

Owner's Manual

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INTRODUCTION

TIF5GA

The TIF5GA is a hand-held instrument designed to measure automotive exhaust emissions from vehicles with spark-ignition engines powered by gasoline, alcohol, compressed natural gas (CNG) or liquefied gasolineeum gas (LPG).

WARNING!

It is not intended for use on diesel-powered vehicles or other compression ignition engines, where serious damage would occur to the measuring system.

The analyzer uses non-dispersive infra-red absorption to measure and display the volume concentrations of hydrocarbons (HC), carbon monoxide (CO) and carbon dioxide (CO₂). The concentration of oxygen (O₂) and oxides of nitrogen (NOx) are measured by electrochemical sensors. The analyzer also calculates and displays airfuel ratio or Lambda.

The analyzer has a data capture facility that allows it to store up to 480 measurement screens at sample intervals from one to ten seconds, allowing emissions to be measured over a period of up to 1 hour 20 minutes. This is a major benefit when carrying out emission measurements under load conditions, e.g. on road test or dynamometer tests. The stored data can be reviewed on screen, printed out in tabular format or uploaded to a PC.

The analyzer is powered direct from the host vehicle 12V battery using alligator-clip type connectors, or via the cigarette lighter socket. Two warm-up periods are available, allowing the user to choose between a one-minute warm-up time which is sufficient for general diagnostic work or a ten-minute warm up period where more accurate readings are required. After either of the warm up periods the analyzer automatically reverse flushes the pneumatic system and zeroes the analyzer prior to measurements taking place.

A user-friendly menu system allows the changing of system parameters and adding a print header or message to the printout.



Figure 1. General View Of Analyzer

OVERVIEW OF THE ANALYZER.

Description

The analyzer is a hand held instrument housed in an ABS enclosure. It comes complete with all ancillary leads and probe assembly and is contained in a rugged carrying case.

Figure 1 is a plan view of the analyzer showing the display and control panel. The display is an alphanumeric liquid crystal display (LCD) and has four lines of twenty characters. It is back-lit for viewing in poor light and contrast control is provided. The illustration shows the normal measurement display.

The multifunction membrane keypad is a domed tactile type with positive feel and is easily cleaned. An audible beeper indicates when a key has been pressed.

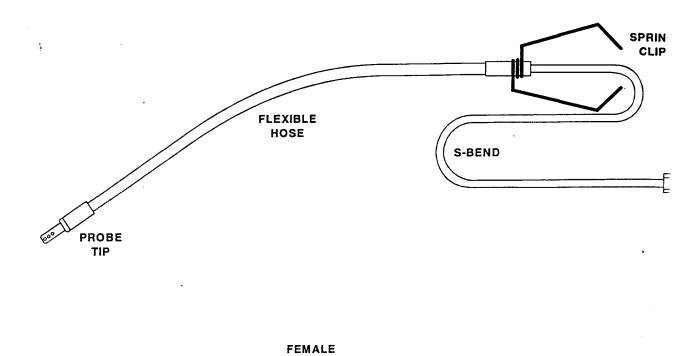
The analyzer is fitted with a parallel printer port and an RS-232 compatible serial port for a serial printer or for interfacing to a PC.

A 12V socket allows the removal of the power lead when not in use.

The sampling probe assembly is illustrated in figure 2. It consists of the following components:

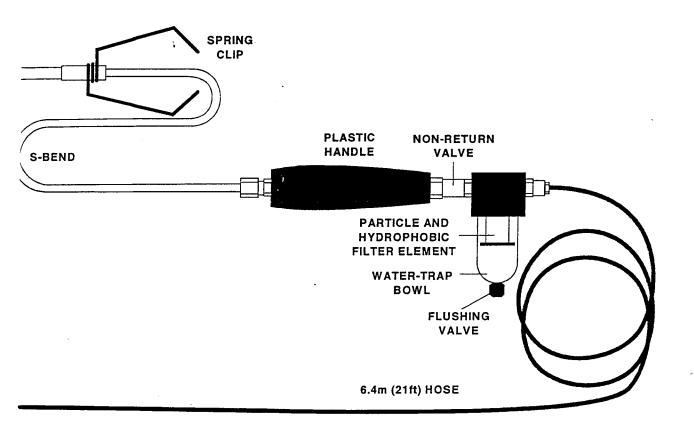
- brass sample tip with sampling ports in the side walls
- · flexible hose assembly for insertion in vehicle exhaust
- · spring retaining clip
- · stainless steel S-bend
- plastic handle
- non-return valve
- Filter bowl with particle/hydrophobic filter and water flush valve
- 6.4 metre (21ft) hose with quick connect female connector

The probe assembly is connected to the analyzer by way of a quick coupling, which can be removed for easy storage. The probe handle is fitted with a filtration assembly, which can be dismantled for maintenance.



SNAP-ON CONNECTOR

Figure 2. Probe Assembly



KEYPAD FUNCTIONS

Standby Key

When pressed during normal display mode, this key turns off the pump to prolong its life, but the electronics remain powered up. Normal measurement can be resumed by pressing any key. The auto-zero timer continues to run during standby, so if the unit is in standby for more than 10 minutes, a zero will be performed on resuming normal operation.

Review, Back, Forward and Cue Keys

These keys are used for the data recording function and menu operations. Their function varies according to the operating mode and is described in more detail later.

Record/Index Key T

When pressed during normal display mode, this key starts data recording. If it is pressed again during recording an index mark will be added to the next screen stored and the index number will be increasesed.

Stop Key

This key is used to stop data recording or playback and also to cancel various menu operations before they are completed.

Print Key

When pressed during normal display mode, or data playback mode, this key activates the print function. A menu screen then offers a choice of print options.

Zero Key ZERO

When pressed during normal display mode, this key makes the analyzer perform a zero and resets the auto-zero timer.

Up Cursor Key 🛕

When pressed during normal display mode, this key lightens display contrast. In various menu modes it is used to increases the value of numbers or other characters.

Menu Key MENU

When pressed during normal display mode, this key selects the main menu for setting up the analyzer.

Help Key HELP

When pressed during normal display mode, this key puts the analyzer into on-screen help mode. Pressing any other key after pressing HELP displays the function of that key. Pressing HELP again returns to normal operation.

Down Cursor Key ▼

When pressed during normal display mode, this key darkens display contrast. In various menu modes it is used to decreases the value of numbers or other characters.

Enter Key 🙀

This key is used to confirm completion of an operation in the various menu modes.

GAS SYSTEM CONDITIONING

Sampling Probe

The probe tip takes exhaust gas into the system through six entry ports in the sidewall of the tip. The gas is fed to the analyzer first through the filter assembly then via the probe hose, which terminates at a quick coupling. When in the zero mode the analyzer takes in ambient air through a charcoal filter to remove any contaminants that could affect the zero reading. This filter is housed within the analyzer. Every time a zero is carried out a reverse flushing procedure takes place which empties the filter housing of collected water through an automatic release valve at the base of the filter.

SAFETY PROCEDURES

Warnings & Cautions

- Follow all safety warnings and cautions in this operator's manual.
- Always operate the analyzer in a well-ventilated area.
- Running an engine indoors without providing adequate ventilation can cause Carbon Monoxide poisoning resulting in nausea, dizziness and or death.
- When carrying out work around a running engine always adhere to safety pre
 cautions, do not wear loose fitting clothes near rotating engine parts and where
 applicable, always wear safety goggles.
- Use extreme caution when working near hot exhaust systems, radiators, etc. Use
 the insulated handle when removing the probe from the exhaust, the probe tip
 can become extremely hot.
- Warning: use extreme caution when working near high-tension circuits, ignition coils, spark plug leads, etc., these components can cause severe injury.
- Do not use carburetor sprays or fuel injection cleaning fluids when carrying out emission tests, inaccurate readings may occur if they become ignited.
- The gases produced by a battery are highly explosive.
- Smoking, naked flames or sparks near a battery could cause an explosion.
- Always apply the handbrake on the vehicle under test and in the case of automatic transmission vehicles put into the park position.
- Do not place the analyzer on a hot surface or place in a position where vibration could dislodge it.

PREPARING FOR MEASUREMENT

Preparing The Vehicle

Ensure the area where the vehicle is to be tested is well ventilated, remember that vehicles emit poisonous carbon monoxide, which can seriously damage health.

Bring the vehicle up to normal operating temperature before carrying out any emission tests.

Power Up

While the vehicle is warming up, connect the analyzer to the host vehicle's 12V supply. A two function power cable is supplied. One part contains the two battery post clips terminating in a cigarette lighter type socket, the second part contains a cigarette lighter plug terminating in the analyzer power connector. To use direct from the host vehicle battery, join the two parts together and plug directly into the analyzer jack plug located at the front of the analyzer, a knurled threaded collar secures this end to the analyzer. Alternatively, if using, on a road test separate the two leads and plug the cigarette lighter plug into the vehicles lighter socket. A red LED will illuminate on the cigarette lighter plug to show power is on in either configuration. There is no power switch on the analyzer, once power is supplied the display screen will illuminate and show the first screen message.

While the analyzer is warming up, place the probe in the exhaust tailpipe ensuring that the spring clip connects to the inner walls of the pipe and the filter bowl assembly hangs down vertically. Connect the quick coupling to the analyzer input connector, (note; the quick coupling will only connect to the appropriate gas inlet which is fitted with an "O" ring). The remaining connector on the analyzer is the waste exhaust gas outlet, ensure this is not covered or blocked.

Initial Screen Prompts and Warm-Up Sequence

On powering up the analyzer, the following start-up screen will appear for about two seconds.

TIF 5GA
EXHAUST GAS ANALYZER

The start-up screen is followed by the language selection screen. The currently selected language has an asterisk to the left of it. If you wish to select a different language you have two seconds to do so by pressing the appropriate key. After this the analyzer goes into its warm-up procedure.

*ENGLISH	PRESS	4-4
DEUTSCH	PRESS	-4
ESPANOL	PRESS	₽
FRANCAIS	PRESS	++

^{*}Note: Languages available will depend on the country where the analyzer was purchased.

After the language selection screen, a warm-up selection screen appears.

FOR EXTENDED WARMUP
PERIOD (10 MIN.)
PRESS ANY KEY

If you require an extended, 10 minute warm-up, press any key. If a key is not pressed, after two seconds the analyzer automatically goes into a one-minute warm-up. It is recommended that 10 minute warm-up be selected if the analyzer has been switched off for more than 5 minutes. If you are simply moving the analyzer directly from one test vehicle to another, one-minute warm-up is adequate.

The analyzer will now go through its automatic sequence of warming up, backflushing the probe, sampling ambient air and zeroing the analyzer.

Warming Up

Backflushing

Sampling Ambient

Zeroing

After warm-up and zeroing, the normal measurement screen is displayed.

CO) 0.36	HC) 732
CO2}13.83 A/F}14.30	02) 1.19 NOX) 418
1999/02/17	10:32.34

The following parameters are displayed:

- CO % vol.
- HC ppm vol.
- CO₃ % vol.
- O, % vol.
- A/F or Lambda
- Date Year/Month/Day
- Time Hours: Minutes. Seconds (24 hour format)

BASIC FUNCTIONS

Setting Display Contrast

The display contrast may be set at any time that the normal measurement screen is displayed. To make the display lighter, press . To make the display darker, press

The optimum contrast setting is when the display characters are solid black but the rectangular outline of the character matrix cannot be seen.

Once the display contrast has been set, the setting is stored in non-volatile memory and does not need to be set again, even if power to the analyzer is disconnected. The only time contrast may need to be re-adjusted is if there is a big change in temperature, which can affect display contrast.

Standby Mode

Whenever the analyzer is switched on but not being used, it should be placed in standby mode by pressing (1).

STANDBY MODE
PRESS ANY KEY FOR
NORMAL OPERATION

This turns off the pump to prolong its life, but the electronics remains powered up and normal display may be resumed by pressing any key. During standby mode, the auto-zero timer keeps running, so that a zero will be performed on exiting standby if the analyzer has been in standby for more than 10 minutes. The pump is also switched off during all menu operations except calibration, but the auto-zero timer does not run during these operations.

Manual Zero

The zero reading of each measurement parameter will drift slightly with time and temperature. Automatic zeroing is performed every 10 minutes, but the zeroing sequence can be called up at any time by pressing ZERO. Pressing ZERO resets the auto-zero timer, so the next auto-zero will be performed 10 minutes after the manual zero.

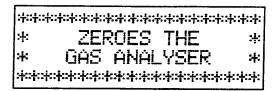
Help

On-screen help provides information about the function of each key. To activate help, press HELP followed by any other key, e.g.

Press HELP. The help information screen will appear.

PRESS A KEY TO GET HELP ABOUT THAT KEY. PRESS HELP AGAIN TO QUIT.

Press ZERO. The help screen for the zero key will appear.



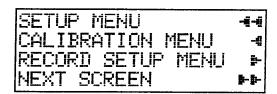
Any number of keys may be pressed to get help about each one, before pressing again to return to normal display.

SETTING UP THE ANALYZER

The analyzer has been set up and calibrated at the factory. However, you may wish to customise the setup to suit your own requirements.

Changing The Fuel Type and Air-Fuel Display

The analyzer calculates and displays air-fuel ratio or Lambda for up to four different types of fuel. To change the type of fuel or air-fuel display, press MENU. The following screen will appear:



Press to select the SETUP MENU.



To change the fuel type press \bigcirc or \bigcirc . Four fuel types are available:

- GASOLINE
- ALCOHOL
- CNG (Compressed Natural Gas)
- LPG (Liquefied Gasolineeum Gas)

To change the air-fuel display, press to select 1 or to select air-fuel ratio.

Once you have made your selection, you may press to confirm the selection and return to the normal display, or press if you wish to cancel the operation and abandon the changes.

If, however, the fuel used by the vehicle has a non-standard composition, you may wish to change the hydrogen constant (H_{cv}) and oxygen constant (O_{cv}) of the fuel. You should only do this if you know the H_{cv} and O_{cv} values of the fuel, as changing H_{cv} and O_{cv} may affect the accuracy of the air-fuel calculation.

To change HCV and OCV, press | The following screen will appear:



The following keys are used to change the values of these parameters:

- increases a digit.
- decreases a digit.
- moves the flashing cursor to the next digit.
- moves the flashing cursor to the previous digit.
- skips to start of O_{cv}.
- skips back to start of H_{cv}.

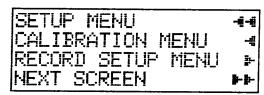
When the values are correct, press to save the new values and return to the main display, or press figure if you wish to cancel the operation and abandon the changes.

Changing Data Capture (Recording) Parameters

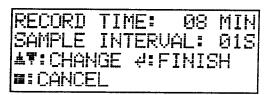
The data capture facility allows up to 480 screens of data to be recorded. Measurements may be taken at intervals from one second to 10 seconds, allowing recordings from 8 minutes maximum length up to 80 minutes maximum length.

To set the record parameters:

Press MENU. The following screen will appear:



Press to select RECORD SETUP MENU. The following screen will appear:



Press to increases the sample interval and to decreases the sample interval, the total record time will change accordingly.

Once you have set the record time and sample interval, press U to save the new values and return to normal display, or press if you wish to cancel the operation and abandon the changes.

Note: Changing the record setup erases any previously stored data.

Setting The Clock

The analyzer's built-in clock is provided to date and time stamp printouts. It is year-2000 compliant up to 2089 and displays date and time in the format:

YYYY/MM/DD HH:MM.SS.

The clock is powered by a lithium battery with a lifetime of approximately 5 years.

To set the clock:

Press MENU. The following screen will appear:



Press to select NEXT SCREEN.



Press to select SET CLOCK MENU. The following screen will appear:



The following keys are used to set the date and time:

- increases a digit.
- decreases a digit.
- moves the flashing cursor to the next digit.
- moves the flashing cursor to the previous digit.
- skips to start of TIME.
- skips back to start of DATE.

Note: Thousands and hundreds of years cannot be changed manually but change automatically depending on tens of years value. Seconds cannot be changed but are reset to zero on return to normal display.

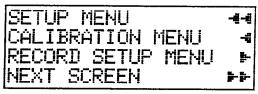
Once you have set the date and time, press [H] to save the new values and return to normal display, or press [III] if you wish to cancel the operation and abandon the changes.

Changing The Print Header

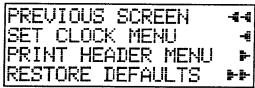
The analyzer can store a print header consisting of 4 lines of up to 20 characters. This is printed at the top of any printout from the analyzer.

To change the print header:

Press MENU. The following screen will appear:



Press to select NEXT SCREEN. The following screen will appear:



Press to select PRINT HEADER MENU. A help screen appears for about two seconds, then the print header screen appears.



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The following keys are used to change the print header:

advances a character.
advances a character.
moves the flashing cursor to the next digit.
moves the flashing cursor to the previous digit.
skips to end of line.
skips back to start of line.
Once you have changed the print header, press [] to save the new header and
return to normal display, or press if you wish to cancel the operation and abandon the changes.

Notes:

The print header may be programmed in only one language. It does not change if the display language is changed.

Only ASCII characters may be put into the print header. Other characters may be downloaded using the optional PC interface software, but it is up to the user to ensure that they display and print correctly.

Restoring Factory Defaults

This menu option allows the following parameters to be returned to their factory settings:

Fuel	Gasoline
Air-Fuel Display	A/F for USA, Lambda for Europe
H_{cv}	1.726
H _{cv} O _{cv}	0.018
CO Tag Value	5.00%
HC Tag Value	2000 ppm
NO _x Tag Value	1000 ppm
*Recording Time	8 minutes

1 second

To restore factory defaults:

*Sample Interval

Press MENU. The following screen will appear:



Press to select NEXT SCREEN. The following screen will appear:



^{*}Note: Restoring defaults erases any data stored in the data capture memory.

Press | again to select RESTORE DEFAULTS. The following screen will appear:



Press to restore factory settings and return to normal display, or press you wish to cancel the operation.

DATA CAPTURE (RECORDING)

The data capture feature allows the analyzer to capture and store up to 480 screens of data. It works just like a tape recorder. You can start a recording, stop it, restart it, stop it again, play it back, forward wind and rewind it. You can also add index marks to divide the recording into different segments for easy identification, just like different "tracks" on a tape recording. This is particularly useful when you want to record engine performance under a number of different driving and/or load conditions.

Finally, the recorded data can be printed out, or uploaded to a PC when you return to base. The data is stored in non-volatile memory, so it is saved even when the analyzer is switched off and will stay in the memory until you overwrite it with a new recording.

The RECORD SETUP menu allows you to set the sample interval, i.e. the number of seconds between each measurement. This also determines the total recording time (maximum recording time = 480 x sample interval). The sample interval can be set from one to ten seconds, in one second increasess, giving recording times from 8 minutes to 80 minutes. If you want to record frequent changes in the measured data you should set the sample interval to a low value. If, on the other hand, you want to record for a long time, you should set the sample interval to a high value.

Starting A New Recording

To start a new recording from the beginning of the "tape" (i.e. beginning of memory), you must first check that the sample interval and record time are set correctly, as described on page 16, then make sure that the "tape" is "rewound". There are two ways of doing this:

 Select the RECORD SETUP MENU, change the record time and sample interval if necessary, and press enter. This will erase any old data and reset the recording to the start of memory.

2.	Press to enter playback mode, then press and hold until the TIME read 00:00. Press to return to normal display. Press to start recording. The following screen will appear:
	CO} 0.36 HC} 732 CO2}13.83 O2} 1.19 A/F}14.30 NOX} 418 TIME:10:36 INDEX:▶02
	The time display at the bottom left of the screen will start off at the set recording time and will decreases in I second intervals.
	Note that the time display is just a timer that indicates the recording time remaining. It does not correspond to the sample interval, except where that is 1 second. For example, if the sample interval is set to 4 seconds the time will start at 32 minutes and count down in seconds, but measurements will only be taken at 32:00, 31:56, 31:52 etc.
	If you wish to mark a particular event, press again. This will put an index mark on
	the <i>next</i> screen saved, and will increases the index number. This is analogous to having different tracks on a normal tape recording. The index mark tags the start of the "track" and the index number identifies which "track" it is.
	As the index function tags the next screen to be recorded, it is important to ensure that
	the recording continues for at least one sample interval after is pressed, otherwise
	the index mark will not be registered.
	To stop the recording at any time, press . To re-start the recording, press again. The recording will continue from where it left off.
	The analyzer does not perform auto-zeroes during data capture, so it is recommended that long recording sessions should be broken up into several segments if possible and a manual zero performed between each segment.

Memory Full

Once the record time has counted down to zero the memory wil be full and no further recording can take place. The following screen will appear:



Press to stop the recording and return to normal display mode.

Replaying A Recording

To replay a recording, first stop the recording by pressing

Enter playback mode by pressing any of the four keys . The following screen will appear:

CO> 0.36	HC)	732
(002)13.83	02)	1.19
A/F)14.30	NOX)	418
TIME: 10:36	INDE:	<: - 02

These keys now control the playback as follows:

- (Review) skips back to the screen with the previous index mark.
- (Back) steps back one screen.
- (Forward) steps forward one screen.

(Cue) skips forward to the screen with the next index mark.

The elapsed time is shown on the left of the display. When or is pressed, this increases or decreases by a time equal to the sample interval.

Continuing A Recording

To continue a recording after playback it is first necessary to "forward wind" to the end of the recording. If this is not done, the new recording will erase all or part of the old recording. To do this, press and hold, until the TIME display ceases to increase.

PRINTING

The analyzer can print to either the serial or parallel data port. The recommended printer is the optional serial printer model TIF5GA-2. Other types of printer may be suitable, but this is not guaranteed.

The following data can be printed:

The currently displayed screen can be printed from either normal display or from data playback mode.

The contents of the data memory can be printed in tabular format from either the normal display or from data playback mode.

To print, first ensure that the printer is connected and on-line, then press following screen will appear:



Press | to print the current screen to the parallel port.

Press to print the current screen to the serial port.

Press to print the data memory to the parallel port.

Press | to print the data memory to the serial port.

CALIBRATION

Field calibration of the analyzer should be carried out every 6 months, using certified calibration gases.

Procedures And Precautions When Using Calibration Gases

The analyzer should be warmed up for at least 15 minutes before performing a calibration.

Gases used for calibration are toxic and/or flammable. The calibration area should be designed so that sample gas cannot leak into the atmosphere and that gas from the analyzer exhaust port is extracted safely. Apart from health hazards, calibration gases in the atmosphere will get into the ambient input and affect the zero, so the air in the calibration area should have a ventilation system to give frequent changes.

Calibration gas from the cylinder should be supplied to the analyzer at atmospheric pressure via a gas bag with an inlet and outlet port. Do not force gas into the analyzer under pressure as this will give invalid readings and may damage the pump and sensors.

Gas expanding from the cylinder will cool, so the procedure is to fill the gas bag from the cylinder whenever it falls below about one-quarter full, and to let it reach ambient temperature before doing a calibration. The first filling of a new bag will be contaminated by air in the tubing and should be discarded by sucking the gas out of it with the analyzer. This procedure should also be followed if air has got into a bag due to the one of the ports being open to atmosphere.

The connection hose to the analyzer should be as short as possible. It should be fitted with a manual on-off cock close to the female inlet port connector, and a non-return valve. This is to prevent air getting into the calibration gas if a backflush (zero) is accidentally performed with the sample gas connected.

Calibration accuracy is affected by temperature and barometric pressure, which should be as close as possible to 25°C (77°F) and 1013 mBar (29.91 in. Hg). Units should carry a calibration sticker stating the calibration date, temperature and barometric pressure.

Immediately before doing a calibration, always do a zero operation before connecting the calibration gas.

Calibration Gases

The following calibration gas mixtures are recommended:

CO and HC Calibration Gas

4-6% vol. Carbon Monoxide

2000 - 3000 ppm vol Propane

12 -14 % vol. Carbon Dioxide

Balance Nitrogen

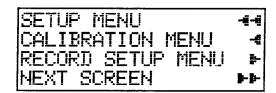
NOX Calibration Gas

1000 - 2000 ppm Nitric Oxide (NO)

Balance Nitrogen

CO and HC Calibration

To calibrate the analyzer for CO and HC, press MENU. The following screen will appear:



Press of for CALIBRATION MENU. The following screen will appear:



Press for CALIBRATE CO/HC. The following screen will appear:

CO TAG: 5.00 ½ HC TAG: 2000 PPM CONNECT CAL GAS: 4:CONTINUE :CANCEL

Check that the tag values shown are the same as the concentrations printed on the label of the calibration gas bottle. If they are different, press to quit this menu and change the tag values as explained.

If the tag values are correct, make sure the supply of calibration gas is connected and press [4]. The following screen will appear:

When calibration is complete, the following message will appear on the display:

CALIBRATION DONE. DISCONNECT CAL GAS. PRESS ANY KEY. ********

Disconnect the calibration gas and press any key. The reading should settle down with the CO reading close to the tag value and HC reading approximately half the tag value. The reason for this is that calibration is done using propane but vehicle exhaust gases contain alkanes of higher molecular weight. The calibration routine takes account of this but in the normal reading mode propane gives about half the HC reading of normal exhaust gases.

The calibration routine has built-in safeguards to prevent an incorrect calibration if there is no gas supply or if the tag values are entered incorrectly (e.g. 200 ppm instead of 2000 ppm). In this case the calibration will fail. If the CO calibration fails, the following message will appear on the display:

CO CALIBRATION OUT OF RANGE. CHECK GAS SUPPLY AND TAG VALUE 4:CONTINUE :CANCEL

If HC calibration fails, the same message will appear but with "HC" instead of "CO". Check that the tag values are correct and that the gas supply is OK. Press

to repeat the calibration or to cancel the procedure.

NO_x Calibration

The procedure for NO_x calibration is identical to that for calibrating CO and HC, except that the NO_x calibration menu is used.

If the NOX calibration fails, the calibration failure message will appear with the word "NO $_{\rm x}$ ".

Changing Tag Values

If the volume concentrations shown on the cylinder of calibration gas are different from the values shown in the calibration menu, the tag values must be changed. To change the tag values, selct the calibration menu as before and press of the CHANGE CO/HC TAG or for CHANGE NOX TAG. One of the following screens will appear:

CO TAG: 5.00 % HC TAG: 2000 PPM ---:SELECT. AT:CHANGE 4:FINISH =:CANCEL

NOX TAG: 1000 PPM ---:SELECT. AF:CHANGE 4:FINISH =:CANCEL *********

The following keys are used to change the values of these parameters:

increases a digit.
decreases a digit.
moves the flashing cursor to the next digit.
moves the flashing cursor to the previous digit.
skips to start of HC value (CO/HC tag screen only).
skips back to start of CO value (CO/HC tag screen only).
When the values are correct, press to save the new values and return to the main
display, or press if you wish to cancel the operation and abandon the changes.

EMISSION FUNDAMENTALS

Combustion Fundamentals

To understand and make interpretations of emission readings a basic understanding of the combustion process will be found to be useful.

In a gasoline-powered engine, normal combustion is the igniting of a compressed mixture of hydrocarbon fuels and air, taking place in the combustion chamber.

Typically, internal combustion engines burn, or oxidize, a mixture of air and fuel in the ratio of 14.7:1, by weight. This being the ideal mixture is termed "stoichiometric". This air/fuel ratio is where hydrocarbons (HC) and carbon monoxide (CO) are at their lowest and as close to perfect combustion that can be attained.

Combustion efficiency is often expressed in terms of Lambda, where Lambda is the actual air/fuel ratio divided by the stoichiometric air/fuel ratio. Thus the ideal value of Lambda is 1.

Fuel is basically a compound of hydrogen and carbon, and in the oxidization, or burning process, ideally the oxygen will combine with the carbon to form carbon dioxide ($\rm CO_2$) and with the hydrogen to form water ($\rm H_2O$). In some countries, especially in the Far East, regulations require the addition of oxygenates to the basic fuel compounds. These may affect the $\rm H_{cv}$ and/or $\rm O_{cv}$ values of the fuel, which may need to be changed in the SETUP MENU to give a correct air/fuel ratio or Lambda calculation..

When a fuel mixture is lean, there is too much air and too little fuel; vice versa, when there is too much fuel and too little air the mixture will be rich. The internal combustion engine is still inefficient, even with ideal stoichiometric mixtures. Therefore other compounds are formed during the combustion process and are emitted from the exhaust to the atmosphere. These include;

- (a) carbon monoxide (CO)
- (b) hydrocarbons (HC)
- (c) oxygen (O₂)
- (d) oxides of nitrogen (NO_x)

Gas Fundamentals

Hydrocarbons (HC)

Hydrocarbons are the paraffins or alkane compounds made up of hydrogen and carbon atoms $C_nH_{(2n+2)}$. These start with the gas methane (CH₄) and go all the way up to the solid paraffin waxes with long chains of carbon atoms. Gasoline is a mixture of alkanes that are liquid at room temperature, including hexane, heptane and octane.

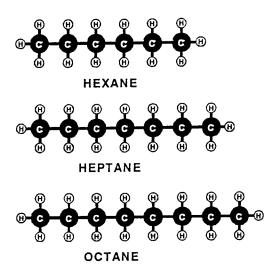


Figure 3. Molecular Structure Of Some Alkanes

HC is the unburnt gasoline vapor present in the vehicle's emissions. HC emissions are at their lowest with an air/fuel ratio around 15.8:1. High HC emissions are the result of incomplete combustion if the mixture is either too rich or too lean.

Carbon Monoxide (CO)

CO is formed when fuel is ignited but only partially burned due to a lack of oxygen. This results in the mixture being too rich to support a good combustion. As the air/fuel ratio rises above stoichiometric, the CO level decreases and the mixture is further leaned out. CO is a good indicator of a rich mixture but a poor indicator of a lean one.

Carbon Dioxide (CO2)

 CO_2 is a product of combustion. If the ideal mixture were completely burned during combustion only CO_2 and H_2O would be present in the emissions. At the ideal stoichiometric ratio of 14.7:1 the CO_2 level would be around 15%.

Oxygen (O,)

The level of O_2 in exhaust emissions is an excellent indicator of air/fuel ratio leanness. When the fuel mixture is richer than 15:1, the O_2 stays at a steady low level. The O_2 rises as the mixture becomes leaner due to a lesser amount being used in the combustion process. Higher levels of O_2 are therefore proportional to leaner air/fuel ratios.

Oxides of Nitrogen (NOx)

The earth's atmosphere contains approximately 78% nitrogen and 21% oxygen by volume. At high temperatures (above 1370°C) the two combine with each other to form harmful oxides of nitrogen, which include nitric oxide (NO) and nitrogen dioxide (NO₂). Under some engine conditions the temperature in a combustion chamber may exceed this level. Up to a point, combustion chamber temperatures are higher with lean mixtures, peaking at an air/fuel ratio of around 18:1 (1 1.25). As this is not a normal operating condition for a modern engine, high NO_x readings may indicate a lean mixture. Combustion chamber temperatures are also higher under load conditions, so NO_x emissions will be higher with the engine on load, for example pulling uphill in a high gear.

Using Exhaust Emission Readings For Diagnostic Purposes

Detecting problems relating to ignition, fuel, emission control and exhaust, are enhanced by the understanding of the major two pollutants, HC and CO. O₂ and CO₂ are considered to verify the readings of the other emissions. Listed below are examples of engine faults and emission readings one could expect to see.

Emission results are listed as (H) high, (L) low, and (M) medium in place of specific readings.

Problem		Emission HC CO CO, O,		
Fuel injection misfire under a closed loop condition	L	L	Н	Н
Rich mixture	M	Н	L	L
Lean condition, ignition misfire, vacuum/air leak	Н	L	L	Н
Mixture rich, misfire on ignition system	Н	Н	L	Н
Exhaust leaking after the catalytic converter	L	L	L	Н
Good combustion efficiency and catalytic converter working	L	L	Н	L

An engine running in a too rich condition will pollute more. There will generally be misfiring, and contamination of the catalytic converter is inevitable. There will also be evidence of a poor return on MPG (fuel consumption). An engine in too lean a state will also be problematic. Misfire under load conditions, incomplete combustion, damage to such items as valves etc., are all consequences of too lean a mixture.

In today's modern vehicle, emissions are controlled on a number of fronts. The use of a catalytic converter and engine management systems using an O₂ sensor fitted in the exhaust pipe, control the emission of pollutants.

An engine that is running efficiently in a closed loop condition (that is, where the engines various sensors supply data to the ECU) will show readings which average; HC 50ppm, CO .04%, CO $_2$ 14% and O $_2$ 1.5%. The O $_2$ sensor reacts to the level of O $_2$ in the exhaust before the catalytic converter, and tells the ECU to make the mixture richer or leaner, to maintain as near to stoichiometric combustion as possible.

MAINTENANCE AND TROUBLESHOOTING

Maintenance Procedures

The analyzer has been designed with the minimum of maintenance requirement.

The surface area of the analyzer enclosure should be periodically wiped over with a clean cloth. The keypad is a sealed membrane type which can be easily cleaned without damage. Do not clean with solvents.

Periodically remove the probe tubing from the probe assembly by unscrewing the ferrule and pulling the tube off the tailpiece. Disconnect the tube from the analyzer by

unplugging the quick coupling. Using a compressed airline gently blow air through the tube.

Do not attempt to blow compressed air through the tube with any part of it still connected to the analyzer or probe, serious damage could occur.

Check the filter assembly weekly for particulate accumulation. Remove the filter bowl by twisting ant-clockwise. Clean out the bowl with a clean cloth.

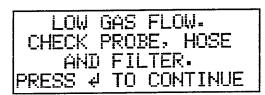
Do not use solvent-based cleaning agents or thinners, this will attack the bowl composition. Pull off the filter element and inspect for wear and damage, replace with only the recommended element replacement listed in the spare parts section of this manual.

Analyzer Troubleshooting

The analyzer has a number of built-in self-diagnostic procedures to check for proper operation during normal display mode and zeroing.

Low Gas Flow

If the gas flow falls below about 200ml/min the following message will appear on the display:



Low gas flow may be due to a variety of reasons:

- · Probe tip blocked by dirt
- · Gas inlet or outlet hose trapped or kinked
- Dirty filter
- · Water lock in filter bowl due to blocked drain valve

In the event of a blockage occurring in the gas flow system the procedure listed in the maintenance section should be carried out. If this procedure does not clear the fault, there may be an internal fault in the unit.

O₂ Sensor Ageing

The O₂ sensor has a nominal output of 10mV in air, but this reduces as the sensor ages to a point where the sensor no longer functions reliably. During zeroing, the analyzer

calibrates the O_2 sensor using ambient air, assuming 20.80% oxygen by volume. If the output of the O_2 sensor is very close to its minimum usable value, the following message will appear:

02 SENSOR WEAK,
PLEASE CHANGE SOON.
PRESS 4 TO CONTINUE

Measurements may still be made after pressing, but the error message will appear at every zeroing. The $\rm O_2$ sensor should be changed as soon as possible.

If the O₂ sensor is not changed and the output falls below the minimum acceptable value, the following message will appear after zeroing and the beeper will sound:

02 SENSOR DEAD, NO FURTHER MEASUREMENTS POSSIBLE. PLEASE CHANGE SENSOR.

No further measurements can now be made until the O2 sensor has been changed.

Changing The O₂ Sensor

To change the O_2 sensor, unplug the unit from its power source and disconnect the probe. Remove the six recessed retaining screws from the back of the case, and carefully pull off the back. The O_2 sensor is the white cylindrical component screwed into the manifold, next to the grey NO_2 sensor. Carefully disconnect the 3-pin Molex connector, and unscrew the sensor anti-clockwise. Screw in the new cell by hand until the rubber-sealing ring begins to compress. **Do not over-tighten.** Replace the Molex connector, which is configured to fit in only one position. Replace the rear cover and power up the analyzer in the 10 minute warm-up mode.

NO_x Sensor Ageing

The NO_x sensor also has a limited life, but as its output can only be checked with a NO_x input, there is no automatic warning. The only way to check the NO_x sensor is during calibration or by comparing the NO_x reading with that of a known good unit. However, an indication of NO_x sensor failure is an unusually low NO_x reading, less than 100 ppm.

The procedure for changing the NO_x sensor is the same as that for changing the O_2 sensor. It is suggested that the NO_x sensor is replaced only by a qualified service engineer, as it must be calibrated after replacement using a special gas mixture.

TIF5GA

REPLACEMENT PARTS

Description	Part No.
NOx sensor	TIF5GA-3
O2 sensor	TIF5GA-4
Complete probe assembly (including filter/trap)	TIF5GA-5
Probe hose assembly	TIF5GA-6
12V Power lead (both parts)	TIF5GA-7
Box of 5 filter elements	TIF5GA-8
OPTIONAL ACCESSORIES	
Accessory	Part No.
PC software complete with interface lead	TIF5GA-1
Thermal printer with interface lead	TIF5GA-2

SPECIFICATION

Measurement System Non-dispersive infra-red absorption optical bench for

CO and HC measurement

Electrochemical sensor for O₂ measurement

Electrochemical sensor for NO_x measurement

Gas Sampling System Exhaust Probe with particle and hydrophobic filter,

6.3 metre (21 ft) hose, electric diaphragm pump

Gas Flow Rate 300ml/min typ.

Response Time 13 seconds max.

Display 20 character x 4 line alpahanumeric LCD with

LED backlight. 5 mm character height 5 x 7 dots

Display Resolution

CO 0-9.99% Vol. (resolution 0.01 %)

HC 0-9999 ppm Vol. (resolution 5 ppm)

CO 0-20% Vol. (resolution 0.01 %)
O2 0-25% Vol. (resolution 0.02 %)

Nox 0-4000 ppm (resolution 4 ppm)

Lambda 0-99.99 (resolution 0.01)
AFR 0-99.99 (resolution 0.01)

Control Panel 14 key tactile membrane keypad

Interface 15 pin D sub female Centronics-compatible

parallel printer port

9-pin D-sub male RS-232-compatible serial port

(8 data bits, no parity, 1 stop bit)

OPERATING CONDITIONS

Warm up time 1 minute diagnostic mode/10 minutes full stability.

Zero interval (automatic) Every 10 minutes.

Supply voltage +12V to +16V from host vehicle power

supply or AC adapter.

Supply current 700mA typ. 1000mA max.

Operating temperature range 0 to +40°C

Optional accessories Thermal printer/interface cable.

PC interface software

WARRANTY PROCEDURES

This instrument has been designed and manufactured to provide unlimited service. The electrical circuit, infrared bench, pump and valving systems, power cord and probe assembly (excluding filter) are covered by a One Year Limited Warranty. The O₂ and NOx sensors are covered by a 90 Day Limited Warranty. These warranty periods commence upon purchase by the original end user, and are limited to repair or replacement at the sole discretion of TIF Instruments, Inc.

This Warranty does not apply to insturments that have been misused, tampered with, or damaged through neglect or improper use. The Warranty does not cover filters, internal or external, nor the hose assembly.

Should the unit become inoperative, carefully review the Maintenance section of this manual to determine if there is a field repairable problem. If after reviewing and performing appropriate maintenance, the unit remains inoperative, contact TIF Customer Service at 1-800-327-5060 (call 01-305-757-8811 if outside the USA, Canada, and Puerto Rico) for a Return Material Authorization (RMA). You will be given current repair costs and instructions on how and where to return the unit for service. Pack the unit in its origingal shipping carton, or equivalent, and return, freight prepaid, as instructed.

Repaired or replaced tools will carry an additional 90 day warranty. For additional information, or technical support, contact TIF Customer Service at the number above.