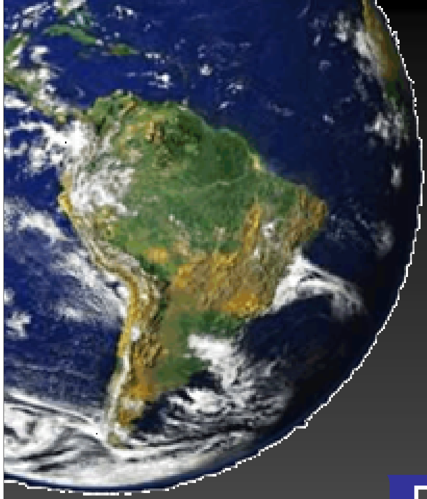


RS DYNAMICS

ECOPROBE 5

Operator’s Manual

ECOPROBE 5

Operator's Manual

CONTENTS

INTRODUCTION: Glossary

The Abbreviations, Terminology and Illustrations used in this manual are:

1. Abbreviations

AUT - Automatic

CF - Correction Factor

°C - degrees Centigrade

C - Carbon

H - Hydrogen

C–H - Carbon-Hydrogen bond

eV - electron volt

g - gram

mg - milligram

µg - microgram

GPS - Global Positioning System

GPS specific abbreviations: Refer to Window W. 16 on p. 38 for a list.

IP - Ionisation Potential

IR - Infrared

HC - Hydrocarbon [plural: HC's]

l - litre

m - metre

m^3 - cubic metre

mm - millimetre

NR - No Response

NAPL - Non Aqueous Phase Liquid [liquid hydrocarbon with a density less than that of water; in other words a floating product]

PCB - Poly Chlorinated Biphenyl

ppm - parts per million

ppb - parts per billion

PID - Photo-Ionisation Detector

UV - Ultra Violet

VOC - Volatile Organic Compound

Certain synonomous terms are used interchangeably in the text. These are –

[Soil] gas and vapor

Hydrocarbon and organic

Gasoline and petrol.

Diagrams and illustrations that are referenced in the text, are designated as Figures e.g. Fig.1, Fig. 2, etc.

Displays that appear on **ECOPROBE 5**'s screen and referenced in the text, are designated as Windows e.g. W.1, W. 2, W. 3.2, etc.

The main applications of **ECOPROBE 5** are fast mapping, monitoring and delineating contaminated areas, and identifying the contaminant sources and migration paths. Measuring by means of **ECOPROBE 5** is fast and economical and eliminates the expensive laboratory analysis of spectrally known and identical samples.

As many as one hundred stations can be measured in a day. Resulting contour or wire-frame maps take only minutes to construct using advanced **ECOPROBE 5** data logging system in combination with **ECOPROBE_VIEW** communication software and graphic software Surfer for Windows.

ECOPROBE 5 measures the concentration of a contaminant vapor phase in a subsurface soil environment. These values are proportional to the contaminant concentration but cannot exactly define the precise amount of liquid contaminant present in the soil. Once the impacted area is surveyed, it is recommended that a sample be taken where the highest contamination was recorded and also several samples from the boundary of the contaminated area (Fig.1) for a laboratory analysis to determine the concentration range of the contaminant.

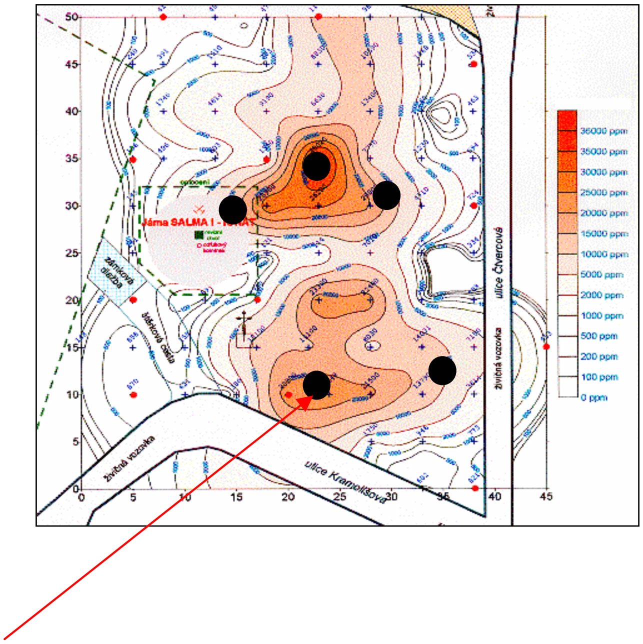


Fig. 1 - Five samples for laboratory investigation were taken from the above area where 250 stations were measured using **ECOPROBE 5** for fast surveying of the contaminated site.

INTRODUCTION

ECOPROBE 5 introduces a new level of flexibility, convenience, and quality to *in situ* detection and analysis of the vapor phase of volatile organic compounds.

ECOPROBE 5 comprises two independent analytical systems:

1. **Photo-ionization analyzer (PID)** measuring total concentration of volatile organic compounds (VOC)
2. **Infra-red analyzer (IR)** providing separate measurements of methane, petroleum group of hydrocarbons and carbon dioxide.

In addition to the above parameters, temperature, pressure and oxygen are also measured.

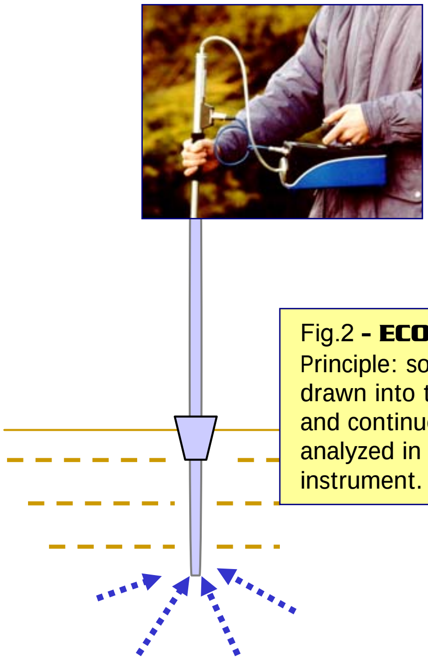


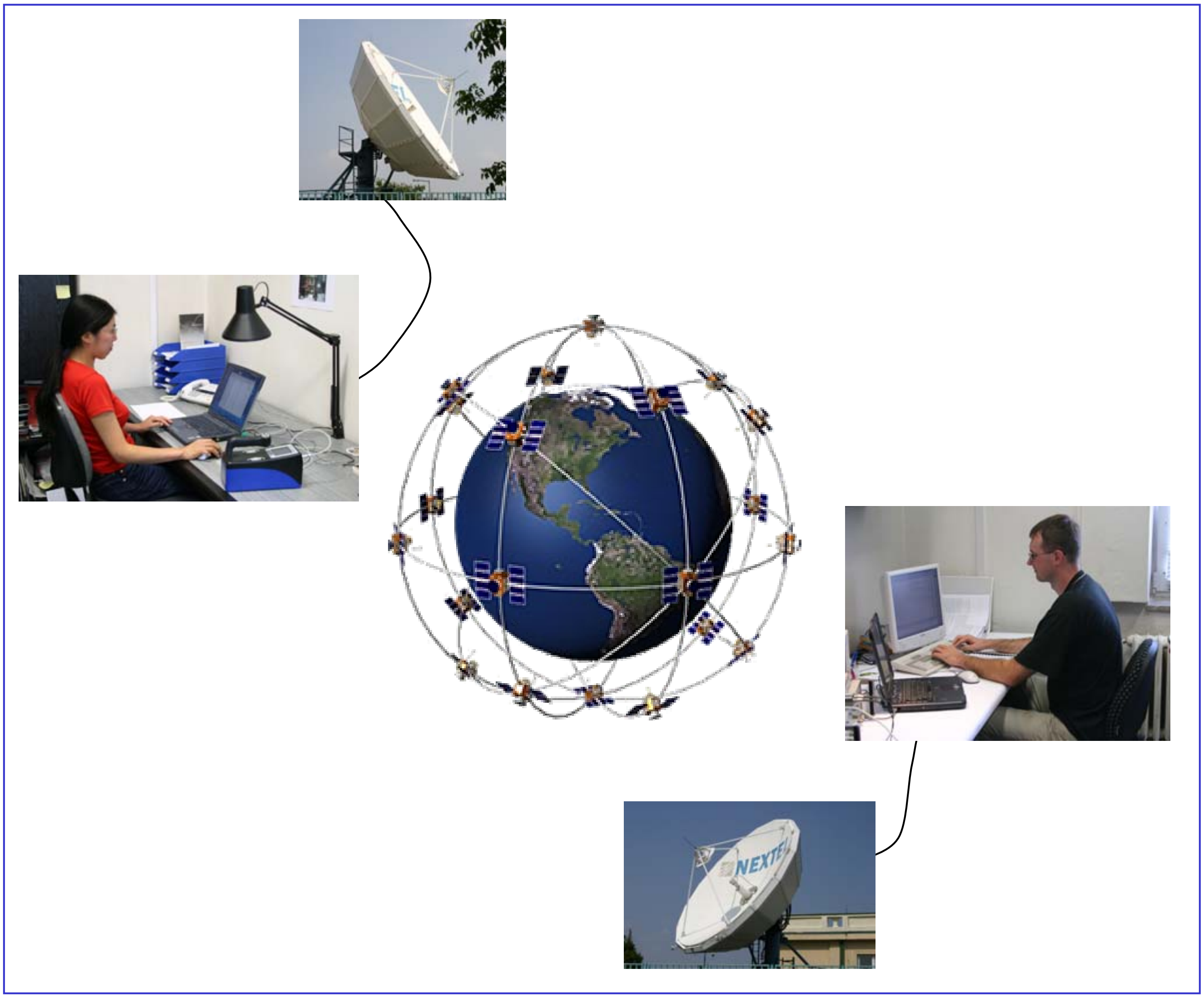
Fig.2 **- ECOPROBE 5** Principle: soil gas is drawn into the probe and continuously analyzed in the instrument.

This ideal combination of analytical systems provides a set of high precision data measured simultaneously in the subsurface environment and designed especially for cost effective soil contaminant surveys and various other environmental tasks.

INTERNET COMMUNICATION BETWEEN A REMOTE **ECOPROBE 5** AND A REMOTE COMPUTER

Innovative technology provides Internet communication between a remote **ECOPROBE 5** and a computer located anywhere – for example in your office or at **RS DYNAMICS** Ltd.

In this way you can set up the instrument, calibrate or download data from a remote **ECOPROBE 5**, or have it checked, adjusted or upgraded by the manufacturer from any place worldwide.



For more information kindly refer to the manual for communication and data acquisition software ***"ECOPROBE_VIEW".***

APPLICATIONS

Main Applications

- Detection, delineation and monitoring of hydrocarbon contamination of soils from fuel and other spills.
- Fast and convenient monitoring of UST (underground storage tanks) and pipelines for leakage.
- Monitoring of contaminant plume migration.
- Monitoring of *in situ* bioremediation processes where bacteria consume oxygen and generate heat, methane and carbon dioxide. Routine monitoring at fixed locations can track both the progress and the efficiency of the process. The results provide a good indication of bacterial activity and also of the contaminant concentration.
- Detection and monitoring of methane flux over decommissioned coal mines.

Other Applications

Following applications require operator experience to decide (or consult the **RS DYNAMICS** representative or manufacturer) if the **ECOPROBE 5** system is suitable for a given task.

- Waste dumps & agricultural waste measurement.
- Detection and monitoring of toxic gasses in industrial plants and in agricultural environments .
- Detection and monitoring of product leaks in the chemical/petrochemical industry.
- Air pollution monitoring.
- Others

ECOPROBE 5 can be also used as a sophisticated sampling device. An absorbent cartridge can be connected to the instrument outlet, collecting the soil gas which has been already measured.

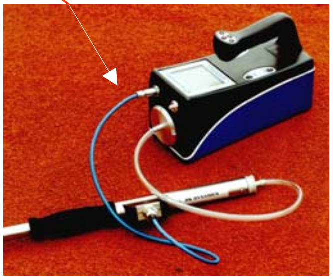
THE FIELD SURVEY

Mapping a contaminant plume in soil is the most common application of **ECOPROBE 5** (Figs.1 and 2). An experienced operator is capable of boring holes and carrying out the measurement without additional assistance. In difficult soil conditions, or if a rapid sample rate is required, an assistant can help with boring holes and cleaning probes.

It is strongly recommended to charge the instrument's batteries overnight before a day's investigation.

What Do You Need for a Field Survey

- Fully charged **ECOPROBE 5**.
- Sampling probe.
- GPS antenna for GPS logging.
- Spare dust filters and tubing.
- Iron brace and hammer or drill for making holes.
- A measuring tape to establish a grid for standard logging.
- Pumping device for cleaning the sampling probe (such as that used for inflating rubber mattresses).
- Connecting cable between the temperature sampling probe and the instrument – if the soil temperature is required.
- Battery charger.
- Connector splitter for simultaneous connection of the temperature sampling probe and GPS antenna, if needed (optional item).



Take care to avoid any liquid from seeping directly into the instrument's sampling aperture! This will cause serious damage to the analytical units and it will invalidate the warranty. **!**

ECOPROBE_VIEW : DATA TRANSFER & DATA ACQUISITION SOFTWARE

Data collected in the field can be easily transferred by **ECOPROBE_VIEW** communication software from **ECOPROBE 5** to the computer.There are two versions of the communication software – **Light** and **Plus**. **Plus** version comprises additional optional features. Only basic information about data logging and data interpretation is discussed here as **ECOPROBE_VIEW** software is described in the software manual.

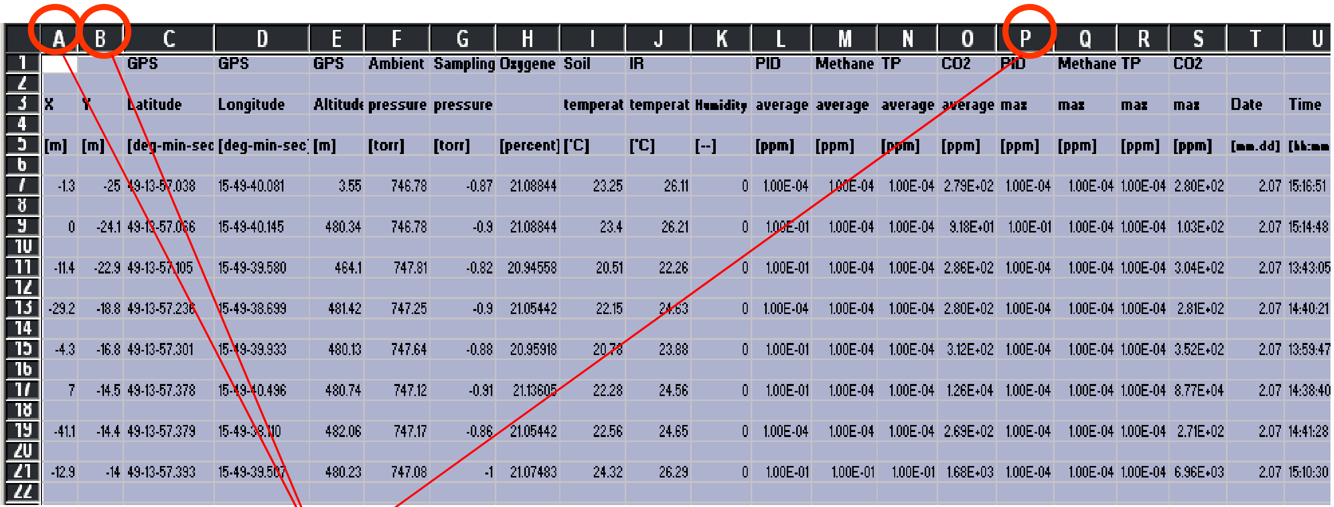
The **ECOPROBE 5** provides standard surface data logging and optional GPS logging. Both allow freedom of movement between any station at a specific locality. All data are stored in the instrument's memory according to the surface X ,Y or GPS coordinates. This system of data logging represents a powerful tool for obtaining interpretation results promptly.

The **ECOPROBE_VIEW** software ensures user-friendly data transfer from the instrument to the computer providing basic graphic data interpretation and a data spreadsheet. A data spreadsheet is created from all the data which are saved according to the coordinates.

For obtaining contour and wire-frame maps of contamination the user needs graphic software Surfer (Golden Software) and proceed according to the Surfer manual. Surfer can directly use the spreadsheet values for obtaining contour and wire-frame maps in a very short time.

Obtaining the contour and wire-frame maps using Surfer in brief (Fig. 3): Contour and wire-frame maps can be obtained from Surfer using three columns of **ECOPROBE_VIEW** data spreadsheet, where the first two columns are columns A and B which are linked with X and Y coordinates. Third column is a selected parameter for which the wire-frame map is required (for instance P for PID max.). The procedure is described in the manual for Surfer software.

To create a wire-frame map for methane, select columns A, B and Q and apply the same procedure as for PID. A complete set of maps allows the interpretation of the data as described on page 72.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1			GPS	GPS	GPS	Ambient	Sampling	Oxygene	Soil	IR		PID	Methane	TP	CO2	PID	Methane	TP	CO2		
2																					
3	X	Y	Latitude	Longitude	Altitud	pressure	pressure		temperat	temperat	Humidity	average	average	average	average	max	max	max	max	Date	Time
4																					
5	[m]	[m]	[deg-min-sec	[deg-min-sec	[m]	[torr]	[torr]	[percent]	[°C]	[°C]	[--]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[mm.dd]	[hh:mm
6																					
7	-1.3	-25	49-13-57.038	15-49-40.081	3.55	746.78	-0.87	21.08844	23.25	26.11	0	1.00E-04	1.00E-04	1.00E-04	2.79E+02	1.00E-04	1.00E-04	1.00E-04	2.80E+02	2.07	15:16:51
8																					
9	0	-24.1	49-13-57.066	15-49-40.145	480.34	746.78	-0.9	21.08844	23.4	26.21	0	1.00E-01	1.00E-04	1.00E-04	9.18E+01	1.00E-01	1.00E-04	1.00E-04	1.03E+02	2.07	15:14:48
10																					
11	-11.4	-22.9	49-13-57.105	15-49-39.580	464.1	747.81	-0.82	20.94558	20.51	22.26	0	1.00E-01	1.00E-04	1.00E-04	2.86E+02	1.00E-04	1.00E-04	1.00E-04	3.04E+02	2.07	13:43:05
12																					
13	-29.2	-18.8	49-13-57.236	15-49-38.699	481.42	747.25	-0.9	21.05442	22.15	24.63	0	1.00E-04	1.00E-04	1.00E-04	2.80E+02	1.00E-04	1.00E-04	1.00E-04	2.81E+02	2.07	14:40:21
14																					
15	-4.3	-16.8	49-13-57.301	15-49-39.933	480.13	747.64	-0.88	20.95918	20.78	23.88	0	1.00E-01	1.00E-04	1.00E-04	3.12E+02	1.00E-04	1.00E-04	1.00E-04	3.52E+02	2.07	13:59:47
16																					
17	7	-14.5	49-13-57.378	15-49-40.496	480.74	747.12	-0.91	21.13605	22.28	24.56	0	1.00E-01	1.00E-04	1.00E-04	1.26E+04	1.00E-04	1.00E-04	1.00E-04	8.77E+04	2.07	14:38:40
18																					
19	-41.1	-14.4	49-13-57.379	15-49-38.110	482.06	747.17	-0.86	21.05442	22.56	24.65	0	1.00E-04	1.00E-04	1.00E-04	2.69E+02	1.00E-04	1.00E-04	1.00E-04	2.71E+02	2.07	14:41:28
20																					
21	-12.9	-14	49-13-57.393	15-49-39.507	480.23	747.08	-1	21.07483	24.32	26.29	0	1.00E-01	1.00E-01	1.00E-01	1.68E+03	1.00E-04	1.00E-04	1.00E-04	6.96E+03	2.07	15:10:30
22																					

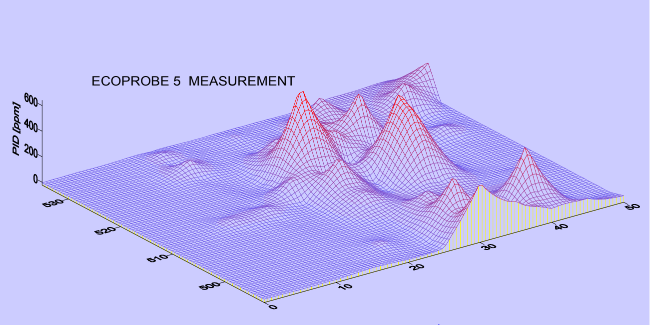


Fig.3 - Wire-frame map
obtained from PID data above.

SOIL VAPOR SURVEY

The gases found in pore spaces in soil and rock formations are known as soil vapor. The composition of this gaseous phase, in particular the presence of organic compounds, reveals vital information about the pollution of the subsurface environment.

Organic compounds constitute a group of contaminants which impact severely on groundwater resources. The presence and distribution of such pollutants can be detected using a technique known as Soil Vapor Survey (SVS) which is based on an analysis of the soil vapor.

The following types of contaminants can be monitored:

1. Liquid hydrocarbons - mainly petroleum products, and chlorinated hydrocarbons such as industrial solvents and pesticides.
2. Organic vapors from landfills and from gas leaks.

In situ soil vapor measurements are affected by several subsurface factors of which the most important are:

1. Presence of methane: As a product of natural biodegradation, methane occurs in varying concentrations everywhere in the subsurface soil environment.

2. Soil permeability: Soils with differing permeability create differing soil vapor flux conditions. Due to their texture, relatively impermeable soils such as clay produce soil vapor for a much shorter period of time compared to highly permeable soils such as sand.

Other factors are:

3. Zoning: Differences in the physical properties such as vapor pressure, solubility in water, mobility in the subsurface, resistance to degradation etc. of the various components of a complex contaminant, may give a heterogeneous character to a pollution plume.

4. Surface contamination: A pollutant occurring in the surface layer will seriously distort the distribution and concentration patterns of an underlying, deep source of contamination.

5. Age of a contaminant: All petroleum products experience some degree of natural biodegradation in the subsurface environment. Lighter HC's are more readily degraded than the heavier compounds. After a certain period of time the spectral composition of contaminants will dramatically change; moreover, some contaminants may become morphologized, that is composed of non-toxic aromatic compounds which are outside the basic hydrocarbon spectrum.

6. Soil temperature: With increasing soil temperature, vapor density decreases which, in turn, promotes the vapor diffusion rate.

7. Soil moisture: The presence of moisture reduces the effective porosity, which has a negative effect on the migration and volume of soil vapor available for measuring.

8. Type of contaminant: For the SVS to be applied successfully, the contaminant in question must manifest a sufficiently high vapor pressure. Some compounds such as transformer oils, PCB's and certain phenols, have a very low vapor pressure and require a special sampling technique.

The presence of methane and widely differing soil permeability are the two crucial distorting factors in soil vapor surveys. Both parameters dramatically affect the measured values of contaminant concentrations. Without the benefit of the ECOPROBE 5 method, these misleading results can cause severe misinterpretation of both the *in situ* and also the laboratory data.

ECOPROBE 5 provides a separate measurement for methane and displays sequences of measured values on the screen, thereby providing important information about the potential of soils of differing permeabilities to yield sufficient soil vapor. To illustrate this point, the graphs below were obtained using the same amount of clay and sand soil samples, into which identical quantities of contaminant had been mixed (Figs. 4 and 5).

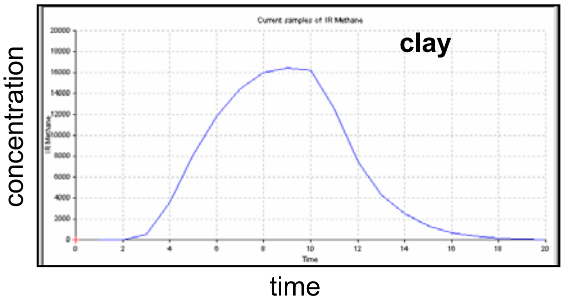


Fig. 4 -Sequence of measured values from a clay soil sample with poor permeability . The sharp decay of the curve indicates low porosity of the soil.
Evaluated by **ECOPROBE_VIEW** software.

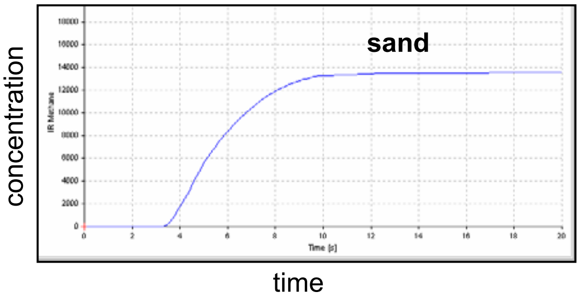


Fig. 5 - Sequence of measured values from a sand soil sample with good permeability. The “zero” decay of the curve indicates the high porosity of the soil.
Evaluated by **ECOPROBE_VIEW** software

In contrast to sand, clay yields soil vapor for a much shorter period of time.

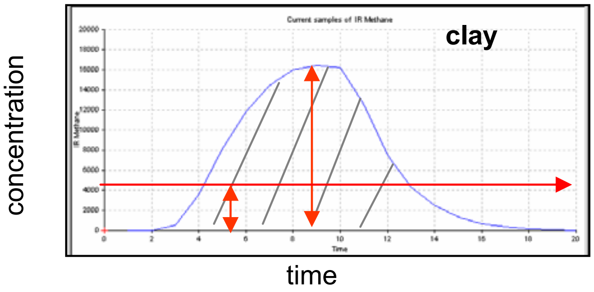


Fig.6 – The difference between the maximum concentration (long vertical arrow) and the average concentration (short vertical arrow).

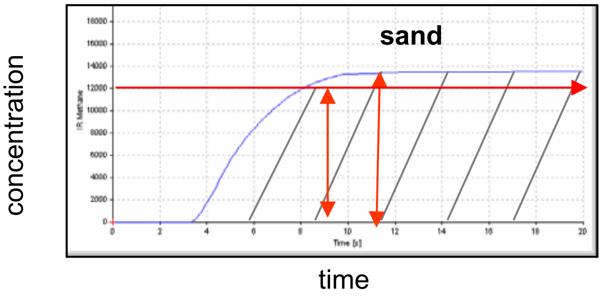


Fig.7 – The difference between the maximum concentration (long vertical arrow) and the average concentration (short vertical arrow).

The integrated time concentration values measured for clay and sand, respectively, differ from the maximum concentration obtained for each environment. Compare the cross hatched area and the vertical arrow of each diagram (Figs.6 and 7).

ECOPROBE 5’s measuring cycle at a station varies usually from 20 to 30 seconds. During this interval the software finds the highest measured value that indicates the maximum contaminant concentration in the soil vapor.

Graphs showing sequences of measured values at a station can be stored on the instrument memory and used for subsequent data interpretation.

1. INSTRUMENT DESCRIPTION

Fig. 8 - Display panel and handle controls

1.1 BASIC CONTROLS (Fig. 8)

Display Panel -- Four Keys Arranged in Two Islands

ON/OFF	Switches the instrument On/Off.
LIGHT	While holding down the key, ◄/► is used to switch the screen back light On/Off; ▲/▼ is used to change the screen contrast.
ESC	Terminates a current operation and returns to the *Main Menu.*
RUN	Starts measuring the station with the displayed coordinates.

Handle Control -- Four Arrowed Keys

These are multi-functional switches and their actual operation or function depends on the specific menu displayed.

▲/▼	(Up/Down)	Moves the cursor up/down through a menu.
◄	(Left)	Escapes from a current menu to return to the previous level and saves a selected option.
►	(Right)	Selects an option from a menu, or initiates a procedure/operation.

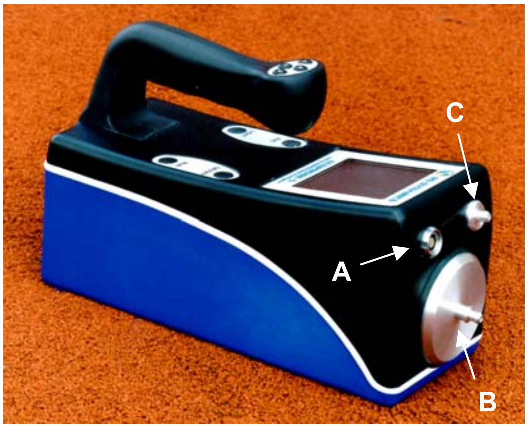


Fig. 9 - The front of the instrument

1.2 The Front of the Instrument (Fig. 9)

A. Multifunctional connector for the charger, PC, GPS receiver and alternative power source like solar batteries or a car charging cable.

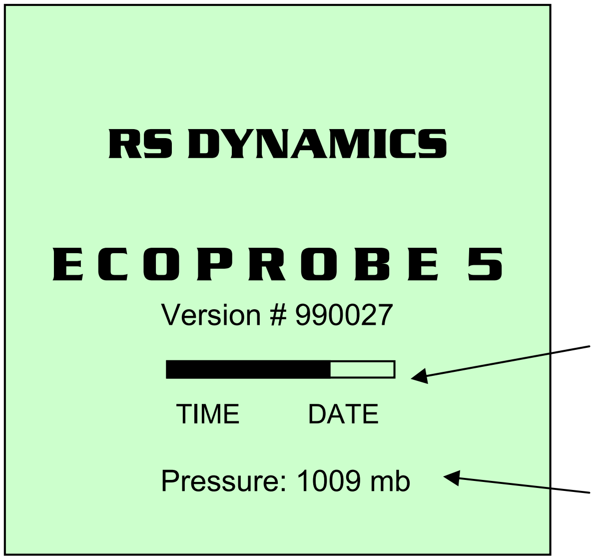
B. Gas inlet

C. Gas outlet

Do not allow any liquid to enter the sampling aperture. The resulting serious damage to the analytical units is not covered by the warranty!

2. STARTING UP ECOPROBE 5

By pressing the ON/OFF key on the display panel, the instrument will boot up in about two seconds and display the *Welcome Menu (Window W.1).*



RS DYNAMICS

ECOPROBE 5

Version # 990027

TIME DATE

Pressure: 1009 mb

Battery power indicator.

Atmospheric pressure indicator.

W.1 -Welcome Menu

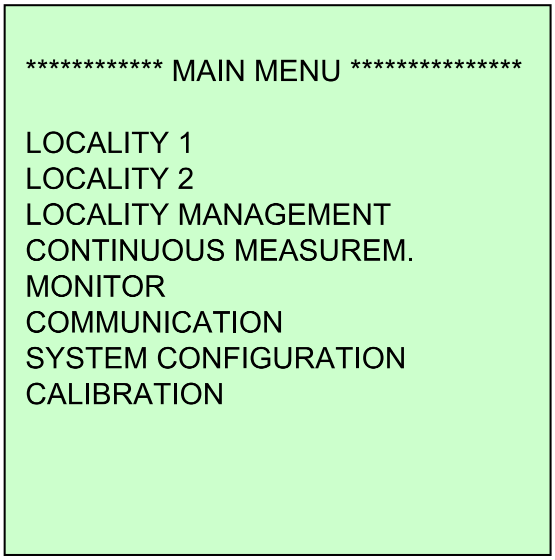
Press the right arrow on the handle control to open the *Main Menu* (Window W. 2).

If the instrument has not been used for 5 minutes in standard mode, it switches itself off to reduce the current consumption.

In GPS data logging mode, the instrument switches itself off after 30 minutes of no operation.

In monitoring mode the instrument will switch itself off only when the battery is fully discharged.

2.1 MAIN MENU (Window W. 2) – BRIEF DESCRIPTION



************ MAIN MENU ***************

LOCALITY 1
LOCALITY 2
LOCALITY MANAGEMENT
CONTINUOUS MEASUREM.
MONITOR
COMMUNICATION
SYSTEM CONFIGURATION
CALIBRATION

W. 2 - Main Menu

LOCALITY 1 (or 2)

After selecting a new locality by using the *Locality Management* option, this item opens a measuring mode to start measurement of the locality.

LOCALITY MANAGEMENT

Enables you to set and delete localities and monitoring stations.

CONTINUOUS MEASUREMENT

Allows continuous measurement without any data being logged**.**

MONITOR

Enables automatic monitoring of contamination at a predetermined sampling rate.

COMMUNICATION

Enables transferring data from **ECOPROBE 5** to a PC or notebook.

SYSTEM CONFIGURATION

Allows editing the default values of the *Configuration File.*

CALIBRATION

Enables you to perform a Single Point Calibration. This item is part of the calibration procedure.

Each item of the Main Menu contains sub-menus.
Use ▲/▼to scroll through the menu, and ► to access a selected item.

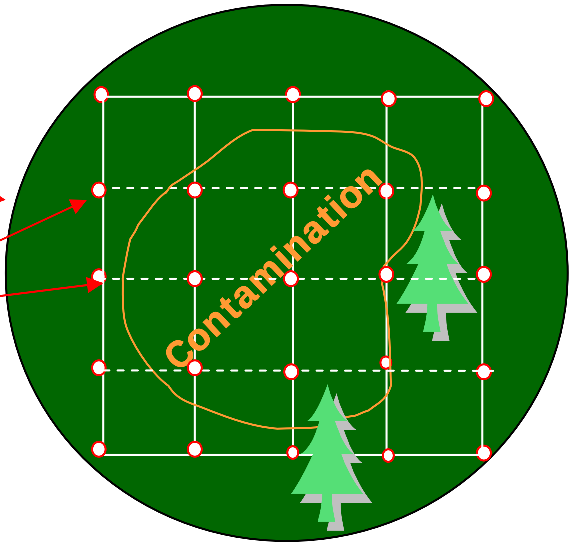
In the following Chapters the options *LOCALITY MANAGEMENTS* and *LOCALITY 1 (or 2)* are described. These options are related to the setting the instrument before measuring and to the real measurement with **ECOPROBE 5**. The other options of the *Main Menu* are described on p. 42.

Locality and Station (Fig.10)

What do the terms *Locality* and *Station* mean?

The term *Locality* means the entire investigated area/site.

The term *Station* means a point within the given *Locality*, where a measurement is taken.



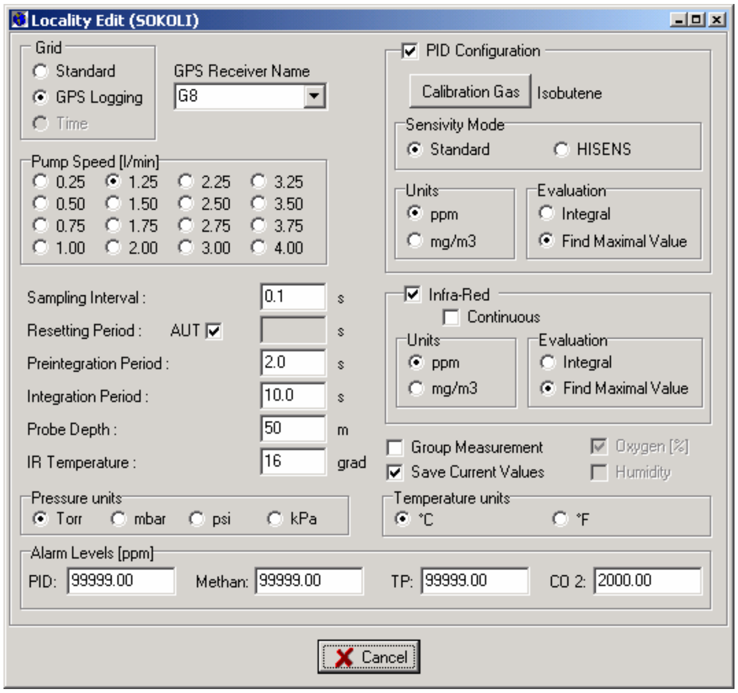
3. SETTING UP **ECOPROBE 5**

Before starting to measure it is necessary to set the parameters for the locality to be surveyed. This procedure can be done either directly in the instrument or using **ECOPROBE_VIEW** software. Both procedures open the *Configuration File* with default settings (Window W.3 and Fig.11). The default value of the different parameters can be changed in either the *Configuration File* or in the **ECOPROBE_VIEW** program.

Default values represent well-proven settings suitable for a general survey. Besides providing a guideline, these values facilitate setting up a new locality, and they should be used until the operator has sufficient experience to select an optimum combination for a given environment.

```
LOCALITY1:                     noname
-----------------------------------------------------------
Grid:        Standard
X Increment:                   10.0 m
Y Increment:                   10.0 m
-----------------------------------------------------------
Group Measurement:             No
Pump Speed:                    1.25 l/mim
Sampl. interval                0.1 s
Reset period:                  AUT  s
Preint. period:                  5  s
Integr. period:                20 s
Probe Depth:                   0.50m
Save Curr. Val.:               No
Temperature:                   99  grad
PID On/Off:                    On
Range:                         STANDARD
Calibration gas:               118 Isobutene
Units:                         ppm
Evaluation:                    Maximum
-----------------------------------------------------------
Infra-Red On/Off:               On
Continuous Measurement::        On
Units:                         ppm
Evaluation:                    Maximum
-----------------------------------------------------------
Oxygen:                        On
Temperature units:             C
Pressure units:                 kPa
PID Alarm:                      1000
methane Alarm:                 99999
TP Alarm :                     99999
CO2 Alarm:                     99999
-----------------------------------------------------------
Save Configuration
```

W. 3 -Configuration File showing default values.



Locality Edit (SOKOLI)

Grid: ○ Standard ● GPS Logging ○ Time

GPS Receiver Name: G8

☑ PID Configuration

Calibration Gas: Isobutene

Sensivity Mode: ● Standard ○ HISENS

Units: ● ppm ○ mg/m3

Evaluation: ○ Integral ● Find Maximal Value

Pump Speed [l/min]: ○ 0.25 ● 1.25 ○ 2.25 ○ 3.25 ○ 0.50 ○ 1.50 ○ 2.50 ○ 3.50 ○ 0.75 ○ 1.75 ○ 2.75 ○ 3.75 ○ 1.00 ○ 2.00 ○ 3.00 ○ 4.00

Sampling Interval : 0.1 s

Resetting Period : AUT ☑ s

Preintegration Period : 2.0 s

Integration Period : 10.0 s

Probe Depth : 50 m

IR Temperature : 16 grad

☑ Infra-Red ☐ Continuous

Units: ● ppm ○ mg/m3

Evaluation: ○ Integral ● Find Maximal Value

☐ Group Measurement ☑ Oxygen [%]

☑ Save Current Values ☐ Humidity

Pressure units: ● Torr ○ mbar ○ psi ○ kPa

Temperature units: ● °C ○ °F

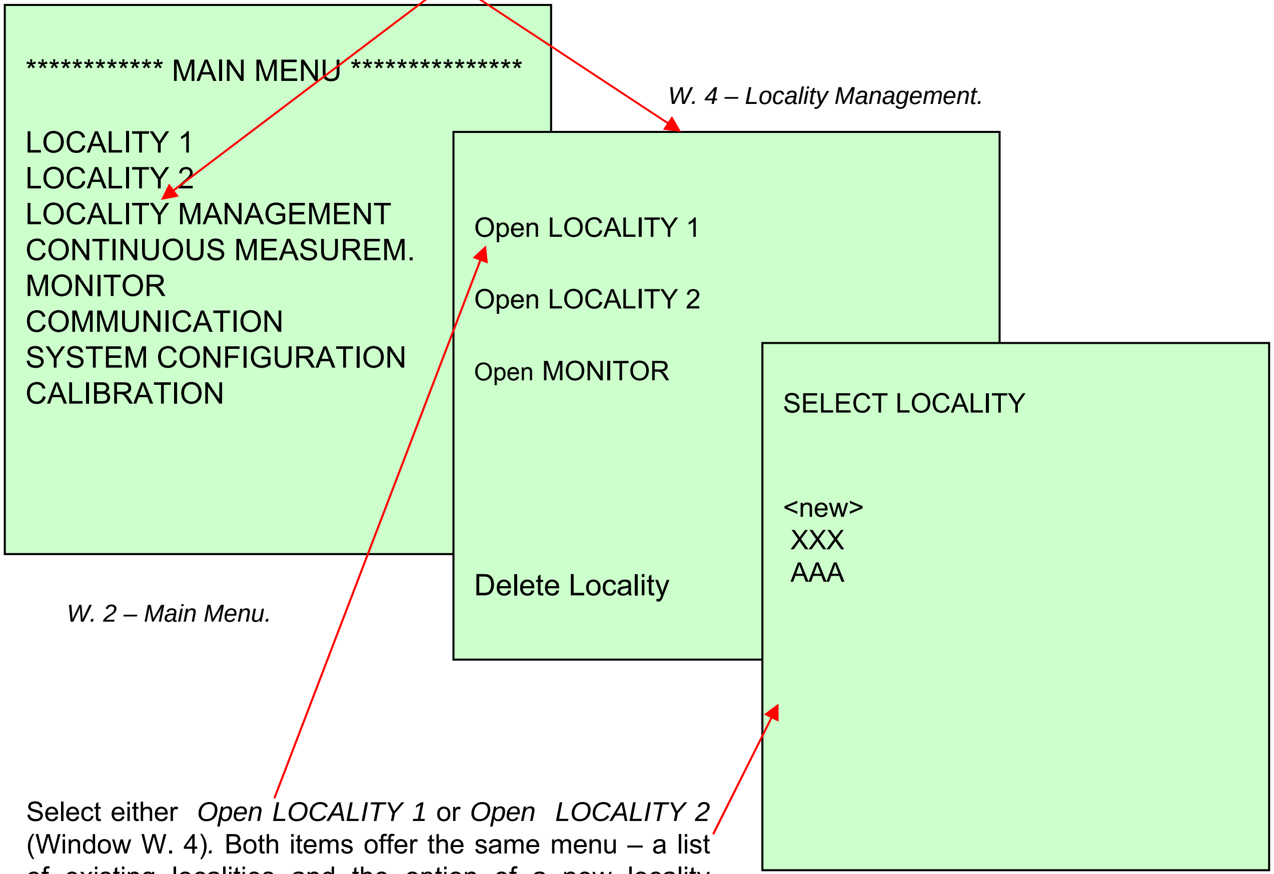
Alarm Levels [ppm]: PID: 99999.00 Methan: 99999.00 TP: 99999.00 CO 2: 2000.00

Fig. 11 - **ECOPROBE_VIEW** software display from the computer.

In the following chapter we describe how to set the parameters in the *Configuration File* (Window W.3) for an area to be investigated and how to understand various parameters.

3.1 SETTING UP THE LOCALITY PARAMETERS

To enter a name of the locality to be surveyed and to make possible changes to the parameters you have to open the *Configuration File* (Window W. 3) for a new locality. Select *LOCALITY MANAGEMENT* from the *Main Menu* (Window W. 2) and open Window W. 4.



************ MAIN MENU ***************

LOCALITY 1
LOCALITY 2
LOCALITY MANAGEMENT
CONTINUOUS MEASUREM.
MONITOR
COMMUNICATION
SYSTEM CONFIGURATION
CALIBRATION

W. 2 – Main Menu.

Open LOCALITY 1

Open LOCALITY 2

Open MONITOR

Delete Locality

W. 4 – Locality Management.

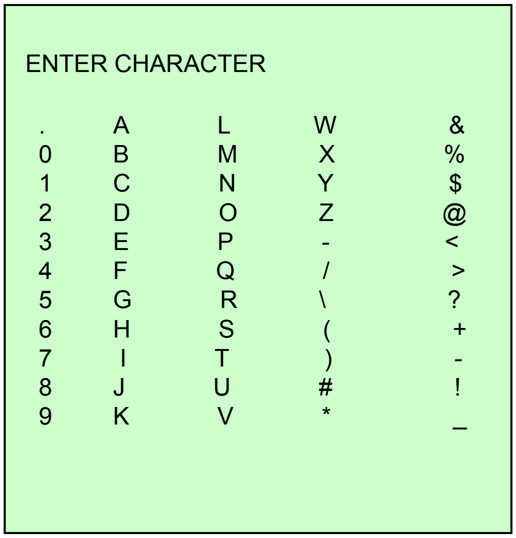
SELECT LOCALITY

<new>
XXX
AAA

W. 5. - List of existing localities.

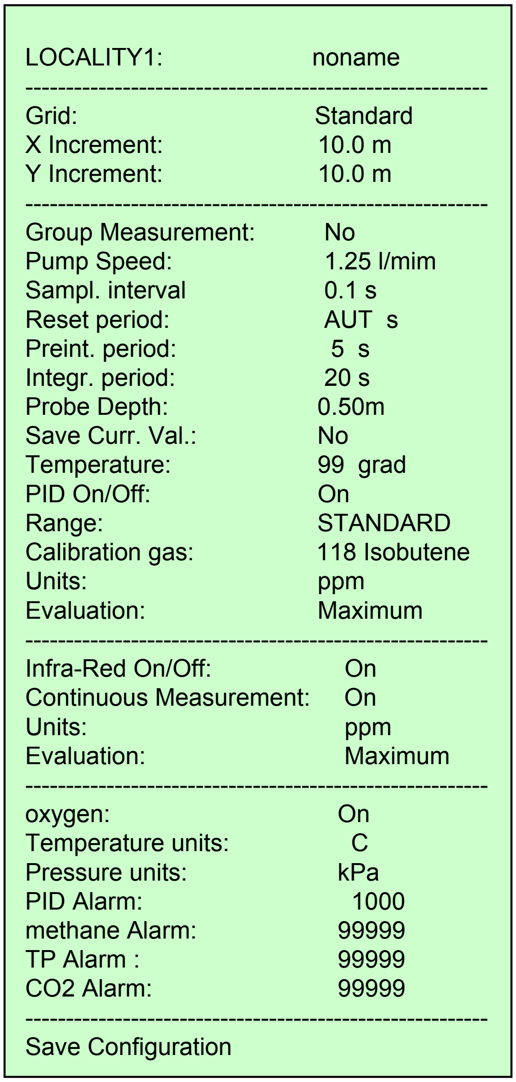
- Select either *Open LOCALITY 1* or *Open LOCALITY 2* (Window W. 4). Both items offer the same menu – a list of existing localities and the option of a new locality (Window W. 5).
- Select the option < *new* >. The *Configuration File* with default settings will be displayed on the instrument screen (Window W. 3).

- To enter a name of a new locality, the cursor has to be placed on the item *LOCALITY: noname* (Window W. 3) .
- Press right arrow on the instrument handle (►) to open *Enter Character Menu* (Window W. 6) to type the name:
- Scroll through the Menu with ▲/▼.
- Select a character with ►.
- The selected character will appear above the list of characters
- Continue completing the locality title by selecting other characters.
- Use ▲ to navigate to the completed name.
- When the cursor is on the name of the locality, use ► to confirm/store the title and to return to the *Configuration File.*
- The selected name will appear instead the word *noname* (for example ABC).



```
ENTER CHARACTER

.     A     L     W     &
0     B     M     X     %
1     C     N     Y     $
2     D     O     Z     @
3     E     P     -     <
4     F     Q     /     >
5     G     R     \     ?
6     H     S     (     +
7     I     T     )     -
8     J     U     #     !
9     K     V     *     _
```

W. 6 - Enter Character Menu



```
LOCALITY1:                  noname
-----------------------------------------------------------
Grid:                       Standard
X Increment:                10.0 m
Y Increment:                10.0 m
-----------------------------------------------------------
Group Measurement:          No
Pump Speed:                 1.25 l/mim
Sampl. interval             0.1 s
Reset period:               AUT  s
Preint. period:              5  s
Integr. period:             20 s
Probe Depth:                0.50m
Save Curr. Val.:            No
Temperature:                99  grad
PID On/Off:                 On
Range:                      STANDARD
Calibration gas:            118 Isobutene
Units:                      ppm
Evaluation:                 Maximum
-----------------------------------------------------------
Infra-Red On/Off:             On
Continuous Measurement:       On
Units:                        ppm
Evaluation:                   Maximum
-----------------------------------------------------------
oxygen:                       On
Temperature units:             C
Pressure units:               kPa
PID Alarm:                      1000
methane Alarm:                99999
TP Alarm :                    99999
CO2 Alarm:                    99999
-----------------------------------------------------------
Save Configuration
```

W. 3 - Default Configuration File.

The locality can now be stored without making any further changes by selecting the option *Save Configuration* at the end of the *Configuration File.* Or use the left arrow and follow the instructions on the screen to return to the *Main Menu* and continue measuring this locality.

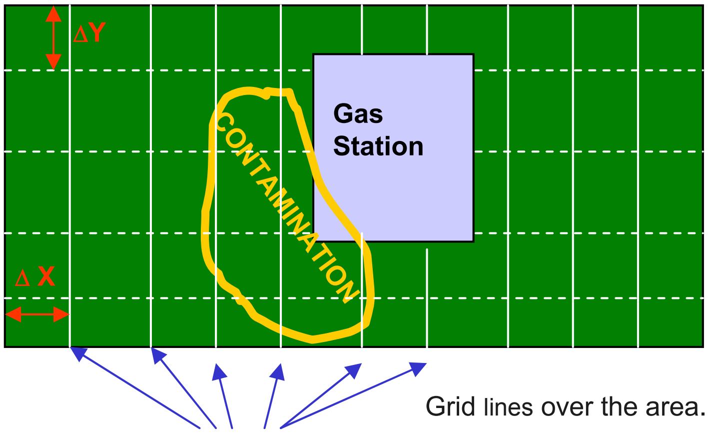
In case you need to change other parameters, the following description will help you to understand their meaning and provides instructions for changing their values.

The next parameter “GRID” enables you to select between *Standard* and *GPS* data logging system.

3.2 GRID

Standard

This parameter allows data logging of all measured values according to the allocated X,Y coordinates.
Standard data logging is a versatile tool for network field measurement and subsequent data interpretation. Network is defined by number of *lines* and number of *stations* on the line. The operator can move to any X,Y station to record its X and Y coordinates together with all measured data. Changing the increments ΔX and ΔY enables you to proceed by the most suitable measuring interval and thus select an optimum network scheme for a given environment. Decimal and negative values can also be entered. Measured values are saved in an orderly manner in the network system.



Grid lines over the area.

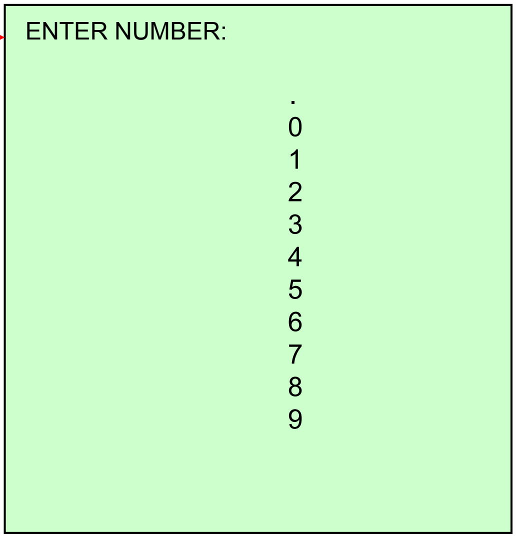
Fig. 12 - ΔX and ΔY increments of the grid pattern

Setting ΔX, ΔY values in the *Configuration File* defines the basic network grid which may be changed together with X and Y values of coordinates later in the field according to the site requirements directly from the *Measuring Mode* window (see chapter about measurement).

Y increment (ΔY):

With the cursor positioned on ***Y increment*** option use ► to open *Enter Number Menu* (Window W. 7) to change the value of the increment (in meters). The number setting is similar to *Enter Character Menu* for entering a name of a locality.

X increment (ΔX); as above.



ENTER NUMBER:

.
0
1
2
3
4
5
6
7
8
9

W. 7 - Enter Number Menu

Use ► on the item GRID to switch from *STANDARD* to the *GPS Logging* option*.*

GPS logging: This advanced parameter allows GPS coordinates to be introduced automatically. The coordinates of any location are obtained from an external GPS receiver. The operator just moves over the site while taking measurements without any reference to a grid pattern. All data are saved according to GPS coordinates (latitude, longitude) to create a data spreadsheet for the fast 3-D interpretation.

GPS logging is optional and requires purchasing software upgrade and one of GPS receivers provided by **RS DYNAMICS** Ltd. It is also possible to use various GPS receivers available on the market. These receivers must be adapted by **RS DYNAMICS** Ltd. for **ECOPROBE 5** technical specifications.

For more details about GPS logging and receivers see Chapter 5.

> *Note:* The **ECOPROBE 5** automatically creates a data spreadsheet from all data which are saved according the X and Y coordinates. Graphic software Surfer can directly use the spreadsheet for obtaining contour and wire-frame maps of contamination.

3.3 GROUP MEASUREMENT

This parameter enables you to decide if the measurement will be performed with or without resetting. Resetting procedure is described on the next page.

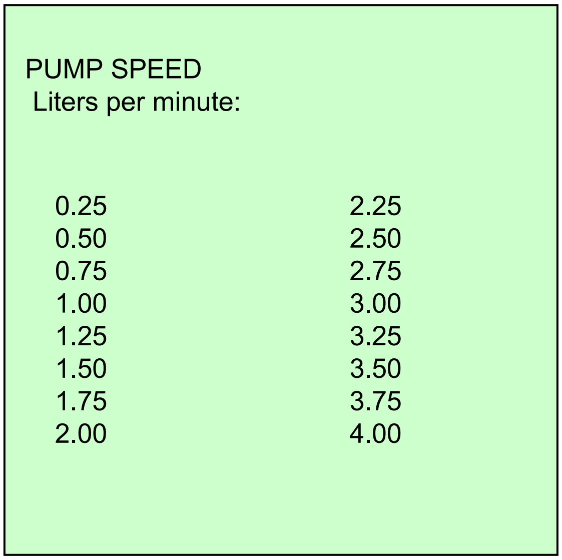
NO is used for a standard survey. Resetting cycle is performed automatically before each measurement using ambient fresh air. This mode is suitable for most environments.

YES is used when measuring in a contaminated atmosphere. For example in a contaminated factory or refinery where it is not possible to get fresh air for resetting, or when using **ECOPROBE 5** as a monitoring station without a special valve enabling the instrument to switch to the fresh air. The instrument can perform a resetting cycle only when pressing the RUN button on the instrument's front when the notice AUTOCALIBRATION appears on the display panel (before the "WARMING UP and MEASURING period). The instrument may be beeping. Release the RUN button when WARMING UP message is displayed. In this case ambient fresh air must be used for resetting. Move to outside the building, far from the polluted air or use a calibration bag with fresh air. At the start of a day's survey, reset the instrument using the above mentioned procedure (using the RUN button) for proper setting of the instrument. If possible, repeat the resetting several times during the day to ensure better stability and accuracy of the instrument reading.

3.4 PUMP SPEED

Enables you to select the speed of the pump and therefore the amount of air to be analyzed during the measuring cycle. A higher speed may be selected for instance in a poor permeable soil environment.

- ► Opens a menu with a selection of pump speeds ranging from 0.25 to 4.0 l/min (Window W. 8). The recommended value for general survey is 1.0 l/min or 1.25 l/min.
- Use ▲/▼ to select a speed.
- ► Confirms /stores the selected value and returns to the *Default Configuration File.*



PUMP SPEED
Liters per minute:

0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
3.75
4.00

W. 8 - Pump Speed Menu

3.5 SAMPLING INTERVAL

The instrument may store data at a pre-set rate (sampling interval) when measuring a station, if the option *Save current values* is set on YES (see below). The value of the *Sampling interval* can be changed by opening *Enter Number Menu* (Window W.9) and it ranges from 0.1s to 1s.

The trace of measurements at a station can be displayed on a PC using **ECOPROBE_VIEW** communication software (Fig 13). Data collected at a sampling interval of 0.1s provide a precise course of measurement trace, but a large part of the disk memory is taken up. For a general survey, it is recommended to use a sampling interval about 0,5 second.

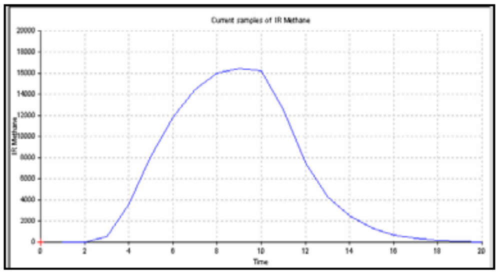


Fig. 13 – Trace of measuring at a station obtained from **ECOPROBE _VIEW** software**.**

3.6 MEASURING PROCEDURE

The standard measuring procedure comprises three phases, namely RESETTING, PRE-INTEGRATION and INTEGRATION cycles.

3.6.1 RESETTING CYCLE

When the measuring procedure is initiated, the instrument draws in air and displays a message **"Resetting"** on the screen. During the resetting operation the instrument ensures that --

1) The instrument's analytical chambers are cleaned by flushing out all contaminated vapor from the previous measuring cycle.
2) Analytical units are stabilized and reset to a 'zero' condition.

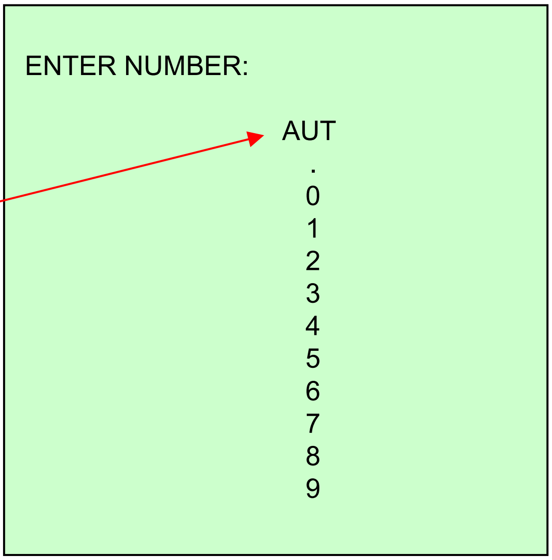
It is important that during resetting no tubes are connected to the instrument, and that only fresh/clean air is drawn in (Fig. 14).

The instrument measures the incoming air and this value is used as a base level or **'zero'**. Whereas fresh/clean air provides a true zero value (no contamination), contaminated air produces an exaggerated or false base value which is equal to the concentration of the contaminant. This means that if the contaminated air contributed a false base value of, say, 20 ppm, then subsequent results would be too high by that amount.

Fig. 14 **-** NO tubing must be connected to the instrument inlet during the resetting cycle.

Therefore, it is important that when measuring in a polluted environment such as a factory or at a surface spill, the instrument be taken to an environment with fresh/clean air for resetting. However, if this is not possible, it is recommended that a cylinder with fresh air is used for each resetting cycle.

For general environmental tasks use “AUT” (Automatic) resetting (Window W.9). In this case the duration of resetting interval is controlled by internal operating software. Resetting time is directly related to the level of the last measured concentration. The heavier the hydrocarbons, the longer the time necessary for cleaning of the analytical units. Resetting time may thus range from 10 to 30 seconds and stops when the analyzers are clean and ready for the next measurement. The following measurement must be done in a short time to ensure that analytical parts keep their precise setting. By extending the time between resetting and measuring the zero setting may slightly fluctuate around zero.



W. 9 - Enter Number Menu (for Resetting).

3.6.2 PRE-INTEGRATION PERIOD

After the resetting phase has been completed, the prompt *Press* -> appears on the screen to continue with the measuring cycle by starting the pre-integration phase.

During the pre-integration period air is drawn into the instrument without data being stored on the disk. This initial pumping phase enables the soil vapor to reach the analytical system. This procedure also suppresses the tendency of the vapor to condense on the internal surfaces of the probe and of the instrument in cold weather.

For measuring in the standard mode, a pre-integration value of 5 seconds is recommended. This value may be changed by opening and selecting from the *Enter Number Menu* (Window W. 7). In ‘difficult’ subsurface conditions where a low soil vapor flux is anticipated, the pre-integration period should be reduced to 2 seconds.

For measuring in the HI-SENS mode, values of 6 or 7 seconds is recommended to achieve the highest possible stabilisation of the PID system.

3.6.3 INTEGRATION PERIOD

The actual measuring of the contaminant concentration is done on soil vapor which is drawn into the instrument. **ECOPROBE 5** processes the signal from the analytical units at a rate of 10 measurements per second and it displays the progress of these data in four graphs representing the PID and IR channels. These graphs may be saved and used for data interpretation. At the end of the integration period the results are displayed on the screen and saved on the disk.

Recommended value for the integration period is 20 seconds and it can be changed by accessing the *Enter Number Menu* (Window W 7).

3.7 PROBE DEPTH

The depth of the hole into which the probe is inserted is noted. The value can be changed by accessing the *Enter Number Menu* (Window W. 7). This note is only for information and is not used for any internal software evaluations.

3.8 SAVE CURRENT VALUES

The measuring trace (see also “Sampling Rate” above) from PID and IR channels at any station can be saved and displayed later on a PC using **ECOPROBE_VIEW** communication software. (“Save Current Values” option is set on “YES”). The possibility of recording the progress of measurements provides an insight into the soil conditions. Nevertheless, saving “Current values” uses disk space and this should be considered while working with the instrument.

3.9 TEMPERATURE

Enter the ambient air temperature for the record. Default value is “99 grad” which means that no value has been inserted. This note is only for your information and is not used for any internal software evaluations.

3.10 ANALYZERS

The next step is to select the operating mode of the PID and IR analyzers. Those analyzers which are not actually needed for an investigation can be switched off to save battery current..

3.10.1 PID

ON/OFF

Switches the PID analytical mode ON/OFF

RANGE:

STANDARD The measuring range is from 0.1 ppm to 4000 ppm. Results are displayed in **ppm** or **in mg/m^3**. This mode is used for general soil contamination survey.

HI-SENS Very sensitive mode. Results are displayed in **ppb** or in **μg/m^3**.The upper limit of this mode is 100 ppm. If the measured value exceeds 100 ppm, a message “over” is displayed on the screen. HI SENS mode is extremely sensitive and is intended for special measurements where the influence of other factors (moisture, tubing contaminant residue etc.) is limited.

PID CALIBRATION GAS

► Opens a window with a selection of around 200 different spectral compounds that can be used for the automatic calibration of the PID unit (see page 59 about the PID analyser).

- Use ▲/▼ to select a compound;
- ► confirms/stores the selected item and returns to the *Configuration File.*

Default selection is Isobutene (identical to Isobuthylene), that is used also in laboratory chromatographs.

UNITS

Values can be displayed in ppm or in mg/m^3 which can be selected by pressing ►.

EVALUATION

Resulting values can be displayed as “Maximum” or as “Integral”.

Maximum:	The instrument will find the maximum value, and this setting is recommended for a general survey (see soil vapor survey on p.12)
Integral:	The instrument will calculate a numerical average of all measured values.

The final spread sheet obtained from **ECOPROBE_VIEW** software contains both the maximum and integral values (Fig. 3).
Recommended value is “**Maximum”** and it can be switched by pressing ►.

3.10.2 INFRA-RED

ON/OFF Switches the IR analytical mode ON/OFF

CONTINUOUS MEASUREMENT

Off:	The instrument switches automatically the IR unit off when the integration (measuring) period is completed, and turns it on at the next measured station. This mode saves battery current, but slightly reduces the accuracy of measurement .
On:	IR unit is continuously switched on which secures higher stability of measurement. This mode consumes more current.

The operator has to decide which mode is more suitable for the given environment.

The other settings are selected as for the PID analyzer.

3.10.3 PID and IR ALARMS

PID ALARM
Methane ALARM
TP ALARM
CO_2 ALARM

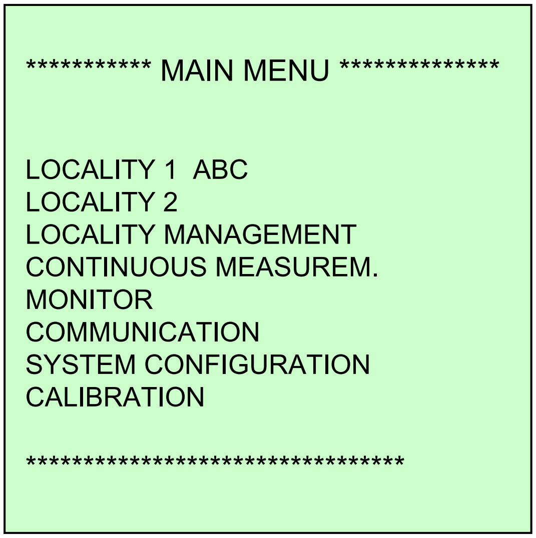
Alarm Level can be set by selecting from the *Enter Number Menu* (Window W.7). If the contaminant concentration exceeds the entered level of any channel, the instrument will start beeping and stops when the concentration falls under the preset value.

3.11 SUMMARY

Now we are at the end of the parameters of the *Configuration File*. Store the locality by selecting the option *Save configuration* at the end of the *Configuration File* (or use the left arrow and follow the instructions on the screen) to return to the *Main Menu* (Window W. 9.1).

If you entered the *Configuration File* using the option *Open LOCALITY 1* (see Window W 4) the new locality (ABC) is linked with *LOCALITY 1.* The name of this locality will be displayed after the option *LOCALITY 1* in the *Main Menu.*

If you entered the *Configuration File* using the option *Open LOCALITY 2,* the new locality is linked with *LOCALITY 2.* The name of the locality will be displayed after the option *LOCALITY 2* in the *Main Menu.* In this way you can link one locality with *LOCALITY 1* and one locality with *LOCALITY 2. LOCALITY 1* and *LOCALITY 2* directly open measuring modes of the localities*.* By selecting either *LOCALITY 1* or *LOCALITY 2* in the *Main Menu* it is easy to switch from one locality to another while working in the field. This procedure is particularly useful for measurement in two different depth levels in the same borehole. Measurement from one depth level can be associated with *LOCALITY 1*, from another depth level with *LOCALITY 2*.



```
*********** MAIN MENU **************


LOCALITY 1  ABC
LOCALITY 2
LOCALITY MANAGEMENT
CONTINUOUS MEASUREM.
MONITOR
COMMUNICATION
SYSTEM CONFIGURATION
CALIBRATION

*********************************
```

W. 9.1 - Main Menu after entering a new locality

By selecting *LOCALITY 1 ABC* in the *Main Menu* you can start surveying the locality. (see Chapter 4 – Measurement - Standard Grid).

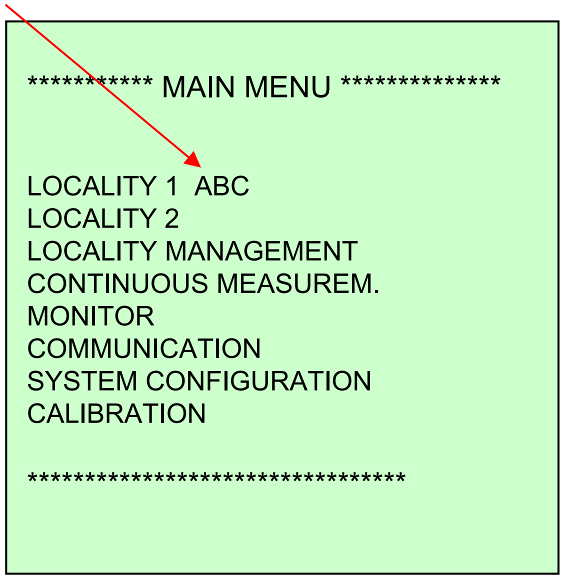
3.12 SELECTING AN EXISTING LOCALITY

If you have already measured a locality some time ago and you need to continue investigating it, select *LOCALITY MANAGEMENT*, then *Open LOCALITY 1 (or Open LOCALITY 2)* -- see Window W 4 -- and in the list of localities, select this locality – for example “XXX”. Its *Configuration File* will be opened which can either be changed or you can return without making any changes to the *Main Menu* by pressing ◄ and following the instructions on the screen. The selected locality is associated with *LOCALITY 1* or with *LOCALITY 2* and it can be measured by pressing the right arrow on *LOCALITY 1 XXX (or LOCALITY 2 XXX)* items in the *Main Menu.*

4. MEASURING – STANDARD GRID

4.1 MEASURING IN THE FIELD

Now we can initiate the actual measuring procedure.
After setting the parameters and returning to the *Main Menu* the name of the locality is displayed after *LOCALITY 1* – in our case ABC (Window W. 9.2).

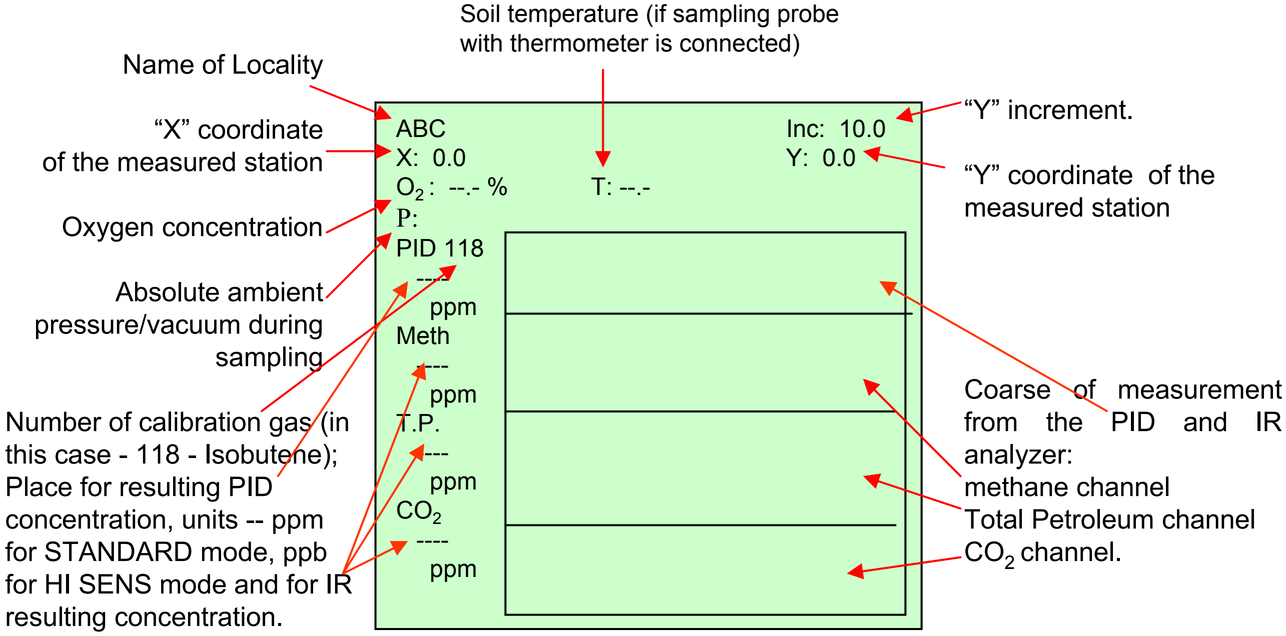


```
*********** MAIN MENU **************

LOCALITY 1  ABC
LOCALITY 2
LOCALITY MANAGEMENT
CONTINUOUS MEASUREM.
MONITOR
COMMUNICATION
SYSTEM CONFIGURATION
CALIBRATION

**********************************
```

W. 9.2 – Main Menu.

Select *LOCALITY 1 ABC* to open its measuring mode (Window W. 10.1).

Description of the *Measuring Mode*
(Standard data Logging)



```
ABC                          Inc:  10.0
X:  0.0                      Y:  0.0
O2 :  --.- %      T: --.-
P:
PID 118
  ----
    ppm
Meth
  ----
    ppm
T.P.
  ---
    ppm
CO2
  ----
    ppm
```

Soil temperature (if sampling probe with thermometer is connected)

Name of Locality

“X” coordinate of the measured station

Oxygen concentration

Absolute ambient pressure/vacuum during sampling

Number of calibration gas (in this case - 118 - Isobutene); Place for resulting PID concentration, units -- ppm for STANDARD mode, ppb for HI SENS mode and for IR resulting concentration.

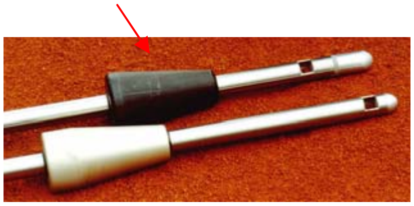
“Y” increment.

“Y” coordinate of the measured station

Coarse of measurement from the PID and IR analyzer:
methane channel
Total Petroleum channel
CO$_2$ channel.

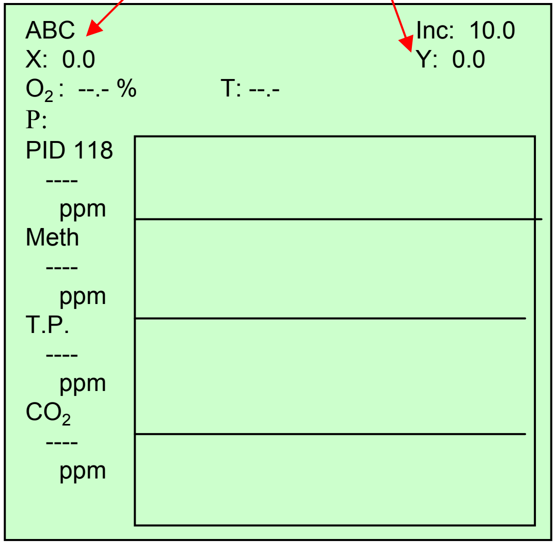
W. 10.1 – Measuring Mode

- Make a hole at the first station of the new locality using a brace or a similar field tool **(never use the sampling probe).**
- Pull out the brace and with minimum delay insert the probe vertically straight down. Do not rotate the probe while inserting it into the hole as rotation may let soil into the probe tip perforation and prevent air from entering into the probe.
- Make sure that the hole is quickly and perfectly sealed with the probe sealing cone which can be moved up or down.



- After inserting the probe into the hole**,** ensure that soil vapor can be withdrawn from the sampling probe by trying to suck air from the probe outlet. The probe must allow easy pumping of the air. If soil blocks the probe tip perforation, soil vapor cannot be withdrawn and the apparatus will record either no reading or a distorted value not representing the real contaminant concentration. High under-pressure during the measurement may also indicate a blocked probe.

  Wait a while before measuring in order to stabilize the soil gas conditions within the hole. This time interval must be equal for all stations of the locality and depends on the soil texture. For very permeable soils this time interval may be short (30 seconds, for example). For semi-permeable soils and in windy weather when the hole is strongly aired, the time interval needs to be considerably longer (for example 2 minutes).
- Measure the first station: While M*easuring Mode* of the locality is displayed on the instrument screen (Window W.10.2), press "RUN" button for measuring the first station X = 0, Y = 0. The *RUN* button is used to start measuring the station with the displayed coordinates, for measuring the first station, or for re-measuring a station that has already been surveyed.
  The measuring cycle starts with a resetting period.



ABC
Inc: 10.0
X: 0.0
Y: 0.0
O_2: --.- %
T: --.-
P:
PID 118
----
ppm
Meth
----
ppm
T.P.
----
ppm
CO_2
----
ppm

W. 10.2 – Measuring Mode.

While resetting, the plastic tubing and other parts **must not be connected** to the gas inlet to ensure that fresh air is let into the instrument.

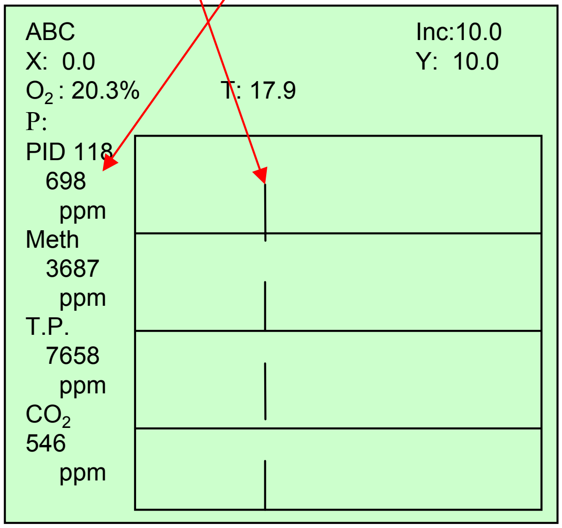
Resetting ensures:

1) cleaning the inner parts of the instrument of contaminated air from a previous measuring cycle.
2) stabilizing and finding zero conditions of analytical units.

When all contaminated air is flushed from the analytical chambers during resetting, the instrument considers the value of clean air from outside as zero. Usually, air around you is clean and may be used for resetting. However, if we should measure in an environment where the atmosphere is contaminated and has approximately 20 ppm (service stations, refineries, etc.) and this air is used for resetting, the instrument would consider the contamination concentration as zero. It means 20 ppm would be regarded 'zero' or the base level. If you were to measure about 80 ppm in the soil, the actual value would be around 100 ppm.

When the zero value is fixed set after resetting, the following measurement must be done in a short time to ensure that analytical units maintain a precise setting. With more time allowed between resetting and measurement the setting of zero may slightly drift around zero.

- When the resetting is completed the notice *Press ->* is displayed. **Connect** the plastic tubing and the dust filter between the instrument and the probe which has already been positioned in the hole. Confirm the option *Press->* to start measuring the station. The soil vapor is drawn through the probe and continuously analyzed in the instrument. Measuring traces for the different parameters from the PID and IR analyzers will be displayed in the window W 11.1. After the measuring cycle has been completed, the final concentrations are displayed on the left side of the screen, and also graphically as vertical lines.



ABC
Inc:10.0
X: 0.0
Y: 10.0
O_2: 20.3%
T: 17.9
P:
PID 118
698
ppm
Meth
3687
ppm
T.P.
7658
ppm
CO_2
546
ppm

W. 11.1 - Measuring Mode Menu. (Values and vertical concentration lines of the first station are displayed.)

- After the station has been measured, the operator will disconnect the tubing from the instrument (the tubing and dust filter stay connected to the probe), remove the probe from the hole and manually clean the tip perforation to remove the residual soil particles before moving on to the next station.

  If a contamination was indicated the operator should clean the probe by blowing it out to remove all residual gas and condensation from inside the probe. Clean air can be blown through by means of a manual pumping device such as that used for inflating rubber mattresses. It is important not to blow into the sampling probe with your own breath as this may cause moisture to enter the probe and may give incorrect results.

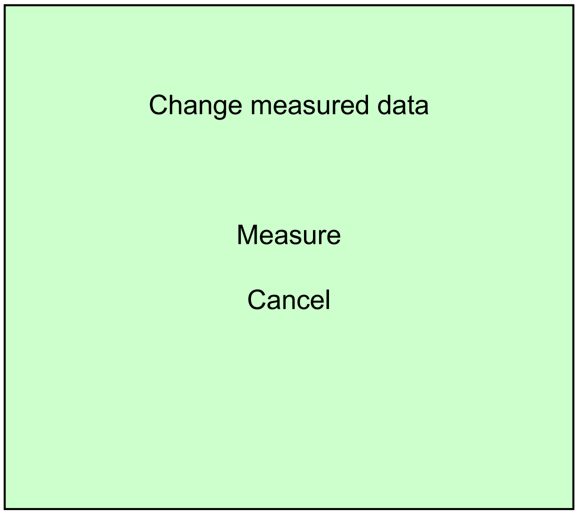
  After measuring a contaminated station, use a new set of tubing and dust filter for the next station The operator must prepare in advance and carry sufficient spare tubing and dust filters into the field. After completing a contaminated station, the used tubing and dust filter are stored for future cleaning. Used tubing will usually self-clean when placed on the room heater overnight and is ready to use on the next day. Dust filters may stay contaminated and their residual contamination must be measured before re-using in the field.

- At the next station the operator will repeat the measuring procedure by making a hole and inserting the probe. Wait a while before starting to measure by pressing right arrow on the instrument handle. Always use the right arrow to start measuring the next station, because it means that the "Y" coordinate is increased by the selected increment. The measuring cycle starts with resetting and follows the described procedure.

4.2 REPEATING A SELECTED STATION

- If you need to re-measure a station do not use the original hole as the soil vapor conditions may have been changed by the first effort. Always make a new hole about 30 cm away from the previous one. In the *Measuring Mode* of the instrument *(Window* W.11.1)select the station you want to re-measure using left/right arrow button on the instrument handle*.* Press the *RUN* button and window W.12 will be displayed.

- Select *Measure* from the displayed menu (Window W.12). The measurement of the station with the displayed coordinates is repeated. The original values will stay on the screen. Both original and new values are stored in the instrument disk and are available in the data sheet after transferring data to a computer using **ECOPROBE_VIEW** software.



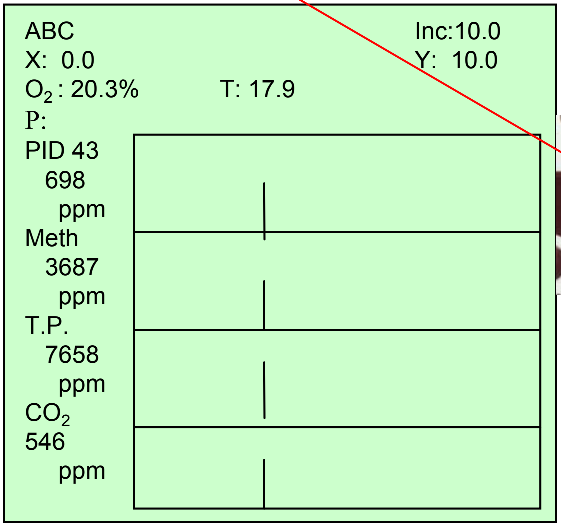
W. 12 - Repeating the selected station.

4.3 DATA LOGGING USING THE STANDARD GRID

There are two possibilities for selecting a station to be measured within the grid of the specific locality. The data are logged according their coordinates.

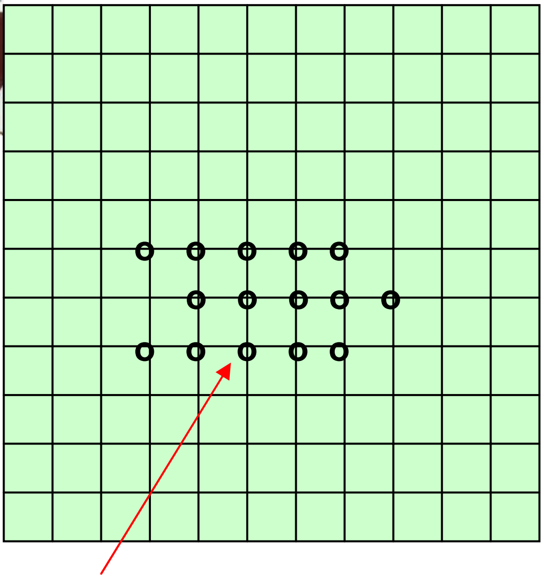
A. First option

- From the *Measuring Mode* (Window W.11.2), you can move to the graphic overview of the measured stations by using ▲ on the instrument handle.



ABC Inc:10.0
X: 0.0 Y: 10.0
O_2 : 20.3% T: 17.9
P:
PID 43
698
ppm
Meth
3687
ppm
T.P.
7658
ppm
CO_2
546
ppm

W. 11.2 - Measuring Mode.



W. 13 - Measured stations of specific locality.

- The grid with measured stations will be displayed on the screen (Window W. 13).

- Browse the grid by means of the four handle arrows. Select any station you want to measure and press *RUN* on the instrument panel to start its measurement.

- To return to the *Measuring Mode*, press *ESC.*

Note:

The grid with the last selected ΔX and ΔY increments is always displayed on the screen. All the stations measured in this grid are displayed as **“o”.**

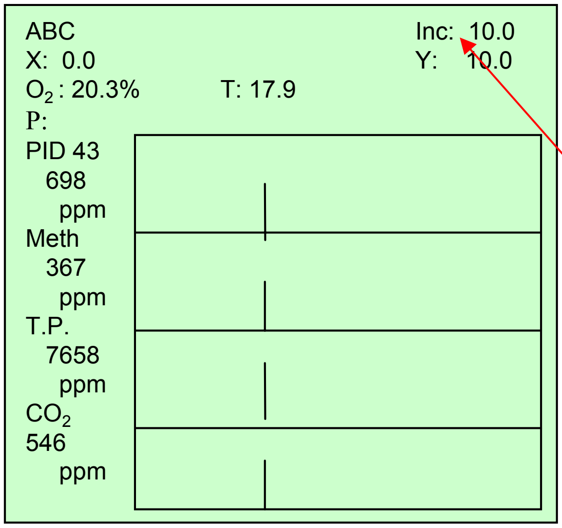
The stations that are not measured in the last set grid may be displayed as **“x”** or **“z”**

The sign **“x”** means that there is a measured station at this point of the grid together with one or several stations measured in the vicinity of the **“x”** station.

The sign **“z”** means that there is a station or several stations measured in the vicinity of this point. The station located exactly at this point has not been measured.

To view the measured stations around “x” and “z” points on the screen, you have to change the increments of the grid to the previously defined grid, as is described in the following chapter.

B. Second option: Entering Coordinates and Increments Numerically



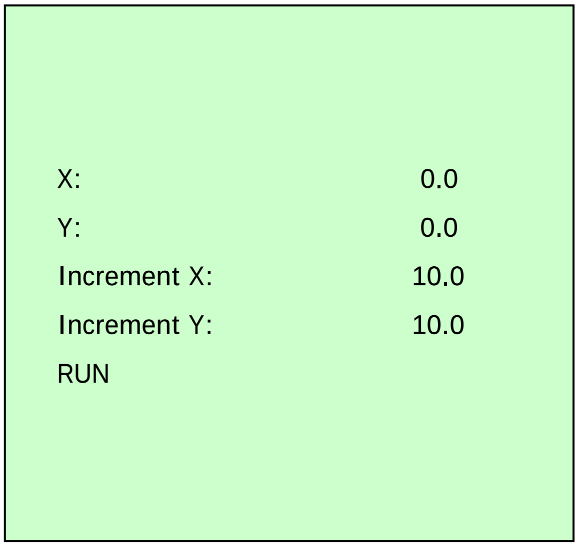
ABC
X: 0.0
O_2 : 20.3% T: 17.9
P:
PID 43
698
ppm
Meth
367
ppm
T.P.
7658
ppm
CO_2
546
ppm

Inc: 10.0
Y: 10.0

W. 11.3 - Measuring Mode Menu

- Press ▼ on the instrument handle while the *Measuring Mode* is displayed on the screen (Window W. 11.3).

- The cursor has moved to the upper right-hand corner on the *Inc.* item.
  Note: Here you can change the sign of the ⊿Y increment by pressing the right handle arrow. Negative increment enables you to move backwards in the grid system along the next (or selected) line. In this way it is not necessary to move all the way back to start measuring from the station where the Y coordinate is zero.
- Press ▼ again.
- Window W.14 will appear.



X: 0.0
Y: 0.0
Increment X: 10.0
Increment Y: 10.0
RUN

W. 14 - Window for changing coordinates and increments.

- Use ► at any of the first four items to open the *Enter Number* window for changing increments and coordinates. Change the values according to your needs and return to the window W. 14.
- Press right arrow ► at the *RUN* item to start measuring the selected station.
- ◄ will take you back to the *Measuring Mode.*

Both these options enable you to skip any station or select a station you need to measure within a grid of a given locality.

4.4 CLOSING DOWN

Always clean the anaytical units after a day's work by measuring two stations in the 'test'locality or by switching into the continuous mode and measuring for approximately one minute with no tube connected to the gas inlet of the instrument.

If you are going to finish measuring, press ESC button on the display panel to return to the Main Menu. All data are automatically saved.

Then press ON/OFF button to switch the instrument off.

4.5 HINTS FOR THE FIELD MEASURING

- **Never use the same hole for a repeat measurement of a station** as some of the soil gas could already have escaped. Repeat measurements can produce distorted results, especially in poorly permeable soils.

- Contaminants such as transformer oil that are specially designed with a very low vapor phase, wet clay and other poorly permeable soils, create very difficult or even impossible conditions for measuring soil gas. Such situations generally require extensive operator experience.

- Measuring below freezing point can usually cause serious problems since the contaminants usually do not produce much vapor. The surface is also covered by the frozen layer which causes homogenization of contaminant vapor concentration under the frozen "lid" and this effect brings about loss of localization of contaminant sources and generally all the anomalies.

- Using dust filters considerably extends calibration and service intervals. Connect a piece of plastic tube to **ECOPROBE 5** gas inlet (Fig. 15). Connect the filter and then with another plastic tube connect the sampling probe. Use standard plastic petrol filters sold at service stations as consumables (for instance Shell stations).

  Always keep the dust filter connected in the same position to avoid letting dust into the instrument!

  Dust filters may become contaminated and it is essential to carry extra filters into the field as replacement.

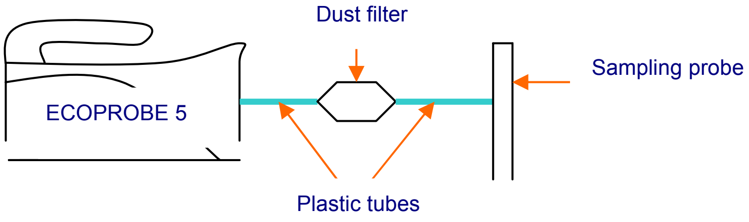


Fig.15 - Connection of the dust filter.

- Although there is a **water valve** fitted to the **probe**, **it is best to avoid inserting the probe into water that may accumulate in a hole.** If a probe is inadvertently inserted into a 'wet' hole, the reading will be close to zero or much lower than expected, because the water valve does not allow vapor to be drawn in. The position of the sampling probe has to be vertical. Do not tilt the probe since the water valve may cut off the air as it is not designed to operate in an off vertical position. When surveying a potentially waterlogged terrain, use a stick to test each hole for seepage water.

- If a delicate measurement is required, the probe may be eliminated. Use only plastic tubes with a dust filter, in which case always ensure that there is no possibility of liquid being drawn into the instrument.

Heavily contaminated soil vapor may leave a hydrocarbon residue in the entire sampling system, and it is therefore advisable that the probe and its connecting tube receive special care when being cleaned.

Cleaning the probe

The sampling probe must be cleaned from residual gas and condensation if contamination was found at a station. Cleaning the probe should be carried out using fresh, non-polluted air. The higher the concentration and the heavier the hydrocarbons at the measured station, the higher will be the volume of air needed for cleaning. The probe cleaning can be minimized in the case of soil gas containing contaminants originally present in a gas phase such as methane. On the contrary, soil gas containing abundant vapor of heavy oils demands greater volume of cleaning air. Clean air can be blown through by means of a manual pumping device such as that used for inflating rubber mattresses. It is important not to blow into the sampling probe with your breath as this may cause moisture to enter the probe and may give incorrect measurements.

Attention needs to be paid to the sampling apertures at the bottom of the sampling probe, which has to be cleaned of residual soil after removal from the hole.

At some contaminated localities there may be a floating contaminant layer at the ground water table. If the sampling probe is inserted directly into the pollutant, the probe will be contaminated. In order to avoid false readings afterwards, immediately clean out the entire probe and pumping inlet with a household dishwashing detergent and then use clean water for rinsing. Never use organic based detergents since their vapor can affect the measured values and cause incorrect results.

Connecting tubes

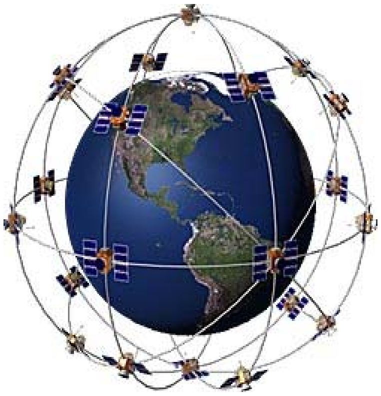
Special care is needed with the plastic connecting tubes between the probe and apparatus. There is an effect of diffusion of hydrocarbons into plastic. The quality of the plastic materials varies. For example, if a plastic tube of average quality is used to measure a contaminant concentration higher than 10 000 ppm, the residual contamination could contribute some tens or hundreds ppm towards the next measurement. The worst type, however, is the soft white silicon tube, while the best is transparent colorless or blue or slightly green plastic tubes intended for medical purposes. All black rubber tubes are to be avoided. Careful cleaning of the tubes together with the sampling probe is recommended. When measuring a delicate locality with dramatic shifts between very high and very low concentrations from one station to another, the best solution is to use a set of tubes equal to the expected number of stations to be measured within one day. At each station a clean tube is to be applied. Used tubes usually self-clean if placed on a room heater overnight. The next day they are ready to be used again.

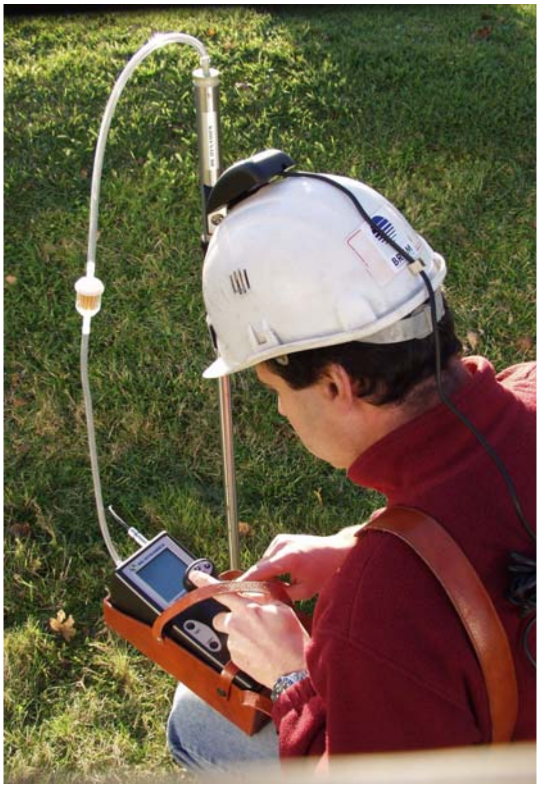
It is a good practice to set up a locality for "warming up" the instrument and for test measurements. Before starting to measure, the IR unit needs to be stabilised. Measure three "warming up" stations in the test locality to avoid any incorrect readings at the beginning of the day's survey. Use this locality also for checking if plastic tubing, dust filters etc. are contaminated.

5. MEASUREMENT - GPS LOGGING

About Global Positioning

GPS – The Global Positioning System, has changed the way people navigate the oceans, the skies and land. Commercial use of GPS has proven invaluable in many fields. It has revolutionized surveying and it can be used to track everything from migrating animal herds to the creep of the earth's crust.





GPS works on the principle of triangulation. By knowing its distance from three or more satellites, the receiver can calculate its position by solving a set of equations. Information from three satellites is needed to calculate longitude and latitude at a known elevation; four satellites are needed to include altitude as well. Satellites orbit the earth twice a day at an altitude of 10 900 miles, repeatedly broadcasting their position and the time. The atomic clock aboard each satellite keeps time by atomic vibration and is accurate to one second in 30 years!

The fastest and comfortable mapping of contaminated sites

GPS under development by the U.S. Department of Defense for more than twenty years consists of twenty-one satellites, plus three back-up satellites in predictable orbits around the earth. The system provides 24-hour positioning information regardless of the weather.

GPS satellite orbital information is referenced to WGS 84 which is an earth - fixed global reference frame using latitude and longitude coordinate system to locate points on the Earth's surface.

Lines of longitude are circles that intersect both the North and the South Poles. Lines of longitudes are measured in half circles of 0º to 180º East and from 0º to 180º West from the Royal Greenwich Observatory in Greenwich, England.

Latitude is measured as an angle from the equator of the Earth (0º) to the North Pole (90º North) or to the South Pole (90º South). Lines of latitude are described by circles that run parallel to the equator's plane, and grow progressively smaller as they get closer to the poles.

ECOPROBE 5 and GPS

ECOPROBE 5 is the first world class earth scientific instrument with a fully integrated GPS positioning system

The GPS system in ECOPROBE 5 can be used if a specific software is activated and if a special RS DYNAMICS GPS receiver is available (optional).

GPS logging

GPS logging is a very effective data logging system with no need for concern about coordinates while measuring in the field. Coordinates are displayed / stored in the world geodetic format WGS 84 (latitude - GPS W, longitude - GPS L, altitude - GPS R) and also displayed in surface metres (X,Y,Z).

What do X,Y,Z "surface" coordinates mean?

Imagine a plane tangent to the global ellipsoid, made at the first measured station to the global ellipsoid (Fig. 16). The coordinates of the first measured station are X=0, Y=0. Coordinates of all other stations are related to the first station (X=0,Y=0). This system facilitates orientation in the field, but slightly reduces the accuracy of positioning of the measured stations.

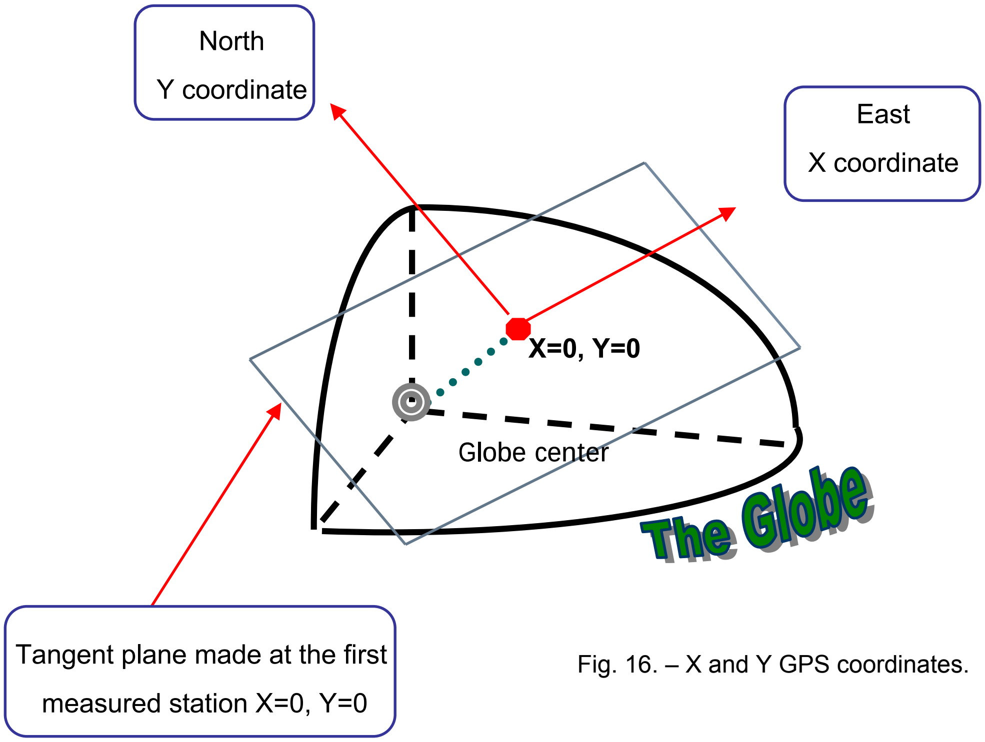


Fig. 16. – X and Y GPS coordinates.

Measured data are stored according to time. Communication software **ECOPROBE_VIEW** enables you to display and to export to other graphic software a data table with coordinates in the world geodetic format WDS 84.

Depending upon accuracy requirements, users may select from various GPS systems –

- Meter precision
- Decimetre precision
- Centimetre precision

1. Meter precision

Precision ranges from 1 to 7 meters using a standard GPS antenna.

2. Decimetre precision

This GPS system uses "Differential GPS techniques". This involves two 12-channel GPS receivers. Base station is located at a known point and transmits data over a radio link to the Moving station. Moving station calculates precise position by using the signals from satellites, and the data received from the Base station.

3. Centimetre precision

The same GPS system using "Differential GPS techniques" as above. To fix a position with centimetre accuracy "Post-processing procedure" is used by which the errors inherent to raw GPS data are removed after the field work has been completed.

ECOPROBE 5 system fully integrates all of the above options. In all categories recommended GPS receivers are required for which the system is especially configured.

Usually **ECOPROBE 5** is offered with an **ECOPROBE 5** Smart Antenna

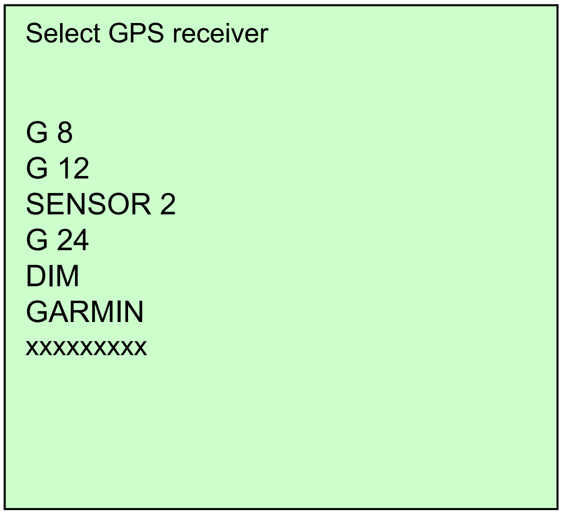
GPS Smart Antenna is extremely small, easy to handle and can access signals from twelve satellites. Nothing more is needed to utilize the GPS measurement. Smart Antenna uses energy from **ECOPROBE 5**'s battery thus, reducing the daily operating life of the instrument. Nevertheless, a battery in a good condition should supply the instrument with connected GPS antenna for a day's field work.

The GPS Smart Antenna is directly connected to the **ECOPROBE 5'**s multifunctional connector. It is recommended that it be fixed to the top of the operator's helmet (for instance, by means of a velcro fastener) to achieve the highest position for getting the best signal and also to avoid shielding of the operator's head

Fig. 16 – Working with the GPS Smart Antenna.

CONFIGURING GPS LOCALITY IN **ECOPROBE 5**

- Select a new locality and open its *Configuration File* (Window W.3) Change the default *Standard Grid* to *GPS logging* by pressing the right arrow on the instrument handle. A menu with a selection of commonly used GPS receivers will be opened on the instrument screen (Window W. 15).

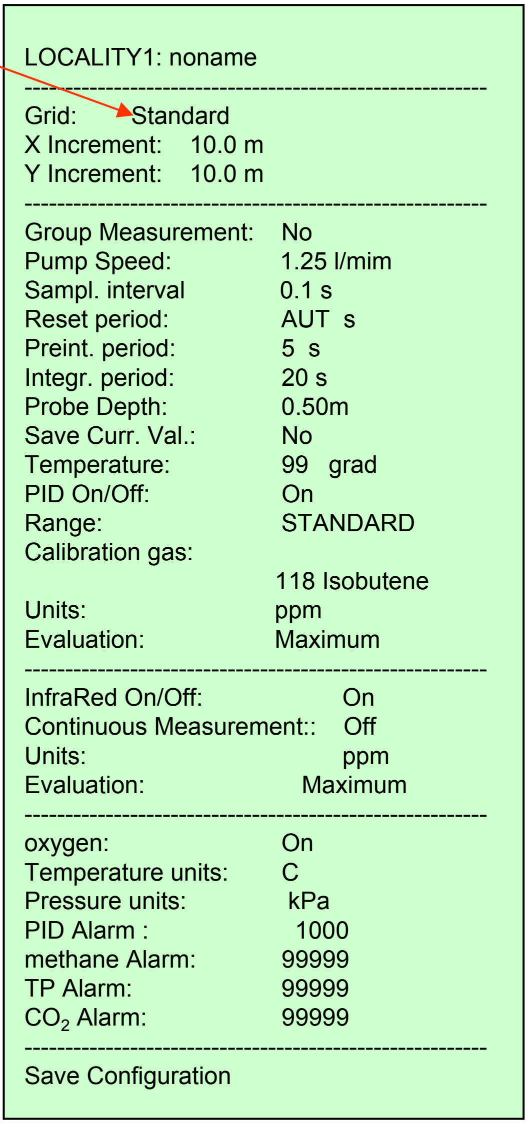


```
Select GPS receiver


G 8
G 12
SENSOR 2
G 24
DIM
GARMIN
xxxxxxxxx
```

W. 15 - *List of GPS receivers*

It is possible to add most GPS receivers to the **ECOPROBE 5** GPS system. This modification is optional and requires software and receiver configuration by **RS DYNAMICS** Ltd.

- Select your type of GPS receiver and confirm by pressing the right arrow. GPS Smart Antenna is labelled as **GARMIN** in the List of GPS Receivers (Window W.15)
- Set all other parameters as described in Chapter 3 of this manual.



```
LOCALITY1: noname
-------------------------------------------------------
Grid:          Standard
X Increment:    10.0 m
Y Increment:    10.0 m
-------------------------------------------------------
Group Measurement:    No
Pump Speed:           1.25 l/mim
Sampl. interval       0.1 s
Reset period:         AUT  s
Preint. period:       5  s
Integr. period:       20 s
Probe Depth:          0.50m
Save Curr. Val.:      No
Temperature:          99   grad
PID On/Off:           On
Range:                STANDARD
Calibration gas:
                      118 Isobutene
Units:                ppm
Evaluation:           Maximum
-------------------------------------------------------
InfraRed On/Off:              On
Continuous Measurement::      Off
Units:                        ppm
Evaluation:                Maximum
-------------------------------------------------------
oxygen:               On
Temperature units:    C
Pressure units:        kPa
PID Alarm :             1000
methane Alarm:        99999
TP Alarm:             99999
CO2 Alarm:            99999
-------------------------------------------------------
Save Configuration
```

W. 3 - Default Configuration File

This setting allows fully automatic GPS coordinate logging of any location obtained from a GPS receiver.

IMPORTANT NOTE!

If you intend to measure a locality with a GPS receiver, always remember to set up *"GPS logging"* in the *"Configuration File"* (as is explained above) and **select the proper type of receiver.**

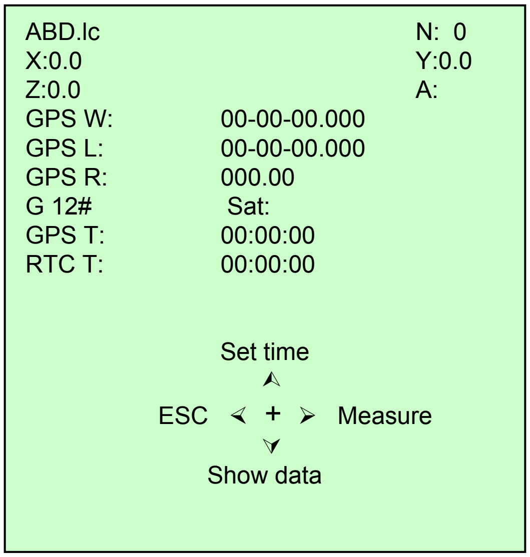
If a locality has been originally configured as a *" Standard Grid "* **it must not** be subsequently changed to *"GPS logging"* or any other type of GPS receiver. In this case the instrument **will not operate** due to the different format of data logging! If you need to make a change, open a new locality and select the necessary parameters.

!

GPS FIELD SURVEY

1. To start measuring, connect the GPS antenna to **ECOPROBE 5**, switch on the instrument and configure a GPS locality you want to measure. Return to the *“Main Menu”* and select the item “*LOCALITY 1 (or 2)”* which is followed by the name of the GPS locality you have typed in the *“Configuration File”.* The GPS welcome window is opened (W.16)

(Note: the operator must stay outside the building, otherwise the GPS antenna could not read the signal)



```
ABD.lc                              N:  0
X:0.0                               Y:0.0
Z:0.0                               A:
GPS W:          00-00-00.000
GPS L:          00-00-00.000
GPS R:          000.00
G 12#            Sat:
GPS T:          00:00:00
RTC T:          00:00:00
```

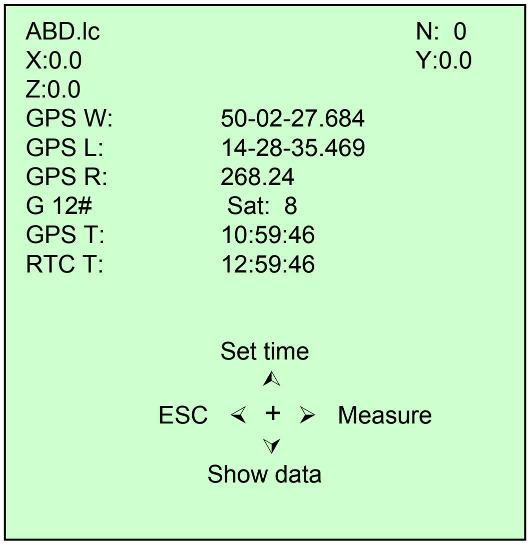
W.16 – GPS Welcome Menu.

Description:

ABD.lc	Name of the Locality
N	Number of measured stations
X	X coordinate (related to the first measured station)
Y	Y coordinate (related to the first measured station)
Z	Altitude
A	Accuracy of measured position is displayed for 12 channel receivers and higher.
GPS W	Latitude (WGS 84); degrees, minutes, seconds
GPS L	Longitude (WGS 84); degrees, minutes, seconds
GPS R	Altitude
G12	Type of the GPS receiver
# Sat:	Number of satellites in use
GPS T	Absolute GPS time
RTC T	Local time

Set time	Use ▲ to open “Enter Number Menu” to set the local time difference from Absolute GPS time (Greenwich Mean Time). The setting is valid only if hours, minutes and seconds are identical.
ESC	◄ returns to the previous menu.
Show data	▼ enables you to review measured data.
Measure	► starts measuring the next station.

2. Coordinates, time and number of satellites will appear on the screen after several minutes (Window W.17). The number of satellites is usually low at first, but it will increase with time.

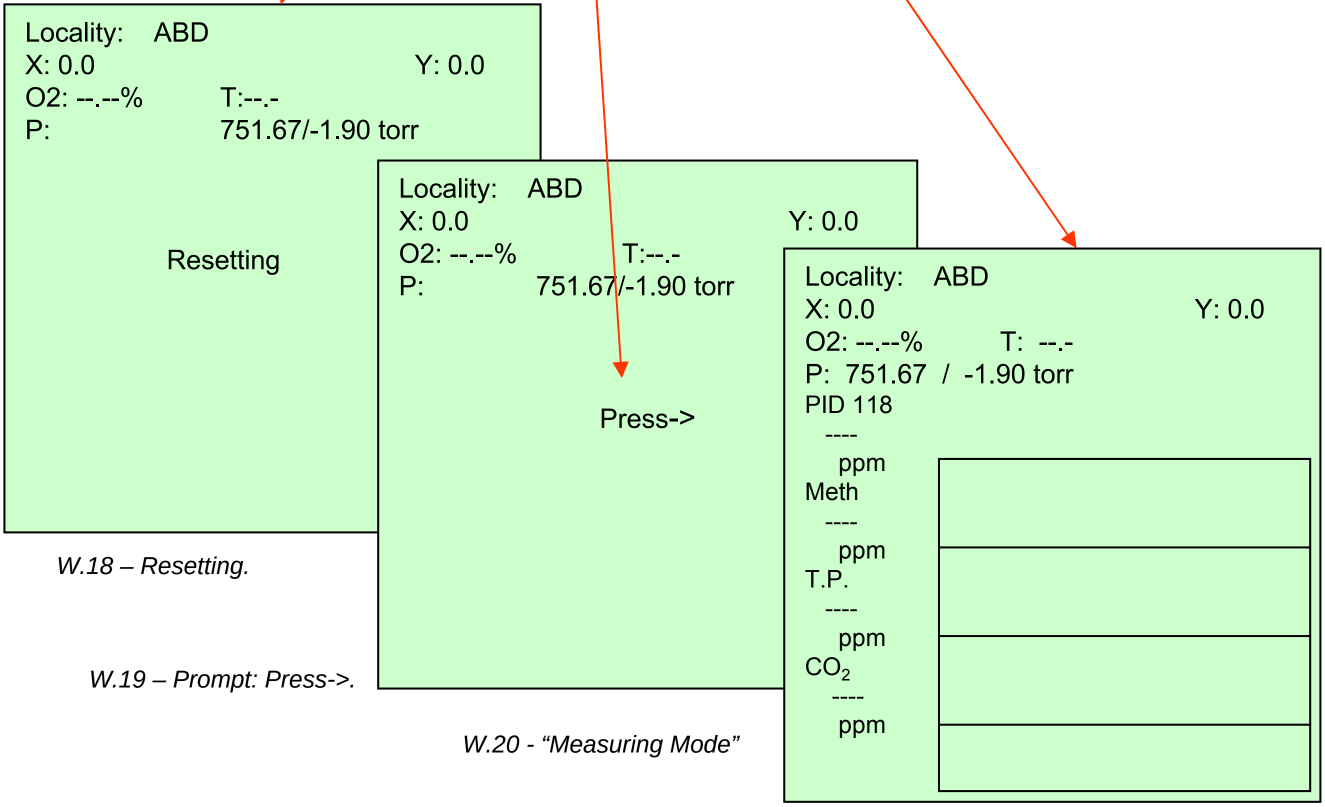


ABD.lc N: 0
X:0.0 Y:0.0
Z:0.0
GPS W: 50-02-27.684
GPS L: 14-28-35.469
GPS R: 268.24
G 12# Sat: 8
GPS T: 10:59:46
RTC T: 12:59:46

W. 17 - Welcome GPS Menu showing time, coordinates and number of satellites.

3. Move to the first station. Wait for about 10 minutes to let the GPS system stabilize and to access the relevant satellites. **The coordinates of the first measured station must be defined precisely**. After allowing ample time, press the right arrow on the instrument handle to start measuring the station.The measuring cycle starts with resetting (Window W.18) and at the same time the coordinates of antenna position are recorded by the instrument. The operator should already be in position at the station to be logged and measured.

4. After resetting, and activating the prompt *"Press->"*, the *"Measuring Mode"* window will be displayed on the instrument screen. Press the right handle arrow again to start the measuring (Windows W.18, W.19 and W.20).



Locality: ABD
X: 0.0 Y: 0.0
O2: --.--% T:--.-
P: 751.67/-1.90 torr

Resetting

W.18 – Resetting.

Locality: ABD
X: 0.0 Y: 0.0
O2: --.--% T:--.-
P: 751.67/-1.90 torr

Press->

W.19 – Prompt: Press->.

Locality: ABD
X: 0.0 Y: 0.0
O2: --.--% T: --.-
P: 751.67 / -1.90 torr
PID 118
---- ppm
Meth
---- ppm
T.P.
---- ppm
CO_2
---- ppm

W.20 - "Measuring Mode"

5. After completing the measurement, the *Measuring Mode Menu* will disappear and *Welcome GPS Menu* (Window W.16) is displayed. Use the option *Show data* to review the measured values or *Measure* for measuring the next station.

6. Move to the next station and allow the GPS system to stabilize. Generally one minute is enough for all stations, except for the first station where more time is required. Observe the changing number of satellites and if it does not increase, start measuring the station.

To achieve good accuracy, the GPS receiver needs to access seven or eight satellites. The lower the number of visible satellites the accurate are the calculated coordinates. The accuracy is also affected by the position of the satellites during the day. Six or seven satellites in good positions may give better accuracy than eight satellites which are relatively distant or poorly visible.

The interferences and reflections of the satellite signals in streets, forests and among tall buildings may cause insufficient accuracy of measured coordinates. Satellites are also shielded by the trees and buildings. If there are less than three to four satellites visible, the receiver cannot collect sufficient information. **ECOPROBE 5** does not allow measuring and it starts “beeping”. In this way the instrument prevents inaccurate data from being stored in the memory. Press any arrowed button to stop the “beep” and return to the “Welcome GPS menu”. If the GPS signal is still insufficient, it is possible to continue the survey by using a locality opened in the “Standard Grid”. Return to the GPS locality when more than four satellites are visible.
It is recommended to use a long rod for the GPS receivers when measuring in wooded areas. The GPS receiver is placed on the top of the rod to get the best possible signal using an antenna extension cable provided by **RS DYNAMICS** Ltd.

If the survey of a particular site is stopped and continued after any period of time, always allow the GPS system to stabilize at the first new station. After switching the system on, monitor the number of satellites and if after about five minutes it coincides, continue measuring the station at any new position. The coordinates of the original station measured first, are safely kept in the instrument memory and coordinates of all other stations are related to it.

HINT:

You can easily return to any station of the surveyed locality after any period of time. Switch on **ECOPROBE 5**, open the *“Welcome GPS Menu”* of the given locality and observe the changing surface coordinates on the screen. They can navigate you to any measured station you want to review, or to a new position.

If the locality is stored only in your computer and you want to continue the survey later, it is possible to transfer the locality data back to the instrument using the **ECOPROBE_VIEW** software, maintaining all the configuration and position data.

6. DELETING A LOCALITY FROM **ECOPROBE 5**

If a locality is not required any longer, download the data to the computer and delete the locality in ECOPROBE 5 to create space on the instrument disk. To delete a locality, select *LOCALITY MANAGEMENT* from the *Main Menu* (Window W.2) and window W.4 will appear.

W.2 - Main Menu

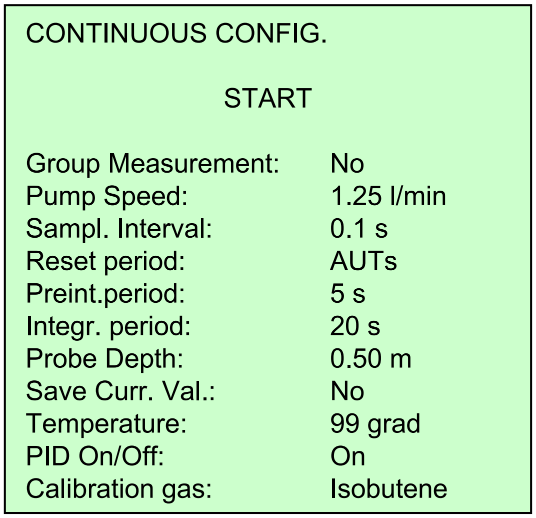
W.4 -Locality

Item *Delete Locality* provides a way to delete localities in the instrument. Select the item and follow the instructions on the screen.

7. CONTINUOUS MEASUREMENT

Allows continuous operation without any data being logged which gives you fast screening for a gas leak at the surveyed area.

- To start, select the item *CONTINUOUS MEASUREMENT* in the *Main Menu (Window W.2).*
- Window W.21 will be opened offering an option *START* and displaying a default *Configuration File* that can be changed to the operator's specifications.



```
CONTINUOUS CONFIG.

                START

Group Measurement:    No
Pump Speed:           1.25 l/min
Sampl. Interval:      0.1 s
Reset period:         AUTs
Preint.period:        5 s
Integr. period:       20 s
Probe Depth:          0.50 m
Save Curr. Val.:      No
Temperature:          99 grad
PID On/Off:           On
Calibration gas:      Isobutene
```

W. 21 - Continuous Measurement Menu

- Press *START* for resetting.
- When displayed, confirm *Press* -> with right handle arrow.
- Continuous measurement will start after a short pre-integration period.
- Press *ESC* to stop measuring at any time and to return to the *Main Menu.*

The instrument switches itself off after 15 minutes of operation in the *Continuous mode* as the analytical units may become slightly unstable and need to be reset. To continue measuring it is necessary to start *Continuous Measurement* again. The measuring cycle starts with resetting which allows the analytical units to stabilize themselves for the next 15 minutes of operation.

Note: After the instrument has been switched off in the field, the IR unit needs to be stabilized. It is recommended to measure two "blind" stations (set up "Test locality" in the instrument for making various test measurements) or use CONTINUOUS MEASUREMENT mode for about one minute before starting to measure again. The operator can thus avoid incorrect readings at the first measured station.

8. MONITORING

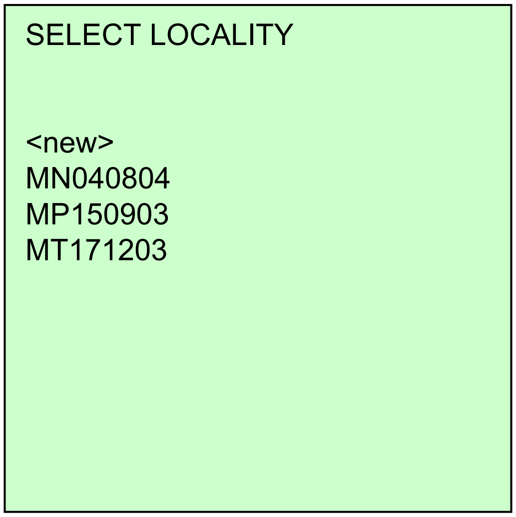
ECOPROBE 5 can be used to operate automatically as a monitoring station. You can preset parameters in *Monitoring Station Configuration File* (Window W.23) and leave the instrument anywhere to monitor.

8.1 How to enter and measure a monitoring station

- For entering a **new** monitoring station use *LOCALITY MANAGEMENT* from the *Main Menu* (Window W.2) and then *MONITOR* to access a list of monitoring stations (Window W.22).
  Select <*new*>. *Monitoring Station Configuration File* will be opened (Window W.23). Enter the name of the monitoring station (for instance MNSALEM). After entering the name and making possible changes to the parameters, return to the *Main Menu* by selecting *Save Configuration* at the end of the *Configuration File* or by pressing ◄ and following the instructions on the screen.

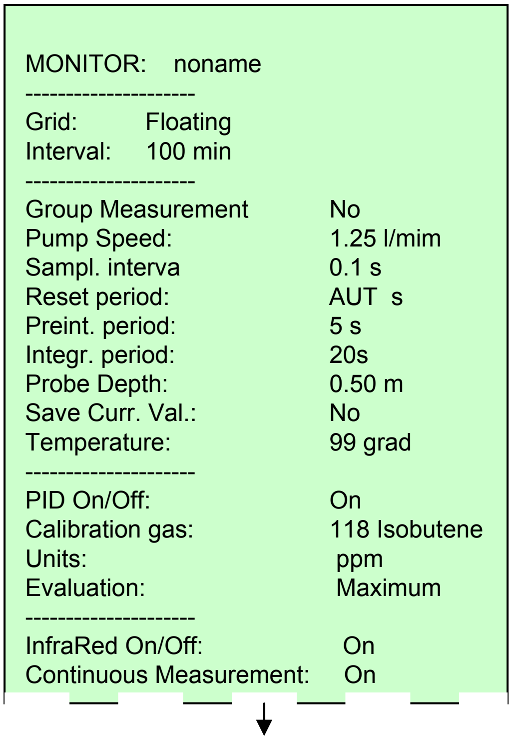
  The name of the new main monitoring station (MNSALEM) will be displayed after *MONITOR* in the *Main Menu. A*ll measured data are organized according to date, which improves sorting data from a monitoring site. Measurements at a particular monitoring station are logged in 24-hour time periods, and the data are stored according to the day (date) of observation. To accomplish this, each day a new monitoring sub-station is created. When you select the item *MONITOR MNSALEM* in the *Main Menu,* you will enter a measuring mode for the sub-station. The name contains only the first two letters of the main monitoring station's name and the current date – for instance MN040804. At the end of the pre-set time interval the instrument will start measuring and all data for the day will be stored in this monitoring sub-station. The next day the instrument will automatically create a new sub-station (MN050804). This name will contain again the first two letters of the main station and the new date. In this way data are stored for 10 days. Then the first monitoring sub-station is permanently deleted to create space on the instrument's disk. To obtain data from the first day's monitoring, it is necessary to visit the station and download the data to the computer within 10 days.

- For entering an existing monitoring station use *LOCALITY MANAGEMENT* from the *Main Menu* and then *MONITOR* to access a list of monitoring stations (Window W.2). Select the name of the particular monitoring station. Its *Monitoring Station Configuration File* (Window W.22) will be opened for possible changes. If you do not want to make any changes just return to the *Main Menu* by pressing ◄ and following the instructions on the screen. The name of the selected monitoring station will be displayed after *MONITOR* in the *Main Menu.* Select this item to start measuring.



```
SELECT LOCALITY


<new>
MN040804
MP150903
MT171203
```

W.22 - List of monitoring stations.



```
MONITOR:    noname
---------------------
Grid:          Floating
Interval:     100 min
---------------------
Group Measurement          No
Pump Speed:                1.25 l/mim
Sampl. interva             0.1 s
Reset period:              AUT  s
Preint. period:            5 s
Integr. period:            20s
Probe Depth:               0.50 m
Save Curr. Val.:           No
Temperature:               99 grad
---------------------
PID On/Off:                On
Calibration gas:           118 Isobutene
Units:                      ppm
Evaluation:                 Maximum
---------------------
InfraRed On/Off:            On
Continuous Measurement:     On
```

W.23- Monitoring Station Configuration File

MONITORING STATION CONFIGURATION FILE

MONITOR: **no-name**

Enter the name of the monitoring station. It is recommended to add **M** to the name to distinguish the **monitoring station** from a locality (Window W.22).

GRID

Floating: At the end of the selected time interval the instrument will repeat the measuring cycle. Default value of the interval can be changed by pressing ►. *Enter Number Value* window will be opened for entering a new value.

Fixed start: This option enables you to select the start time by opening the item *"Delay"* in the sub-menu and setting the time in minutes after midnight. This means that the instrument will not operate from midnight until the given (set) time. From the starting time onwards, the instrument will repeat measuring always at the end of a selected interval, which can be set in the *"Interval"* option.

GROUP MEASUREMENT

For **monitoring mode** it is recommended having *Group measurement* switched to ***YES***. The instrument performs a resetting cycle only once at the start of the operation. The resetting cycle can, however, be started anytime by pressing the *RUN* key on the display panel for longer than one second.

If maximum precision and sensitivity are required it is necessary to operate in the standard mode by changing the Group measurement to ***NO***. Each measuring cycle is preceded by a resetting interval. In this case a valve box with its own power supply is required to provide clean air to the instrument for resetting. This item is available as an accessory from **RS DYNAMICS** Ltd.

All other parameters of the *Monitoring Station Configuration File* (Window W.23) are set as for the *System Configuration File.*

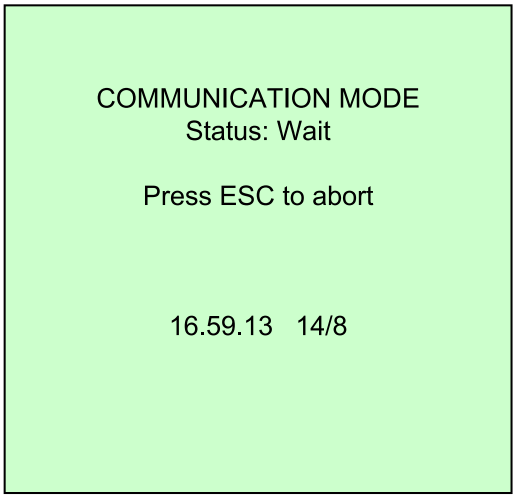
Electrical power needed for an extended operation is supplied either by the **ECOPROBE 5** charger or by solar cells. The manufacturer can provide a set of solar cells to meet the conditions of a particular environment, which in turn, depends on the amount of available solar energy.

9. COMMUNICATION

This mode is used for establishing communication between **ECOPROBE 5** and a PC.

- Connect **ECOPROBE 5** which must be switched Off, with the appropriate cable to the PC and then turn **ECOPROBE 5** On.

- Select *COMMUNICATION* in the *Main Menu*. ► opens Window W.24.



COMMUNICATION MODE
Status: Wait

Press ESC to abort

16.59.13 14/8

W.24 - Communication Mode

- All subsequent commands are issued from the computer (see **ECOPROBE_VIEW User Manual).**

This procedure enables transferring data from **ECOPROBE 5** to a PC or notebook. The user friendly software **ECOPROBE_VIEW** running under WINDOWS 95/98/2000/WinNT4.0 or XP, facilitates rapid transfer of data and its graphic presentation.

Press the *ESC* button to return to the *Main Menu.*

10. DEFAULT CONFIGURATION FILE

Enables you to change the basic default settings of the *Configuration File* (Window W.3), which is always offered when any new locality is opened.

If necessary, you can reconfigure this default *Configuration File* to meet any definite requirement.

However, if you are not very experienced, it is advisable not to make any changes to the default settings.

To make changes:

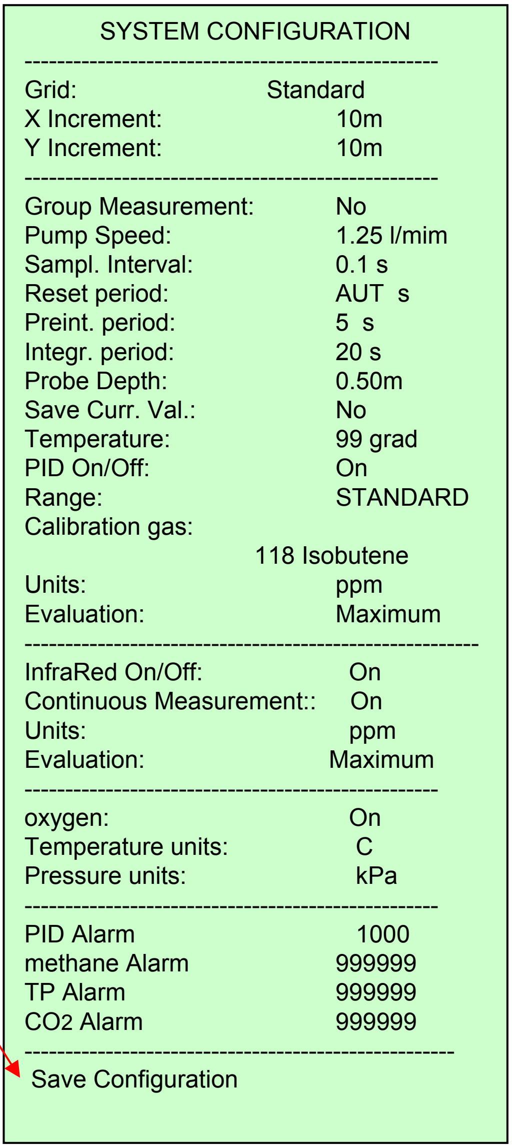
- Select *SYSTEM CONFIGURATION* in the *Main Menu.*
- ► opens default *Configuration File.*
- Use the same procedure as in the case of configuring *Locality or Monitor Configuration File.*

There are two ways of **saving changes** in the default *Configuration File.*

- Select *Save Configuration* at the end of the file.

or

- Press ◄ and follow the instructions on the screen.



```
SYSTEM CONFIGURATION
---------------------------------------------------
Grid:                         Standard
X Increment:                          10m
Y Increment:                          10m
---------------------------------------------------
Group Measurement:            No
Pump Speed:                   1.25 l/mim
Sampl. Interval:              0.1 s
Reset period:                 AUT  s
Preint. period:               5  s
Integr. period:               20 s
Probe Depth:                  0.50m
Save Curr. Val.:              No
Temperature:                  99 grad
PID On/Off:                   On
Range:                        STANDARD
Calibration gas:
                      118 Isobutene
Units:                        ppm
Evaluation:                   Maximum
--------------------------------------------------------
InfraRed On/Off:               On
Continuous Measurement::       On
Units:                         ppm
Evaluation:                   Maximum
---------------------------------------------------
oxygen:                        On
Temperature units:             C
Pressure units:                kPa
---------------------------------------------------
PID Alarm                       1000
methane Alarm                 999999
TP Alarm                      999999
CO2 Alarm                     999999
-----------------------------------------------------
 Save Configuration
```

W.3 - Default Configuration File.

11. CALIBRATION

The **ECOPROBE 5** system software and **ECOPROBE_VIEW** computer software incorporate three advanced tools for the precise calibration of all analytical channels, thus ensuring high accuracy of all evaluated data.

1. **ECOPROBE 5**'s internal software enables fast **Single Point** calibration of the PID analyzer, all channels of IR analyzer, oxygen and pressure analyzers and the probe thermometer.
2. Another way to calibrate the oxygen and pressure analyzers and the probe thermometer is by using **ECOPROBE_VIEW_Light/Plus** software. For more details see the User Manual for communication software.
3. The **ECOPROBE_VIEW_Plus** software ***advanced calibration*** tool enables users to modify the original factory calibration curve that might be affected by contamination, by dust or by other field influences. It can be used for PID and all IR measuring channels. For modifying the entire calibration curve, the user has to obtain several standards of calibration gas with various concentrations. For more details see **ECOPROBE_VIEW_Plus User Manual.**

11.1 ECOPROBE 5's PID CALIBRATION

ECOPROBE 5's PID analyzer is calibrated for Isobutene (Isobuthylene). Isobutene represents the most suitable calibration gas which is also used in laboratory gas chromatographs. At the manufacturer, the PID analyzer is calibrated using several Isobutene standards with different concentrations using the software for “Advanced calibration” (see the manual to communication software).

As the PID analyzer does not have a reference channel to compensate for dust influence in contrast to IR analyzer, it has to be calibrated more frequently. For a fast correction of the PID analyzer, the operator can calibrate it by using the Single Point Calibration procedure with a 100 ppm Isobutene standard that is supplied as part of **ECOPROBE 5** calibration kit.

During a field investigating the PID analyzer may become dusty or optical passages may become dirty due to a deposit of various particles such as aerosol droplets, due to proper operational procedures not being observed (dust filters not used), or if the instrument had been operated for a long period of time. A layer of dust and various other compounds on the surface of optical system causes attenuation of excitation energy (“light beam”) resulting in a decrease of the measured values. This attenuation is of the multiplicative character and does not affect the shape of the calibration curve created at the manufacturer or by the customer using **ECOPROBE_VIEW_Plus** software. It changes only the direction of the existing curve.

Because the change caused by attenuation has a multiplicative character, it is quite easy to compensate for it by the application of inverse multiplicative action. This is done by the following procedure:

a) During the "Single Point Calibration", the system measures first the response for the calibration standard, for example instead of 100 ppm the measured value is 88 ppm; it means the multiplicative attenuation is possible to express by the factor 0.88.

b) The system compares the measured result (88 ppm instead of 100 ppm), and calculates the correction coefficient: 1 / 0.88 = 1.136.

The system offers to complete the calibration (recalculation) procedure by changing the previous multiplicative correction coefficient to the new value 1.136.

If acceptable, the new coefficient is applied to all subsequent measurements, and attenuation caused by partial shielding of the optical passages is compensated for. The instrument will now measure correct values.

In brief:

1. The *"Single Point Calibration"*, incorporated in the **ECOPROBE 5**'s firmware, is intended to provide fast *in situ* correction of instrument's response that might be changed due to internal dusting or depositing of various particles, causing attenuation of light beam sources used for both the PID and IR optical analytical systems.
2. The *"Single Point Calibration"* is not a tool for creating or editing calibration curves, for this purpose use the "Advanced Calibration" incorporated in **ECOPROBE_VIEW_Plus** software.
3. The *"Single Point Calibration"* process is not able to provide maximum accuracy of the system in the full dynamic range, it is only for fast correction in the field. For accurate calibration of the full dynamic range it is necessary to use the *"Advance Calibration"* incorporated in **ECOPROBE_VIEW_Plus** software using more calibration standards.
4. The *"Single Point Calibration"* checks the operation capability of the instrument in a fast and reliable way.
5. The *"Single Point Calibration"* checks the dusting level of the instrument: The higher the calibration coefficient, the more the PID analytical parts are dusty.

CALIBRATION

To extend the “Single Point” calibration and cleaning interval of the PID analytical unit the operator has to use a **dust filter** inserted between **ECOPROBE 5** gas inlet and the sampling probe. The filter should be changed depending upon the amount of dust and extent of contamination of the measuring environment. If heavily contaminated soil gas was drawn into the instrument, the filter should be changed before starting the next measurement.

To determine the extent to which a filter is contaminated, set up a locality for test measurements and measure the filter contamination in the routine way. ***After*** *the resetting period, connect only the filter by means of a short piece of tubing and measure. The degree of contamination will indicate if the filter should be replaced.*

Filters are consumable items which can be purchased from service stations e.g. Shell, or from automotive spares shops.

Calibration interval depends on the absolute accuracy required and on the dust condition of surveyed terrain. **Even though filters are used, the PID unit may accumulate dust and the calibration procedure must be repeated.**

Calibration intervals:

▪ From 1 to 6 months	if not working in dusty environment and using dust filters.
▪ Once a week	if working in a dusty environments with dust filters.
▪ Every day	if precise quantitative values are required.

The **ECOPROBE 5**’s accessories include a calibration kit for PID Single Point calibration consisting of:

- **Cylinder with calibration standard** -- LINDE 100 ppm Isobutene (Isobutylene and/or Isobuthylene is the same compound) mixed with synthetic air. Content of the cylinder (2l/150 atm) is sufficient for about 200 calibrations if the gas is not wasted.
  Calibration gas refills may be purchased from any company providing calibration standard gases for gas chromatography (Air Products, SIAD, LINDE and others).

- **Calibration valve** for releasing the gas from the cylinder.

- **LINDE plastic/metal bag and valve** for collecting gas from the cylinder.

11.2 PID SINGLE POINT CALIBRATION PROCEDURE (Figs. 17.1 to 17.5)

Fig.17.1– Calibration valve on gas cylinder.

Fig.17.2 – Calibration bag.

- In case you calibrate the PID analyzer for the first time, you have to unscrew the sealing cap from the cylinder and fit the calibration valve.
- The concentration of the calibration gas in the cylinder may not be exactly 100 ppm as it may vary +/-10%. The actual value is written on the cylinder certificate.In our case the concentration was 104 ppm. About 1 liter of gas is enough to complete the calibration.
- Prepare a short length of plastic tubing to connect the calibration bag to the instrument.
- Create a new locality for calibration (for instance *CALIB.lc*) using the *LOCALITY MANAGEMENT* item in the *Main Menu* (Window W2). Make sure that the configuration file of the *CALIB.lc* locality is set up properly. If you need to calibrate Standard mode, PID must be set on *Standard*, calibration gas on *Isobutene*, units on *ppm*. Other parameters such as pump speed, etc. should be set to the same values as you will use for measuring in the field.
- Return to the *Main Menu* and select *LOCALITY 1 (or 2) CALIB* to open its measuring mode. Let the instrument measure several points to allow it to stabilize. The next point will be used for the calibration measurement.
- Fill the calibration bag from the gas cylinder and immediately close the valves on the **cylinder** and on the **bag**. For easier operation, the bag's plastic tube can be sealed with your thumb.
- Start the measuring cycle: **After** the resetting period, use the short plastic tube to connect the bag to **ECOPROBE 5** with minimum delay, and open the valve on the bag. Press the right arrow on the instrument handle to confirm the option "Press" on the screen to start the measuring.

Fig.17.3 – Calibration bag.

Fig.17.4 – Calibration bag connected.

Fig.17.5 – Calibrating.

- Keep the bag connected until the instrument stops measuring.

ECOPROBE 5 *may display for instance the following values:*

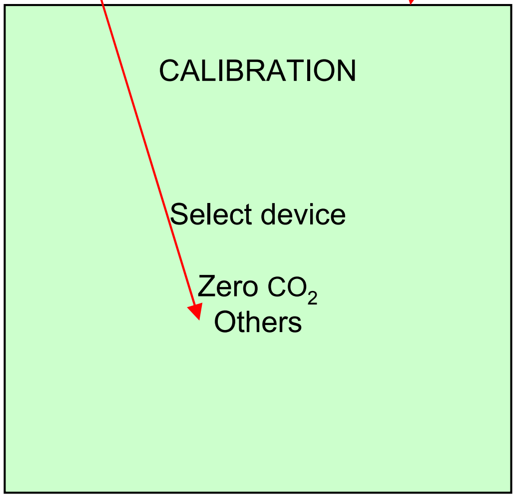
- 99.4 ppm of Isobutene on PID analyzer, 0 ppm on IR methane channel, 560 ppm on IR TP channel (Isobutene is recorded on TP channel and **not** on the methane channel) and 0 ppm CO_2 on IR CO_2 channel. Pressure during the measurement was 959.56 mb, and the thermometer probe was not connected.

- For calibrating the PID analyzer we will use only the 99.4 ppm PID value.

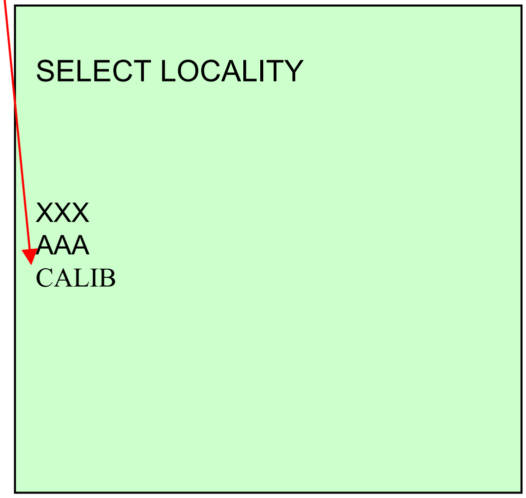
- Press *ESC* on the instrument to return to the *Main Menu* and select the item *CALIBRATION* to initiate the calibration procedure. *Calibration Menu* (Window W.25) will be opened.

- Select *Others* for calibrating the PID/ IR analyzers, O2, pressure or thermometer and use the right arrow to open the list of measured localities (Window W.5.1) .

- Select the locality with the calibration measurement (CALIB.lc). Window (W.26) for selecting the point with calibration values will be opened.



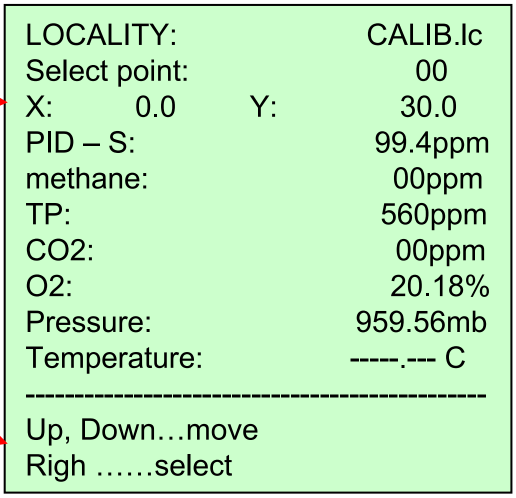
W.25 - Calibration Menu



W.5.1 - List of Localities

- Use **up** and **down** arrows to browse the [measured] points of the locality *CALIB.lc.* These arrows change the coordinates and also the corresponding values of the points. In our case, first two points were used to stabilize the instrument. The third one (X=0.0, Y=30.0) comprises the data of the calibration measurement (99.4 ppm on PID analyzer, 0 ppm on methane channel, 560 ppm on IR TP channel, 0 ppm of CO_2 on IR CO_2 channel and pressure 959.56 mb.

Select this point by pressing the **right** arrow as advised on the bottom of the instrument screen.
Window W.27.1 will be displayed.



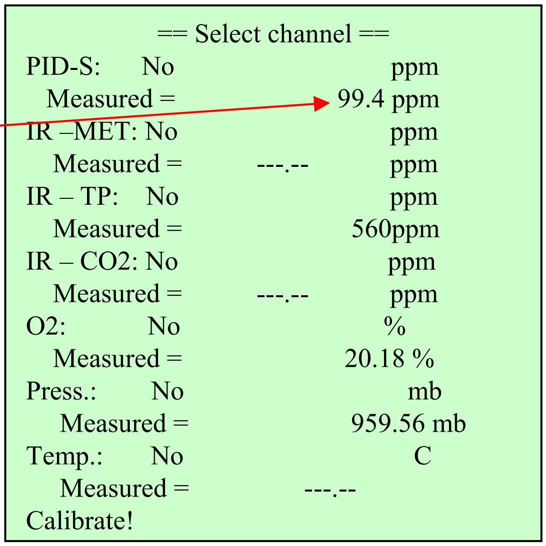
LOCALITY: CALIB.lc
Select point: 00
X: 0.0 Y: 30.0
PID – S: 99.4ppm
methane: 00ppm
TP: 560ppm
CO2: 00ppm
O2: 20.18%
Pressure: 959.56mb
Temperature: -----.--- C

Up, Down…move
Righ ……select

W.26 - Window for selecting the point with calibration values (In this case the given point has coordinates X=0.0, Y=30.0)

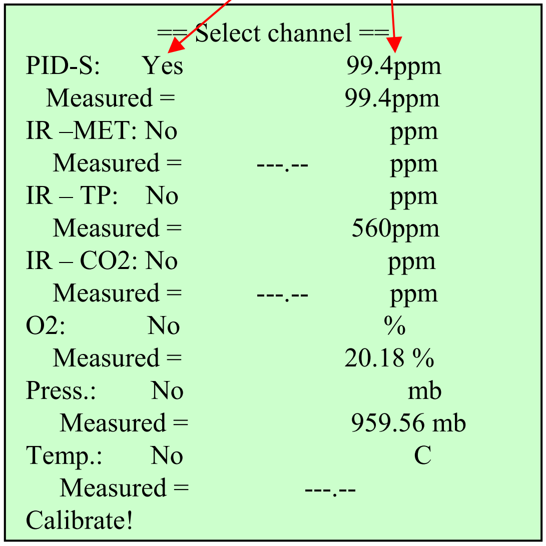
- When window W.27.1 is open, the cursor is positioned on *PID–S* item (S: Standard mode). The value of the calibration gas Isobutene was 104 ppm. **ECOPROBE 5** measured 99.4 ppm instead of 104 ppm Isobutene, and this measured value 99.4 is displayed on the screen.

- For calibrating the PID analyzer we have to activate it by changing *No* after the *PID-S* item, to *Yes* by pressing the **right** arrow. The same value as the *measured value* will now appear at the top of the second column – in our case 99.4 (Window W.27.2).



```
         == Select channel ==
PID-S:     No                  ppm
  Measured =                99.4 ppm
IR –MET: No                    ppm
   Measured =        ---.--    ppm
IR – TP:   No                  ppm
   Measured =               560ppm
IR – CO2: No                   ppm
   Measured =        ---.--    ppm
O2:         No                 %
   Measured =              20.18 %
Press.:     No                  mb
    Measured =             959.56 mb
Temp.:      No                  C
    Measured =         ---.--
Calibrate!
```

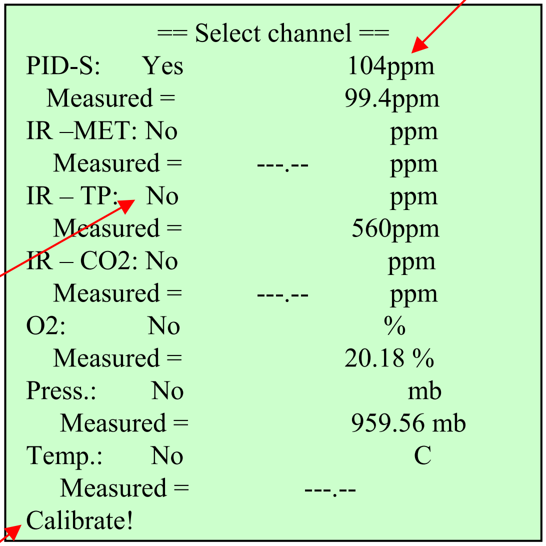
W.27.1 - Selection of analyzers for calibration.



```
         == Select channel ==
PID-S:    Yes               99.4ppm
  Measured =                99.4ppm
IR –MET: No                    ppm
   Measured =        ---.--    ppm
IR – TP:   No                  ppm
   Measured =               560ppm
IR – CO2: No                   ppm
   Measured =        ---.--    ppm
O2:         No                 %
   Measured =              20.18 %
Press.:     No                  mb
    Measured =             959.56 mb
Temp.:      No                  C
    Measured =         ---.--
Calibrate!
```

W.27.2 - Selection of analyzers for calibration.

- Press the **down** arrow and the cursor will move to the right. Pressing the **right** arrow opens a window with numbers which enables you to type in a new value. Type in the actual value of the calibration standard used – in our case, 104 ppm. The value 104 will now appear instead of the previous 99.4 (Window W.27.3).



```
         == Select channel ==
PID-S:     Yes               104ppm
  Measured =                99.4ppm
IR –MET: No                    ppm
   Measured =        ---.--    ppm
IR – TP:   No                  ppm
   Measured =               560ppm
IR – CO2: No                   ppm
   Measured =        ---.--    ppm
O2:         No                 %
   Measured =              20.18 %
Press.:     No                  mb
    Measured =             959.56 mb
Temp.:      No                  C
    Measured =         ---.--
Calibrate!
```

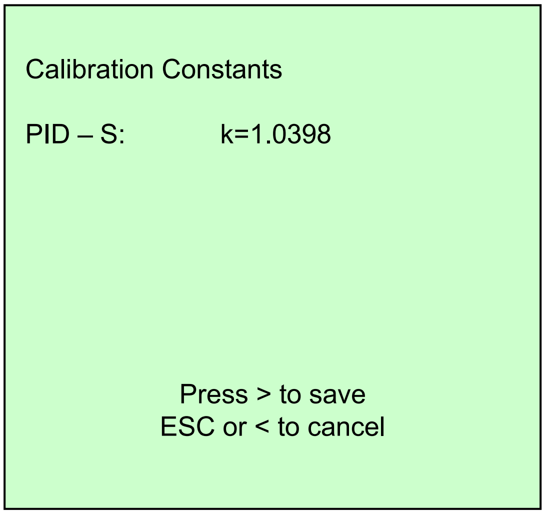
W.27.3 - Selection of analyzers for calibration.

- Leave *No* after the other analyzers as we do not intend calibrating them. Calibration of the other analyzers is described later.

- Go to item *Calibrate!* (Window W.27.3) and select it with the **right** arrow. The instrument will recalculate the calibration constant and display it (Window W.28).

- Pressing the **right** arrow will save the calibration constant and return you to the *Calibration Menu.* You can continue calibrating the other analyzers or return to the *Main Menu.*

- If you do not want to continue with the calibration, press *ESC* or the **left** arrow to return to the *Main Menu* without making any changes to the previous setting of the instrument.



Calibration Constants

PID – S: k=1.0398

Press > to save
ESC or < to cancel

W.28 - Window with the resulting calibration constant

The value of the calibration constant provides and indication of the condition of the analytical unit. If it becomes dusty, the constant value increases. For the PID it may vary from 0.1 to 20. **If the value exceeds 20, the system will not allow the calibration procedure to be carried out, and the PID analytical unit will have to be cleaned.**

If completion of calibration is not allowed, it may be also due to expired calibration gas. Obtain a refill and repeat the calibration procedure before having the analytical unit cleaned.

Never repeat the calibration of the same channel or analyzer immediately! It is necessary to measure at least one point in any locality before doing the calibration procedure again.

11.3 SINGLE POINT CALIBRATION OF IR ANALYZER

For IR methane, IR total petroleum and IR CO_2 channels the same Single Point calibration procedure as for the PID unit is valid. The IR analytical unit requires calibration over a much longer time interval as the unit has a reference channel capable of compensating for dust, moisture, and temperature influences. The standard IR calibration interval is about 12 months depending on the dust conditions. The calibration gases for IR channels are not supplied by the manufacturer and it can be purchased directly from companies providing laboratory and technical gases like Linde, Siad and others.

Both IR Methane and IR Total Petroleum channels are calibrated with methane. For their Single Point calibration use a gas comprising 10 000 ppm methane mixed with nitrogen.

For calibrating the CO_2 channel use a gas comprising 10 000 ppm CO_2 mixed with nitrogen.

Reserve one calibration bag for calibrating the IR Methane and IR Total Petroleum channels and a second bag for calibrating the CO_2 channel. Do not interchange them as they may contain residues of calibration gases and thus cause inaccurate results.

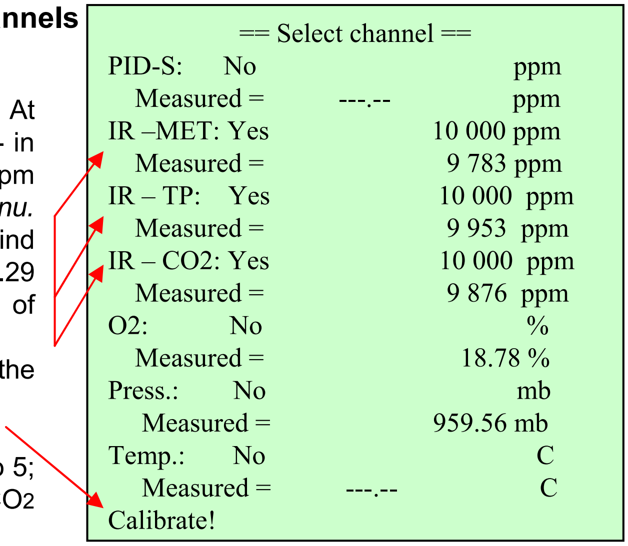
For calibrating all IR channels simultaneously, it is possible to use a mixture of 10 000 ppm of methane and 10 000 ppm of CO_2 (mixture with nitrogen). In this case only one calibration bag is needed for this mixture of calibration gases.

The calibration bags are not cheap and they should be kept in good order. Do not crease them -- they may lose their gas-holding capacity.

11.4 Single Point Calibration Procedure of IR channels

The procedure is similar to calibrating the PID analyzer. At the calibration locality measure the calibration standard -- in our case a mixture of 10 000 ppm methane and 10 000 ppm CO_2). Then go to *CALIBRATION in* the *Main Menu.* Continue the calibration procedure as described above. Find the point with measured standard, and in the window W.29 activate the IR channels and type in the actual values of calibration standard.
Go to *Calibrate!* and complete the calibration according the described procedure for the PID analyzer.

The calibration constant for methane may vary from 0.3 to 5; for total petroleum channel from 0.1 to 30, and for CO_2 channel from 0.5 to 2.



```
              == Select channel ==
PID-S:      No                         ppm
   Measured =          ---.--          ppm
IR –MET: Yes                   10 000 ppm
   Measured =                   9 783 ppm
IR – TP:    Yes                10 000  ppm
   Measured =                   9 953  ppm
IR – CO2: Yes                  10 000  ppm
   Measured =                   9 876  ppm
O2:           No                         %
   Measured =                     18.78 %
Press.:      No                         mb
    Measured =                 959.56 mb
Temp.:      No                           C
    Measured =          ---.--           C
Calibrate!
```

W.29 - Selection of IR channels for calibrating the IR analyzer.

For calibrating CO_2 go directly to the CALIBRATION item in the Main Menu without measuring a calibration locality; select ZERO CO_2 in the Calibration Menu and follow the instructions on the screen. This procedure is an exception for zero CO_2.

11.5 CALIBRATION OF THE PROBE THERMOMETER, OXYGEN AND PRESSURE ANALYZERS

PROBE THERMOMETER CALIBRATION (Fig. 18)

- Insert the probe with its thermometer and a precise external thermometer, which must show tenths of degrees, into a bottle of tap water and wait until the temperature stabilizes(about 30 minutes).
- After the stabilization period, go to the calibration locality *CALIB.lc* and let the instrument measure two or three points to allow it to stabilize.
- Connect the probe with the appropriate cable to **ECOPROBE 5.** The probe is still in the bottle of water.
- Read and note the temperature of the external thermometer.
- Start the measurement. After measuring remove the probe from the water and disconnect it from the instrument.

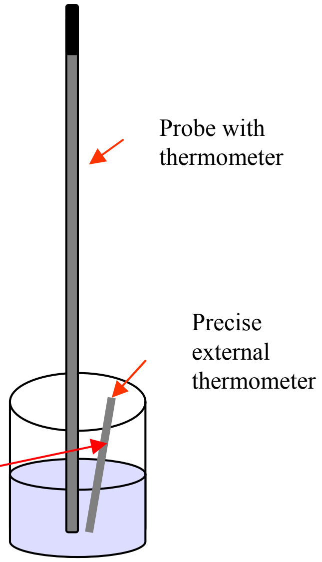
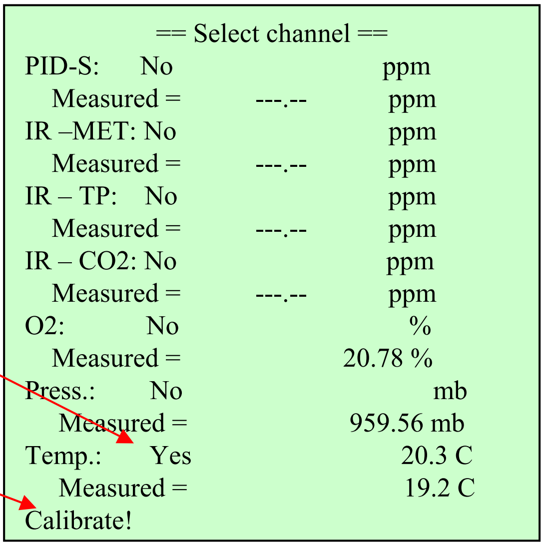


Fig. 18 - Probe thermometer calibration.

- Go to the *Main Menu* (Window W.2), select *CALIBRATION* and continue the calibration procedure as described for the calibration of the PID analyzer. In Window W. 30 activate *Temp* and type in the actual value measured by the precise external thermometer.
- Go to *Calibrate!* (Window W.30) and complete the calibration according to the described procedure.

.

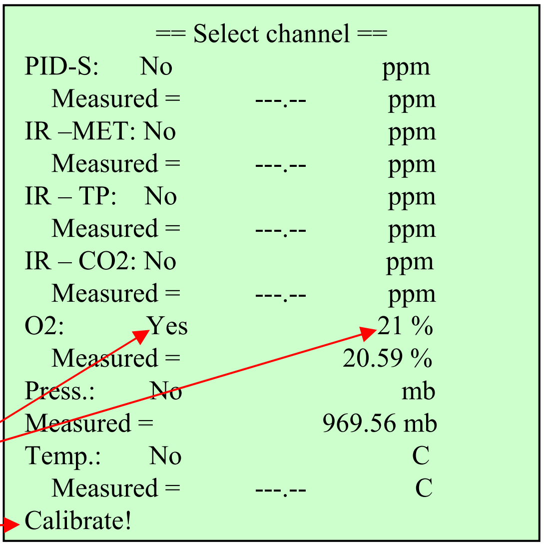


```
            == Select channel ==
PID-S:     No                        ppm
   Measured =        ---.--          ppm
IR –MET: No                          ppm
   Measured =        ---.--          ppm
IR – TP:   No                        ppm
   Measured =        ---.--          ppm
IR – CO2: No                         ppm
   Measured =        ---.--          ppm
O2:          No                        %
   Measured =                    20.78 %
Press.:      No                       mb
    Measured =                  959.56 mb
Temp.:       Yes                  20.3 C
    Measured =                    19.2 C
Calibrate!
```

W.30 - Selection of analyzer for calibration of the probe thermometer.

OXYGEN ANALYZER CALIBRATION

- To calibrate the oxygen analyzer you have to place the instrument outside in fresh air where the oxygen concentration is 21%, or use an oxygen calibration standard.
  Go to the calibration locality *CALIB.lc* (Window W.26) and let the instrument measure two or three points to allow it to stabilize itself.
- Measure one station in the fresh air without any tubing connected. After measuring go to the *Main Menu,* select *CALIBRATION* and continue the calibration procedure as described for the calibration of the PID analyzer. In window W.31 activate *O2* and type in “21” if the instrument was calibrated with fresh ambient air, or type in the real value of the O2 calibration standard used .
- Go to *Calibrate* and complete the calibration according to the described procedure.



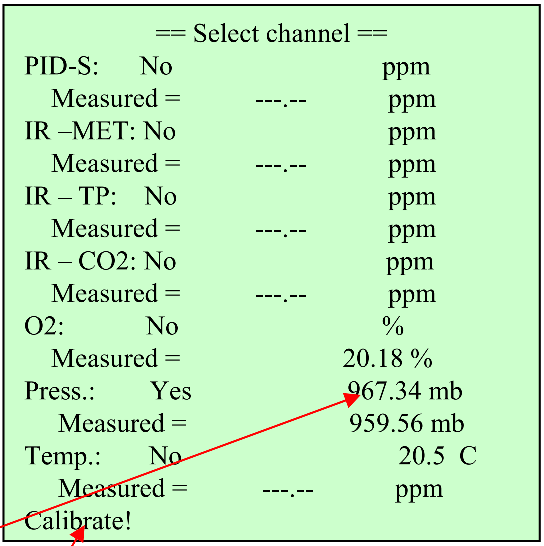
```
        == Select channel ==
PID-S:     No                  ppm
   Measured =          ---.--   ppm
IR –MET: No                    ppm
   Measured =          ---.--   ppm
IR – TP:    No                 ppm
   Measured =          ---.--   ppm
IR – CO2: No                   ppm
   Measured =          ---.--   ppm
O2:            Yes            21 %
   Measured =               20.59 %
Press.:        No               mb
Measured =                969.56 mb
Temp.:       No                  C
   Measured =          ---.--    C
Calibrate!
```

W.31 - Selection of analyzer for oxygen calibration.

Note: For calibrating the oxygen analyzer it is also possible to use a two-point calibration procedure implemented in **ECOPROBE_VIEW** software*. This calibration may also use a standard with zero concentration of oxygen (nitrogen). In this way a more reliable calibration and compensation for the decay of the oxygen sensor are obtained.*

PRESSURE ANALYZER CALIBRATION

- No tubing must be connected to the instrument inlet. Just start measuring – you do not need any standard since you measure only atmospheric pressure.
- Open the calibration locality *CALIB.lc* and let the instrument measure two or three points to allow it to stabilize itself.
- After measuring, go to the *Main Menu (Window W.2),* select *CALIBRATION* and continue the calibration procedure as was described for the calibration of the PID analyzer.
- In the window W.32 activate the pressure channel. To continue the calibration you have to know the atmospheric pressure from the nearest meteorological station. Meteorological services usually provide the latest values of atmospheric pressure on their web sites. If you need to calibrate pressure precisely, you have to recalculate the pressure value for your actual altitude.
- Type in the obtained value from the meteorological station as the actual value of atmospheric pressure.
- Go to *Calibrate!* and complete the calibration according to the described procedure.



```
        == Select channel ==
PID-S:     No                  ppm
   Measured =          ---.--   ppm
IR –MET: No                    ppm
   Measured =          ---.--   ppm
IR – TP:    No                 ppm
   Measured =          ---.--   ppm
IR – CO2: No                   ppm
   Measured =          ---.--   ppm
O2:            No              %
   Measured =               20.18 %
Press.:        Yes          967.34 mb
    Measured =              959.56 mb
Temp.:        No               20.5  C
    Measured =          ---.--    ppm
Calibrate!
```

W.32 - Selection of analyzer for pressure calibration.

The calibration constant for temperature, pressure and oxygen may vary in tenths or hundreds of units.

Another method to calibrate oxygen and pressure analyzers and the probe thermometer is to use the **ECOPROBE_VIEW** *software. The procedure is described in the manual.*

ECOPROBE 5 ANALYTICAL SYSTEMS

ECOPROBE 5 comprises two analyzers for gas – photo-ionization analyzer (PID) and infra-red analyzer (IR).

Each analyzer uses a different principle for gas analysis, and the interpretation of results from each analyzer thus require a different "interpretation view".

The following is an explanation of both analyzer principles in general and also their utilization in **ECOPROBE 5**'s instrumentation and methodology.

12. PID ANALYZER

PID

Photo Ionization Detectors (PID's) measure low levels of VOCs (Volatile Organic Compounds) and other toxic gases. Many Hazardous Material incidents involve VOCs and the sensitivity of PID's to VOCs make them an invaluable tool for initial incident assessment, leak detection and spill delineation.

What are some common VOCs ?

VOCs are chemical compounds widely used in industry and include:

- Fuels (produce the majority of Hazardous Materials incidents)
- Degreasers
- Solvents, Paints, Plastics and Resins.

However, not all the compounds/products can be measured by PID.

How does a PID work? (Fig. 19)

A PID uses an ultraviolet light source (Greek: photo = light) to break down chemicals into positive and negative ions (ionization) that can easily be measured with a detector. The detector measures the charge of the ionized gas and converts the signal into current. The current is then amplified and displayed as “ppm”.

After passing through the PID measuring chamber, the ions recombine to form the original gas. PID’s are non-destructive, they do not alter the gas permanently, and allow the gas to be used for further analysis.

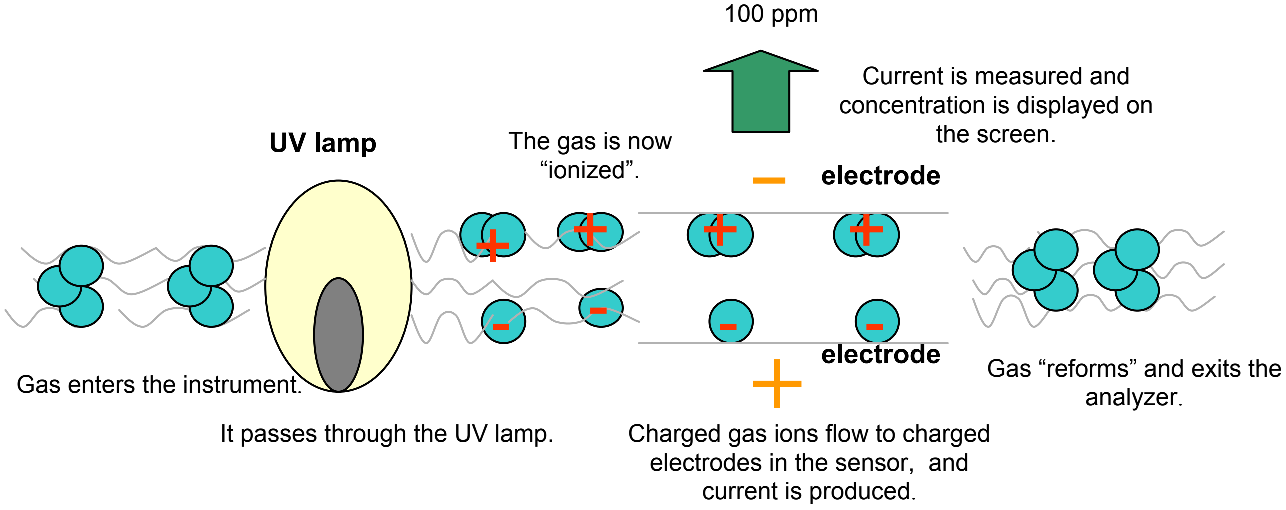


Fig. 19 – Schematic presentation of a PID analyzer.

What does a PID measure?

The largest group of compounds measured by a PID are the Organics -- compounds containing Carbon molecules. These include:

- Aromatics - compounds including a benzene ring such as benzene, ethyl benzene, toluene and xylene.
- Ketones & Aldehydes - compounds with C=O bond including acetone, methyl ethyl ketone and acetaldehyde.
- Amines & Amides - Carbon compounds containing nitrogen, like diethyl amine.
- Chlorinated hydrocarbons - trichloroethylene, perchloroethylene, etc.
- Sulfur compounds – mercaptans.
- Unsaturated hydrocarbons - like butane and octane.
- Ammonia (Inorganic).
- Semiconductor gases - arsine (inorganic), phosphine.
- Nitric oxide.
- Bromine and Iodine.

What PID’s do not measure?

- Radiation.
- Air (N_2, O_2, CO_2, H_2O).
- Common toxics (CO, HCN, SO_2).
- Natural gas (methane, propane, ethane).
- Acid vapours (HCl, HF, HNO_3).
- Others - freons, ozone (O_3).

PID detection generally requires a more detailed description to understand its principle, calibration and interpretation that what is offered in this text.

PID SELECTIVITY

ECOPROBE 5 PID analyzer is calibrated only for one calibration gas – Isobutene (Isobuthylene). **A PID analyzer does not provide a selective analysis of a given contaminant, but measures total concentration** of presented volatile organic compounds (VOC) and other toxic gases including chlorinated hydrocarbons.

How can we understand the fact that there are more than 200 calibration compounds stored in the instrument’s memory?

The user must first determine the identity of the measured compound, or the compound that is dominant in the measured chemical. Once the compound is identified, the PID sensitivity can be adjusted to that compound by selecting it from the list installed in **ECOPROBE 5** in the *“Configuration file”* . The resulting reading will show the total concentration of VOC, but with respect to the selected dominant compound, and will be therefore close to the quantitative value.

Example: If Isobutene is selected in **ECOPROBE 5** which is being used to measure a benzene leak of one ppm, the PID will display two ppm because it is twice as sensitive to benzene as it is to Isobutene. Once we have identified the compound as benzene, then the PID scale can be set to benzene and the PID will accurately read one ppm if exposed to one ppm of benzene.

Unknown contaminant

The main task of a general field survey is fast mapping, monitoring and delineating of contaminated areas, and identifying the contaminant sources and paths. When approaching an **unknown** chemical release, set the PID to **Isobutene as its calibration gas.** The measured values will be relative but proportional to the contaminant concentration over the surveyed area and will provide the operator with a map of the contaminant plume, its source and its migration route.

Single-compound contaminant

Imagine the simplest situation when the contaminant consists of one known compound only. If you select it from the list of calibration compounds in the *“Configuration file”* you will get an accurate concentration of the single-compound contaminant.

Gas Mixture Detection

Commonly a contaminant is a *complex mixture of various compounds*. The measured values provide information about the total concentration of the contaminant, but **not** about the separate compounds.

In the case of a common hydrocarbon contaminant, e.g. a petroleum product, the operator can select one of the hydrocarbon mixtures, e.g. diesel fuel, jet fuel, etc., from the list of measured compounds. The results are close to quantitative values.

In case you need to be sure about the contaminant composition, it is recommended to have a sample analyzed by a laboratory. From the results, select the most prevalent chemical compound from the list provided by **ECOPROBE 5.** The measured data will be more precise and closer to the quantitative values.

The above mentioned selection of the calibration gas and measured values are sufficient for a routine Soil Contamination Survey to provide a fast and cost effective identification of the relative concentration cloud, contaminant sources, migration routes and the size of the impacted area.

Advanced

In case the given Soil Contamination Survey task requires more precise evaluating (not standard), apply the following procedure:

- Assume that the contaminant and soil characteristics are approximately homogeneous over the given environment.
- Select the compound that characterizes the contaminant, from the list of measured compounds.
- Select five holes for a comparative study. Compare the **ECOPROBE 5** values from the five holes with laboratory analyzed samples from the **same** five holes.
  Note: The soil gas sampling procedure requires expertise and careful planning!
- Determine the correlation coefficient for these samples. If the coefficient is approximately the same for all samples, use it to multiply the entire set of values from the measured locality to get semi-quantitative results.

ECOPROBE 5's PID analyzer has two ranges:

HISENS – Lower detection limit is a few ppb; upper limit is 100 ppm. Output can be selected also in µg/m^3. HISENS mode is extremely sensitive, suitable for measuring air contamination – near petrol pumps, etc. It is not suitable for measuring contamination of the ambient air. For Soil Contamination Survey tasks it is necessary to thoroughly observe the methodology of field measuring (cleaning procedures, etc.) since factors like moisture, presence of methane or under-pressure may influence the results. HISENS mode enables you to measure even cutting and transformer oils in a subsurface environment, if the proper measuring procedure is followed.

STANDARD – Lower detection limit is 0.1 ppm; upper limit varies from 2000 to 4000 ppm depending on the measured compound (output also in mg/ m3).

Application of ECOPROBE 5's PID Analyzer

1. For measuring small values of contaminant concentration.
2. For measuring a wide spectrum of contaminants.
3. For quantitative measurements.

Table of Measured Compounds

The table of measured compounds on the next page helps you to make a preliminary assessment if a contaminant can be detected by the PID analyzer. The data are valid for PID lamps used in laboratory gas chromatographs. However, field conditions may be slightly different and it is good practice to try the **ECOPROBE 5** PID analyzer's response to a particular contaminant if we are not sure whether the instrument can be used for surveying a particular polluted terrain.

The Ionization Potential of a compound provides an indication of whether it can be detected by a PID analyzer with a specific lamp. The Ionisation Potential (IP), of various organic and also some inorganic compounds, and their response to certain lamps, are listed in the table.

Ionization Potential

All elements and chemicals can be ionized, but they differ in the amount of energy they require. The energy required to displace an electron and ionize a compound is called Ionization Potential and it is measured in electron volts (eV). The light energy emitted by a UV lamp needed for the ionization of a compound, is also measured in eV. If the IP of the compound is less than the eV output of the lamp, then the chemical will be ionized and measured by the PID analyzer. If the IP of the compound is higher than the energy output of the lamp, the compound will not be ionized and it is not possible to measure it using the PID analyzer.

Correction Factor (CF)

Correction Factors (CF) are used to adjust the sensitivity of the PID to directly measure a particular chemical compared to the calibration gas Isobutene. The CF's are applied automatically in **ECOPROBE 5** after selecting a specific compound. The values in the table are just for your reference.

Table of measured compounds: Example 1:

We need to measure benzene. A PID with 10.6 eV lamp is twice as sensitive to benzene (CF = 0.5) as it is to the calibration gas Isobutene (CF=1.0) (Fig. 20). So if we are measuring 1 ppm of benzene and in the *"Configuration file"* in **ECOPROBE 5** is selected Isobutene, we will see approximately 2 ppm on the display of the PID. If we select benzene in the "Configuration file", the **ECOPROBE 5** software will multiply 2 ppm by CF 0.5 and display the true reading of benzene (about 1 ppm).

Compound Name	Formula	Lamp 9.8 eV	Lamp 10.6 eV	Lamp 11.7 eV	IP [eV]
Benzene	C6H6	0.55	0.5	0.6	9.25
Benzonitrile	C7H5N	NR	1.6	NR	9.62
Chloroform	CHCl3	NR	NR	3.5	11.37
Isobutene	C4H8	1	1	1	9.24

Fig. 20 – Excerpt from the table of measured compounds.

Example 2: The ionization potential of chloroform is 11.37 eV. It means that this compound requires energy of 11.37 eV to be ionized. This energy can be provided only by 11.7 eV lamp and chloroform can be detected only with this lamp.

Table: NR (No Response) means that the selected compound cannot be detected with the given lamp

The IP and CF are only for your information and estimation if a specific chemical can be detected by the PID analyzer. If the given chemical is selected in the "Configuration file", **ECOPROBE 5**'s internal software processes and recalculates all the data and displays definitive results.

TABLE OF MEASURED COMPOUNDS

NR means No Response to the particular compound.

Compound Name	Formula	Lamp 9.8 eV	Lamp 10.6 eV	Lamp 11.7 eV	IP [eV]
Acetaldehyde	C2H4O	NR	5.5	NR	10.23
Acetic Acid	C2H4O2	NR	22	2.6	10.66
Acetic Anhydride	C4H6O3	NR	6.1	2	10.14
Acetone	C3H6O	1.2	1.1	1.4	9.71
Acetonitrile	C2H3N	NR	NR	100	12.19
Acetylene	C2H2	NR	NR	2	11.4
Acrolein	C3H4O	42	3.9	1.4	10.1
Acrylic Acid	C3H4O2	NR	12	2	10.6
Acrylonitrile	C3H3N	NR	NR	1.2	10.91
Allyl alcohol	C3H6O	NR	2.4	1.7	9.67
Allyl chloride	C3H5Cl	NR	4.3	0.7	9.9
Ammonia	H3N	NR	9.7	5.7	10.16
Amyl alcohol	C5H12O	NR	5	NR	10
Aniline	C7H7N	0.5	0.5	0.5	7.72
Anisole	C7H8O	NR	0.8	NR	8.21
Benzaldehyde	C7H6O	NR	NR	1	9.49
Benzene	C6H6	0.55	0.5	0.6	9.25
Benzonitrile	C7H5N	NR	1.6	NR	9.62
Benzyl chloride	C7H7Cl	NR	2	0.7	
Bromobenzene	C6H5Br	NR	0.6	0.5	8.98
Bromoform	CHBr3	NR	2.5	0.5	10.48
Bromopropane,1-	C3H7Br	150	1.5	0.6	10.18
Butadiene	C4H6	NR	1	1.1	9.07
Butadiene diepoxide,1,3-	C4H6O2	25	3.5	1.2	~10
Butane	C4H10	NR	NR	1.2	10.53
Butanol, 1-	C4H10O	70	4.7	1.4	9.99
Butene, 1-	C4H8	NR	0.9	NR	9.58
Butoxyethanol, 2-	C6H14O2	1.8	1.2	0.6	<10
Butyl acetate, n-	C6H12O2	NR	2.6	NR	10
Butyl acrylate, n-	C7H12O2	NR	1.6	0.6	
Butylamine	C4H11N	NR	7	NR	8.71
Butyl cellosolve		NR	NR	NR	
Butyl mercaptan	C4H10S	NR	0.5	NR	9.14
Carbon disulfide	CS2	NR	1.2	0.3	10.07
Carbon tetrachloride	CCl4	NR	NR	1.7	11.47
Chlorine	Cl2	NR	NR	1	11.48
Chloro-1,3-butadiene, 2-	C4H5Cl	NR	3	NR	
Chlorobenzene	C6H5Cl	0.44	0.4	0.39	9.06
Chloro-1,1-difluoroethane, 1- (R-142B)	C2H3ClF2	NR	NR	NR	12
Chlorodifluoromethane	CHClF2	NR	NR	NR	12.2
Chloroethane	C2H5Cl	NR	NR	1.1	10.97
Chloroethanol	C2H5ClO	NR	NR	NR	10.52
Chloroethyl methyl ether, 2-	C3H7ClO	NR	3	NR	
Chloroform	CHCl3	NR	NR	3.5	11.37
Chlorotoluene, o-	C7H7Cl	NR	0.5	0.6	8.83
Chlorotoluene, p-	C7H7Cl	NR	NR	0.6	8.69
Crotonaldehyde	C4H6O	1.5	1.1	1	9.73
Cumene	C9H12	0.58	0.5	0.4	8.73
Cyanogen bromide	CNBr	NR	NR	NR	11.84
Cyanogen chloride	CNCl	NR	NR	NR	12.34
Cyclohexane	C6H12	NR	1.4	NR	9.86
Cyclohexanol	C6H12O	NR	NR	1.1	9.75

Compound Name	Formula	Lamp 9.8 eV	Lamp 10.6 eV	Lamp 11.7 eV	IP [eV]
Cyclohexylamine	C6H13N	NR	1.2	NR	8.62
Cyclopentane	C5H10	NR	NR	0.6	10.51
Decane	C10H22	4	1.4	0.4	9.65
Diacetone alcohol	C6H12O2	NR	0.7	NR	
Dibromoethane, 1,2-	C2H4Br2	NR	1.7	0.6	10.37
Dichlorobenzene, o-	C6H4Cl2	0.54	0.47	0.38	9.08
Dichlorodifluoromethane	CCl2F2	NR	NR	NR	11.75
Dichloroethane, 1,1-	C2H4Cl2	NR	NR	NR	11.06
Dichloroethane, 1,2-	C2H4Cl2	NR	NR	0.6	11.04
Dichloroethene, 1,1-	C2H2Cl2	NR	0.9	NR	9.79
Dichloroethene, c-1,2-	C2H2Cl2	NR	0.8	NR	9.66
Dichloroethene, t-1,2-	C2H2Cl2	NR	0.5	0.3	9.65
Dichloro-1-fluoroethane, 1,1- (R-141B)	C2H3Cl2F	NR	NR	2	
Dichloropropane, 1,2-	C3H6Cl2	NR	NR	0.7	10.87
Dichloro-1-propene, 2,3-	C3H4Cl2	1.9	1.3	0.7	<10
Dichloro-1,1,1-trifluoroethane, 2,2- (R-123)	C2HCl2F3	NR	NR	10.1	11.5
Diesel Fuel #1	m.w. 226	NR	0.9	NR	
Diesel Fuel #2	m.w. 216	NR	0.7	0.4	
Diethylamine	C4H11N	NR	1	NR	8.01
Diethylaminopropylamine,3-	C7H18N2	NR	1.3	NR	
Diethylmaleate	C8H12O4	NR	4	NR	
Dimethylacetamide, N,N-	C4H9NO	0.87	0.8	0.8	8.81
Dimethylamine	C2H7N	NR	1.5	NR	8.23
Dimethyl disulfide	C2H6S2	0.2	0.2	0.2	7.4
Dimethylformamide, N,N-	C3H7NO	NR	0.8	NR	9.13
Dimethylhydrazine, 1,1-	C2H8N2	NR	0.8	0.8	7.28
Dimethyl sulfate	C2H6O4S	~23	~20	2.3	
Dioxane, 1,4-	C4H8O2	NR	1.1	NR	9.19
Epichlorohydrin	C2H5ClO	~200	8.5	1.4	10.2
Ethane	C2H6	NR	NR	15	11.52
Ethanol	C2H6O	NR	12	8	10.47
Ethanolamine (Not Recommended)	C2H7NO	NR	~4	~3	8.96
Ethene	C2H4	NR	10	3	10.51
Ethoxyethanol, 2-	C4H10O2	NR	3.5	NR	9.6
Ethyl acetate	C4H8O2	NR	4.6	NR	10.01
Ethyl acrylate	C5H8O2	NR	2.4	1	(<10.3)
Ethylamine	C2H7N	NR	0.8	NR	8.86
Ethylbenzene	C8H10	0.52	0.5	0.5	8.77
Ethylene glycol	C2H6O2	NR	16	6	10.16
Ethylene oxide	C2H4O	NR	19	3	10.57
Ethyl ether	C4H10O	NR	1.1	NR	9.51
Ethyl formate	C3H6O2	NR	NR	1.9	10.61
Ethyl hexyl acrylate, 2-	C11H20O2	NR	1.1	0.5	
Ethyl (S)-(-)-lactate	C5H10O3	13	3.2	1.6	~10
Ethyl mercaptan	C2H6S	NR	0.6	NR	9.29
Ethyl sulfide	C4H10S	NR	0.5	NR	8.43
Formaldehyde	CH2O	NR	NR	0.6	10.87
Furfural	C5H4O2	NR	0.9	0.8	9.21
Gasoline #1	m.w. 72	NR	0.9	NR	
Gasoline #2, 92 octane	m.w. 93	1.3	1	0.5	
Glutaraldehyde	C5H8O2	1.1	0.8	0.6	
Hexane, n-	C6H14	300	4.3	0.5	10.13

Compound Name	Formula	Lamp 9.8 eV	Lamp 10.6 eV	Lamp 11.7 eV	IP [eV]
Hexene, 1-	C6H12	NR	0.8	NR	9.44
Hydrazine	H4N2	NR	2.6	2.1	8.1
Hydrogen	H2	NR	NR	NR	15.43
Hydrogen peroxide	H2O2	NR	NR	NR	10.54
Hydrogen sulfide	H2S	NR	3.3	1.5	10.45
Iodine	I2	0.1	0.1	0.1	9.4
Isobutane	C4H10	NR	100	1.2	10.57
Isobutanol	C4H10O	19	3.8	1.5	10.02
Isobutene	C4H8	1	1	1	9.24
Isobutyl acrylate	C7H12O2	NR	1.5	0.6	
Isoflurane		NR	NR	NR	
Isooctane	C8H18	NR	1.4	NR	9.86
Isopar G Solvent	m.w. 148	NR	0.8	NR	
Isopar M Solvent	m.w. 191	NR	0.7	0.4	
Isophorone	C9H14O	NR	NR	3	9.07
Isoprene	C5H8	0.69	0.6	0.6	8.85
Isopropanol	C3H8O	500	6	2.7	10.12
Isopropyl acetate	C5H10O2	NR	2.5	NR	9.99
Isopropyl ether	C6H14O	NR	0.8	NR	9.2
Jet fuel JP-4	m.w. 115	NR	1	0.4	
Jet fuel JP-5	m.w. 167	NR	0.6	0.5	
Jet fuel JP-8	m.w. 165	NR	0.6	0.3	
Kerosene		NR	NR	NR	
Mesitylene	C9H12	0.36	0.35	0.3	8.41
Methane	CH4	NR	NR	NR	12.51
Methanol	CH4O	NR	NR	2.5	10.85
Methoxyethanol, 2-	C3H8O2	4.8	2.4	1.4	10.1
Methoxyethoxyethanol, 2-	C7H16O3	2.3	1.2	0.9	<10
Methyl acetate	C3H6O2	NR	NR	1.6	10.27
Methyl acrylate	C4H6O2	NR	3.7	1.2	-9.9
Methylamine	CH5N	NR	1	NR	8.97
Methyl bromide	CH3Br	110	1.7	1.3	10.54
Methyl t-butyl ether	C5H12O	NR	0.9	NR	9.24
Methyl cellosolve		NR	NR	NR	
Methyl chloride	CH3Cl	NR	NR	0.7	11.22
Methylcyclohexane	C7H14	NR	1.1	NR	9.64
Methylene chloride	CH2Cl2	NR	NR	0.89	11.32
Methyl ethyl ketone	C4H8O	0.86	0.9	1.1	9.51
Methylhydrazine	C2H6N2	1.4	1.2	1.3	7.7
Methyl isobutyl ketone	C6H12O	NR	1.2	0.9	9.3
Methyl isocyanate	C2H3NO	NR	4.6	1.5	10.67
Methyl mercaptan	CH4S	NR	0.6	NR	9.44
Methyl methacrylate	C5H8O2	NR	1.4	1.4	9.7
Methyl propyl ketone	C5H12O	NR	0.9	0.8	9.38
Methyl-2-pyrrolidinone, N-	C5H9NO	1	0.8	0.9	9.17
Methyl salicylate	C8H8O3	NR	2	NR	
Methylstyrene, a-	C9H10	NR	0.5	NR	8.18
Mineral spirits		NR	0.7	0.39	
Naphthalene	C10H8	0.45	0.4	0.4	8.13
Nitric oxide	NO	NR	5.2	2.8	9.26
Nitrobenzene	C6H5NO2	2.6	1.9	1.6	9.81
Nitropropane, 2-	C3H7NO2	NR	NR	2.6	10.71

Compound Name	Formula	Lamp 9.8 eV	Lamp 10.6 eV	Lamp 11.7 eV	IP [eV]
Nonane	C9H20	NR	2	NR	9.72
Octane, n-	C8H18	13.2	1.8	NR	9.82
Pentane	C5H12	80	8.4	0.7	10.35
Peracetic acid	C2H4O3	NR	NR	2.3	
Peracetic/Acetic acid mix	C2H4O3	NR	50	2.5	
Perchloroethene	C2Cl4	0.69	0.57	0.31	9.32
PGME	C6H12O3	2.4	1.5	1.1	
PGMEA	C6H12O3	1.65	1	0.8	
Phenol	C6H6O	1	1	0.9	8.51
Phosphine in N2	PH3	NR	2	1.4	9.87
Photocopier Toner		NR	0.5	0.3	
Picoline, 3-	C6H7N	NR	0.9	NR	9.04
Pinene, a-	C10H16	NR	0.3	0.5	8.07
Pinene, b-	C10H16	0.38	0.4	0.4	~8
Piperylene, isomer mix	C5H8	0.76	0.7	0.6	8.6
Propane	C3H8	NR	NR	1.8	10.95
Propanol, n-	C3H8O	NR	6	1.7	10.22
Propene	C3H6	NR	1.7	NR	9.73
Propionaldehyde	C3H6O	NR	1.9	NR	9.95
Propyl acetate, n-	C5H10O2	NR	3.5	NR	10.04
Propylene oxide	C3H6O	NR	6.5	2	10.22
Propyleneimine	C3H7N	1.5	1.3	1	9
Pyridine	C5H5N	0.78	0.7	0.7	9.25
RR7300 (PGME/PGMEA)	C4H10O2/C6H12O3	NR	1.4	1	
Stoddard Solvent - see Mineral Spirits		NR	NR	NR	
Styrene	C8H8	0.45	0.4	0.4	8.43
Sulfur dioxide	SO2	NR	NR	NR	12.32
Tetrachloroethane, 1,1,1,2-	C2H2Cl4	NR	NR	1.3	~11.1
Tetrachloroethane, 1,1,2,2-	C2H2Cl4	NR	NR	0.6	~11.1
Tetraethyllead	C8H20Pb	0.4	0.3	0.2	~11.1
Tetraethyl orthosilicate	C8H20O4Si	NR	0.7	0.2	~9.8
Tetrafluoroethane, 1,1,1,2-	C2H2F4	NR	NR	NR	
Tetrafluoromethane	CF4	NR	NR	NR	>15.3
Tetrahydrofuran	C4H8O	1.9	1.7	1	9.41
Therminol		0.9	0.7	NR	
Toluene	C7H8	0.54	0.5	0.51	8.82
Tolylene-2,4-diisocyanate	C9H6N2O2	1.4	1.4	2	
Trichloroethane, 1,1,1-	C2H3Cl3	NR	NR	1	11
Trichloroethane, 1,1,2-	C2H3Cl3	NR	NR	0.9	11
Trichloroethene	C2HCl3	0.62	0.5	0.4	9.47
Trichlorotrifluoroethane, 1,1,2-	C2Cl3F3	NR	NR	NR	11.99
Triethylamine	C6H15N	NR	1.3	NR	7.5
Trifluoroethane, 1,1,2-	C2H3F3	NR	NR	34	12.9
Trimethylamine	C3H9N	NR	0.9	NR	7.82
Turpentine	C10H16	NR	0.4	NR	
Undecane	C11H24	NR	2	NR	9.56
Vinyl actetate	C4H6O2	NR	1.2	NR	9.19
Vinyl bromide	C2H3Br	NR	0.4	NR	9.8
Vinyl chloride in N2	C2H3Cl	NR	2	0.6	9.99
Vinyl-2-pyrrolidinone, 1-	C6H9NO	1	0.8	0.9	
Xylene, m-	C8H10	0.5	0.4	0.4	8.56

Table of measured compounds

Diesel and gasoline fuels are the most common contaminants encountered in a soil vapor survey. The Table of measured compounds also offers data for the most generally occurring petroleum fuels such as Diesel fuel #1, Diesel fuel #2, Gasoline #1, Gasoline #2, Jet fuel JP-4, Jet fuel JP-5, Jet Fuel JP-8. Selecting the most suitable mixture enables you to get results which are close to quantitative values.

ECOPROBE 5 is equipped with 10.6 eV ionization lamp. Other lamps are optional and may be ordered from the manufacturer. All lamps feature selective methane suppression.

The table is valid only for a PID analyzer and has no connection with the IR analyzer. IR analyzer operates on a different principle.

ECOPROBE 5's PID ANALYZER CHARACTERISTICS

- Detection limit: 0.1 ppm for STANDARD mode; low ppb values for HISENS mode.
- Calibration for quantitative vapor phase determination for over 200 compounds.

  Zero response for methane which is measured separately by the IR unit.
- Large dynamic range (low ppb to 4000 ppm), fast response (0.5 sec).
- Ion lamp 10.6 eV (other energy levels are optional).
- STANDARD mode with **ppm or mg/m3** output or HISENS mode with **ppb or μg/m3** output.

PHOTO- IONISATION BREAKDOWN (QUENCHING)

Generally, the photo-ionisation process has physical limitations. For a concentration higher than a certain value the ionization process will breakdown. Further increase of concentration may even lead to a diminished output. The average value of photo-ionisation breakdown limit is around 4 000 ppm but it varies for different spectral compounds.

To indicate this phenomenon by means of operating software is not usually possible and is not available for PID instruments on the market.

ECOPROBE 5 indicates a concentration level that exceeds the photo-ionisation breakdown limit, mainly by a low “breakdown” value **(hundreds of ppm).** It may also display the message **“over”** on the instrument screen. The mode in which the breakdown is announced depends on various factors such as particular compounds, the speed of the breakdown process, concentration level, etc. All these parameters, which are valid for the **STANDARD** mode only, should be considered in the interpretation.

The graph in Fig.21 illustrates the position of the highest contamination on a survey line, in the interval from 8 to 14 m (metres) , where message “over” was displayed.

Response of **ECOPROBE 5** PID unit, in the STANDARD mode, to an increasing concentration of contaminant.

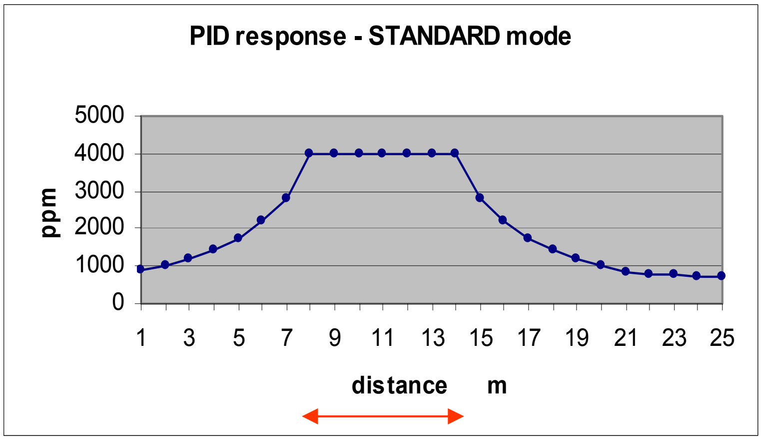


Fig. 21 - Position of the highest contaminant concentration.

The graph in Fig. 22 shows a **typical example**, where the highest contamination is represented by small "breakdown" values. The measured values along the survey line, increase from the edges to the centre of the plume. When the concentration is higher than the photo-ionization breakdown limit, the photo-ionisation process collapses and values of several hundreds ppm are indicated erroneously by the instrument.

The most common type of **ECOPROBE 5** PID unit in the STANDARD mode's response to an increase in the concentration of a contaminant.

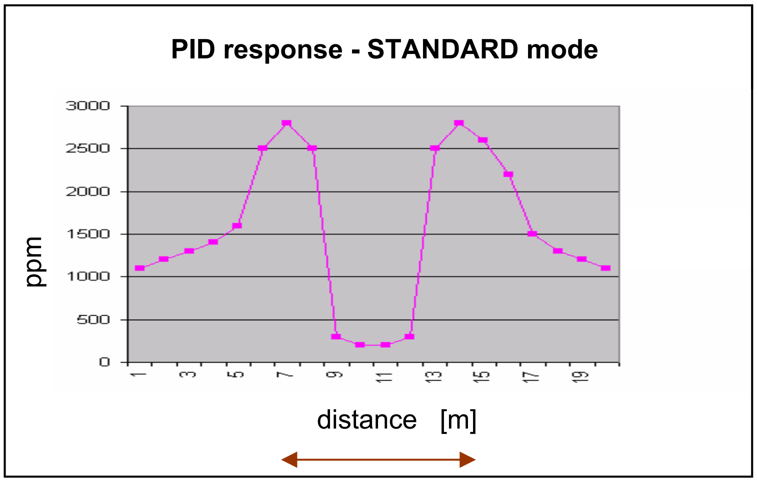


Fig. 22 - Position of the highest contaminant concentration.

In case of the **HI SENS mode** (Fig. 23), the measured limit is 100 ppm. Higher values of concentration are almost **always** indicated by the message "over" displayed on the screen and the value of 100 ppm is linked with the measured station. The graph in Fig. 23 shows the position of the highest contamination on a line using the **HI SENS** mode.

Response of the PID unit in the HISENS mode to an increase in the concentration of a contaminant.

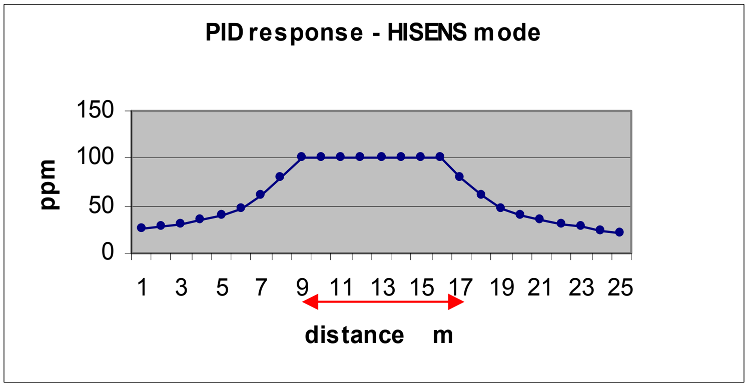


Fig. 23 – Position of the highest contaminant concentration.

Example: The wire-frame map (Fig. 24a) was obtained from a polluted site. The area on the left shows high contamination. Its shape may be interpreted as a photo-ionization breakdown with the highest contamination in the centre domain .

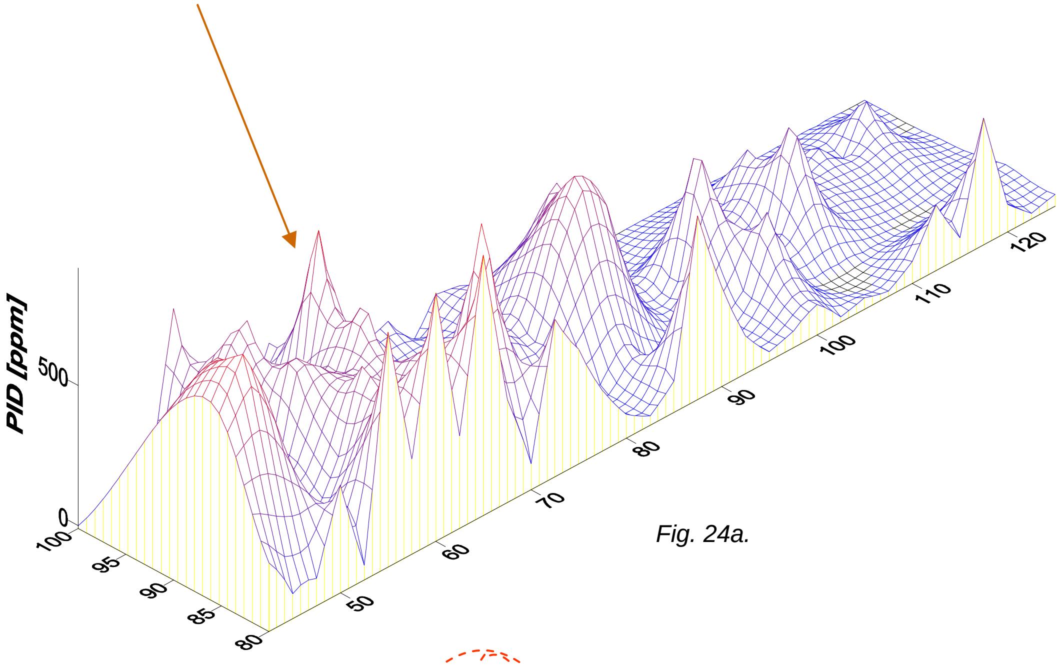


Fig. 24a.

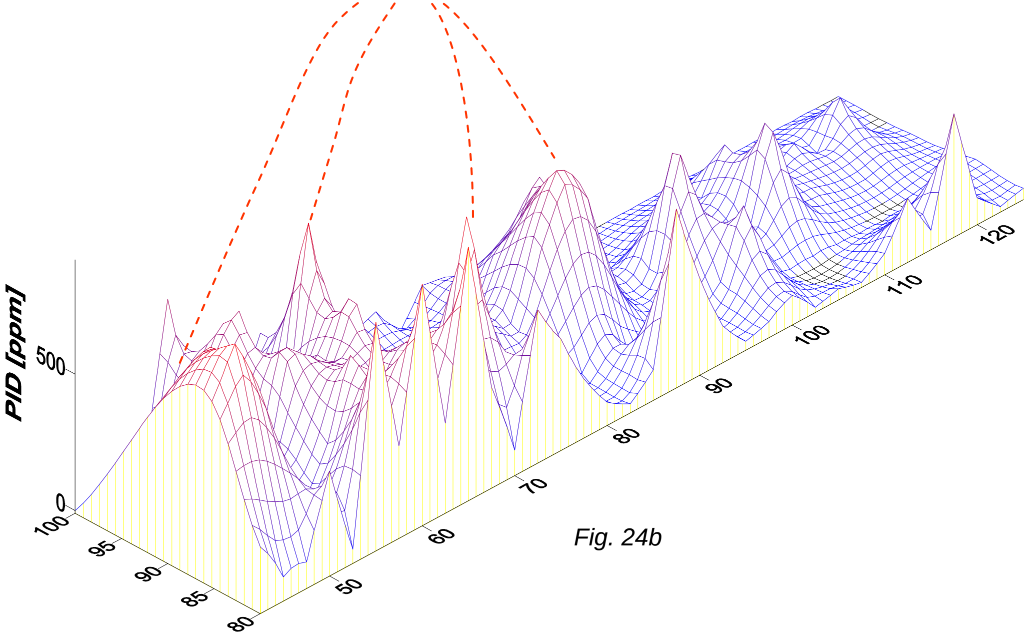


Fig. 24b

Figs. 24a and 24b – Illustration and interpretation of the PID breakdown phenomena.

A comparison between PID and IR results always produces a better overview of the polluted site. If hydrocarbons are present in the contaminant, a correlation between PID (in Standard mode) and IR unit outputs can be observed after a photo-ionisation breakdown of the PID unit.
If the contamination consists of other compounds (non hydrocarbons), there is no response of the IR unit.

13. IR ANALYZER

- Infrared radiation is essentially heat radiation. This fact will be familiar to anyone who has ever felt the heat radiated from a hot oven, and has observed the dark red glow arising when the heat becomes stronger.
- Most gases have their characteristic spectrum in the infrared range. Those spectra reflects a molecule's composition in such a way that no two molecular gases have the same IR spectrum. IR spectra are the fingerprints of gases, and thus allow gases to be uniquely identified.
- By transmitting a beam of IR radiation through air, or through any particular volume of gas, and recording how much is transmitted at selected spectral lines, one may determine which gases are present and their respective concentration.

Infra-red Detection

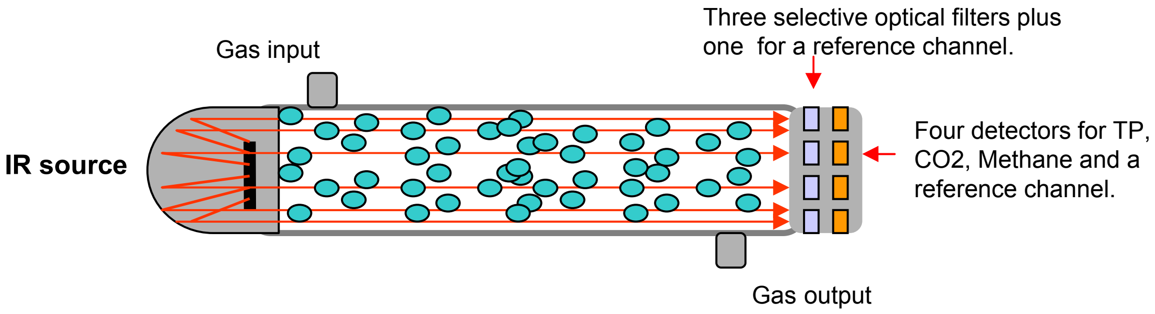


Fig. 25 – Schematic presentation of an IR analyzer.

A beam of IR wide spectrum radiation passes through the sampled gas column which moves through the IR tube (Fig. 25). This causes oscillation of the sub-microscopic particles of the compound. Oscillation consumes energy at a group of particular spectral lines creating a phenomena known as infra-red atomic absorption. The consumed energy is directly proportional to the concentration of the measured compound. Therefore the higher the concentration, the higher the absorption of energy at the characteristic wavelength. Each selective optical filter lets through only one wavelength of the radiation typical for the measured compound. A detector behind the optical filter measures the attenuation of the energy that is directly proportional to the measured concentration.

Field experience has proved that an IR analyzer is essential for a general Soil Contamination Survey because the contaminant concentration is often above 4000 ppm, where PID detection cannot be used.

If hydrocarbons are present in the contaminant, consequent continuity between PID and IR outputs can be observed.

Applications of ECOPROBE 5 IR Analyzer

1. **Relative and fast *in situ* monitoring of contaminant vapor with a concentration up to 500 000 ppm.**
2. **Separate reading for methane, hydrocarbon group and CO_2.**

Features:

Three independent channels with ppm or mg/m^3 output options, plus one reference channel.

- Methane channel – ensures a separate measurement of methane.
  Range: 0 - 500 000 ppm; lower detection limit: 50 ppm,

- Total Petroleum channel: Petroleum comprises a mixture of hundreds of different hydrocarbon compounds. This channel is defined as a wide spectum window, where the range of wavelengths corresponds to that of petroleum-based hydrocarbon pollutants with C-H bonded molecules. Generally, if a pollutant contains at least one C-H bonded compound it could be detected by the TP Channel.

  ECOPROBE 5's IR Methane and TP channels are calibrated for methane which has four C-H bonds. If we detect for example propane (C_3H_8) with eight C-H bonds we can estimate that for the same concentration as for methane (CH_4) the signal from the instrument should be doubled. As not all bonds in a propane molecule have enough “space” – due to molecular structure – for proper vibration and consequently for absorbing the maximum amount of energy, the resulting signal will be a little lower than double.

  We can say that most hydrocarbons can be detected. However, we have to keep in mind that with an increase in the degree of chlorination we can expect lower, and in some cases close to zero, response on the TP channel. The response will decrease as follows:

  - Aliphatic or saturated hydrocarbons [alkanes, cycloalkanes]
  - Unsaturated aliphatic hydrocarbons [alkenes, alkines]
  - Substituted aromatic hydrocarbons [methyl benzene]
  - Aromatic hydrocarbons [benzene]
  - Saturated hydrocarbons [alkyl halides, e.g. dichloropropane]
  - Unsaturated halogenated hydrocarbons [dichloroethylene]

  The resulting output from TP channel represents the concentration of the hydrocarbon contaminant as a whole, *including methane,* with no separation of particular compounds.

  Range of measurement: 0 - 500 000 ppm; lower detection limit: 50 ppm.

- Carbon dioxide channel – ensures separate, one specific wavelength measurement of carbon dioxide with no interference from other compounds. Range of measurement: 0 - 500 000 ppm; detection limit: 50 ppm,

- Reference channel – reference channel window is located at that wavelength of the IR radiation spectrum where no other compounds interfere and the output reading is influenced only by dust, moisture or other disturbing factors. Other IR channels are influenced by these disturbing factors in the same way. The instrument processes all signals and subtracts the value of the signal from reference channel from the signals coming in from IR Methane, TP and CO_2 channels. In this way, undesirable influences from disturbing factors are eliminated and the real value of the contamination is displayed.

HOW CAN WE UNDERSTAND AND INTERPRET THE RESULTS FROM THE IR METHANE AND IR TOTAL PETROLEUM CHANNELS?

Both IR Methane and IR Total Petroleum channels are calibrated for methane.The results of the IR methane channel corresponds exactly with the actual methane concentration.

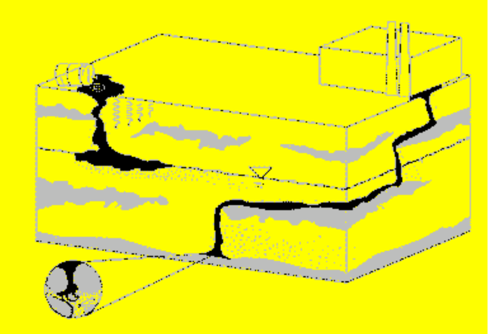
Results of IR Total petroleum channel:

1. If only methane is present and no other hydrocarbons, the results of the methane channel and the IR Total Petroleum channel show the actual amount of methane.
2. If a mixture of methane and other hydrocarbons is present, the IR Total Petroleum channel measures the amount of petroleum hydrocarbons and methane. This value is higher than the result recorded by the methane channel.
3. If only hydrocarbons are present and no methane – there is no reading on the methane channel, the IR Total Petroleum channel measures the total amount of petroleum hydrocarbons. It is necessary to take into account that this channel is calibrated for methane and that the measured value does not reflect the precise quantity of hydrocarbon present. The resulting value is generally 6 – 10 times higher than the actual concentration of hydrocarbons. You can map the area in a relative way or divide the results approximately by 10. Compare the IR TP value with the PID value at a station where methane is not present. Ensure that the TP concentration is not above the photo-ionization breakdown limit.

Since the IR TP channel is calibrated for methane and the PID analyzer on Isobutene, you will never get the same quantitative data from both analyzers. Reading of IR Total Petroleum channel may be 6 - 10 times higher than the reading of the PID analyzer, calibrated on Isobutylene (see previous paragraph and previous page). To obtain comparative readings from IR TP channel and PID channel, both analyzers should be calibrated for the same gas!

Important Note:

For the interpretation of soil vapor data it is essential that all available and relevant information regarding the surveyed terrain is taken into consideration. The most important information required, comprises *inter alia* general geology, the local soil profile, soil characteristics, hydrogeological conditions, site history, dates of spillages, the type and volume(s) of the contaminant(s) involved, etc. Without these contributions, an interpretation of ECOPROBE 5 data may be flawed.



14. DATA INTERPRETATION

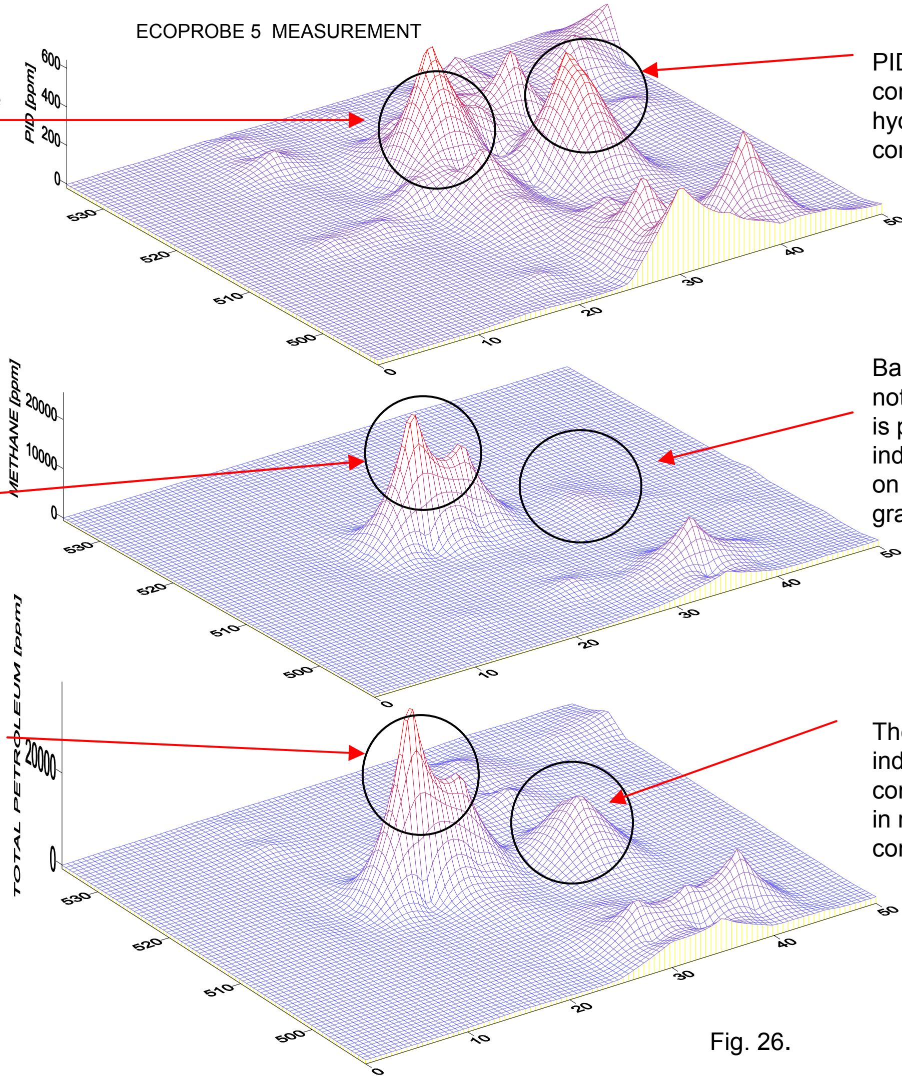
- The different parameters measured by **ECOPROBE 5** help to distinguish various contaminants and facilitates a more accurate overall view of the contamination.
- Methane, CO_2, oxygen and temperature levels indicate subsurface bacterial activity.
- Separate measurements of methane and other hydrocarbons help to distinguish between old and new contamination.
- Sequences of measured values at one station reflect soil texture and porosity.

CASE STUDY 1 (Fig.26): The following wire frame maps were obtained from a site at a railway terminal where the hydrocarbon products were transferred from tank wagons into underground storage tanks. The leakage from pipes and badly-protected high volume tanks caused serious LNAPL pollution with a thick layer of kerosene at the water table. The site is underlain by permeable sandstone and alluvial sediments which are very suitable for a Soil Contamination Survey. Some 100 stations were measured in one day.

We will use the wire frame maps for clarifying the interpretation of PID and IR data received from **ECOPROBE 5** in the field. The wire frame maps show clear differences between older and more recent contamination.

Old contamination:

Recent contamination:



The **PID** results indicate contamination from a wide spectrum of volatile organic compounds (excluding methane). In the case of hydrocarbon contamination PID measures mostly hydrocarbon compounds.

PID indicates contamination (mostly hydrocarbon compounds)

The **Methane** channel indicates extensive bacterial activity (bacteria produce methane) typical of long standing contamination.

Bacterial activity has not yet started. There is practically no indication of methane on the methane graph.

The **TP channel** measures petroleum hydrocarbons including methane. Old contamination shows up mostly as methane on the TP graph, but the hydrocarbon product is still present. Values on TP channel are higher than on the methane channel; see also PID indication.

The TP values indicate hydrocarbon compounds present in recent contamination.

Fig. 26.

CASE STUDY 2 (Fig. 27)

The study site is in the area where the hydrocarbon products were transferred to tank wagons about 10 years ago. The task was to survey the site for possible residual contamination.

An old and almost biodegraded contamination is indicated between 25 and 35 meters (distance) at the profiles 5 and 10.

Some hydrocarbon pollution remains as the PID channel indicates the presence of organic compounds at the given part of the surveyed site.

IR methane channel indicates presence of methane.

IR TP channel measures methane plus hydrocarbon compounds. The TP value perfectly correspond with methane channel, which indicates old contamination, showing up as methane, with much bacterial activity resulting in methane production.

IR CO_2 channel indicates increasing concentration of CO_2 , which is connected to bacterial activity (bacteria produce CO_2 and consume O_2).

The graph shows a decrease in oxygen, which corresponds well with the increase of CO_2 .

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Conclusion:

Methane, CO_2 and O_2 values indicate old contamination with a high bacteria activity Some residual contamination is still present.

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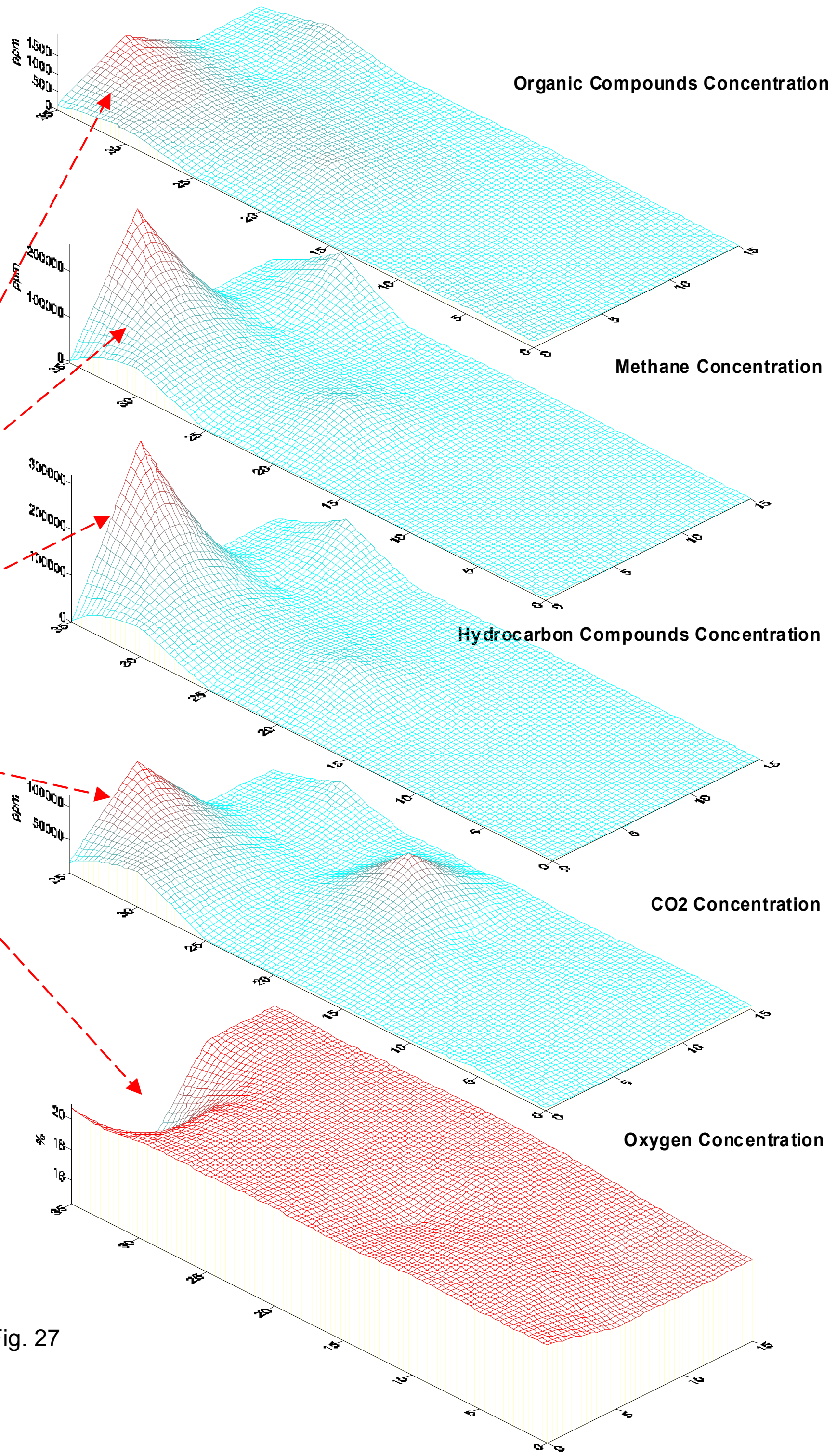

Fig. 27

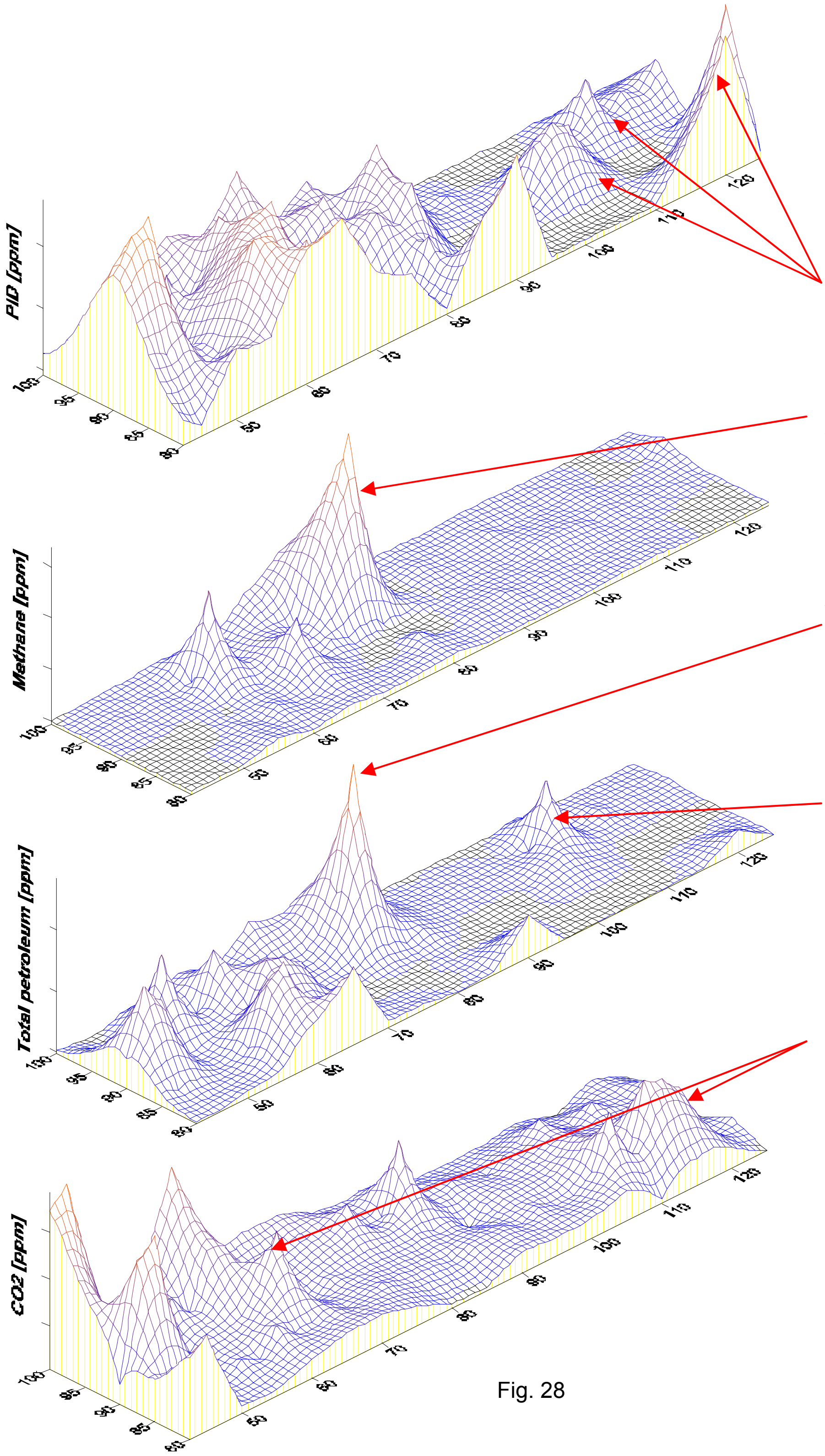

Fig. 28

CASE STUDY 3 (Fig. 28)

PID measurements made at the railway station shows the largest hydrocarbon contamination from 40 to 95 m along all profiles. Several small contaminated domains in the surveyed area, are confirmed by the IR TP analyzer (see the third graph)

Methane channel shows relatively high concentrations of methane, which is characteristic of old contamination where bacterial activity has already started.

At the position of the main contamination, the TP channel shows higher values than the methane channel. This indicates the presence of hydrocarbon contamination. There is also an indication on the TP channel at 100 –110 m on the profiles 95 and 100, of fresh hydrocarbon contamination. No methane is present.

Bacterial activity is expressed by high concentrations of CO2 at the position of the main contaminated area (compare also with the PID channel).

15. GENERAL

15.1 POWER SUPPLY

Use the system **ECOPROBE 5** charger to charge or to continuously supply the unit. A continuous supply is required for the instrument in a semi-permanent application such as the “MONITOR” mode. You can also use solar cells to supply the unit. Using a car cigarette lighter socket for charging the instrument is also possible.

When the battery is considerably weak, the message “WEAK BATTERY” will be displayed at the end of the resetting period. It is possible to measure about ten more stations. The same message will appear at the end of each resetting period until the new message “DEAD BATTERY” is displayed. The instrument will not allow measuring the next station. Press ► to return to the “Main Menu”. Charge the battery by connecting the charger to the multifunctional connector in front of the instrument.

Charging time depends basically on the power output of the DC source. The system charger will charge the internal battery to the full condition within about four hours. Charging mode is indicated by flashing of the red light. When charging is completed, the instrument will switch to the supply mode. The red light of the IR window in the front of the instrument lights continuously.

A fully charged battery pack can power **ECOPROBE 5** for full day’s soil vapor investigation. Boosting the battery over lunch or during an extended break is, however, advisable. An overnight charge will restore the battery to full capacity. **During extended storage, the battery should be charged every two to three weeks.**

15.2 WARRANTY

Abuse and mishandling are excluded from the warranty that covers the instrument and original accessories for twelve (12) months against faulty workmanship and defective components. **ECOPROBE 5 contains no operator serviceable units or parts**, and any unauthorised attempt to open the instrument will invalidate the warranty. Damage to the instrument caused by unqualified operation of the instrument, sucking water into the analytical units or using the instrument for purposes not specified in the operator’s manual will also cancel the warranty.

15.3 TROUBLESHOOTING

If the system hangs and stops responding press three buttons on the display panel – ESC, LIGHT and RUN at the same time. Then switch off the **ECOPROBE 5** by pressing the ON/OFF button. Press ON/OFF button again to reboot the instrument. The instrument will show the *“Main Menu”* screen and will continue in proper operation. Nevertheless, the *“Welcome Menu*” (Window W.1) will be lost from the instrument firmware and may be restored later by the manufacturer using the internet connection.

Experience has proved that **ECOPROBE 5** system is robust and the above problem has never been experienced by any **ECOPROBE 5** user**.**

IMPORTANT NOTES

- **NEVER allow water or any liquid to be drawn into the unit !**
- **Use standard gas filters when measuring in the field.**
- **Using the IR unit ON, never set the resetting interval shorter than 10 seconds. AUT resetting mode or more than 20 seconds fixed interval is recommended time for proper operation**
- **Always clean the analytical units after use by measuring two stations in the "test" locality with no soil gas drawn in.**
- **Do not use the display backlight if not necessary. It noticeably discharges the instrument battery.**
- **Charge the instrument battery regularly even if not in use. Proper interval – 3 weeks.**

Notes:

Notes: