Environmental Equipment, Inc.

IMR 1400-IR

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INTRODUCTION

Thank you for purchasing the ***IMR® 1400-IR combustion gas analyzer***.
Please read the following instructions before operating the unit for the first time.

Proper handling is necessary to make full use of the outstanding performance and features of this combustion gas analyzer.

IMPORTANT INFORMATION:

- Use the instrument just within the recommended temperature range.
- Never measure without the dust filter and condensation trap.
- The dust filter must be cleaned/replaced when dirty.
- The Condensation trap must be checked and the condensed water removed if necessary.
- ***IMR®*** *or an authorized service facility must re-calibrate the* ***IMR® 1400-IR*** *once a year to ensure the accuracy and performance.*

SAFETY INSTRUCTIONS

Please make sure that you read this section carefully for use of your new combustion gas analyzer.

- Follow all warnings and instructions marked on the product or displayed on the screen.
- The AC inlet should only be connected to a socket with a protective earth contact.
- Any adjustment or maintenance of the analyzer under voltage should be avoided.
- The maintenance of the analyzer should be done by qualified personal and the instrument must be turned off and unplugged.
- Do not take the analyzer out of the box during the warranty period. If you do so, then the warranty is null and void.
- Do not use this analyzer in water.
- Never spill water or any liquid on the analyzer.

1 DESCRIPTION

The **IMR® 1400-IR** is a state of the art combustion gas analyzer and comes in various versions.
The table below should help to define the model and the built-in features.

Table 1: IMR® 1400 versions

	O2	CO	CO2-IR	NO	NO2	SO2	HC	Printer	Memory	RS232 Interface	12VDC	Ambient Temp.	Soot	Draft	CO-Bypass
IMR® 1400-IR	X	X	X	O	O	O	O	X	X	X	X	X	X	X	X

X - standard O - optional
Max. 4 sensors - standard O2,CO and CO2 and one more is optional

All **IMR® 1400-IR** models measure and calculate besides the above mentioned parameter these parameter:

- Flue gas temperature
- Excess air
- Combustion efficiency
- Heat losses
- Carbon dioxide CO_2 (NDIR)
- Carbon monoxide COp (corrected to 0%O2)
- Nitric oxide NOp (corrected to 0%O2) (if equipped with a NO sensor)
- Nitrogen dioxide NO2p (corrected to 0%O2) (if equipped with a NO2 sensor)
- Sulfur dioxide SO2p (corrected to 0%O2) (if equipped with a SO2 sensor)

1.1 FUNDAMENTALS

Gas flow
A built-in sampling pump is drawing the flue gas through the gas-sampling probe into the analyzer.

1. The gas flows through the gas-sampling probe to the condensation trap.
2. Then the gas passes through a particle filter where dust particles are removed.
3. Then the gas enters the sensor chamber.

Gas temperature
The gas temperature is measured by using a thermocouple located at the tip of the gas-sampling probe.

Electrochemical sensors
The electrochemical sensors can be damaged

- if exposed to small particles **- never measure without a dust filter**
- if water / condensation comes in contact with the sensors - **empty condensation trap**

Service / Calibration
A "Service" message will be displayed after 1000 hours of operating time.
IMR® Environmental Equipment, Inc. recommends checking the calibration once a year.

Operating Temperature
50°F..104°F / 10 °C..40 °C
If the unit is brought in from the cold, then it should be allowed to warm up for a few minutes.

Storage Procedures: IMPORTANT!

Storage Temperature
-4°F..122°F / -2 °C..50°C
When not in use or in storage, please make sure to keep the analyzer plugged into a wall outlet (AC) or cigarette lighter adapter (12VDC-power socket must be equipped) if storing in a vehicle.
This will ensure that the analyzer maintains a constant battery charge and will function properly if needed.
Prolonged periods of disuse without charging the battery may result in a weak battery and the battery can loose its ability to hold the charge.

2 SYSTEM DESCRIPTION

2.1 OVERVIEW

Please check now if the unit is equipped with all the ordered features and accessories.

IMR® 1400 - IR

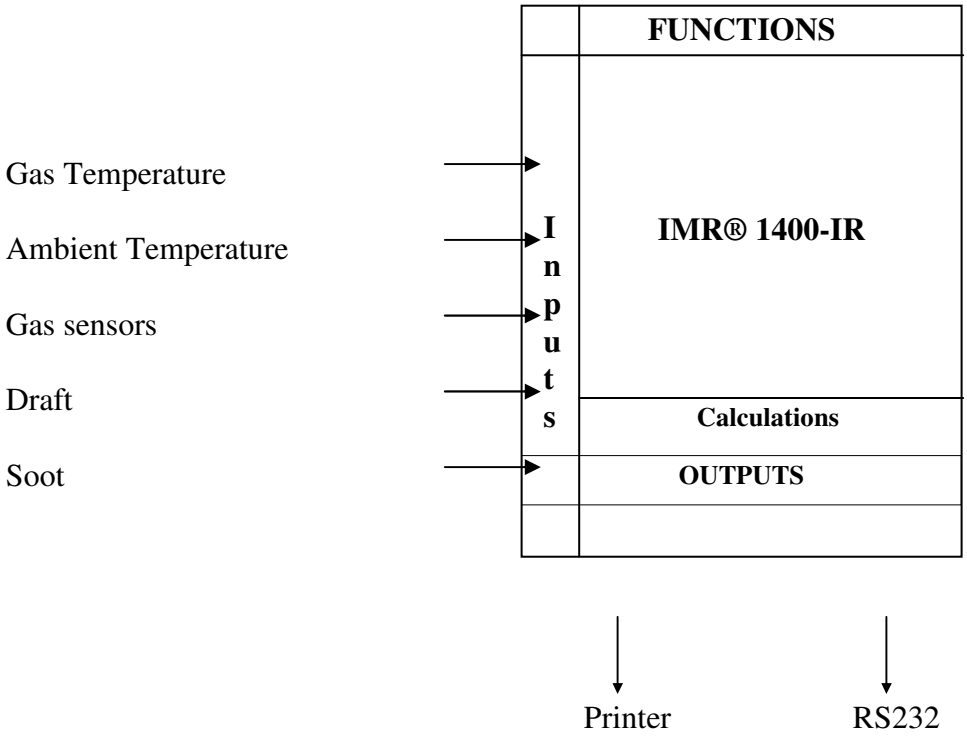
Features and Accessories (if equipped):

- Backlit LCD
- 12 push buttons
- Gas sampling probe
- Ambient temperature probe
- Thermal printer
- RS232 interface
- 12VDC power inlet
- Rechargeable battery
- CO bypass w/ purging pump
- Draft measurement
- Soot measurement w/ soot filter paper and comparison scale
- Memory
- O2 electrochemical sensor
- CO electrochemical sensor
- CO2 NDIR-sensor
- Up to 1 more sensor (NO, SO2, NO2, HC)
- Aluminum case
- Manual
- Power Cord
- Calibration certificate

2.2 FUNCTION OVERVIEW

Measurements
- Gas Temperature
- Ambient Temperature
- Draft
- Soot
- O_2, CO , CO2
- NO, SO2, NO2, HC (max. 1)

Calculations
- Efficiency
- Losses
- Excess Air
- COp
- NOp, NO2p, SO2p (if equipped)



2.3 TECHNICAL DATA - STANDARD RANGES

Other measurement ranges and probe lengths are optional available.

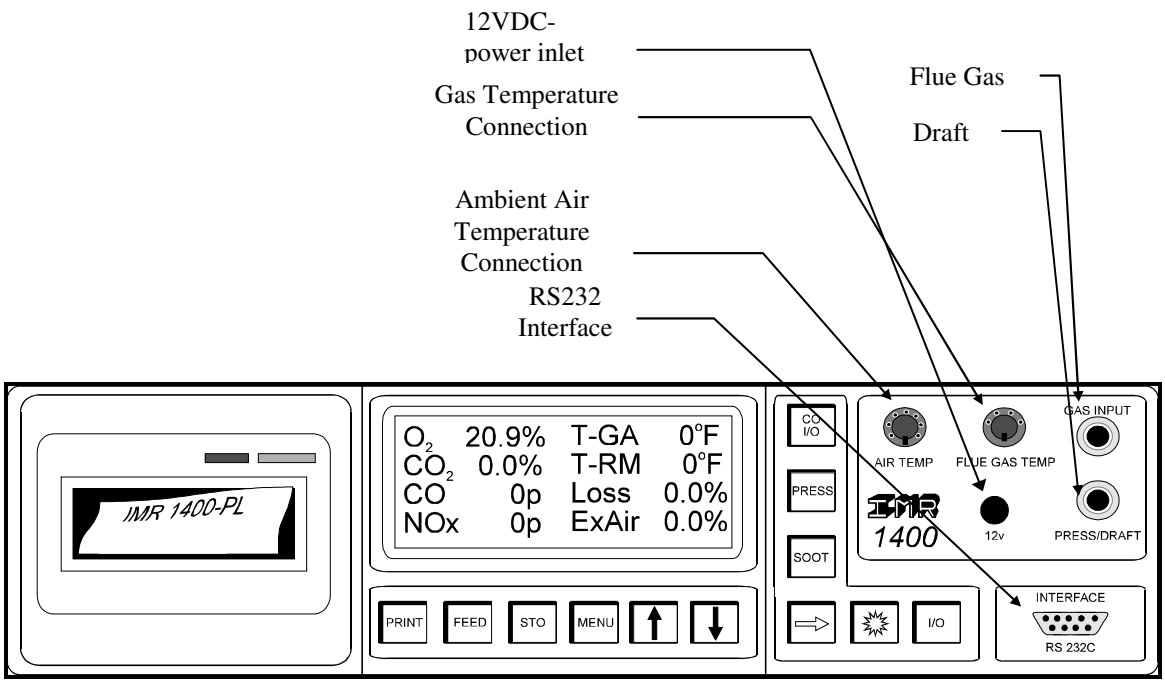
Table 2: Technical Data

PARAMETER	***PRINCIPLE***	***RESOLUTION***	***ACCURACY***	***RANGE***
O_2 Oxygen	Electro-chemical cell	0.1 Vol.%	± 0.2 %	0-20.9Vol. %
CO_2 Carbon dioxide	NDIR-sensor	0.01 Vol.%	5 %	0-30.00 Vol.%
CO Carbon monoxide	Electro-chemical cell	1 ppm	Z	0-2000 ppm
COp CO (0%O2)	Calculation	1 ppm	5 %	
NO Nitric oxide	Electro-chemical cell	1 ppm	Z	0-2000 ppm
NOp NO (0%O2)	Calculation	1 ppm	5 %	
NO_2 Nitric dioxide	Electro-chemical cell	1 ppm	5 %	0- 100 ppm
NO_2p NO_2 (0%O2)	Calculation	1 ppm	5 %	
SO_2 Sulfur dioxide	Electro-chemical cell	1 ppm	5 %	0-4000 ppm
SO_2p SO_2 (0%O2)	Calculation	1 ppm	5 %	
HC Hydrocarbons	Solid state sensor	0.1%	5 %	0-100% LEL
TG Flue gas temperature	NiCr-Ni Thermocouple	1K	± 2 %	-4°F / 2192°F -20°C / 1200°C
TA Air temperature	Semiconductor	1K	± 0.5 K	-4°F / 248°F -20°C / 120°C
P Draft	Solid state	0.004" H_2O 0.01 hPa	± 2 %	-12" / 20" H_2O -30hPa / 50hPa
CO_2 Carbon dioxide	Calculation	0.1 Vol.%	± 0.2 %	0- CO_2 max
Efficiency	Calculation	1 %	± 0.5 %	0-99.9 %
Losses	Calculation	1 %	± 0.5 %	0-99.9 %
Excess Air	Calculation	1 %	± 2 %	0-999 % or 0-9
Soot	Filter paper method DIN 51402			0 - 9 comparison scale

Other measurement ranges are available upon request Max. 4 gas sensors
Z: 0 - 20% of full scale: 1% of full scale
20 - 100% of full scale: 5% of reading

Power Inlet	110VAC/60hz or 230VAC/50hz 12VDC
Battery	Sealed lead acid 6VDC- Five-hour charge time - Battery status on LCD
Display	4-line, 20-character illuminated LCD - manual switch for light
Printer	Thermal printer - paper width 58mm - built-in
Gas sampling probe	If the unit is equipped with soot measurement - Heated probe handle (175°F / 80°C) for accurate soot measurement. Heated element only operates when unit is connected to AC. - Type S, probe length 10.6" / 270mm, hose 11.5' / 3.5m If the unit is not equipped with soot measurement - Type E, probe length 9.8" / 250mm, hose 8.2' / 2.5m
Ambient air probe	Length 5" / 130mm, line 9.8' / 3m
Condensation Trap	Inline with integrated filter
Filter	In-line - four micron - washable
Case	Rugged wood/aluminum case with compartment for gas sampling probe, ambient air probe, power cord and accessories.
Operating temperature	50°F..104°F / 10°C..40°C
Storing temperature	-4°F..122°F / -2°C..50°C
Calibration	Automatic 3-minute zero calibration - 30-second re-calibration.
Fuels	USA Natural gas, Fuel oil #2, Fuel oil #6, Propane, Bagasse, Wood, Anthracite coal and 5 programmable fuels European Oil light, Natural gas, Town gas, Coal gas, Liquid gas, Coke, Wood and 5 programmable fuels

2.4 SYSTEM CONNECTIONS



2.4.1 Probe

The gas-sampling probe with its plug and hose has to be connected to the analyzer before it can be turned on and must stay connected during the whole measurement.
If the gas-sampling probe is not connected, then the analyzer does not make an accurate calibration and an error message will be displayed.

Type S (if equipped with soot measurement)
The probe S has a heated handle and a hose for each the flue gas measurement and the draft measurement (double hose). Both hoses must be connected to their fittings all the time.
It also has a connection line to connect the thermocouple with the analyzer.

a) Thermocouple - Connect the thermocouple plug (5-pos) with the 'flue gas temp' socket of the analyzer

b) Flue gas - Connect the hose, which has the condensation trap inline to the barbed fitting 'gas input'

c) Draft - Connect the second hose to the barbed fitting 'Press/Draft'

The heating element of the probe handle is only working when the analyzer is connected to the AC.

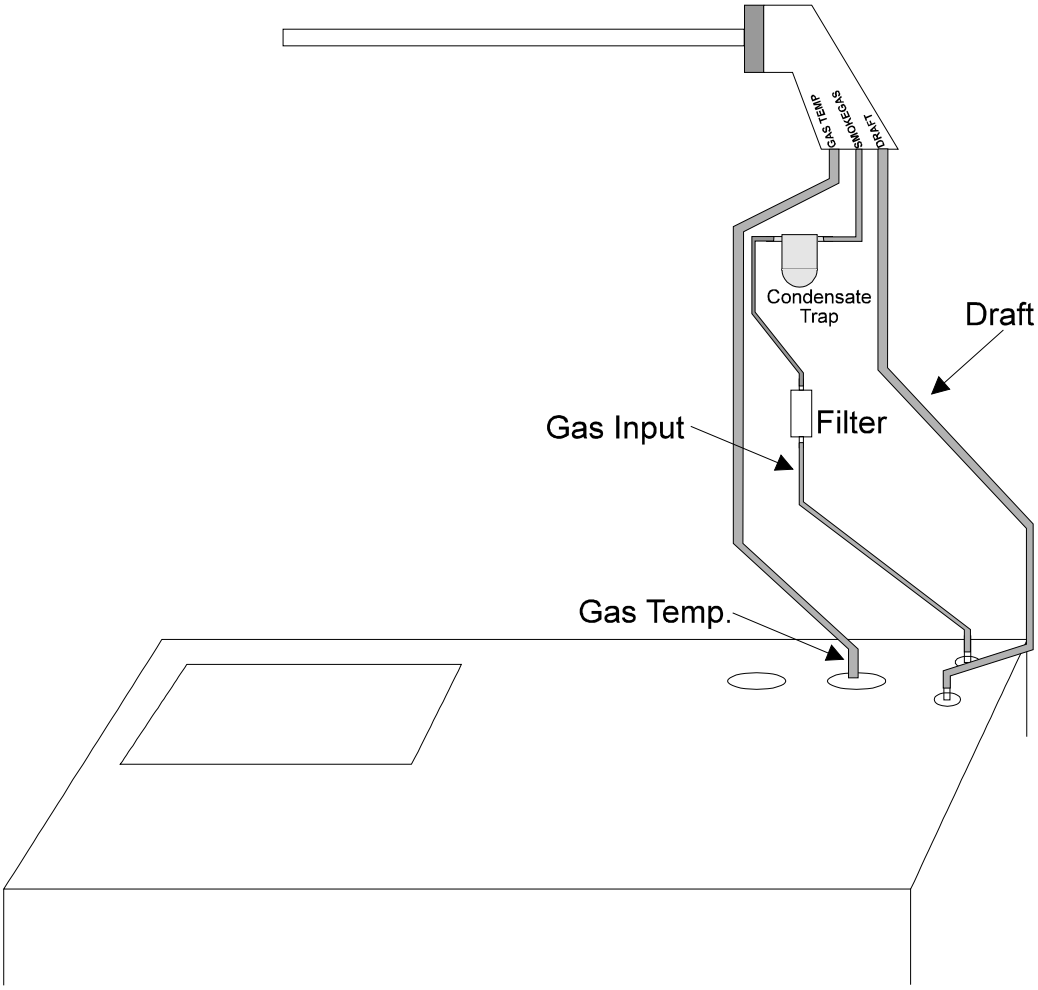
Type E
The probe E has one hose for both the flue gas measurement and the draft measurement.
It also has a connection line to connect the thermocouple with the analyzer.

a) Thermocouple - Connect the thermocouple plug (5-pos) with the 'flue gas temp' socket of the analyzer

b) Flue gas - Connect the hose to the barbed fitting 'gas input'

The hose must be connected to the 'gas input' fitting for the regular flue gas measurement.
The hose must be connected to the 'Press/Draft' fitting only for the draft measurement and it must be connected back to the 'gas input' fitting after the draft measurement is completed.

Gas sampling probe (type S) connection:



2.4.2 Ambient air temperature probe (if equipped)

The ambient air temperature probe can be connected to the instrument for the calibration.
If the ambient air temperature probe is connected, then it has to stay connected for the whole measurement, otherwise there will be an error message.
If the ambient air temperature probe is not connected to the instrument for the calibration, then the unit does not need the ambient air temperature probe and it does not show an error message.

The ambient air temperature probe measures the temperature of the air that is used for the combustion process.
The measured temperature is needed for various calculations.

Connect the plug (4-pos) of the ambient air probe with the 'air temp' socket of the analyzer.

2.4.3 Gas fitting

The gas hose of the gas-sampling probe must be connected to the gas fitting.

2.4.4 Draft fitting (if equipped)

The draft hose of the gas-sampling probe must be connected to the draft fitting.

2.4.5 12VDC power inlet (if equipped)

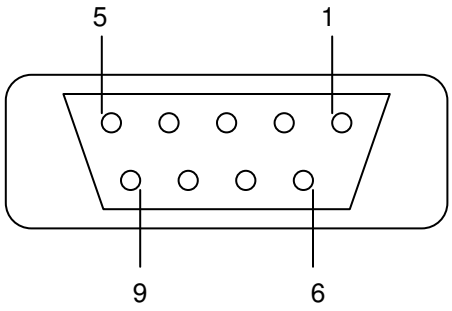
The 12VDC-power inlet can be used to charge the battery without AC.
A car battery could charge the analyzer via this power inlet.
The needed cable to connect the analyzer to a car lighter can be ordered by IMR®.
Connection: Tip +

2.4.6 RS232 interface (if equipped)

The RS232 serial interface can be used to transfer data from the analyzer to a PC.
Real time data or stored data can be transferred.
ASCII signs are getting transferred.
The serial connection to a PC must be a 'Null-modem connection'.

RS232 female connector 9-pos.

1-
2-
3- TXD transmit data
4-
5- GND ground
6-
7-
8- CTS clear to send
9-



Connection to a PC (null-modem connection):

IMR® 1400	PC 9-pos	PC 25-pos
3 TXD	2 RXD	3 RXD
5 GND	5 GND	7 GND
8 CTS	7 RTS	4 RTS

Serial data format

A character has 8 data bits, no parity and 2 stop bits.

ASCII "Computer" format:

```
Start (→)
Station
Fuel
Units (ppm, etc.)
NOx (according TA-Luft)(1)
Date
Time
No. of samples
Time of samples
Room Temperature
O2
H2S
CO
CO2
NO2
NO
Draft
Gas Temperature

Losses
Excess Air
Stop (←)
```

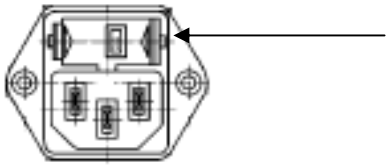
2.5 POWER

The **IMR® 1400-IR** works on 230VAC/50Hz or 110VAC/60Hz.
A fuse selector next to the AC inlet sets the voltage.

The analyzer is able to work without being connected to the AC by using the power of the internal rechargeable lead acid battery.

However IMR® recommends connecting the analyzer always to the AC during measurement or during storage.

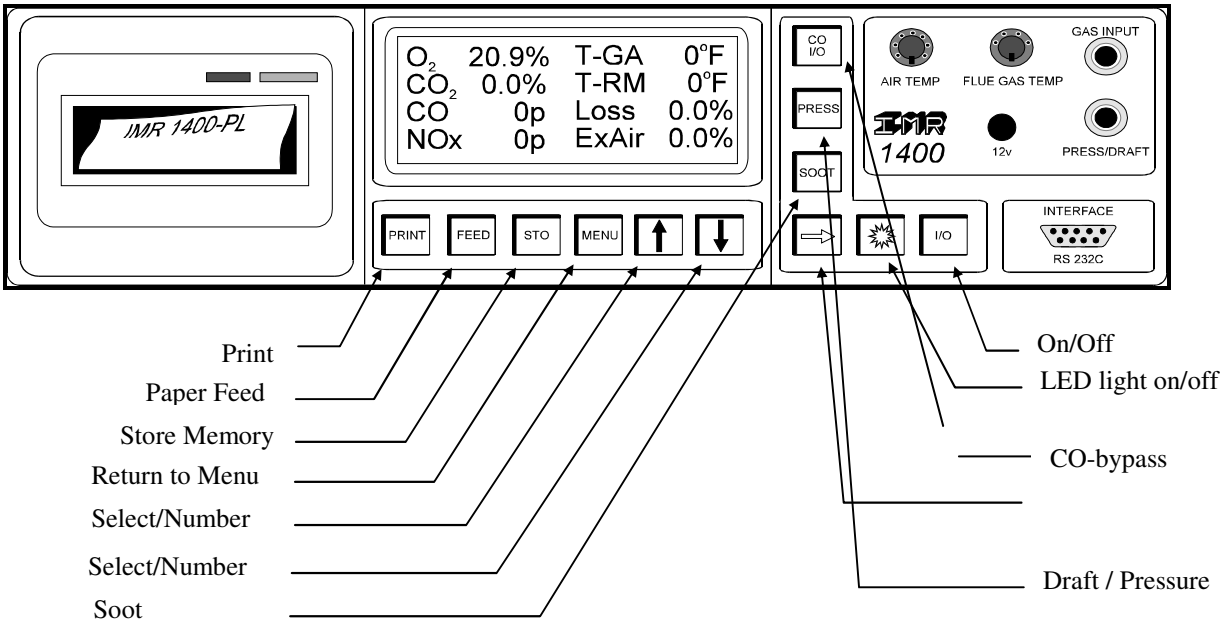
AC-inlet

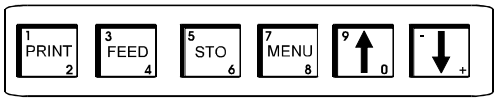


Fuse drawer settings:
220 - 220VAC to 240VAC
100 - 100VAC to 120VAC

2.6 BUTTON FUNCTIONS

The On/Off button (I/O) and the light button are always active and can be pushed in any situation. All other buttons are not always active and their active status and function will be described in the following sections.





1st Push →	1	3	5	7	9	-
2nd Push →	2	4	6	8	0	+

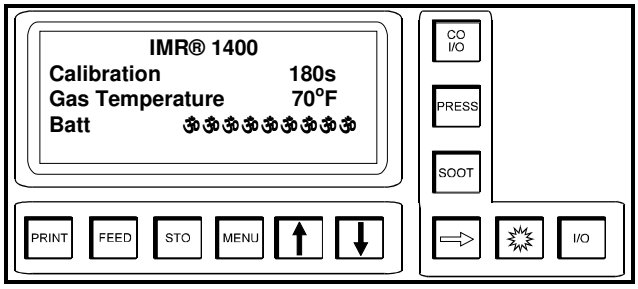
3 OPERATION

3.1 TURNING ON

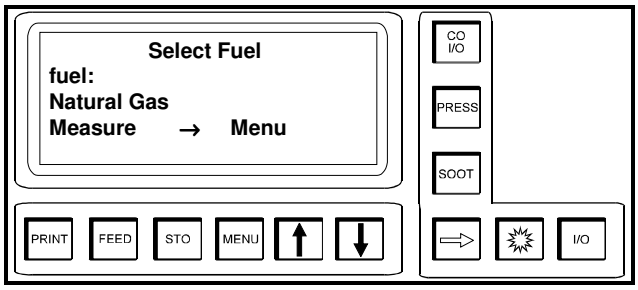
Connect the gas-sampling probe to the analyzer and do not insert the probe into the flue gas at this point. The gas-sampling probe has to be in ambient air during the zero calibration.

Turning the unit on and zero calibration starts and takes 180 seconds

Start of the zero calibration



After 180 seconds / zero calibration finished



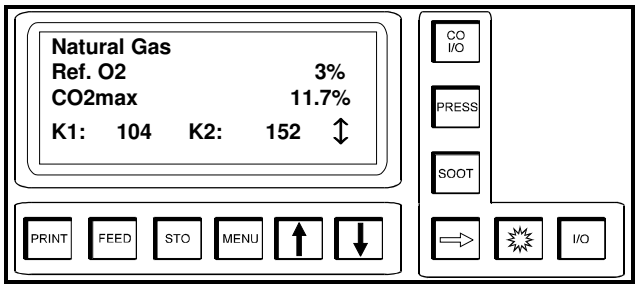
Active buttons

Start measurement	
Fuel type selection	

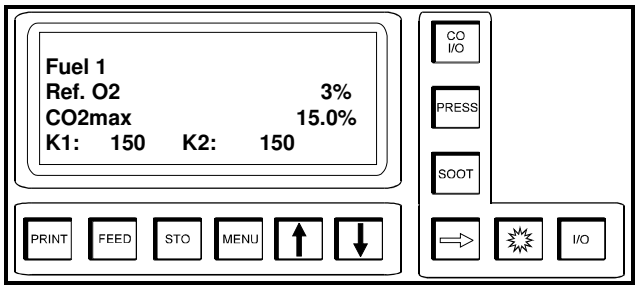
3.2 FUEL TYPE SELECTION

The **IMR® 1400-IR** has most common fuels (7 different fuel types) programmed and 5 more fuel types are programmable by the user.
After the calibration has finished the analyzer needs to know the fuel used by the combustion process. This information is necessary to calculate the combustion parameters correctly.

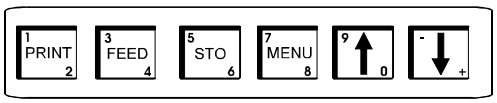
Fuel type selection: One of the 7 programmed fuels



Fuel type selection: Programmable fuel



Active buttons

Move fuel type up	
Move fuel type down	
Enter edit mode (only programmable fuel) Select parameter (only in edit mode)	
Numeric keys (only in edit mode)	
Exit fuel menu and save the chosen fuel	

Fuel types

USA	European
- Natural Gas	- Oil light
- Fuel #2	- Natural gas
- Fuel #6	- Town gas
- Propane	- Coal gas
- Bagasse	- Liquid gas
- Wood	- Coke
- Anthracite coal	- Wood

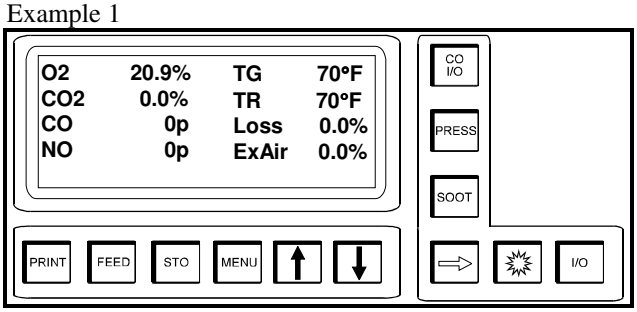
Programmable fuel

If the used fuel type is not programmed, then the user can program a special fuel type with its parameters.
Choose one of the five special fuel types to edit the needed parameters.
The programmable fuels show an arrow '→' on the right bottom corner (see above schematic). Push the '→' button to enter the edit mode and start putting in the needed parameters. The parameters must be known before starting to program the fuel.

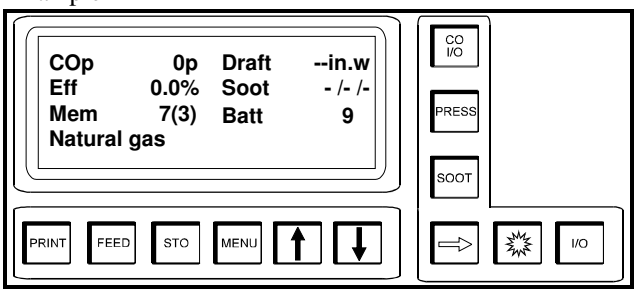
3.3 MEASUREMENT MENU

The measurement menu shows all measured and calculated parameter as well as date/time, fuel type, memory capacity and battery capacity. The measurement menu has 2-4 pages depending on model and configuration.

Example 1



Example 2



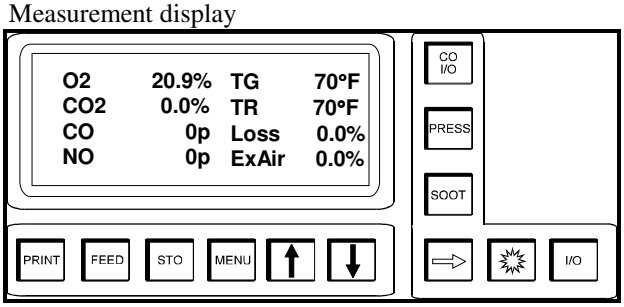
Active buttons

Page up	↑	Activating soot measurement	SOOT
Page down	↓	Entering menu selection	MENU
One data transfer via RS232	→	Storing measurement	STO
On/Off CO-bypass	CO I/O	Feed printer	FEED
Activating draft measurement	PRESS	Enter print mode	PRINT

3.3.1 Measurement

Insert the gas-sampling probe into the stack gas after the calibration has finished and the fuel type has been selected. Lock the tube with the cone at this point.
The sensors need approx. 3 minutes for an accurate and stable reading. The measurement is displayed on the LCD and / or a printout can be made and /or the measurement can be stored. There is no reading for soot or draft unless each measurement is activated and the values stored.

Measurement display

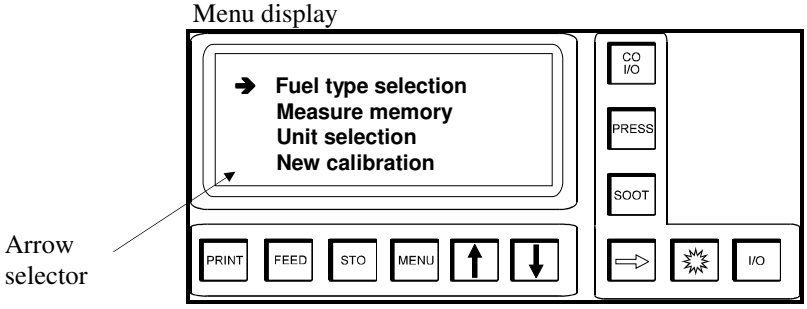


3.3.2 Menu

Press the 'menu' button to enter the menu from the measurement menu. 

The analyzer has a measurement menu and a menu. The menu helps the user to set the fuel, the units and much more.
Move the arrow selector in front of the menu and enter the menu by pressing the '→' button.

Menu display



Active buttons

Move arrow selector up	
Move arrow selector down	
Enter specific menu	
Back to measurement menu	

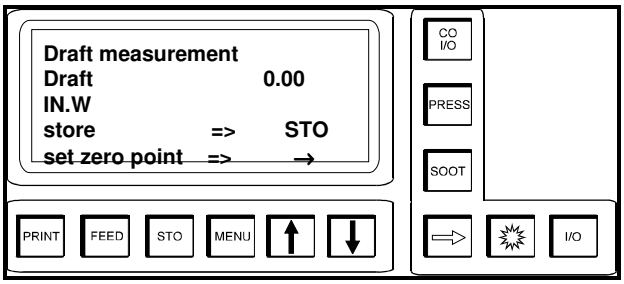
Menu

Fuel type selection	Select fuel type
Measure memory	Select stored data
Unit selection	ppm - mg/m3 -mg/m3(ref.O2) - mg/kWh
New calibration	30 seconds re-calibration
S.C. Interface	Set Baud-rate for Interface RS232
Date / Time	Set date and time
Service menu	Detailed information about sensors, temperature, unit status, etc.
Select language	English, German, French

3.3.3 Draft measurement (if equipped)

Activate draft measurement by pressing the 'PRESS' button from the measurement menu. PRESS

Draft measurement display



Active buttons

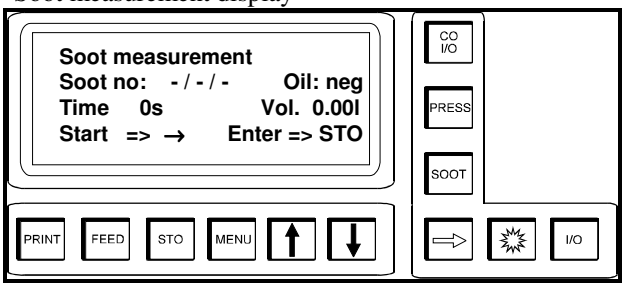
Set zero point	→
Store draft measurement	STO
Return to measurement menu	MENU

The pump is turned off for the duration of the draft measurement.
The draft hose of the gas-sampling probe has to be connected to the draft fitting.
The gas sampling probe has to be out of the stack to set an accurate zero point (ambient atmosphere) by pressing '→' button.
After the draft measurement is finished the measured value can be stored by pressing 'STO'.
The measured value is now on the measurement display and it will be printed out with the other measurement values.

3.3.4 Soot measurement (if equipped)

Activate soot measurement by pressing the 'SOOT' button from the measurement menu. SOOT

Soot measurement display



Active buttons

Select oil derivatives in edit mode	↑	Return to measurement menu	MENU
Select oil derivatives in edit mode	↓	Enter edit mode to enter soot no.	STO
Start soot cycle	→		
Numeric keys (only in edit mode to enter soot no.)	1 PRINT 2 · 3 FEED 4 · 5 STO 6 · 7 MENU 8 · 9 ↑ 0 · - ↓ +		

The pump is turned off and the soot filter paper has to be inserted into the slot of the gas-sampling probe handle. Push the back of the handle to open the slot.
Hit the '→' button to start the soot measurement. The pump will draw 1.63l of flue gas into the unit, according the regulations for the soot measurement.
After the first cycle is finished, move the soot paper to another spot and start another measurement by pushing the '→' button.
A total of 3 measurements are needed to perform an accurate soot measurement.

After three samples are taken compare the soot spots on the filter paper with the comparison scale and enter the result into the **IMR® 1400-IR**.
To enter the soot numbers push the 'STO' button and then enter the three soot numbers by using the numeric buttons.
If there are any oil derivatives on the soot paper enter 'yes', if not enter 'no'.
The soot numbers are now on the measurement display.
The average value of the three numbers is calculated and will be on the measurement printout.

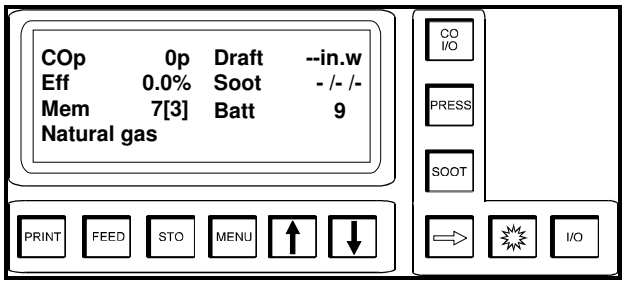
3.3.5 Memory (if equipped)

Push the 'STO' button in the measurement menu to store a measurement.

Each measurement consists of date / time, fuel type and all measured and calculated parameter. The **IMR® 1400-IR** stores up to 220 measurements.
The memory is divided into 10 blocks (0-9) with 22 measurements each.

Memory status
The memory status is located on one of the measurement menu pages.

Measurement display with memory status



Example: Mem 7[3] measurement number 7, block 3

See the memory menu description on how to print or transfer stored data.

3.3.6 CO-Bypass (if equipped)

The **IMR® 1400-IR** is configured with a CO bypass valve and also with a purging pump.
If the CO sensor range is exceeded, then the CO-bypass valve will automatically bypass the CO sensor and no more flue gas comes in contact with the sensor. At the same time a purging pump pushes out the remaining flue gas that is left in the chamber and tubing.
The bypassed CO sensor has to be turned back on manually.
If it is known that the flue gas contains a high CO concentration, then the CO sensor can be manually switched off.

The CO-bypass valve ensures that the CO-sensor will not be damaged if accidentally exposed to high levels of CO and the purging pump helps the CO sensor to return faster to a normal condition.

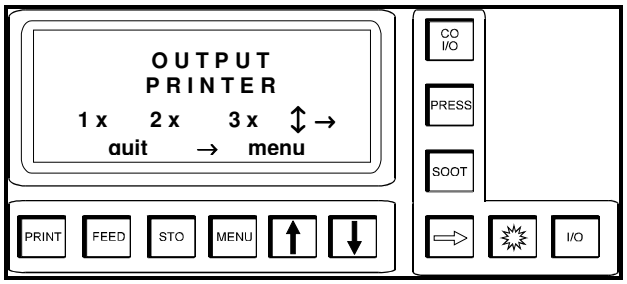
3.3.7 Printer (if equipped)

The **IMR® 1400-IR** is equipped with a built-in thermal printer. The paper width is 58mm.

Important: - Use only the original IMR® thermal paper with a width of 58mm.
- Make sure that the thermal side of the paper is on the right side.

To print push the 'PRINT' button from the measurement menu. 

Print menu



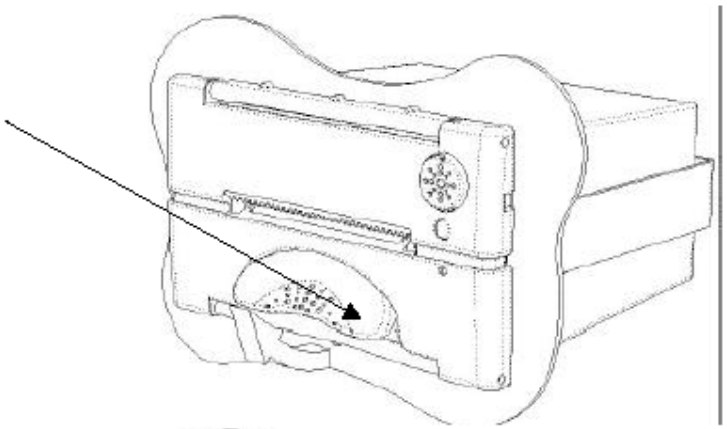
Active buttons

Select number of printouts		Return to measurement menu	
Select number of printouts		Start printing	

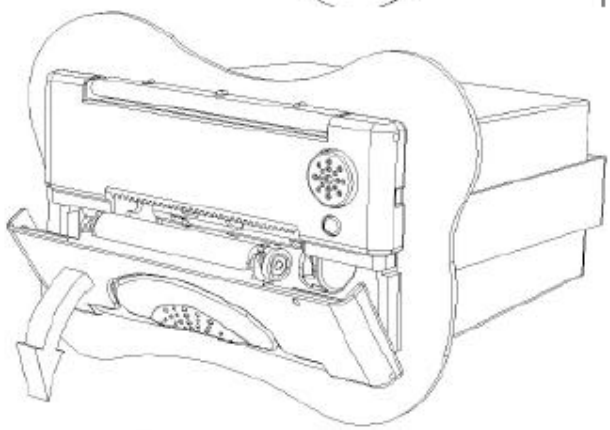
Pushing the 'PRINT' button enters the print mode.
The **IMR® 1400-IR** has the ability to print one, two or three printouts of the same measurement.
The selected number (1, 2 or 3) flashes on the display and pressing the '→' button prints the selected number of printouts.
To select another number of printouts press the '↑' button and / or the '↓' button.
The printer starts printing right after the number of printouts was confirmed and the analyzer returns right away to the measurement menu.

Opening the printer

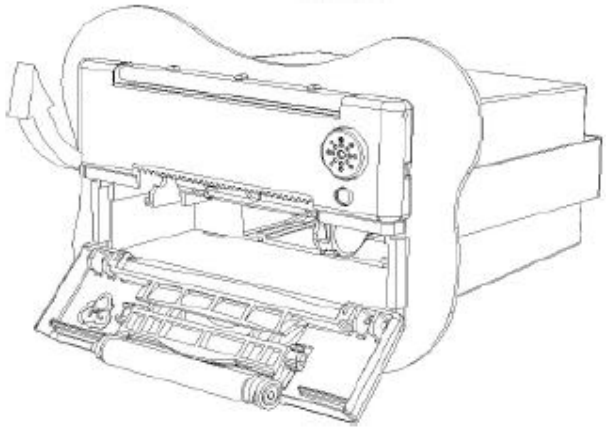
Step1:
Use the index finger to pull *release lever* open



Step 2:
Continue to swing open this door until it is held in the fully opened position.



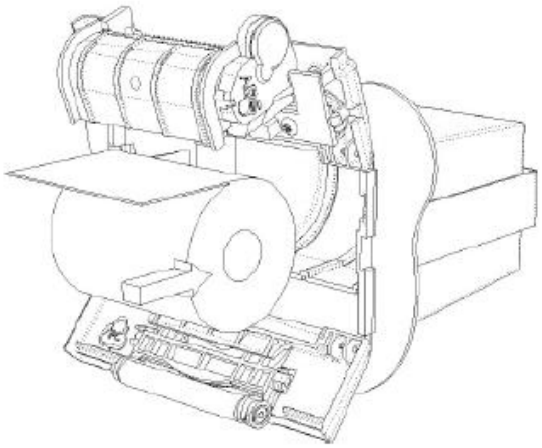
Step 3:
Swing open the door with the *printer mechanism* attached (normally top door), until it is in the fully open position.
Do not grip the tear bar or the print head whilst opening.



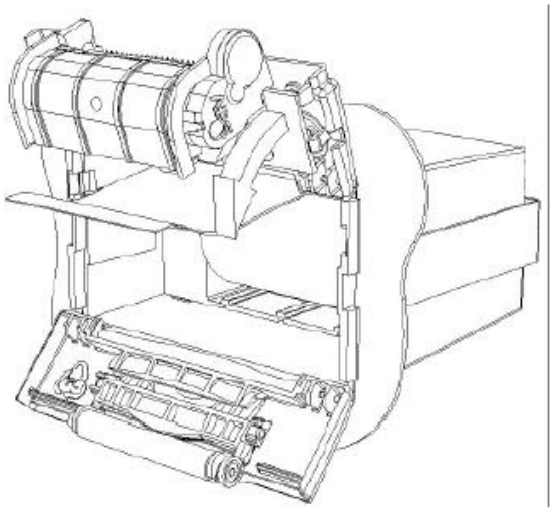
Changing the paper

Step 1
To open the doors please follow the procedure as detailed in the section 'Opening The Doors', above.

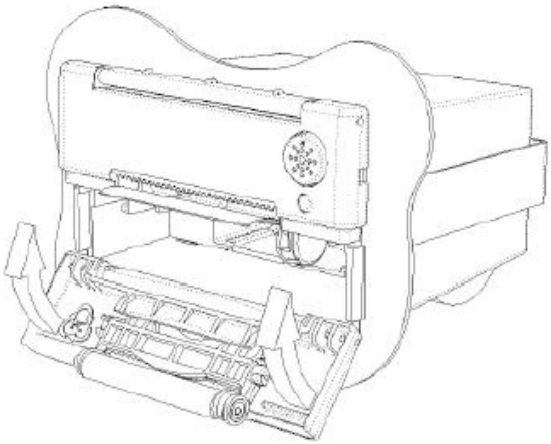
Step 2
Discard a few turns in case they have been damaged or have glue on.
Ensure the coated surface is orientated correctly to contact the print head.



Step 3:
Close *printer door*, ensuring the paper is carefully aligned in the paper path.



Step 4:
Close *release lever* door.
Apply pressure to both sides of the door.
When the LED stops flashing the printer is ready to print.



3.3.8 FEED (if equipped with printer)

Press the 'feed' button to do a paper feed.

3.4 SUBMENUS

To enter the menu mode press the 'MENU' button from the measurement menu.
The menu consists of various submenus.

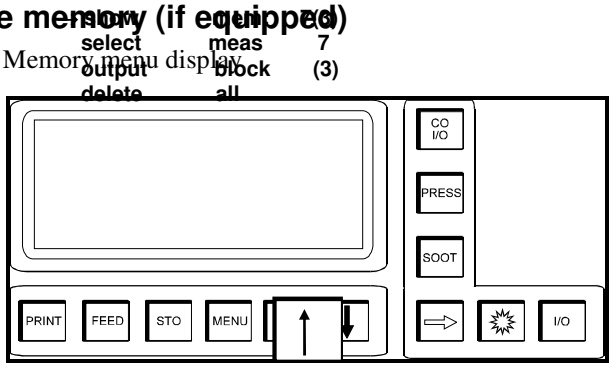
Fuel type selection
Measure memory
Unit selection
New calibration
S.C. Interface
Date / Time
Service menu
Select language

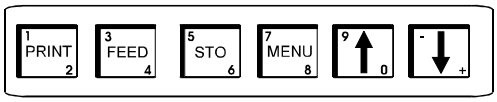
3.4.1 Fuel type selection

Please see section 3.2 on how to select a fuel type.

3.4.2 Measure memory (if equipped)

Memory menu display

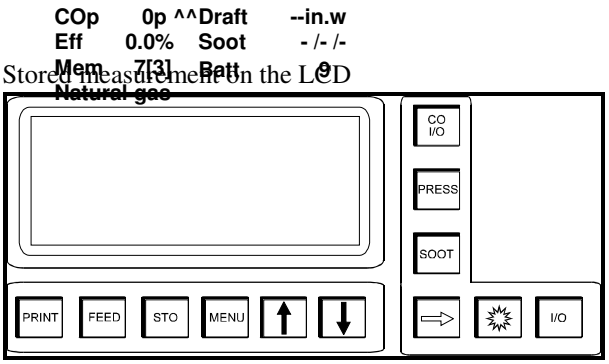


Select menu point		Return to menu	
Select menu point		Enter menu point	
Numeric keys (only in edit mode)			

Show:

Displaying a stored measurement on the LCD.

The arrow selector must be in front of the submenu point 'show' and then the '→' button has to be pressed to display a stored measurement on the LCD (e.g. measurement 7, block 3).
Pressing the 'PRINT' button can print out a stored measurement.



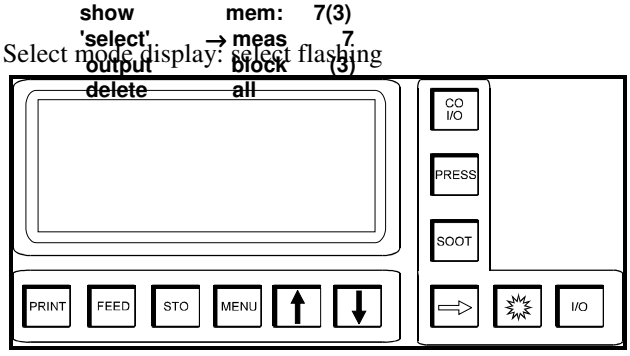
Stored measurement on the LCD

A stored measurement has two '^' on the top line between the two columns.

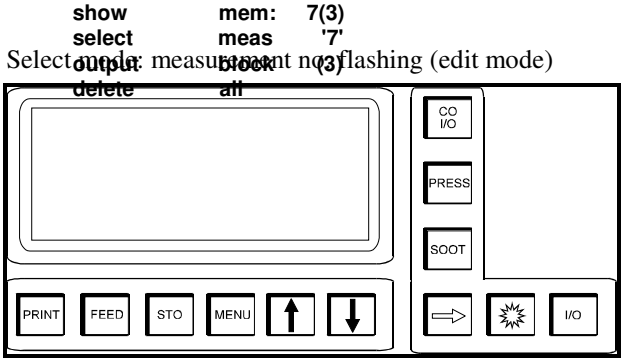
Select:

Selection of a stored measurement

The arrow selector has to be in front of the submenu point 'select' and the '→' button has to be pressed to enter this mode.
If the mode is entered, then the word 'select' is flashing and the arrow selector is in front of 'meas' (measurement) or by using the ' ↑' button and / or '↓' button in front of 'block'.
Press 'MENU' to exit the 'select mode'.



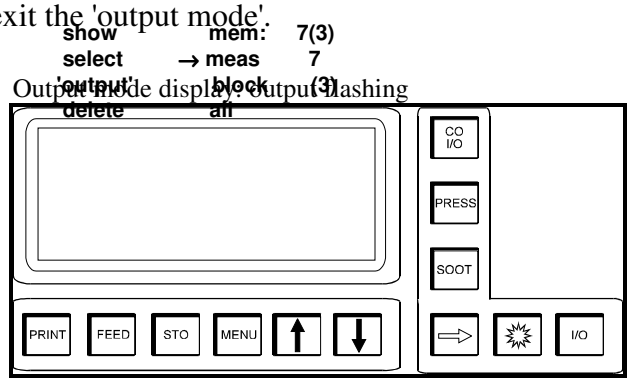
Select mode display: select flashing



Select mode: measurement no. flashing (edit mode)

If the arrow selector is in front of 'meas', then press the '→' button to choose another measurement (measurement no. is now flashing).
Use the ' ↑' button and / or the '↓' button to get the arrow selector in front of 'block' and choose another block by pressing the '→' button (block no. is no flashing).
To select another measurement or block use the numeric buttons and enter the wanted number.
When finished press the '→' button to exit the edit mode.

Output:
Transferring stored data via the RS232 interface
The arrow selector has to be in front of the submenu point 'output' and the '→' button has to be pressed to enter this mode.
If the mode is entered, then the word 'output' is flashing and the arrow selector is in front of 'meas' (measurement) or by using the ' ↑' button and / or '↓' button in front of 'block' or 'all'.
Press 'MENU' to exit the 'output mode'.



Output mode display: output flashing

If the arrow selector is in front of 'meas', then the '→' button can be pressed and the selected measurement will be transferred.

If the arrow selector is in front of 'block', then the '→' button can be pressed and the selected block will be transferred.
If the arrow selector is in front of 'all', then the '→' button can be pressed and all stored measurements will be transferred.

Delete:

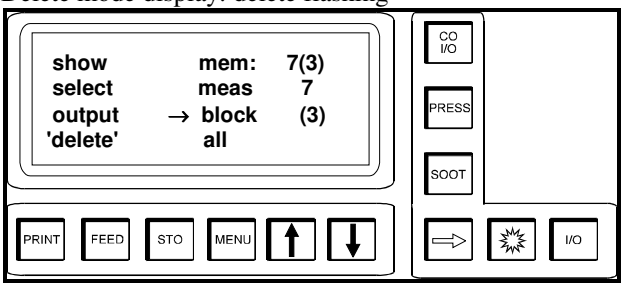
Delete stored measurements

The arrow selector has to be in front of the submenu point 'delete' and the '→' button has to be pressed to enter the mode.

If the mode is entered, then the word 'delete' is flashing and the arrow selector is in front of 'block' or by using the ' ↑' button and / or '↓' button in front of 'all'.

Press 'MENU' to exit the 'output mode'.

Delete mode display: delete flashing



If the arrow selector is in front of 'block', then the '→' button can be pressed and the selected block and all its data will be deleted.

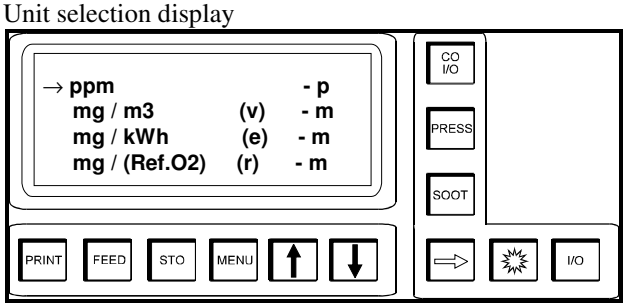
If the arrow selector is in front of 'all', then the '→' button can be pressed and all stored measurements will be deleted.

3.4.3 Engineering unit selection

The CO, NO, NO2 and SO2 values can be shown as
- ppm
- mg / m3
- mg / kWh
- mg / Ref.(O2)

CO, NO, SO2 and NO2 are measured in ppm and the default setting is ppm.
Please see section 4.1.5. and 4.1.6 on how to calculate the different engineering units.

Unit selection display



Active buttons

Select units	↑	Return to menu (save units)	MENU
Select units	↓	Return to menu (save units)	→

ppm (parts per million):
The arrow selector must be in front of 'ppm' and then the 'menu' button pressed to show all the toxic sensor values in ppm. The **IMR® 1400** shows ppm as 'p'.

mg / m3 (value converted from ppm to mg per norm cubic meter at 0°C):
The arrow selector must be in front of 'mg/m3' and then the 'menu' button pressed to show all the toxic sensor values in 'mg/Nm3'. The **IMR® 1400** shows mg/Nm3 as 'm' and the symbol 'v' behind the sensor symbol.

mg / kWh(value converted from ppm to mg per kWh):
The arrow selector must be in front of 'mg/kWh' and then the 'menu' button pressed to show all the toxic sensor values in 'mg/kWh'. The **IMR® 1400** shows mg/kWh as 'm' and the symbol 'e' behind the sensor symbol.

mg / (Ref.O2) (value converted from ppm to mg referenced to Oxygen acc. to TA-Luft):
The arrow selector must be in front of 'mg/(Ref.O2)' and then the 'menu' button pressed to show all the toxic sensor values in 'mg/(Ref.O2). The **IMR® 1400** shows mg/(Ref.O2) as 'm' and the symbols 'r' and 'v' behind the sensor symbol.

3.4.4 New calibration

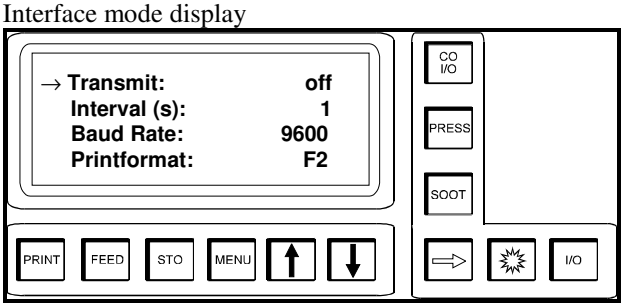
The analyzer turns off and on to start a new calibration cycle.
This re-calibration takes 30 seconds, because all the sensors were already powered up.

3.4.5 S.C. Interface (if equipped)

The interface mode enables the user to start a data transfer, set intervals between the transfers, set baud rate and set the measurement printout format.

A null-modem cable from IMR® is needed to connect the **IMR® 1400** via the RS232 interface to a PC.

Interface mode display



Active buttons

Select mode	↓	Return to menu	MENU
Select mode	↑	Start transfer Change settings	→

Transmit:
The arrow selector must be in front of 'transmit' and then the '→' button can be pressed to transmit data.
Data (one measurement) will be transferred every x seconds ('x' interval setting in seconds) and with a baud rate of y ('y' baud rate).

Interval (s):
The arrow selector must be in front of 'interval' and then the '→' button can be pressed to change the interval settings by one second.
The intervals can be set from 1-15 seconds.

Baud Rate:
The arrow selector must be in front of 'baud rate'.
By pressing the '→' button the baud rate setting changes.
Baud Rate settings: 1200 / 2400 / 4800 / 9600 / 19200 / 38400

Printformat:
The arrow selector must be in front of 'printformat'.
By pressing the '→' button the print format setting changes.
Print format settings: F1 / F2 / F3 / F4
Default setting: F2

Example: IMR® 1400 with O2, CO, NO and SO2 sensor (units selected ppm)

F1

```
******************
*   IMR® 1400    *
******************

 Date       Time
04.11.99
10:33:51am

Measurement:     1
Natural Gas
CO2max    11.8  %
Ref. O2     15  %

Gastemp    249 °F
Roomtemp    78 °F
O2         13.0  %
CO2         4.5  %
CO         3003 ppm
NO         2001 ppm
SO2        1001 ppm

Exc. Air  2.65  %
Losses    20.8  %
Effic.    79.2  %
```

F2

```
*****************
*  IMR® 1400    *
*****************

 Date       Time
04.11.99
10:33:51am

Measurement:
1
Natural Gas
CO2max    11.8  %
Ref. O2     15  %

Gastemp    249 °F
Roomtemp    78 °F
O2         13.0  %
CO2         4.5  %
CO         3003
ppm
CO (0%O2) 7945
ppm
NO         2001
ppm
NO (0%O2) 5294
ppm
SO2        1001
ppm
SO2(0%O2) 2648
ppm

Exc. Air  2.65  %
Losses    20.8  %
Effic.    79.2  %
```

F3

```
*****************
*   IMR® 1400   *
*****************

 Date       Time
04.11.99
10:33:51am

Measurement:
1
Natural Gas
CO2max    11.8  %
Ref. O2     15  %

Gastemp    249 °F
Roomtemp    78 °F
O2         13.0  %
CO2         4.5  %
CO         3003
ppm
CO (0%O2)
8516mg/kWh
CO (Ref.)
2804mg/m3
NO         2001
ppm
NO (0%O2)
9312mg/kWh
NO (Ref.)
3069mg/m3
SO2        1001
ppm
SO2(0%O2)   --
mg/kWh
SO2(Ref.)
2136mg/m3

Exc. Air  2.65  %
Losses    20.8  %
Effic.    79.2  %
```

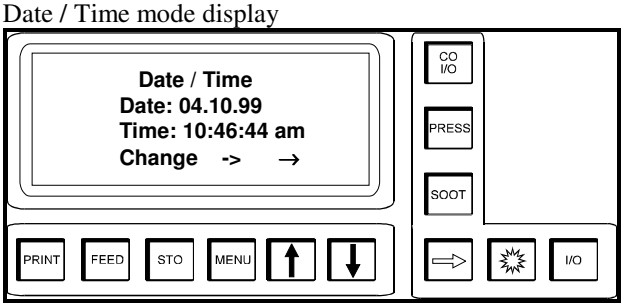
F4

```
*****************
*  IMR® 1400    *
*****************

 Date       Time
04.11.99
10:33:51am

Measurement:
1
Natural Gas
CO2max    11.8  %
Ref. O2     15  %

Gastemp    249 °F
VL-Temp     78 °F
O2         13.0  %
CO2         4.5  %
CO         3003
ppm
CO (0%O2) 7945
ppm
CO (0%O2)
8516mg/kWh
CO (Ref.)
2804mg/m3
NO         2001
ppm
NO (0%O2) 5294
ppm
NO (0%O2)
9312mg/kWh
NO (Ref.)
3069mg/m3
SO2        1001
ppm
SO2(0%O2) 2648
ppm
SO2(0%O2)   --
mg/kWh
SO2(Ref.)
2136mg/m3

Exc. Air  2.65  %
Losses    20.8  %
Effic.    79.2  %
```

3.4.6 Date / time

The date/time mode enables the user to set the clock.

Date / Time mode display

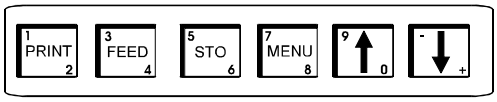


Active buttons

Enter edit mode (confirm entry)

Return to menu

Numeric keys (only in edit mode)



Enter the edit mode by pressing '→' button.

USA: *12.00a.m. - 12.00p.m.*
Month - Day - Year
Europe: *00.00 - 24.00*
Day - Month - Year

The first digit of the date is flashing. Enter now the first digit of the date by using the numeric keys. Confirm the first digit by pressing '→' button and the second digit starts flashing. Enter now the second digit of the date and confirm it.
Do the same procedure with all the date and time digits.
After confirming the last digit the flashing stops and the clock starts running.
Exit the date/time mode by pressing the 'Menu' button (exit only in not editing mode).

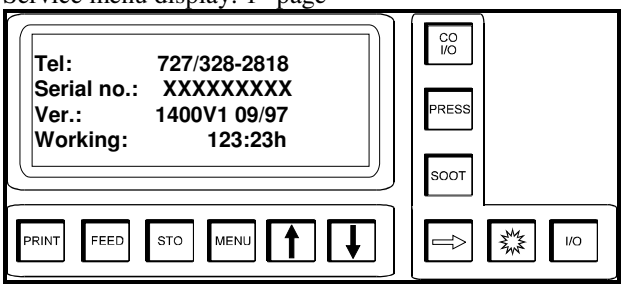
USA: Use the '↑' and '↓' buttons to select 'am ' or 'pm'.

3.4.7 Service menu

The service menu contains information about the sensors, working hours, serial no., service telephone number and more service information.

IMR® recommends printing (and then faxing the printout to IMR®) the service menu if any questions or problems occur.

Service menu display: 1st page



Active buttons

Page down		Return to menu	
Page up		Print service menu	

The service menu has 8 pages. Only the first two pages are important for the customer.

1st page: Service telephone no.
Serial no.
Program version
Working hours

2nd page: Measuring ranges of the gas sensors

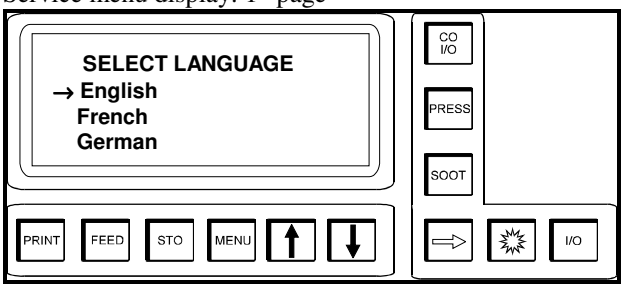
3.4.8 Select language (if equipped)

Following languages can be chosen

- English
- French
- German

More languages are available upon request.

Service menu display: 1st page



Active buttons

Move selector	↑	Return to menu	MENU
Move selector	↓	Confirm language	→

English / French / German:
The arrow selector must be in front of the wanted language and then the '→' button can be pressed to change the language setting.
Exit the language mode by pressing the 'menu' button.

4 CALCULATIONS

The **IMR® 1400-IR** calculates most parameters that are important for the measurement of a combustion process:

- Heat losses
- Combustion Efficiency
- Excess Air
- CO, NO, SO2, NO2 ppm value corrected to 0% Oxygen
- mg/Nm3, mg/kWh, mg/Ref.O2

4.1 USA - ASME CALCULATIONS

This section describes the formulas according to the ASME as well as the principles of the calculation.

Table 3: ASME Fuel constants

Fuel	HHV	CO_{2max}	%C	%S	$\%H_2$	%M
Natural gas	21830	11.7	69.4	0	22.5	0
Propane	21573	13.8	81.6	0	18.4	0
Kerosene	19942	15.12	86.5	0	13.2	0
Distillate #1	19423	15.4	86.6	0	13.3	0
Anthracite coal	12680	19.9	80.6	0	2.4	0
Bituminous coal	14030	18.5	80.1	0	5.0	0
Fuel #2	18993	15.7	87.3	0	12.5	0
Fuel #5	18909	16.3	88.7	0	10.7	0
Fuel #6	18126	16.7	88.5	0	9.3	0
Bagasse	8200	20.3	45	0	6.4	50
Wood	8800	20.0	50	0	6.5	10
Bark	8500	20.0	52	0	5.5	15

4.1.1 Heat losses based on ASME equations (ASME PTC 4.1)

- Total heat loss (H_L)

  heat loss = heat loss (dry gas) + heat loss (H2) + heat loss (moisture)

  $$H_L = H_{LDG} + H_{LH2} + H_{LM} = BTU\ /\ lb$$

  Heat loss in %

  $$HL\% = \frac{H_L}{HHV} \times 100 = \%$$

- Heat loss due to dry gas

  $$H_{LDG} = P_f \times 0.24 \times (T_g - T_a)$$

  Where

  $$P_f = \frac{11(CO_2) + 8(O_2) + 7(CO + N_2)}{3(CO_2 + CO)} \times \frac{\%C}{100} \times \frac{\%S}{100} = BTU\ /\ lb(as\ fired\ fuel)$$

- Heat loss due to moisture formed from H_2 in fuel

  $$H_{LH2} = \frac{9(H_2)}{100} \times (h_g - h_a) = BTU\ /\ lb(as\ fired\ fuel)$$

- Heat loss due to moisture in fuel (H_{LM})

  $$H_{LM} = \%\frac{moisture}{100} \times (h_g - h_a) = BTU\ /\ lb(as\ fired\ fuel)$$

  Tg = Flue gas temperature (^oF)
  Ta = Air temperature (ambient) (^oF)
  %C= Percent by weight in fuel analysis of carbon (see table)
  %S = Percent by weight in fuel analysis of sulfur (see table)
  $\%H_2$= hydrogen in a fired fuel by weight
  %moisture= %moisture as fired fuel by weight
  N_2 = Percent by volume in flue gas => $100\text{-}CO_2\text{-}O_2\text{-}CO$
  h_g = Enthalpy of water vapor at 1 psia and T_g
  h_a = Enthalpy of liquid water at T_a
  hg-ha= 1080 + 0.4(Tg-Ta)
  HHV = high heating value of fuel (see table)

- Combustion Efficiency

  Efficiency = 100% - heat loss

4.1.2 Excess air

In practice it is not possible to achieve a perfect combustion using the theoretically required amount of air. Therefore excess air is needed.
The ratio of the volume of air to the volume of air theoretically required is excess air.

$$ExAir = 100 \times \frac{O_2 - \frac{CO}{2}}{.2682(N_2) - O_2 - \frac{CO}{2}}$$

4.2 USA AND EUROPEAN CALCULATIONS

This section describes the calculations that are used in the USA and Europe.

4.2.1 CO-corrected to 0% O2

The CO quantity in flue gases with a specific O_2 content can be converted into a corrected CO.

$$CO(0\%) = CO_{meas.} \times 20.9 / (20.9 - O_{2}meas.)$$

COmeas = measured CO

The **IMR® 1400-IR** also calculates all other toxic sensor measurements to a corrected 0% value (NO (0%), SO2 (0%), NO2 (0%)).

Please contact IMR® if different corrected CO-calculations are required (e.g. corrected to 3%O2).

4.2.2 Converting ppm into volume/weight ratio

The following conversion factors are the basis for the conversion of ppm into mg/Nm^3 (referred to 32^{o}F / 0^{o}C gas temperature):

CO → *1ppm = 1.25mg/Nm3*
NO2 → *1ppm = 2.05mg/Nm3*
SO2 → *1ppm = 2.86mg/Nm3*
NO → *1ppm = 1.34mg/Nm3*

4.2.4 Converting ppm into volume/weight ratio with reference to the O_2 value

The toxic gas values can be displayed and printed in mg/m^3 with reference to a volume-percentage-content of oxygen depending on the fuel. Therefore the measurement value must be converted on the basis of the measured content of oxygen:

$$E_B = (20.9 - O_{2B}) / (20.9 - O_{2M}) \times E_M$$

E_B: Emission with reference to the oxygen content in mg/m^3
E_M: Measured emission in mg/m^3
O_{2M}: Measured oxygen content (%)
O_{2B}: Content of reference oxygen (%)

Table 4: Reference O2 values

	Fuel oil	Natural gas	Town gas	Coal gas	Liquid gas	Coke	Wood air-dry
O_{2B}	3%	3%	3%	3%	3%	7%	11%

The reference content of oxygen for the programmable fuel is set at 3%.

Please contact IMR® if any other than the above-mentioned O2 reference values are required.

4.3. EUROPEAN CALCULATIONS

This section describes the calculations that are used in Europe.

4.3.1 Heat losses qA

Complete utilization of heat emitted during the combustion process is desirable, as is a very small heat loss of flue gases. The loss of free heat is caused by the temperature difference between the fuel air mixture entering the furnace and gases evolved. The larger the amount of excess air and thereby the volume of flue gas and the higher the flue gas temperature the higher the losses and smaller the combustion efficiency.

In the case of the **IMR® 1400-IR** the calculation of the combustion efficiency/flue gas losses is in accordance to 'BImSCHV'.

$$q_A = (t_A - t_L) q_A \times \frac{A_2}{20.9 - O_2} + B(\%)$$

q_A: Flue gas losses in %
t_A: Flue gas temperature in °C
t_L: Combustion air temperature in °C
O_2: Oxygen in dry flue gas in %

Table 5: Fuel constants according to 'BImSCHV'

	Oil light	Natural gas	Town gas	Coal gas	Liquid gas	Coke	Wood (air-dry)
CO_{2max}	15.5	11.8	13.7	12.5	13.5	20.5	20.3
A_2	0.68	0.66	0.63	0.60	0.63	0.65	0.65
B	0.007	0.009	0.011	0.011	0.008	0.008	0.008
O_{2B}	3%	3%	3%	3%	3%	7%	11%

Combustion Efficiency:

$$Eta = 100 - q_A(\%)$$

Programmable fuel: calculation of flue gas losses

$$q_A = f \times (t_A - t_L) / CO_2(\%)$$

with

$$f = CO_{2\,max} \times 0.038$$

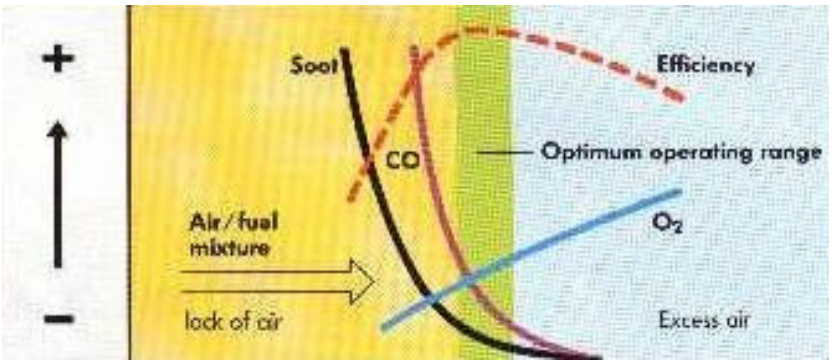
4.3.2 Excess air LAMBDA

In practice it is not possible to achieve complete combustion using the theoretically required amount of air, as it is hardly possible to disintegrate the fuel such that all molecules receive the necessary amount of air. Therefore, excess air is employed. The ratio of the volume of air employed to the volume of air theoretically required is called excess air / Lambda.

$$Lambda = 20.9 / (20.9 - O_2 meas.)$$

The excess air value must be kept low, as it needs to be heated resulting in a decrease of the flame temperature and an increase of the flue gas temperature, thereby deteriorating the efficiency.

Combustion chart



5 ERROR MESSAGES

The **IMR® 1400-IR** has several functions to identify any problems with the unit.
If an error occurs, then an error message is displayed and the error should be cleared before the measurement can be continued.

Load Batt
The battery voltage is lower than 5.3V.
Finish the measurement and charge the battery. If possible continue the measurement with the unit connected to the AC.

Batt Empty
The battery voltage is below 5.0V.
The equipment cannot be used at this point and it will turn off automatically. Connect the unit to the AC and once the battery has a minimal charge, the unit can be operated while connected to the AC.

T-gas probe?
The gas-sampling probe is not connected to the unit. Connect the probe and check the connection.

T-room probe?
The air temperature probe is not connected to the unit. Connect the probe and check the connection.

T-room>248 °F
The room temperature is above the operating temperature. Remove equipment from this high temperature and allow probe to cool down.

T-gas>176 °F
This message appears together with “new calibration”. The gas temperature is too high for a proper calibration. The gas-sampling probe must be in ambient (room) air for calibration.

T-gas>2192 °F
The gas temperature is too high. Take gas-sampling probe out of the stack or it will be damaged.

O2-sensor defect
The O2 sensor is either defective or the unit was not allowed to calibrate in fresh air. The sensor voltage is less than 800mV.
Repeat the calibration and if the error message continues to appear, then let the unit run and purge with fresh air for several hours (mostly: moisture in the sensor chamber).
If the purging does not help, then the O2 sensor must be replaced.

CO-sensor defect
The CO sensor is either defective or the unit was not allowed to calibrate in fresh air.
Repeat the calibration and if the error message continues to appear, then the CO sensor must be replaced.

NO / SO2 / NO2 / HC / CO2 -sensor defect
The sensor is either defective or the unit was not allowed to calibrate in fresh air.
Repeat the calibration and if the error message continues to appear, then the sensor must be replaced.

CO-overflow
The concentration of CO in the stack gas is higher than the sensor range.
Take the probe out of the stack and leave the unit running until the CO value comes back to 0ppm (only if unit does not have a CO-bypass). Overflows can damage the sensor and decrease its life expectancy.

NO / SO2 / NO2 / HC / CO2 -overflow
The concentration of the specific gas in the stack gas is higher than the sensor range.
Remove the probe from the stack and leave the unit running until the value comes back to 0ppm. Overflows can damage the sensor and decrease its life expectancy.

New calibration
Indicates that there was a problem during the calibration procedure.
This message usually occurs with additional messages to identify the problem.

Soot channel defect
The soot measurement took too long and the pump is not able to draw 1.63l flue gas into the analyzer.
Check the soot filter paper and probe, there could be also a problem with the pump.

Memory error
All programmed parameters will be set to their default settings.
Date, time and any programmed fuels have to be re-programmed.
A discharged battery mostly causes this error.

Memory full
All memory spaces are full
Erase some measurements or blocks to store additional measurements.

Memory block empty
The selected memory block does not contain any stored measurements.

PC connection?
The unit does not detect a connection to a PC.
Check the interface cable (null-modem cable) and make sure the PC is connected to the analyzer and the interface of the PC is in good working condition.

Output error
Usually indicates unit is out of paper or the printer cable is not connected.

Store error
Unit calculated wrong checksum.
Erase some measurements or blocks.

6 WARRANTY

IMR® Environmental Equipment, Inc., 3634 Central Ave., St. Petersburg, FL, 33711, USA states the following:

IMR®, as manufacturer, hereby grants the following worldwide IMR® warranty for an IMR® analyzer purchased from an authorized dealer.

1. The IMR® warranty shall entitle every IMR® customer to demand a free replacement or repair of the defective parts from any IMR® dealer authorized for the respective IMR® unit.

2. The IMR® warranty shall be granted on the factory new unit and shall commence on the date of the delivery of the original IMR® unit to the customer. It shall last for a period of twelve months regardless of the type and the intensity of use and regardless of any change of owner, which may occur during this warranty period.

3. The IMR® warranty shall refer to absence of faults with respect to the state of the art nature of the sold unit in terms of material and finish. The warranty for all parts fitted during the twelve-month warranty period shall end with the unit warranty.

4. After the establishment of a material or production fault by IMR® or the authorized IMR® dealer, the faults will be eliminated by means of free repair or replacement. Replaced parts shall become the property of IMR®.

5. No warranty claims may be made for maintenance and setting work, cleaning or other utility materials required for the function of the unit and other wear parts unless they have a direct bearing on work performed under the warranty.

6. The terms and conditions for the acknowledgement of this warranty shall be the presentation of the fully completed warranty card, which must contain the confirmation from the authorized IMR® dealer on its delivery and, if applicable, the prescribed maintenance work.

7. The IMR® warranty shall only be applicable if

a. The analyzer has been maintained in accordance with the instructions issued by the manufacturers and the operating instructions by an authorized IMR® dealer.
b. Only original IMR® spare parts have been used for any repairs.
c. The unit has been used properly, the operating instructions observed and the unit has not been used for a purpose other than the one for which it has been designed.
d. The IMR® unit has been left in its original design and meets the original IMR® specifications.

e. The fault is not due to external influences or use for a purpose other than the one for which it has been designed.
f. Exclusively authorized IMR® dealers have made repairs to the IMR® unit.
g. The IMR® unit has been sent to an authorized IMR® dealer immediately after the fault was discovered.

7. Warranty time for the analyzer is 12 months, including sensors.

7 SPARE PARTS

Please specify model and serial number when ordering spare parts.

Other ranges are available upon request.

DESCRIPTION	PART-NO
Filter	72200
Pack of 10	72201
Filter for condensation trap	72550
Pack of 10	72551
Thermal paper w=58mm	71250
Soot filter paper	70350
Comparison scale	90300
Condensation trap	91101
O2-Sensor	AAA32-240-04
CO-Sensor 0-2,000ppm	AB505-WOB-5B
NO-Sensor 0-2,000ppm	AF505-WOC-5B
NO2-Sensor 0-100ppm	AG506-WOO-5B
SO2-Sensor 0-4,000ppm	AD506-WOO-5B
HC-Sensor 0-100%LEL	190-00-HC-LEL
Ambient temp. probe, long	90500
Ambient temp. probe, short	92400
Battery 6V, 4Ah	E*000089
Gas probe E, 250mm	94200
Gas probe S, 270mm	94100
Fixture cone, ∅ 8mm	90106
Print head, w=58mm	MTP-201-24
Printer, w=58mm	DPU20/24-CF
Printer, w=80mm	130-3000-PR
Pump	SP500

8 CALIBRATION

This section describes how to adjust the gas sensors of an **IMR® 1400-IR**.

IMPORTANT: Only authorized dealer and service stations should do this adjustment.

All toxic sensors are adjustable. The O2 sensor is not adjustable.

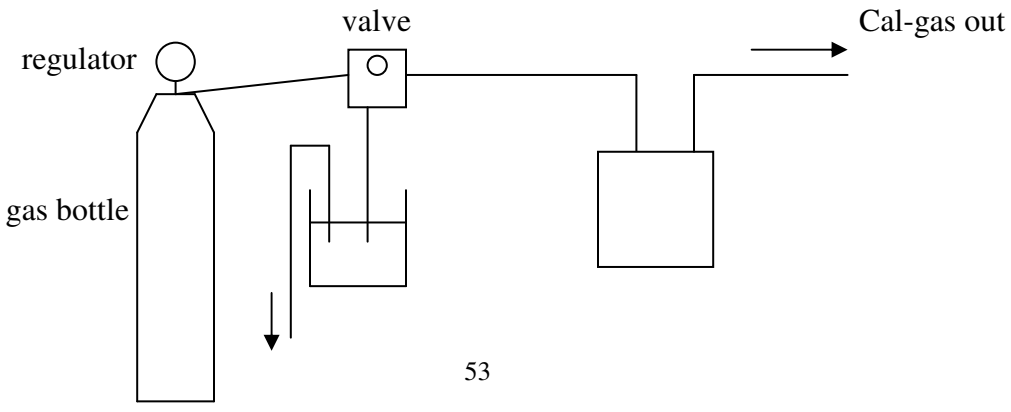
Calibration gas
Calibration gas is needed for each toxic sensor and for the oxygen sensor.

Cal-Gas	Concentration	Tolerance
Oxygen O2	≈ 10 Vol.%	2%
Carbon monoxide CO	≈ 400 ppm	5%
Carbon dioxide CO2	≈ 10 Vol.%	2%
Nitric oxide NO	≈ 100 ppm	5%
Nitric dioxide NO2	≈ 30 ppm	5%
Sulfur dioxide SO2	≈ 900 ppm	5%
Methane CH4 (HC)	≈ 5000 ppm	5%

These are concentrations for an **IMR® 1400-IR** with standard ranges. If it is known what the measurement concentration will be, then the concentration of the calibration gas can be changed to meet the requirements of the expected measurement range.

The balance of the calibration gas should be nitrogen N2. The balance N2 is needed to check the unit and its components for possible leaks.
All the toxic calibration gases are needed to adjust the analyzer to the known concentration of the calibration gas.
The Oxygen gas is needed to check the O2 sensor and its performance.

Calibration set-up



bubbler vessel

exhaust

IMR® 1400-IR set-up

- Unit must be taken out of aluminum box
- 4 Screws are located at the bottom of the analyzer
- Take of the AC-inlet
- Slide unit out of aluminum box
- Connect gas sampling probe
- Turn-on and let the analyzer calibrate
- Enter the measurement menu and switch to the page where all the toxic sensors (in ppm) and the oxygen value is shown

O2 - check

- Apply O2-test gas
- Wait three minutes to get a stable reading
- Measured O2 value must be within 0.1Vol% of the calibration gas
- Take a printout of the reading and take the gas off
- If the sensor does not meet the specification, then it must be exchanged

O2-sensor change:
- Unplug the two pins from top of the O2-sensor
- Take the O2-sensor out by turning it counter-clockwise (bayonet fitting)
- Put in the new O2-sensor and put the two pins on the new O2-sensor
- Wait thirty minutes (O2-stabilization) and then the unit is ready

CO / NO2 / SO2 / HC / NO - check

Important:

Toxic sensors are marked with rings and each sensor is connected to one specific circuit board (amplifier). A potentiometer will be on each of these amplification boards.

Mark	
NO:	orange ring
NO2:	black ring
SO2:	green ring
HC:	different shape

- Apply the specific test gas
- Wait three minutes to get a stable reading

- Measurement of the gas must be within the tolerance, which will be stated on the original calibration certificate of IMR®
- Adjust the reading if necessary by turning only the potentiometer on the circuit board of the specific sensor
- Take a printout of the reading and take the gas off
- Let the sensor recover for five minutes, it must reach 0 ppm.
- Repeat this cycle three times
- If the sensor does not reach the concentration or cannot be adjusted, then it must be changed (please call **IMR®** for information).

Leak check:

If all the sensors are checked and adjusted, then it is necessary to check for possible leaks. A leak might occur in the filter, condensation trap, etc. Therefore it is necessary to connect all hoses and components to the unit.

The leak test will be done with nitrogen N2 and the oxygen measurement must be 0%. If the O2 does show a higher value, then there is a leak somewhere.

- Apply N2 gas
- Wait three minutes to get a stable reading
- Measured O2-value must be < 0.1 Vol.%
- Take a printout of the reading and take the gas off
- If the reading is > 0.1 Vol.% then the unit has a possible leak
- Check all the components (probe, filter, condensation trap, pump, hoses)
- Repeat this cycle until it is sure that the unit has no leak

9 IMR®

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