DGA 1000
Diagnostic Gas Analyzer

Snap-on Diagnostics

Table of Contents

Using this Manual

This manual contains instructions for setup and use of the ***DGA 1000 Gas Analyzer*** and dynamometers. A table of contents and is provided to make this manual easy to use.

Some of the information shown in text or illustrations is obtained using optional equipment. A ***Snap-on*** Sales Representative can determine option availability.

For Service or Technical Support, call Emissions Technical Support Group at 1-800-225-5768.

Conventions

This section contains a list of conventions used in text.

Check Note

A check note provides additional information about the subject in the preceding paragraph.

Example:

✓ Keep the probe tip openings clean and free of debris.

Testing Tips

Testing tips provide information that applies to a specific test. Each testing tip is introduced by this icon for easy identification.

Example:

❒ Check vehicle manufacturer specifications and procedures before testing.

Chapter References

Additional information in text is referenced by chapter number and section name.

Example:

For additional information refer to *Chapter 4– Maintenance*.

Equipment Damage

The possibility of damage to vehicle or equipment is introduced by a signal word indicating this condition.

Example:

IMPORTANT

After extended testing, operate the engine at 1500 RPM with no load for several minutes with the cooling fan in place. This helps reduce test induced engine heat.

Safety Messages

Safety messages are provided to help prevent personal injury and equipment damage. All safety messages are introduced by a signal word indicating the hazard level. The types of safety messages are:

⚠DANGER

Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury to the operator or to bystanders.

⚠WARNING

Indicates a potential hazard which, if not avoided, could result in death or serious injury to the operator or to bystanders.

⚠CAUTION

Indicates a potential hazard which, if not avoided, may result in minor or moderate injury to the operator or to bystanders.

The three-part message panel, used with safety messages, uses three different type styles to further define the potential hazard:

- Normal type states the hazard,
- **Bold type** states how to avoid the hazard, and
- *Italic type* states the possible consequences of not avoiding the hazard.

Some safety messages contain visual symbols with signal words.

Example:

Risk of burns.
Do not remove radiator cap unless engine is cold. Pressurized engine coolant may be hot.
Hot engine coolant can cause serious burns.

Abbreviations

The following abbreviations are used in this manual.

A	current, amperage
AIR	Air Injection Reaction
C	carbon
CNG	Compressed Natural Gas
CO	carbon monoxide
CO_2	carbon dioxide
COMM	communication
DTC	Diagnostic Trouble Code
EGR	exhaust gas recirculation
FID	flame ionization detector
H	hydrogen
HC	hydrocarbons
Hz	hertz
km/h	kilometers per hour
lb	pound
LPG	Liquefied Petroleum Gas (Propane)
mV	millivolt
MIL	malfunction indicator lamp
NDIR	Non-Dispersive Infrared
NO	nitric oxide
NO_2	nitrogen dioxide
NOx	oxides of nitrogen
NRLHP	normal road load horsepower
O_2	oxygen
OBD	On-board Diagnostics
OIML	International Organization of Legal Metrology
PC	personal computer
PCV	positive crankcase ventilation
ppm	parts per million
RPM	revolutions per minute
TPS	throttle position sensor
vol	volume
°C	degrees Celsius
°F	degrees Fahrenheit

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Copyright Information

Safety Information

For your safety, read this manual thoroughly before operating the Analyzer System.

The ***DGA 1000 Gas Analyzer*** is intended to be used by skilled, professional, and properly trained automotive technicians. The safety messages presented here and throughout this user’s manual are reminders to the operator to exercise extreme care when using this test instrument.

There are many variations in procedures, techniques, tools and parts for servicing vehicles, as well as in the skill of the individual doing the work. Because of the vast number of test applications and variations in the products that can be tested with this instrument, the manufacturer cannot possibly anticipate or provide advice or safety messages to cover every situation. It is the automotive technician's responsibility to be knowledgeable of the system that is to be tested. It is essential to use proper service methods and test procedures and to perform tests in an appropriate and acceptable manner that does not endanger your safety, the safety of others in the work area or the equipment or vehicle being tested.

It is assumed that, before using this tool, the operator has a thorough understanding of vehicle systems. understanding the principles and operating theories of vehicle systems is necessary for competent, safe and accurate use.

Before using the ***DGA 1000 Gas Analyzer***, always refer to and follow the safety messages, and applicable test procedures provided by the manufacturer of the vehicle or equipment being tested.

Read All Instructions

Read all instructions and safety messages in this manual. All safety messages in this section contain a signal word, a three-part message, and, in some instances, a symbol/pictorial.

The signal word indicates the level of hazard in a situation.

- Danger indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury to the operator or bystanders.
- Warning indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury to the operator or bystanders.
- Caution indicates a potentially hazardous situation which, if not avoided, may result in moderate or minor injury to the operator or bystanders.

Safety messages in this section contain three different type styles.

- Normal type states the hazard.
- **Bold type** states how to avoid the hazard.
- *Italic* type states the possible consequences of not avoiding the hazard.

An icon, when present, gives a graphical description of the potential hazard.

IMPORTANT SAFETY INSTRUCTIONS

⚠DANGER

Vehicle exhaust gases contain carbon monoxide (CO), which is a colorless and odorless lethal gas.

- **Perform tests in a well-ventilated area and route exhaust outside while testing with engine running.**
- **Only run engines in a well-ventilated area (4 turns of air per hour) and avoid breathing exhaust gases.**

Extended breathing of exhaust gases can cause injury.

Ignition coils, coil terminals and spark plugs emit high voltages.
Do not touch ignition coils, coil terminals and spark plugs while they are in operation.
These components may cause injury.

⚠WARNING

Engine systems can malfunction expelling fuel, oil vapors, hot steam, hot toxic exhaust gases, and other debris.
Wear safety goggles, user and bystander.
Engine systems that malfunction can cause injury.

Risk of fire.

- **Wear safety goggles and protective clothing, user and bystander.**
- **Do not position head directly over or in front of the carburetor or throttle body. Do not pour gasoline down the carburetor or throttle body when cranking or running the engine, when working with fuel delivery systems or any open fuel line. Engine backfire can occur when the air cleaner is out of normal position.**
- **Do not use carburetor sprays or fuel injector cleaning solvents when performing diagnostic testing.**
- **Keep a dry chemical (Class B) fire extinguisher rated for gasoline, chemical and electrical fires in the work area.**

Fire can cause death or serious injury.

WARNING

A test vehicle may move if not properly prepared.

- **Block the drive wheels before performing a test with the engine running. Unless instructed otherwise, set the parking brake and put the gear selector in neutral (standard transmission) or park (automatic transmission). If the vehicle has an automatic parking brake release, disconnect the release mechanism for testing and reconnect when testing is completed.**
- **Do not leave a running engine unattended.**

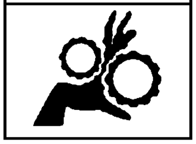
A moving vehicle can cause injury.

Gases produced by batteries are highly explosive.

- **Avoid sparks when connecting or disconnecting power leads to battery.**
- **Always connect red positive (+) power lead to positive (+) battery terminal and the black negative (-) power lead to a good vehicle ground as far away from the battery as possible.**
- **Avoid making accidental connection between battery terminals through tools, jumper leads, etc.**
- **Keep lighted cigarettes, sparks, flames and other ignition sources away from batteries.**
- **Always keep a dry chemical (Class B) fire extinguisher near work area.**

Battery explosion can cause injury.

⚠WARNING



The engine compartment contains electrical connections, and hot or moving parts.

- **Do not place test equipment or tools on fenders or other places in the engine compartment.**
- **Keep yourself, test leads, clothing, and other objects clear of electrical connections and hot or moving engine parts.**

Contact with electrical connections and hot or moving parts can cause injury.

⚠CAUTION

Misdiagnosis may lead to incorrect or improper repair and/or adjustment.
Do not rely on erratic, questionable, or obviously erroneous test information or results. If test information or results are erratic, questionable, or obviously erroneous, make sure that all connections and data entry information are correct, and that the test procedure was performed correctly.
Improper repair and/or adjustment may cause vehicle or equipment damage or unsafe operation.

SAVE THESE INSTRUCTIONS

1

Introduction

The ***DGA 1000 Gas Analyzer*** is a versatile test instrument for analyzing exhaust gases of internal combustion engines. When used with other tools and equipment, the analyzer can also detect and locate ignition, fuel, exhaust, emission control, and engine service problems.

It is generally assumed that the fuel, ignition, and emission control systems are functioning properly when exhaust gas concentrations are within limits specified by the vehicle manufacturer or the local, state or federal government. If exhaust gas concentrations exceed those specified limits, repairs or adjustments are probably needed. For more information on emissions and exhaust gases, refer to *Chapter 5–Fundamentals*

✓ Always follow manufacturer specifications when working on emission control devices to comply with anti-tampering laws.

Functional Description

Front Panel

The front of the analyzer includes controls for operating the unit, the monitor screen for viewing tests and the printer, which provides a written record of test results. Descriptions of the items labeled on the analyzer front view follow *Figure 1-1*.

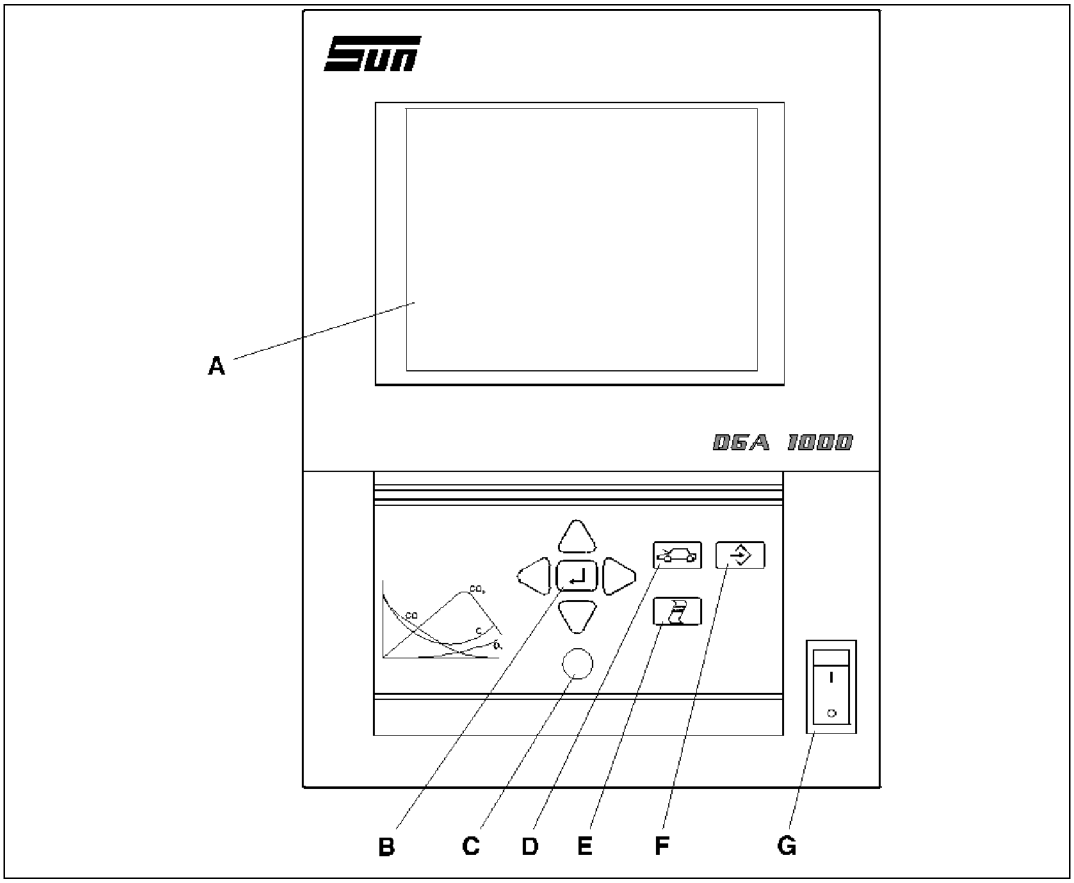
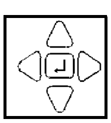


Figure 1-1: Analyzer—Front Panel View

A—9" Video Display Screen

Displays all screen information and symbols available for use with each screen.

B—Enter Key and Arrow Keys



Use the:

— Middle ENTER key to select a chosen item or symbol.

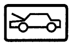
— Arrow keys (▶ ◀) around the ENTER key to:

- Select a menu item or a symbol,
- Move up and down to change a selected value, or
- Move forward and backward within screens.

C—Infrared Sensor

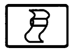
Receives the signals from the optional remote control.

D—Vehicle Set-up Key



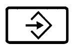
Use to set-up the vehicle information when in emissions measurement display.

E—PRINT Key



Use to:
- — Access message/customer input screen.
- — Press TWICE to start printing.

F—Freeze/Store Key



Use to:
- — Stop or freeze all test screen information necessary for saving a screen to memory.
- — Press TWICE to store information to memory.

G—On/Off Switch

Use to:
- — Turn the electrical power on and off.

Back Panel

Important features for analyzer operation and maintenance are located on the back panel. Descriptions of the items labeled on the analyzer back panel follows *Figure 1-2*.

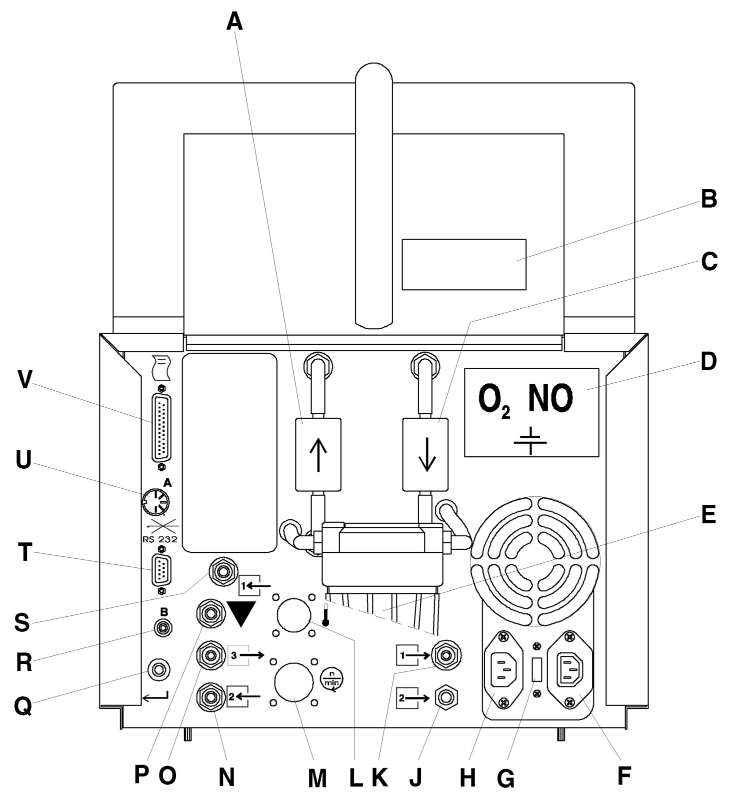


Figure 1-2: Analyzer—Back Panel View

A—Filter

Sample, secondary in-line filter.

B—Printer

24 columns.

C—Filter

In-line water drain filter.

D—O_2 and NO Sensor Cover

Remove this cover to replace O_2 or NO cells.

- O_2 sensor detects concentrations of oxygen in the exhaust gas sample.
- NO sensor (optional) detects concentrations of nitrogen oxides in the exhaust gas sample.

E—Primary Filter Bowl Assembly

Removes moisture and other exhaust contaminants that are potentially harmful to the analyzer.

F—Main AC Power Source

Connection for the AC power cord.

G—Voltage Switch
Use this switch to select either 230VAC or 115VAC power input.

H—Auxiliary Outlet
Use this outlet to connect optional equipment.

J —Filter Bowl Water Drain Input
Water from filter bowl inlet port.

K—Gas Sample Exhaust [1] Outlet
Vehicle gas sample exit port from NO cell.

L —Optional Oil Temperature Probe Port
Use this connection for the optional temperature probe, optional part number 6004-0407-04.

M—RPM Pickup Port
Use this connection for the grey RPM pickup.

N—Sample Gas Port
Connect the exhaust sample hose/probe to this inlet.

O—Water Outlet
Sample filter bowl water drain.

P—Calibration Gas Inlet
Use this inlet to supply calibration gas to the analyzer.

Q—Optional Lightpen ENTER Button Port
Use this connection for the single wire on lightpen harness.

R—Optional Lightpen Port
Lightpen connector, part number 7009E9321-97.

S—Clean Air Inlet Port
Has a charcoal filter installed to filter the ambient air going into the gas bench for calibration.

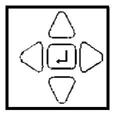
T —RS 232 Port
For communication to an external data logging PC.

✓ Contact ***Equiserv*** for additional information.

U—Keyboard Port
Connection for the optional keyboard.

V—Service Key Port
Service connection is only used by a Service Representative.

Screen Displays



The screen displays a number of universal symbols to allow easy navigation around the various menu and screen displays using the ENTER and ARROW key pad.

Additional details of these symbols follow *Figure 1-3*.

✓ Use the arrow keys (▶ ◀) followed by the ENTER key to select items in Group 1 functions.

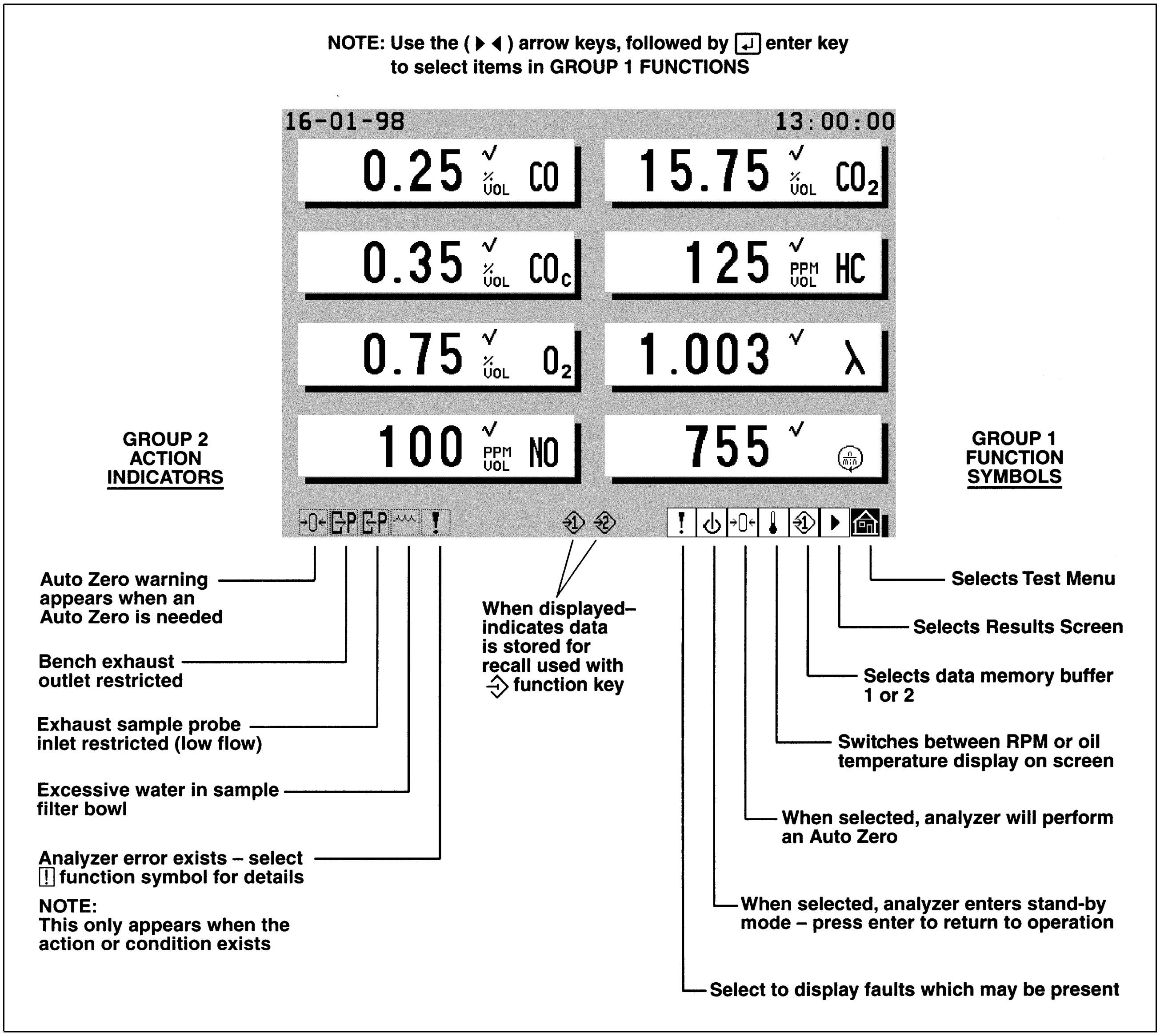
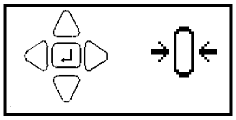


Figure 1-3: Screen Displays

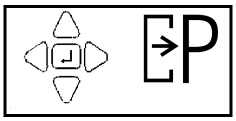
Action Indicators

On the lower left side of the Measurement Screen, a status symbol is displayed when a fault or error occurs.



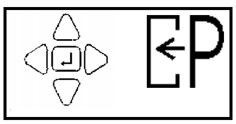
Auto zero/Auto calibration

A pre-warning that indicates a Auto zero/Auto calibration is required. Auto zero/Auto calibration is automatically performed by the analyzer when measurements are stopped. Measurements can be continued for a maximum of 30 minutes while the Auto zero/ Auto calibration symbol displays. After this time, the analyzer stops measurements and performs an Auto zero.



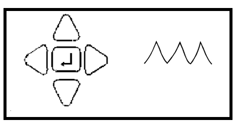
Bench Exhaust Flow Problem

Indicates that the gas bench exhaust is blocked.



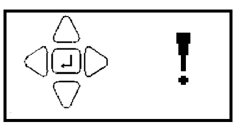
Low Flow

Indicates that the sample probe or hose is restricted.



Water

Indicates that there is too much water in the filter bowl assembly or the water filter is clogged. Wait until the analyzer removes the water from the bowl or empty the water from the bowl.



Warnings/Errors

Refer to *Chapter 4–Control and Error Status* for more information and how to solve error codes.

Function Selection Symbols

Selection symbols, shown in *Figure 1-4*, display on the lower right of the screen.

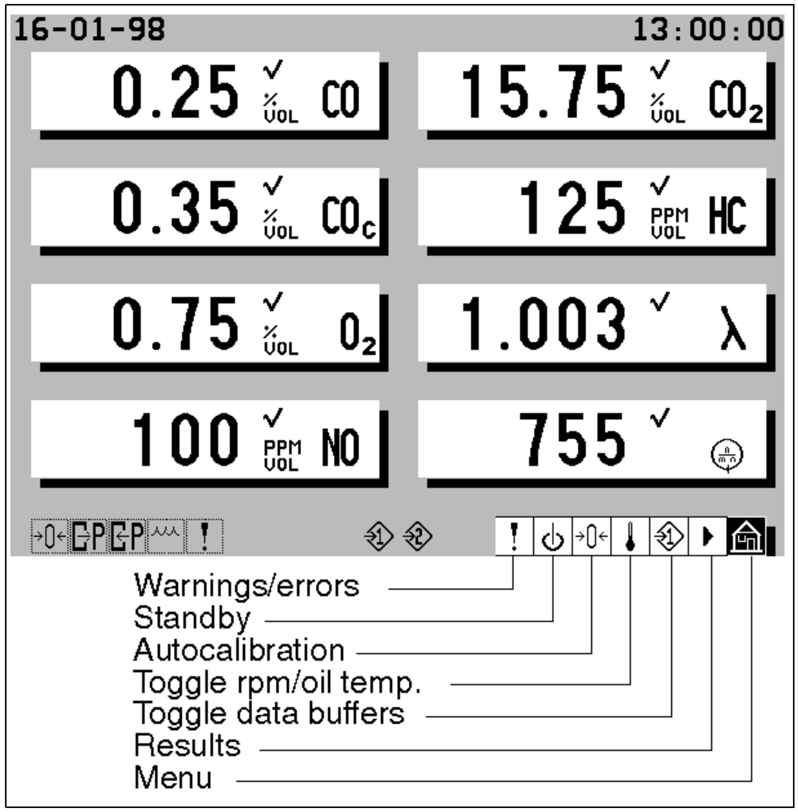
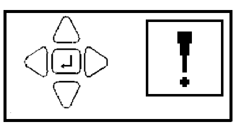


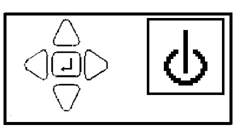
Figure 1-4: Selection Symbols on Measurement Screen



Warnings/Errors

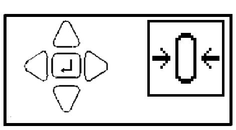
Select with arrow keys, and press ENTER to get information about the warning symbols which can appear on the left side of the screen.

✓ Follow the instructions on the screen to solve the error. Most of the errors can be solved easily. When there are error codes mentioned, refer to *Chapter 4–Maintenance* for a list of error codes.



Standby

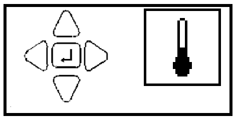
Select with arrow keys, and press ENTER to put the analyzer in the STANDBY mode. The pump stops running. Press ENTER to start the pump again. The analyzer does an Auto calibration and a HC hang-up check. The unit returns to normal operation.



Auto zero

Select with arrow keys, and press ENTER to perform an Auto calibration/Auto zero. The analyzer performs a forced Auto calibration/Auto zero followed by a HC hang-up check.

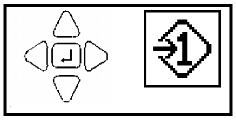
✓ If the action symbol appears on the left of the screen, select Auto zero to correct the error.



Toggle RPM/Oil Temp

Select with arrow keys, and press ENTER to switch between RPM indication and oil temperature indication on the screen.

✓ When the NO Measurement option is not installed, both RPM Measurement and Oil Temp are shown on the screen.

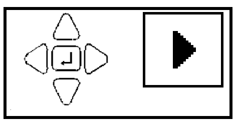


Select Data Memory Buffers and Limits Sets

— Select with arrow keys, and press ENTER to select data buffer 1 or 2 into which data may be stored when the FREEZE/STORE button ( ) is pressed TWICE.

— When this is done, the number 1 and/or 2 appears in the middle of the screen to show measurements are stored.

✓ If emission limits are activated, limit set 1 is active when data buffer 1 is selected and limit set 2 is active when data buffer 2 is selected. Measurements are continuously compared with the limit values and indications are given on the Measurement Screen as too high (↑), too low (↓) or correct (✔).



Results

— Select with arrow keys, and press ENTER to look at measurements results in data buffer 1 and 2. The left column shows the results of data buffer 1, the right of data buffer 2.

— Select with right arrow (▶) on the bottom right of the Results Screen to add customer information to the measurements results and press to print the results or Esc to exit without printing.

— Press the PRINT key on the front panel to print the results.

✓ On the Results Screen shown in *Figure 1-5*, results of data buffer 1 or 2 can be deleted by selecting the correct number and pressing ENTER. The program displays "**Clear data buffer(s)?**". Select Yes to clear the data of buffer 1 or 2.

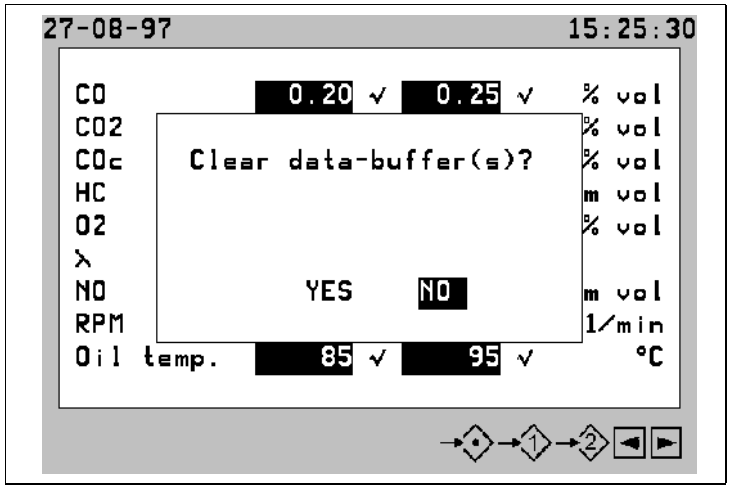
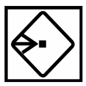
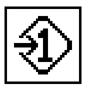


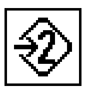
Figure 1-5: Clearing Data Buffer(s)



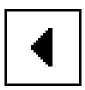
Clear Buffers
Select to clear all data in memory.



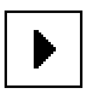
Data Memory Buffer 1
Select to clear data memory buffer 1.



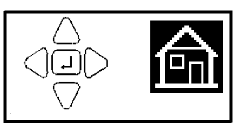
Data Memory Buffer 2
Select to clear data memory buffer 2.



Left Arrow Key
Select left arrow key (◀) to return to Measurement Screen.



Right Arrow Key
Select right arrow key (▶) and ENTER to add a text message to printout.



Menu
Select with arrow keys (▶ ◀), and press ENTER to go to the specific menu.

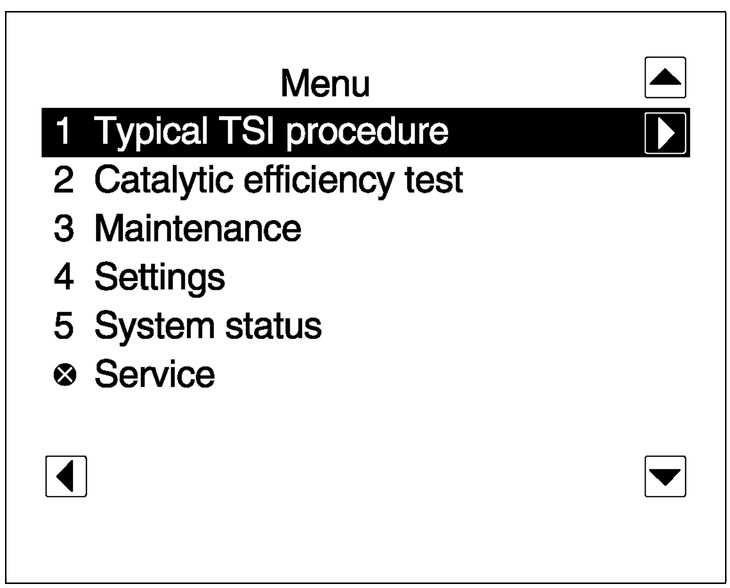
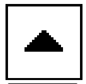


Figure 1-6: Function Menu

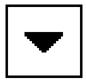
Screen Navigation Symbols

There are also symbols used to indicate the presence of additional screens and selections. The following symbols indicate:



You can move to the previous line.

There is a previous screen.



You can move to the next line.

There is a next screen.

Optional Accessories

Standard Keyboard (not shown)

The keyboard can be used to access and exit a screen, or navigate within a screen. The function of the keys on the keyboard are the same as for a normal PC. The functions of the keyboard are as follows:

- Use arrow keys to move from field to field.
- Press ENTER to accept an entry or selection.
- Press number and/or letter keys to enter field information.

Optional Lightpen

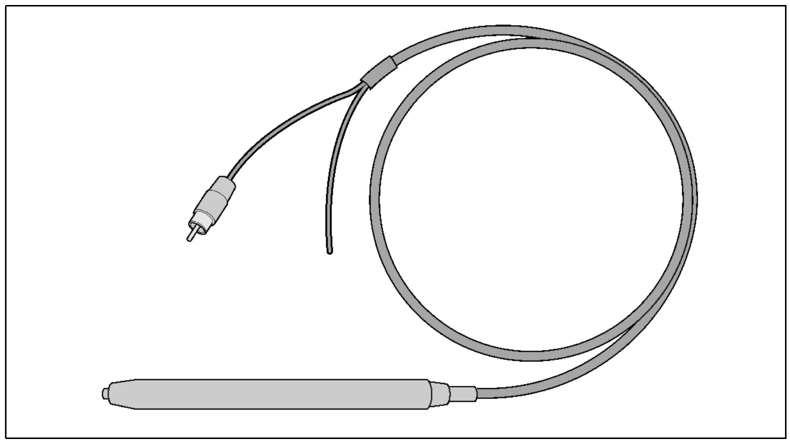


Figure 1-7: Lightpen

Use the optional lightpen, part number 7009E9321-97, to select menu symbols on the screen and to switch between screens by positioning the lightpen on an arrow symbol. When the lightpen is correctly positioned, press on the lightpen to activate the ENTER to select the item.

Optional Oil Temperature Probe

Used to monitor engine oil temperature during testing. Tests can be performed without probe. However use of the probe ensures the vehicle engine is at the correct test temperature.

Optional Remote Control Keypad Kit

Use the optional remote control. part number 7009E9321-98, as your keyboard when providing computer input from a remote location.

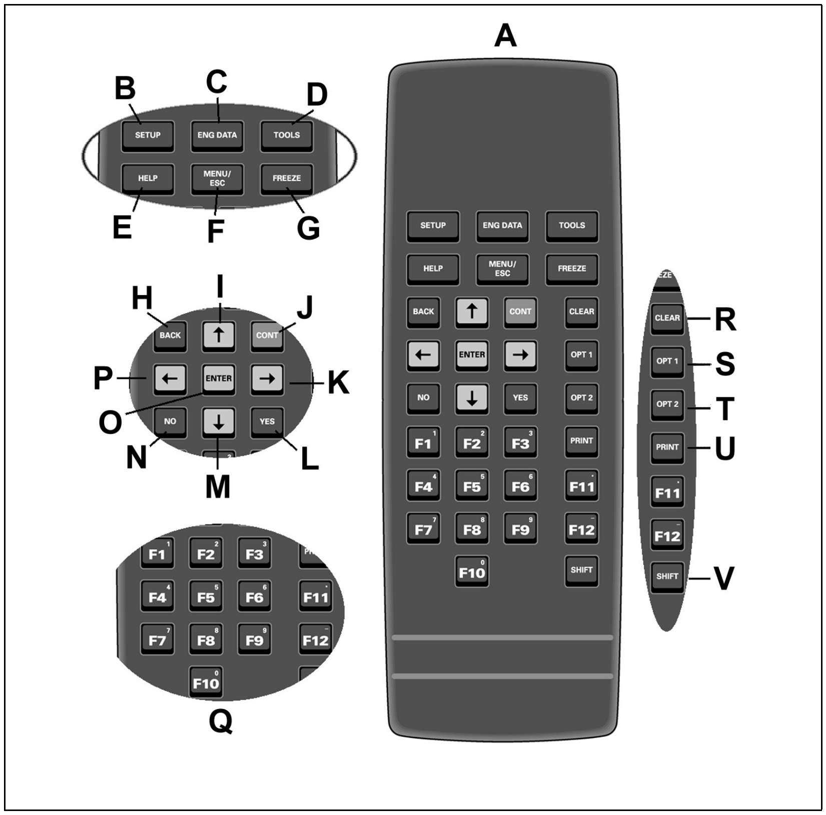


Figure 1-8: Remote Control Keypad

A—Remote Control Unit

Use the keys to access, navigate, or exit the ***DGA 1000 Gas Analyzer*** software from a remote location.

B—Setup

Use this key for the Vehicle set-up menu.

C—Eng Data

Not used for ***DGA 1000 Gas Analyzer*** emissions testing.

D—Tools

Not used for ***DGA 1000 Gas Analyzer*** emissions testing.

E—Help

Not used for ***DGA 1000 Gas Analyzer*** emissions testing.

F—Menu/ESC

Press to return to the previous menu or to abort a test.

G—Freeze

Stops or freezes all test screen information necessary for saving a screen to Memory. Press TWICE to store information into the memory.

H—Back

Not used for ***DGA 1000 Gas Analyzer*** emissions testing.

I —Up Arrow
Press to move cursor toward top of screen.

J —CONT
Not used for ***DGA 1000 Gas Analyzer*** emissions testing.

K—Right Arrow
Press to move cursor toward right side of screen.

L —Yes
Not used for ***DGA 1000 Gas Analyzer*** emissions testing.

M—Down Arrow
Press to move cursor toward bottom of screen.

N—NO
Not used for ***DGA 1000 Gas Analyzer*** emissions testing.

O—Enter
Press the ENTER key to complete data entry.

P—Left Arrow
Press to move cursor toward left side of screen.

Q—Function/ Numeric Keys
Press these keys to select various numbered menu items.

R—Clear
Not used for ***DGA 1000 Gas Analyzer*** emissions testing.

S—Opt 1
This key is reserved for future use.

T—Opt 2
This key is reserved for future use.

U—Print
Press to print display screen or I/M test results.

V—Shift
Not used

Specifications

Power Supply

Input Voltage	115VAC or 230VAC
Watts	575

Shipping Weight

41.9 lbs (19 kg)

Dimensions

Height	16.50" (423 mm)
Width	12.75" (326 mm)
Depth	22.88" (586 mm)

Measurements

	Range/Resolution	Accuracy
CO	0.000–9.999	±3%
	10.00–14.00	±5%
CO_2	0.00–18.00	±5%
HC	0–2000	±3%
	2000–5000	±5%
	5000–9999	±5%
O_2	0.00–25.00	±5%
NO	0–5000	±5%
RPM	0–9999	±0.5%
°C	-10–150	±5%
°F	14–302	±5%
Lambda (λ)	0.500–2.000	(calculated)
AFR	5.00–25.00	(calculated)

Operating Conditions

Maximum ambient temperature
113 °F (+45 °C)

Minimum ambient temperature
35.5 °F (+2 °C)

Relative humidity
Up to 90%, non condensing

Maximum atmospheric pressure variation
10.15–15.95 psi (700–1100 mbar).

Warm-up Time

One minute

Propane Equivalence Factor (P.E.F.)

P.E.F. value 0.530

General Setup Tips

- ❒ Read and follow the procedures in this manual.
- ❒ Keep the probe tip openings clean and free of debris.
- ❒ Do not place the probe tip in liquids or allow liquids to be drawn into the analyzer sampling system. Contamination affects the accuracy of any tests.
- ❒ Do not place the probe in an exhaust pipe until the vehicle is at normal operating temperature. This allows time for the exhaust system to vaporize residual moisture.
- ❒ Never move the analyzer by pulling on the probe, sample hose or power cord.
- ❒ Never drive over the probe, sample hose or power cord.
- ❒ Never set liquids on the analyzer that could spill and run into the ventilation holes.
- ❒ Clean off any spills, like gasoline, brake fluid, cleaning solvents, etc., from the exterior of the analyzer immediately to protect the finish.
- ❒ Always keep the calibration gas bottle valve in the closed position, except when performing calibration procedure.
- ❒ Perform a Leak Check (vacuum) daily, and also after probe changes and filter service, to ensure accurate analysis. For additional information refer to *Chapter 4–Maintenance*.
- ❒ Prolonged use of the analyzer in conjunction with a dynamometer and a hot-running vehicle under load may damage the sample probe and affect readings.
- ❒ The O_2 sensor has an average life expectancy of 12–18 months, regardless of how often the analyzer is used.
- ❒ The NO sensor has an average life of 15–18 months after installation. It is powered by an internal battery in the analyzer. The analyzer must run for at least 12 hours over a 30 day period to maintain this battery at full charge.

Standard Lead Connections

To Analyzer

1. Make sure the on/off switch (G) is set to off (O). See *Figure 1-9*.

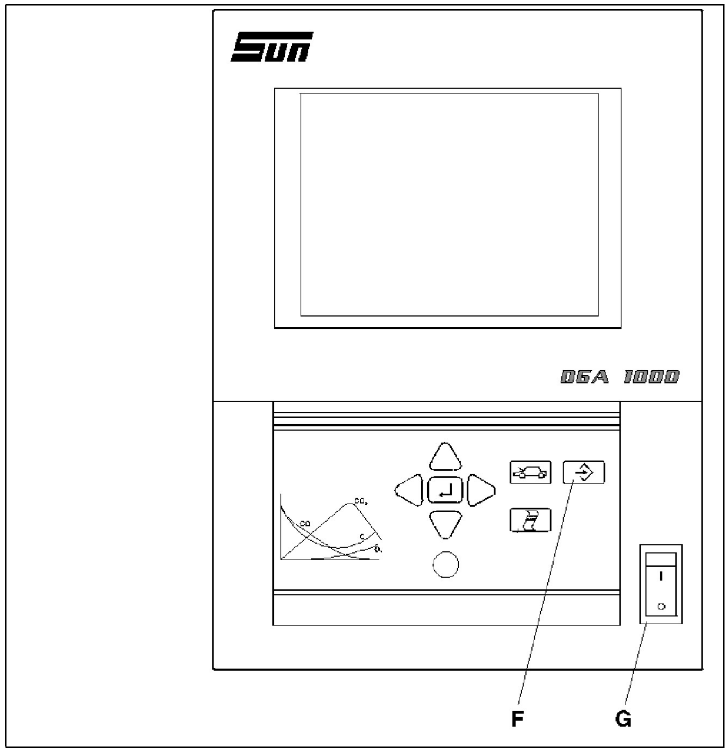


Figure 1-9: Front Panel

2. Plug the power cord into the AC power source (F) on the back panel of the analyzer. Plug the other end into a standard 120VAC grounded electrical outlet. See *Figure 1-10*.

✓ Make sure the voltage switch (G), at the main input receptacle of the analyzer, is set to the correct voltage before connecting the analyzer to a power source.

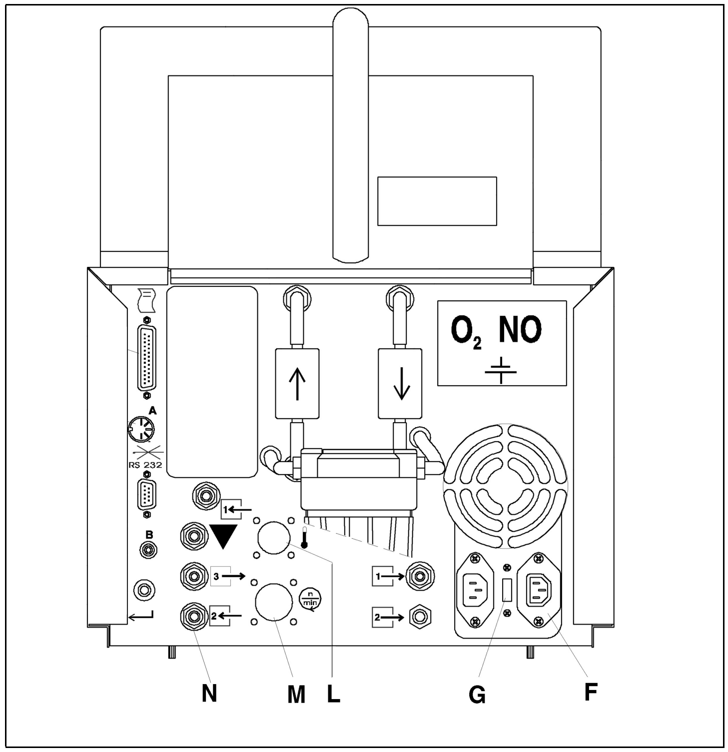


Figure 1-10: Back Panel

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✓ An optional 12V power adapter, part number 2-2650, is also available. This allows the analyzer to be powered by a vehicle battery.

3. Insert the keyboard connector to the keyboard port (U).
4. Connect the exhaust sample probe to the sample gas port (N).
5. Insert the RPM pickup lead into the RPM pickup port (M).
6. Insert the optional oil temperature probe into the oil temperature probe port (L).

Connecting to a Vehicle

1. Insert the exhaust gas probe into the vehicle tail pipe. Make sure the sample probe is fully inserted.
2. Connect the RPM pickup as follows:
   — Use the grey inductive pickup, part number 6004E9312-95, when a spark plug wire is available to connect the clamp, preferably near the distributor.

✓ Tests may be performed without an RPM connection.

✓ An optional orange capacitive pickup, part number 6004E9313-19, is available when a spark plug wire is not accessible. Connect it to an injector body (cylinder No.1), to the outside of the insulation of an injector wire, or a group of injector wires (max. three).

✓ Route the pickup lead clear of any moving parts.

Connecting the Optional Temperature Probe to the Vehicle

1. Connect the temperature probe.

⚠CAUTION

The dipstick may be hot. Route the temperature probe clear of any moving parts.

2. Check the engine oil level. If needed, add oil of the proper grade and viscosity to bring the level up to the full mark.
3. Remove the engine oil dipstick.
4. Align the thermocouple end of the temperature probe with the measurement end of the dipstick. Straighten the probe while following the dipstick up to the point where the dipstick seats in the dipstick tube. Adjust the moveable rubber stop on the probe to this location.
   — This presets the probe depth to ensure that the thermocouple submerges in oil to the same level as the dipstick. This is necessary for accurate readings.
5. Insert the probe into the dipstick tube until the rubber stop comes in contact with the dipstick tube.

✓ Since the ***DGA 1000 Gas Analyzer*** was released, two types of oil temperature probes have been used (Euro and US probe).

— Euro probe, part number 6004E9312-99, is no longer available. Order the US probe and adapter.
— US probe, part number 6004-0407-04
— US probe, part number EAX0035L10A, adapter cable is used for older ***DGA 1000 Gas Analyzer*** units.

Temperature Probe Tips

IMPORTANT

The engine should be at normal operating temperature.
Typically, 185°F (85°C) is nominal oil temperature, 149°F (65°C) is low, and 221°F (105°C) is high, on an engine operated under moderate loads and moderate speeds. Generally, engine oil temperature does not reach a nominal value at engine idle speeds. Proper oil temperature depends on the engine operating conditions, but can be considered acceptable if it is within this low to high range.

✓ When the analyzer set-up is completed, refer to *Chapter 2–Analyzer Screen Display Features* to continue with Vehicle set-up. To perform gas measurements, refer to *Chapter 3–Vehicle Testing*.

Start-up

1. Make lead connections to the analyzer and the vehicle. Refer to *To Analyzer, page 1-17* and *Connecting to a Vehicle, page 1-18*.
2. Turn the analyzer power switch on (I). The Start-up Screen displays.
3. Allow the analyzer to perform Warm-Up, Auto zero calibration and HC hang-up check. This takes about 2.5 minutes.
   — When the unit starts up after a Standby period, it performs the Auto zero calibration and HC hang-up check.
   — When the analyzer completes the warm-up cycle, it enters in the operating mode and the gas measurement page displays. When the exhaust sample probe is installed, the measurement results of the exhaust gases are shown on the Measurement Screen *Figure 1-11*.

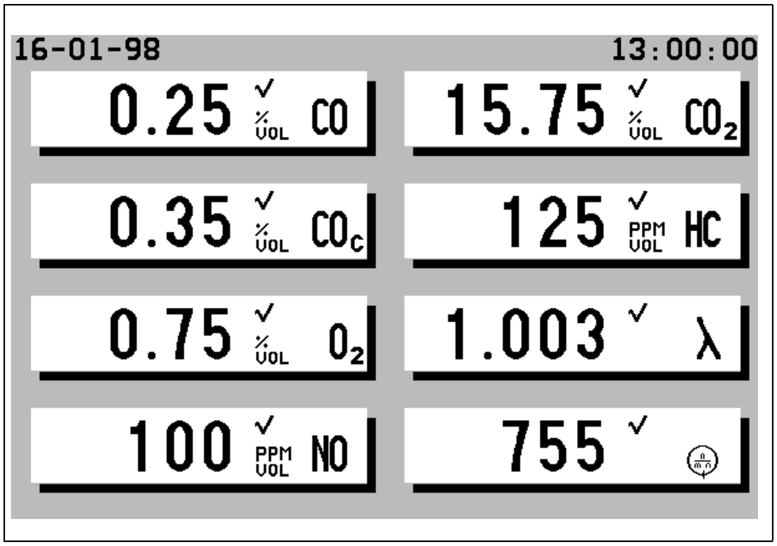


Figure 1-11: Measurement Screen

For more information on the Measurement Screen, refer to *Chapter 2–Analyzer Screen Display Features*.

Analyzer Screen Display Features

2

This chapter explains the purpose of each screen, the symbols on each screen, and how to access and exit the screens.

✓ Before performing measurements make sure all test setup information of the vehicle under test is correct. Press the vehicle setup key ( ) to program setup information.

Measurement Screen

This is the default screen after power up of the analyzer. This general purpose display can be used for diagnostic and repair.

✓ A Warm-up, Auto zero calibration, and HC-hang-up Check is performed automatically when the analyzer is turned ON.

✓ The Measurement Screen displays when successful start-up is complete.

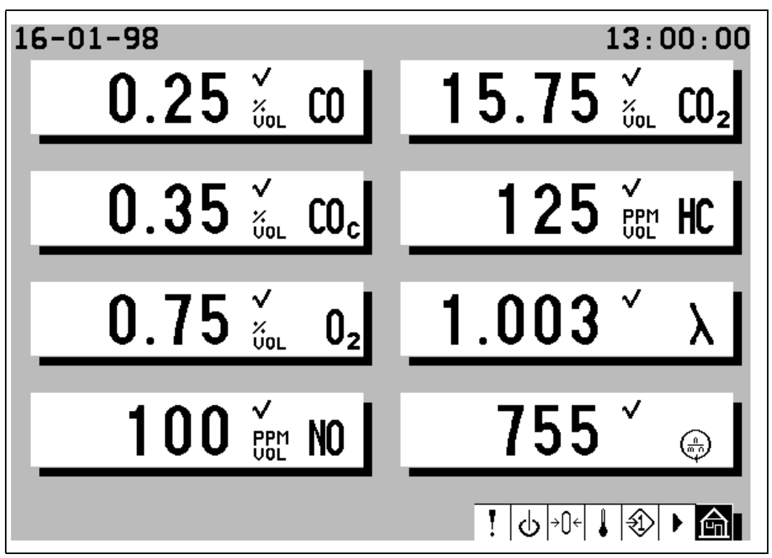


Figure 2-1: Measurement Screen

The Measurement Screen displays the following information.

- Carbon monoxide, CO, measured in % volume
- Carbon monoxide corrected, CO_c, measured in % volume
  — For additional information refer to *CO Corrected, page 2-2*.
- Oxygen, O_2, measured in % volume
- Nitric oxides, NO, measured in parts per million ppm
- Carbon dioxide, CO_2, measured in % volume

- Hydrocarbons, HC, measured in parts per million
- Lambda, λ, or on the same display Air Fuel Ratio, AFR, a numeric number
  - — For additional information refer to *Lambda and AFR Calculation, page 2-4*.
- Engine speed, RPM X, or oil temperature, select preferred value by toggling the icon on the lower right of the screen. Engine speed measured in revolutions per minute, and oil temperature measured in degrees Fahrenheit.

CO Corrected

The ***DGA 1000 Gas Analyzer*** performs a CO measurement correction when CO and CO_2 are less than (<) 15% for gasoline. See *Figure 2-2*. This correction may be required for vehicles with an air leak in the vehicle exhaust system. While the correction may not always be required, the analyzer performs the CO correction when necessary to provide the most accurate measurements possible.

The following are some examples of CO and CO_2 measurements:

— **$CO + CO_2$ <15**

Formula:

$$\text{CO CORRECTED } (CO_c) = CO \times \frac{15}{CO + CO_2 \text{ READ}}$$

As an example using *Figure 2-2*.

	OR
CO = **3**	CO = **3**
CO_2 = **6**	CO_2 = **13**
CO_c = **5**	CO_c = **3**

✓ Converter equipped vehicles will effect CO_c values.

✓ The formula for CO Corrected changes depending on the fuel type selected. Values by fuel type are:

- — Gasoline 15%
- — Methane 12%
- — LPG 14%

The following is a chart showing the resulting content of a CO correction:

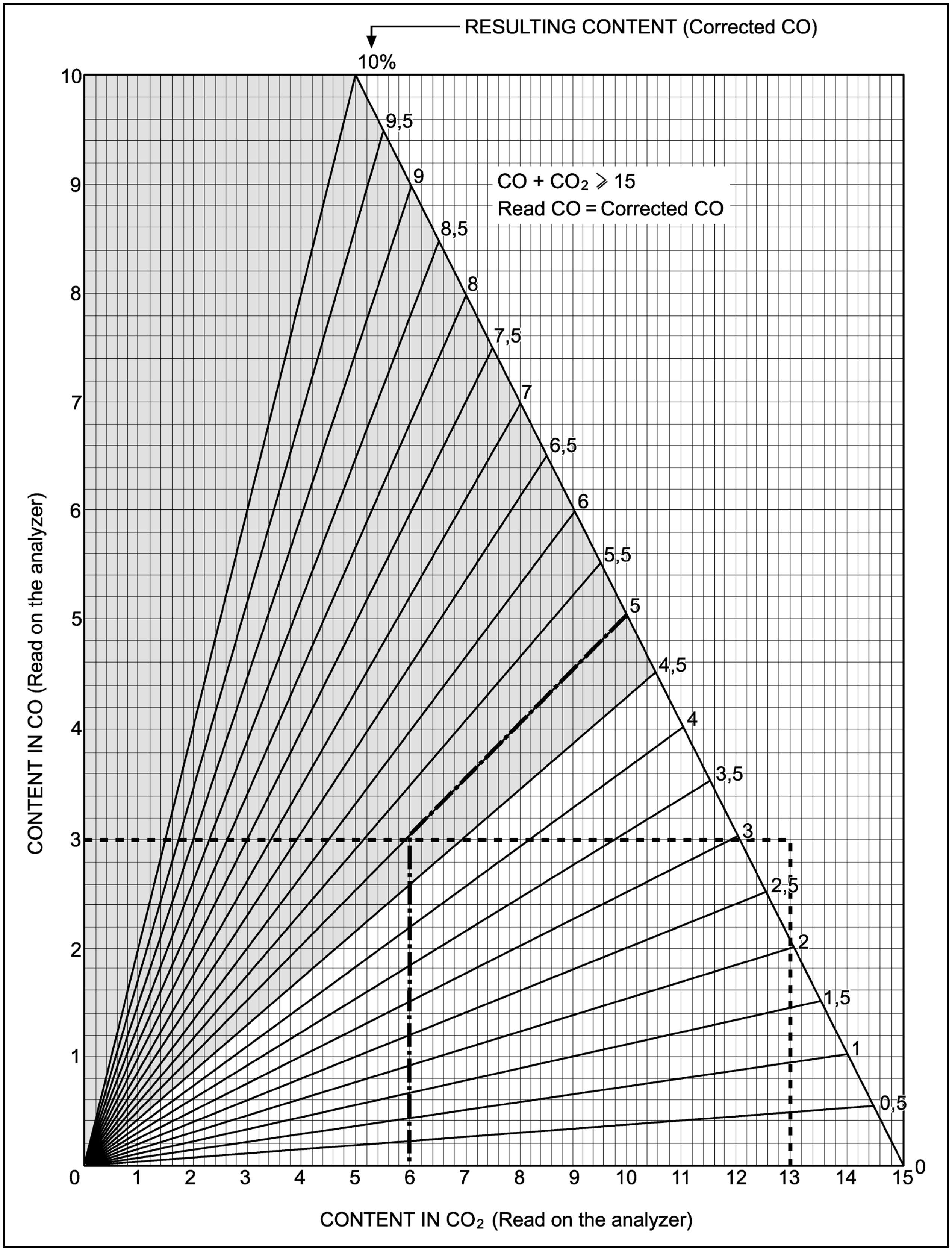
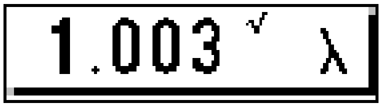


Figure 2-2: Corrected CO

Lambda and AFR Calculation



The ***DGA 1000 Gas Analyzer*** uses the Brettschneider formula to calculate Lambda (λ) and Air Fuel Ratio (AFR) values during the emission tests.

Lambda (λ) and Catalytic Converter Efficiency

Lambda is another characterization of the stoichiometric perfect combustion point. The λ formula includes a factor for the specific fuel used. Different fuels have different stoichiometric air-fuel ratios, but optimal combustion is always achieved when Lamda = 1.00. Smaller λ numbers indicate a rich air-fuel ratio; larger λ numbers indicate a lean air-fuel ratio.

The figure below shows the relationship between certain pollutant exhaust gases and catalytic converter efficiency. Optimal combustion (λ = 1) is characterized by a highly-efficient conversion of the pollutants HC, CO, and NO_x into CO_2, H_2O, and N_2.

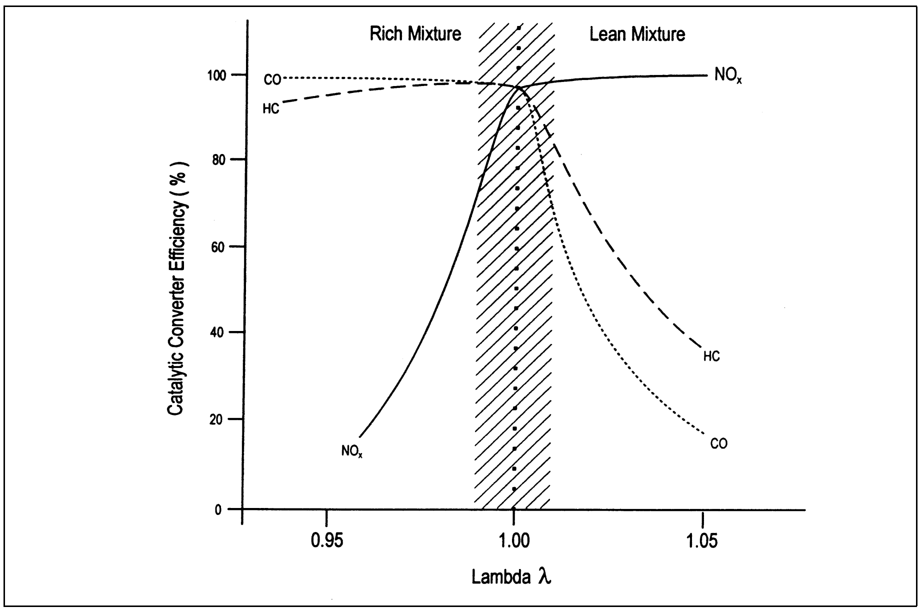


Figure 2-3: Relationship Between Certain Pollutant Exhaust Gases and Catalytic Converter Efficiency

O_2 and NO_x Measurement

O_2 and NO_x gas concentration are measured using electrochemical (fuel cell) sensors. A fuel cell sensor provides an electrical response that is proportional to the concentration of the sample gas.

Air-Fuel Ratio and the Stoichiometric Point

For each fuel used in an internal combustion engine, there is an air-fuel ratio that optimizes the combustion process. For common gasoline, that ratio is 14.7 pounds of air to 1 pound of gasoline. This ratio varies with each type of fuel. The point of optimal combustion is called the stoichiometric point. The combustion process burns fuel and oxygen. The following by-products result from the combustion process:

- Mechanical force and heat.
- The pollutants HC (hydrocarbons), CO (carbon monoxide), NO_x (oxides of nitrogen), and SO_2 (sulfur dioxide).
- The favorable gases CO_2 (carbon dioxide), O_2 (oxygen), and H_2O (water vapor).

The figure below shows the relationship between the air-fuel ratio and certain exhaust gases. Note that optimal combustion is identified by a low level of O_2, a high level of CO_2, and low levels of the pollutants HC and CO.

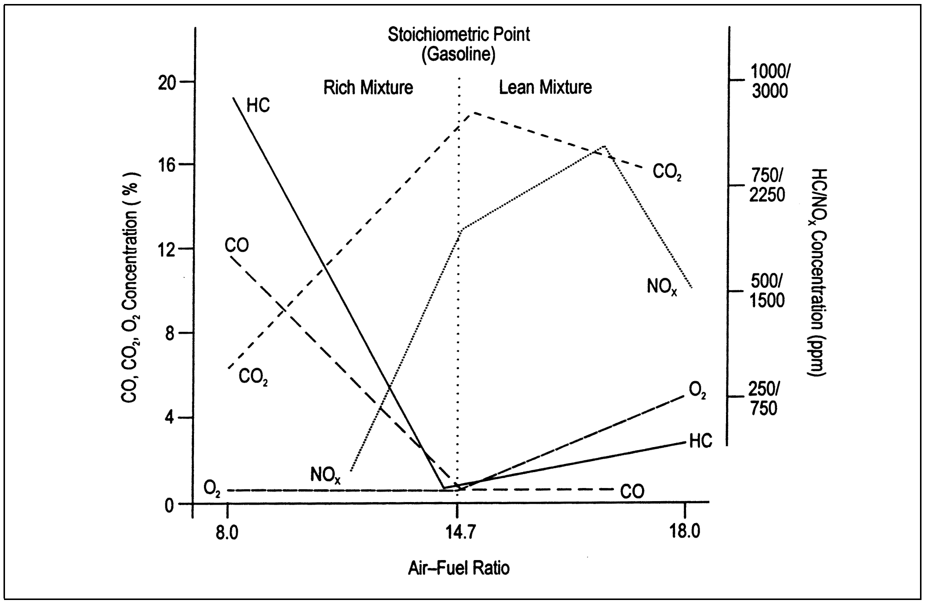
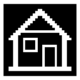


Figure 2-4: Relationship Between Air-Fuel Ratio and Certain Exhaust Gases

Test Menu 

This section details menu selection items and their submenus.

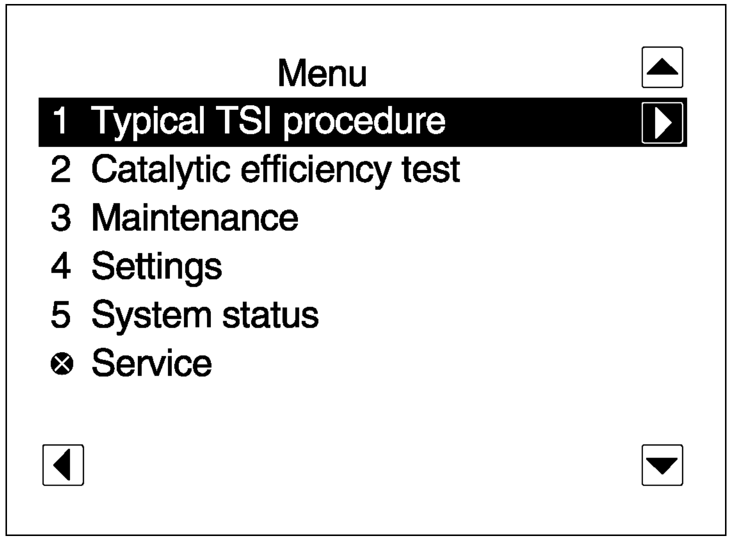
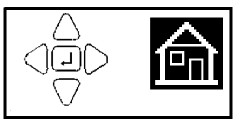


Figure 2-5: Menu



Using the arrow keys (▶ ◀), move to the Home icon and press ENTER. The Test Menu displays as shown *Figure 2-5*.

✓ This section contains a complete description of each test function shown in *Figure 2-5*.

1. Typical TSI Procedure

A preprogrammed idle test sequence can be performed at idle and high speed with or without RPM.

✓ Additional detail procedures for this test are found in *Chapter 3–Vehicle Testing*.

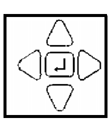
2. Catalytic Efficiency Test

A preprogrammed special test procedure to determine how well a catalytic converter is functioning.

✓ Detail procedures are found in *Chapter 3–Vehicle Testing*.

✓ Optional Catalytic Converter Test Kit, part number EAKO232L00A, is recommended to perform this test procedure. Instructions for this kit are in *Chapter 3–Vehicle Testing*.

3. Maintenance



Use the down arrow (▼) and press ENTER or select number 3 to do the following checks on the analyzer. Use the up/down arrow and the right arrow to select the required check. For more information on maintenance, refer to *Chapter 4–Maintenance*.

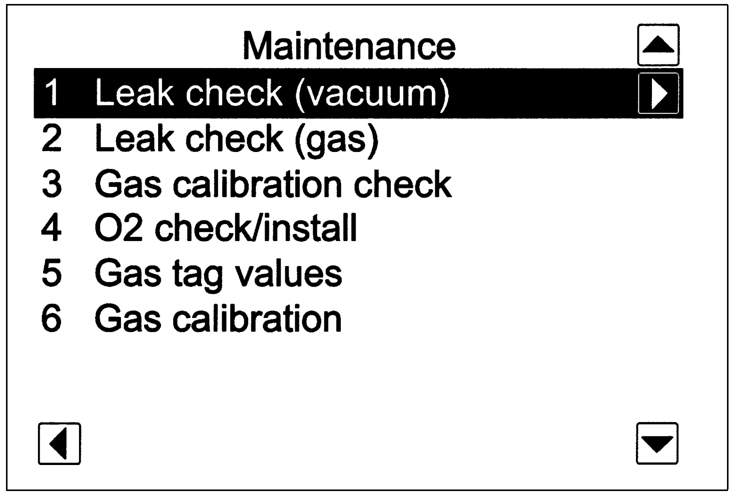
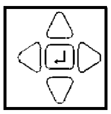


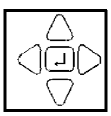
Figure 2-6: Maintenance Screen



Leak check (vacuum)

This test determines if there is an air leak in the gas sample handling system of the analyzer. Follow the instructions on the screen. Press Enter or the right arrow (▶) to begin the test.

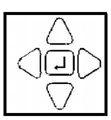
✓ The exhaust sample probe must be blocked for this test. The pump draws a vacuum and the analyzer checks for any leaks in the system. It is advised to perform a Leak check often. Refer to *Chapter 4–Maintenance*.



Leak check (gas)

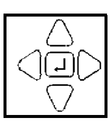
This test checks if there is an air leak in the gas handling sample system of the analyzer using vehicle exhaust. Follow the instructions on the screen. Press Enter or the right arrow (▶) to begin the test.

✓ The exhaust sample probe must be inserted in the exhaust of the vehicle. The pump draws exhaust gases into the system, the exhaust sample probe must be blocked and then system checks if the CO_2 value changes. When the CO_2 change exceeds a certain value, a leak is present in the sample system. Refer to *Chapter 4–Maintenance* for additional details.



Gas calibration check

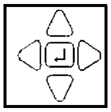
This test checks the gas measurement system with use of a calibration gas which has a known concentration of various gases. This mixture is determined by local authorities and is used to calibrate emission analyzers. Refer to *Chapter 4–Maintenance* for additional details.



O_2 cell check/install

This test checks the O_2 cell in the analyzer. Follow the instructions on the screen. Press Enter or the right arrow (▶) and ENTER as prompted.

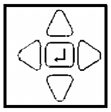
✓ The analyzer indicates when to replace the O_2 cell. Refer to *Chapter 4–Maintenance*.



Gas tag values

Use this function to enter calibration gas bottle values for gas calibration.

✓ The calibration gas values must be entered to perform a gas calibration. Refer to *Chapter 4–Maintenance*.



Gas calibration

Use this function in conjunction with gas tag values to perform a gas calibration.

✓ A gas calibration kit is required to use this function. Refer to *Chapter 4–Maintenance*.

4. Settings (from Test Menu)

Select and press ENTER to change the system settings.

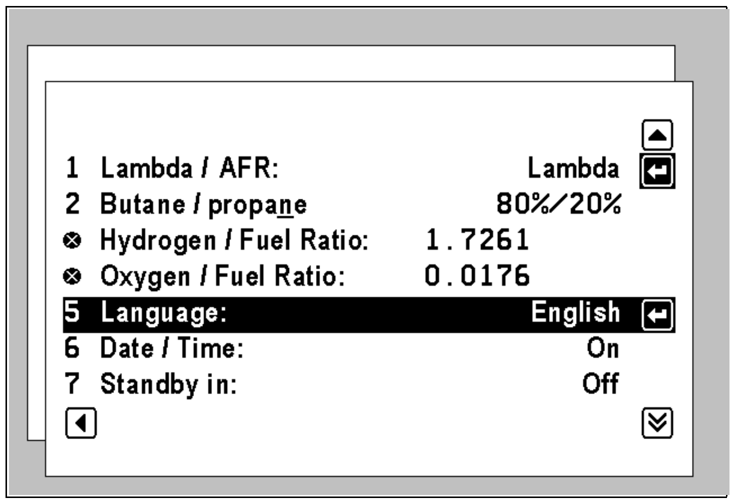
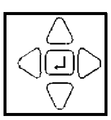


Figure 2-7: Settings Screen 1

Lambda or AFR

Select either Lambda (λ) or AFR (Air Fuel Ratio) for display on the Measurement Screen. To change the setting:

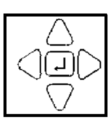


— Press ENTER,
— Arrow (▲ ▼) to select choice, and then
— Press ENTER for desired choice.

✓ For additional information refer to *Lambda and AFR Calculation, page 2-4*.

LPG

Select the correct mixture between C_4H_{10} (butane) and C_3H_8 (propane) of the LPG fuel used by the vehicle under test.

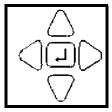


To change ratio press ENTER and then arrow (▲ ▼) to select various combinations. Press ENTER when desired mix is obtained.

✓ U.S.A. propane is, on average, 0% butane and 100% propane.

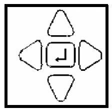
Hydrogen/Fuel Ratio (HCV) and Oxygen/Fuel Ratio (OCV)

H_{CV} is the ratio between hydrogen and carbon in the fuel. O_{CV} is the ratio between oxygen and carbon in the fuel. These values are used for calculation of Lambda. The values are automatically set dependent on fuel type and can not be changed!



Language

Select a language for the analyzer display. (Currently only English is available.)



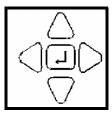
Date and Time

Use to change or reset the time display in the right-hand upper corner of the screen.

— To change press ENTER or arrows (▲ ▼). Press ENTER when desired time is obtained.

— Press left arrow (◀) to exit.

✓ Hour is displayed in the 24 hour format in the set time screen. (i.e.: 1:00 pm = 13)



Standby Mode

The system automatically goes into a standby mode by selecting the elapsed time (5 min, 15 min, 30 min or 60 min) after the last key stroke or at the end of measurements. To change press ENTER and then arrows (▲ ▼). Press ENTER when desired option is obtained.

— Select OFF when the automatic Standby mode is not required. Standby mode can then be manually switched on by pressing the Standby symbol on the Measurement Screen.

Figure 2-8: Settings Screen 2

Print-out Header Set up

Enter the shop name, address, phone number, etc. to print as a header on the test results printout.

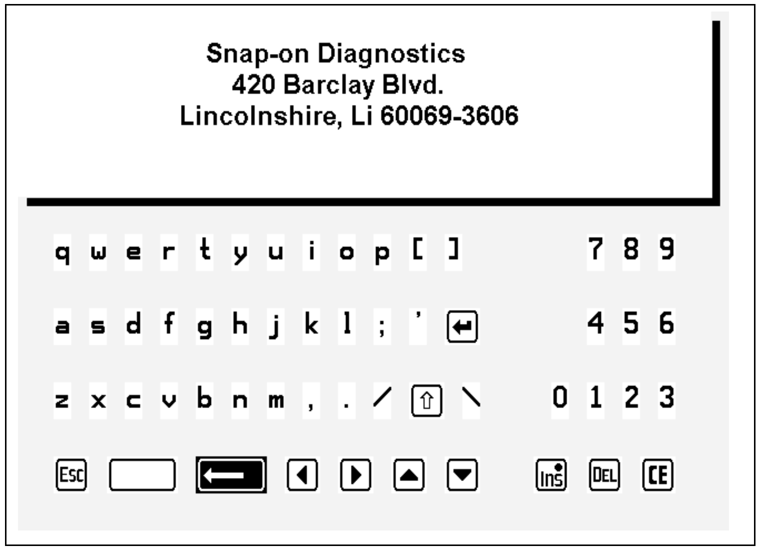


Figure 2-9: Print-out Header Set-up Screen

After entering the information, press the Esc key to exit and save.

Print-out Message

Enter standard field names for the customer information you want to use. The information entered on this screen, as shown in *Figure 2-10*, prints on the Test Results Printout. The procedure for entering data is similar to the Print-out Header Set-up. Header Set-up and Message Set-up need to be set only once and is then stored in a non-volatile memory. Only four lines are allowed.

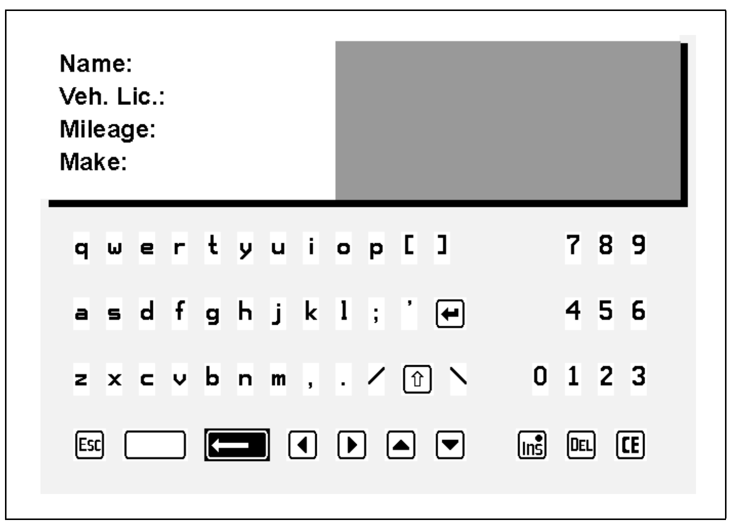
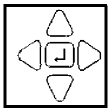


Figure 2-10: Print-out Message Set-up Screen

Press the Esc key to exit and save.

5. System Status



System information about the ***DGA 1000 Gas Analyzer*** displays on this screen. Only a Service Representative can modify these items and the information may be requested when you require service. System status information can NOT be changed by the operator. Two menu choices are available as indicated by the icon. The left arrow (◀) returns you to the Main Test Menu.

✓ Gas tags values can be set by the operator in Maintenance mode when customer gas cal in service mode is set to 3gas or 4gas.

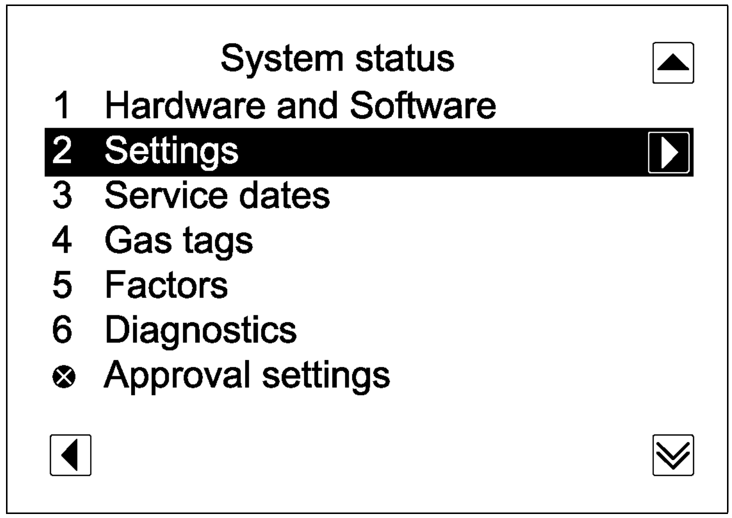


Figure 2-11: System Info Screen

The following section details each menu selection.

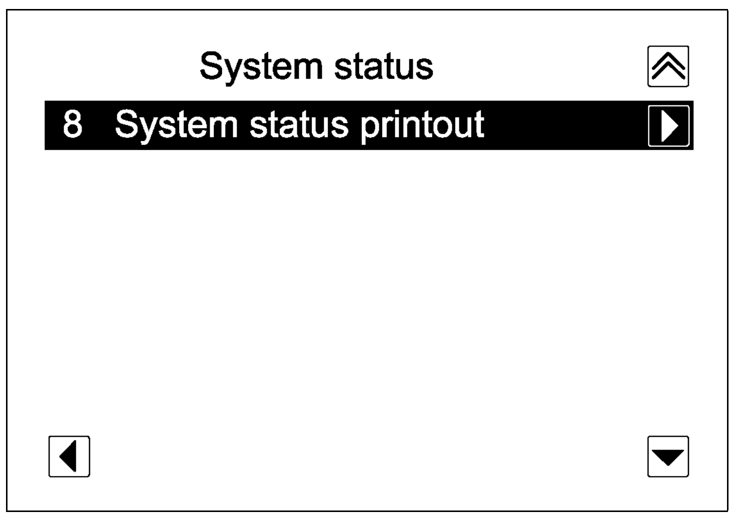


Figure 2-12: System Info Screen 2

It may be helpful when service is required to print the system status using this selection.

1. Hardware and Software (View Only)
Shown is an example of the ***DGA 1000 Gas Analyzer*** hardware and software configuration display in *Figure 2-13*.

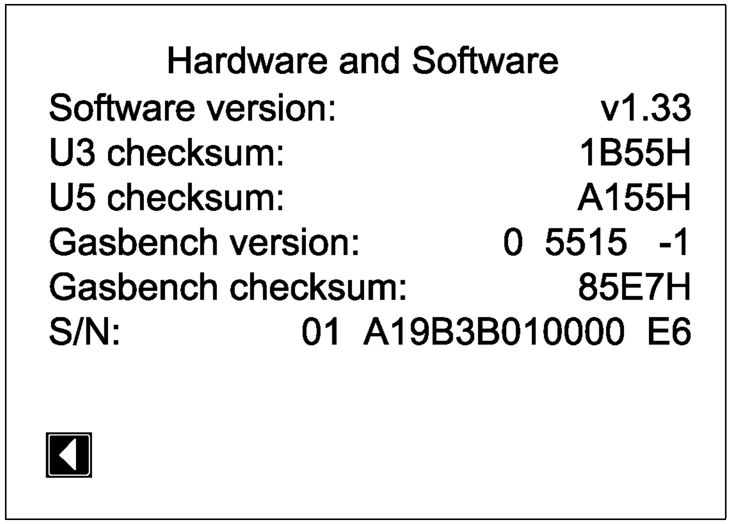


Figure 2-13: Hardware and Software Screen

2. Settings (View Only)
Three Settings Screens display ***DGA 1000 Gas Analyzer*** settings. The settings are configured during first installation of the analyzer and can only be changed by a Service Representative. The normal defaults are listed in *Figure 2-14*, *Figure 2-15* and *Figure 2-16*.

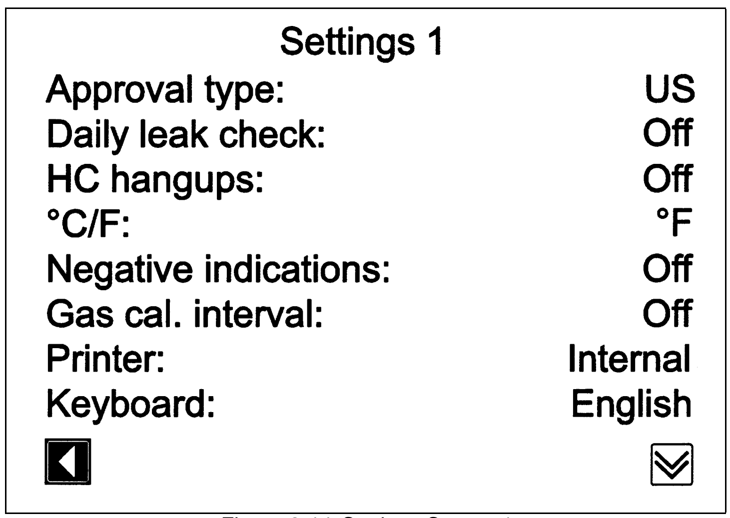


Figure 2-14: Settings Screen 1

Settings 2	
NO option:	On
Protocol:	4(8IN)
Baudrate:	9600
Interval delay:	Off
Lean burn:	On
Custom gas cal:	Off
Date/time format:	US
Lambda/AFR:	Lambda

Figure 2-15: Settings Screen 2

Settings 3	
Language:	English
Daylight savings time:	On
Standby in:	Off
Service flags:	9600

Figure 2-16: Settings Screen 3

3. Service Dates (View Only)

Service Dates Screen gives an overview of last checks and calibrations. It also shows when the NO cell and O_2 cell need to be replaced. The analyzer automatically indicates when these cells need replacement.

Service dates	
Last gas calibration:	xx-xx-xxxx
Next gas calibration:	xx-xx-xxxx
Last leak check:	xx-xx-xxxx
Last NO calibration:	xx-xx-xxxx
Last O2 calibration:	xx-xx-xxxx
NO cell installation:	xx-xx-xxxx
O2 cell installation:	xx-xx-xxxx

Figure 2-17: Service Dates Screen

4. Gas Tags

Gas Tags Screen shows the gas values used during analyzer calibration. These values can be set by the operator using this page. The values in *Figure 2-18* are recommended.

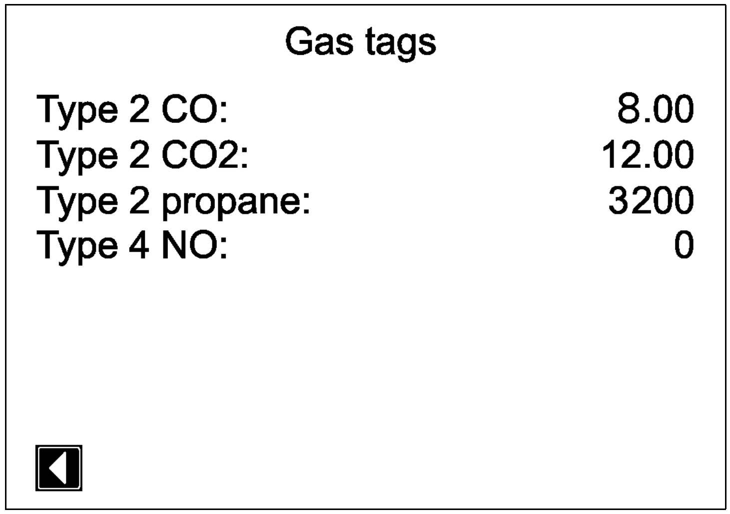


Figure 2-18: Gas Tags Screen

✓ Type 4 NO is used only when the analyzer has the NOx option installed.

5. Factors (View Only)

Factors Screen shows the calibration factors used during analyzer calibration and can only be configured by a Service Representative.

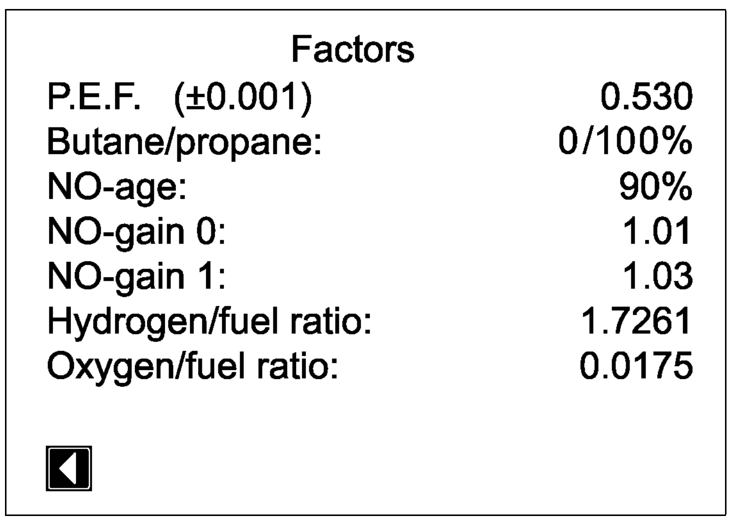


Figure 2-19: Factors Screen

6. Diagnostics (View Only)
Diagnostics Screen displays the number of service entries performed by the Service Representative.

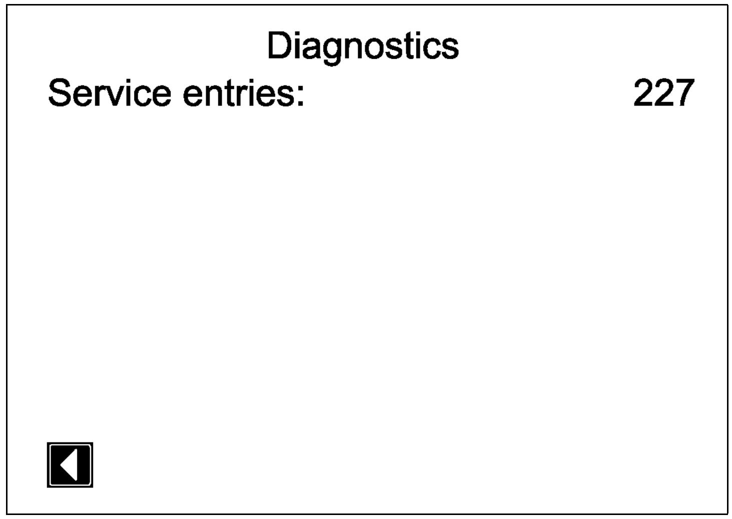
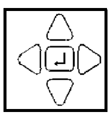


Figure 2-20: Diagnostics Screen

7. Approval Settings
Approval Settings are only accessible to a Service Representative.



8. System Status Printout
When the System Status Printout Screen displays, press the right arrow key (▶) to print.

Service

The Service Menu can only be accessed by an authorized Service Representative.

✓ If the Service Menu is inadvertently selected, enter any number in the ID field and press ENTER to return to where you were before selecting the Service Menu.

3

Vehicle Testing

This chapter contains information necessary to:
- Prepare a vehicle for testing,
- Perform tests, and
- Evaluate test data.

Preliminary Checks

Conduct a thorough inspection of the vehicle before performing any analysis or troubleshooting with the analyzer. Accurate engine performance diagnosis depends on proper operation of related components or systems. Perform the following inspection, repairing and replacing items as required. Careful visual checks may lead to correcting a problem. Examine all the following systems and components:

Fluid Levels

- Engine oil
- Transmission fluid
- Coolant

Filters

- Air cleaner
- Fuel filter
- Crankcase breather
- Charcoal canister filter
- Air injection pump filter

Hoses—Connections, Cracks, Leaks, etc.

- Vacuum hoses for splits, kinks, proper connections and routing
  — Check thoroughly for any leak or restriction.
- Fuel system hoses
- Cooling system hoses

Belt—Cracks, Tension, Glazing, etc.

- Alternator
- Air conditioning
- Power steering pump
- Air injection pump
- Fan

Exhaust System

- Exhaust pipes and connections
  - Connections should be tight and with no obvious leaks or obstructions.
- Catalytic converter
- Air management system
  - Check valves should not leak.
- Diverter valve/air switching valve
  - Valve should not stick or leak into closed off port.

Electrical System

- Wiring
  - Check for proper connections, pinches, cuts, corrosion, etc.
- Engine/power control module grounds and sensors
  - Ensure that all are clean, tight, and in their proper location.
- Cranking system circuits
- Charging system circuits
- Ignition system circuits
  - Check ignition wires for cracking, hardness, proper routing and carbon tracking.
- Fuel system
- Battery
  - Check state of charge, general condition and connections.

Basic Engine Functions

- Engine timing
- Idle speed
- Air leaks
  - Check throttle body mounting area and intake manifold sealing surfaces.
- Fuel feedback system

Verify the Customer Complaint

Perform On-Board Diagnostic (OBD) checks before attempting to analyze data collected for diagnosing a driveability or emissions complaint. Determine that:

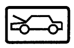
- Engine/power control module and check engine or malfunction indicator lamp (MIL) operates correctly, and
- No diagnostic trouble codes (DTC) are stored.

Testing Tips

- ❒ Read and follow the safety instructions in *Safety Information* in this manual.
- ❒ Always comply with the governing emission control standards and regulations in your locality when testing exhaust emission levels.
- ❒ Check vehicle manufacturer specifications and procedures before testing.
- ❒ Do not test exhaust emissions on vehicles that are smoking excessively or are in obvious need of engine repair. Testing exhaust gas under such conditions may contaminate the sampling system and cause inaccurate readings.
- ❒ Always follow vehicle manufacturer specifications when working on emission control devices to comply with anti-tampering laws.
- ❒ Test engines only when they are at normal operating temperature.
  - — Testing a cold engine does not provide useful test results due to fuel mixture enrichment.
  - — A cold engine test contaminates the sampling filter quickly, requiring more frequent analyzer service intervals.
- ❒ Before testing tail pipe emission levels, make sure the engine is at normal operating temperature.
- ❒ Repair leaks in the exhaust system prior to testing. Leaks adversely affect analyzer readings.
- ❒ Disable Air Injection Reaction (AIR) systems before performing some diagnostic tests. This provides undiluted gas samples and inhibits catalytic converter operation. Check the procedure prescribed by the manufacturer for disabling the AIR system.
- ❒ Insert the sample probe fully into the tail pipe when testing exhaust emissions to prevent diluted readings.
- ❒ Exhaust samples can be diluted by outside air entering twin tail pipes connected to a common resonator or muffler. Block off the pipe not being used for the sample probe when testing these exhaust systems.
  - — Remove the device blocking the tail pipe when testing is complete.
  - — Do not block a tail pipe when operating a vehicle on a chassis dynamometer.

Setting Up the Vehicle

For all types of vehicle testing, gas display, TSI procedure or catalytic testing, some vehicle information should be entered into the analyzer as described in this section. Once this action is completed, all types of test can be performed without reentering the data.



1. Press the Vehicle Set-up key on the analyzer front panel or the SETUP key on the remote control to access the Vehicle Set-up Screen. The following settings must be done prior to gas measurements using the standard default Gas Value Display Screen:

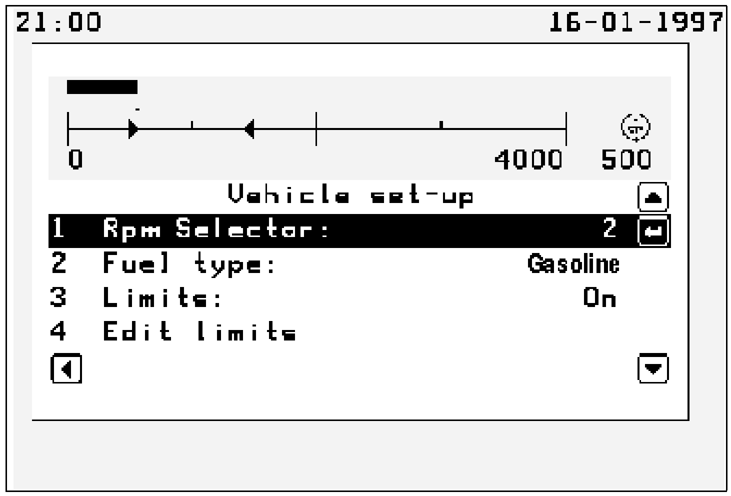
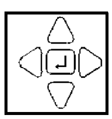


Figure 3-1: Vehicle Set-up Screen

✓ This screen displays automatically when performing a TSI procedure.

RPM Selector



Use the RPM selector to select the correct setting to display engine RPM. Press ENTER and the arrows (▲ ▼) until the correct number displays as follows and then press ENTER to select.

— Setting 1: use when RPM pickup is connected to a single plug wire.

— Setting 2: use for waste spark type engines.

— Setting to Match Engine Number of Cylinders: use if pickup is connected to coil wire.

✓ If unsure which setting to use, with the engine running, change the setting, observe the RPM display and use the setting that results as the correct RPM value.

Ignition Systems with a Conventional Distributor

— When the RPM pickup is connected to the ignition coil secondary wire, set the RPM selector to the number of cylinders of the vehicle. The RPM signal is divided by the number of cylinders to give the correct RPM indication. Set the RPM selector to 1 when the RPM pickup is connected to a cylinder's spark plug wire.

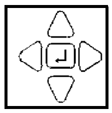
Direct Ignition Systems

— Set the RPM selector to 1 if the optional orange capacitive clamp is connected to one coil primary lead. When connected to an injector lead, the RPM selector depends on the injector frequency. Check with the vehicle's RPM indicator for correct RPM indication on the analyzer.

Waste Spark Ignition Systems: (one coil per two cylinders)

— Set the RPM selector to two.

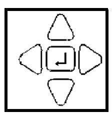
Fuel Type



Select the correct fuel type used by the vehicle, i.e. Petrol (Gasoline), LPG (Liquefied Petroleum Gas) or CNG (Compressed Natural Gas). Arrow down ( ) or press 2 for fuel type then ENTER. Next, press the up and down arrows ( ) to display fuel types. Press ENTER to select.

✓ This is important for correct Lambda values.

Limits



Set the Emission Limits function to ON. Arrow down ( ) to the item or press 3 then arrow up or down ( ) and press ENTER for ON or OFF when the gas measurements are done using limits for the measured gases. Set to OFF when no limits are used.

Screen Indicators

If limits are on, arrows appear on the Gas display screen to indicate if the values are as shown below.

— (↑) Up arrow—measured value is above the limit.

— (↓) Down arrow—measured value is below the limit.

— (✔) Check—value is correct.

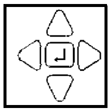
Edit Limits

There are two different Edit Limits functions in the software. The procedure in this section describes setting limits and can be used for either limits function.

- One set is used when the Setup key ( ) is pressed
  — Limits set in the Setup ( ) Menu are stored in memory and retained when there is no power to the ***DGA 1000 Gas Analyzer***.
- The second set is used with the TSI procedures function *only* for the Catalyst Testing procedure.
  — Limits set in the TSI procedure are only in effect for a single test on the same vehicle and do not remain in memory. Once a test is completed the values entered are lost.

✓ The Edit Limits function is *not* used for the Non-Catalyst-2 or Catalyst-1 Test Procedures. These procedures have other limits that can be changed.

✓ The TSI procedure, Set 2 of the Catalytic Test, only contain entries for CO% and RPM at idle.



To set limits for the vehicle being tested, use the down (▼) arrow key to edit limits or press 4. The Set Limits Screen displays. Arrow up or down (▲ ▼) to the item you want to change and press ENTER. Press the left (◀) arrow key to exit.

Setting limits at first may seem complex, but with a little practice they become easy. Use the following general notes to help enter limits.

* = no limit is entered. This symbol must be used for:

	Minimum
CO	*
CO_c	*
HC	*
	Maximum
OIL	*

• = decimal point, for example a maximum CO would be 2.00

– = a negative value. This should never be used.

✓ All minimum and maximum will accept 6 characters. For example, for a 1996 vehicle the following limits could be used.

	Minimum	Maximum
CO	*	1.20
CO_2	12.00	15.00
CO_c	*	1.20
HC	*	220
O_2	0.00	1.50
λ	0.97	1.03
NO	800	1050
RPM	600	800
OIL	100	*

✓ Be careful when entering limit numbers. For example, to enter 1.00 in a six character field (XXXXXX), move 4 places from the right and then type 1.00.

✓ The limits consist of two sets, Set 1 and Set 2. Use the Set 1 for measurement at high RPM.

✓ Changing limit settings can only be done when Limits is set to ON.

✓ Set 2 is for low RPM.

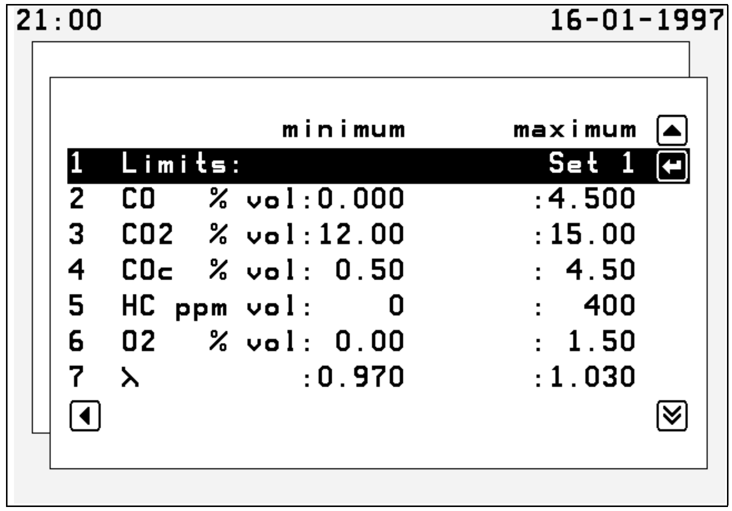


Figure 3-2: Set 1 Limit Screen 1

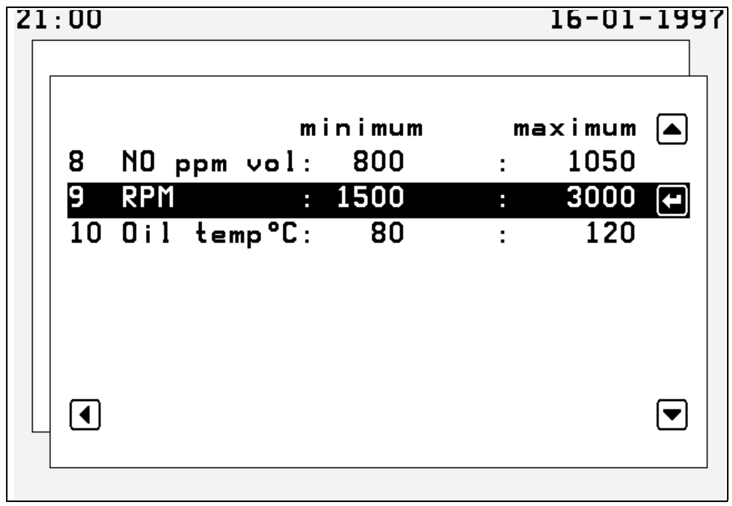


Figure 3-3: Set 1 Limit Screen 2

✓ When settings are changed, and a measurement was previously stored, the ongoing data in the memory is cleared.

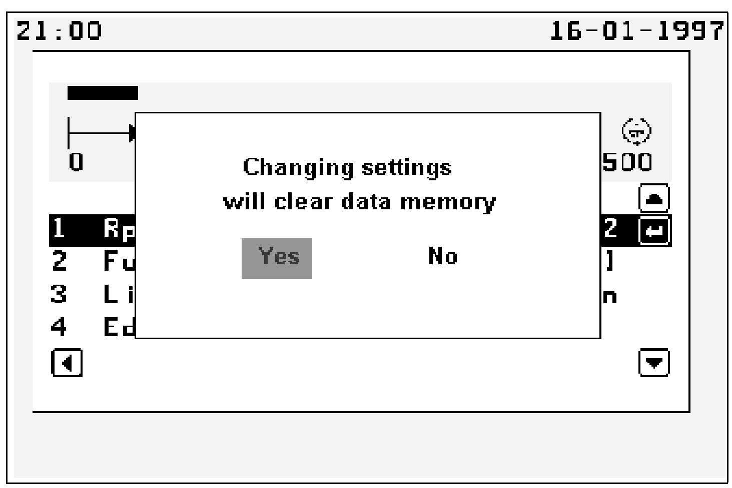


Figure 3-4: Changing Settings

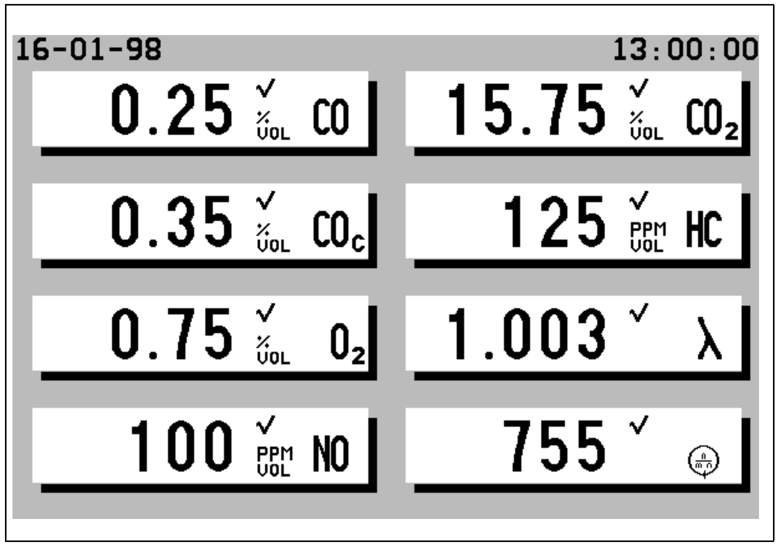


Figure 3-5: Measurement Screen

General Emissions Measurements

After setting up the vehicle, RPM selector, fuel type, limits on/off, and edit limits used, use the Diagnostic Gas display to read various emission gases. Refer to *Chapter 7–Diagnostic Technique* for more information.

To Test

1. Set up the vehicle, press key and enter the information.
2. To know when certain values are exceeded, turn on limits and observe the up arrow (↑), down arrow (↓), or check mark (✔) in the Gas display boxes.
3. After the Auto zero and hang-up test are completed, insert the sample probe in the tail pipe and connect an exhaust removal system.
4. Once gases display, up to two sets of data may be stored using the key on the analyzer front panel. Press the key once to enter the storage mode and a second time to store the information.

✓ The key displays on the center of the screen when data is stored.

✓ To view the stored data on the Gas Display Screen, select the ▸ key. The stored results may be viewed, printed or cleared.

✓ The test can be performed with or without RPM and oil temperature, if desired.

✓ If limits are ON, the first set of stored values are compared to Limit Set 1. The second stored values are compared to Limit Set 2.

Two-Speed Idle (TSI) Test

The “typical” TSI procedure function contains three different procedures:

- Non-Cat 1 (single speed test)
- Non-Cat 2 (single speed test)
- Catalytic Test (two speed test).

The Limits function, if turned on, can be used for all three tests.

✓ Remember, any limits entered only apply to for as long as the same vehicle is being tested. When the exit the menu, limit values revert to the defaults.

The two-speed idle test consists of operating the engine at a higher engine speed, 2500 RPM, and a lower engine speed, idle. During the higher speed mode, exhaust dilution is checked by monitoring CO and CO_2, and the engine is conditioned to allow an optimum exhaust emission idle test.

Test results are used to verify whether exhaust gas concentrations emitted from the vehicle are within limits specified by the vehicle manufacturer or the government. If exhaust gas concentrations exceed those specified limits, repairs or adjustments are indicated.

✓ The test procedure used in the program is referred to as a "pre-condition two speed idle" and it consists of a number of steps that must be followed exactly to test the vehicle properly. Taking too long to perform the test can cause the procedure to abort automatically.

General Setup Procedure

Secure the vehicle as follows:

1. Place the shift selector in Park or Neutral.
2. Position wheel chocks snug to the tire tread of both front and rear of non-drive wheels.
3. Turn off all vehicle accessories.
4. Select typical TSI procedure from the Test Menu. Press ENTER and Home ( ) to get to the Test Menu.
5. Set up the vehicle using information in *Setting Up the Vehicle, page 3-4*.
6. Select the type of TSI test desired:
   — Non-Cat 1 (single speed test)
   — Non-Cat 2 (single speed test)
   — Catalytic Test (two speed test).
7. Enter the Limits to test against, if desired and only if the Limits function is turned on.
8. Select Start Tests.
9. Allow the Auto zero and hang-up test to proceed.
10. Start the engine and allow engine speed to stabilize.
11. Insert the exhaust probe a minimum of 12” into the tailpipe.

12. Follow the screen prompts.

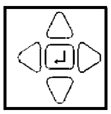
✓ Note the test can be done without RPM or oil temperature by pressing the ENTER with the ▶ arrow key.

13. When the display reads BRING RPM INTO WINDOW, depress the accelerator pedal to increase engine speed to the desired speed. The Typical TSI Test Screen provides a graph that shows the engine speed in RPM.

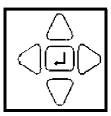
14. Hold engine at that speed for the duration of the test. The countdown timer on the TSI Test Screen shows the seconds remaining for the test.

15. When the test is complete, stop the engine and remove the sample probe.

16. The Results Screen displays followed by a display of the actual gas values.



17. The Customer Information Screen displays. Fill in the information as desired. Press ENTER when prompted to print a report.



✓ To skip printing, select ESC and then either (◀ ◀) Repeat or the Home 🏠 to abort.

Catalytic Efficiency Test

This test is accessed from the Test Menu and can be used to diagnose an excessive emissions failure resulting from a damaged or tampered catalytic converter. A specified amount of propane, is flowed through a preheated converter and the resulting CO_2 and HC levels are measured at the tailpipe with the exhaust gas analyzer. Use the catalytic converter test kit, part number EAK0232L00A, to introduce propane through a large manifold vacuum source such as: PCV system or power brake vacuum booster hose. The amount of flow to inject depends on the engine displacement (in Liters) and whether the vehicle is equipped with a single or dual converter. Within the preheated converter, most of the propane is oxidized into CO_2, however; a small amount of propane passes through unchanged. By measuring the amount of CO_2 produced and the level of unconverted HC, it is possible to determine catalytic converter efficiency, relative to a Pass or Fail. Typically 4–6% CO_2 is produced for the specified amount of propane.

Optional Catalytic Converter Test Kit

Safety Information

IMPORTANT SAFETY INSTRUCTIONS

The catalytic converter test kit, part number EAK0232L00A, is intended for use by properly trained, skilled professional automotive technicians. Safety warnings and cautions in this section and throughout this manual are reminders to operator to exercise extreme care when using this test instrument.

There are many variations in procedures, techniques, tools, and parts for servicing vehicles, as well as in the skill of the individual doing the work. Because of the numerous test applications and variations in the products that can be tested with this instrument, ***Snap-on*** cannot possibly anticipate or provide advice or safety messages to cover every situation. It is the automotive technician's responsibility to be knowledgeable of the system being tested. It is essential to use proper service methods and test procedures and to perform tests in an appropriate and acceptable manner that does not endanger your safety, safety of others in the work area, or vehicle or equipment being tested.

It is assumed the operator has a thorough understanding of vehicle systems before using the catalytic converter test kit. Understanding of these system principles and operating theories is necessary for competent, safe and accurate use of this test.

Use equipment only as described in this manual.

Introduction

Use the optional catalytic converter test kit with the ***DGA 1000 Gas Analyzer*** to determine if a catalytic converter is capable of functioning properly and to diagnose emissions failures that are a result of a damaged or tampered catalytic converter.

Functional Description

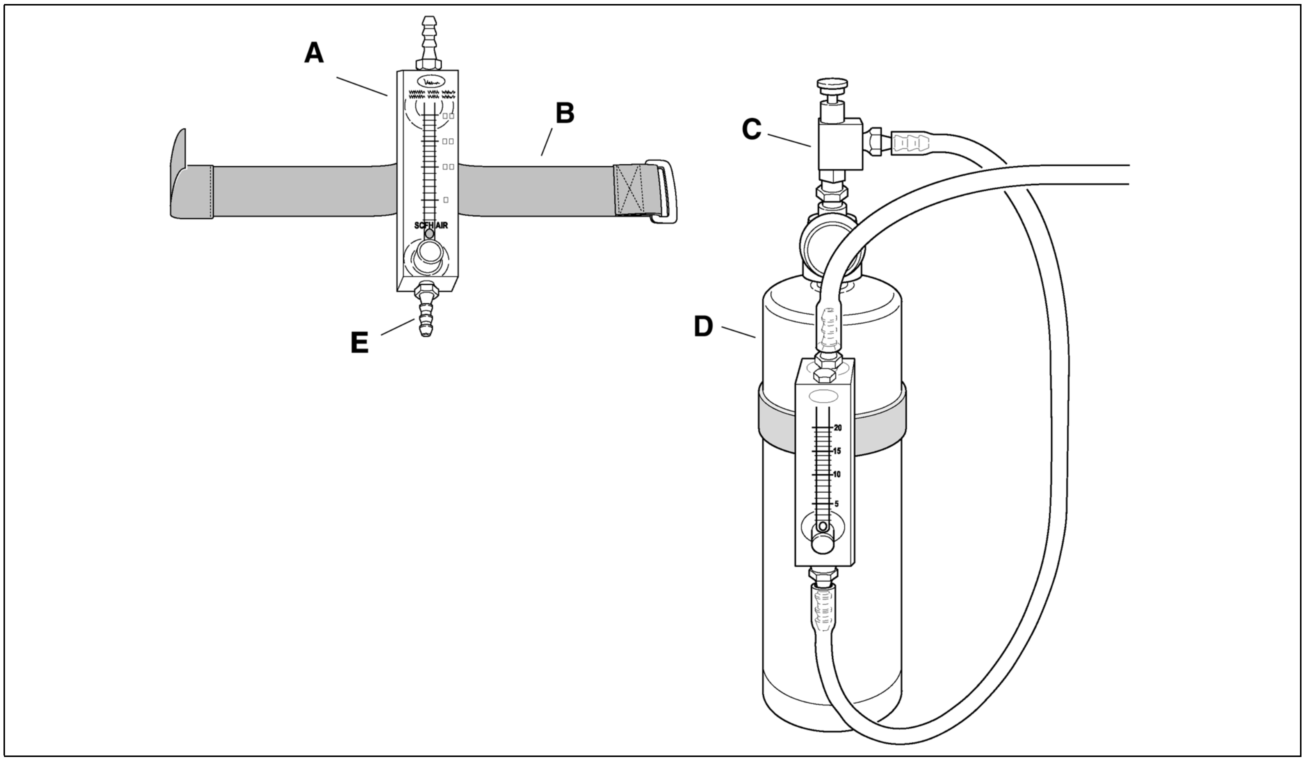


Figure 3-6: Catalytic Converter Test Kit

A—Flow Meter

Part number 1-15381. Use to set rate of propane flow.

B—*Velcro* Strap

Part number 5-3245. Attaches flow meter to propane tank.

C—Propane Enrichment Assembly

Part number EAA0259L00A. Controls flow of propane.

D—Propane Tank

Tank not included and must be purchased separately. Shown for kit assembly purposes only.

E—Brass Barb Fitting

Part number 0647-0070. Connects hoses to flow meter.

Bracket, Flow Meter (not shown)

Part number EAS2300L00A. Attaches ***Velcro*** strap to flow meter.

Screw (not shown)

Part number 1-1003. Attaches bracket to flow meter.

Catalytic Converter Test

The Catalytic Converter Test is performed manually and is fully under the operator's control. This allows the test to be run even if engine RPM measurements are not easily accessible. In that case, follow the screen prompts to complete the test. The test must be completed within five minutes after vehicle warm-up or the catalytic converter may cool and the test results may be invalid.

✓ This catalytic converter test does not identify a restricted catalytic converter.

What the Catalytic Converter Does

The catalytic converter reduces normal "engine-out" (pre-catalytic converter) pollutants (HC, CO and NO_X) to acceptable levels. Anything that causes the engine-out pollutants to exceed normal levels reduces the effective life of the catalytic converter. The catalytic converter requires precise control of the air/fuel ratio to operate at peak efficiency. Anything that disrupts the air/fuel ratio—such as an engine that burns oil—reduces catalytic converter efficiency and potentially increases failure.

How the Catalytic Converter Test Works

This test requires injecting a specified amount of propane through a preheated catalytic converter. Use the propane enrichment assembly, part number EAA0259L00A, to inject propane upstream of the catalytic converter. The amount of propane flow depends on the engine displacement and whether the vehicle is equipped with a single or dual converter. Within the preheated converter, most of the propane is oxidized into CO_2. However, a small amount of propane passes through the converter unchanged. It is possible to determine catalytic converter efficiency by measuring the amount of CO_2 and the level of unconverted propane.

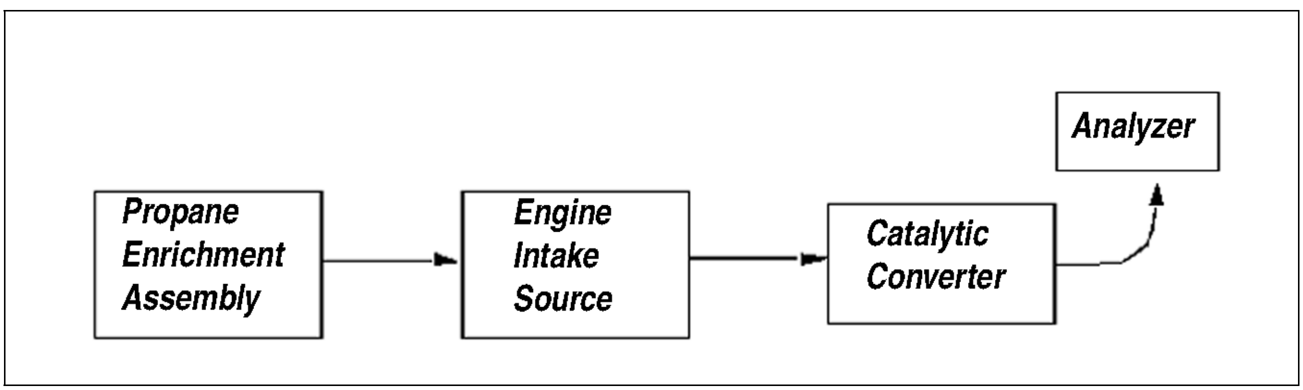


Figure 3-7: Catalytic Converter Test Overview

Pre-test Inspection

During emission troubleshooting, the catalytic converter should be the last item to be tested and/or repaired. Perform the following inspection before starting the catalytic converter test.

❒ Make sure all diagnostic trouble codes are repaired.

❒ Make sure all engine controls and emission controls are operating correctly. To verify correct operation of the emission control system, check O_2 sensor for proper operation.

❒ Always comply with the governing emission control standards and regulations in your locality when testing exhaust emission pollutant levels.

❒ Make sure engine systems are within specifications, especially timing.

❒ Replace catalytic converters with severe rust or case damage.

❒ The catalytic converter should not rattle when given a quick rap. A rattle may indicate the substrate has broken. If the substrate is broken the catalytic converter will soon fail and may plug the exhaust.

❒ Always follow vehicle manufacturer specifications when working on emission control devices to comply with anti-tampering laws.

❒ Do not test exhaust emissions on vehicles that are smoking excessively or are in obvious need of engine repair. Testing exhaust gas under such conditions may contaminate the sampling system and cause inaccurate readings.

❒ Repair leaks in exhaust system prior to testing. Leaks adversely affect analyzer readings.

Test Preparation

Before performing tests in this manual be sure that:

- Analyzer is on, warmed up and calibrated,
- Leads and probes are connected to vehicle in standard configuration,
- Vehicle parking brake is applied.
- Gear selector is in:
  - — Neutral, if equipped with a manual transmission, or
  - — Park, if equipped with an automatic transmission.
- Drive wheels are blocked,
- Parking brake is set, and
  - — If vehicle equipped with automatic parking brake release, disable release mechanism.
- All testing tips and safety requirements are observed.

Before Testing

Assemble the following equipment and be sure to have the information described in this section available.

❒ Propane supply tank.

❒ Flow meter, part number 1-15381. The flow rate is based on the engine displacement and exhaust system configuration.

❒ Propane enrichment assembly, part number EAA0259L00A.

❒ Assorted rubber hoses and "tees". It is advisable to obtain a rubber "stopper" with a hole in the center to connect to a brake booster hose.

❒ Battery charger. It may be necessary to connect a battery charger to boost the battery if cranking RPM drops too low during the test.

❒ Identify how to disable the fuel and ignition systems. For additional information refer to *Disabling the Fuel System, page 3-17* and *Disabling the Ignition System, page 3-17*.

✓ Check in the vehicle owner's manual or use an information system to locate the vehicle power distribution center(s).

❒ Locate propane injection point.

❒ Vehicles with single catalytic converters

— Perform the test by adding the specified amount of propane through a large manifold vacuum source on the engine like the PCV or power brake vacuum booster hose.

❒ Do not exceed specified propane flow. Excessive propane overheats the catalytic converter.

❒ On vehicles with multiple tailpipes exiting the muffler, the exhaust probe may be placed in any functional tailpipe.

❒ On vehicles with multiple tailpipes, cap unused openings with appropriate plug device.

— This is especially important if an exhaust venting system is connected to the tailpipe. The system may pull air in through the unused tailpipe and dilute measurements.

❒ On closed loop carbureted engines the proper propane flow is determined by analyzing the exhaust CO_2 level resulting from the initial cranking event (purging of residual gases).

— CO_2 less than 2% - use full amount of propane as determined from the engine displacement value chosen during setup.

— CO_2 between 2% and 4% - use one-half the amount of propane specified in the *Conversion Table for Proper Propane Flow, page 3-16* for the engine displacement value chosen during setup.

❒ Do not exceed specified propane flow. Excessive propane will overheat converter.

❒ Operate engine at 2500 RPM for 3 minutes to pre-heat the catalytic converter.

❒ The catalytic converter test should be conducted within five (5) minutes of preheating the converter.

❒ It may be necessary to connect a battery charger to the vehicle if cranking RPM drops dramatically during catalytic converter testing.

❒ Disabling ignition system may require:
— Removing battery feed to ignition coil(s)
— Removing secondary coil wire from distributor cap and ground it

❒ Disabling fuel system may require:
— Removal of fuse(s)
— Disconnect injector harness
— Disconnect fuel pump connector
— Disabling fuel pump relay/inertia switch

Conversion Table for Proper Propane Flow

Engine displacement (cc)*	1000	1500	2000	2500	3000	4000	5000	6000	7500
Liters per minute (L/min)	2.4	2.8	3.1	3.5	3.8	4.2	5.2	6.0	7.1
Standard cubic feet per hour (SCFH)	5.0	5.8	6.7	7.5	8.0	9.0	11.0	12.7	15.0

* Note: 1 liter = 1000 cc

Disabling the Fuel System

Refer to the vehicle manufacturer's procedure for disabling the fuel system. Some common methods of disabling the fuel system follow.

Inertia Switch	– Most Ford vehicles are equipped with an inertia switch. Lifting the plunger on the top of the switch deactivates the fuel pump. After "tripping" the switch, crank the engine to burn any residual fuel in the fuel rail.
Fuel Pump Relay	– May be centrally located in the power distribution or maxi-fuse panels, remove this relay to disable the fuel pump.
Fuel Injector Fuse(s)	– Usually located in the fuse panel, removing this fuse disables the fuel injectors.
ECM/PCM Power Fuse(s)	– Usually located in the fuse panel, removing this fuse can disable the fuel injectors. Sometimes it disables the fuel and ignition systems. Be sure to check for spark. **IMPORTANT:** Read trouble codes before removing fuses. Learned memory may be erased when these fuses are removed.

Disabling the Ignition System

Refer to the vehicle manufacturer's procedure for disabling the ignition system. Some common methods of disabling the ignition system follow.

⚠DANGER **Always verify that there is no spark before injecting propane into the intake.**

External Coils and Coil Wire	– Disconnect primary wiring connector from ignition coil. – Remove coil secondary wire from distributor cap and with a jumper wire connect it to a known good ground.
Internal Coils	– Disconnect primary wiring connector from the distributor or from igniter module.
Distrubutorless Ignition	– ECM/PCM Power Fuse(s) - Usually located in the fuse panel, these fuses can be removed and the ignition may be disabled. **IMPORTANT:** Read trouble codes before removing fuses. Learned memory may be erased when these fuses are removed. – Remove connector at ignition module, igniters or coilpack(s).
Ignition Control Relay	– Usually located in the power distribution or maxi-fuse panel, this relay can be removed to disable the ignition system.
Ignition Control Fuse	– Usually located in the power distribution or maxi-fuse panel, this fuse can be removed to disable the ignition system.

Catalytic Converter Test Set-up

✓ Two people are required for this procedure.

1. Connect the oil temperature probe and RPM pickup. Insert the exhaust probe.
2. Input the vehicle information.
3. Start procedure. Information displays on the Start Procedure Screens.

✓ Beginning with step 4, items shown in **Bold** type are instructions which display directly on the screen.

✓ Starting with step 6, the test must be completed within 5 minutes.

✓ It is strongly recommended you practice this procedure and become familiar with it before attempting to diagnose a customer vehicle.

4. Start the engine and run at high idle until the oil temperature is > 176°F or select the right (▶) arrow key and ENTER to continue.

   Engine warmed when oil temperature >80 degrees C
   — Oil temperature and RPM display.

5. Continue to run engine at high speed to preheat the catalyst.

   Catalyst preheating *(counts down).*

6. **Turn engine off and:**
   Disable ignition
   Disable injection (5 min. count down to allow time to accomplish.)

   Press ENTER when ready.

7. **Depress accelerator**
   Ready to crank in 5s

8. **Cranking** *(counts down).*
   — CO_2 and HC values are displayed while cranking to clear residual gases in exhaust system.

   — **Stop cranking**
   — **Release pedal**

   — Press ENTER to continue.

9. **Are you sure that ignition was disabled?**
   YES **NO** (make choice)

10. **Are you sure that injection was disabled?**
    YES **NO** (make choice)

11. **Are you sure that the engine was cleared of residual gases?**
    YES **NO** (make choice)

12. **Adjust propane to a flow of:**
    Example (based on default engine displacement value of 2000cc):
    — 3.1 (L/min) Liters per minute
    — 6.7 (SCFH) Standard Cubic Feet per Hour

✓ Refer to the *Conversion Table for Proper Propane Flow, page 3-16*.

Then press ENTER.

13. **Connect propane enrichment device to engine.**
    Press continue.

✓ If at this point the Catalytic Converter cooled down the following message appears:

Catalytic Converter cooled down.
Select [next page] to repeat warm-up.

14. Crank the engine.
    Start cranking and
    Propane flow in 5s.

    Throttle valve completely closed, initiate cranking and depress push valve on propane enrichment device to start propane flow.

15. **Cranking** *(counts down).*
    Stop propane flow
    Stop cranking

16. **Pass/Fail Chart is displayed.**
    This is followed by the actual test value.
    — This chart does not display if the test is invalid.

    The actual results may be printed by selecting print. Enter the customer vehicle information. When ready, press the ENTER key and a printout is produced.

✓ Print results before the last results screen appears.

When testing is completed, re-enable ignition and fuel systems.

4

Maintenance

The ***DGA 1000 Gas Analyzer*** is a precision diagnostic instrument that requires little maintenance. The maintenance and service procedures presented in this chapter are those which the operator can perform. All other services should be performed by an authorized Service Representative.

This chapter contains Maintenance and Troubleshooting information. Accessory Kit information, Maintenance Parts information and a list of Options are found at the end of the manual.

Maintenance Schedule

The following items require periodic maintenance:

- Leak check (vacuum)
  - — Refer to *1– Leak Check Vacuum, page 4-4* for more information.

    ✓ The Leak check is automatically initiated after warm-up if the Daily Leak check in Settings of the System Info Menu is set to ON. Settings can only be configured by a Service Representative.

- Leak check (gas)
  - — This is an alternative check. (*Not for U.S.A. use*.)

Sample System

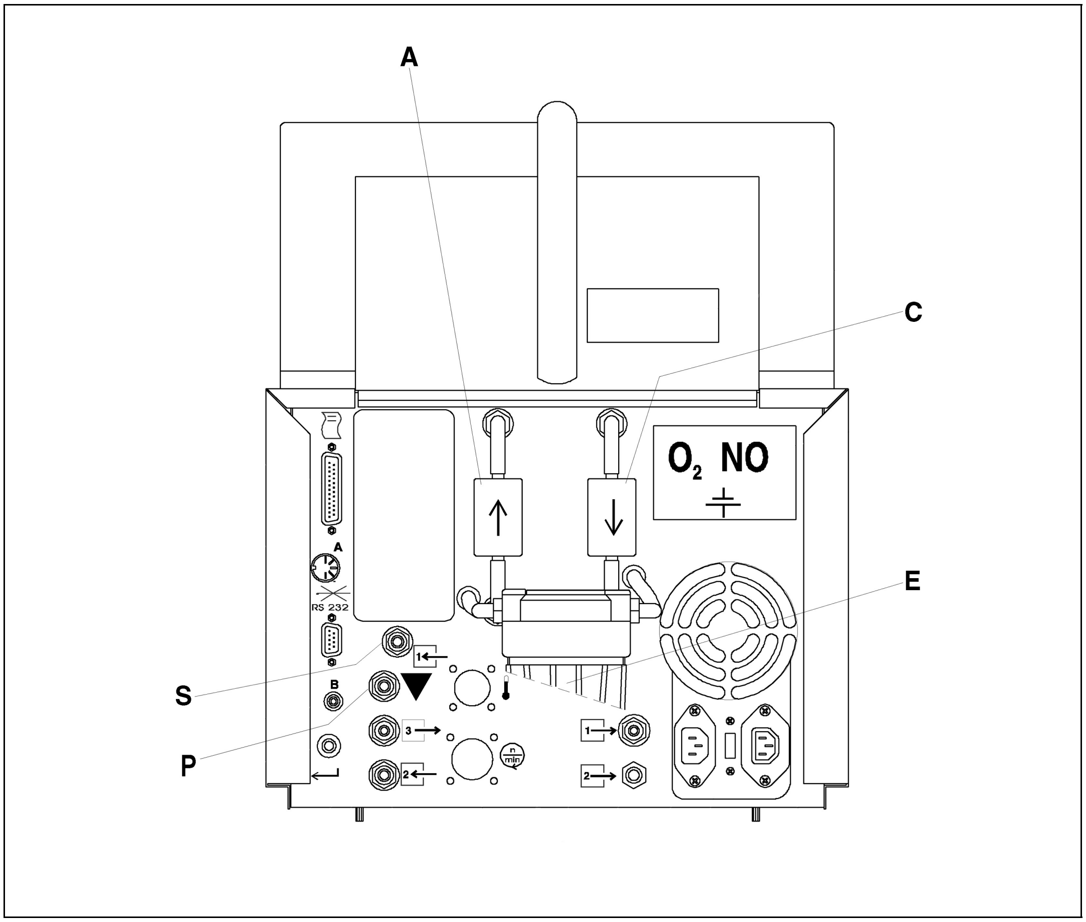


Figure 4-1: Analyzer—Back Panel View

The analyzer contains three filters and a charcoal filter to protect and extend the analyzer sample system life.

Three filters, A, C and E shown in *Figure 4-1*, must be serviced at regular intervals. How often depends to a large extent on the use of the analyzer. The following are minimum intervals for replacement.

A—Filter, Secondary Inline

- Sample, secondary in-line filter.
- Replace every six months with part number 7096E9061-03.
  — To replace the filter, remove the tubing from each end and insert the new filter.

  ✓ Pay attention to the flow arrow.

C—Filter, Water Filter

- In-line water drain filter.
- Replace every six months with part number 7009E9323-46.
  — To replace the filter, remove the tubing from each end and insert the new filter.

  ✓ Pay attention to the flow arrow.

E —Primary Filter Bowl Assembly

- Removes moisture and other exhaust contaminants that are potentially harmful to the analyzer.
- Inspect daily and replace every two week with part number 7096E9062-77.
  — To replace the filter, unscrew the locking ring, which connects the bowl to the upper housing, to gain access to the filter.
  — Unscrew the filter retainer nut on the bottom, and remove and install the new filter.

✓ When the filter bowl is removed, be careful not to loosen or misalign the o-ring seal in the top portion of the filter housing. If the o-ring does not properly seal, a failed leak check will occur.

✓ If desired and also recommended, the bowl may be washed with soap and water. Never use a solvent on the bowls.

✓ Do not overtighten filter retainer or bowl ring. Snug is fine.

✓ If the water symbol ( ) appears on the left of the screen or if a low flow symbol ( ) appear at any time during operation, the primary filter must be replaced immediately.

— Stop testing and perform sample system maintenance.
— The low flow ( ) can also be caused by a plugged sample hose or probe. Check these along with sample system service.

P —Calibration Gas Inlet

Use this inlet to supply calibration gas to the analyzer.

✓ Pressure at this port must not exceed 10 psi.

S —Clean Air Inlet Port, Charcoal Filter

- A charcoal filter is installed to filter the ambient air going into the gas bench during calibration.
- Replace yearly with part number 7096E9061-54.
  — To replace the filter, remove the old filter from the tubing and insert the new filter.

✓ If one is present, pay attention to the flow arrow.

O_2 Cell and NO Cell Service

Do not attempt to replace these cells on your own. When the warning icon (!) displays in the lower right of the screen, cell replacement is required. Contact ***Equiserv***.

✓ Under most conditions, depending on use, the NO cell lasts 15–18 months and the O_2 cell 12–18 months.

There are a number of functions in the Maintenance Menu. Some may be used to insure analyzer performance, some that should not be used and some that cannot be used.

The following choices are available on the Maintenance Menu:

1 **Leak Check Vacuum**
2 **Leak Check Gas**
3 **Gas Calibration Check**
  —Values CO, HC CO_2
  —HC **Represents: Propane/Hexane**
  —λ calculated for: Gasoline/Natural Gas Propane
  —Warnings/Errors
4 O_2**/Check Install**
⊗ 5 **Gas Tag Values**
⊗ 6 **Gas Calibration**

✓ ⊗ These two items cannot be accessed in normal set-up.

1– Leak Check Vacuum

This test checks if there is an air leak in the sample system of the analyzer. Follow the instructions on the screen. In this test the exhaust sample probe must be blocked with the exhaust probe sealing tool, part number 0787-0035. The pump pulls a vacuum and the analyzer checks for any leaks in the system.

Seal the probe as instructed on the screen. The test will proceed automatically and display the results.

If a failure occurs, disconnect the hose at the analyzer and repeat the procedure. If a pass occurs, fix hose and probe. If a fail occurs, check primary filter and then contact your Service Representative.

2–Leak Check Gas

Not for U.S.A.
This test checks if there is an air leak in the sample system of the analyzer. Follow the instructions on the screen. In this test the exhaust sample probe must be inserted into the exhaust of the vehicle. The pump draws exhaust gases into the system. Then the exhaust sample probe must be blocked with the exhaust probe sealing tool, part number 0787-0035. The system checks if the CO_2 value changes. When the CO_2 change exceeds a certain value, an air leak is present in the system.

3–Gas Calibration Check

Using the optional regulator, the Gas Calibration Check allows the flow of calibration gas into the calibration port so the accuracy of the analyzer can be determined. The resulting values that display on the screen are “live” as calibration gas flows into the port and should match gas bottle values within ±5%.

Set the analyzer to:
- HC Represents: Propane
- λ calculated for: Gasoline
- Warnings/Errors: NONE

4–O_2/Check Install

This function must be used when the O_2 is replaced. It is not necessary to use this function at any time other than O_2 cell replacement.

5–Gas Tag Values

Use the Gas Tag Values function to enter calibration gas bottle values of the calibration gas used for gas calibration.

✓ If ⊗ displays next to the menu choice, no entry can be made.

If values are entered, the following displays:

Type 1 Low, used to enter low range cal gas for:

CO	1.0
CO_2	6.0
Propane	300

✓ Values shown here are recommended.

Type 2 High, used to enter high range cal gas for:

CO	8.00
CO_2	12.0
Propane	3200

✓ Values shown here are recommended.

Type 3 Low, used to enter low range NO if required:

NO 300

Type 4 High, used to enter high range NO if required:

NO 3000

✓ Only ***Equiserv*** can perform a two point calibration.

6–Gas Calibration

As delivered, the analyzer can be gas calibrated by a Service Technician with one or two cylinders of calibration gas. If you desire to perform the calibration, use the gas regulator, part number 0131-0031-01, and hose, part number, 5-052351-405 for the procedure.

✓ It is recommended that ***Equiserv*** calibrate your analyzer once every six months. However, the following procedure will allow you to calibrate the analyzer if desired.

✓ The recommended calibration gas, part number 0271-0099-01, is gas with concentrations of:

— CO 8.0
— HC 3200 = propane
— CO_2 12.0
— NO 3000

Without the NO option, part number 0271-0088-01

— CO 8.0
— HC 3200 = propane
— CO_2 12.0

1. In the Test Menu, select item 3, Maintenance, and then item 6, Gas Calibration.
2. Connect the calibration gas regulator to the calibration gas port, item P in *Figure 1-2*.

✓ Make sure the regulator is set properly for proper pressure, 5–10 psi output.

3. Follow all screen prompts.
   — The analyzer performs an Auto zero.
   — Open the calibrator gas bottle value and press ENTER to begin calibration when prompted.
4. The process continues automatically. When completed, the Results Screen displays. Turn off the calibration gas bottle value as soon as this screen appears.
5. On the right side of the Results Screen, GOOD/BAD is identified for each gas. The actual values read during calibration are shown on the left.
6. If calibration fails, BAD displays. Repeat the calibration. Check all steps, tag values, gas bottle connection before you begin. If the unit fails again, contact your Service Representative.

Test Leads

✓ Inspect all test leads weekly for cuts, kinks and abrasions etc.

✓ Take care when routing leads across an engine that they do not come into contact with any moving engine components of hot surfaces such as exhaust manifolds etc.

✓ The test leads and the mains power cable retain a favorable appearance if cleaned regularly using a water-free hand-cleaner and wiped dry.

✓ Induction clamps, such as the trigger clamps, should be kept free from oil, grease and other contaminants and should be cleaned to minimize false triggering and therefore false measurements.

Front Panel and Exterior

To maintain the appearance of the analyzer, periodically clean the exterior with a soft, damp, lint-free cloth. Use a mild detergent to remove grease.

⚠CAUTION

Do not use solvents like acetone, benzine, gasoline, etc. They can damage plastic components and affect analyzer accuracy if they contaminate the sampling system. Clean any surface spills immediately to protect the cabinet and prevent any spillage from entering the cabinet vents.

Keyboard and Remote Control

Clean the keyboard and the remote control with a mild detergent and a soft cloth.

⚠CAUTION

Do not use solvents acetone, benzine, gasoline, etc. They can damage plastic components and affect correct operation of the components. Clean any surface spills immediately to protect the keyboard and remote control.

CRT Screen

Clean the screen with a glass cleaner and a soft cloth.

⚠CAUTION

Do not use solvents like acetone, benzine, gasoline, etc. Do not use abrasive which can scratch or mark the screen.

Sample Probe and Hose

Probe

Check
Periodically check the holes at the end of the probe for dirt and debris.

Clean
Disconnect the hose from the analyzer at the sample inlet. Using a small pointed tool, clean the probe and blow away any debris using compressed air.

⚠CAUTION

Do not apply compressed air to the probe tip without disconnecting the sample hose from the filter assembly. Back pressure could damage the sampling system.

Replace

1. Remove the sample probe from the hose.
2. Install the new probe on the hose.
3. Leak check procedure in this chapter.

Sample Hose

The sample hose must be free of cuts and abrasions that may cause leaks. Follow the *1– Leak Check Vacuum, page 4-4*.

Troubleshooting

Use the information in this section to solve equipment problems.

Messages

On the Measurement Screen, status symbols display when the analyzer fails to perform an action or fails a test.

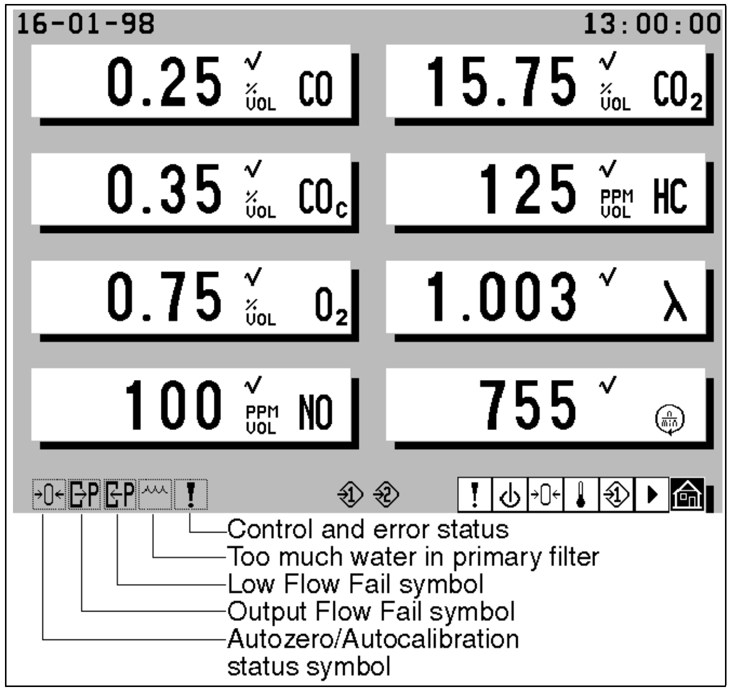
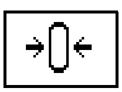
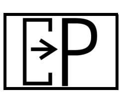


Figure 4-2: Status Symbols



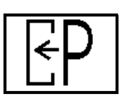
Auto zero/Auto calibration

The Auto zero/Auto calibration symbol is a pre-warning which indicates that an Auto zero/Auto calibration is required. This is automatically performed by the analyzer when the measurements are stopped. The measurements can be continued for a maximum of half an hour while the symbol is on. Then the analyzer stops the measurements and the Auto zero is performed.



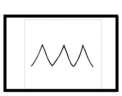
Output Flow Fail

The Output Flow Fail symbol indicates that the exhaust sample flow output is obstructed.



Low Flow

The Low Flow symbol indicates that the sample system input flow is restricted.



Too Much Water in Filter Bowl

When there is Too Much Water in Filter Bowl assembly or the water filter is clogged, this symbol displays. Wait until the analyzer has removed the water from the bowl or replace the water filter.

Control and Error Status

When this symbol is selected, the analyzer shows more information about the control and error status of the analyzer.

The control and error status information consists of two screens. The first screen gives general information about the condition of the analyzer. Select the down arrow (▼) to go to the next screen.

The second screen shows the control and error status codes and the Gas bench error codes.

✓ When Gas bench errors are shown, indicated by a number, switch the analyzer OFF then ON again to reset. If problem persists, contact your Service Representative.

The control and error status can be indicated as a message on the first screen or a figure between 0 and 22 on the second screen.

Below all control and error status codes are listed with their explanation and possible solution to the problem.

Control and Error Status

AUTO ZERO CALIBRATION

Solution: No action required.

CHANGE NO SENSOR

Solution: This error appears only when an NO cell is installed (optional). The lifetime of the NO cell has expired. The NO cell needs replacement. Contact your Service Representative.

CHANGE O_2 SENSOR

Solution: Change the O_2 cell. Contact your Service Representative.

GAS BENCH DRIVER ERROR

Solution: Contact your Service Representative.

GAS LEVEL AT AUTO ZERO TOO HIGH

Solution: The ambient air is polluted. Make sure the ambient air is free of fumes (gasoline, petrol etc.). Ventilate the working area. Check that the charcoal filter is “fresh.”

HC HANG-UP

Solution: When this fault persists for a very long time (more than 1/2 an hour), clean or replace the Gas filter, clean Sample Probe and Bowl filter, and exhaust hose. To clean the hose and probe, remove hose from the analyzer and blow out with shop air at low pressure.

INTERNAL TEMP. LIMIT EXCEEDED

Solution: Move analyzer to a location with lower ambient temperature. Activate the STANDBY mode. After approx. 6 seconds deactivate the STANDBY mode.

IR GAS CALIBRATION REQUIRED

Solution: The system needs a IR Gas calibration. Calibrate with Gas or contact your Service Representative.

LEAK CHECK REQUIRED

Solution: Perform Leak check (vacuum) procedure.

LOW FLOW

Solution: The Gas filter or Exhaust Sample probe is clogged. Replace Gas filter or clean Exhaust Sample Probe.

NEW O_2 SENSOR NOT WITHIN LIMITS

Solution: Contact your Service Representative.

NO FLOW

Solution: The analyzer pump is not running. Try to restart the pump by activating and deactivating the STANDBY mode. When the pump does not run, contact your Service Representative.

NO GAS CALIBRATION REQUIRED

Solution: The system needs a Gas calibration using NO. Contact your Service Representative.

NO SENSOR NOT CONNECTED

Solution: The NO sensor (option) is not installed.

O_2 SENSOR NOT CONNECTED

Solution: Contact your Service Representative.

OUTPUT FLOW FAILURE

Solution: The Gas Sample Outlet is clogged. Activate the STANDBY mode. Clean the Gas Sample Outlet. Deactivate the STANDBY mode.

PRE-WARNING CHANGE O_2 SENSOR

Solution: Contact your Service Representative.

PRE-WARNING IR GAS CALIBRATION REQUIRED

Solution: Calibrate with Gas or contact your Service Representative.

SIBENCH ERROR OR WARNING

Solution: This code appears together with a Gas bench error. Contact your Service Representative.

TEMPERATURE MEASUREMENT ERROR

Solution: Switch the analyzer OFF and then ON again to reset. If fault persists, contact your Service Representative.

TOO MUCH WATER IN PRIMARY FILTER

Solution: Wait until the analyzer has removed the water from the bowl, or the water filter may be clogged.

VACUUM MEASUREMENT ERROR

Solution: Switch the analyzer OFF and then ON again to reset. If fault persists, contact your Service Representative.

Accessory Kit

The ***DGA 1000 Gas Analyzer*** is delivered with an Accessory Kit, part number 7009E9321-24. The kit is used to make the analyzer complete for first operation. The kit contains the following parts:

Power cord.. 6001-0197-01
Exhaust probe assembly 7009-1869-00
Exhaust hose 30 ft. (9.5 m EAH0015L10A
Clip, 3/8", hose 3994-0008-04
Sealing tool, exhaust probe 0787-0035-00
O_2 sensor 7096E4060-31
Bowl filter 7096E9062-77
Hose, plastic 3/16" 0669-0229-00
Inline water filter 7096E9323-46
Inline secondary filter......................................7096E9061-03
Grey RPM pickup...6004E9312-95
Keyboard kit...7009E9321-99
Stand.. EEKR104A
Manual ZDGA1000

Maintenance Parts

Inline secondary filter 7096E9061-03
Inline water filter 7009E9323-46
Primary filter 7096E9062-77
Clean air filter, charcoal 7096E9061-54
Printer paper 7096E4060-13

Options

Thermal printer kit 7009E9321-23
Lightpen kit 7009E9321-97
NO sensor kit 7009E9321-27
DC/AC converter 2-2650
Remote control kit..7009E9321-98
Oil temperature probe, ... 6004-0407-04
Capacitive RPM pickup, orange 6004E9313-19
Regulator.. 0131-0031-01
Hose... 5-05231-405

Technical Support

For Service or Technical Support, call Emissions Technical Support Group at 1-800-225-5768.

5

Fundamentals

This chapter contains essential information required to understand and interpret analyzed combustion by-products and information provided by the analyzer. Included is a description of how and where combustion by-products form in an engine and common methods used to help reducing their formation.

Combustion and Air-Fuel Ratios

In a gasoline-powered internal combustion engine, normal combustion is burning a compressed mixture of hydrocarbon fuel and air in the combustion chamber. This action causes the compressed fuel mixture to expand, producing the pressure required to move the pistons downward. *Figure 5-1* shows the air-fuel mixture inside a cylinder being ignited by the spark plug.

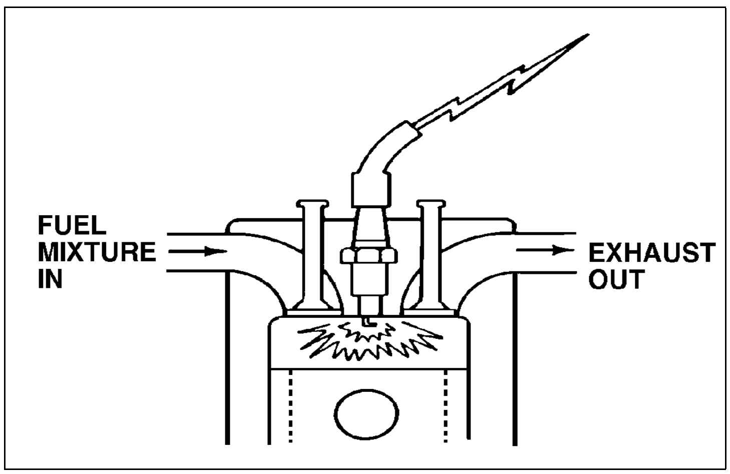


Figure 5-1: Combustion Process

The fuel induction system of a gasoline engine mixes vaporized gasoline, a hydrocarbon, with air in a given proportion. There must be more air than fuel to keep the vaporized fuel in suspension and to supply oxygen for combustion.

✓ Air-fuel ratios are measured by weight, not volume. An air-fuel ratio of 12:1 is 12 pounds of air mixed with one pound of fuel.

The ideal air-fuel ratio for perfect combustion in a gasoline engine is 14.66:1, commonly referred to as 14.7:1. This is the stoichiometric ratio or stoichiometric fuel mixture. Under perfect conditions, the combustion of a stoichiometric air and fuel mixture results in carbon dioxide (CO_2), water (H_2O) and nitrogen (O_2), all of which are harmless.

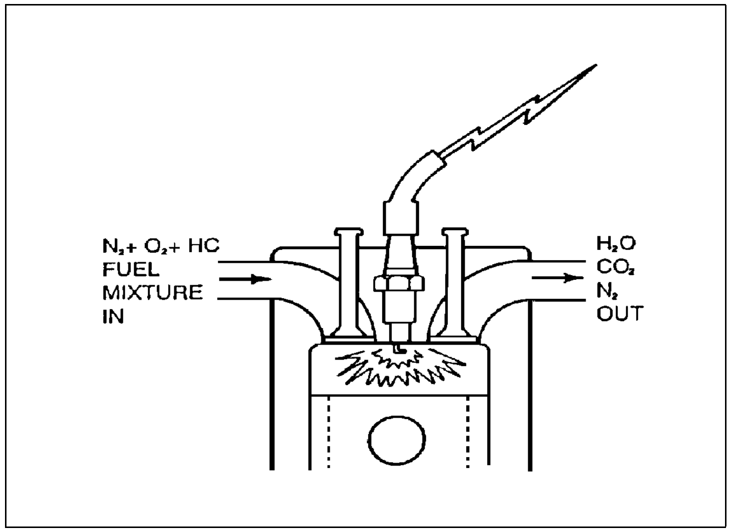


Figure 5-2: Ideal Combustion By-Products

A lean fuel mixture has too much air or too little fuel. A rich fuel mixture has too much fuel or too little air.

Combustion Emissions

Internal combustion engines are not 100% efficient, even with ideal fuel mixtures. For this reason, other substances form in the combustion chamber during combustion and exhaust from the engine. Major by-products of “real-world” combustion include:

- Oxides of nitrogen (NO_x)
- Hydrocarbons (HC)
- Carbon monoxide (CO)
- Oxygen (O_2)

Because exhaust gases relate to health and environmental concerns, federal and state agencies regulate automobile emissions.

Oxides of Nitrogen (NO_X)

Air in the atmosphere, and air admitted into the combustion chamber of an engine, consists of about 78% nitrogen (N_2) and about 21% oxygen (O_2) by volume. Nitrogen does not contribute to, or detract from, combustion. When exposed to heat above 2000°F (1093°C), oxygen and nitrogen combine. Since combustion chamber temperatures easily exceed 2500°F (1371°C) under some engine conditions, such as under load, O_2 combines with N to form harmful oxides, including nitrogen monoxide (NO) and nitrogen dioxide (NO_2). These are part of a group of oxides commonly known as oxides of nitrogen (NO_x).

NO_x is an engineering term for an unknown mixture of nitrogen oxides. NO_x includes all the N compounds formed in the combustion chamber of an engine, especially NO and NO_2. The X subscript in place of numbers indicates that all NO compounds are included.

Of the nitrogen oxide compounds, NO is the only compound with appreciable importance to engine combustion. NO formed in the combustion chamber persists during the exhaust stroke where it reacts with additional O_2, forming NO_2.

NO is one of the gases that may be checked to determine if the vehicle complies with specifications. *Figure 5-3* shows the concentration of NO_x in relation to air-fuel ratio before treatment in a three-way catalytic converter.

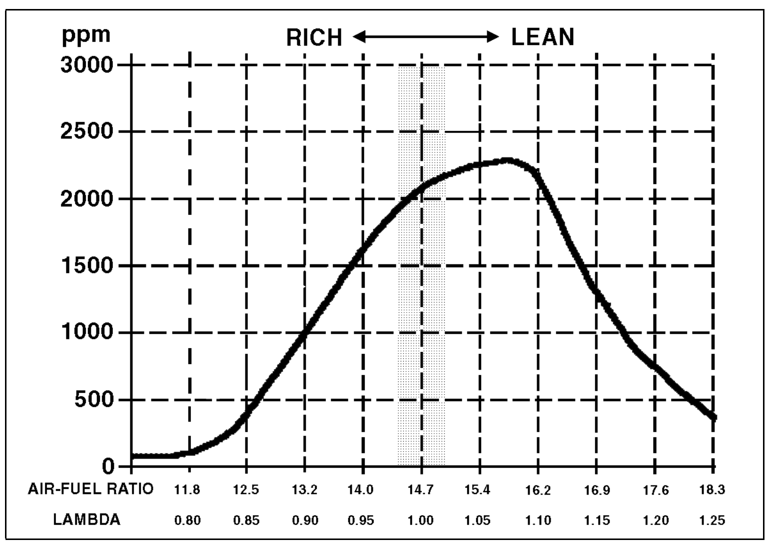


Figure 5-3: NO_X Versus Air-Fuel Ratio

When based only on air-fuel ratio, NO_x levels peak at about 15.8:1. Many other factors affect actual NO_x formation besides air-fuel ratio.

The formation of NO_x does not affect engine performance. However, some devices used to prevent the formation of NO_x can affect engine performance and contribute to higher levels of HC and CO when not functioning properly.

Some of the devices and factors that affect the formation of NO_x are:

✓ The following descriptions should be considered individually, that is with minimal effect from other dynamic variables.

- Exhaust Gas Recirculation (EGR)
  - EGR dilutes the air-fuel mixture, lowers combustion chamber temperature, and reduces flame speed. When operated at a steady state of about 50 km/h, five percent EGR on a typical engine can reduce NO_x emissions by as much as forty percent. Ten percent EGR can reduce NO_x emissions about eighty percent. However, HC emissions increase with higher EGR rates. An inoperative EGR system does not decrease NO_x emissions.
- Valve Timing
  - Intake and exhaust valve timing, (amount of overlap, lift and duration) can affect inlet charge dilution and combustion chamber temperature the same as EGR, but can not be easily changed.
- Spark Timing
  - Increasing spark advance at any load and speed increases NO_x emissions.
- Intake Manifold Vacuum
  - A decrease in intake manifold vacuum increases load and temperature, and decreases the mass of residual gases. As a result, combustion time decreases. This increases maximum cycle temperature which increases emissions.
  - An increase in intake manifold vacuum decreases load and temperature, and increases the mass of residual gases. As a result, combustion time increases. This decreases maximum cycle temperature which decrease NO_x emissions.
- Engine Speed
  - An increase in engine speed increases flame speed due to turbulence. This reduces heat losses per cycle and tends to raise compression, combustion temperature and combustion pressure. An increase in engine speed with rich mixtures (which burn faster) increases NO_x formation because of reduced heat losses at higher speeds. An increase in engine speed with lean mixtures (which burn slower) decreases NO_x formation because of late burning.
- Compression Pressure
  - An increase in compression pressure causes an increase in combustion chamber temperature. This increases the formation of NO_x. Engine design, camshaft design, valve timing, and supercharging/turbocharging affect compression.
- Intake Air Temperature
  - High intake air temperatures can increase NO_x formation.
- Coolant Temperature
  - Higher coolant temperature increases cylinder and gas temperature. This increases NO_x formation. Improper coolant temperature can cause cylinder and combustion chamber deposit build-up, increasing compression ratio and, consequently, NO_x concentration.

- Carbon Build-up
  - Carbon in the combustion chamber reduces combustion chamber volume. This increases compression pressure and increases the air and fuel mixture temperature which contributes to NO_x formation.
- Fuel Octane
  - Low octane fuel burns faster and less controlled than higher octane fuel. This can cause NO_x formation.
- Air and Fuel Mixture
  - Lean Engine Operation
- Engine pinging indicates lean engine operation and the formation of NO_x. Any condition that causes the engine to run lean can cause an increase in the formation of NO_x. If the mixture and exhaust are too lean, the converter can convert HC and CO but can not control NO_x.
- Rich Engine Operation
  - Rich mixtures and high CO can mask an NO_x problem. When an engine has carbon build-up from the rich condition and the cause of excessive richness is corrected, the resulting leaner condition can cause increased NO_x formation. Also, the three-way catalytic converter requires CO to convert NO_x to N and CO_2. So, high CO levels can mask high NO_x levels.
- If the mixture and exhaust are too rich, the converter can reduce NO_x but can not control HC and CO.
- Catalytic Converter
  - A dual-bed or three-way type catalytic converter in good working order can reduce NO_x emitted from the engine as it passes through the catalytic converter. If the mixture and exhaust are rich, the converter can reduce NO_x but can not control HC and CO. If the mixture and exhaust are too lean, the converter can convert HC and CO but can not control all of the NO_x.
- Humidity
  - An increase in mixture humidity can help reduce formation of NO_x due to the drop in maximum combustion chamber flame temperature.
- Air Pump Operation
  - Air pump pressure can overcome the exhaust pressure in a three-way catalytic converter if, during deceleration, air is pumped into the converter instead of diverted into the atmosphere. Under this condition, air can backflow into the reducing portion of the catalyst, increasing NO_x formation.
- Fuel Injector Problems
  - Restriction of one injector on an engine with port fuel injection causes that cylinder to run lean and the cylinder temperature to increase, forming NO_x. NO_x levels in other cylinders remain normal, therefore, NO_x levels at the tailpipe are only slightly high.
  - When an injector spray pattern is abnormal, hot spots can form within the cylinder and increase NO_x formation.

✓ Excessive NO_x emissions may be caused by the effects of several of these devices or factors at one time.

Hydrocarbons (HC)

HC is an organic compound composed of one hydrogen (H) and one carbon (C) atom. The HC in gasoline engine exhaust is unburned gasoline vapor that is measured in parts per million (ppm). HC levels in engine exhaust vary with the air-fuel ratio.

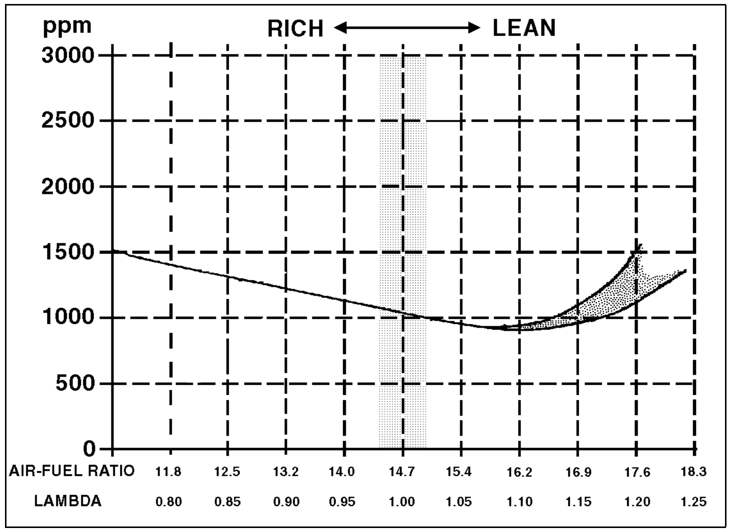


Figure 5-4: Hydrocarbons Versus Air-Fuel Ratio

The lowest HC emissions occur at an air-fuel ratio of about 16:1. Since no engine combustion is perfect, some vaporized HC in the combustion chamber remains unburned and leaves the engine with exhaust gases. The amount of HC depends largely on combustion chamber design.

Also, HC increases dramatically when the fuel mixture is too lean or rich to support complete combustion, or when ignition does not occur in the combustion chamber at all.

When compared along with O_2 and CO_2 readings, HC can also indicate catalytic converter efficiency.

Gasoline evaporating from the carburetor and the fuel tank are also sources of HC, known as evaporative emissions.

Carbon Monoxide (CO)

CO is an exhaust by-product formed when combustion occurs with less than the ideal volume of oxygen (rich fuel mixture). This combines a carbon atom with an oxygen atom. Carbon in the combustion chamber comes from the HC fuel, and oxygen from inducted air.

When the fuel mixture in the combustion chamber is richer, meaning more HC and less air, the concentration of CO in the exhaust is higher. Therefore, anything causing a rich air-fuel ratio results in high CO concentrations in the exhaust.

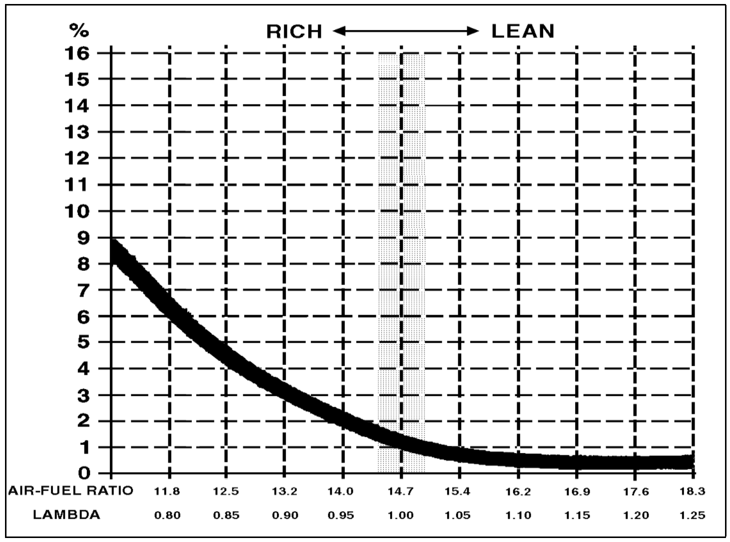


Figure 5-5: Carbon Monoxide Versus Air-Fuel Ratio

Figure 5-5 shows that the CO level decreases as the air-fuel ratio approaches about 15:1, and maintains this low level even while the mixture is further leaned out. Because of this, CO is a good indicator of fuel mixture richness, but a poor indicator of leanness. This makes the HC and CO content in the exhaust a good measure of engine performance, besides being important for compliance with clean air laws.

Carbon Dioxide (CO_2)

CO_2 is a combustion product formed when one carbon atom bonds with two oxygen atoms, and by the oxidation of CO in the catalytic converter. Unlike CO, CO_2 is comparatively harmless.

CO_2 is a good indicator of combustion efficiency because its volume in the exhaust peaks just before the stoichiometric air-fuel ratio.

CO_2 peaks when the combustion chamber fuel mixture approaches about 15:1, and decreases when the mixture becomes more lean or more rich. CO_2 level is used to check exhaust system integrity, since significant leaks lower CO_2.

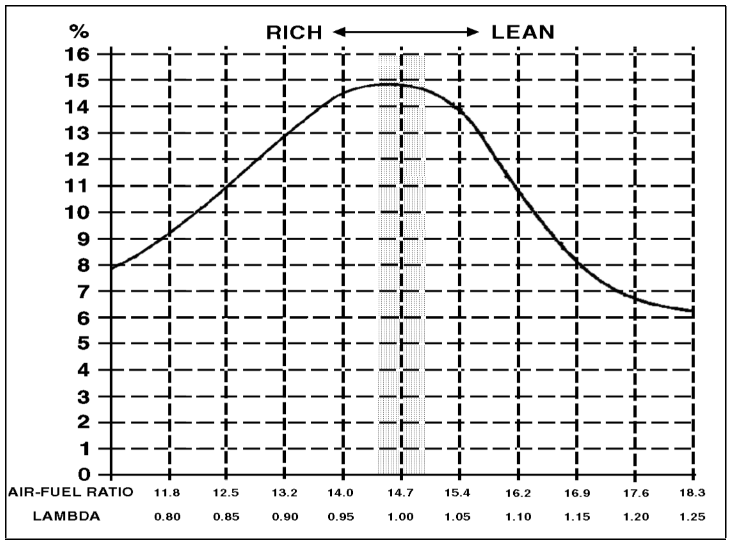


Figure 5-6: Carbon Dioxide Versus Air-Fuel Ratio

Oxygen (O_2)

The level of O_2 in exhaust gas is an indicator of air-fuel ratio leanness. The O_2 is present in the air the engine inducts and mixes with the HC for combustion. Since the atmosphere is about 21% O_2, the percentage of O_2 in the exhaust gas after combustion indicates air-fuel ratio leanness.

In *Figure 5-7*, the O_2 concentration is at a steady low level when the fuel mixture is richer than about 15:1, because all available O_2 is consumed in the combustion process. As the mixture gets leaner, O_2 steadily increases, because less is used in combustion. Higher concentrations of O_2 in the exhaust are therefore directly proportional to leaner air-fuel ratios.

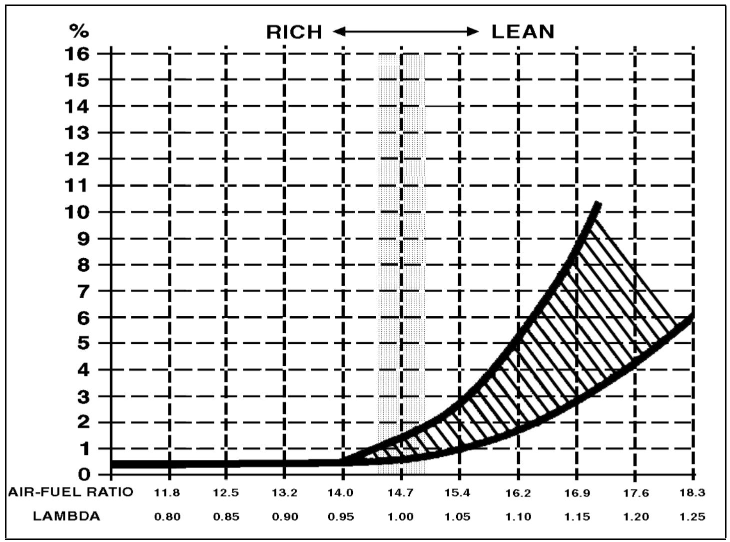


Figure 5-7: Oxygen Versus Air-Fuel Ratio

Interpreting Air-Fuel Ratios and Emissions

The relationship between the air-fuel ratio and exhaust gases monitored by the analyzer are:

- HC is lowest when the air-fuel ratio is ideal because most of the fuel is consumed in combustion. Richer or leaner mixtures, or ignition problems cause HC to increase because of incomplete combustion.
- CO is lowest when the air-fuel ratio is nearly ideal because there is less O_2 and C left over. This is due to more complete combustion occurring at stoichiometric ratios. Richer than ideal mixtures cause CO levels to increase; leaner mixtures have little effect.
- CO_2 levels are highest when air-fuel ratios are close to ideal, and decrease when the mixture becomes richer or leaner.
- O_2 levels are near zero when the air-fuel ratio is near stoichiometric, since most of the O_2 consumed in combustion. It remains low with richer mixtures, and increases when the mixture leans out.
- NO_x is lowest when the air-fuel ratio is either very rich or very lean and highest when the air-fuel ratio is slightly lean and when the engine is under load.

Stoichiometric Fuel Mixture

The stoichiometric air-fuel ratio (14.66:1) is near the point where the emission levels drastically change. The stoichiometric air-fuel ratio, where the HC and CO levels are lowest, is as close to perfect combustion as can be attained.

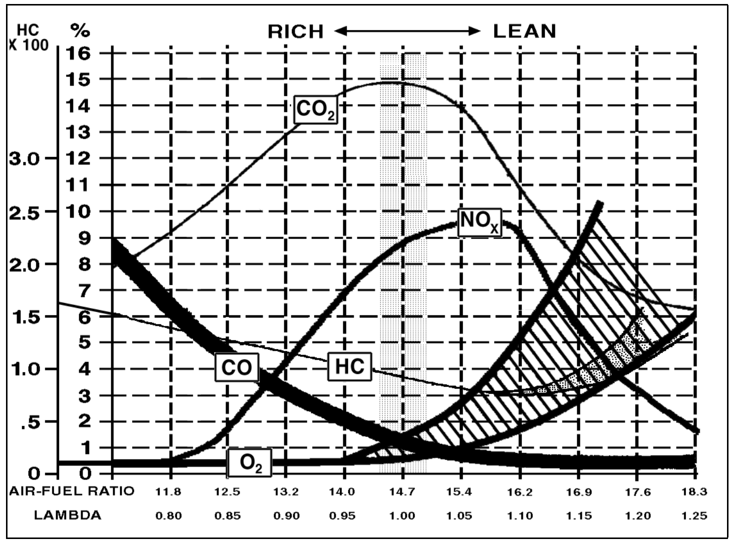


Figure 5-8: Major Combustion By-products Versus Air-Fuel Ratio

✓ The term lambda is often used instead of air-fuel ratio. Lambda is a numerical value of the measured air-fuel ratio relative to the ideal air-fuel ratio. Lambda equals one (1) when the air-fuel ratio is stoichiometric. Lambda is less than one when the air-fuel ratio is rich, and is greater than one when lean.

Because combustion temperatures and the air-fuel ratio requirements can change in engines under dynamic load, the only way to ensure that the air-fuel ratio remains close to stoichiometric under most operating conditions is to use a feedback system to monitor oxygen content of exhaust gas. This feedback system reports back to a computer that calculates fuel delivery and commands the fuel injector or carburetor to deliver the necessary amount of fuel required to maintain the correct air-fuel ratio.

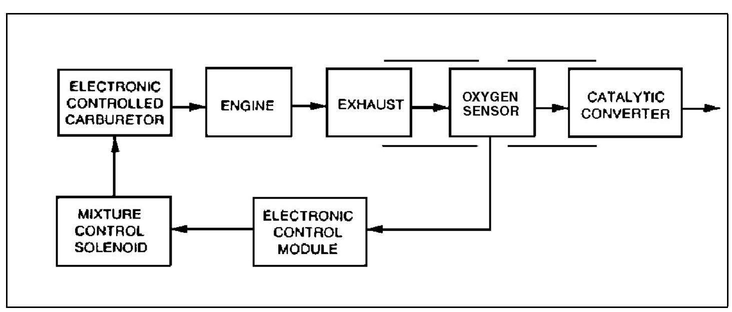


Figure 5-9: Carbureted Fuel Feedback System

Catalytic Converters

The first attempt at reducing emission levels in automobiles was to get air-fuel ratios as close to stoichiometric as possible. However, even engines designed for low emissions, and that are operating properly, may not have HC and CO emission levels low enough to meet clean air standards. To assist in lowering these emissions, catalytic converters were installed.

A catalyst is a substance that increases the rate of a chemical reaction without being used up itself. Automobile catalytic converters contain a combination of three noble metals - platinum (Pt), palladium (Pd) and rhodium (Rh). These metals are applied to small beads or ceramic baffle materials, called substrates, that provide a tremendous surface area for exhaust gases to contact the noble metal catalysts.

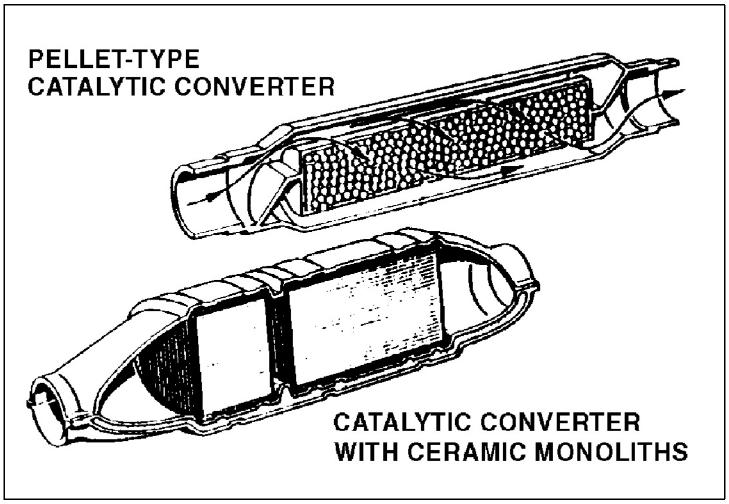


Figure 5-10: Typical Catalytic Converters

In operation, exhaust gases pass into the catalytic converter from the engine, where the exhaust gases flow past the catalytic metals. Contact of the exhaust gases with these metals causes reactions, known as catalytic oxidation, adding O_2 to the molecular structure of HC and CO. This turns the HC into water (H_2O) and the CO into CO_2. These converters are called oxidation or two-way converters since they only treat two gases.

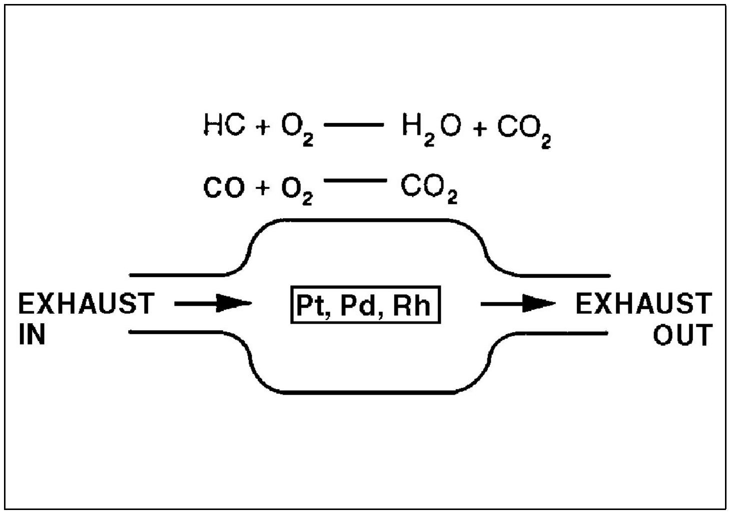


Figure 5-11: HC and CO Oxidation in a Catalytic Converter

Oxidation of any compound requires an abundance of O_2. Some engines use Air Injection Reaction (AIR) or pulse air type systems to provide the supplemental O_2 needed. These systems supply additional air to the exhaust manifold or catalytic converter.

As converter technology has progressed, catalysts treating NO_x compounds were developed. With a reduction reaction, these catalyst reduced NO_x to N_2 and O_2. Three-way converters oxidize HC and CO and reduce NO_x. These converters are even more sensitive to air-fuel ratio because the reduction of NO_x is efficient only at stoichiometric air-fuel ratio.

Two-way and three-way catalytic converters only lower HC, CO and NO_x by a certain amount. When an engine operates properly, the converter decreases emissions to levels lower than the amount specified by state and federal regulations.

Figure 5-12 shows NO_x versus air fuel ratio after being treated by a three-way catalytic converter. NO_x levels are typically low when the air-fuel ratio is more rich than stoichiometric. When the air-fuel ratio is near stoichiometric and more lean than stoichiometric, NO_x levels increase, then fall to slightly lower values as the air-fuel mixture continues to get leaner.

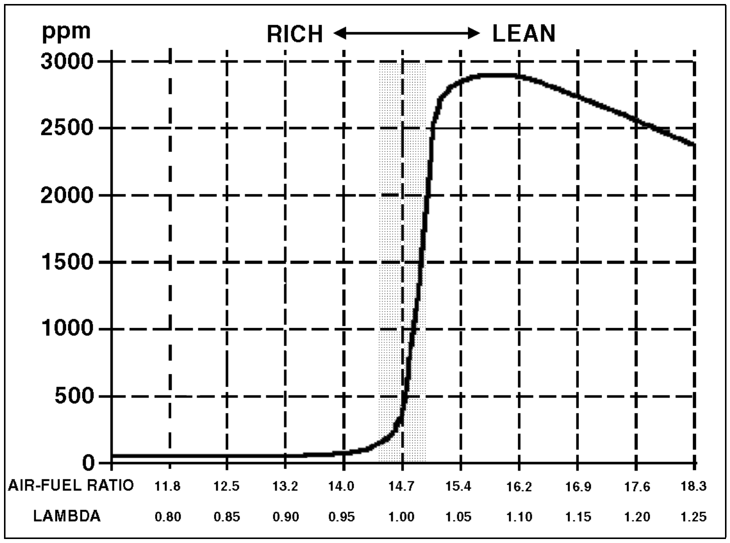


Figure 5-12: NO_X Vs. Air Fuel Ratio After Three-Way Converter Treatment

Catalytic converters oxidize HC, CO and NO_x producing H_2O, CO_2 and N_2. Therefore, monitoring HC and CO does not give an accurate picture of engine performance because the catalytic converter alters these gases. Using the analyzer to monitor O_2, CO_2, HC, CO and NO_x provides a more accurate method of monitoring engine operation on vehicles with a catalytic converter.

Vehicle Testing Procedures

6

Testing Gasoline-Fueled Vehicles

Diagnosis from the exhaust gas sample can be difficult on an engine that has any combination of the following systems:

- Catalytic converter,
- Computer control with an O_2 sensor and fuel injection,
- Air management,
- Exhaust gas recirculation,
- Evaporative emission control,
- Electronic spark timing, electronic spark control or both,
- Positive crankcase valve (PCV), and
- Distributorless ignition.

Multiple sensors and specific conditions affect each of these systems and the list of probable causes for abnormal exhaust concentrations provides so many variations that a different approach must be used to interpret the readings. For additional information, refer to *Chapter 7–Diagnostic Technique* and *Data Analysis Guidelines*.

Testing Propane-Fueled Vehicles

Test vehicles with propane-fueled engines using the same techniques and information described for testing gasoline-fueled engines with the following exceptions:

- Typical CO readings at idle are 1-1.5% vol. More than 3% vol is not acceptable.
- At cruise speed, typical CO readings are about 1% vol. More than 2% vol is not acceptable.
- 1% vol CO is equal to an air-fuel ratio of about 14.6:1.
- 2% vol CO is equal to an air-fuel ratio of about 14:1.
- Typical HC readings at idle are 50–250 ppm.

Data Collection Modes

Test procedures for collecting emission data may include:

No-Load Testing

- In shop bay
- On a chassis dynamometer
- At idle
- At idle and at a specified engine speed
- At idle and at a specified vehicle speed

Under Load Testing

- Steady state testing
- Transient Tests
  — Requires following a drive cycle trace on a dynamometer. The drive consists of periods of acceleration, deceleration and idle.

Engine Conditioning

Some vehicles require special conditioning before testing exhaust emissions other than the procedure that follows. Failure to follow the recommended procedures for these vehicles may cause invalid test results or a vehicle to fail state tail pipe emission tests, even when all systems are operating as designed.

✓ Some vehicles have an underhood label that specifies the procedure to follow for a valid emission test.

1. Warm the engine to normal operating temperature, then insert the exhaust sample probe into the tail pipe.
2. Raise the engine speed to 2000 RPM and maintain for 30 seconds or drive at 30 mph (50 km/h) for 30 seconds on a chassis dynamometer.
3. Read the exhaust concentrations on the analyzer screen.

Tail Pipe Exhaust Gas Sampling

1. Insert the sample probe into the vehicle tail pipe. Make sure that the sample probe is fully inserted.
2. Switch on the ***DGA 1000 Gas Analyzer*** and leave it in the Measurement Screen.
3. Read the exhaust concentrations on the screen.
4. Compare the values to local, state, federal and/or manufacturer specifications.

If values exceed specifications, further diagnostic testing of the vehicle may be required.

✓ A fuel-injected engine that meets all of the emission requirements may still have problems masked by the feedback fuel control system. Consult the vehicle maintenance schedule and perform the recommended service that may be required, including service on emission control devices.

Testing Under Load

When sampling exhaust gases, NO readings can be observed at idle, low speeds and low load operating conditions. However, since NO is mainly formed under load (high combustion chamber temperatures), effective testing must be performed under load using a chassis dynamometer or by driving on the road.

Using a chassis dynamometer, the vehicle weight must be considered and the appropriate normal road load horsepower (NRLHP) applied to simulate the changing load applicable to a vehicle when driven on a level road. The drive to collect data may be to accelerate, cruise or decelerate as necessary in order to operate the vehicle under conditions that aid in:

- Identifying emission failure areas,
- Reducing emissions in general, and
- Locating/correcting drive ability problems.

Interpreting the data monitored is the same in each case. Consider the information in the theory and interpretation sections of this manual to aid the diagnosis. Consider also, the vehicle owners complaint and/or the symptoms that relate to the complaint. Drive ability and emissions symptoms can consist of the following, or combinations of the following:

- Will not crank,
- Cranks, will not start,
- Hard starting,
- Malfunction indicator lamp on,
- Engine stalls,
- Hesitation, sag, stumble, and or
- Lack of power, sluggish or spongy,
- Surge, chuggle,
- Engine miss or cut out,
- Backfire,
- Spark knock, detonation,
- Engine noise,
- Excessive exhaust emissions or fails emission test,
- Poor fuel economy,
- Incorrect idle,
  - high
  - rough
  - unstable
- Jumps, jerks,
- Excessive exhaust odor,
- Excessive exhaust smoke,
- Fuel odor, and/or
- Dieseling, run on.

Diagnosis may require using a variety of specific tests and test equipment, depending on the drivers complaint and/or the symptoms related to the complaint. If a combination of complaints/faults are involved, consider the devices and factors that could possibly affect those areas. Remember, one device/factor may affect several areas; and/or, several devices/factors may affect one area.

On-Road and Dynamometer Testing Under Load

Exhaust emission testing with a chassis dynamometer can be performed in the same way a stationary vehicle is tested in the shop bay, except that the engine operates under load, simulating operating conditions on the road, except for traffic, turning corners and weather conditions.

✓ Prolonged use of the analyzer in conjunction with a dynamometer and a hot-running vehicle under load may damage the sample probe and affect readings.

On-road testing provides “real world” information about a vehicle. However, on-road testing requires two people one to drive and one to monitor the analyzer display. On-road testing also offers less than ideal test conditions since the sample probe may fall out of the tail pipe if not secured properly and it may be difficult to achieve the desired drive cycle due to traffic and weather conditions.

Drive Cycles

A drive cycle is a specific, repeatable pattern of acceleration, cruise, deceleration and idle is followed. The following drive cycles may be used:

- 90 Second Drive Cycle,
- Hard Acceleration Drive Cycle,
- High Cruise Drive Cycle, or
- On-Board Diagnostic (OBD) II Drive Cycle.

✓ The 90 Second, Hard Acceleration, and High Cruise Drive Cycles are typically used for drive ability testing where a repeatable drive pattern is helpful.

1. Position the analyzer inside the vehicle such that a person other than the driver can control and monitor the display.
2. Route the sample hose and probe and the clear plastic vapor vent hose out a partially open window.
   — Although a vehicle moving down the road develops very little condensation and the air stream flowing across the open vent hose end dilutes vapors immediately, it may be necessary to add an extension to the vapor vent hose to help prevent corrosive condensation damage to the vehicle surface.
3. Route the sample hose and probe along the vehicle body and insert the probe into the vehicle tail pipe. Make sure that the sample probe is fully inserted.
4. Secure and support the sample hose along the vehicle body. Use duct tape about 30" (75 cm) long, folded in half and taped to itself, wrap the tape around the hose once or twice at the middle of the tape. Position the tape ends through a partially open window, door and/or trunk lid and tie several loose knots with the tape and shut the opening onto the tape.

5. Insert the sample probe into the tail pipe and secure to prevent it from falling out of the tail pipe. When performing this test on the road, the probe can be secured by tying the exposed metal portion of the sample probe with "mechanics wire" to an adjacent bracket, like the bumper brackets, shipping tie down hooks, fuel tank straps, etc.
6. Enter the Measurement page.
7. Perform one of the following drive cycles, as desired.

90 Second On Road Drive Cycle

- Accelerate to about 30 mph (50 km/h), at medium throttle. If the vehicle has a manual transmission, it should be in third gear at 35 mph (55 km/h).
  — For the first 30 to 40 seconds, vary the vehicle speed between 25 and 35 mph (40 to 55 km/h).
- Come to a stop, and wait about 5 seconds.
- Accelerate to about 50 mph (80 km/h), at medium throttle. If the vehicle has manual transmission, it should be in high gear at 80 km/h
  — Vary the speed between about 50 to 55 mph (80 to 90 km/h) for about another 40 seconds.
- Decelerate to idle and end drive cycle.

Hard Acceleration Drive Cycle

- Accelerate to about 15 mph (25 km/h), at moderate throttle.
  — From 15 mph (25 km/h), accelerate to 55 mph (90 km/h) in about 10 seconds with automatic transmission upshifting normally or manual transmission in third gear at 90 km/h.
- Maintain speed at 55 mph (90 km/h) for about 10 seconds, then decelerate back to 15 mph (25 km/h).
- Repeat this cycle once more so emissions levels can be compared cycle to cycle.

High Cruise Drive Cycle

- Accelerate to about 55 mph (90 km/h), at moderate throttle the vehicle should be in high gear at 55 mph (90 km/h).
  — Vary the speed between about 45 to 55 mph (70 to 90 km/h) for about 90 to 120 seconds.
- Decelerate to idle and end drive cycle.

On-Board Diagnostic (OBD) II Drive Cycle

Disconnecting the vehicle battery, powertrain control module (PCM) or certain components controlled by the PCM on vehicles with OBD II may cause a “not ready for I/M testing” condition. In this condition, the vehicle will not perform properly. Following a specific OBD II Drive Cycle restores normal operation of the PCM. Perform this drive cycle on the road or use the dynamometer. Select Road Simulation load type from the Dyno Control Panel Screen when using the dynamometer.

While driving, OBD II systems perform a series of tests on specific systems, monitoring then adjusting to compensate for those conditions. These conditions are called an OBD II Drive Cycle, and requires just over 11 minutes to complete.

OBD II Drive Cycle

1. Run the engine for at least 4 minutes or until engine coolant is about 180°F.
2. Idle the engine for 45 seconds.
3. Accelerate to 45 mph (1/4 throttle) for about 10 seconds.
4. Drive at steady throttle between 30 and 40 mph for 60 seconds.
5. Drive between 20 and 40 mph for 4 minutes.
6. Decelerate and idle for 10 seconds.
7. Accelerate to 55 mph (1/2 throttle) for 10 seconds.
8. Drive at steady throttle between 40 and 60 mph for 80 seconds.

Air Pump Test

An engine-driven air pump is sometimes used to lower CO and HC by pumping fresh air into the exhaust system at pressures up to approximately 5 psi (0.35 bar). This supplies additional O_2 to the hot gases to allow continued combustion, resulting in lower levels of HC and CO at the tail pipe. However, this combustion occurs outside the combustion chamber.

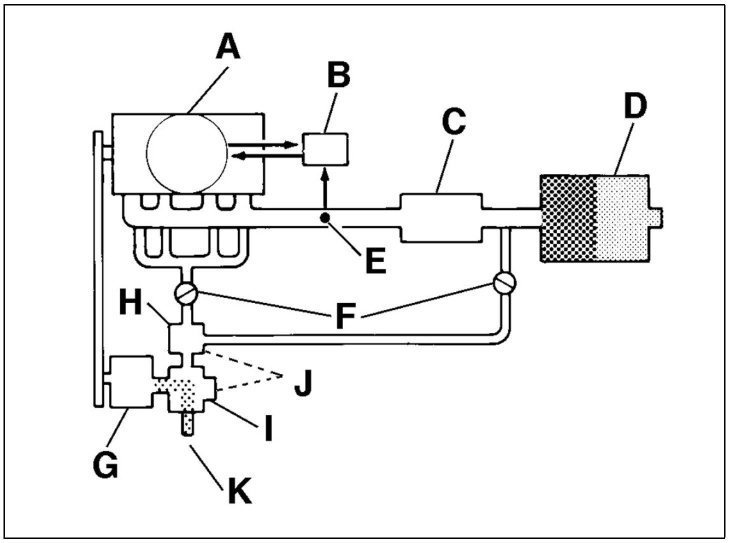


Figure 6-1: Typical Air Pump System

A – Closed Loop Fuel Control
B – Electronic Control Module (ECM)
C – Reducing Catalyst
D – Oxidizing Catalyst
E – O_2 Sensor
F – Check Valves
G – Air Pump
H – Port Solenoid
I – Converter Solenoid
J – Electrical Signals from ECM
K – Bypass Air to Atmosphere

These systems usually consist of a belt-driven air pump, air bypass or diverter valve, check valves, connecting plumbing, and sometimes an air pump intake filter. *Figure 6-1* shows a typical air pump system, with other components, making up a feedback control system.

When the air pump system is working properly, HC, CO and CO_2 readings are lowered and O_2 readings are raised. For this reason, additional air from the air pump must be taken into consideration when monitoring exhaust gas concentrations.

Testing Tip

- ❒ Some systems may divert air pump output to the air cleaner housing or the atmosphere under some conditions. This could lead to incorrect test results. Before replacing components, understand the system operation.

Test

1. Record exhaust gas readings while the engine is at 1500 RPM.
2. Disconnect the air pump outlet hose while maintaining the same engine speed, or restrict air pump output by pinching the air hose with a pliers.
3. Record and compare readings.

Interpretation

- With the air pump operating O_2 should be about 3–8% vol above the reading taken when the pump is disconnected.
- With the air pump disconnected or restricted, O_2 should decrease and HC, CO and CO_2 reading should increase.

Test results different from these indicate a problem with the air pump system. Follow manufacturer guidelines for troubleshooting and repairs.

Carburetor Adjustments

Vehicles Without Feedback Fuel Systems

Adjusting the carburetor using the analyzer requires an understanding of how each adjustment can affect the air-fuel mixture.

Adjustments that make an engine run richer than ideal, meaning more fuel/less air, should increase the HC and CO readings, while decreasing the O_2 and CO_2 readings in the exhaust. Adjustments that make an engine run leaner than ideal, meaning more air/less fuel, should decrease the HC, CO and CO_2, while increasing the O_2 reading. When the air-fuel mixture is so lean that one or more cylinders misfire, HC and O_2 readings increase and CO and CO_2 readings decrease.

Make all carburetor idle mixture adjustments using the recommended procedures of the engine manufacturer. When the manufacturer gives a CO setting, use the analyzer to make the necessary adjustments.

On vehicles where CO specifications are not available, use the analyzer to ensure that the emission readings are at, or below, legal limits and consistent with the year, make and model of the engine being tested.

Lean-Misfire Adjustment Test

1. Observe the CO reading.
   — If greater than zero, proceed to step 2.
   — If not greater than zero, turn the mixture screw(s) to enrich the mixture. If there are two adjustment screws, adjust both screws an equal number of turns.
2. Lean the mixture with the adjustment screw(s) 1/4 turn at a time until HC begins to increase. Pause between adjustments and allow the readings to stabilize.
3. Back the screw(s) out 1/4 turn.
4. Compare the CO and HC readings with the specifications of the engine manufacturer and readjust the mixture as required to obtain the correct readings.

Lean-Drop Adjustment Test

1. Turn the mixture screw(s) to obtain the highest RPM. If there are two adjustment screws, adjust each screw for a 10 RPM drop (20 RPM total) and back each one out 1/4 turn.
2. Lean the mixture with the adjustment screw until a 20 RPM drop is obtained, then adjust 1/4 turn richer. If there are two mixture screws, adjust both screws for a 10 RPM drop and back off 1/4 turn.
3. Compare the CO readings with the specifications of the engine manufacturer and readjust the mixture as required to obtain the correct readings.

Interpretation

If the required exhaust gas readings cannot be obtained by following manufacturer recommended procedures, further diagnostic testing is required. Possible causes of problems include:

- Faulty ignition or compression,
- Vacuum leaks,
- PCV system malfunctions, and
- Carburetor related problems.

Accelerator Pump Test

When the throttle is opened rapidly, engine speed should increase without hesitation. If there is a hesitation, the problem could be a malfunctioning accelerator pump.

Test

1. Note the CO reading at idle.
2. Note the change in the CO readings from the idle readings for each throttle change:
   — 1/4 throttle snap,
   — 1/2 throttle snap, and
   — Full throttle snap.
3. Allow the engine to return to idle speed between throttle changes and idle at least 10 seconds to allow the CO reading to stabilize.

Interpretation

- Unless otherwise specified by the vehicle manufacturer, each throttle snap should result in an increased CO reading.
  — The resulting increase at full throttle should be about twice the 1/2 throttle increase, and the total increases in CO reading for all three throttle changes will usually be between 1.5% vol and 3.5% vol.
- If the CO reading decreases before increasing, or does not increase, the accelerator pump is not functioning properly.
  — Check the linkage adjustment before attempting to repair the pump mechanism.

Power Valve Test

The power valve supplements the fuel supply at higher speeds, since richer mixtures are needed for maximum engine power and performance. The power valve can either be a diaphragm or a vacuum operated piston connected to metering rods. Regardless of the type, verification of power valve operation can be performed by creating a momentary “near zero” intake manifold vacuum. Under this condition, the power valve lifts from its seat and supplements the fuel flow. It is important to verify this operation. It is also important to verify that the power valve is re-seated.

Test

1. Disconnect the accelerator pump linkage.
2. Stabilize the engine at approximately 2000 RPM using the fast idle cam.
3. Note the CO reading.

4. While holding the fast idle cam with one hand, quickly open and return the throttle to the same fast idle position.

CAUTION **It is possible for the engine to backfire during this test. Never position yourself in a way that could expose you to the heat/flame of an intake system backfire.**

✓ It is important to always return to the same fast idle cam position to check for proper re-seating of the power valve.

5. Observe the CO reading.

Interpretation

- The CO reading should increase a minimum of 1% vol when the engine is accelerated.
- If the CO does not increase, a malfunctioning power valve is indicated.
- A momentary increase in, and return to, the original CO and HC readings is expected when the throttle is opened and returned to fast idle position.

High Fuel Level In Float Chamber Test

If the float level is set too high or the float is heavy due to absorbed fuel, the engine may:

- Have a rough idle,
- Be difficult to restart when hot, and
- Have a high CO reading at idle.

✓ Floats made of nytrophyl are more prone to this condition.

Test

1. Bounce the vehicle several times with the engine running.
2. Note the CO reading.

Interpretation

- A fluctuating CO reading indicates a high fuel level in the float chamber.
  — Verify that the float level setting and float weight meet manufacturer specifications.

Combustion Gases in the Cooling System Test

Use the cooling system of a vehicle as a window for evaluating the condition of an engine when a blown head gasket, cracked engine block, or cracked cylinder head is suspected. This test confirms the presence of exhaust gases in the cooling system, but does not pinpoint the exact source of entry. Use conventional tests to identify the cause of the combustion leak.

⚠CAUTION

- **Coolant at high pressure and temperature can escape from the radiator when the cap is removed and during engine operation under load. Use extreme caution when testing the engine under load with the radiator cap removed.**
- **Coolant under high pressure and temperature may cause severe personal injury.**
- **Remove the radiator cap only with engine cold.**

Testing Tip

❒ Combustion gases leaking into the cooling system are usually more easy to detect when the engine is operated under load while sampling above the cap opening.

Test

1. Remove the radiator cap.
2. Hold the probe tip above the radiator filler neck.

⚠CAUTION

Do not let the probe touch the coolant or draw coolant into the sampling system. Liquid contamination of the sampling system ruins analyzer accuracy and can cause damage to the system.

3. Note the HC reading.

Optional Test

Use this test method to eliminate the possibility of contaminating the sampling system with coolant.

1. With the cooling system safely uncapped, place a plastic bag over the cap opening.
2. Briefly run the engine to collect a sample of any gases that may be escaping from the cooling system.
3. Insert the sample probe into the bag.
4. Note the HC reading.

Interpretation

- Any HC reading indicates combustion leakage into the cooling system.
- Continue with conventional testing to pinpoint the exact source of exhaust entry.

Fuel Leak Test

The analyzer is extremely sensitive to fuel vapor, even at relatively low concentrations. Use this test to find leaks in fuel system components long before the liquid fuel is visible. Any part of the fuel system can develop leaks, but common leakage areas include:

- Mechanical fuel pump vent holes,
- Charcoal vapor storage canister,
- Fuel filler cap,
- Fuel lines, and
- Fuel tank seams, flanges and rusty areas.

Testing Tips

❒ Gasoline fumes are heavier than air. Keep the probe on the lowest side of the area being tested when searching suspected leak areas.

❒ Air stream in the immediate area may affect test results. Shield the probe from wind draft or stop the engine when testing near a running engine. Small leaks may require testing after a stabilization period in a breeze-free location.

Test

1. Hold the sample probe near suspected leak areas.

⚠CAUTION

Do not put the probe in direct contact with the fuel or allow it to draw liquid into the sampling system. Fuel contamination of the sampling system ruins analyzer accuracy and can cause damage to the system.

✓ When working near a running engine, shield the probe from drafts or stop the engine if possible to avoid vapor contamination from other areas.

2. Note the HC reading.

Interpretation

- HC readings above baseline < 10 ppm HC traces indicate fuel leakage.

Exhaust Leak Test

The analyzer is extremely sensitive to HC, even at relatively low concentrations. Therefore, it is useful for checking exhaust system components for leaks. A leak in the exhaust system can lower the HC, CO and CO_2 readings at the tail pipe, while raising the O_2 reading.

Testing Tips

CAUTION

Avoid touching the exhaust system with the probe. Scaling particles from the exhaust system may contaminate the sampling system and affect analyzer accuracy.

❐ Choke the carburetor intake slightly or partially block the tail pipe with a socket having an outside diameter no larger than 1/2 the inside diameter of the tail pipe.
— Some exhaust systems have a small hole in the muffler to allow moisture formed in the system to drain out. This does not affect test results and exhaust leakage from this hole is normal.

❐ On pulse air systems, carefully check the fresh air side of the check valve while the engine is running. An HC reading in this area suggests a defective check valve, which can cause vehicle performance problems since exhaust gases are being fed into the intake air of the engine. If this occurs over a long period, corrosion of the throttle body/carburetor can block air bleeds and other vital orifices, causing increasingly poor engine performance.

❐ With the air injection system disabled, CO_2 readings less than 8% vol indicate that ambient air is entering the sample. Check the integrity of the exhaust system and the exhaust sample hose to see if ambient air is reaching the sample probe from the tail pipe.

Test

1. With the engine running, move the probe along the exhaust system and watch for any sudden increases in HC.

2. Hold the probe near suspected surfaces of all exhaust system components.

3. On vehicles with air pumps and pulse air systems, check the components associated with these systems.

Interpretation

The HC reading increases in the area of an exhaust leak.

Fumes In Passenger Compartment Test

When an exhaust leak into the passenger compartment is suspected, the vehicle should be tested immediately.

⚠DANGER

Exposure to carbon monoxide gas can cause nausea, headaches, drowsiness and death in as little as 30 minutes. The cause of any exhaust fumes in the passenger compartment should be eliminated before operating the vehicle.

Testing Tip

❒ On air-cooled engines, test around heater ducts for exhaust fumes.

Test

1. Place the probe inside the vehicle through an open window. Close the window on the hose, being careful not to pinch it.
2. Allow the engine to run at idle for 15 or 20 minutes.
3. Note the analyzer readings.

Interpretation

- When compared to an ambient air sample, near zero readings for HC and CO indicate that no exhaust gas is present in the passenger compartment at this time.
- If CO or HC above baseline traces is detected, check:
  - — Exhaust system for leaks,
  - — Weather stripping for improper sealing, and
  - — Vehicle body for rust and missing body plugs.

No-Start Condition—Fuel Test

A vehicle that cranks over but does not start, could be experiencing:

- Mechanical engine problem,
- Ignition system problem, or
- Fuel delivery problem.

Use the following test to help determine if the fuel supply system is the problem.

Testing Tip

❒ If the TPS fails in a way that mimics a wide-open throttle, even though the throttle is closed, fuel delivery will be severely limited or shut off completely due to the clear-flood function built into the engine control computer. In this event, this test will indicate a fuel delivery problem even though no other components may have failed. Always check TPS voltage on engines with electronic fuel injection if the engine turns over but will not start. Certain engine mechanical problems, particularly those relating to valve timing, can prevent the movement of fuel through the combustion chamber even if the fuel system is otherwise working properly. In these cases, valve timing problems may be noticed when the engine turns over. A change in normal engine cranking rhythm could indicate valve timing problems.

Test

1. Insert the sample probe into the vehicle tail pipe.
2. Crank the engine for 15 seconds.
3. If no CO value is displayed, partially block induction system air intake and check for vacuum while cranking the engine.

✓ On vehicles with electronic fuel injection, check:
— Electronic control module fuse,
— Fuel injector fuse,
— Fuel pump relay/inertia switch, and
— Throttle position sensor (TPS).

Interpretation

- When the engine gets fuel while cranking, the HC reading increases,
  — This indicates fuel system operation from the fuel tank, through the engine and out the exhaust.
- Poor vacuum with some HC reading could indicate a fuel system problem in carbureted engines.

After troubleshooting systems with catalytic converters for no-start conditions, allow time for the fuel to evaporate from the converter before starting the engine. Starting the engine with a catalytic converter loaded with an excessive amount of unburned fuel vapor can damage the converter.

7

Diagnostic Technique

Interpreting gas concentrations under a given set of conditions becomes a matter of:

- Understanding engine operation and the system or systems under test,
- Understanding the relationships of exhaust gas concentrations to each other, to the engine operation and to the catalytic converter, and
- Applying logic to the possible causes, while eliminating those that are not probable, and selecting the most likely of the possible causes.

Applying logic becomes the diagnostic technique used to determine the cause of unacceptable readings, together with a course of action that includes one or more of the following variables:

- Change engine speed, load, or both,
- Defeat air management,
- Enrich the fuel mixture with propane,
- Create a vacuum leak to lean the fuel mixture, and
- Use other test equipment such as an oscilloscope, vacuum gauge, or scanner.

Data Analysis Guidelines

Use the following information when analyzing data to isolate a specific problem. It is important to remember that by-products of combustion depend on the air-fuel ratio.

Stoichiometric Air-Fuel Ratio

- Lambda = 1.00 at stoichiometric air-fuel ratio.
- CO and O_2 are equal at the stoichiometric air-fuel ratio.
- CO_2 is an indicator of combustion efficiency that peaks at or near the stoichiometric air-fuel ratio, and decreases with a lean or rich air-fuel ratio.
- NO in the range of 1700 to 2500 ppm is typical on an engine running at stoichiometric without EGR.
  — With EGR, NO levels are usually between 500 and 1000 ppm.

Lean Air-Fuel Ratio

- Lambda is greater than 1.00. If Lambda = 1.10, this means 10% excess air compared with stoichiometric.
- High HC is an indicator of excessive leanness and misfires.
- O_2 is a better indicator of leanness and misfires than HC.
- High O_2 indicates an excessively lean air-fuel ratio.
- NO is highest when CO and HC are lowest.

✓ Air injection systems should be disabled to prevent false readings.

Rich Air-Fuel Ratio

- Lambda is less than 1.00. If Lambda = 0.90, there is only 90% of the required air for stoichiometric.
- Low O_2 indicates a rich mixture.
- High CO readings usually indicate a fuel mixture richer than stoichiometric.
- High HC readings usually indicate excessive unburned fuel caused by lack of ignition or by incomplete combustion.
  — Common causes include a faulty ignition system, vacuum leaks and fuel mixture problems.

Miscellaneous

- When CO goes up, O_2 goes down.
- When O_2 goes up, CO goes down.
- O_2 combines with HC to form CO_2 and H_2O.
- O_2 combines with CO to form CO_2.
- O_2 and CO_2 are indicators of exhaust system integrity, sample hose and probe integrity, or both.
- O_2 is essential for proper operation of the catalytic converter.
  — O_2 is essentially unchanged by the catalytic converter, providing a “window” through the catalytic converter to the engine.
  — O_2 readings are higher on vehicles with properly operating air injection systems.
- With the air injection system disabled and the CO above 1%, the catalytic converter is O_2 starved.
  — Without O_2 it does not “light off,” allowing exhaust concentrations to be more like readings taken ahead of the converter.
- Minimal NO is produced while an engine idles.
- An excess of O_2 reduces HC and CO emissions.
- A deficiency of O_2 reduces NO.
- NO forms in the combustion chamber at peak temperatures 2500°F (1370°C).
- NO levels increase as O_2 levels increase.

Air-Fuel Ratio Effects

Figure 7-1 contains some of the results possible when the air-fuel ratio is sustained at conditions ranging from too lean to too rich.

CONDITION	RESULTS
Too Lean	Poor engine power Misfiring at cruising speeds Burned valves Burned pistons Scored cylinders Spark knock or ping
Slightly Lean	High gas mileage Low exhaust emissions Reduced engine power Slight tendency to knock or ping
Stoichiometric	Best all-around performance
Slightly Rich	Maximum engine power Higher emissions Higher fuel consumption Lower tendency to knock or ping
Too Rich	Poor fuel mileage Misfiring Increases air pollution Oil contamination Black exhaust Catalytic converter damage

Figure 7-1: Air-Fuel Ratio Conditions and Results

Five Gas Combination Readings

This chart lists some of the possible combinations of exhaust gas values and the most likely cause(s). Variables do not include secondary air.

Legend: L = low; M = moderate; H = High

CO	CO_2	HC	O_2	NO	Possible Problems / Conditions
H	L	H	L	L	Thermostat or coolant sensor faulty. cold running engine
L	H	L	L	H	Thermostat or coolant sensor faulty - hot running engine
L	L	L	H	L	Exhaust leak after catalytic converter
L	H	L	H	M	Injector misfire, catalytic converter operating efficiently
H	H	H	H	H	Injector misfire
H	H	H	H	H	Catalytic converter not working
H	H	H	H	H	Combination of rich mixture and vacuum leak
					Air-fuel ratio too rich:
H	L	LM	L	L	rich fuel mixture
H	L	LM	L	L	leaking fuel injectors
H	L	LM	L	L	incorrect carburetor adjustment
H	L	LM	L	L	power valve leaking
H	L	LM	L	L	choke operating rich
H	L	LM	L	L	float level too high
H	L	LM	L	L	air filter dirty
H	L	LM	L	L	EVAP canister purge system fault
H	L	LM	L	L	PCV system problem
H	L	LM	L	L	engine control computer malfunctioning
H	L	LM	L	L	crankcase contaminated with raw fuel
MH	L	LM	L	H	all of the above with catalytic converter operating efficiently
H	L	H	H	L	rich mixture with ignition misfire
					Air-fuel ratio too lean
L	L	H	H	H	lean fuel mixture
L	L	H	H	H	ignition misfire
L	L	H	H	H	vacuum leaks/air leaks (between air flow sensor and throttle body)
L	L	H	H	H	EGR bad or vacuum hoses mis-routed
L	L	H	H	H	carburetor settings incorrect
L	L	H	H	H	fuel injector bad
L	L	H	H	H	O_2 sensor bad or failing
L	L	H	H	H	engine control computer malfunctioning
L	L	H	H	H	float level too low
					Major engine fault;
LM	L	LM	L	LM	compression low
LM	L	LM	L	LM	camshaft lobe lift insufficient
LM	L	LM	L	H	Ignition timing over advanced
LM	L	LM	L	H	Spark plug wire grounded or open
LM	L	LM	L	MH	Engine control computer compensating for a vacuum leak
L	H	L	L	L	Good combustion efficiency and catalytic converter

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