INSTRUCTION MANUAL

Four Gas Infrared Analyzer

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SAFETY GUIDELINES

TO PREVENT ACCIDENTS THAT COULD RESULT IN SERIOUS INJURY
AND/OR DAMAGE TO YOUR VEHICLE OR TEST EQUIPMENT,
CAREFULLY FOLLOW THESE SAFETY RULES AND TEST PROCEDURES.

SAFETY EQUIPMENT

- **Fire Extinguisher**

Never work on your car without having a suitable fire extinguisher handy. A 5-lb. or larger CO_2 or dry chemical unit specified for gasoline/chemical/electrical fires is recommended.

- **Fireproof Container**

Rags and flammable liquids should be stored only in fireproof, closed metal containers. A gasoline soaked rag should be allowed to dry thoroughly outdoors before being discarded.

- **Safety Goggles**

We recommend wearing safety goggles when working on your car to protect your eyes from battery acid, gasoline, and dust and dirt flying off moving engine parts.

NOTE: Never look directly into the carburetor throat while the engine is cranking or running, as sudden backfire can cause burns.

LOOSE CLOTHING AND LONG HAIR (MOVING PARTS)

Be very careful not to get your hands, hair or clothes near any moving parts such as fan blades, belts, and pulleys or throttle and transmission linkages. Never wear neckties or loose clothing when working on your car.

JEWELRY

Never wear wrist watches, rings or other jewelry when working on your car. You'll avoid the possibility of catching on moving parts or causing an electrical short circuit which could shock or burn you.

VENTILATION

The carbon monoxide in exhaust gas is highly toxic. To avoid asphyxiation, always operate vehicle in a well ventilated area. If vehicle is in an enclosed area, exhaust should be routed directly to the outside via leakproof exhaust hose.

SETTING THE BRAKE

Make sure that your car is in **park** or **neutral** and that the **parking brake is firmly set.**

NOTE: Some vehicles have an automatic release on the parking brake when the gear shift lever is removed from the **PARK** position. This feature must be disabled when it is necessary (for testing) to have the parking brake engaged when in the **DRIVE** position. Refer to your vehicle service manual for more information.

HOT SURFACES

Avoid contact with hot surfaces such as exhaust manifolds and pipes, mufflers (catalysts), the radiator, and hoses. Never remove the radiator cap while the engine is hot, as escaping coolant under pressure may seriously burn you.

SMOKING AND OPEN FLAMES

Never smoke while working on your car. Gasoline vapor is highly flammable, and the gas formed in a charging battery is explosive.

BATTERY

Do not lay tools or equipment on the battery. Accidentally grounding the **"HOT"** battery terminal can shock or burn you and damage wiring, the battery or your tools and testers. Be careful of contact with battery acid. It can burn holes in your clothing and burn your skin or eyes.

When operating any test instrument from an auxiliary battery, connect a jumper wire between the negative terminal of the auxiliary battery and ground on the vehicle under test. When working in a garage or other enclosed area, auxiliary battery should be located at least 18 inches above the floor to minimize the possibility of igniting gasoline vapors.

HIGH VOLTAGE

High voltage—30,000-50,000 volts—is present in the ignition coil, distributor cap, ignition wires, and spark plugs. When handling ignition wires while the engine is running, use insulated pliers to avoid shock. While not lethal, a shock may cause you to jerk involuntarily and hurt yourself.

JACK

The jack supplied with the vehicle should be used only for changing wheels. Never crawl under car or run engine while vehicle is on a jack.

VEHICLE MANUAL, SOURCES FOR SERVICE INFORMATION

The following is a list of publishers who have service manuals for your specific vehicle at nominal cost. Write to them for availability and prices, specifying the make, style and model year of your vehicle.

American Motors Corp.
Myriad
8835 General Drive
Plymouth Township
Michigan 48170

Chrysler Corporation
Dyment Distribution Service
Service Publication
20026 Progress Drive
Strongsville, Ohio 44136

Ford Publication Dept.
Helm Incorporated
Post Office Box 07150
Detroit, Michigan 48207

Buick
Tuar Company
Post Office Box 354
Flint, Michigan 48501

Oldsmobile
Lansing Lithographers
Post Office Box 23188
Lansing, Michigan 48909

Cadillac, Chevrolet, Pontiac
Helm Incorporated
Post Office Box 07130
Detroit, Michigan 48207

OTHER SOURCES—Nonfactory Domestic and Import Cars

Chilton Book Company
Chilton Way
Radnor, PA 19089

Cordura Publications
Mitchell Manuals, Inc.
Post Office Box 26260
San Diego, CA 92126

Motor's Auto Repair Manual
Hearst Company
250 West 55th Street
New York, NY 10019

IMPORTANT

CONSULT THE VEHICLE MANUAL FOR SPECIFIC TUNE-UP INFORMATION AND TEST PROCEDURES. ALWAYS FOLLOW THE MANUFACTURER'S SPECIFICATIONS AND TEST PROCEDURES FOR ADJUSTING DWELL ANGLE AND IDLE SPEED, ESPECIALLY ON VEHICLES WITH MODERN ELECTRONIC IGNITION AND EMISSION CONTROLS. DO NOT ATTEMPT TO SERVICE A VEHICLE WITHOUT THE MANUFACTURER'S INSTRUCTIONS AND SPECIFICATIONS.

DESCRIPTION

The **FOUR (4) GAS INFRARED EXHAUST ANALYZER** is an easy to operate instrument that has been designed for fast and accurate testing of spark ignited, gasoline powered engines through the sampling of four (4) of the gasses present in the exhaust of the engine. The sampled gasses are: Carbon Monoxide (CO), Hydrocarbon (HC), Carbon Dioxide (CO_2), and Oxygen (O_2).

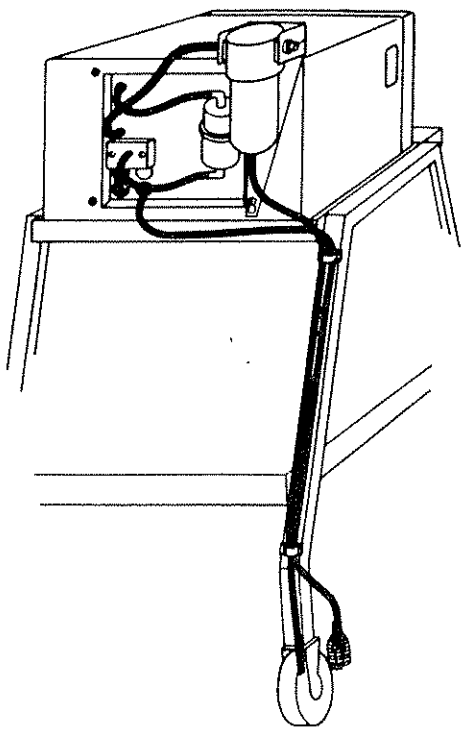
This instrument is ideally suited for checking combustion efficiency and emission levels on both catalytic converter equipped, and non-converter equipped vehicles. Your unit has been carefully assembled, tested and factory calibrated. Note that calibration accuracy is affected by altitude. We recommend that if your location is greater than 1700 feet above sea level that your instrument be recalibrated with gas prior to its first use. See the calibration section of this manual. If you do not know your altitude, call the airport nearest you for this information. Your unit is supplied with a twenty-five (25) foot sample hose and probe assembly, dust cover, and power cable for connection to any standard twelve (12) volt automotive style battery. Optional accessories include a 115 Volt AC power supply (which eliminates the need for a twelve (12) volt battery), calibration gas, and a regulator kit for this gas.

PRIMARY FILTER KIT INSTALLATION

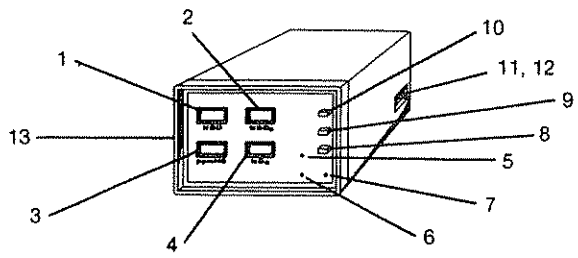
Your analyzer comes complete with a two (2) stage filtering system. The secondary filter comes installed, however, the primary filter must be installed. The primary filter kit includes the following parts: one filter bracket assembly, one short length of tubing, one long length of tubing with drain valve, and two hose clamps.

Follow the simple instructions and Figure 1 below.

1. Loosen the two (2) screws on the right side of the rear of the analyzer.
2. Slide the filter bracket assembly onto the screws. Retighten the screws to secure the filter assembly to the analyzer.
3. Connect the short length of tubing from the port on the back of the analyzer to the barbed fitting on the primary filter assembly.
4. Connect the long length of tubing to the barbed fitting on the bottom of the primary filter bowl.
5. Two (2) adhesive clamps are provided to secure both drain hoses. The drain hoses should be positioned so that they are off the floor and protected from damage.
6. Connect the sample hose to the remaining fitting on the inlet of the primary filter.



PRIMARY FILTER INSTALLATION
FIGURE 1



CONTROLS, DISPLAYS, AND INDICATORS
FIGURE 2

FOUR GAS ANALYZER CONTROLS, DISPLAYS, AND INDICATORS (See Figure 2)

1. **% CO DISPLAY** — Liquid Crystal Display (LCD) indicates carbon monoxide content of exhaust gas from .00%—9.99%.
2. **% CO_2 DISPLAY** — LCD indicates carbon dioxide content of exhaust gas from 0.0%—20.0%.
3. **PPM HC DISPLAY** — LCD indicates hydrocarbon content of exhaust gas from 0—1999 parts per million.
4. **% O_2 DISPLAY** — LCD indicates oxygen content of exhaust gas from 0.0%—25%.
5. **CALIBRATE INDICATOR** — Illuminates during warm up and at any time the analyzer is in the calibrate mode.
6. **STANDBY INDICATOR** — Illuminates during warm up and at any time the analyzer is in the standby mode.
7. **RUN INDICATOR** — Illuminates during warm up and at any time the analyzer is in the run mode.
8. **CALIBRATE SWITCH** — Depress to switch the unit to the calibrate mode.
9. **RUN/STANDBY SWITCH** — Depress to switch the unit between the run and standby modes.
10. **POWER SWITCH** — Depress to turn the unit ON or OFF.
11. **FUSE** — Depress the bottom of the fuseholder to remove the fuse, or the top of the fuseholder to re-install the fuse. **Replace only with a 6 amp, 250 volt fuse as was originally installed.**
12. **POWER CONNECTOR** — Connect the battery cable or the output cable from the optional power supply to this connector.
13. **CALIBRATION CONTROL COVER** —(Not Visible) Pull the pins to remove this cover which will expose the calibration controls.

LIQUID CRYSTAL DISPLAY (LCD) MESSAGES

Periodically during the operation of the analyzer various messages may appear in one or more of the LCD displays, indicating a problem or a condition which may need attention. Below is a listing of these messages.

1. **HEL LO** — Displayed across the % CO and % CO_2 displays during the warm up period.
2. **CAL** — Displayed on all displays whenever the analyzer is in the calibration mode.
3. **LO FLO** — Displayed across the % CO and % CO_2 displays. It is displayed alternately with measurement indications whenever sample gas flow is restricted. Check the sample hose, filters, and plumbing for a restriction.
4. **ERR** — Displayed on individual displays when an error in calibration adjustment occurs or if the analyzer's optical system becomes fogged wtih moisture. Should this occur, remove, empty, and reinstall the filters if they contain water. Disconnect the sample hose from the primary filter and allow the unit to operate in the RUN mode. This will draw in fresh air and dry out the optical system. Finally, push the front panel **calibrate** switch. See the troubleshooting guide in this manual for further information.
5. **UUU** — Displayed on individual displays when an under range condition occurs. Push the front

panel **calibrate** switch when this message appears.

6. **ooo** — Displayed on individual displays when an over range condition occurs (A higher concentration of the gas being measured has been sampled by the analyzer than it is capable of displaying.). As with the **ERR** message, moisture fogging of the optical system may cause this message.

7. **LO BAT** — Displayed in the upper left corner of the display as follows:

   If during the warm up mode of operation the power supply voltage (battery or optional power supply) to the analyzer drops below approximately 12.2 volts, the LO BAT message will appear on the % O_2 LCD display. In all other modes of operation all of the displays will show the LO BAT indication. Note that whenever there is a low battery indication, the analyzer may not give accurate readings. It is therefore important to determine the cause of, and correct the reason for, the low battery voltage.

HOOKUP, START AND WARM-UP

1. Make sure the power switch is in the **OFF** position.

   VEHICLE BATTERY POWER

   A. Plug the blue connector of the supplied battery cable into the side of the analyzer.
   B. Connect the RED clip to the positive (+) battery terminal.
   C. Connect the BLACK clip to the negative (-) battery terminal or a clean secure engine ground.

   OPTIONAL 115 VAC POWER SUPPLY

   A. Connect the power supply to a source of 115 VAC.

> **NOTE**
>
> When using the external 115 VAC power supply, make certain you have an "electrically clean" source of 115 volts. Heavy duty power equipment such as air compressors can cause momentary power fluctuations. These fluctuations may cause the analyzer's internal microcomputer to "lock up." If this should occur, turn the unit off for five (5) seconds and then back on.

   B. Plug the blue connector into the side of the analyzer.

> **NOTE**
>
> Under typical shop conditions, this analyzer has a warm up time of 10 to 20 minutes from a cold start-up. If the instrument is to be used regularly throughout the day, it is recommended that it be left on all day in the **STANDBY** mode when not in use. If an auxiliary battery is to be used to power the instrument, it should be capable of providing a minimum of 12.3 volts continuously. The **"LO BAT"** messages on the LCD displays will flash when battery voltage drops below 12.2 volts indicating that the instrument's circuitry may not be electronically stable, and the readings not reliable.

2. Depress the power switch to turn the unit ON. The following sequence of events will occur:

   A. All segments of the four (4) LCD displays will illuminate for ten (10) seconds as a self test. As all four (4) displays are identical, they should all look alike during this self test.
   B. The three (3) function indicator LEDs (calibrating, standby and run) will illuminate.
   C. At the end of the ten (10) seconds, the top two (2) displays (% CO and % CO_2) will show **HEL LO** and the bottom right display (% O_2) will begin a 600 second (10 minute) countdown. This signals the beginning of the warm up period. If at the end of the 600 seconds the analyzer's internal micro-computer has determined that the instrument is not sufficiently warm, it will begin a second 600 second warm up period. During the second 600 second cycle, the calibrating LED will flash to indicate this mode. If at any time during the warm up period the microcomputer senses that all internal circuitry is sufficiently warm and stabilized, it will end the warm up cycle at that time.
   D. At the end of the warm-up period, the unit automatically proceeds to the self calibration mode. This is indicated by all displays showing **CAL** and the calibrating LED illuminated. The initial calibration takes approximately 1 to 1-1/2 minutes.
   E. When the automatic calibration is complete, the instrument will switch to the standby mode. The calibrating LED turns off, and the standby LED illuminates. The LCD displays should indicate **close** to the following:

% CO	=	.00
% CO_2	=	.0
PPM HC	=	0
% O_2	=	20.8

NOTE

It is normal for these readings to drift a minimal amount with time. See **POST WARM-UP MODES OF OPERATION, 1. CALIBRATION** below.

NOTE

Ambient air (the air we breathe) contains approximately 20.8% oxygen.

POST WARM-UP MODES OF OPERATION

1. **CALIBRATION** — The analyzer's internal microcomputer continuously monitors internal circuit drift. When the instrument is cold, and drift is excessive, the instrument will switch to the automatic calibration mode frequently. Once it has fully warmed up and stabilized, it will automatically recalibrate itself much less frequently. If at any time excessive drift is shown by one or more of the displays (excessive drift is evident in the **RUN** mode with the sample hose disconnected from the instrument so that it is drawing fresh air), the unit can be manually switched to the calibration mode by depressing the front panel **calibrate** switch.
2. **STANDBY** — The standby mode of operation keeps the analyzer fully warmed and stable, so that it is ready for immediate use. The vacuum pump is off in the standby mode. When the analyzer is to be used regularly throughout the day, leave it in the standby mode whenever there is no vehicle testing in progress.
3. **RUN** — The run mode is used for vehicle testing. The vacuum pump is running, and exhaust is drawn through the sample hose, through the dual filtering system, into the instrument for analysis, and is ultimately exhausted.

CAUTIONS ON ANALYZER USE

1. This analyzer should not be used for testing diesel engines since the excessive particulate emissions will clog hoses, filters and internal parts.
2. The engine should be fully warmed before inserting the probe into the tailpipe. Cold engines produce excessive pollutants and water vapor which will quickly clog the filters. **Do not allow the filters to fill with water to the point that it would enter the analyzer. Serious damage may result!**
3. **Any adjustments to the vehicle must be done in accordance with the vehicle manufacturer's instructions and within appropriate federal and state guidelines.**
4. Due to the sensitivity and accuracy demanded from this unit, it is recommended that it be operated only from an equipment stand, or if a stand is not available, a sturdy, stable surface.
5. Do not use this analyzer in an unprotected (rain, snow, etc.) environment or in freezing conditions (Water vapor may freeze in the gas sampling system and restrict gas flow and/or damage the analyzer.).
6. This analyzer is not approved for use on vehicles which are operated in confined or poorly ventilated areas (indoors).
7. When using this analyzer on propane fueled vehicles, CO, CO_2 and O_2 are read directly as displayed, however, the correct HC reading is obtained by dividing the displayed reading by the propane equivalency factor listed on a decal on the rear panel of the unit next to the secondary filter assembly.

   EXAMPLE:

   Unit propane equivalency factor = .51
   Displayed reading = 300
   300 / .51 = 588

   In this example, the actual HC content of the exhaust gas would be 588 PPM.

THE FOUR (4) SAMPLED GASSES

Listed below are the four (4) gasses that are sampled and displayed by the analzyer and a brief description of each.

HYDROCARBON (HC)

All petroleum based products contain many hydrocarbon compounds. These compounds can enter the atmosphere either through evaporation or exhaust. When HC is measured from the tailpipe, the measurement represents unburned fuel in parts per million of hydrocarbon (HC). Any condition which would cause the fuel not to burn completely such as a misfire due to **either lean or rich mixture** will contribute to a high HC reading. Insufficient spark or an incorrectly timed spark are common ignition problems that will cause high HC readings. Note that catalytic converters will reduce HC readings.

CARBON MONOXIDE (CO)

Carbon monoxide forms as a result of insufficient oxygen available during the combustion process (**rich** mixture). Unlike HC, CO only forms as a result of combustion. As an example, a lean misfire will produce excessive HC, but because there is no combustion, no CO will form. Conversely, a rich mixture will produce

high HC and CO; high CO because of insufficient oxygen available to burn the fuel, and high HC because not all of the fuel was burned but rather was exhausted out the tailpipe. High CO readings are typically the result of fuel system problems such as a dirty air filter, sticking choke, improper float setting, or a rich idle mixture setting. Specific to fuel injected engines, high readings may be caused by leaky injector(s), high fuel rail pressure, or a computerized engine control system malfunction. Note that as with HC, catalytic converters will reduce CO readings.

CARBON DIOXIDE (CO_2)

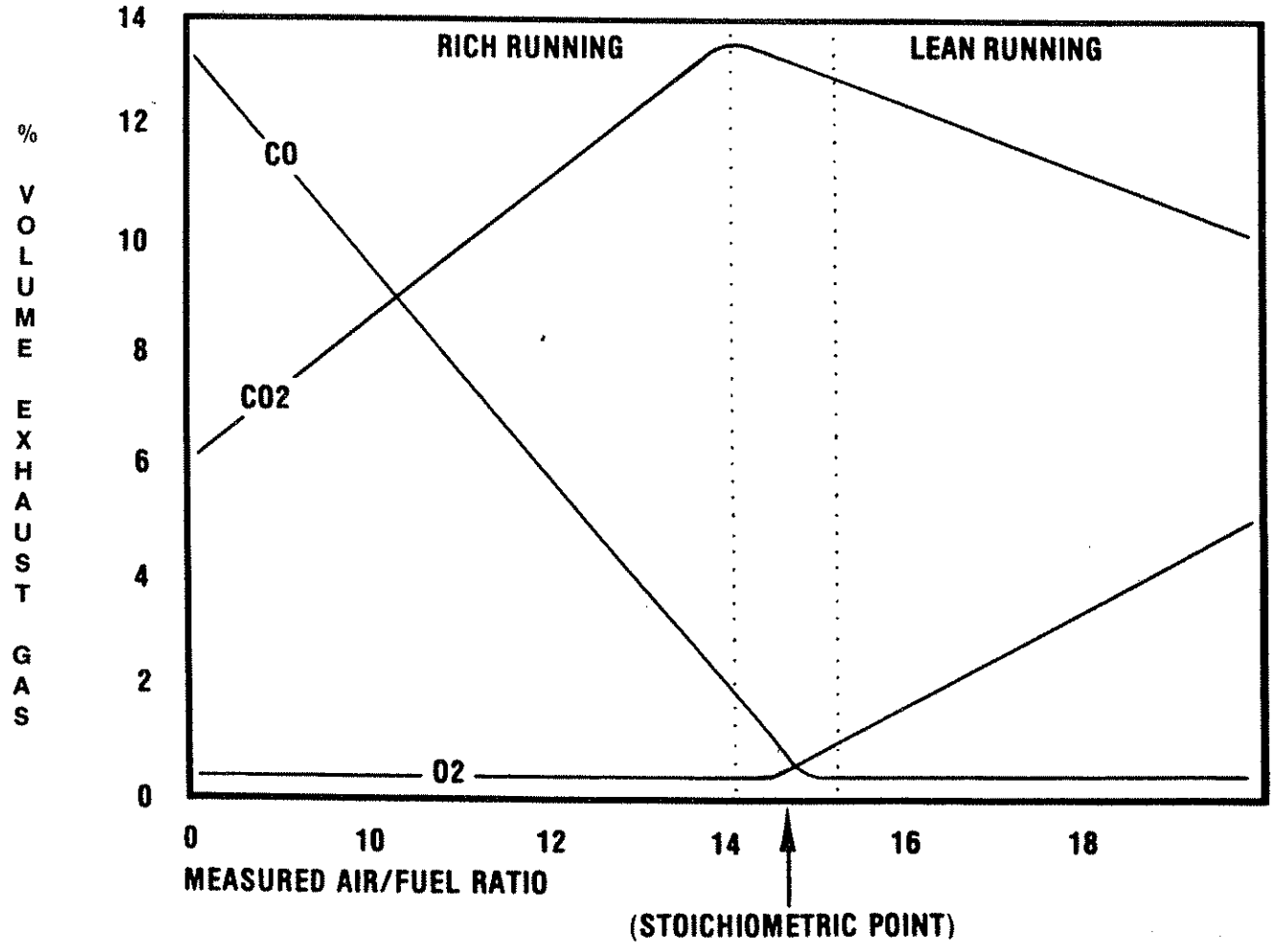
Carbon dioxide (CO_2) is an excellent indicator of combustion efficiency. Generally speaking, an engine is operating as efficiently as it can when carbon dioxide is at its peak value (%), whether or not the vehicle is equipped with a catalytic converter. This will usually occur in the range of 12% to 15%. Once any ignition malfunctions or other engine problems are solved, the CO_2 reading can assist in obtaining the proper carburetor mixture adjustment.

OXYGEN (O_2)

The primary benefit of oxygen is that it indicates a lean condition. As the air/fuel ratio leans, the oxygen level will rise. If the mixture is leaned to the point of misfire, the O_2 level will rise quickly. Lean misfire is confirmed by observing HC and CO along with O_2. If CO is low, O_2 is high, and HC is high and unsteady, the engine is in a lean misfire condition.

AIR/FUEL RATIO

At the center of all emission control techniques is the precise control of the air/fuel ratio. By closely controlling the air/fuel ratio the engine will burn the mixture efficiently. The "ideal" or **stoichiometric** mixture is 14.7 pounds of air to 1 pound of fuel (commonly expressed 14.7 to 1). The stoichiometric point is shown in the graph (Figure 4) below.



STOICHIOMETRY GRAPH
FIGURE 4

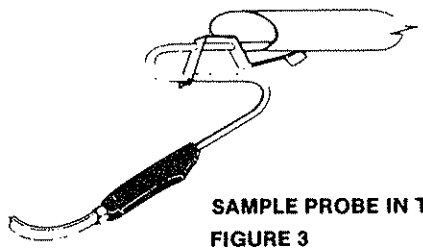
TYPICAL EMISSION LIMIT GUIDELINES

Use these guidelines only if manufacturer's specifications are not available.

YEAR	% CO	% CO_2	PPM HC	% O_2
1968 — 1969	Below 4%	Above 8%	Below 450 PPM	.1-4%
1970 — 1974	Below 3.5%	Above 8%	Below 450 PPM	.1-5%
1975 — 1978	Below 2%	Above 8%	Below 250 PPM	.1-5%
1979	Below 2%	Above 8%	Below 220 PPM	.1-5%
1980	Below 1.2%	Above 8%	Below 220 PPM	.1-5%
1981 & Later:				
(Idle)	Below 1.2%	Above 8%	Below 220 PPM	.1-5%
(2500 RPM)	Below 1%	Above 8%	Below 200 PPM	.1-5%

GENERAL TEST INSTRUCTIONS (ALL VEHICLES)

1. Unless specifically instructed otherwise by the vehicle service manual, disconnect the air injection system (air pump or pulseair). (Leaving this system connected will alter the true exhaust readings.)
2. Fully warm the engine under test (upper radiator hose is hot) before inserting the sample probe into the tailpipe. (Cold engines produce excessive pollutants and water vapor which can contaminate the analyzer quickly.)
3. Insert the sample probe into the tailpipe as shown in Figure 3. The clamp will hold the probe in place.
4. Switch the analyzer to the **RUN** mode of operation.
5. Allow the readings on the analyzer to stabilize and compare them to the manufacturer's specifications for the engine under test. If manufacturer's specifications are not available, see the "**TYPICAL EMISSION LIMIT GUIDELINES**" table above.



SAMPLE PROBE IN TAILPIPE
FIGURE 3

CARBURETOR ADJUSTMENT

NOTE

All carburetor adjustments must follow manufacturer's instructions and specifications and also fall within any emission guidelines established by federal and/or state governments for the model year vehicle under test.

NOTE

When performing mixture adjustment on the fuel system (carburetor), turn the adjustment screws no more than 1/16th to 1/8th of a turn at at time, allowing the analyzer's displays to stabilize between adjustments.

PRELIMINARY STEPS

1. Follow the appropriate vehicle service manual procedures for removing idle mixture screw limiter cap(s) or hardened plug(s) to gain access to the mixture adjustment screw(s).
2. In the case of a multibarrel carburetor (two mixture adjustment screws), lightly seat the screws and then back them out an equal number of turns. This balances the carburetor. A typical starting point is 1-1/2 to 4 turns counterclockwise from a lightly seated position. Your vehicle service manual may recommend a specific starting point in which case that specification should be used.

MIXTURE ADJUSTMENT (VEHICLES WITHOUT CATALYTIC CONVERTERS)

1. **Read and follow GENERAL TEST INSTRUCTIONS (ALL VEHICLES) through PRELIMINARY STEPS as listed above.**
2. Set the curb idle speed as specified by the vehicle emission control label or vehicle service manual.
3. With the engine fully warmed and operating at curb idle, observe the readings on the analyzer. Pay particular attention to the HC and CO readings. If the mixture is rich, turn the mixture screw(s) clockwise to lean it, if the mixture is lean, turn the mixture screws counterclockwise to enrichen it. In the case of multibarrel carburetors, turn the mixture screws equally so that carburetor balance is maintained. Adjust the mixture so that HC is at a minimum level, and CO is low. (This should simultaneously bring O_2 close to a minimum value, and CO_2 close to a maximum value.) It may be necessary to readjust the curb idle speed dur-

ing the mixture adjustment procedure. Check all idle adjustments when mixture adjustment is complete and reset as necessary.

When all adjustments are complete, be sure to reconnect the air injection system, and any other systems or devices disconnected for test purposes.

MIXTURE ADJUSTMENT (VEHICLES WITH CATALYTIC CONVERTERS)

1. **Read and follow GENERAL TEST INSTRUCTIONS (ALL VEHICLES) through PRELIMINARY STEPS as listed above.**
2. Set the curb idle speed as specified by the vehicle emission control label or vehicle service manual.
3. With the engine fully warmed and operating at curb idle, observe the readings on the analyzer. Because the catalytic converter reduces HC and CO, these two (2) gasses are not a **true** indicator of the engine's emission levels. Note that these gasses are **reduced** by the converter, **not eliminated,** and therefore the readings can be helpful. The carburetor can be more accurately adjusted by observing O_2 and CO. A lean mixture is evident by excessive O_2, and a rich mixture is evident by low to no O_2 and excessive CO. If the mixture is rich, turn the mixture screw(s) clockwise to lean it; if the mixture is lean, turn the mixture screws counterclockwise to enrichen it. In the case of multibarrel carburetors, turn the mixture screws equally so that carburetor balance is maintained. Lean the mixture while observing the O_2 display. When O_2 begins to rise sharply, the engine has reached the point of lean misfire. At this point, enrichen the mixture until O_2 drops back, and CO is at a low level. (This should simultaneously bring CO_2 close to a maximum value and HC to a reasonably low level.) It may be necessary to readjust the curb idle speed during the mixture adjustment procedure. Check all idle adjustments when mixture adjustment is complete and reset as necessary.
4. When all adjustments are complete, be sure to reconnect the air injection system, and any other systems or devices disconnected for test purposes.

CARBURETOR MIXTURE TEST (HIGH RPM)

With the vehicle in neutral or park, run the engine at 2000 to 2500 RPM and observe the O_2 reading. The readings for vehicles with catalytic converters and mechanical carburetors should range from 1.0% to 4.0% O_2. Readings of over 4.0% O_2 indicate an excessively lean mixture, while readings under 1.0% indicate an excessively rich mixture. Electronically controlled carburetors should show less than 1.0% O_2, and approximately 1.0% CO to maintain good drivability and low emission levels.

AIR INJECTION SYSTEM TEST

The level of O_2 in the exhaust can be used to determine if the air pump is working on emission controlled vehicles. With the engine running and the air pump operating, observe the level of O_2 shown on the display. Disconnect the air pump or pinch off the outlet hose if possible. If the O_2 level drops by 2.0% to 5.0% from the previous reading, then the air pump is working correctly.

CATALYTIC CONVERTER TEST

On a properly tuned vehicle with a catalytic converter, the O_2 will be approximately equal to the CO. If the O_2 level exceeds the CO level, and the CO reading is above .5% then the catalytic converter is malfunctioning.

ACCELERATOR PUMP TEST

Adjust the engine speed to approximately 1000 RPM and allow the readings on the analyzer to stabilize. Snap accelerate the engine while observing the HC and CO displays. These readings should rise sharply and then return quickly to their original levels. If no significant increase is observed in these readings and/or the vehicle stumbles badly during heavy acceleration, it indicates that the accelerator pump is not operating correctly and the carburetor should be serviced accordingly.

MANIFOLD LEAK TEST

The analyzer can be used to detect air leaks into the intake manifold when a vacuum gauge indicates abnormally low engine vacuum or when a lean misfire in one or two cylinders is suspected. With the engine operating at curb idle, squirt a small amount of solvent (carburetor cleaner) along the gasket and bolts of the intake manifold and at the base of the carburetor. Apply the solvent to limited areas at a time allowing time for the analyzer to react. When HC and CO rise sharply, the location of the leak has been determined.

PCV VALVE TEST

Remove the PCV valve from the engine, but do not remove the hose leading to the intake manifold or base of the carburetor. Run the engine at idle while observing the CO and O_2 readings. If there is no change in the CO or O_2 readings, the PCV system is malfunctioning. An increase of 1.0% or more O_2, or a decrease of 1.0% or more CO, indicates too much crankcase dilution by either excessive blow-by gasses or a contamination of the oil by fuel.

INTERPRETATION OF THE READINGS

ENGINE CURB IDLE RPM RESULTS

Excessive CO readings can be caused by:

1. Over advanced initial ignition timing.
2. Idle mixture adjustment too rich.
3. Restricted PCV system.
4. Curb idle RPM too low.
5. Restricted air filter.

6. Leaking carburetor accelerator pump or power circuits.
7. Air pump inoperative.
8. Sticking choke.
9. Malfunctioning emission control systems.
10. Engine not at normal operating temperature (too cold).
11. Restricted vapor canister filter.

Excessive HC readings can be caused by:

1. Over advanced initial ignition timing.
2. Excessive oil consumption.
3. Low compression.
4. Leaking gaskets (intake manifold, carburetor area).
5. Defective valves, guides or lifters.
6. Defective rings, pistons or cylinders.
7. Idle mixture adjustment too lean (lean misfire).
8. Idle mixture adjustment too rich (incomplete combustion).
9. Malfunctioning emission control systems.
10. Engine not at normal operating temperature (too cold).
11. Vacuum leak.
12. Unbalanced carburetor (mixture adjustment, multiple barrel only).

Excessive HC and CO readings can be caused by:

1. Idle mixture adjustment too rich (incomplete combustion).
2. Malfunctioning carburetor.
3. Engine not at normal operating temperature (too cold).
4. Excessive fuel pump pressure.
5. Vacuum leak.
6. Improper valve adjustment.

Excessive O_2 with low CO readings can be caused by:

1. Air pump left connected during testing.
2. Idle mixture adjustment too lean.
3. Vacuum leak.
4. Curb idle speed improperly set.
5. Metering rods improperly positioned.
6. Internal air or vacuum leak in the carburetor.
7. Restricted idle system.
8. Restricted main metering system.
9. Exhaust system leak(s).

Excessive CO with low O_2 readings can be caused by:

1. Idle mixture adjustment too rich.
2. Restricted air filter.
3. Sticking choke.
4. Restricted air bleeds.
5. Restricted PCV system.
6. Curb idle speed improperly set.
7. Vapor canister malfunctioning.

Below normal CO_2 readings can be caused by:

1. Incorrect idle mixture adjustment.
2. Restricted air filter.
3. Sticking choke.
4. Exhaust system leak(s).

PERIODIC MAINTENANCE

SAMPLE HOSE AND PROBE ASSEMBLY

1. Inspect the hose for cuts or abrasions which may cause vacuum leaks.
2. Inspect the hose for kinking or crushed sections that may restrict exhaust flow.
3. Remove the sample hose from the primary filter fitting. Using compressed air, blow through the hose from the quick disconnect end to dislodge any dirt or carbon which may have accumulated inside of the hose. **Do not use compressed air on the analyzer or filtering system as internal damage may occur.**
4. Check the holes at the end of the sample probe to make sure they are free from dirt and carbon.

PRIMARY (LARGE) FILTER WITH DRAIN VALVE

1. Inspect this filter daily for accumulation of liquid or any foreign matter. The plastic filter bowl unscrews for easy cleaning. Do not allow the liquid level to rise above the baffle in the filter bowl.
2. The drain valve located in the spring guard at the end of the drain hose should require minimal maintenance. This valve will open to drain water only when the pump is not running (**standby**, **calibrate**, or unit turned **OFF**). If air bubbles are observed in the drain hose near the valve when the analyzer is in the **RUN** mode, switch the analyzer to **STANDBY** and allow all water to drain. If the problem persists, remove the drain valve and flush it out with warm water.

SECONDARY (SMALL) FILTER

1. Inspect this filter daily for accumulation of liquid or any foreign matter. The filter element should be replaced when it becomes significantly discolored.
2. Remove the filter as follows:
   A. Pull the filter assembly from its retaining clip on the back panel.
   B. Grasp the filter housing top with one hand and the bottom with the other hand, and twist the two (2) halves apart (approximately 1/8 turn).
   C. Remove the old filter element and replace it with a new one.
   D. Flush the mesh filter element with warm water, or if it is beyond cleaning, replace it with a new one.
   E. Re-assemble the filter following the diagram on the back panel of the analyzer.
   F. Snap the filter assembly back into its retaining clip.

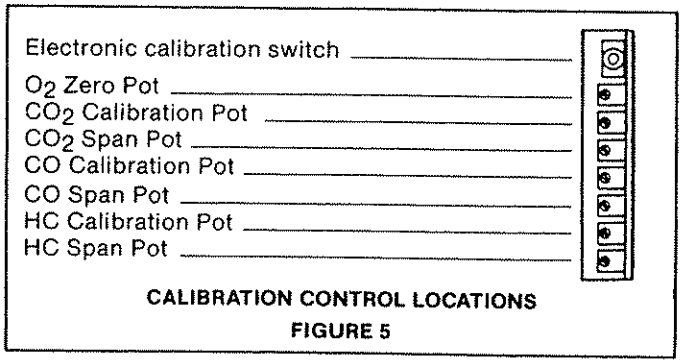
CALIBRATION

Your analyzer left the factory completely calibrated with known concentrations of the required gasses. The analyzer may be re-calibrated on location either with or without gas. When the analyzer is calibrated with gas,

these known gas values are not only used to calibrate the analyzer, but are also adjusted into the analyzer's micro-computer. When the analyzer is re-calibrated without calibration gas, these values are recalled from the micro-computer and used to re-calibrate the analyzer. As is evident from this explanation, until you re-calibrate the analyzer with calibration gas the first time, the calibration procedure without gas will be based upon the original factory gas calibration. Although the calibration procedure without gas will restore accuracy to the "electronics" portion of the analyzer and is recommended at regular intervals, it cannot compensate for deterioration (dirt, aging, etc.) in the optical section of the analyzer as the gas calibration will.

CALIBRATION PROCEDURE (WITHOUT CALIBRATION GAS) (FIGURE 5)

1. Allow the analyzer to warm up for at least thirty (30) minutes with the pump running.
2. Remove the calibration control cover on the left side of the analyzer to expose the internal calibration adjustments.
3. Push the front panel **CALIBRATE** switch and allow the unit to complete its calibration cycle.
4. Push the electronic calibration switch. See Figure 5 below.
5. Allow the LCD displays to stabilize.
6. Adjust the O_2 control pot to 0.0% on the display.
7. Adjust the CO_2 span pot to 13.0% on the display.
8. Adjust the CO span pot to 8.00% on the display.
9. Adjust the HC span pot to 1600 PPM on the display.
10. Push the front panel **CALIBRATE** switch and allow the unit to complete its calibration cycle.
11. Re-install the calibration control cover.



CALIBRATION CONTROL LOCATIONS
FIGURE 5

CALIBRATION PROCEDURE (WITH CALIBRATION GAS) (FIGURES 5 & 6)

NOTE

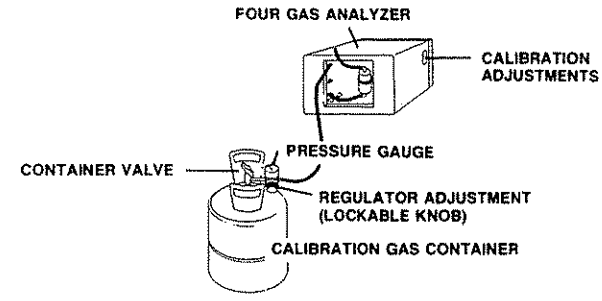
As indicated above, the only way to calibrate the optical section of the analyzer is with calibration gas. The calibration gas necessary to calibrate your instrument is available through your dealer or representative. This gas is supplied in a typical propane style container, but is **non-refillable.** One tank of calibration gas will provide approximately 80 minutes of use with the regulator set at the recommended pressure of 10-15 psi.

NOTE

Before performing the gas calibration test, it is necessary to calculate the Hydrocarbon (HC) reading to which the HC display will be adjusted. This is done by multiplying the propane reading listed on the gas calibration tank times (x) the propane equivalency factor listed on a sticker on the back of the analyzer near the secondary filter.

EXAMPLE:
Unit propane equivalency factor = .51
Gas container propane listing (PPM) = 3000
.51 x 3000 = 1530

In this example the HC display would be adjusted to read 1530 PPM.



GAS CALIBRATION DIAGRAM
FIGURE 6

1. Allow the analyzer to warm up for at least thirty (30) minutes with the pump running.
2. Push the front panel **CALIBRATE** switch and allow the unit to complete its calibration cycle.
3. Set the analyzer to the **STANDBY** mode of operation.
4. Disconnect the top filter hose from the top fitting on the analyzer.
5. Connect the hose from the calibration gas tank/-regulator to the top fitting on the analyzer.
6. Remove the calibration control cover.

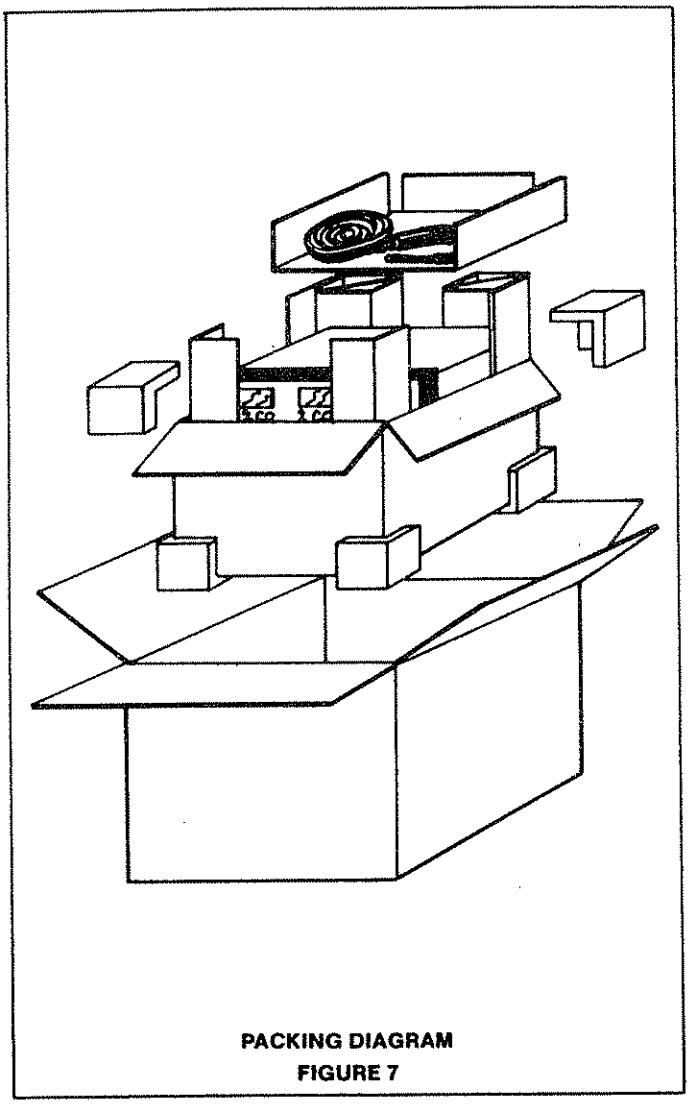
7. Turn on the gas container valve. Adjust the regulator for a gas pressure of 10-15 psi and allow the displays to stabilize.
8. Adjust the CO_2 span pot until the CO_2 display equals the amount of CO_2 shown on the container.
9. Adjust the CO span pot until the CO display equals the amount of CO shown on the container.
10. Adjust the HC span pot until the HC display equals the value calculated as instructed in the note above.
11. Turn off the valve on the gas container, and remove the gas container hose from the top fitting of the analyzer. Reconnect the top filter hose.
12. Push the analyzer's **RUN** switch. Allow the instrument to run for a minimum of one (1) minute to exhaust all calibration gas.
13. Push the front panel **CALIBRATE** switch and allow the unit to complete its calibration cycle.
14. Push the electronic calibration switch.
15. Allow the LCD displays to stabilize.
16. Adjust the CO_2 calibration pot until the CO_2 display reads 13.0%.
17. Adjust the CO calibration pot until the CO display reads 8.00%.
18. Adjust the HC calibration pot until the HC display reads 1600 PPM.
19. Push the front panel **CALIBRATE** switch and allow the unit to complete its calibration cycle.
20. Re-check the calibration by pushing the electronic calibration switch. The displays should indicate as follows:

Oxygen	O_2	.0%
Carbon Dioxide	CO_2	13.0%
Carbon Monoxide	CO	8.00%
Hydrocarbon	HC	1600 PPM

21. Re-install the calibration control cover.
22. Push the front panel calibrate switch and allow the unit to complete its calibration cycle. The analyzer is now ready for use.

PACKING MATERIALS

Do not discard any of the packaging from your analyzer! You have purchased a precision and delicate instrument. In the event that it ever needs to be returned to the factory for service, package it carefully in the original shipping containers to ensure maximum protection. See Figure 7 below.



PACKING DIAGRAM
FIGURE 7

TROUBLESHOOTING GUIDE

SYMPTOM	SUGGESTED SOLUTION
Unit will not turn on	Check fuse—if defective, replace only with a 6 amp, 250 volt type. If replacement fuse blows, analyzer needs to be serviced. Check power cable polarity—RED to (+), BLACK to (-). Check power cable connection at unit. Check power cable with ohmmeter for continuity. Power switch in ON position. If using external 115 VAC power supply, check that indicator light on power supply is ON. Check outlet for 115 VAC, tripped breaker, etc. If indicator light is on, check for 13 to 16 Volts DC at power supply connector. If no or low volts at connector with indicator light on, power supply needs to be serviced.
Not all display segments and function LEDs are lit on initial power up	Analyzer needs to be serviced.
Displays will not change (frozen)	Turn analyzer OFF, wait five (5) seconds and turn back ON. If the analyzer is being powered from the external power supply, make sure that the 115 VAC supply is "electrically clean." Heavy duty equipment such as air compressors can cause line voltage drops when they start up.
Low flow **(LO FLO)**	Check sample hose and probe for blockage. Check primary and secondary filter assemblies and associated plumbing for cleanliness, blockages, and connection integrity. Remove top left hose from rear of analyzer (indicated by gas calibration sticker). If low flow indication persists, the analyzer needs to be serviced.
Low battery **(LO BAT)**	Battery (or power supply) voltage is too low for proper operation. See **LIQUID CRYSTAL DISPLAY (LCD) MESSAGES**, No. 7 earlier in this manual for a complete explanation.
Pump runs, but no suction at sample hose—no **LO FLO** indication	Remove top left hose from rear of analyzer (indicated by gas calibration sticker). (Analyzer must be in **RUN** mode.) Place finger over fitting on analyzer. If suction is felt and **LO FLO** indicator comes on, the pump and all internal plumbing are functioning properly. Check for correct and tight hose connections, filters properly assembled and tight ("O" rings in place) and duck bill drain valve in place and not leaking.
CO, CO_2, and HC read low, while O_2 remains excessively high **during vehicle testing**	Air leak in sample hose/filter/plumbing system which is allowing outside air in with the exhaust gas and is thereby diluting it.
Analyzer will not come out of **CAL** mode, **calibrating** LED flashes	Push the **run/standby** switch to force the analyzer out of the **CAL** mode. Observe the displays for the error **(ERR)** message. The display(s) that shows the error **(ERR)** message did not self calibrate properly. Push the front panel **calibrate** switch to attempt the self calibration cycle again. If this fails, perform the electronic or gas calibration procedure. If this fails, the analyzer needs to be serviced.
HC wanders erratically in standby (or run with sample probe in fresh air).	It is normal for the HC display to vary from approximately -10 through 0 to +10. If the variation is greater than this, check for other sources of hydrocarbons such as spilled gasoline, oil, kerosine, etc. or shop rags still wet from any of these petroleum products. In a multi-bay shop, check for other vehicles whose engines may be running poorly or whose tailpipes are not vented to the outside.

REPLACEMENT PARTS

KEY NO.	PART NO.	DESCRIPTION
1	60 84920	Sample Probe Flexible Metal Hose
2	60 84900	Sample Probe Handle Assembly
3	60 06300	Sample Hose (25 ft.)
4	60 55710	Quick Connect Female Hose Connector
5	60 59250	Secondary Filter Assembly—Complete
6	400-1416	Primary Filter Assembly—Complete
7	1000-2469	Secondary Filter Elements Package
8	180-915	Spring Guard
9	400-1417	Duckbill Valve
10	400-1418	Nylon Tubing
11	01 71891	Battery Cable
	60 90550	Fuse (6 Amp 250 Volt) *(Not illustrated)*
	60 97237	Oxygen Sensor *(Not illustrated)*
	2-1990	Instruction Manual *(Not illustrated)*

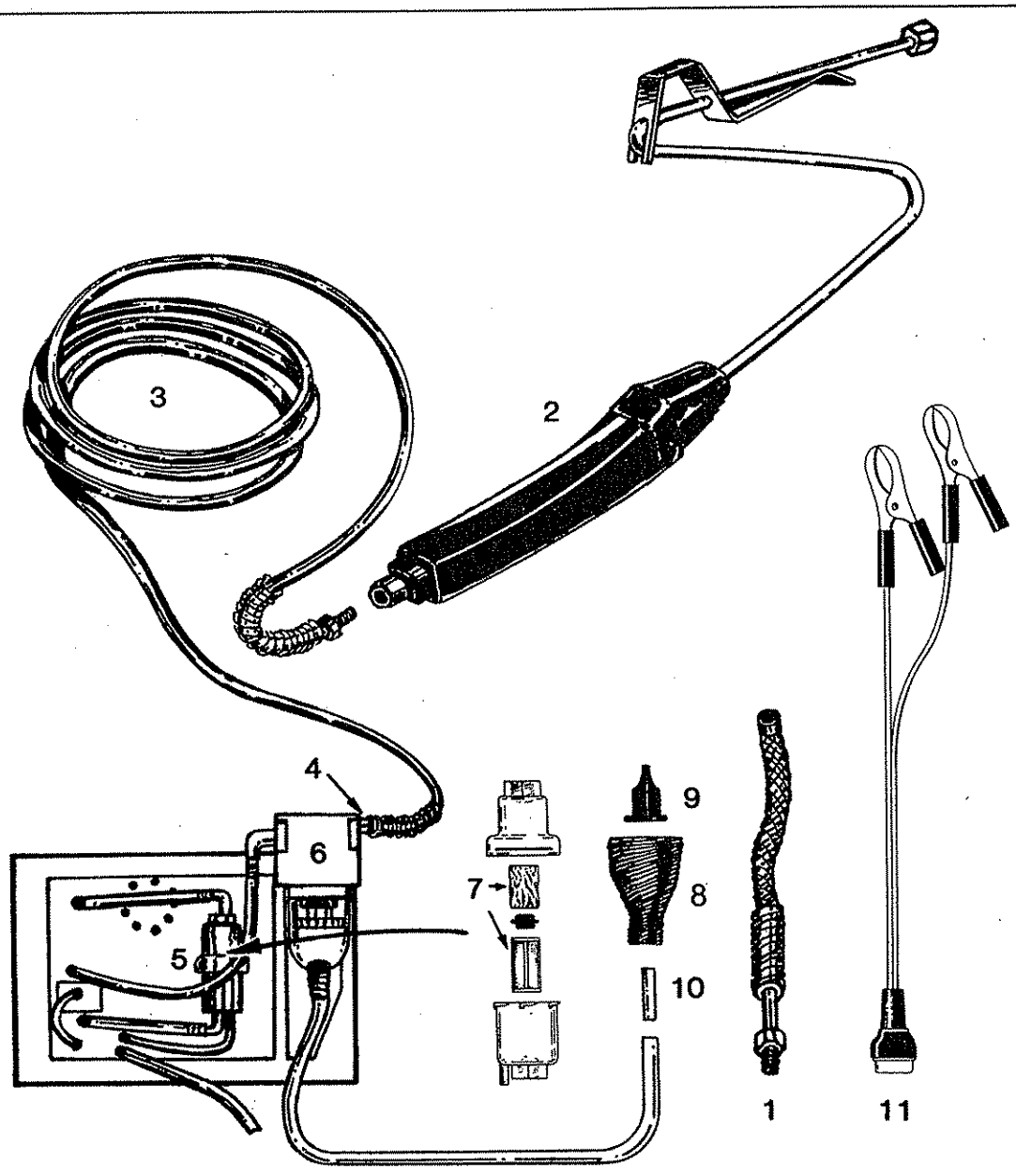


FIGURE 8

KAL EQUIP 4650 ACCESSORY CHECK-OFF SHEET

ACCESSORY CARTON			
DESCRIPTION	PART NUMBER	QTY	CHECK
INSTRUCTION MANUAL	2-1990	1	
POWER CORD	38-1772	1	
PRIMARY FILTER KIT	1000-2254	1	
DUST COVER	400-1455	1	
EXH. GAS SAMPLE HOSE 25'	60 06300	1	
EXH. GAS SAMPLE PROBE HANDLE	60 84900	1	
EXH. GAS SAMPLE FLEX HOSE	60 84920	1	
CARDBOARD INSERT TRAY FLAT	4-2133	1	
WARRANTY CARD	2-1916	1	

PACKED BY:_____ DATE:_____

KAL EQUIP 4650 ACCESSORY CHECK-OFF SHEET

ACCESSORY BAG			
DESCRIPTION	PART NUMBER	QTY	CHECK
SECONDARY FILTER ELEMENT	60 59240	2	
FILTER ELEMENT	60 02810	1	
COUPLING FEM. Q.D. 1/8 PIPE	60 55710	1	

PACKED BY:_____ DATE:_____

2-217101

ORIGINAL

f/n: AP185

Model #4650 Reference Guide

HEL LO ---- Displayed across the %CO and %CO2 displays during the warm-up period.

CAL ---- Displayed on all displays whenever the analyzer is in calibration mode.

LO FLO ---- Displayed across the % CO & % CO2 displays. CHECK sample hose, filters, & Plumbing for a restriction or clog.

ERR ---- Error in calibration or if the analyzer's optical system becomes fogged with moisture. If This occurs, remove, empty, & reinstall the filters, reason they might contain water. Disconnect the sample hose from the primary filter & allow the unit to operate in the RUN mode. This will draw in fresh air & dry out the optical system.

UUU ---- Push the front panel CALIBRATE switch.

OOO ---- The same as "ERR".

LO BAT ---- Will display % O2 indicates that the power source is to LO to power the unit. It's below 12.2 volts.

DEFINITIONS

(HC) HYDROCARBONS ---- Unburned fuel from the tailpipe measured in parts per milliom (PPM). "CAUSES" Insufficient spark or incorrectly timed spark are common ignition problems. Catalytic converters reduces HC readings.

(CO) CARBON-MONOXIDE- Insufficient oxygen to burn the fuel. "CAUSES" Dirty air filter, sticky choke, improper float setting or rich idle mixture setting. Fuel injector engines, leaky injectors. Catalytic conv. Will reduce CO readings.

(CO2) CARBON-DIOXIDE--- Optimum range is 12% to 15%. If not in Range HC & CO are not displaying incorrectly.

(O2) OXYGEN ---- If AIR/FUEL ratio is lean to the point of misfire O2 levels rises quickly. "CAUSES" CO is low, O2 is high and HC is high and unsteady, the engine is in a Lean Misfire condition.

(A/F) AIR/FUEL RATIO ---- The ideal A/F ratio is known as the STOICHOMERIC mixture which is 14.7 lbs. of air to 1 lb of fuel (commonly expressed 14.7 to 1).

NOTE: Not recommended for Diesels.
When using Propane fueled vehicles, CO, CO2 and O2 are read directly as Displayed. The HC reading is obtained by dividing the displayed reading by the propane equivalency factor listed on a decal on the rear panel of the unit next to the secondary filter assembly.

Example ------ Unit propane equivalency factor = .51

Displayed reading = 300

300 / .51 = 588 PPM

Hydro-Carbons are 588 Parts Per Million