficiency is not known, it may be computed by using the engine's BSFC (brake-specific fuel consumption, in BTU's per BHP-HR) as follows:

ENGINE EFFICIENCY = 2547/BSFC

NOTE: Emissions units measurements in PPM, MGM, #/B and GBH are carried out on a dry basis as required by the EPA's 40CFR75. (The ENERAC Model 700 is an extractive analyzer, whose conditioning system removes most of the water vapor before the sample reaches the sensors).

NOTE: Values of emissions in #/B and GBH are fuel and CO_2 dependent. The fuel parameters for certain typical fuels used in the analyzer (i.e. the F- factors for anthracite, etc.) have been modified to be identical to those specified in 40CFR60 Appendix A method 19 of the code of federal regulations. Consult ENERAC, Inc., for details and correction factors.

NOTE: NO and NO_X emissions in #/B or GBH are computed as NO_2!

5) PRESSURE UNITS: Set the pressure units for DRAFT measurement.

6) OXYGEN REFERENCE: Many environmental regulations require that the concentration of pollutants measured is corrected to some reference value of oxygen other than the actual concentration at the time of the measurement. Typical oxygen reference values are 0% (air free), 3%, 7% or 15%. Use the **UP / DOWN** keys to select the desired oxygen reference, then press the **ENTER** key. The range is 0-20% in 1% increments. To return to uncorrected measurements, press the **UP** or **DOWN** key until the display reads:

```
Oxygen Reference: TRUE
```

NOTE: Setting the OXYGEN REFERENCE to a value other than TRUE affects values of emissions concentrations in PPM and MGM. It does not affect values in #/B or GBH!

7) PUMP: The current pump status is displayed here followed by the duty-cycle of the sample pump. The pump states are:
   a) AUTO — In this state the analyzer will automatically switch between low or high measurement modes for CO.
   b) OFF — Sample and dilution pumps are turned off.
   c) SAMPLE — This is the standard, low-range, measurement mode.
   d) DILUTE — This is the extended, high-range measurement mode.
   e) PURGE — This setting purges the sensors with ambient air.

The sample pump has two duty-cycle settings: one for the low-range, and one for the high-range (DILUTED). The duty-cycle of each can be adjusted with the **UP / DOWN & ENTER** keys.

DUAL RANGE OPTION

8) DILUTE CO: When the PUMP is in AUTO mode, this is the threshold of the CO channel between the low and high ranges.

NDIR OPTION

9) CO-IR THRESHOLD: Above this threshold, the CO concentration is measured with the NDIR bench and displayed as a percentage (%). Before the threshold is reached, the CO is measured with the electrochemical sensor and reported in the selected measurement units.

10) COOLER DUTY: This setting controls power to the thermoelectric cooler. See Chapter 4.

11) THERMAL EFF: Set the thermal efficiency of the engine under test. See MEASURE UNITS above.

12) BAUD RATE: This is the speed at which the analyzer is set to communicate with a computer. The computer usually manages the baud rate.

13) VELOCITY UNITS: (Velocity Option) Select between feet per second (FPS) and cubic feet per minute (CFM), or meters per second (MPS) and cubic meters per minute (CMM). Computation of CFM/CMM units requires setting the stack size.

14) STACK SIZE: (Velocity Option) When measuring cubic feet per minute (CFM) and cubic meters per minute (CMM), be sure to enter the stack size, which is the cross-sectional area in square inches of your exhaust stack.

CHAPTER 7

INTERNAL DATA STORAGE

The ENERAC Model 700 has 500 internal storage buffers. Each buffer stores one complete set of emissions data. The STORE MENU allows the operator to store data and manage the internal storage buffers. The last line of the STORE MENU shows the current buffer. You can save all of the measured parameters at any time by selecting the first menu choice: Store Current Buffer.

```
Store Current Buffer
Select Buffer...
Start Average Test
Start Periodic Store
Select Interval: 1m
Review Buffer...
Name Buffers...
Erase Buffer...
00: BUFFER #000
```

Besides saving a snap-shot of the analyzer's readings, you can have the analyzer run an average of its readings, or you can make use of its ability to store data automatically on a periodic basis.

1. STORE CURRENT BUFFER: The unit will store one set of data into the buffer currently selected. The index number and the name of the current buffer is shown at the bottom of the STORE screen.

2. SELECT BUFFER: Selecting this item will display an index of the analyzer's 500 internal storage buffers. Buffers that are used have an icon next to their index number. The selected storage buffer is indicated by the reverse color line. When data is stored, the pointer will automatically advance to the next available buffer. If you want to store data in a different location, use the UP/ DOWN, & ENTER keys to select a new buffer. As you scroll up and down, buffers containing data show their date and time at the bottom of the display. Empty buffers show the word **empty**.

3. START/STOP AVERAGE TEST: The analyzer will start averaging all channels. When you come back to the STORE MENU and choose: **Stop Average Test,** the averages will be saved to the current buffer.

4. START/STOP PERIODIC STORE: This will turn on the periodic store function. In this mode, the unit will continuously store data to consecutive buffers at an interval specified on the next line. Once enabled, this line will read: **Stop Periodic Store.**

5. SELECT INTERVAL: The time between each data store is set here. This can range from 10 seconds to 60 minutes.

6. REVIEW BUFFER: This choice allows you to view previously saved data. Press **ENTER**. The display will switch to the data screen, with the last saved data set displayed. The time and date when the data was saved will appear at the bottom of the display. Use the **UP / DOWN** keys to scroll through the buffers.

```
EFF:OVER%  CO :    0PPM
ST :  80°F NOx:    0PPM
OXY:20.9%  NO :    0PPM
HC :    0PPM NO2:  0PPM
CO2: 0.0%  SO2:    0PPM
AIR:OVER%  DFT: 0.0”
000: BUFFER #000
JAN 01 ’19   12:45:00
```

7. NAME BUFFERS: This choice will take you to another screen where you can rename one or more buffers. This is useful if you use several buffers together to form a test series. Select the starting test index by pressing **ENTER,** then use the **UP / DOWN** keys to set index. Press **ENTER** to confirm setting. Next, press **DOWN / ENTER** to select the ending test index.

```
***  NAME  BUFFERS  ***
Starting Buffer: 00
Ending Buffer:   00
Name:xxxxxxxxxxxxxxxx
1 2 3 4 5 6 7 8 9 0 ◀
A B C D E F G H sym ▶
I J K L M N O P shift
Q R S T U V W X Y Z
```

Press **DOWN.** The alphanumeric keyboard will appear. Use the **UP / DOWN / LEFT / RIGHT** keys to navigate around the keyboard, and press **ENTER** to select the letter or number. For lower-case letters, highlight **shift** and press **ENTER**. For symbols, highlight **sym** and press **ENTER**. The arrows in the corner will move the cursor forward or backward through the buffer’s name.

8. ERASE BUFFER: This option is used to erase stored data. Data that has been stored in the analyzer’s memory will be retained even after the instrument has been shut off and its batteries removed. To erase the contents of a specific buffer, use the **UP / DOWN** keys to move the arrow to the desired buffer. As you scroll up and down, buffers containing data show their date and time at the bottom of the display. Empty buffers show the word **empty**. If you wish to erase all 500 of the analyzer’s stored data, move the arrow to the entry **ALL BUFFERS** and press **ENTER**.

CHAPTER 8

INTERNAL PRINTER

The PRINT MENU allows the user to print test records.

```
Print Test Record
Start Test Log
  Log Interval: 5S
Print Buffer...
Edit Customer Name..
Calibration Record
Paper Feed On/Off
```

ENERAC 700
Serial #: 000000
Company Name
TEST RECORD

JAN 1 ‘19 12:45:00

Efficiency: 00.0 %
Ambient Temp: 70 °F
Stack Temp: 70 °F
Oxygen: 20.9 %
CO: 0 PPM
CO_2: 0.00 %
Hydrocarbons: 0 PPM
NO: 0 PPM
NO_2: 0 PPM
NO_X: 0 PPM
SO_2: 0 PPM
Stack Draft: 0 ”WC
Excess Air: 100 %
Air/Fuel Ratio: XXX
Lambda: XXX
Equival Ratio: XXX

Fuel: #2 OIL/DIESEL
Oxygen Reference: TRUE
NO_X Control Temp: UNDER 30C
Stack Size:

ENERAC M700
Serial #: 000000
Company Name
TEST LOG

JAN 1 ‘19 12:45:00

Fuel: #2 OIL/DIESEL

```
ST: OXY:  CO:  AIR: EFF:
XXX XX.X  XX.X XXX  XX.X
XXX XX.X  XX.X XXX  XX.X
XXX XX.X  XX.X XXX  XX.X
F   %     PPM  %    %
```

Oxygen Reference: TRUE

PRINT TEST RECORD: This option will print a test record of the current stack parameters.

PRINT TEST LOG: This option begins a log of the following combustion parameters: stack temperature, oxygen, carbon monoxide, excess air, and efficiency.

LOG INTERVAL: This selects the interval between each log entry. The interval can be set between 1 and 60 seconds.

PRINT BUFFER: This option is used to print data stored in the analyzer’s memory. Each line corresponds to one storage buffer. Buffers containing data show an icon next to the index number. When you scroll up and down, the date (month/day) and time (hour/minute) when the data was stored appear at the bottom; empty buffers show the word `empty`. To print the contents of a specific buffer, use the **UP / DOWN** keys to move the arrow to the desired buffer and press **ENTER**. If you wish to print all of the analyzer’s stored data in sequence, move the arrow to the entry `ALL BUFFERS` and press **ENTER**.

EDIT CUSTOMER NAME: This will display a screen where you can change the information printed at the top of each printout. Usually the customer name appears here. To edit this information, use the **UP / DOWN / LEFT**

/ RIGHT keys to navigate around the keyboard, and press **ENTER** to select the letter or number. For lower-case letters, highlight **`shift`** and press **ENTER**, for symbols, highlight **`sym`** and press **ENTER**. The arrows in the corner will move the cursor forward or backward through the name.

CALIBRATION RECORD: This option will print a record of each sensor's last calibration, including the date of calibration and span gas value used.

PAPER FEED: This toggles the printer's motor on and off, advancing the paper out the top of the analyzer as needed. The motor will not turn if there is no paper present.

CHAPTER 9

CALIBRATION

Every instrument must occasionally be calibrated against some known value of a parameter in order to make sure that its accuracy has not deteriorated.

Usually, the first point chosen is the zero value (called zeroing the instrument). On the Model 700, all of the sensors are zeroed together. This is known as an 'autozero' and includes a short countdown, typically 60 seconds.

The instrument must be zeroed in a true "zero" environment. Otherwise it will assume as "zero" any non-zero conditions present and show erroneous readings! Additionally, the probe, which contains the thermocouple, must be at room temperature during the autozero procedure.

The second calibration point has to be set by using some known value of the parameter being calibrated. For example, certified 200 PPM carbon monoxide gas is fed to the analyzer in order to calibrate the CO sensor at 200 PPM. For temperature sensors the second point is not required.

You must *always* span calibrate the instrument whenever you replace a sensor, *unless* you have requested a **pre-calibrated sensor**. Sensors pre-calibrated at the factory come with a calibration factor that must be entered into the analyzer. Span gas is *not required* with pre-calibrated sensors if the new factor is entered correctly on the SENSOR FACTOR screen. To access the SENSOR FACTOR screen, hold the **SETUP** key and press the **DISPLAY DATA** key three times. Move the cursor down to the appropriate sensor, and then enter the new factor using the **UP / DOWN / LEFT / RIGHT** and **ENTER** keys.

The ZERO - SPAN MENU, shown here, lets you zero all of the sensors, and span-calibrate each sensor individually.

```
**** CALIBRATION ****
 Zero All Sensors
 AutoZero Errors
 Sensor History
 Amb Temp:  74 °F
 Zero Time: 60sec
 Span Time:120sec
 Span CO:   200 PPM
 Span H2:  1000 PPM
 Span NO:   200 PPM
 Span NO2:  200 PPM
 Span SO2:  200 PPM
 Span CO-IR:  1.5 %
 Span   CO2: 10.0 %
 Span HC:  1000 PPM
 Span Draft:-10 "wc
```

ZERO ALL SENSORS: At the end of a countdown the analyzer will be zeroed. This will set the zero point of the electrochemical sensors (CO, H, NO, NO_2, SO_2), the NDIR bench parameters (CO, CO_2 & HC), and the stack temperature thermocouple and draft (or) velocity sensor. The O2 sensor will be calibrated to 20.9% (normal atmospheric O2 concentration) at the end of the procedure as well.

AUTOZERO ERRORS: If any sensors were out of range during the last autozero they will be listed on the `AUTOZERO ERRORS` screen.

SENSOR HISTORY: The SENSOR HISTORY screen is a record of the last calibration for each electrochemical and NDIR sensor.

AMBIENT TEMPERATURE: The ambient temperature, as measured inside the analyzer, is shown here. Press the **ENTER** key to adjust the ambient temperature reading. The display will show:

```
AMB T OFFSET: 0C
```

Use the **UP / DOWN** keys to set the value, in degrees Celsius, to add or subtract to the measured ambient temperature.

ZERO TIME: The analyzer has an autozero countdown to ensure proper stabilization of all sensors. The autozero countdown should be at least 60 seconds. If you wish to adjust the countdown time for autozeroing the analyzer, use the **UP / DOWN** keys accordingly. If equipped with an NDIR bench, the minimum countdown time is 40 seconds, the lowest allowable time setting.

SPAN TIME: When carrying out a span calibration, you must introduce the span gas for an appropriate amount of time before the analyzer executes the span calibration. This setting, which is the same for all sensors, controls this time interval. The time is indicated in seconds, but a minimum of 2 minutes of span gas feeding is required for proper calibration. *For NO and CO calibrations 4 minutes is recommended. For NO_2 and SO_2 calibrations 8 minutes is recommended.*

SPAN XXXX: The remaining lines of the SPAN MENU are used for carrying out span calibrations of the individual CO, NO, NO_2, SO_2, NDIR, combustibles, and stack draft/velocity sensors

A. AUTOZEROING THE INSTRUMENT

When you turn the instrument on, you can press the **ENTER** key to begin an autozero straightaway. To start the autozero procedure at any time, press the **ZERO/SPAN** key and choose: **`Zero All Sensors`**. The autozero countdown will commence.

- Check that the probe's sampling line and electrical connections are secure.
- Check that the probe tip is at room temperature.

It is very important that at the moment of "zeroing" the probe tip is at room temperature and the environment is clean and free of carbon monoxide or other gases. It may be a good idea to zero the analyzer outdoors, before entering the facility. Some protocols, such as EPA's Method 7E, require a cylinder of certified zero gas for zeroing the analyzer.

At the end of the autozero period all of the sensors are calibrated to their zero-point. All sensors will read zero, except for oxygen, which will read 20.9%, and the temperature sensors, which will read the ambient temperature.

NOTE: In practice AUTOZEROING is only needed once at the beginning of a day of measurements. The analyzer will not have sufficient zero drift during the next 24 hours to require additional autozeroing procedures.

If you have the NDIR option, the analyzer *must* be autozeroed when the unit is turned on.

If no error messages appear at the end of the countdown, you may proceed with your measurements.

B. SPAN CALIBRATION (Electrochemical sensors, NDIR sensors)

A full span calibration of the instrument is recommended every 2-4 months. If you cannot calibrate the analyzer yourself you should return it to the factory for a complete calibration once a year.

For superior accuracy you should check the calibration of the instrument before each emissions test. The sensors that require a span calibration are: carbon monoxide, carbon dioxide, nitric oxide, nitrogen dioxide, sulfur dioxide, and hydrocarbons. The draft / velocity sensor typically does not need calibration.

You can carry out all span calibrations in sequence or just one if you wish. You will need a separate cylinder of span gas for calibrating each of your analyzer's sensors. You should use certified 2% accuracy span gas.

You must take certain precautions in order to calibrate the sensors properly.

For greatest accuracy it is recommended that you use a span gas value that is close to the emission concentration you expect to measure.

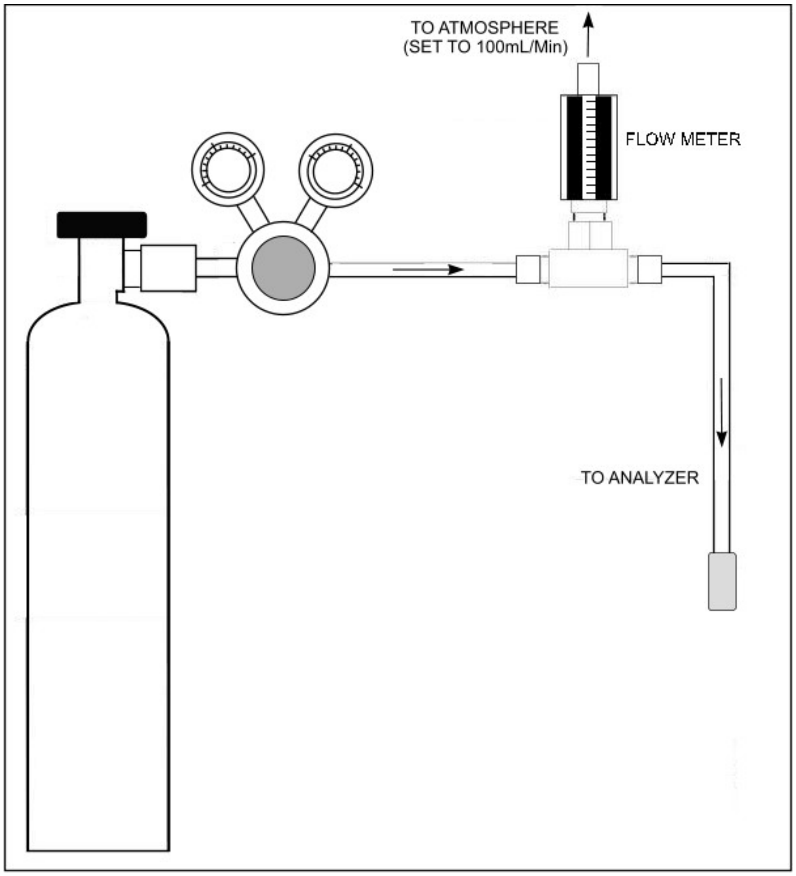
Make sure the concentration of the calibration gas is within the range of each sensor. <u>Do not under any circumstances, use gas that will over-range the sensor</u>.

You must not feed gas to the analyzer under pressure and you must not starve the analyzer's pump for gas. When feeding the gas to the analyzer you must maintain a reasonably constant pressure. This is a requirement of all diffusion-type sensors.

CALIBRATION APPARATUS

During calibration an adequate flow of span gas must be supplied without developing excessive pressure on the sensors. A compressed cylinder of span gas must be equipped with a primary pressure regulator. Connect the calibration equipment to the analyzer's probe with the cylindrical probe adaptor. Feed the span gas to your analyzer with one of the following setups:

1. <u>An open T - connection</u> will ensure that gas is fed at ambient pressure. The regulator valve is used to control the flow of gas to the analyzer. To ensure that the span gas is fed properly and as efficiently as possible, connect a bypass flow-meter at the outlet. Adjust the regulator to maintain approximately 100 cc/min of flow at the outlet. See figure below.



Open T setup

3. An optional demand regulator will automatically supply an adequate flow of gas to the analyzer without wasting any span gas and without venting any toxic gas to your ambient environment. This accessory, shown in the picture below, is available from the factory.

Demand Regulator

TYPICAL SPAN GAS CALIBRATION VALUES

The analyzer supports different ranges for its electrochemical sensors. Calibration values for standard-range sensors are shown here.

The CO span gas can be in the range of 10 - 1500 PPM, 2% accuracy with balance nitrogen, preferably.
The NO span gas can be in the range of 10 - 1000 PPM, 2% accuracy with balance nitrogen, required.
The NO_2 span gas can be in the range of 10 - 500 PPM, 2% accuracy with balance nitrogen, preferably.
The SO_2 span gas can be in the range of 10 - 1500 PPM, 2% accuracy, with balance nitrogen, preferably.

For the NDIR option, the following ranges are allowed:
The CO span gas can be in the range of 1.2 – 15.0%, balance nitrogen.
The CO_2 span gas can be in the range of 9.0 – 20.0%, balance air.
The hydrocarbons span gas can be in the range of 1000 - 30,000 PPM. Use Propane (C_3H_8), balance nitrogen for standard NDIR sensor.

CALIBRATION PROCEDURE

1. The instrument should be autozeroed before a span calibration. Before calibrating *any NDIR* channel an autozero is *required*. (In addition, the NDIR calibration must be carried out within 5 minutes of the autozero.)

2. Connect the calibration apparatus and gas cylinder to the instrument.

3. Press the **DISPLAY DATA** key and observe the appropriate reading as you open the calibration cylinder valve. (If you are using the bypass flow meter, adjust the cylinder valve for a bypass flow-rate of approximately 100 ml/min.

    a. **Check the oxygen reading for confirmation that there is no instrument leak.**
    b. **Observe the readings of the other gas parameters for evidence of cross-sensitivity.**

4. When the display reading for the desired gas has stabilized press the **ZERO/SPAN** key to enter the ZERO - SPAN MENU.

5. Use the **UP, DOWN, & ENTER** keys to select the appropriate SPAN menu item, and to enter the span gas value. First set the hundreds digit, then press **ENTER** to advance the cursor to the tens digit, and repeat for the units digit.

6. Pressing **ENTER** again will bring up the data screen with the confirmation line:

   `PRESS ENTER TO SPAN`

   Press the **ENTER** key to begin the calibration countdown. The unit will wait for the amount of time set as the Span Time. The display will show the time remaining and the span gas value. If adequate response time has been allowed prior to executing span function, the Span Time can be preset to 0 seconds (see page 42).

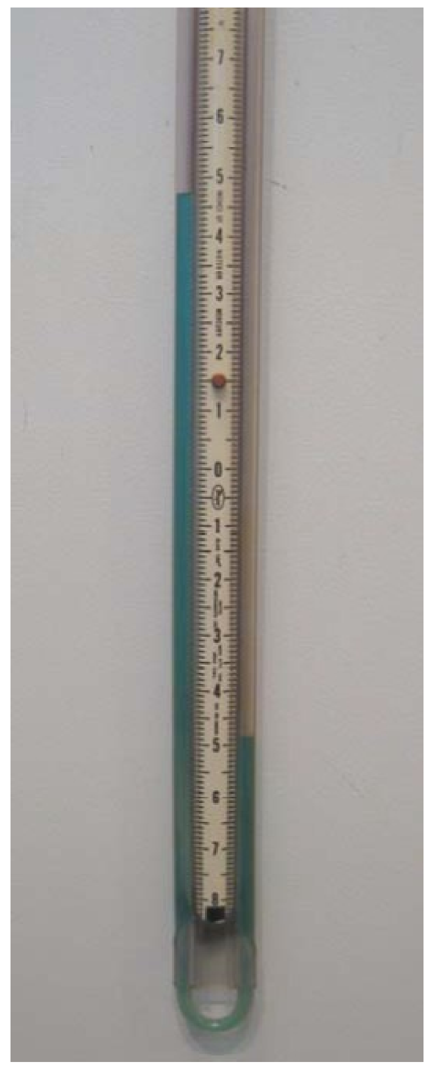
7. When the calibration is finished, check that the display is reading correctly.

C. STACK DRAFT CALIBRATION

To span calibrate the draft sensor, connect a manometer to the end of the probe through a T-fitting. Leave one side of the 'T' open. Restrict the open side of the 'T' with a suitable valve. In the SPAN MENU, use the **UP / DOWN** keys to select a draft calibration span value between 5" and 40". Press the **ENTER** key. The pump will be on and the display will read:

`PRESS ENTER TO SPAN`

Very slowly start closing the intake valve of the apparatus and observe the manometer reading climbing. Once the manometer is reading the same pressure as that which was selected on the SPAN MENU press the **ENTER** key to calibrate the draft sensor at that value.



Manometer

D. STACK GAS VELOCITY CALIBRATION

To span calibrate the velocity sensor, you will need an inclined manometer such as the one shown below. An inclined manometer is a device that allows for very precise pressure measurements. Connect the manometer directly to the velocity input on the side of the analyzer. In the SPAN MENU, use the **UP / DOWN** keys to select a velocity calibration value between .50” and 4.0". Press the **ENTER** key. The display will read:

PRESS ENTER TO SPAN

Apply the pressure that was previously set in the SPAN MENU using an aspirator bulb. Press **ENTER** key to calibrate the velocity sensor at that value.

Inclined Manometer

Aspirator Bulb

CHAPTER 10

COMMUNICATIONS

A. GETTING STARTED

In order to be able to communicate between the analyzer and a computer, a connection must be established in one of three ways:

- Classic RS-232 connection.
- USB connection.
- Bluetooth wireless connection, if equipped.

RS-232 CONNECTION
For RS-232 connections, use a standard 9-pin serial cable. (This is not included) Connections up to 100 ft long are possible. The analyzer's RS-232 port is a DTE-type. Three wires are necessary for communications: TxD (pin 2), RxD (pin 3) and ground (pin 5).

USB CONNECTION
For USB connections, use an A-to-B type USB cable. To establish a USB connection, the FTDI USB driver must first be installed on your computer. The USB drivers for Windows computers are available on the ENERAC website: www.enerac.com.

- When you plug the USB cable from the computer to the analyzer, you should hear an audible tone indicating that the USB connection has been made.
- If you have the FTDI USB driver already installed in your computer, the computer will know and will NOT initialize the "New Hardware Wizard".
- If the New Hardware Wizard appears, you need to install the FTDI USB driver. To install this driver:
  - Download the FTDI USB driver from the ENERAC website and save it to your desktop.
  - The downloaded file will be zipped. Double-click the zipped folder and choose Extract All Files. Extract the files to a folder on the desktop.
  - Follow the instructions in the New Hardware Wizard.
  - You will have to go through the wizard twice, once to install the ftdiport.inf file, and once for the ftdibus.inf file.

BLUETOOTH CONNECTION

For Bluetooth connection, follow the same procedure as you would for any Bluetooth device.

ALL CONNECTIONS

When you connect your analyzer to your computer for the first time, the connection will be assigned a unique comport number. Remember the comport number as it will be needed to open an Enercom session.

You can find the comport associated with your ENERAC in Windows Device Manager.

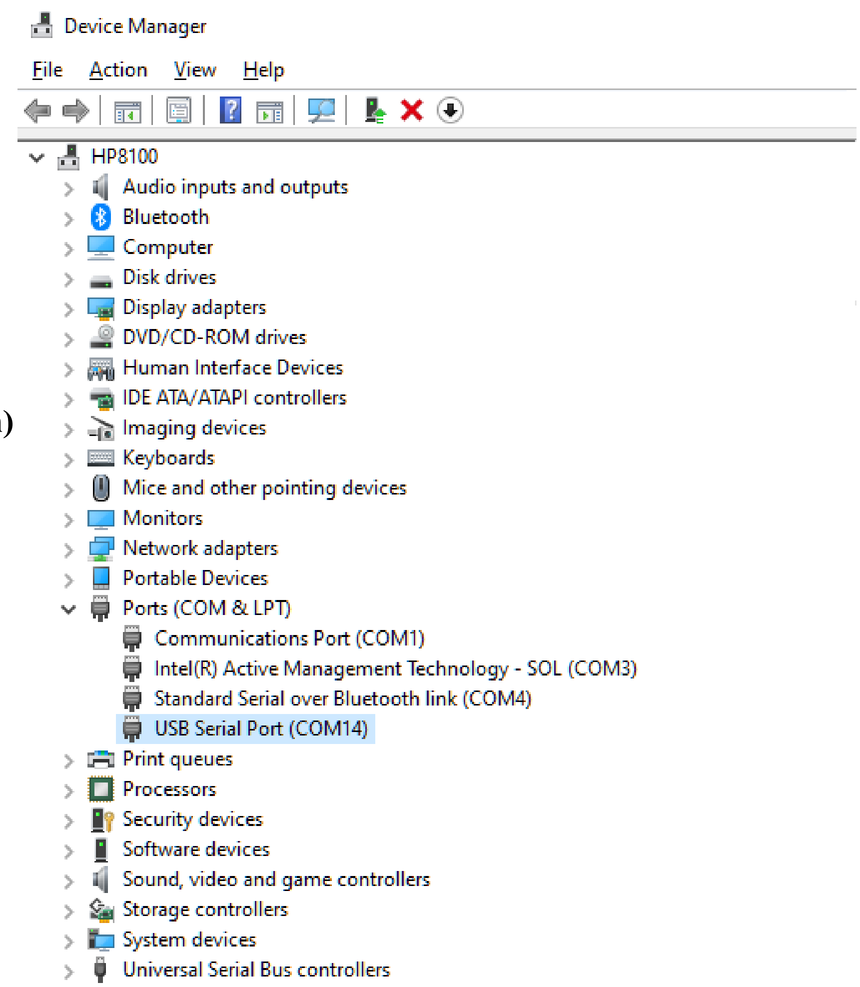
To open the Device Manager:

- Locate Windows Device Manager by searching for it in the desktop search box. (Or go to Windows Control Panel, choose the System icon, then the Hardware tab, and click the Device Manager button).

- A window will open that will list "PORTS" among other items. Click on "PORTS".

- The comports will be listed as:
  - Communications Port **(RS-232)**
  - USB Serial Port **(USB)**
  - Standard Serial over Bluetooth link **(Bluetooth)**

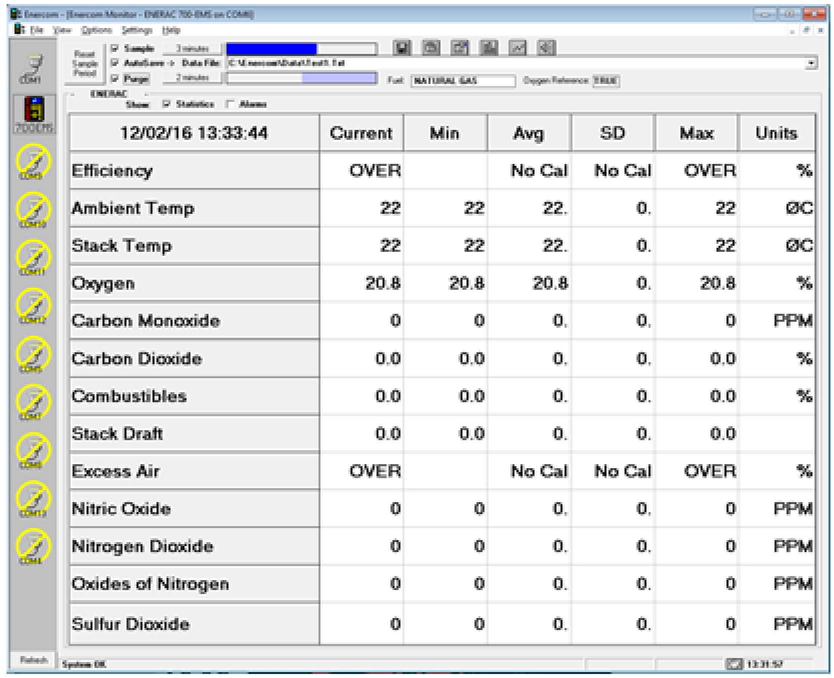
Remember the port number.



B. ENERCOM SOFTWARE

You can enhance the performance and versatility of the ENERAC Model 700 by using the Enercom software program.

The Enercom software is a robust package that allows you to:



12/02/16 13:33:44	Current	Min	Avg	SD	Max	Units
Efficiency	OVER		No Cal	No Cal	OVER	%
Ambient Temp	22	22	22.	0.	22	ØC
Stack Temp	22	22	22.	0.	22	ØC
Oxygen	20.8	20.8	20.8	0.	20.8	%
Carbon Monoxide	0	0	0.	0.	0	PPM
Carbon Dioxide	0.0	0.0	0.	0.	0.0	%
Combustibles	0.0	0.0	0.	0.	0.0	%
Stack Draft	0.0	0.0	0.	0.	0.0	
Excess Air	OVER		No Cal	No Cal	OVER	%
Nitric Oxide	0	0	0.	0.	0	PPM
Nitrogen Dioxide	0	0	0.	0.	0	PPM
Oxides of Nitrogen	0	0	0.	0.	0	PPM
Sulfur Dioxide	0	0	0.	0.	0	PPM

1. Monitor all emissions parameters.
2. Record maximum, minimum, average and standard deviation for all emissions parameters.
3. Select a variety of saving and printing options.
4. Retrieve stored data.
5. Enter custom fuel information.
6. Open a terminal window to communicate directly using serial commands.

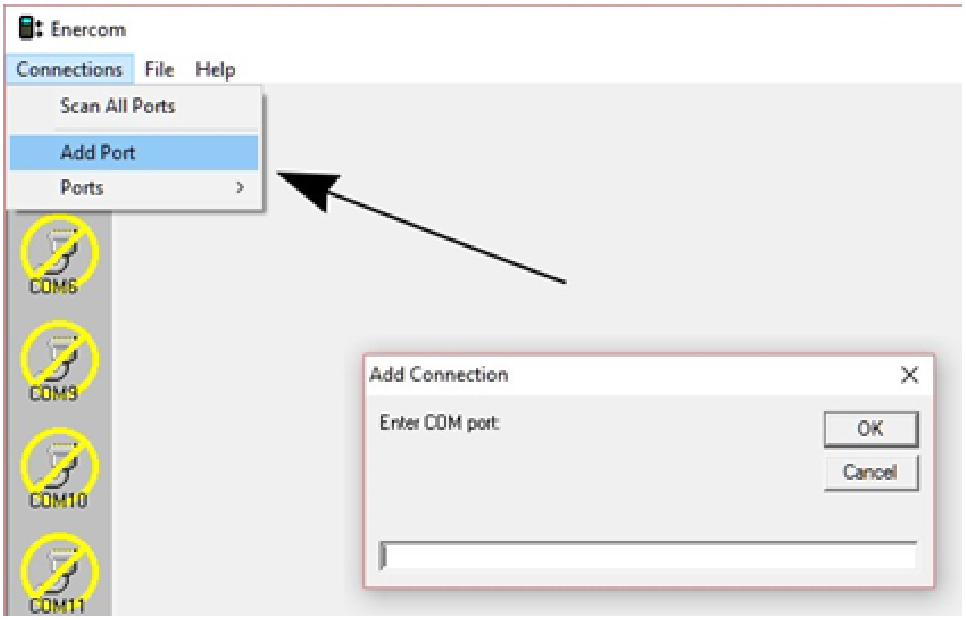
The Enercom software can be downloaded from the website at: www.enerac.com. Consult the Enercom manual for details on installing and operating the program.

STARTING ENERCOM

1 Before starting Enercom, have your analyzer turned on and connected via RS-232, USB or Bluetooth.

2 Start Enercom. If you have connected before, the analyzer icon will appear. If this is the first time you are connecting you will need to add a new port.

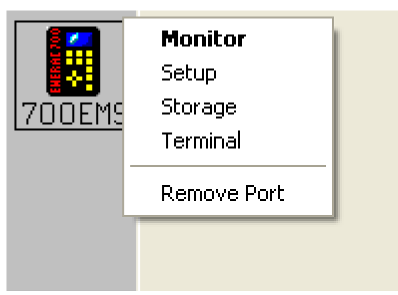
3 On the Enercom window click on “Connections”, then click on “Add Port”.



4 Enter the COM port number which appeared in the Device Manager, and click “OK”.

5 The COM port with its number should appear on the left side of the Enercom window. Enercom will look for an analyzer on this port. After a moment the ENERAC analyzer icon should appear. You are now connected to your analyzer.

6 Click on the ENERAC icon. A menu will appear. Choose “Monitor” from the menu. *(See the ENERCOM manual for further instructions).*



C. SERIAL COMMANDS

The analyzer has a vocabulary of commands that can be used to configure the analyzer or return data from the analyzer. The serial commands are also useful for troubleshooting.

The typical user *will not need to use these commands* as the ENERCOM software provides most of the functions that the operator will need.

If you want to communicate with the analyzer directly, open a terminal with the appropriate protocol:

BAUD RATE: 9600 baud
DATA: 8 bits, 1 stop bit, no parity
HANDSHAKE: None

You can use the Enercom Terminal feature for this.

All commands start with a four-letter ASCII word.

If the command is followed by a question mark then the analyzer will respond with one or more lines of information. For example:

Send: TIME?　　　　Response: 12:45:01

Without a question mark, the command will cause the analyzer to set some parameter to the value sent with the command, or take some other action, such as erasing a specific data buffer. Note that these commands do not elicit a response. For example, to set the clock:

Send: TIME 11:30:00　　　　Response: [none]

The default baud rate is 9600 bps. The analyzer can communicate at several speeds ranging from 1200 to 115,200 bps.

The ENERAC 700 command set follows.

THE ENERAC 700 COMMAND SET

DATA COMMANDS

COMMAND	FUNCTION
ATEM?	Returns the present value of ambient temperature.
BATT?	Returns the present battery voltage.
CDOX?	Returns the present value of carbon dioxide.
CMNX?	Returns the present value of carbon monoxide.
COMB?	Returns the present value of combustible gases.
DRAF?	Returns the present value of stack draft.
EFFI?	Returns the present value of combustion efficiency.
EXAR?	Returns the present value of excess air.
NOXY?	Returns the present value of nitric oxide (NO).
NO2Y?	Returns the present value of nitrogen dioxide (NO_2).
NOXX?	Returns the present value of oxides of nitrogen (NO_X).
OXYG?	Returns the present value of oxygen.
SO2X?	Returns the present value of sulfur dioxide.
STEM?	Returns the present value of the stack temperature
TEXT?	Returns a complete record of all current stack parameters.
VELO?	Returns the present value of stack velocity or flow rate.

SETUP COMMANDS

COMMAND	FUNCTION
ATOF?	Returns the ambient temperature offset in °C.
ATOF XX	Sets the ambient temperature offset to XX°C.
COOL?	Returns the thermoelectric cooler duty cycle.
COOL XX	Sets the thermoelectric cooler duty cycle: XX=50 50% power XX=100 100% power
CORF?	Returns the temperature units.
CORF X	Sets the temperature units: X=F Fahrenheit X=C Celsius
CUST?	Returns the customer name. This name appears on the display and all printouts.
CUST XXXX	Sets the customer name, up to 21 characters long.
DATE?	Returns the present date.
DATE XX/XX/XX	Sets the present date.
FUEL?	Returns the current fuel used.
FUEL NN?	Returns the fuel currently stored in location #NN.
FUEL NN	Changes its current fuel to fuel #NN (1-15).
MODE?	Returns the current emissions units.

MODE X	(Emissions option). Selects the units of emissions measurements (CO, NO, NO_2, NOX, SO_2) as follows: X=P PPM (volumetric) X=M MGM (milligrams/cubic meter) X=# #/B (pounds/million BTU) X=G GBH (grams/brake hp-hour)
OXRF?	Returns the oxygen reference.
OXRF XX	(Emissions option). Sets the oxygen correction factor to any number as follows: XX=0-20 Percent, in 1% steps XX=21 TRUE (No correction for oxygen)
PUMP?	Returns the pump status: SAMPLE, DILUTE, PURGE, or OFF, and pump duty cycle: 0-100%
PUMP0	Turns the sample pump off & turns the purge pump on.
PUMP1	Turns the sample pump on & turns the dilution/purge pump off.
PUMP2	Turns the sample pump & dilution pump on. (High Range Mode)
PUMP XX	Sets the sample pump duty cycle. (10 < XX < 100)
TIME?	Returns the current time.
TIME XX:XX:XX	Sets the current time. (24-hour format)
SIZE?	(Velocity Option) Returns the stack size. (for flow-rate only)
SIZE NNN	(Velocity Option) Sets the stack size, in square inches, used in calculating the flow-rate.
VORF?	(Velocity Option) Returns the current flow/velocity selection
VORF X	(Velocity option). Selects between stack flow rate and stack velocity as follows: X=V Stack Gas Velocity (feet/second) X=F Stack Gas Flow Rate (cubic feet/minute)

MEMORY COMMANDS

COMMAND	FUNCTION
BUFF?	Returns the names of each of the 500 storage buffers.
BUFF NN?	Returns the name of buffer #NN (0-499).
BUFF NN XXX	Sets the name of buffer #NN to XXX. Buffer Name can be up to 11characters.
PRNT XXXX	Sends to the analyzer's printer the message "XXXX" up to 40 characters long. To send more characters, repeat the command.
DUMP?	Returns results of all tests stored in its memory.
DUMP NN?	Returns results of test #NN (0-499).
ERAS NN	Erases the contents of buffer #NN (0-499).
ERAS ALL	Erases the contents of all 500 buffers.

CALIBRATION COMMANDS

COMMAND	FUNCTION
OFFS?	Returns a list of voltage offsets for each sensor.
FACT?	Returns a list of calibration factors for each sensor.
SPAN XX NNN	Span calibrates sensor XX at a span value of NNN PPM or percent. Be sure to feed the correct span gas and wait for the sensor to stabilize before the analyzer receives this command, as it will execute a span calibration immediately.

		Span Range (NNN)	
XX=CO	Carbon Monoxide	10 PPM	1500 PPM
XX=NO	Nitric Oxide	10 PPM	1000 PPM
XX=NO_2	Nitrogen Dioxide	10 PPM	500 PPM
XX=SO_2	Sulfur Dioxide	10 PPM	1500 PPM
XX=CMB	Combustible Gases	0.1 %	5.0 %
XX=DFT	Stack Draft	-5" H_2O	-40" H_2O
XX=COIR	NDIR Carbon Monoxide	1.2 %	15.0 %
XX=CO_2	NDIR Carbon Dioxide	9.0 %	20.0 %
XX=HC	NDIR Hydrocarbons	1000 PPM	30000 PPM

ZERO	Executes an autozero of all analyzer sensors.
ZERR?	Returns a list of sensors that failed autozero.

MASTER COMMANDS

COMMAND	FUNCTION
LOGO?	Returns its current model name (ENERAC M700).
HELP?	Returns a list of all serial commands.
SRAL?	Returns the analyzer's serial number.
TURN OFF	The analyzer powers down.
TURN ON	The analyzer powers up. NDIR option will require a ZERO command. This command is not available via a Bluetooth connection.
VERS?	Returns the current firmware version.
VOLT?	Returns a list of all system and sensor voltages

CHAPTER 11

MAINTENANCE

The ENERAC 700 emissions-analyzer is a sophisticated analytical instrument designed to perform accurate emissions measurements. However, because it is a hand-held instrument that finds uses in many environments, care must be taken to prevent physical and environmental abuse. This will help maintain trouble-free operation.

There are five components that will require periodic service, inspection or replacement. These are:

1. Water trap (inspect for water buildup)

2. Disposable filters (inspect for discoloration and or water)

3. Sensors (electro-chemical sensors typically need replacement after two years)

4. Printer paper (after approximately 200 printouts)

5. Rechargeable battery pack (after a few years of service)

1. Condensation removal

At the end of a measurement, or whenever the trap is full, unscrew and empty the cylindrical water-trap. Check that the O-ring is seated correctly before replacing the trap.

NOTE: Before storing the instrument, shake the probe vigorously to drain it of any condensation as well.

2. Filter replacement

Frequency of particulate filter replacement depends on the type of fuel used. For natural gas you may need to replace the filter once a month. For coal fuels you will need to replace the filter every few days.

You must replace the filter when it becomes discolored. **Never operate the analyzer without its filters**.

a. **Water trap system**

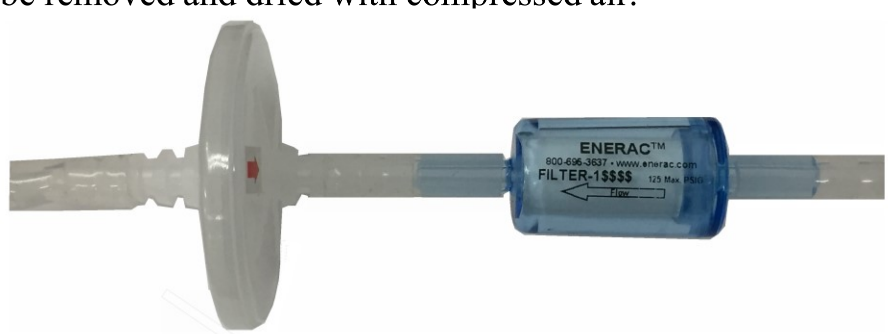
A disposable 20-micron polypropylene filter is located inside the condensation trap assembly. Its function is to prevent soot particles from reaching the analyzer pump and sensors. To replace the filter, unscrew the polycarbonate bowl, then the filter. Replace the filter, then hand tighten the bowl until snug against the internal O-ring.

Water Trap/Filter Assembly

b. Thermo-electric condenser system

The particulate filter is a cylindrical filter for collecting particulates. Replace it when it becomes dirty. When installing a new filter be sure to observe the correct flow orientation, as indicated by the large arrow on filter.

The disc shaped filter, if equipped, is to prevent condensation from entering the unit. If this filter absorbs too much moisture it will stop any further flow to the analyzer. If a replacement filter is not available, the wet condensation filter should be removed and dried with compressed air.



3. Sensor replacement

Sensor replacement should be an infrequent operation, perhaps once every two years or more. The best way to check a sensor's performance is to feed span gas and observe the sensor's response. An autozero error may indicate a problem with a sensor. If you receive an error message for one of the sensors during an autozero, do not replace the sensor at first. Instead, wait a few minutes and then autozero the analyzer again. If you get an error message again, investigate and determine if moisture has entered the sensor area. If so, wait a few hours for the moisture to evaporate and autozero the sensor again. If you still get a sensor failure then you may need to replace the sensor.

To access the electrochemical sensors, you must first remove the bottom section of the back plate on which the sensor manifold housing is mounted. This will expose up to four SEM gas sensors, the (optional) combustibles sensor and the oxygen sensor(s). All gas sensors are mounted directly on the main printed-circuit board.

To replace a sensor, pull the malfunctioning sensor straight off of the printed circuit board. Align the pins correctly when inserting a new sensor.

NOTE: The NO_2 sensor will have a shorting clip on two of its pins. This is to keep the sensor stabilized during storage. Remove the shorting clip before installing.

Be careful not to bend the sensor pins when inserting the new sensor. After the new sensors have been installed, replace the back plate. Wait the following time periods before autozeroing the analyzer:

OXYGEN SENSOR	10 MINUTES
CO SENSOR	12 HOURS
NO SENSOR	12 HOURS
NO_2 SENSOR	10 MINUTES
SO_2 SENSOR	30 MINUTES

Span calibrate the sensors as explained in CHAPTER 9: CALIBRATION. If you are installing a pre-calibrated sensor, use the following procedure:

1) While holding the **SETUP** key, press the **DISPLAY DATA** key three times. The display will show the sensor factors.
2) Press the **DOWN** key until you reach the appropriate sensor, then press **ENTER**.
3) Use the **UP / DOWN** keys to enter the correct factor, digit by digit. Press **ENTER** to move through each digit until all have been entered.

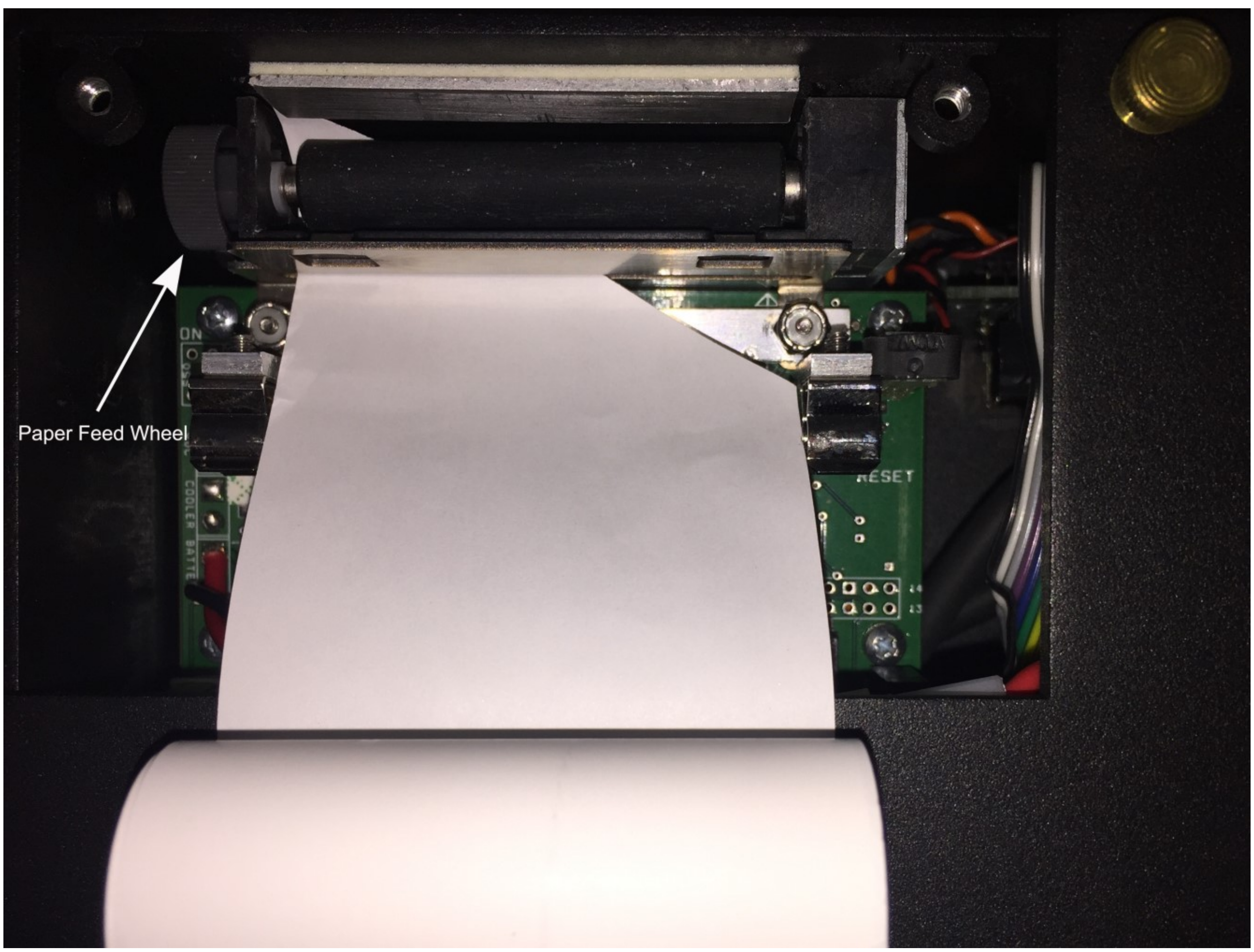
NOTE: There is a hydrogen cross-interference adjustment for the four-electrode carbon monoxide sensor. It is intended to remove the interference of hydrogen from CO measurements. Calibration for this is typically only done when the sensor is being replaced. To calibrate the hydrogen, feed hydrogen gas, typically 100 - 1000 PPM, and follow the same procedure as for the other span gas calibrations.

4. Printer-Paper replacement

The printer uses 2" thermal paper. Keep any spare paper rolls in a cool dark place to prevent paper discoloration.

To replace the thermal paper:

a. Remove the two screws that secure the top cover of the printer.
b. Unroll a few inches of a new roll of thermal paper.
c. Cut the end of the paper on an angle as shown.
d. Make sure to orient the paper so that it unrolls from the bottom.
e. Locate the slot immediately beneath the printer and insert the paper as shown.
f. Use the feed wheel on the side of the printer mechanism to advance the paper.
g. Replace the roll on the spindle and replace the cover.



5. Battery-Pack replacement

The analyzer is typically powered by a rechargeable battery-pack consisting of four, Ni-MH D-size cells. You should get between 4 and 6 hours of operation from a full charge, depending on the thermoelectric cooler power setting.

You can check the condition of the batteries at any time by pressing **SETUP + DISPLAY DATA** keys together. The battery voltage will be listed as **BAT**.

For Ni-MH rechargeable batteries the battery voltage will stay above 4.8 volts for a long time and then drop rapidly. **A minimum of 4.2 volts is required to operate the analyzer.**

The instrument will warn you when the batteries become weak. A "BATTERY LOW" warning will appear.

After a few hundred charge-cycles the rechargeable battery pack will have to be replaced. This can be done in the field.

APPENDIX A

MODEL 700 SPECIFICATIONS

ANALYZER

1. PHYSICAL:
   Material: 0.080” thick aluminum case
   Dimensions (analyzer): 9.8” X 5.7” X 3.12”
   Weight: (analyzer) 6 lbs. (4 “D” size batteries included)
   Carrying case (analyzer & all accessories): 17” X 12” x 6.5”

2. POWER:
   4 “D” size or 6 “D” size (heavy duty) Ni-MH rechargeable batteries.
   120/240 VAC input, 9 V./2.75 A. fast charger. Charging time: 5 hours typical.

3. DISPLAY:
   2.6” x 1.4”, 128 x 64 graphic, chip on glass (white backlit) LCD display.
   Small and large fonts, plus inverted background color for help messages.
   Battery condition & charger operation indicator

1. PRINTER
   2” high resolution, high speed, graphic thermal printer, prints: A.
   current set of data
   B. stored data
   C. periodic data printouts
   D. calibration history

2. PUMPS
   A. Sample pump: high-quality long-life motor (5000 hours),
   B. Dilution & Purge pump (option). Pumping system operates in one of the following modes:
      1. Fixed (low) range, LOW concentrations
      2. Fixed (high) range, HIGH concentrations
      3. Automatic ranging (low or high range)
      4. Purge mode, periodic sampling with purge (CTM-22, CTM-30, CTM-34)
      5. Pumps OFF mode

3. STORAGE
   500 internal memory storage buffers. Each buffer stores one complete set of data.

4. COMMUNICATION
   (Default baud: 9600. Max baud 115,200)
   A. RS-232 serial port
   B. USB port (Type B connector)
   C. Bluetooth wireless: Class 1 (100m)

5. SOFTWARE
   Enercom™ Windows software

6. MISCELLANEOUS
   A. Context-sensitive HELP key
   B. 17 fuel internal library
   C. Thermo-electrically cooled NO (SEM) sensor for negligible zero drifts.

SAMPLE & CONDITIONING SYSTEMS

1. CONDENSATION (WATER) TRAP & FILTER SYSTEM
   A 9” long, 316 Stainless Steel or Inconel probe, a fiber filter, and a polycarbonate water-trap.
   Sampling-line: 1/4” OD x 1/8” ID latex tubing; lengths available from 10’ to 50’.

2. THERMOELECTRIC COOLER SYSTEM
   A 9” Inconel probe & Peltier cooler with a 34cc water-trap, and particulate filter.
   Power required for Peltier: 3 watts supplied by analyzer.
   Sampling-line: 1/4” OD x 1/8” ID Teflon (PTFE) tubing recommended, Viton (standard). Available in lengths from 10 to 25 feet

SENSORS

1. ELECTROCHEMICAL SEM ™ EMISSIONS SENSORS – MULTI-RANGE SENSORS

SENSOR		RANGE	RESOLUTION	ACCURACY
CARBON MONOXIDE (CO)	LOW RANGE	0-1500 PPM	1 PPM	2 PPM OR 2% OF READING
	HIGH RANGE	4500 PPM	1 PPM	10 PPM OR 5% OF READING
NITRIC OXIDE (NO)	LOW RANGE	0-1000 PPM	0.1 PPM	2 PPM OR 2% OF READING
	HIGH RANGE	3000 PPM	1 PPM	5 PPM OR 5% OF READING
NITROGEN DIOXIDE (NO2)	LOW RANGE	0-500 PPM	0.1 PPM	2 PPM OR 2% OF READING
	HIGH RANGE	1500 PPM	1 PPM	5 PPM OR 5% OF READING
SULFUR DIOXIDE (SO2)	LOW RANGE	0-1500 PPM	0.1 PPM	2 PPM OR 2% OF READING
	HIGH RANGE	4500 PPM	1 PPM	5 PPM OR 5% OF READING

Custom ranges for all sensors are available upon request.

2. INFRARED (NDIR) SENSORS

SENSOR	RANGE	RESOLUTION	ACCURACY
HYDROCARBONS	0-2000 PPM 2001-15000 PPM 15001-30000 PPM	1 PPM	4 PPM OR 3% 5% OF READING 8% OF READING
CARBON MONOXIDE	0%-10.00% 10.01%-15%	0.01%	0.02% OR 3% READ. 5% OF READING
CARBON DIOXIDE	0.0% - 16.0% 16.1% - 20.0%	0.1%	0.3% OR 3% READ. 5% OF READING

3. OTHER SENSORS

SENSOR	RANGE	RESOLUTION	ACCURACY
OXYGEN 1-ELECTROCHEMICAL (Concentration)	0 – 25%	0.1%	0.1% ABSOLUTE OR 0.2% OF READING

OXYGEN 2 ELECTROCHEMICAL (High Range – option)	0 – 25%	0.1%	0.1% ABSOLUTE OR 0.2% OF READING
COMBUSTIBLES (Single Range option)	0- 5%	0.1%	10% OF READING OR 0.02%
STACK TEMPERATURE TYPE K T'COUPLE	0 – 2000 F. (1100 C)	1 F (1 C.).	5 F. OR 2% OF READING
AMBIENT TEMPERATURE	0 – 150 F. (65 C.)	1 F.	3 F.
STACK DRAFT PIEZORESISTIVE	+10" - -40" WC.	0.1" WC.	0.3" OR 5% OF READING
STACK GAS VELOCITY S TYPE PITOT TUBE	0 – 200 FT/SEC (2" WC.)	1 FT/SEC	MEETS EPA METHOD 2

COMPUTED PARAMETERS

PARAMETER	RANGE	RESOLUTION	ACCURACY
COMBUSTION EFICIENCY	0 – 100%	0.1%	0.5% OR 2% OF READING
CARBON DIOXIDE (NON – INFRARED)	0 – 20%	0.1%	CALCULATED FROM O2
EXCESS AIR	0 – 1000%	1%	CALCULATED FROM O2
OXIDES OF NITROGEN (NOX)	NO + NO2 RANGES	0.1PPM (SEM SENSORS)	NO + NO2 SPEC'S
EMISSIONS 1 (CO, NO, NO2, NOX, SO2)	0 – 2500 MG/M^3	2 MG/M^3	CALCULATED BASED ON PPM, O2 AND FUEL
EMISSIONS 2 (CO, NO, NO2, NOX, SO2)	0.00 – 99.99 LBS/MBTU	0.01 LBS/MBTU	CALCULATED BASED ON PPM, O2 AND FUEL
EMISSIONS 3 (CO, NO, NO2, NOX, SO2)	0.00 – 99.99 GMS/BHP-HR	0.01 GMS/BHP-HR	CALCULATED BASED ON PPM, O2 AND FUEL
EMISSIONS 4 (VELOCITY OPTION) (CO, NO, NO2, NOX, SO2 & CO2)	0 .00 – 99.99 LBS/HR 0-99.99 TONS/DAY (CO2)	0.01 LBS/HR 0.1 TONS/DAY (CO2)	CALCULATED BASED ON PPM, O2, STACK VELOCITY AND FUEL
STACK GAS FLOW RATE	0 – 65,000 CFM	1 CFM	CALCULATED BASED ON PPM, O2, STACK VELOCITY AND FUEL

APPENDIX B FIRMWARE

PROGRAMMING

On occasion it may be necessary to update the internal software of the analyzer, also known as the firmware. The firmware can be updated in the field with the use of a computer connected to the analyzer through the USB or RS-232 serial port. The Bluetooth connection cannot be used to reprogram the analyzer's firmware. Reprogramming the firmware will not affect the calibration settings or stored data.

Firmware updates can be downloaded from the ENERAC website: www.enerac.com, or can be requested directly from Enerac, Inc.

The current firmware version is displayed on the setup screen.

Updating the firmware

1. Download the firmware installation package. You can save it to your desktop.

2. Extract all of the files in the ZIP archive.

3. Turn on the analyzer.

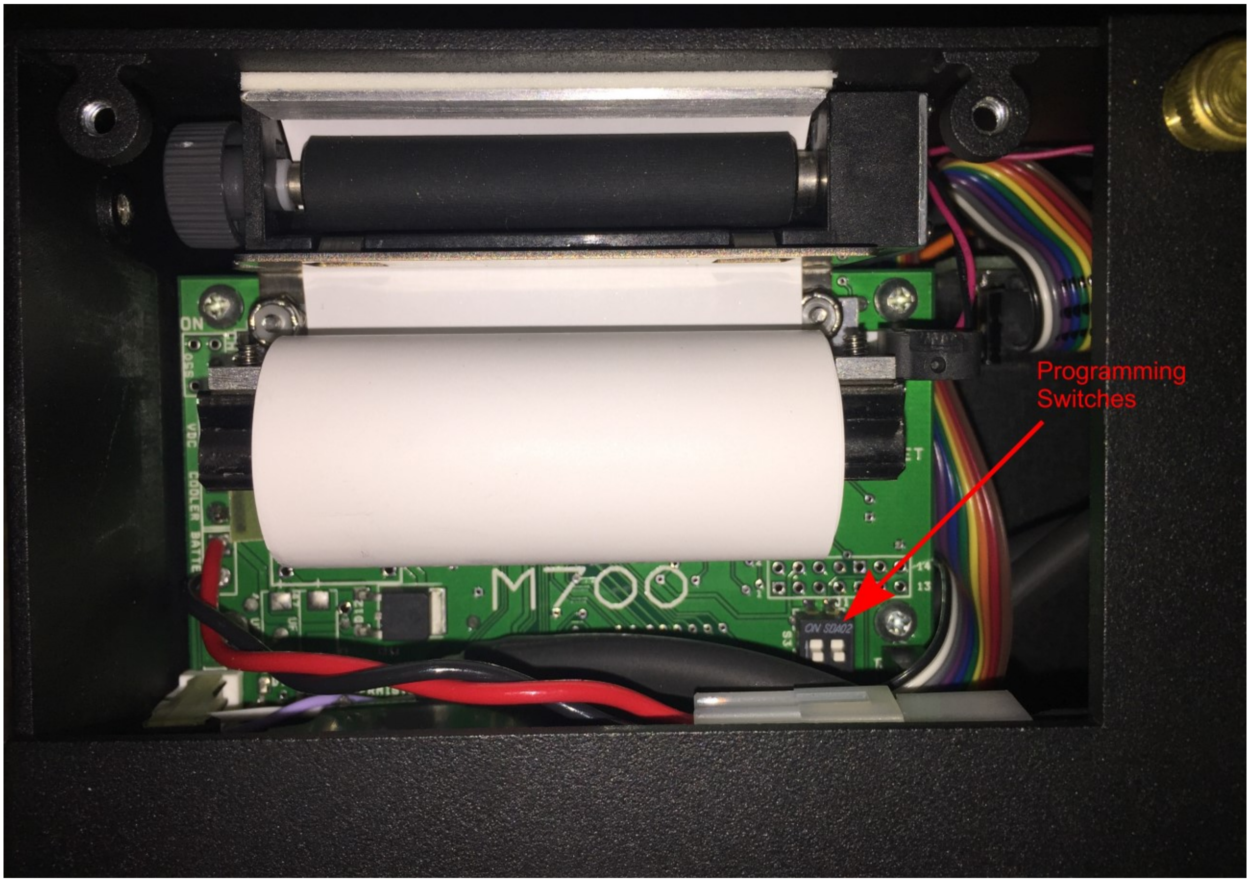
4. Connect the analyzer with a USB or RS-232 cable. Close the ENERCOM program if it is running on your computer.

5. Run the firmware update program (EneracFWP700.exe) in the extracted folder.

6. Enter the comport number when prompted. You can look up the comport number in the Windows Device Manager. (See chapter 10)

7. Answer any additional questions regarding the firmware configuration.

8. When prompted to turn on the programming switches, open the paper compartment of the analyzer and locate the programming switches. These are 2 miniature slide switches (refer to the figure below). Slide both switches to the program position.



9. Enter “c”. The firmware will now be reprogrammed and verified. This will take 2-3 minutes.

10. When prompted, set the programming switches back to their original position and replace the back cover.

11. Turn on the analyzer. Check the firmware version on the **SETUP** screen.

APPENDIX C

EPA TEST METHODS

A SUMMARY OF THE EPA CONDITIONAL TEST METHOD CTM-034 REQUIREMENTS FOR CO, NO_X AND O_2 EMISSIONS

This method is applicable for the measurement of oxygen, carbon monoxide and oxides of nitrogen (NO_X) emissions from sources using gaseous and liquid fuels.

NO_X is the sum of NO (nitric oxide) and NO_2 (nitrogen dioxide) concentrations. If the NO_2 concentration during measurement is known to be less than 10% of NO_X, you may estimate it and add it to NO. If it is more than 10%, you must also measure the NO_2 concentration.

If an NO_2 measurement is required, a chilled condenser must be used, and the inside of the transport line to the analyzer must not get wet. Failure to meet these requirements will result in scrubbing of the NO_2 gas. “The sample line must be designed to prevent condensation”.

Unlike Method 7E, a single calibration span gas is required for each CO, NO and NO_2 calibration.

The sample flow rate must be monitored before and after each test and not vary by more than 10%, or cause the readings to change by more than 3%.

During a measurement cycle, the temperature of the sensors must be monitored and must not change by more than 10 °F.

Unlike Method 7E, clean air may be used to zero the analyzer.

The accuracy requirements for CTM-034 are based on the calibration span gases that are used:

1. Zero calibration error: < 3% of span gas for CO, NO, NO_2
   < 0.3% for O_2
2. Span calibration error: < 5% of span gas for all sensors
3. Interference response: < 5% of span gas for all sensors
4. Repeatability check: < 3% of span gas after four measurement cycles

A SUMMARY OF THE EPA REFERENCE METHOD 7E REQUIREMENTS FOR NO_X EMISSIONS

The currently modified Method 7E now allows for the use of any real-time analyzer, including analyzers using electrochemical sensors, for testing NO_X emissions from stationary sources, provided they meet certain performance test requirements.

The test requirements of Method 7E are generally more rigorous than those of the EPA Conditional Test Method requirements of CTM-030 and CTM-034.

Typically, five to six calibration span gases consisting of NO balance nitrogen and NO_2 balance nitrogen or air are required for electrochemical analyzers. Calibration gases must not be used after their expiration date.

Stack stratification tests are required (typically 12 stack traverses), except for stationary engines (with exhausts less than 4 inches in diameter).

Under certain conditions the moisture content of the flue gas must be measured using EPA Method 4 or another approved method. Moisture correction is required for measurements in pounds/million-BTU.

The probe must be heated until it reaches the moisture removal system. A dry transport line is required from the moisture removal system to the analyzer.

Dual range analyzers are allowed, but they must meet the specifications listed for single range.

For analyzers that are designed ONLY for very low range NO_X measurements (less than 20 PPM), a Manufacturer Stability Test (required by the manufacturer and user) is required. This stability test checks for temperature induced drifts over a 12-hour period, supply voltage effects, and calibration error tests.

1. Before and after each emission test the analyzer must be challenged with three different concentrations of calibration span gases: High-level (20-100% of calibration span), mid-level (40-60%), and low-level (<20% or zero air).
2. These calibration span gases must be certified 2% accurate or better.
3. Zero-air gas may be used in place of low-level span gas. Zeroing in clean air is not permitted.
4. The analyzer sample flow rate must be measured and documented before and after each test, and it must not change by more than 10%.

5. The measured emissions must be between 20% and 100% of the calibration span, which is the high-level calibration span gas. It is suggested that you choose a high-level span gas that is as high as possible, up to 5 times the expected emissions concentration, but do not exceed the range of the sensor.
6. Accuracy requirements are listed below. They are based on the selected concentration of high-level span gas. All accuracy requirements must be met for each test.

   A. Calibration error: < 2% for each calibration span gas concentration
   B. System bias: < 5% (difference between gas introduced at the probe and also directly into the analyzer)
   C. Drift: < 3%
   D. Interference check: < 2.5% for the sum of all interfering gases
   E. Analyzer resolution: < 2% of range
   F. Data recording: 1-minute average, each run

Example:
If the analyzer has an NO range of 1,000 PPM and the measured NO emissions are 150 PPM, you can select a high-level calibration gas up to 750 PPM NO. This is your calibration span. Then the accuracy requirements are: Calibration error <15 PPM, System bias <37 PPM, Drift <22 PPM, Interference check <18 PPM, Analyzer resolution <15 PPM.

This summary addresses many but not all of the requirements of EPA Reference Method 7E.

A SUMMARY OF THE ASTM D6522 TEST METHOD FOR THE DETERMINATION OF NITROGEN OXIDES, CARBON MONOXIDE AND OXYGEN CONCENTRATIONS

This test method covers the determination of nitrogen oxides (both NO and NO_2 required), carbon monoxide (CO) and oxygen (O_2) primarily from GAS FIRED sources using exclusively DIFFUSION BASED ELECTROCHEMICAL SENSORS.

This method was developed by the GAS Research Institute (GRI) with the EPA's assistance.

This method requires a heated sampling system from the probe to a thermo electric condenser and no condensation in the transport line beyond, to the analyzer input, to prevent loss of the NO_2 fraction of total NO_X.

During a test, the sample flow rate must be checked and not change by more than 10%.

The temperature of the NO cell must be monitored during a test (a minimum every 5 minutes) if the analyzer cannot measure negative values. It is not necessary if it measures negative values. (Author's note: This requirement does not address large positive NO drifts with rising temperatures). It is preferable to monitor the NO (ambient) cell temperature at all times. (Check with EPA CTM-034).

A single calibration span gas (labeled upscale calibration gas) is required. No linearity tests are required for CO, NO, and NO_2 provided the manufacturer states that they are linear.

The concentration of the upscale calibration gas must be such that the measurement concentration must fall between 25% and 125% of its value.

For oxygen, a mid-level O_2 gas (i.e. 10% O_2) is required for linearity and clean fresh air is acceptable as zero gas for all sensors.

Analyzer requirements:

1. NOX interference on CO: < 5%
2. Analyzer sensitivity: < 2% of analyzer range, or 1 PPM (0.1 PPM recommended for low NO_X measurements)
3. Analyzer resolution: ≤ 1 PPM. (For O_2: ≤ 0.1%)

Test requirements (based on UCG, upscale calibration gas):

a. Zero calibration error: < 3% of UCG for CO, NO, NO_2 and < 0.3% O_2
b. Upscale calibration error: < 5% UCG for CO, NO, NO_2 and < 0.5% O_2
c. Thirty-minute stability test requirement: < 2% of UCG. (For a 15 minute test: < 1% of UCG)

NOTE: Calibration checks are required before and after each measurement test.

NOTE: There are some special conditions recommended for reciprocating engines and combustion turbines.

APPENDIX D

REPLACEMENT PARTS

Part	Part #
O2 SENSOR (SAMPLE / DILUTION)	ASSOXYGEN-3$
CO SENSOR	SNS$COSEM8CM
NO SENSOR	SNS$NOSEM8NO
NO2 SENSOR	SNS$NO2SEM8ND
SO2 SENSOR	SNSSO2SEM8SN
COMBUSTIBLE SENSOR	ASSHOUCMB3K1
3-GAS SENSOR (CO, CO2 & HC)	OPTNDIR-3GAS
NO SENSOR (700AV)	SNS$NOMEM3NX
HASTELLOY FILTER (SPECIFY MODEL)	FILTER-2KE-2
THERMAL PAPER (3 PER PKG.)	ASSPAKTHR200
BATTERY (PACK OF 4)	BAT-1.2DNIPK
POWER CHARGER	BATCHRG700D$
CAL. KIT (W/OUT GAS)	ASSCALKITDM5
1 FT. OF EXTRA PROBE LENGTH (UP TO 8')	ASSPRB700-XX
10 FT HOSE WITH THERMCOUPLE	ASSHOS700V10
PARTICULATE FILTERS (3 PER PACK)	ASSPAKFLTR1$
IR BENCH FILTER (EACH)	FILT.45MICRO
WATER TRAP (700AV)	ASSWTR700-1$
WATER TRAP FILTERS (700AV) (EACH)	FILTEREK504Y
9" PROBE	ASSPRB700-10
PROBE EXTENTION (EACH)	INC-ASS-2E13
SMOKE OPTION	OPTP700-DPM$
TAIL PIPE BRACKET (700AV)	LTAILPSUPBRA