

EXHAUST GAS ANALYZER
MODEL 900503
USER MANUAL



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1 INTRODUCTION

The 5 Gas Analyzer is a complete, ready-to-use gas analyzer. Just turn on the power switch, connect the hose and probe and push the ZERO button. When the Zero is done, the analyzer is ready to measure exhaust gas. There are three power options, a stainless-steel probe assembly, easy storing sample line, a built-in water trap and particulate filters to protect the analyzer.

1.1 Analyzer features

- Battery powered and self-contained infrared gas analyzer
- Small, lightweight, and rugged with easy to read LED display
- Instant on - fast warm-up and fast gas readings.
- Fuel selection: Allows HC to be measured and displayed as Hexane for Gasoline, Propane for LPG, and Methane for CNG.
- Real time Lambda/air fuel ratio display using HC (Fuel dependent values are used), CO, CO₂, O₂ and NO_x (Opt.) gas measurements.
- Real-time Combustion Efficiency display using HC (Fuel dependent values are used), CO, CO₂, O₂ and NO_x (Opt.) gas measurements.
- Single Button Zero calibration.
- Automatic back flushing empties the water trap/separator.
- Gas calibration automatically adjusts for use of propane. No PEF number calculations are required.
- Includes complete sampling system.
- Operator accessible and maintainable filters.
- PC compatible RS 232 PC interface and supporting software.
- Serial Printer (Optional) support for hardcopy gas data.

1.2 Unpacking Your 5 Gas Analyzer

Contents:

1. 5 Gas Analyzer
2. Tailpipe Probe assembly including detachable flexible probe tip, S-Bend, primary particulate 50mm filter; handle and attached water trap assembly.
3. Sample line assembly.
4. Vehicle battery clip adapter with power socket.
5. External power cord with vehicle power plug
6. External power cord with wall mounted 12V supply.
7. Spare filter kit, 1 ea 50mm filter, 25mm filter, and water trap filter



2 PRINCIPLE OF OPERATION

The analyzer draws a slip sample of exhaust gas using an internal pump. The sample gas is passed through infrared optics and also across chemical sensors. This combination of detection methods is used to determine the gas concentration of various exhaust gases.

There are two distinct detection methods for exhaust gas analysis: non-dispersive infrared (NDIR) for CO, CO₂, and hydrocarbons, and chemical sensors for O₂ and NO_x. NDIR technology is used to measure the concentration of a gas by determining how much infrared energy is absorbed at a select wavelength band that corresponds to a resonant mode spectrum of the molecule being analyzed. For example, the CO₂ molecule has a strong resonance at a frequency relating to the 4.26 micron near infrared wavelength. Therefore, CO₂ will strongly absorb infrared energy at this select wavelength. The more CO₂ molecules there are in the optical path, the more energy gets absorbed. The gas analyzer determines how much energy is absorbed at a specific molecular resonance of a particular gas and then relates this absorption to gas concentration. In general, it is the technique of choice for measuring common exhaust gases as this technology is cost effective, robust, stable, well proven, and by far the most popular method for measuring these gases.

Periodically, the analyzer will sample common air. This is required in order to reset the reference gas values on the analyzer. This process is called “Zeroing” the analyzer. The analyzer has a separate intake port and internal solenoids used for the Zero process.

3 OPERATING ANALYZER

3.1 Installation and Setup

Before assembling and using your analyzer for the first time, you may want to read ahead and familiarize yourself with the front panel displays and controls.

1. Remove the analyzer from the storage case.
2. Remove the probe and sample line assemblies from the storage case.
3. Attach one or both sections of the black sample line to the water trap/separator of the probe, and the other end to the white 25mm diameter filter on the handle of the analyzer.
4. Turn the power switch on. The analyzer will ‘lamp test’ the gas displays, momentarily run the pump and then enable the display with dashes as shown to the right. This is telling you that the analyzer is ready for operation, and that Hexane (C6) is the selected HC for the fuel used.
5. Only at this time (the power-up screen) can the fuel selection be changed.
6. To do so, momentarily push the NOx/OPT button.
7. The HC display will begin to flash.
8. Select the fuel you wish to use (Gasoline = Hexane – C6, LPG = Propane – C3, CNG = Methane – C1) by the UP or DOWN arrow.
9. To save the fuel selection, push the NOx/OPT button again. The HC display will stop flashing, and will show the selected fuel.
10. NOTE: The fuel selection is saved in power safe memory. On the next power-up, the last fuel selected during the previous operation is active. This means the analyzer fuel mode can be set and retained for future use, and does not have to be set each time the analyzer is powered up.
11. Press the ZERO button to start operation. For information on how a zero is performed, see “Zero,” see the Zero Calibration section.



3.2 5 Gas Analyzer Front Panel

The analyzer front panel tells you just what you want, and gives you just the controls that you need. It never gets in your way.



CO Concentration Display

The CO gas concentration is reported in hundredths of a volume percent within the range 0.00% to 9.99%.

HC Concentration Display

The HC gas concentration is reported in ppm (parts per million) within the range 0 to 9999 ppm for Hexane and Propane, and 0.000 to 9.999% for Methane.

CO₂ Concentration Display

The CO₂ gas concentration is reported in tenths of a volume percent within the range 00.0% to 20.0%.

O₂ Concentration Display

The O₂ gas concentration is reported in hundredths of a volume percent within the range 0.00% to 25.0%.

ZERO Calibration Button

Periodically you must “Zero” your analyzer. The Zero Calibration Button is discussed in the Zero Calibration section.

Span Calibration Button Cluster

To maintain the highest gas measurement accuracy, you will occasionally “span” your analyzer. The Span Calibration Buttons are discussed in the Span Calibration section.

Print and Display Button Cluster

These buttons are used to print on the serial printer, and to change the O₂ display to show Lambda or AFR. The NO_x button changes the HC display to show NO_x for the 5-gas analyzer.

3.3 Using Your 5 Gas Analyzer

First choose the power source you wish to use. You can use the on board battery pack, cigarette lighter plug, the optional vehicle battery clip-on cable, or the wall-mounted supply.

- Turn on your analyzer by using the power on switch on the analyzer handle.
- When first powered up, the analyzer first performs a self-test, including a 'lamp test' in which all of the display elements are activated, and the pump and solenoids turned on. At the completion of the self-test, the analyzer will return to its initial state. In order to use the gas analyzer, you must first execute a Zero. When you do so, the analyzer display will show dashes alternating with blanks. This is an indication that the Zero is executing. When the Zero is complete, the analyzer display will begin to show gas readings.

Scheduled Zero Requests:

- Your analyzer will flash dashes on the display to request a Zero after the first 5 minutes of operation and every 30 minutes thereafter. When you see this prompt, you should press the ZERO button on the analyzer for one second when convenient. (The Zero procedure takes 30 seconds and does not require that the probe be removed from the exhaust.) It is also strongly recommended that you zero calibrate the analyzer just before each critical "test." This will maximize the accuracy of your measurements.
- To measure a vehicle's exhaust gas, simply insert the tail pipe probe into the vehicle's exhaust pipe. Make sure it goes in all the way to the first bend of the probe's S-tube. You may use the probe restraint chain to guarantee that the probe does not vibrate out of the tail pipe.

Zero Before Putting the Unit Away:

- After each use you should perform a Zero before you pack the unit away. This will automatically purge the system, and empty the water trap bowl. When the Zero is complete, you can turn off the analyzer and either charge the battery or pack the analyzer away for future use.

3.4 Lambda, AFR, and Combustion Efficiency

To display Lambda, AFR, and Combustion Efficiency, enter the diagnostics screen by momentarily pressing the “λ / AFR” button.



The CO display changes to display ‘-L-’, and the HC display now shows Lambda to 3 decimal places as X.XXX. The CO₂ display changes to read ‘A-F’ and the O₂ display now shows real-time A/F ratio. NOTE: Both Lambda and A/F ratio are calculated from exhaust gas readings, and use the selected fuel constants to complete the calculation. See White Paper #1 - Lambda Calculation – The Brettschneider Equation, general principles and methods for more information about Lambda.

A Lambda value of 1.000 is perfect stoichiometric balance between air and fuel and relates exactly to the normally considered Air/Fuel ratio for gasoline of 14.7:1. Thus, a Lambda of 1.012 is 1.2% lean and 0.988 is 1.2% rich. AFR is directly calculated from the Lambda value by multiplying the stoichiometric value for the selected fuel (14.7 for gasoline) times the calculated Lambda value. E.G., at a Lambda value of 0.988 as above, the A/F Ratio is 14.5.

3.5 Displaying Combustion Efficiency



Pressing the UP arrow changes the CO display to read 'EFF', and the HC display now shows Combustion Efficiency % to 2 decimal places as YY.YY. NOTE: Combustion Efficiency is a measure of the efficiency of the engine to burn fuel, and is calculated from the exhaust gas readings using fuel – specific constants.

NOTE: Combustion Efficiency is calculated from exhaust gas readings, and uses the selected fuel constants to complete the calculation. See White Paper #12 - Combustion Efficiency Calculations for more information about combustion efficiency.

Pressing the DOWN button again changes the display to read Lambda on the HC display. Pressing the " λ / AFR" button again exits the diagnostic mode and changes the displays to read normal gas concentrations.

3.6 Displaying NO_x (Model 9005 Only)

To display Oxides of Nitrogen (NO_x), momentarily press the “NO_x / OPT” button when the analyzer is reading normal gas concentrations.

The HC display will display decimal points in all locations, indicating that it is now displaying NO_x in ppm concentration.



Pressing the “NO_x / OPT” button again changes the HC display back to the normal measuring mode for the selected fuel.

Each time you press the “NO_x / OPT” button the analyzer will alternate between HC and NO_x display.

3.7 ‘LO’ Indication on the O₂ Display

If, after a Zero is complete, there is a flashing ‘Lo’ displayed on the O₂ display, this indicates that the O₂ Sensor is low sensitivity and was providing an out-of-specification output when measuring the oxygen in ambient air during the Zero process. These sensors gradually become less sensitive over time (12 to 18 months), so the analyzer raises this warning when it detects the O₂ sensor is losing sensitivity. Generally, the user has about 30 days left within which he should replace the O₂ sensor, which can be ordered directly from Mustang and installed in the field by the user. The warning can be cleared by pressing any front panel button.

4 CALIBRATION

4.1 Zero Calibration

Zero calibration is a fully automatic function that corrects measurement inaccuracies caused primarily by changes in temperature and empties condensed water from the water trap.

To maintain the best accuracy, you should zero calibrate your analyzer each time it requests it by displaying dashes in the gas concentration displays or before each test.

Follow these steps when you perform zero calibration:

1. Make sure that the water trap's clear bowl and water backflush port is facing down.
2. **IMPORTANT NOTE:** During the first few seconds of zero calibration, the analyzer pump runs backwards, flushing water out of the water trap bowl through the water backflush port. Be sure that the water will drain to a suitable location.
3. Press the zero calibration button. The gas concentration displays will now show blinking dashes to let you know that zero calibration is under way. When zero calibration is finished, these displays will again report gas concentrations (at or very near zero – except for Oxygen, which will be set to 20.6% - room air level).
4. Insert the probe into the exhaust pipe, and observe the displays, stabilize to the exhaust gas readings in about 10 seconds.
5. **NOTE:** It is NOT necessary to remove the probe from the exhaust pipe for subsequent Zeros, as the analyzer switches to a separate gas port for zero air.



4.2 Span Calibration

Your analyzer does not require frequent span calibration to stay within specification. Annual calibration checking service is available from Mustang for a nominal charge.

However, Span calibration is a built-in function of the analyzer, and span calibration is available to remove measurement inaccuracies caused by changes in ambient pressure or long term changes in the analyzer's internal components.

Follow these steps if you perform span calibration:

1. First, you will need calibration gas and a regulator/adaptor. These components are available from Mustang. See the 'Spare Parts' section at the end of this manual.
2. Warm up the analyzer for at least 30 minutes in a stable, room temperature environment.
3. If you have not done so, connect the gas tank, pressure regulator, and adapter tube. Turn on the gas tank valve and confirm that you see tank pressure. Turn the regulator clockwise so that it delivers calibration gas at a very low flow into the adapter tube. Then, turn the regulator CCW to stop the flow.
4. Perform a normal analyzer Zero calibration.
5. Insert the tail pipe probe tip fully into the calibration adapter.
6. Turn the calibration gas regulator CW to deliver a low flow, and observe the gas readings stabilize.

7. Press both the CAL and ZERO buttons (CAL button first). Hold them pressed for about one second.
8. The CO display will read normally while the other displays read "CAL" as shown. (Use the CAL button to select CO as the active gas if the CO display is not reading values.) Then, simply use the UP and DOWN arrow buttons to adjust the gas concentration reading on the analyzer to match the calibration gas tank 'tag' value for each gas.



9. When the CO gas is calibrated, press the CAL button to select the next gas to be calibrated. In this illustration, the HC channel shows it is ready for span calibration. Use the UP and DOWN arrow buttons to adjust the gas concentration reading to match the calibration gas tag value. Note: Your analyzer automatically changes its HC channel to match the HC in calibration gas cylinders. It changes back on CAL mode exit.



10. Each time you press the CAL button the analyzer will step to the next gas channel ready for calibration.
11. When you get to O₂, you will notice that there are two modes for this gas. 'Hi' is used to span calibrate O₂ above 2.00%. Use this if you want to change the O₂ reading on room air – normally 20.6%. 'Lo' is the offset calibration used to adjust O₂ zero readings. Since calibration gas normally has no O₂ in it, this is the normal adjustment using calibration gas. You may adjust the O₂ offset using the 'Lo' mode until it accurately reads 0.00% O₂ using calibration gas.

12. Save, Abort or Restore CAL Values:

- **Save CAL values:**

When you have set and confirmed all gases, press both the CAL and ZERO buttons (CAL button first). Hold them pressed for about one second. (This is the same combination you used to enter the span calibration mode.) The new span calibration values are stored in power safe memory and you are ready for normal gas measurement.

- **Abort Span Calibration – Do Not Save CAL Values:**

If you wish to abort a span calibration because of questionable results, simply press the ZERO button to abort the Span process.

- **Restore Factory CAL Values:**

If you believe that a previous span calibration has been performed incorrectly, you can return to the original factory span calibration by entering the CAL mode as above and pressing and holding (for about one second) both the UP and the DOWN buttons simultaneously.

5 USER MAINTENANCE

5.1 Battery Power and Charging Display

The battery power display serves two functions – display of remaining battery power, and status of the battery charge function.

Whenever the analyzer is running, the top 9 segments of the display indicate charge level. A fully charged battery will light all 9 segments (7 green and 2 Red) – and as the battery discharges, it will be indicated on the display. When there are about 10-15 minutes of operation left, the display should go blank. This is an indication that the operator should change to either the wall-supply or automotive 12V supply to continue testing.

NOTE: When the external supply is plugged into the analyzer, the analyzer will automatically sense that external power is available and switch to using it for power. This power cycle will cause a system reset, which will cause the analyzer to perform a power-on sequence and require that the operator execute a Zero before the new power source can be used.

5.2 Charging the battery

When the external supply (either from the wall supply or from the automotive supply) is attached, the analyzer will recharge the on-board battery whenever the analyzer is in the OFF position. The state of the charge circuit is indicated by the Lowest (red) display element of the battery display.

Flashing Red Bar: The internal battery charging circuit will first ‘search’ for the battery – indicated by blinking of the battery charge indicator once per second.

Steady Red Bar: If a battery is found, the display will change to a steady display, indicating that high charge is being applied to the battery.

Red Bar Off: At the end of the high charge cycle (normally 1 ½ to 2 hours) the display element will go off – and the analyzer will continue ‘trickle-charging’ the battery. This will continue until the analyzer is turned on for use. It is preferred to leave the charger plugged into the analyzer after the high-charge cycle. The battery cannot be overcharged.

Note: Cycling power will start the charge cycle over again. There is no danger of overcharging the battery.

5.3 User Maintenance

Note: There are no user replaceable parts inside the Gas Analyzer housing. Additionally, opening the analyzer case will void your warranty – so it is not recommended to do so.

<p>“Lo’ on O₂ display after a Zero.</p>	<p>This is an indication that the analyzer has detected that the O₂ sensor is low output. This is a self-calibrating sensor that can be ordered from Mustang and installed by the user when necessary.</p>
<p>Slow Response – Dirty Filters</p>	<p>Dirty filters and kinked lines will cause a longer than normal time for the gas data to be displayed. Possible causes include:</p> <ul style="list-style-type: none"> • Dirty, clogged primary particle filter. • Dirty, clogged analyzer particle filter. • Dirty, clogged water trap/separator hydrophobic filter. • Damaged, kinked, or clogged probe or hose.
<p>Primary 50 mm dia Particle Filter: (6 Filters per Year.)</p>	<p>Replace the 50 mm dia primary particulate filter as necessary. As the filter removes and collects carbon soot and other solid particles from the exhaust gases, you will be able to see the particles gradually collect on the front side of the filter. When it is significantly darker than the back side, replace the filter. In normal use, it is expected that the 50 mm dia particle filter will require replacement every 2 months – or 6 times per year.</p>
<p>Analyzer 25 mm dia Filter: (3 Filters per year)</p>	<p>The 25 mm analyzer filter also traps remaining particles from the exhaust gas that passed through the primary filter, and prevents water from entering the analyzer. Inspection and replacement are the same process as the 50 mm dia filter above. In normal use, it is expected that the 25 mm dia filter will require replacement every 4 months – or 3 times per year.</p>
<p>Water Trap/Separator: (3 Filters per year.)</p>	<p>Replace the water trap/seperator’s hydrophobic filter at the same time the 25 mm dia filter is replaced. To replace it, unscrew the clear plastic bowl from the water trap/seperator and pull out the white plastic hydrophobic filter. Install a new one and reassemble.</p>

6 CONSUMABLES, SPARE PARTS AND ACCESSORIES

The following parts and assemblies can be purchased from Mustang Dynamometer.

PART NUMBER	DESCRIPTION
000815	Annual Use Filter Set, (typical 1 yr supply)
101196	50 mm Primary Particle Filter (6 pcs – 1 yr supply)
104156	Water Trap Filter (6 pcs - 2 yr supply)
108126	25 mm Filter, Analyzer (6 pcs – 2 yr supply)
000120	O2 Sensor (18 – 24 months)
000121	NOx Sensor (24 – 36 months)
001182	Quick-Release Flexible Probe Tip
000813	Compact Auto Exhaust Probe
000919	Water Bowl / Check Valve Assy
000410	Sample Line Assy, 20 ft. (1 ea 8 ft section, and 1 ea 12 ft sections)
000690	Calibration Sample Tube
000575	110VAC 50-60 Hz wall-mounted 12V Supply
000835	220VAC 50-60 Hz wall-mounted 12V Supply
000418	Battery Clip to Lighter Socket Cable Assy
000814	Cigarette Lighter Plug to Analyzer Cable Assy
001537	Serial Printer Assembly
106460	PC Display/Data Capture / Report Printing Software

7 GAS ANALYZER SPECIFICATIONS

Gases Measured	CO, HC, CO ₂ , O ₂ , NO Calculates Lambda, A/F Ratio, and Combustion Efficiency
Reporting Range:	CO: 0-10% HC: 0-9,999 ppm Hexane and Propane 0.000 – 9.999% Methane CO ₂ : 0-20% O ₂ : 0-25% NO: 0-5000 ppm Lambda: 0.500-2.000 AFR 7.50 – 30.0 Combustion Efficiency: 0.00 to 99.99%
Resolution:	CO: 0.01% HC: 1 ppm (Hexane and Propane) 0.001% (Methane) CO ₂ : 0.1% O ₂ : 0.01% NO: 1 ppm Lambda: 0.001 AFR 0.1 Combustion Efficiency: 0.01%
Accuracy:	All channels 5% relative.
Repeatability:	All channels 3% relative.
Warm-up:	30 Seconds to 10% accuracy 5 minutes to full accuracy
Operating Environment:	+10 ° to +40 ° C (68 ° to 104 ° F) -500 to 10,000 ft. Altitude
Power:	Self-contained rechargeable battery & adapters to clip-onto vehicle battery or plug into vehicle 12V DC power outlet.
Battery Pack:	Continuous 3 hr. operation per charge.
Wall Supply:	110 VAC/60 Hz 220VAC/50 HZ optional.
Data Port:	Serial DB9 RS-232 Connector, 9600 baud.

8 TECHNICAL SUPPORT, WARRANTY AND SERVICE

Technical Support:

Technical support is available from Mustang Dynamometer at the telephone numbers and email address below. Please feel free to make use of this service in case you have any questions.

Warranty Service Policy:

Your Gas Analyzer is covered by a one-year parts / workmanship warranty.

In order to return the analyzer for service, please contact Mustang Dynamometer for detailed instructions at:

Mustang Dynamometer
2300 Pinnacle Pkwy.
Twinsburg, OH 44087 USA
Tel (330) 963-5400

Email: sales@mustangdyne.com

For product returned under warranty, the customer pays freight charges for product return. Mustang will repair or replace the analyzer and return the analyzer freight prepaid to the customer. There will be no charge for parts, labor, or outbound ground freight for products serviced under warranty.

Non-Warranty Service Policy:

For product no longer under warranty or for malfunctions not warrantable, the customer pays freight charges for product return.

Mustang will evaluate the unit and respond to the shipper with a service estimate for repairs, recommended upgrades and additionally requested parts. Once the service estimate is reviewed and the work authorized by the customer, Mustang will proceed with the service authorized.

The customer will be charged for service and upgrade parts, labor, and outbound freight for products not under warranty.



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