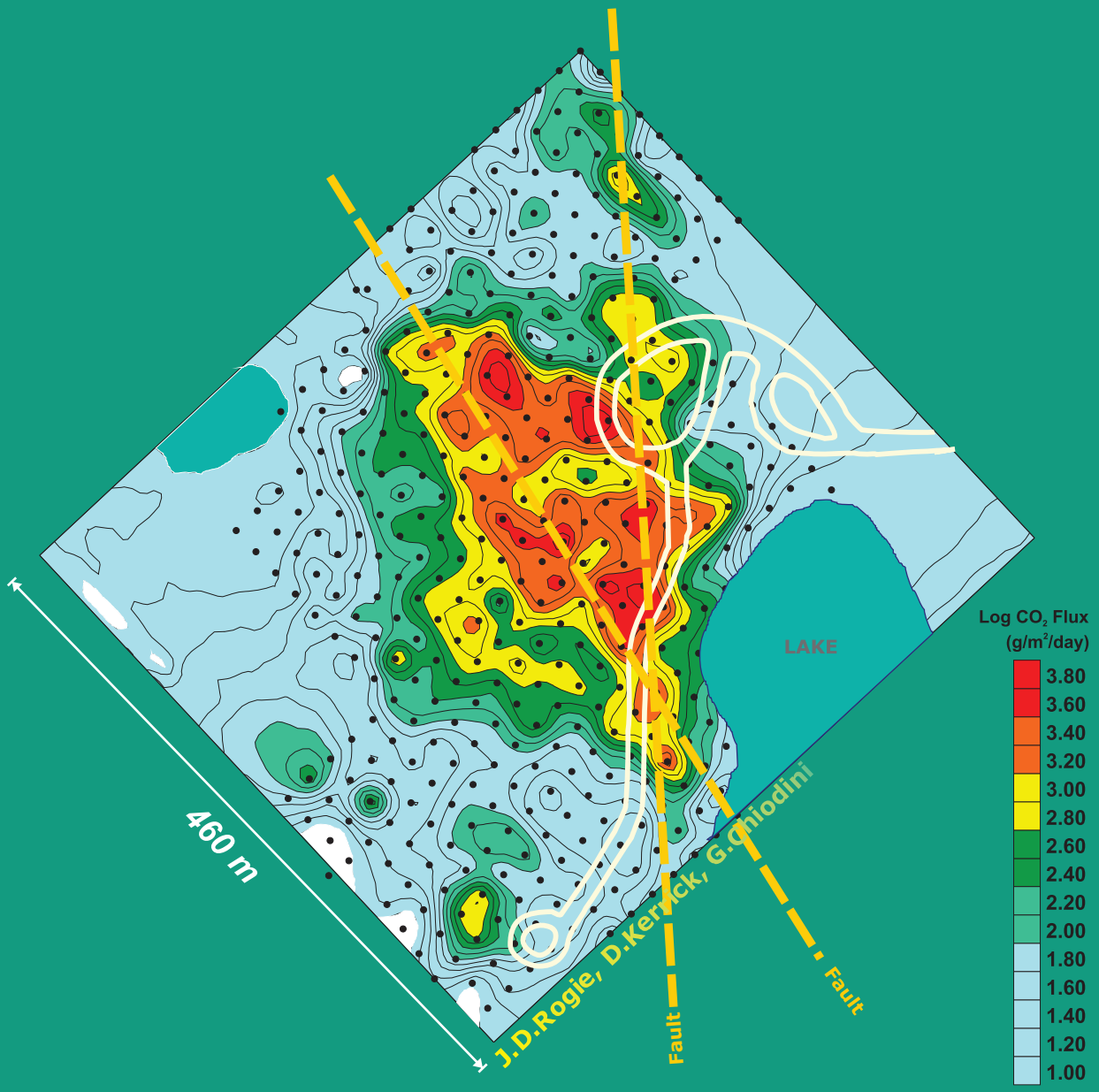
Portable diffuse flux meter with LI-COR CO_2 detector

Handbook

Release 8.2 September 2012



If your equipment requires maintenance in Italy:

BEFORE YOU SHIP THE INSTRUMENT BACK TO ITALY REMEMBER:

- When you ask your shipping agent to send the instrument to Italy check that on the Air Waybill the Airport of destination is **PISA**. Any other airport of destination creates a lot of problems in delivering the items (delay, costs, custom problems, etc).
- Check that the Company your shipping agent chooses lands in Galileo Galilei Airport in Pisa. If not, ask your shipping agent to change the Company or send the items by DHL or UPS or FedEx.
- Mark each item with a serial number, if not already present, and write this number on the document (proforma or original invoice or item list) where you list the parts you are sending back to Italy.
- Specify a correct value of the parts you are sending back in the documents mentioned above.

Pay attention to these rules because Custom law in Italy is very complicated and probably different from your Country.
If you follow these suggestions everything will be easier for you and for us.

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The package contents

List of the Portable fluxmeter components:

Accumulation chambers

- ☐ Accumulation chamber type A
- ☐ Accumulation chamber type B
- ☐ Accumulation chamber type C
- ☐ Accumulation chamber type C-floating

Sensors

- CO_2 ☐ LI820 Detector s/n
- CH_4 ☐ WS-HC Detector s/n
- H_2S ☐ TOX05-H2S Detector s/n
- ☐ Air probe
- ☐ Soil probe

Pocket PC

- ☐ Pocket PC with accessories

Accessories

- ☐ Flux meter handbook
- ☐ Flux meter software CD
- ☐ Battery charger
- ☐ Backpack
- ☐ Q.ty 2 Battery pack

Safety information

Carbon dioxide is a TOXIC GAS.
Carbon dioxide is colorless, odorless, tastless and is heavier than air. Air concentration higher than 5000 ppm can cause dizziness, shortness of breath, rapid pulse. Higher concentrations of carbon dioxide can be **lethal.**
Methane is a colorless, odorless, tastless and very flammable gas.

Hydrogen Sulfide is a poisonous gas:Air concentration higher than few ppm can be **lethal.**

Diffuse carbon dioxide fluxes are normally related to anomalous carbon dioxide air concentration. The user must verify the safety conditions before entering dangerous areas.
The Fluxmeter described in this manual is designed to measure diffuse emission of soil gases and CANNOT be used for different purposes.

The instrument and the electronic accessories are NOT designed to work in explosion risk areas.

Hints

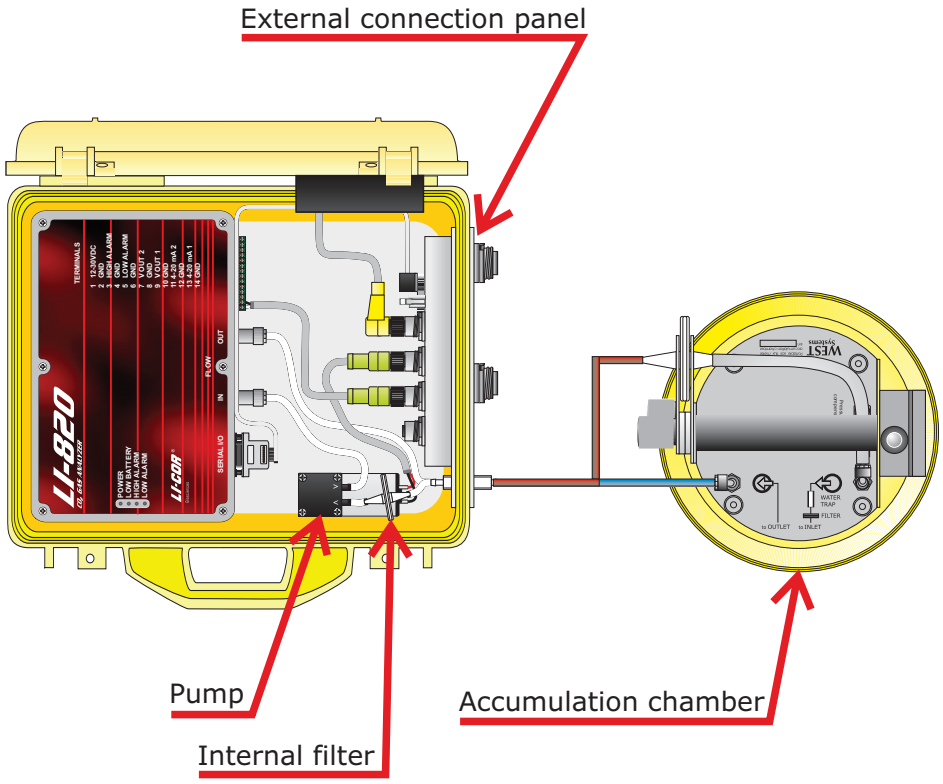
Accumulation chamber (see page 5.2)
The mixing device of the accumulation chamber is powered by an alkaline 9 Volt battery.

Accumulation Chamber (see page 5.3)
About the utilization of the water trap refer to chapter 5.

Quick start guide

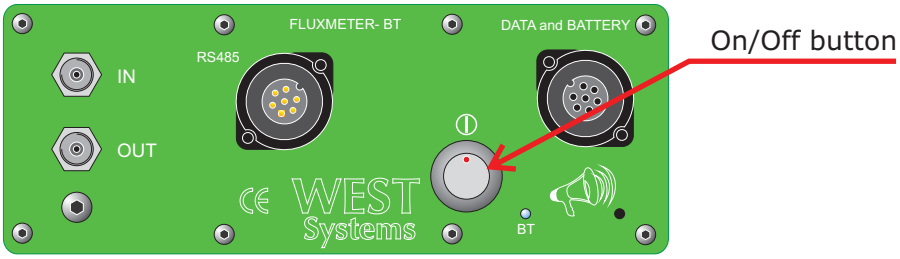
Pneumatic connections

- Check internal connections.
- Check the internal filter.
- Connect the accumulation chamber and check its filter.
- Do not use the magnesium perchlorate water trap if there is H2S in the soil gases (see chapter 4 and 7).



Powering ON

Press the On/Off button on the external connection panel.
The LED on the button will become RED immediately , hold the button until the LED becomes GREEN.



Quick start guide

Please NOTE :

In order to conserve battery-life the instrument will turn OFF automatically after one hour if not under the control of FluxManager software.
When the battery is close to depletion the LED starts to blink, alternating between green and red , continuously.

Pump

- The pump is managed by the instrument and is turned off until you begin a measurement.

Accumulation chamber

- Turn on the mixing device using the switch on the accumulation chamber handle.

PalmTop PDA

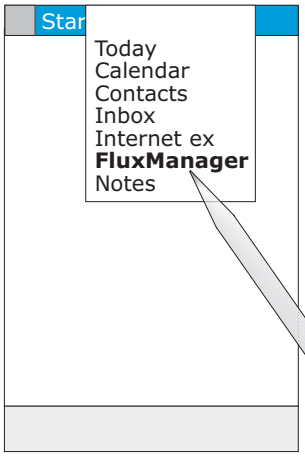
- Turn on the PalmTop. Please refer to the PDA handbook for instructions.

Powering Off

Press the On/Off button on the connection panel.
The LED on the button will become RED immediately, hold the button until the LED is off.

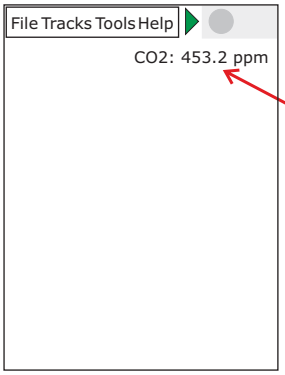
Software FluxManager

How to use the FluxManager software



- The instrument must be ON and connected to the Palmtop (PDA).
- Turn on the PDA.
- Click on Windows Mobile **Start** button.
- Click on **FluxManager** , in a couple of seconds the main screen will appear.

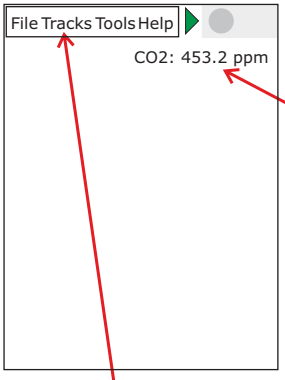
If the FluxManager icon is not present under the Start menu, proceed with the installation of the software. To install, just copy the file FluxManager.exe (furnished in the SD storage card and in the shipping CD) in PDA's directory \Windows\Start Menu.



Status label

Once started, the software loads the last instrument configuration and check its validity. Then FluxManager will show the actual concentration reading of the first gas detector.

If the configuration is no longer valid, or because it's the first run of software, or you reinstalled the software, or you changed the sensor configuration, FluxManager will take you to the sensor configuration menu. Please refer to Appendix A page 4

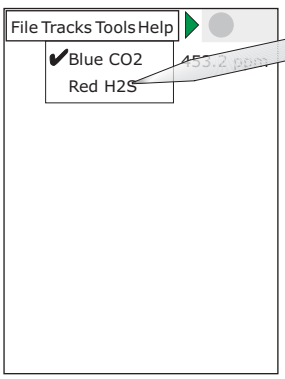


Status label

Now FluxManager is showing the actual CO2 reading

To change the currently displayed detector, select the desired one from the Tracks menu.

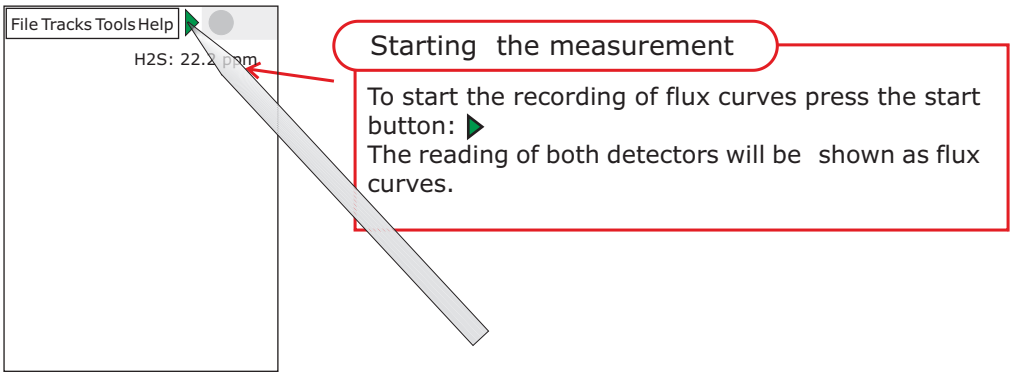
Tracks menu



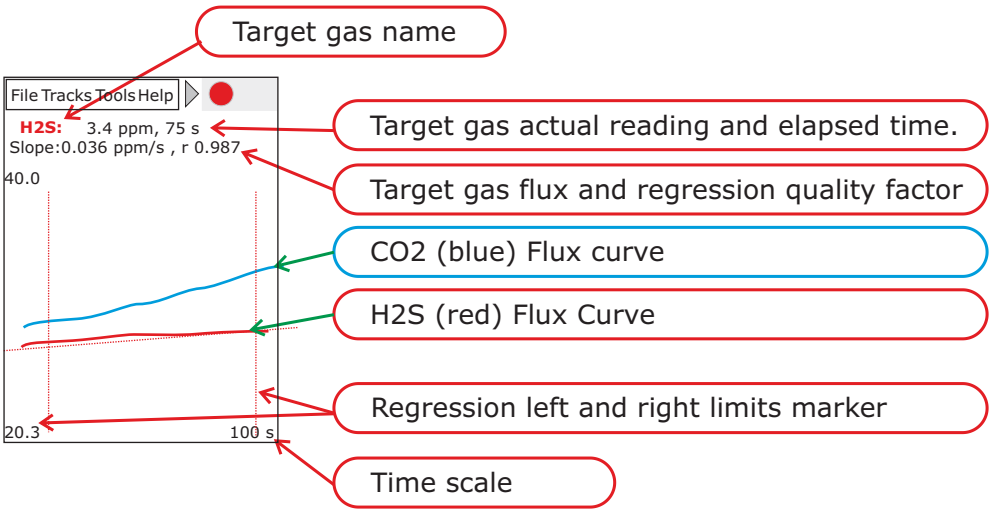
To change the active detector select the desired one from the Tracks menu. A "check" highlights the active track.

When working with the WS-HC detector a periodic reset of the base line value could be necessary. Please see page M.2.

Software FluxManager

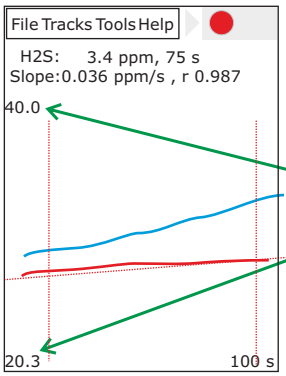


The LICOR LI820 IR sensor is temperature-stabilized in order to reduce the interferences due to the gas sample temperature. If the temperature of the sensor is less than 50°C the software will advise you and will ask if you want start a measurement in these non optimal conditions.
Normally the LI820, after a cold startup needs 3-4 minutes to reach the 50°C temperature and 10-15 minutes to reach a good reading stability. The same considerations about a 20 minutes warm-up period are valid also for the H2S sensor.



While measuring the flux curves of sensors with 'trace' active are shown. The concentration scale maximum and minimum values, as well as the flux and regression quality factor, refer to the selected target gas. Changing the selected gas does NOT affect the recording or the flux computation, but simply changes which information is shown. To facilitate the individuation of tracks the Target Gas Name label has the same color of the track.
To change the active detector select the desired one from the Track menu.

Please note that the track color change is related with the detector ID order , then the H2S track color can be blue or red or another color, depending on the instrument configuration.

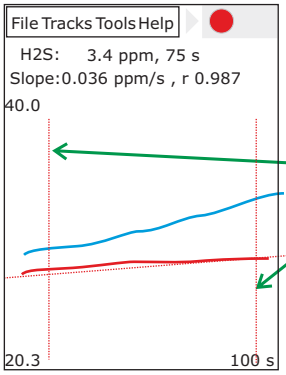


While recording, the plot of target gas concentration is showed in real time: two labels indicate the minimum and maximum value of the plot.

Y axis maximum scale value (ppm)

Y axis minimum scale value (ppm)

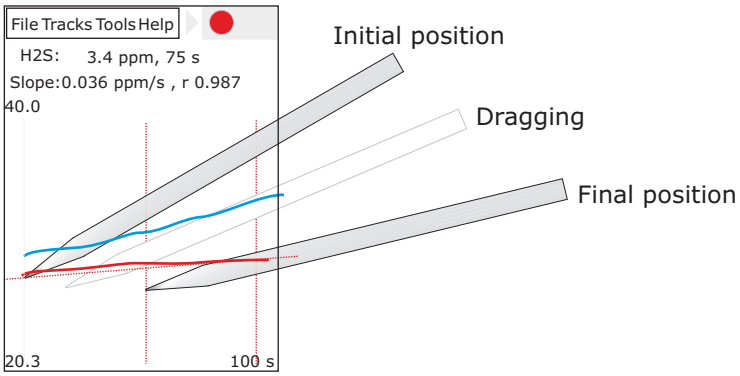
The first touch on the screen will place the left cursor, the second will place the right one. Once both cursors are placed and there are points between the two, the flux (or the slope, if the ACK has not been set) and the regression quality factor information is shown on the screen, and they refer to the selected target gas.
The flux is computed making a linear fit of the curve in the interval between the "left" and the "right" limit.
The selection of the flux curve interval where to compute the flux is critical and a wrong selection can cause an error on the estimation of the flux. In the following pages some examples of the correct interval selection are shown.



Left limit marker

Right limit marker

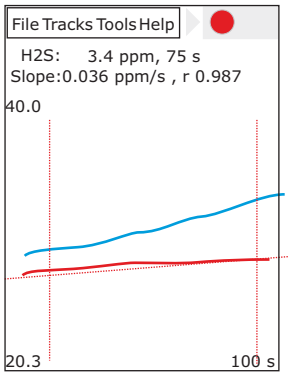
To change the interval move the left and right limits to the desired position. To move the limit you have to touch the screen close to the limit you want to move and drag it to the correct position.
The software will move the limit that's closest to the point you touch on the screen. (See the next example)



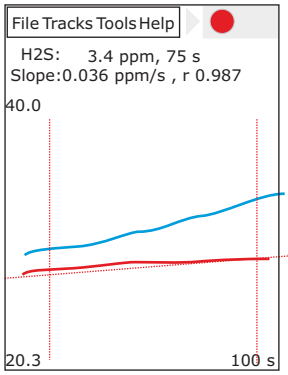
To move the left marker touch the screen close to the left limit marker and drag it as shown in the drawing.

The software will move the closest limit, and it is easier to select the limit to move by touching the screen outside the interval defined by the two limits, for example if you want to move the right limit you have to touch the screen in the right part of the screen, outside the interval, to be sure to select the right marker.

Software FluxManager

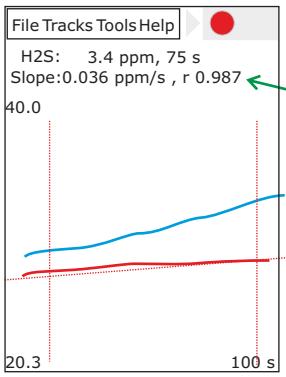


Once having selected the interval FluxManager will compute the regression and the results will be shown as text and as best fit line.



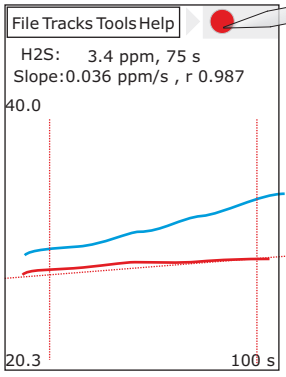
Plot of the flux-curve and of the linear best fit

Each flux curve (H2S, CO2) has a distinct regression interval, then after the computation of the regression of one flux curve you have to select, using the {Track} menu, the other gas flux curve and select the appriopriate regression interval.



Flux and regression quality factor

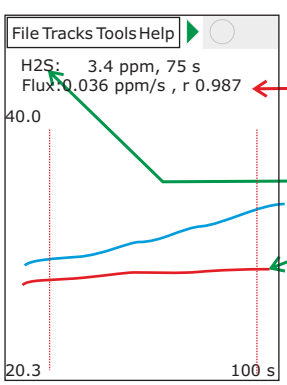
The results of the flux measurement are given, as slope, in ppm/s (ppm per second) or as flux, in m/sm/day (moles per square meter per day, if the ACK factor has been set). Subject matter is investigated in detail in chapter 4.



Normally a flux measurement requires from 90 up to 240 seconds. This depends on the measured flux.
Only while measuring low H2S fluxes a longer period is necessary.

To stop the flux measurement press the Round circle shaped button.

! For a more detailed description of the flux results, the accumulation chamber calibration and the flux measurement units please refer to paragraph 4 of this handbook.

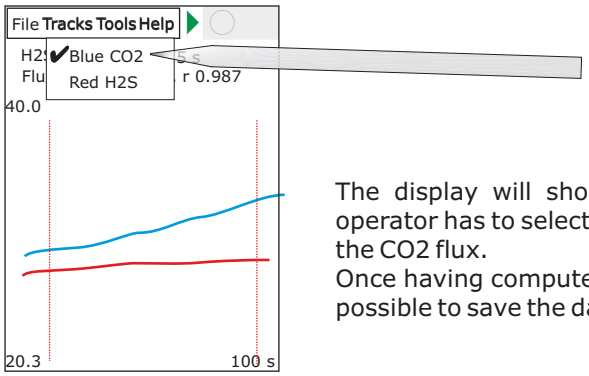


Target gas flux and regression quality factor

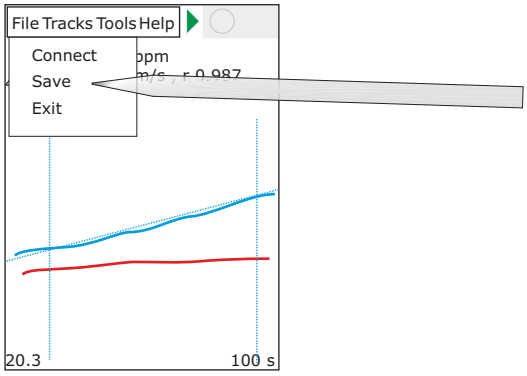
The selected target gas is shown on this label.

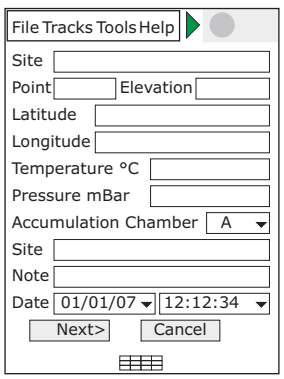
H2S Flux Curve

Once having selected the desired interval where to compute the flux for the target gas, H2S in this example, the operator has to select the second target gas from the Data menu.



The display will show the CO2 information, then the operator has to select the interval range wher to compute the CO2 flux.
Once having computed the flux for both gases, it will be possible to save the data on the PalmTop memory.

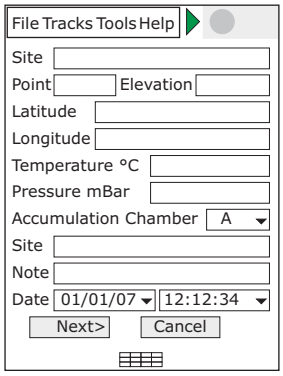




After selecting the [File][Save] menu an information summary form appears.
It will be possible to store some user information such as:

- Site name
- Sampling point #
- Elevation
- Latitude
- Longitude
- User note
- Air temperature
- Barometric pressure

Software FluxManager

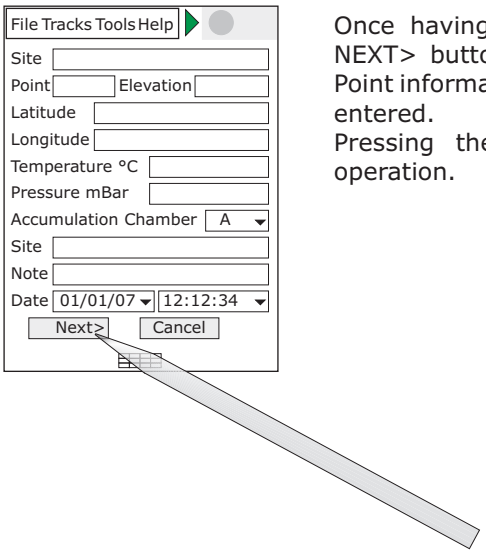


If your instrument is equipped with a LICOR LI8x0 the value of the cell pressure channel will be assigned to the Barometric Pressure field. The pressure is read when the instrument pump is off.

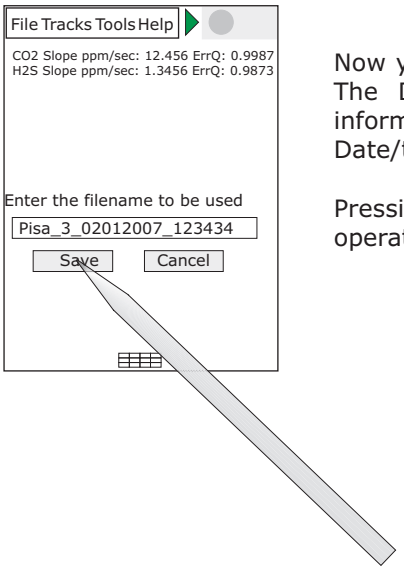
If your instrument is equipped with a WS-HC detector the value of the cell temperature will be assigned to the Air temperature field. Please note that this temperature is normally 3°C more than the real air temperature.

- **Site:** Is the sampling site, for instance "Etna volcano" or "Taiwan-EOF";
- **Point:** is a numerical field that allows you to identify every point on your map. This field will be automatically increased by the software;
- **Elev:** Point elevation in meters or feet;
- **Lat:** Geographical latitude, for example: "N21° 49' 50.2"';
- **Long:** Geographical longitude, for example: "E 121° 10' 50.5";
- **Note:** User notes, feel free to insert any note here;
- **Press.**: The barometric pressure, expressed in mBar (HPa), measured by the instrument if aLICOR is present, or entered by the user if a barometric pressure gauge is not present. Anyway the information can be replaced with a more accurate barometric pressure measurement if available .
- **Temp:** As for the pressure, this information can be replaced with the air temperature or the soil temperature measured by the user, when using the WS-HC detector the cell temperature of the detector is shown by default.

- **Acc.Chamber:** Select the accumulation chamber you're using: Type A, B, C or C-floating.



Once having entered the user information press the NEXT> button to proceed, please note that Site and Point information are considered mandatory and must be entered.
Pressing the **Cancel** button will abort the saving operation.



Now you can modify the default filename, if desidered. The Default filename is composed using the SITE information, followed by the POINT number and then Date/time info.

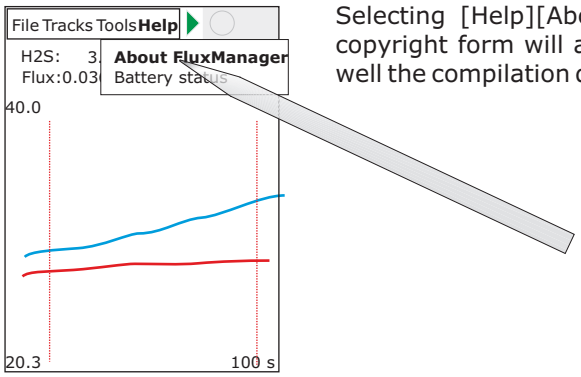
Pressing the **Cancel** button will abort the saving operation.

Now, after you have saved the last measurement, the FluxManager will wait for you to press the Start icon to begin a new analysis.

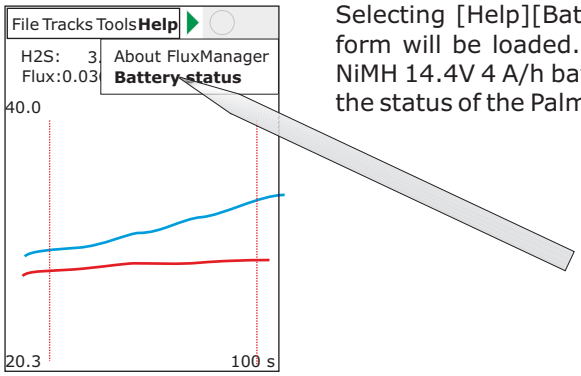
Obviously the data are the most important thing of your work.
It's strongly recommend you take note of the measures in your logbook.

Software FluxManager

Battery status



Selecting [Help][About Flux Manager] menu option a copyright form will appear and the release number as well the compilation date will be shown.

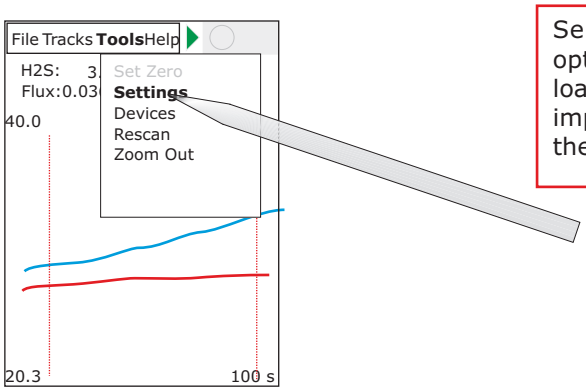


Selecting [Help][Battery Status] menu voice the Power form will be loaded. This form show the status of the NiMH 14.4V 4 A/h battery that supply the instrument and the status of the PalmTop battery.

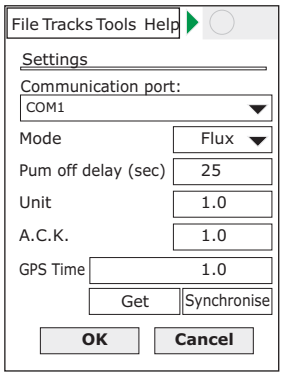
Initial configuration

After the installation the sofware has to be configured in order to be able to connect the fluxmeter. The software communicates with the instrument via a serial RS232 port. This port can change, depending on the palm top brand and configuration. Run FluxManager from the [Start] menu of the palmtop.

Tools menu



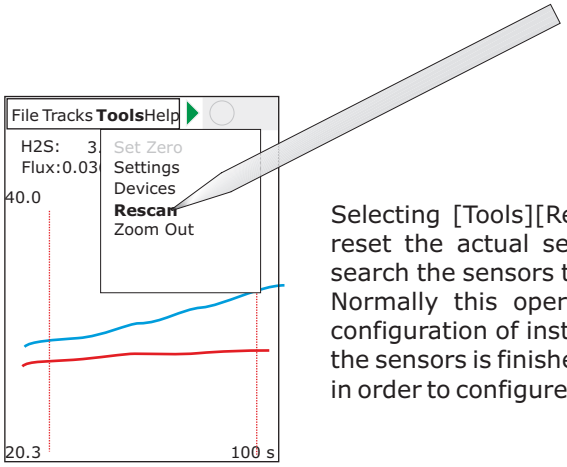
Selecting [Tools][Setting] menu option the settings form will be loaded. This form shows some important information, described in the detail below:



- **Comm port:** Is the number of the communication port that **FluxManager** will use to connect the instrument: The list of the availale serial ports will be shown when you press the down arrow of the combo-box. See Appendix P to get the port to be used.
- **Mode:** This field must be set to: Flux.
- **Pump off delay**: Is the period, expressed in seconds, that the pump remains ON after the end of the flux measurement. This pumping period is useful for the cleaning of the tubes and the sensors cell from the soil gases.
- **A.C.K.:** Is the "constant" of the accumulation chamber. This factor is used to convert the results of the measurement from the basic unit "ppm/sec", to the desired unit, by default, moles per square meter per day. To enter in deeper detail please refer to Chapter 4 of this handbook.
- **GPS TIME**: If you don't see this box, your PDA is not equipped with an integrated GPS, or the GPS is not well configurated (signal this to info@westsystems.com). Press Get to acquire the GPS time. If you have GPS coverage, you will see the time in the text box, otherwise "n.a.". Check also the time zone settings of the PDA (press the Windows Mobile Start button, click Settings, navigate to System tab and select Clock & Alarms. Set the proper time zone). The Synchronise button permits to synchronise the PDA clock from the GPS time. It's important that the clock of the PDA is correct since all the measurements points will be tagged with the PDA date and time.

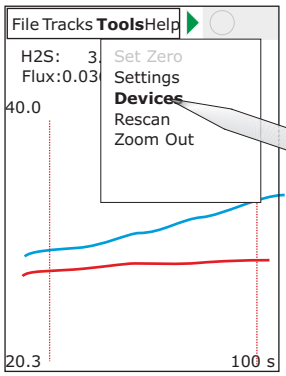
A wrong setting of the CommPort field value can stop the instrument from working.
A wrong setting of the A.C.K. can change the instrument response in an umpredictable way.

After making change press **OK** to accept the new values or **Cancel** to cancel the operation.

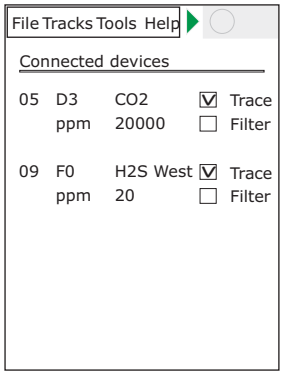


Selecting [Tools][Rescan] menu voice FluxManager will reset the actual sensor configuration and will start to search the sensors that are connected to the instrument. Normally this operation is NOT necessary unless the configuration of instrument is changed. Once the scan of the sensors is finished the "Devices Form" must be loaded in order to configure the working configuration:

Software FluxManager



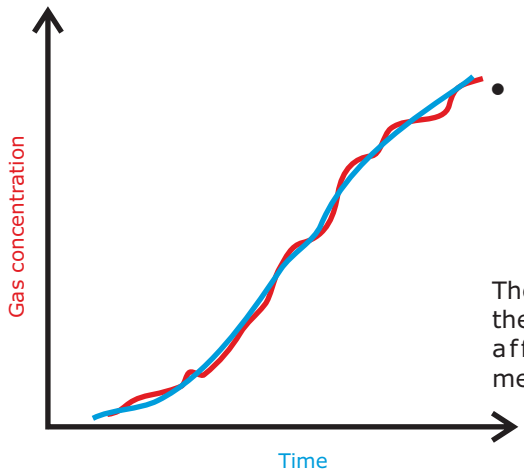
To configure the detectors and the tracks select [Tools][Devices] menu voice. The Connected devices form will be loaded. This form show the list of the detectors and allows the configuration of tracks and filtering.



The list of detectors contains the following information:

- The ID that's is the "Identification" of the detector: In the example 05 is the ID of the CO2 detector and 09 is the ID of the H2S detector. The ID is not user editable and each detector must have a unique ID in the RS485 chain otherwise FluxManager can't work.
- The Type of the detector , in the example D3 is the type assigned to the CO2 and F0 is the H2S one.
- The description of detector: CO2 and H2S.
- The unit used by the detector: ppm.
- Select the **Trace** check-box of the detector you wish to use to measure flux: In this case CO2 and H2S. Only for debug purpose you can check the Temp.°C or Press. mBar., if present, in order to see the variations of barometric pressure or Cell temperature during the flux measurement. You can select up to a maximum of 8 tracks.
- Select Filter check-box to apply a digital low-pass filter to the track: this feature will reduce the noise of the detector.

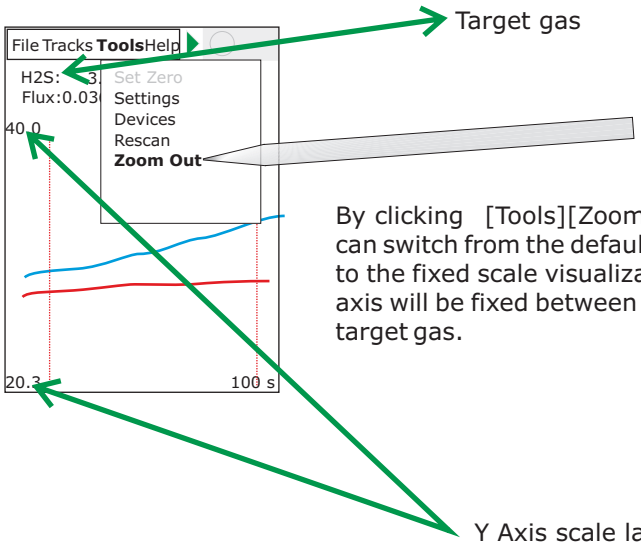
Low pass digital filter



- The filter will"clean" the curve from the noise of the detector that can affect the curve when the concentratration increasing is low. On red the unfiltered curve and on blue the curve after filtering.

The digital filter is designed to do not affect the slope of the curve and then to do not affect the accuracy of the flux measurement.

Changing the visualization scale



By clicking [Tools][Zoom Out] or [Tools][Zoom In] you can switch from the default "autoscale" feature of the plot to the fixed scale visualization: In this case the span of Y axis will be fixed between 0 and the full scale value of the target gas.

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Measuring flux

In this chapter how to measure the flux and how to interpret the results will be explained. Please refer to chapter 2 to learn about the use of the instrument and the FluxManager software. To better understand the this chapter a basic theory is explained:

The theorical flux curve is shown in the figure below: The plot represent the variation of the concentration of the target gas versus time.

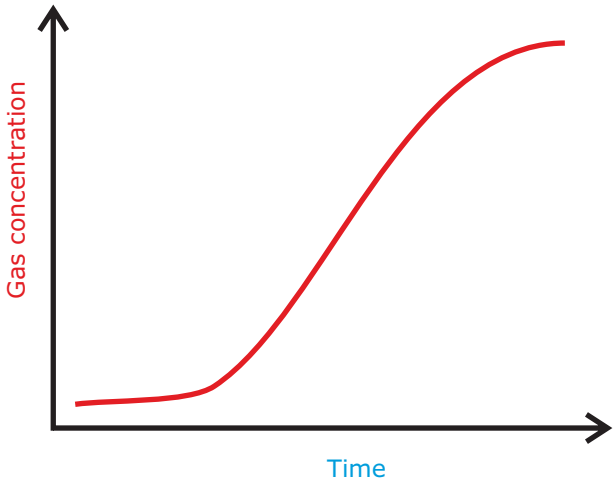


Figure 3.1

In the next figure some characteristic areas of the plot are identified

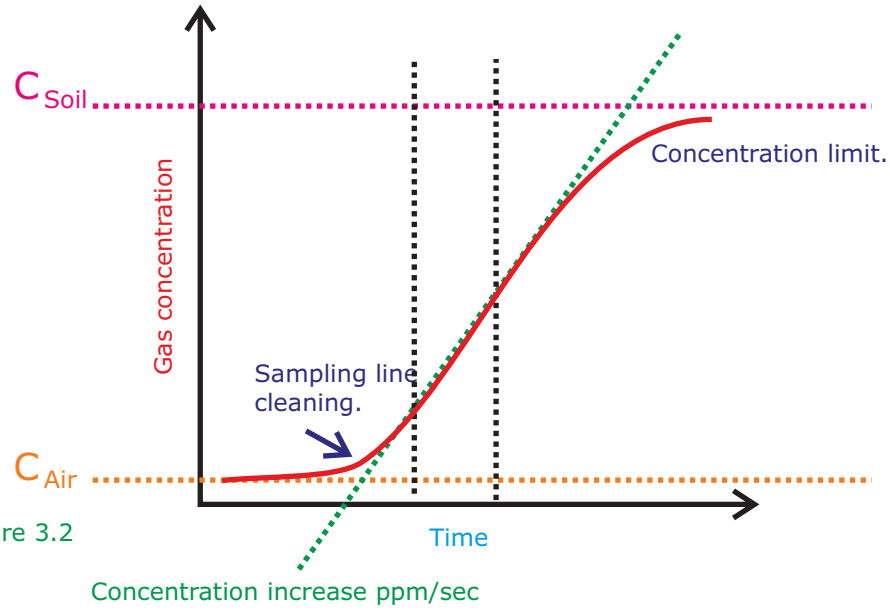


Figure 3.2

C_{Air} is the target gas air concentration, 350 ppm in the case of carbon dioxide , few ppm in the case of other gases. C_{Soil} is the target gas concentration in the soil. A very long recording period is necessary to reach the limit C_{Soil} concentration.

In the first part of the flux curve a "sampling line cleaning" area is highlighted : in this area the gas pumped from the accumulation chamber is replacing the gas into the pump, the tubes and the cell detector cell(Dead volumes). The cleaning efficiency depends on the dead volumes and on the pumping flow.

When the target gas concentration become close to the soil concentration the flux curve slope decreases. Normally the flux curve recording time in not enough to highlight this effect. The carbon dioxide concentration in the anomalous soils is normally more than 5%.

The two vertical lines delimit the good flux curve interval where to compute the flux.

Measuring flux

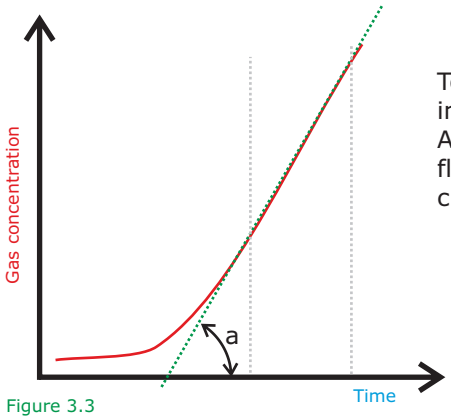


Figure 3.3

To have a good evaluation of the flux the correct interval of the flux curve has to be selected.
A period in the range from two up to four minute of flux curve record is necessary to obtain a good flux curve.

A linear best fit of the flux curve in the interval is computed, in order to evaluate the coefficient **a**, using the following formula:

a, the angular coefficient of the linear fit is computed as:

$$a = \frac{\sum x \cdot y - \frac{\sum x \cdot \sum y}{n}}{\sum x^2 - \frac{\left(\sum x\right)^2}{n}}$$

Where **x** is the time, in second and **y** is the concentration expressed in ppm. Each **summative function** is intended for each point in the flux curve that is within the selected interval.
The number **n** is the number of points used for the flux evaluation.
a has the ppm/sec dimension and is the slope of the the linear regression of the flux curve, and is assumed as the the slope of the flux curve in the selected interval.

ErrQ, the linear regression quality factor is computed as:

$$ErrQ = \frac{\left(\sum x \cdot y - \frac{\sum x \cdot \sum y}{n}\right)^2}{\left[\sum x^2 - \frac{\left(\sum x\right)^2}{n}\right]\left[\sum y^2 - \frac{\left(\sum y\right)^2}{n}\right]}$$

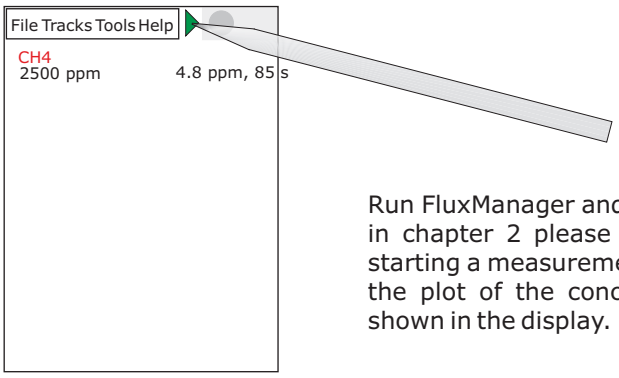
The value of ErrQ can vary in the range from 0 up to 1.
Values of ErrQ close to zero (ErrQ < 0.5) means that the regression is not good and that the linear curve computed does not fit the curve.
Values of ErrQ close to one (ErrQ > 0.9) means that the regression is quite good and the linear curve fits the flux curve very well.
Since the points are homogeneously distributed in the time domain the ErrQ quality factor is a univocal indicator of the regression quality. Please note that when the slope of the regression is zero the ErrQ also has to be zero.

Obtained **a**, the slope of the flux curve expressed in ppm/sec, an additional calculation will be necessary, taking account of the accumulation chamber shape and of the environmental parameters, to transform the slope into a flux evaluation. This matter is described in detail in the chapter 4.

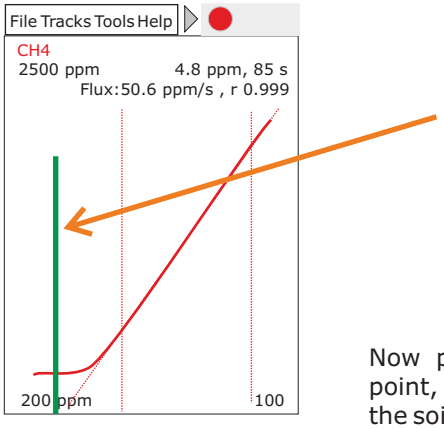
The complete theory of the accumulation chamber method will be not discussed in this handbook and can be found in the papers listed in the Appendix C.

Measuring flux

The measurement

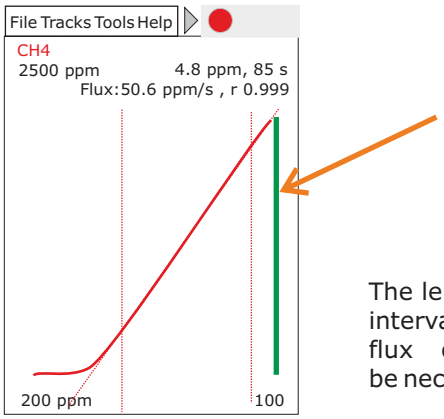


Run FluxManager and start the measurement. As written in chapter 2 please let the detectors warm up before starting a measurement. Having pressed the start button the plot of the concentration of the target gas(es) is shown in the display.



The chamber was placed onto the soil.

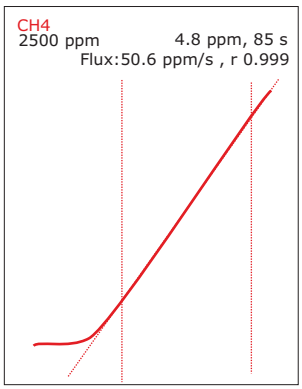
Now place the accumulation chamber in the desired point, checking the perfect sealing of the chamber with the soil.



The chamber was removed from the soil.

The lenght of the flux curve recording is normally in the interval 90-240 seconds. Only when measuring very low flux of methane a 300-360 second measurement could be necessary.

Measuring flux

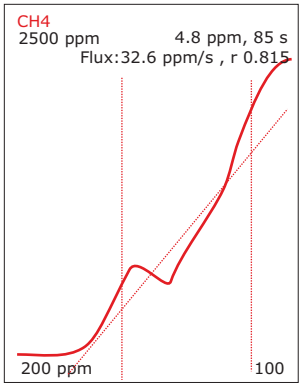


The "perfect" curve

In the figure on the left the display of palmtop during a flux mesurement is shown.

For clearness only the CO2 flux curve is shown.
The shape of the curve is quite perfect and the computation of the flux is done with a very good accuracy: **r** (regression quality factor) very close to 1.

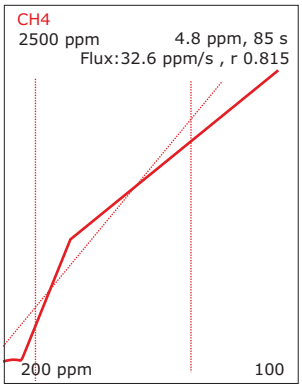
In the following figures some examples of strange shape flux curves:



Air contamination

The flux curve is no longer "linear", the linear best fit curve do not fit exactly the flux curve as pointed out by the regression quality factor (0.815 in the example). This effect is probably due to atmospheric air contamination.

If you obtain this kind of curve check the sealing of the accumulation chamber with the soil or check that tubes, filters and pump are intact.

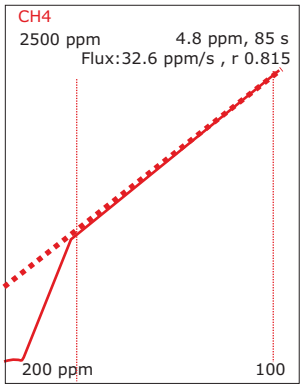


Gas stratification

This shape of curve indicates that the concentration of the target in air, close to the soil, is very high. This stratification is quite common in case of very high flux combined with a very stable atmosphere.

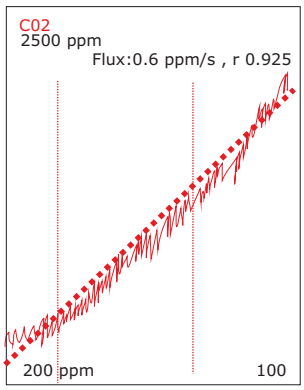
In this case clean the gas line making a measure in air, one meter above the soil surface, and afterwards repeat the flux measurement.

You can use the measurement choosing the second part of the curve for regression computation.



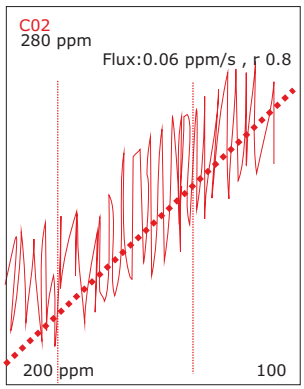
Selecting the second part of the curve the line fits the flux curve very well and the regression quality factor become 0.999.

Measuring flux



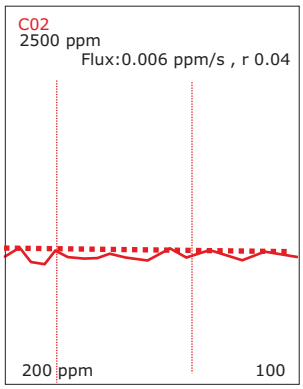
Low fluxes

This type of curve is normal when the flux is low and the "noise" of the detector is comparable with the increase of concentration. This effect is bigger for the methane sensor and is minimum for the carbon dioxide one.



Very low fluxes

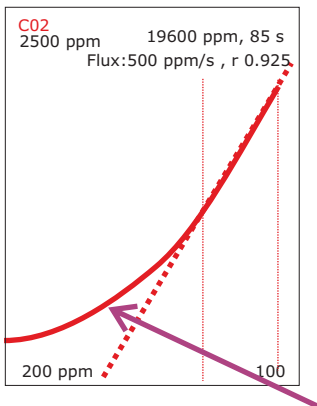
Of course the noise disturbation increases when the flux is very low.



No flux

The curve is flat and the increase of the gas concentration is very low.

- There is no flux.
- Is the pump working?
- Are the tubes correctly connected?



Very high flux

The first part of the curve is not linear. The problem is due to the combined effect of the high flux and the sampling line cleaning. To avoid this increase the flux curve record time until the concentration of gas reachs the full scale value and select the last part of the curve for the flux computation.

This effect is due to the cleaning of the sampling line dead volumes

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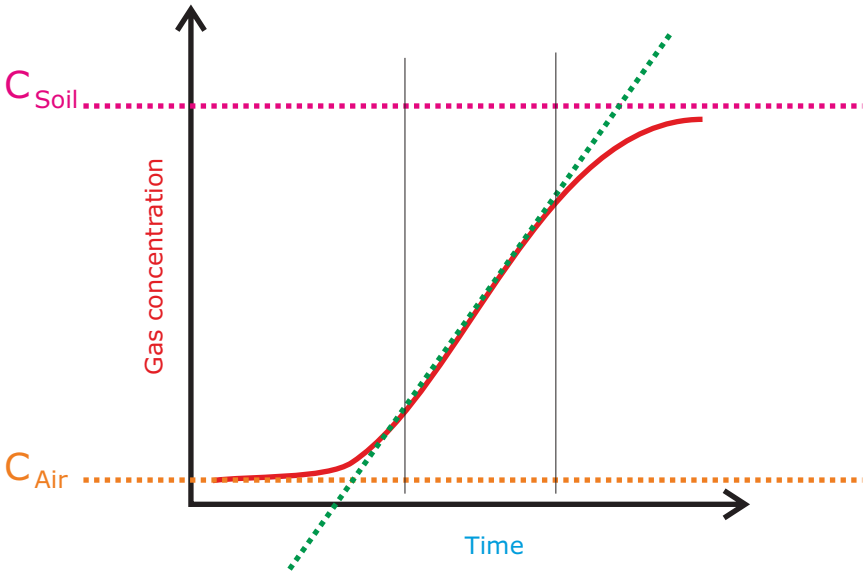
Quantifying the flux

How explained in the chapter 3 the flux is proportional to the concentration increase ratio ppm/sec. The proportionality factor depends on the chamber volume/surface ratio as well as the barometric pressure and the air temperature inside the accumulation chamber.



There are two methods to carry out the field work, in both cases for each measurement you have to record the type of accumulation chamber used, the barometric pressure, and the air temperature.
The variation of few mBar of the pressure and or few degrees of temperature do not affect the evaluation of flux very much, then you can use a mean value for both parameters. Of course that depends on the accuracy you want to reach for the evaluation of flux.
The instrument measures the barometric pressure, using the embedded pressure sensor of the LICOR, with a good accuracy. A platinum Pt100 or a thermo-couple thermometer can be used to measure the air temperature as well as the soil temperature.

Choosing the flux measurement unit

The first measurements made, 10 years ago, with the accumulation chamber was expressed in cm/sec which is a speed, the speed of carbon dioxide flowing out from the soil. During the last ten years several units have been used by volcanologist and by geochemistry researchers. The most common unit is grams/squaremeter per day, but using the same instrument for two gas species to express the flux using this unit means to have two different conversion factors. Actually we use the unit **moles/squaremeter per day** that has two advantages: A single conversion factor for every gas specie and an easy conversion of the flux in grams/sm per day simply multiplying the result expressed in moles/sm per day for the molecular weight of the target gas.

From the [tools][settings] menu you can set the accumulation chamber factor in the "A.c.K." field.

If this factor is set to 1 the instrument will give you results expressed in ppm/sec, that's simply the slope of the curve in the selected interval.

If you set the A.c.K to a value different from 1 the instrument will give you the results expressed in moles per square meter per day.

Please see next page.

Quantifying the flux

Method 1: Measuring the slope

Set the Accumulation Chamber factor to 1 in order to have the flux measurement expressed in the slope unit "ppm/sec" and translate it in the desired unit with a post processing.
Using this method you can focus only on the accumulation chamber interfacing with the soil, the flux curve shape and the other aspects of the measurement, putting off choosing the correct accumulation chamber factor.

Method 2: Measuring the flux directly in moles/sm/day.

To get the results directly in moles/sm/day you have to set the Accumulation Chamber factor to the correct value, taking it from the tables.
For each measurement, if there are variations in the air temperature, or of the barometric pressure, or if you changed the accumulation chamber you have to select the [tools][settings] menu and put the correct accumulation chamber factor in the "A.c.K." field. This operation can be "critical". In any case on the saved files you'll find the results of flux evaluation expressed in both units , the raw ppm/sec and the moles/sm/day computed with the A.c.K. you set.

The accumulation chamber factors

Here following the formula used to compute the A.c.K.:

$$K = \frac{86400 \cdot P}{10^6 \cdot R \cdot T_k} \cdot \frac{V}{A}$$

Where

- **P** is the barometric pressure expressed in mBar (HPa)
- **R** is the gas constant 0.08314510 bar L K^{-1} mol^{-1}
- **T_k** is the air temperature expressed in Kelvin degree
- **V** is the chamber net volume in cubic meters
- **A** is the chamber inlet net area in square meters.

The dimensions of the A.c.K. are

$$K = \frac{moles \cdot meter^{-2} \cdot day^{-1}}{ppm \cdot sec^{-1}}$$

In the table the conversion factors vs temperaure and barometric pressure for the Accumulation Chamber Type A and B are reported.

An example:

You're using the accumulation chamber B, the slope of the flux curve is 2.5 ppm/sec, the barometric pressure is 1008 mBar (HPa) and the air temperature is 22 °C.
From the table B get the value that correspond to the barometric pressure and temperature. In this case I get the value computed for 25°C and 1013 mBar : 0.696.

Then the flux is: 2.5 x 0.696= 1.74 moles per square meter per day.

Accumulation chamber A factors

Volume: $2.756*10^{-3}$ m^3
Area: $3.140*10^{-2}$ m^2

Barometric pressure mBar (Hpa)	Air temperature °C														
	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40
1033	0.382	0.374	0.367	0.360	0.354	0.347	0.341	0.335	0.330	0.324	0.319	0.313	0.308
1013	0.374	0.367	0.360	0.353	0.347	0.341	0.335	0.329	0.323	0.318	0.312	0.307	0.303
993	0.367	0.360	0.353	0.346	0.340	0.334	0.328	0.322	0.317	0.311	0.306	0.301	0.297
973	0.359	0.352	0.346	0.339	0.333	0.327	0.321	0.316	0.310	0.305	0.300	0.295	0.291
953	0.352	0.345	0.339	0.332	0.326	0.320	0.315	0.309	0.304	0.299	0.294	0.289	0.285
933	0.345	0.338	0.332	0.325	0.319	0.314	0.308	0.303	0.298	0.293	0.288	0.283	0.279
913	0.337	0.331	0.324	0.318	0.313	0.307	0.302	0.296	0.291	0.286	0.282	0.277	0.273
893	0.330	0.323	0.317	0.311	0.306	0.300	0.295	0.290	0.285	0.280	0.275	0.271	0.267
873	0.322	0.316	0.310	0.304	0.299	0.294	0.288	0.283	0.278	0.274	0.269	0.265	0.261
853	0.315	0.309	0.303	0.297	0.292	0.287	0.282	0.277	0.272	0.268	0.263	0.259	0.255
833	0.308	0.302	0.296	0.291	0.285	0.280	0.275	0.270	0.266	0.261	0.257	0.253	0.249
813	0.300	0.295	0.289	0.284	0.278	0.273	0.269	0.264	0.259	0.255	0.251	0.247	0.243
793	0.293	0.287	0.282	0.277	0.271	0.267	0.262	0.257	0.253	0.249	0.245	0.241	0.237
773	0.286	0.280	0.275	0.270	0.265	0.260	0.255	0.251	0.247	0.242	0.238	0.235	0.231
753	0.278	0.273	0.268	0.263	0.258	0.253	0.249	0.244	0.240	0.236	0.232	0.229	0.225
733	0.271	0.266	0.260	0.256	0.251	0.246	0.242	0.238	0.234	0.230	0.226	0.222	0.219
713	0.263	0.258	0.253	0.249	0.244	0.240	0.235	0.231	0.227	0.224	0.220	0.216	0.213
693	0.256	0.251	0.246	0.242	0.237	0.233	0.229	0.225	0.221	0.217	0.214	0.210	0.207
673	0.249	0.244	0.239	0.235	0.230	0.226	0.222	0.218	0.215	0.211	0.208	0.204	0.201
653	0.241	0.237	0.232	0.228	0.224	0.220	0.216	0.212	0.208	0.205	0.201	0.198	0.195
633	0.234	0.229	0.225	0.221	0.217	0.213	0.209	0.205	0.202	0.199	0.195	0.192	0.189
613	0.226	0.222	0.218	0.214	0.210	0.206	0.202	0.199	0.196	0.192	0.189	0.186	0.183
593	0.219	0.215	0.211	0.207	0.203	0.199	0.196	0.192	0.189	0.186	0.183	0.180	0.177
573	0.212	0.208	0.204	0.200	0.196	0.193	0.189	0.186	0.183	0.180	0.177	0.174	0.171
553	0.204	0.200	0.197	0.193	0.189	0.186	0.183	0.179	0.176	0.173	0.171	0.168	0.165
533	0.197	0.193	0.189	0.186	0.182	0.179	0.176	0.173	0.170	0.167	0.164	0.162	0.159
513	0.190	0.186	0.182	0.179	0.176	0.172	0.169	0.166	0.164	0.161	0.158	0.156	0.153
493	0.182	0.179	0.175	0.172	0.169	0.166	0.163	0.160	0.157	0.155	0.152	0.150	0.147

Accumulation chamber B factors

Volume: $6.186*10^{-3}$ m^3
Area: $3.140*10^{-2}$ m^2

Barometric pressure mBar (Hpa) \ Air temperature °C	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40
1033	0.835	0.819	0.804	0.789	0.774	0.760	0.747	0.734	0.721	0.709	0.698	0.686	0.675
1013	0.819	0.803	0.788	0.773	0.759	0.746	0.732	0.720	0.707	0.696	0.684	0.673	0.662
993	0.803	0.787	0.772	0.758	0.744	0.731	0.718	0.705	0.693	0.682	0.671	0.660	0.649
973	0.787	0.772	0.757	0.743	0.729	0.716	0.703	0.691	0.679	0.668	0.657	0.646	0.636
953	0.771	0.756	0.741	0.728	0.714	0.701	0.689	0.677	0.665	0.654	0.644	0.633	0.623
933	0.754	0.740	0.726	0.712	0.699	0.687	0.675	0.663	0.652	0.641	0.630	0.620	0.610
913	0.738	0.724	0.710	0.697	0.684	0.672	0.660	0.649	0.638	0.627	0.617	0.607	0.597
893	0.722	0.708	0.695	0.682	0.669	0.657	0.646	0.634	0.624	0.613	0.603	0.593	0.584
873	0.706	0.692	0.679	0.666	0.654	0.643	0.631	0.620	0.610	0.599	0.590	0.580	0.571
853	0.690	0.676	0.664	0.651	0.639	0.628	0.617	0.606	0.596	0.586	0.576	0.567	0.558
833	0.674	0.661	0.648	0.636	0.624	0.613	0.602	0.592	0.582	0.572	0.563	0.553	0.545
813	0.657	0.645	0.632	0.621	0.609	0.598	0.588	0.578	0.568	0.558	0.549	0.540	0.531
793	0.641	0.629	0.617	0.605	0.594	0.584	0.573	0.563	0.554	0.544	0.535	0.527	0.518
773	0.625	0.613	0.601	0.590	0.579	0.569	0.559	0.549	0.540	0.531	0.522	0.514	0.505
753	0.609	0.597	0.586	0.575	0.564	0.554	0.544	0.535	0.526	0.517	0.508	0.500	0.492
733	0.593	0.581	0.570	0.560	0.549	0.539	0.530	0.521	0.512	0.503	0.495	0.487	0.479
713	0.577	0.565	0.555	0.544	0.534	0.525	0.515	0.507	0.498	0.490	0.481	0.474	0.466
693	0.560	0.550	0.539	0.529	0.519	0.510	0.501	0.492	0.484	0.476	0.468	0.460	0.453
673	0.544	0.534	0.524	0.514	0.504	0.495	0.487	0.478	0.470	0.462	0.454	0.447	0.440
653	0.528	0.518	0.508	0.499	0.489	0.481	0.472	0.464	0.456	0.448	0.441	0.434	0.427
633	0.512	0.502	0.492	0.483	0.474	0.466	0.458	0.450	0.442	0.435	0.427	0.421	0.414
613	0.496	0.486	0.477	0.468	0.459	0.451	0.443	0.435	0.428	0.421	0.414	0.407	0.401
593	0.480	0.470	0.461	0.453	0.444	0.436	0.429	0.421	0.414	0.407	0.400	0.394	0.388
573	0.463	0.454	0.446	0.437	0.429	0.422	0.414	0.407	0.400	0.393	0.387	0.381	0.375
553	0.447	0.439	0.430	0.422	0.414	0.407	0.400	0.393	0.386	0.380	0.373	0.367	0.362
533	0.431	0.423	0.415	0.407	0.399	0.392	0.385	0.379	0.372	0.366	0.360	0.354	0.348
513	0.415	0.407	0.399	0.392	0.384	0.378	0.371	0.364	0.358	0.352	0.346	0.341	0.335
493	0.399	0.391	0.384	0.376	0.369	0.363	0.356	0.350	0.344	0.338	0.333	0.328	0.322

Accumulation chamber C factors

Volume: $6.878*10^{-3}$ m^3
Area: $7.116*10^{-2}$ m^2

Barometric pressure mBar (Hpa)	Air temperature °C														
	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40
1033	0,410	0,402	0,394	0,387	0,380	0,373	0,366	0,360	0,354	0,348	0,342	0,337	0,331
1013	0,402	0,394	0,387	0,379	0,372	0,366	0,359	0,353	0,347	0,341	0,336	0,330	0,325
993	0,394	0,386	0,379	0,372	0,365	0,359	0,352	0,346	0,340	0,335	0,329	0,324	0,319
973	0,386	0,379	0,371	0,364	0,358	0,351	0,345	0,339	0,333	0,328	0,322	0,317	0,312
953	0,378	0,371	0,364	0,357	0,350	0,344	0,338	0,332	0,327	0,321	0,316	0,311	0,306
933	0,370	0,363	0,356	0,349	0,343	0,337	0,331	0,325	0,320	0,314	0,309	0,304	0,299
913	0,362	0,355	0,348	0,342	0,336	0,330	0,324	0,318	0,313	0,308	0,303	0,298	0,293
893	0,354	0,347	0,341	0,334	0,328	0,322	0,317	0,311	0,306	0,301	0,296	0,291	0,286
873	0,346	0,340	0,333	0,327	0,321	0,315	0,310	0,304	0,299	0,294	0,289	0,285	0,280
853	0,338	0,332	0,326	0,320	0,314	0,308	0,303	0,297	0,292	0,287	0,283	0,278	0,274
833	0,331	0,324	0,318	0,312	0,306	0,301	0,295	0,290	0,285	0,281	0,276	0,272	0,267
813	0,323	0,316	0,310	0,305	0,299	0,294	0,288	0,283	0,279	0,274	0,269	0,265	0,261
793	0,315	0,309	0,303	0,297	0,292	0,286	0,281	0,276	0,272	0,267	0,263	0,258	0,254
773	0,307	0,301	0,295	0,290	0,284	0,279	0,274	0,269	0,265	0,260	0,256	0,252	0,248
753	0,299	0,293	0,287	0,282	0,277	0,272	0,267	0,262	0,258	0,254	0,249	0,245	0,242
733	0,291	0,285	0,280	0,275	0,270	0,265	0,260	0,256	0,251	0,247	0,243	0,239	0,235
713	0,283	0,277	0,272	0,267	0,262	0,257	0,253	0,249	0,244	0,240	0,236	0,232	0,229
693	0,275	0,270	0,265	0,260	0,255	0,250	0,246	0,242	0,237	0,233	0,230	0,226	0,222
673	0,267	0,262	0,257	0,252	0,247	0,243	0,239	0,235	0,231	0,227	0,223	0,219	0,216
653	0,259	0,254	0,249	0,245	0,240	0,236	0,232	0,228	0,224	0,220	0,216	0,213	0,209
633	0,251	0,246	0,242	0,237	0,233	0,229	0,225	0,221	0,217	0,213	0,210	0,206	0,203
613	0,243	0,239	0,234	0,230	0,225	0,221	0,217	0,214	0,210	0,207	0,203	0,200	0,197
593	0,235	0,231	0,226	0,222	0,218	0,214	0,210	0,207	0,203	0,200	0,196	0,193	0,190
573	0,227	0,223	0,219	0,215	0,211	0,207	0,203	0,200	0,196	0,193	0,190	0,187	0,184
553	0,219	0,215	0,211	0,207	0,203	0,200	0,196	0,193	0,189	0,186	0,183	0,180	0,177
533	0,211	0,207	0,203	0,200	0,196	0,192	0,189	0,186	0,183	0,180	0,177	0,174	0,171
513	0,204	0,200	0,196	0,192	0,189	0,185	0,182	0,179	0,176	0,173	0,170	0,167	0,165
493	0,196	0,192	0,188	0,185	0,181	0,178	0,175	0,172	0,169	0,166	0,163	0,161	0,158

Accumulation chamber C-floating factors

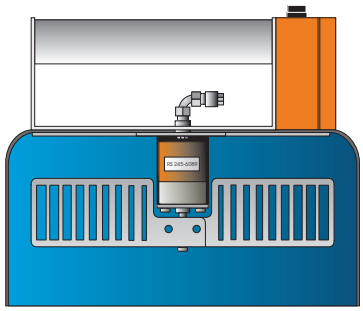
Volume: 11.231*10^{-3} m^3
Area: 6.697*10^{-2} m^2

Barometric pressure mBar (Hpa) \ Air temperature °C	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40
1033	0,711	0,697	0,684	0,671	0,659	0,647	0,636	0,625	0,614	0,604	0,594	0,584	0,575
1013	0,697	0,684	0,671	0,658	0,646	0,635	0,623	0,613	0,602	0,592	0,582	0,573	0,564
993	0,684	0,670	0,658	0,645	0,632	0,622	0,611	0,601	0,590	0,580	0,571	0,562	0,553
973	0,670	0,657	0,644	0,632	0,621	0,610	0,599	0,588	0,578	0,569	0,559	0,550	0,541
953	0,656	0,643	0,631	0,619	0,608	0,597	0,587	0,576	0,567	0,557	0,548	0,539	0,530
933	0,642	0,630	0,618	0,606	0,595	0,585	0,574	0,564	0,555	0,545	0,536	0,528	0,519
913	0,629	0,616	0,605	0,593	0,582	0,572	0,562	0,552	0,543	0,534	0,525	0,516	0,508
893	0,615	0,603	0,591	0,580	0,570	0,559	0,550	0,540	0,531	0,522	0,513	0,505	0,497
873	0,601	0,589	0,578	0,567	0,557	0,547	0,537	0,528	0,519	0,510	0,502	0,494	0,486
853	0,587	0,576	0,565	0,554	0,544	0,534	0,525	0,516	0,507	0,499	0,490	0,482	0,475
833	0,573	0,562	0,552	0,541	0,531	0,522	0,513	0,504	0,495	0,487	0,479	0,471	0,464
813	0,560	0,549	0,538	0,528	0,519	0,509	0,500	0,492	0,483	0,475	0,467	0,460	0,452
793	0,546	0,535	0,525	0,515	0,506	0,497	0,488	0,480	0,471	0,464	0,456	0,448	0,441
773	0,532	0,522	0,512	0,502	0,493	0,484	0,476	0,467	0,460	0,452	0,444	0,437	0,430
753	0,518	0,508	0,499	0,489	0,480	0,472	0,463	0,455	0,448	0,440	0,433	0,426	0,419
733	0,505	0,495	0,485	0,476	0,468	0,459	0,451	0,443	0,436	0,428	0,421	0,415	0,408
713	0,491	0,481	0,472	0,463	0,455	0,447	0,439	0,431	0,424	0,417	0,410	0,403	0,397
693	0,477	0,468	0,459	0,450	0,442	0,434	0,427	0,419	0,412	0,405	0,398	0,392	0,386
673	0,463	0,454	0,446	0,437	0,429	0,422	0,414	0,407	0,400	0,393	0,387	0,381	0,375
653	0,450	0,441	0,432	0,424	0,417	0,409	0,402	0,395	0,388	0,382	0,375	0,369	0,363
633	0,436	0,427	0,419	0,411	0,404	0,397	0,390	0,383	0,376	0,370	0,364	0,358	0,352
613	0,422	0,414	0,406	0,398	0,391	0,384	0,377	0,371	0,364	0,358	0,352	0,347	0,341
593	0,408	0,400	0,393	0,385	0,378	0,372	0,365	0,359	0,353	0,347	0,341	0,335	0,330
573	0,394	0,387	0,379	0,372	0,366	0,359	0,353	0,347	0,341	0,335	0,329	0,324	0,319
553	0,381	0,373	0,366	0,359	0,353	0,346	0,340	0,334	0,329	0,323	0,318	0,313	0,308
533	0,367	0,360	0,353	0,346	0,340	0,334	0,328	0,322	0,317	0,312	0,306	0,301	0,297
513	0,353	0,346	0,340	0,333	0,327	0,321	0,316	0,310	0,305	0,300	0,295	0,290	0,285
493	0,339	0,333	0,326	0,320	0,315	0,309	0,303	0,298	0,293	0,288	0,283	0,279	0,274

Components

Depending on your instrument configuration some of the listed parts may not be provided, please refer to page 1.1 of this handobook to know which components included with your instrument.

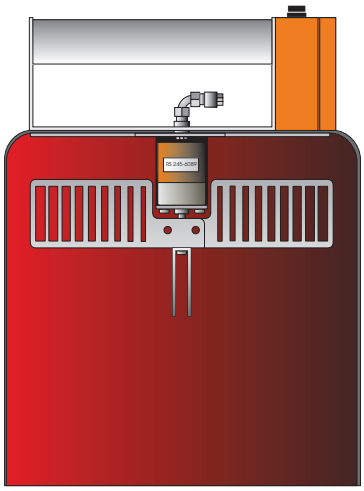
The accumulation chambers



Type A

Internal diameter: 0.2 m (200 mm)
Internal height: 0.097 m (97 mm)
Internal volume chamber: $2.797*10^{-3}$ m^3
Dead volumes (electric engine, filters and detector cell): $4.095*10^{-5}$ m^3

Net volume: $2.756*10^{-3}$ m^3
Base area: $3.140*10^{-2}$ m^2
Mass: 1.650 Kg (with alkaline battery)

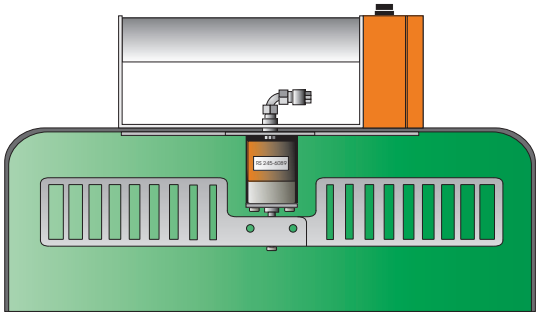


Type B

Internal diameter: 0.2 m (200 mm)
Internal height: 0.198 m (198 mm)
Internal volume chamber: $6.231*10^{-3}$ m^3
Dead volumes (electric engine, filters and detector cell): $4.498*10^{-5}$ m^3

Net volume: $6.186*10^{-3}$ m^3
Base area: $3.140*10^{-2}$ m^2
Mass: 2.150 Kg (with alkaline battery)

With Accumulation Chamber Type B you can measure flux higher than 10000 grams/m^2 x day with more accuracy.

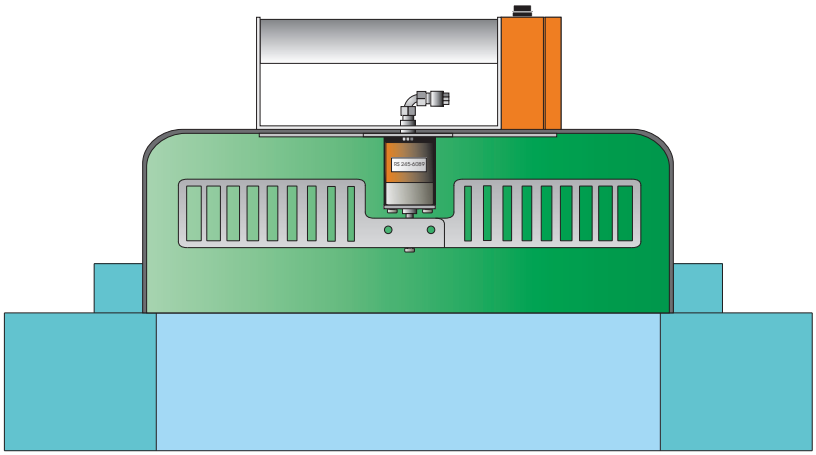


Type C

Internal diameter: 0.3 m (300 mm)
Internal height: 0.97 m (97 mm)
Internal volume chamber: $6.925*10^{-3}$ m^3
Dead volumes (electric engine, filters and detector cell): $4.647*10^{-5}$ m^3

Net volume: $6.878*10^{-3}$ m^3
Base area: $7.116*10^{-2}$ m^2
Mass: 1.900 Kg (with alkaline battery)

The accumulation chambers



Type C-floating

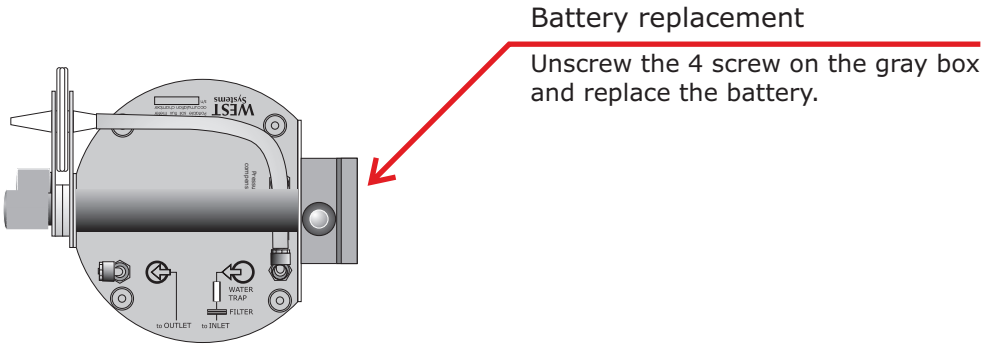
Internal diameter: 0.3 m (300 mm)
Internal height: 0.97 m (97 mm)
Internal volume chamber-floating: $11.277*10^{-3}$ m^3
Dead volumes (electric engine, filters and detector cell): $4.647*10^{-5}$ m^3

Net volume: $11.231*10^{-3}$ m^3
Base area: $6.697*10^{-2}$ m^2
Mass: 2.000 Kg (with alkaline battery)

With accumulation chambers type C-floating you can measure flux over lakes or other water sources.

Mixing device

The mixing device is supplied by a 9 volts battery.

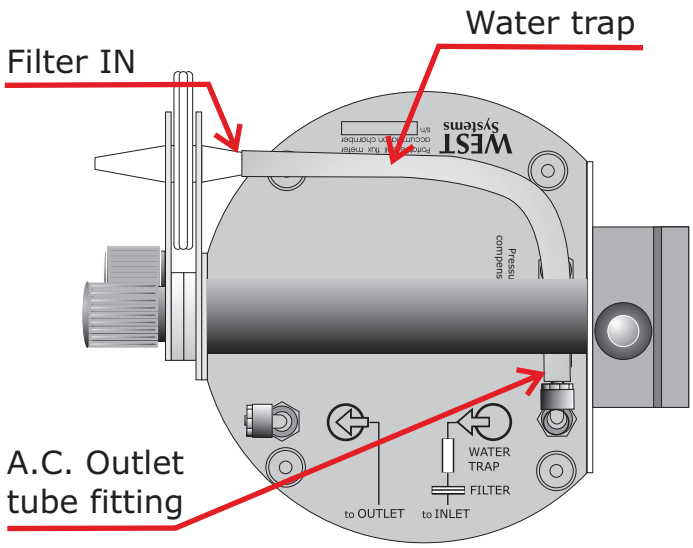


Accumulation chamber electrical specifications

Motor : RS245-6089
Mixing device speed : 80 RPM (rotations per minute)

Battery: 9 Volts MN1604 6L61 Duracell or equivalent
Battery expected life 48 hours

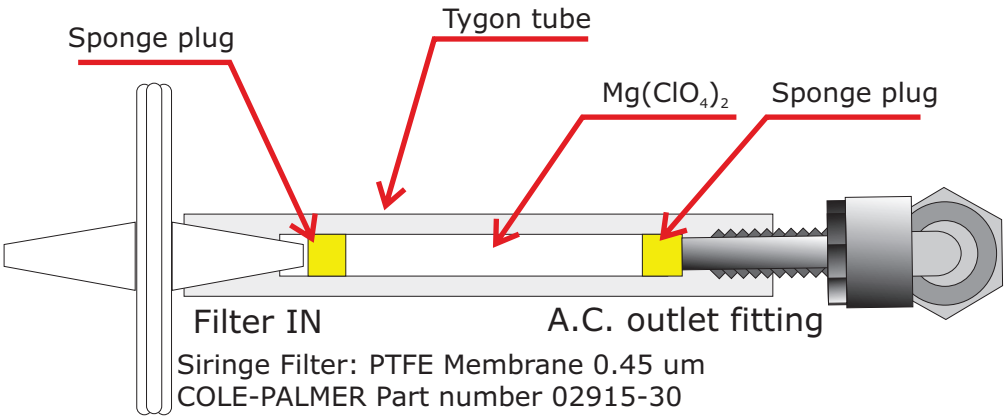
The accumulation chambers



A magnesium perchlorate dessicant trap can be integrated on the accumulation chamber between the outlet fitting of accumulation chamber and the Inlet of the PTFE Filter: It could be used when you're working in a very wet environment to avoid condensation inside the instrument.
Do not use magnesium perchlorate if there is an high methane concentration. Magnesium perchlorate can trigger fire or explosion when in contact with combustible gases.

The trap volume is intentionally very small in order to not add more dead volume in the sampling line.

If you're using it please check the status of the water trap frequently and replace it when necessary.



Siringe Filter: PTFE Membrane 0.45 um
COLE-PALMER Part number 02915-30

DANGER!
Pay attention while handling magnesium perchlorate.
It causes irritation, and contact with combustible materials or powered metals can cause fire or explosion.

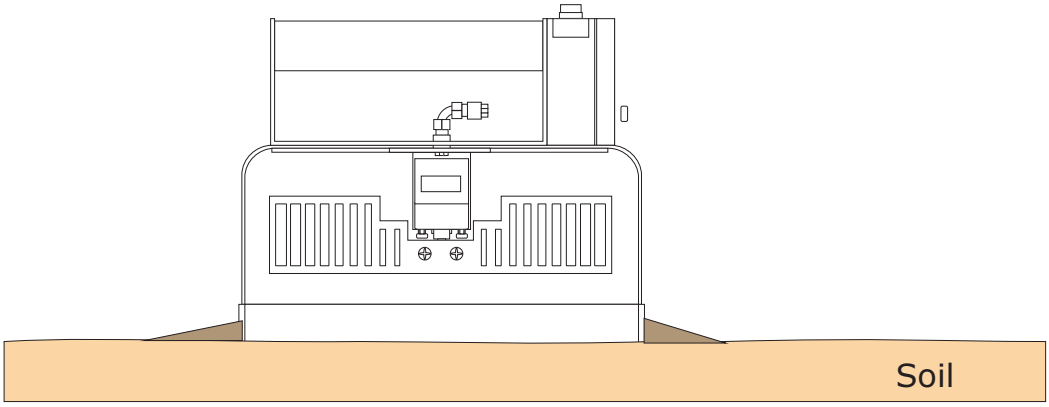
WEST Systems do not provide magnesium perchlorate because its shipping is not allowed by Air Carriers.
The 'Baker Analyzed' company markets magnesium perchlorate with under the "ANYDRHONE" brand.

The accumulation chambers

The instrument is supplied with two accumulation chambers. The type A (Height 100 mm) is useful to increase the sensivity of the instrument to very low fluxes by a factor 2. Under normal use we advise using the type B (Height 200 mm) that can cover a very large range of soil flux with a good sensitivity and linearity.

The accumulation chamber is the main part of your instrument.
The interfacing of the chamber with soil must be performed with great attention.

Once the chamber is placed on soil in the measuring site it has to be verified that the rim is placed correctly on soil in order to avoid atmospheric air to enter the chamber.



If necessary seal the external rim of the chamber with the soil, as in the figure above, carefully putting some earth around the rim.

The measuring site should be disturbed as litlle as possible. J.D.Rogie et al. have demonstrated that if soil is disturbed, for example levelling the ground or digging a hole in order to place the chamber, the flux condition varies in an unpredictable way and takes a long time to stabilize again

On the contrary measures performed on the same site, trying to disturb the soil as little as possible, shows a very good precision and repeatibility.

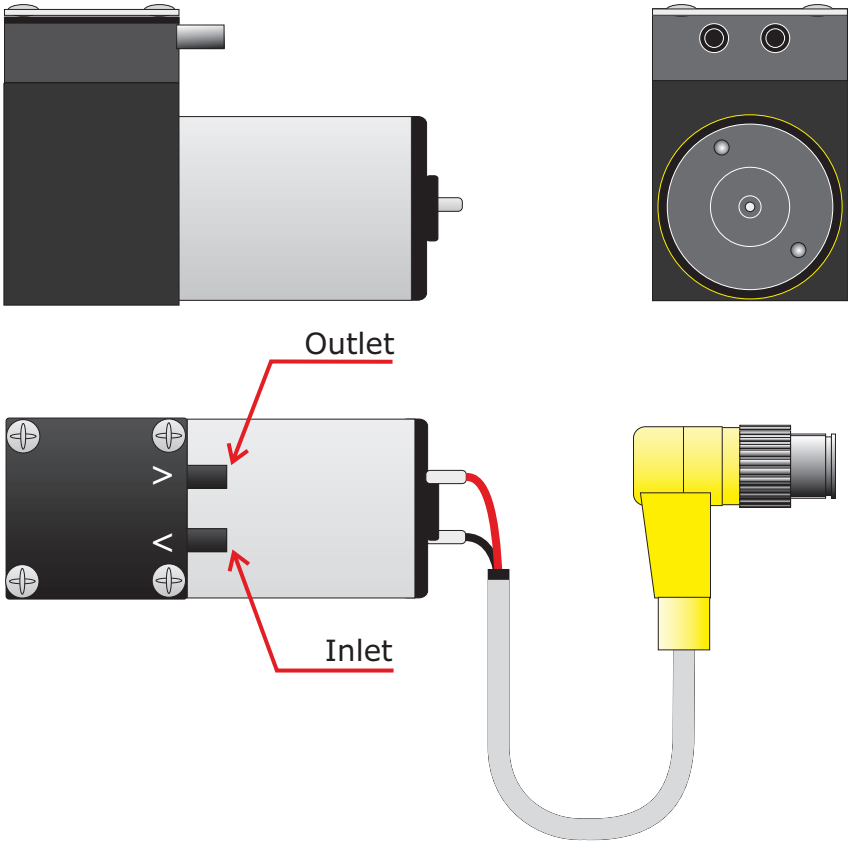
If you plan on sampling underground gas, first perform the flux measurement and then the sampling.

The instrument has good resistance against sulfur gases, but in the case of high concentration of hydrogen sulphide it is better to use a trap in the gas line.
Hydrogen sulphide is very aggressive and therefore we advise reducing to a minimum the instrument (especially the palmtop) and operator exposure to corrosive gases.

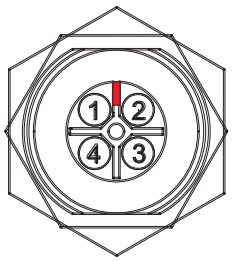
Working in high gas emission areas take care of your safety: Do not work alone and use a gas mask or take adequate precautions.

The pump

Pump drawing



PUMP POWER SUPPLY female panel connector



PIN 1 : 12.0 Volt to positive pole of Pump
PIN 4 : Ground to negative pole of Pump

Pump specifications

Rated flow: 1000 SCCM (Standard cubic centimeter per minute)
Power supply 150 mA @ 12 Volts

Manufacturer #1 ASF THOMAS, Germany
ANR 50020972

Manufacturer #2 KNF, Germany
NMP 02067694

Pneumatic fittings diameter : 4 mm

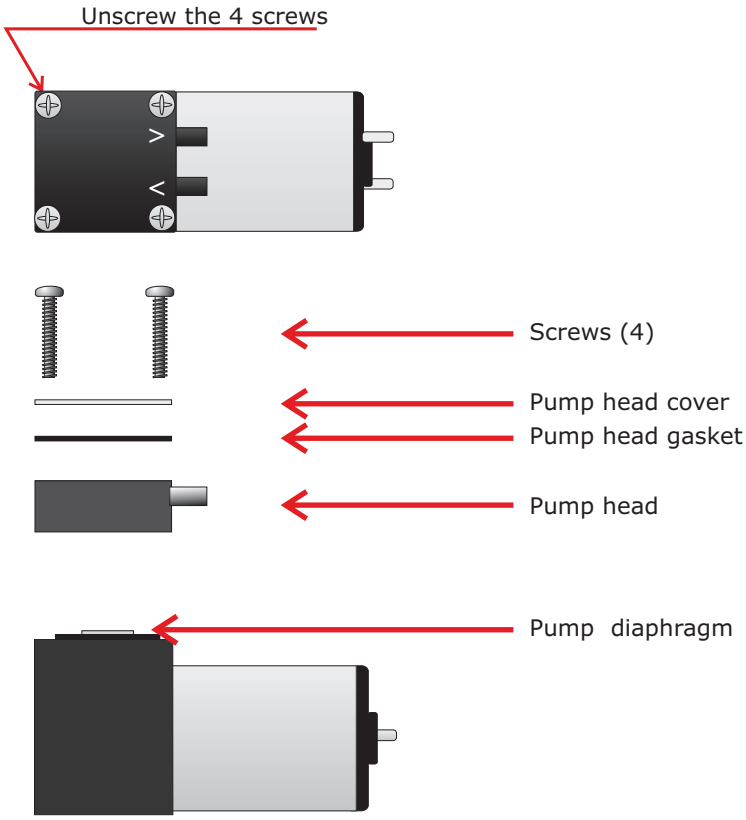
In order to avoid unwanted variation of pumping flow due to power supply the pump is supplied with a stabilized voltage reglulator.

The pump

Pump maintenance

The pump efficiency can be affected by deposits of dust or water. When necessary it's possible to clean the pump:

- Disassemble the pumping head.
- Clean the diaphragm, the washer, and the valves using a compressed air flow.
- Reassemble the head.

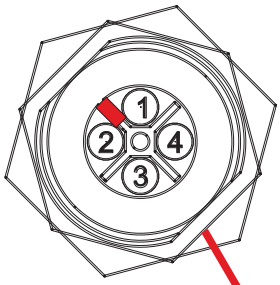


The battery

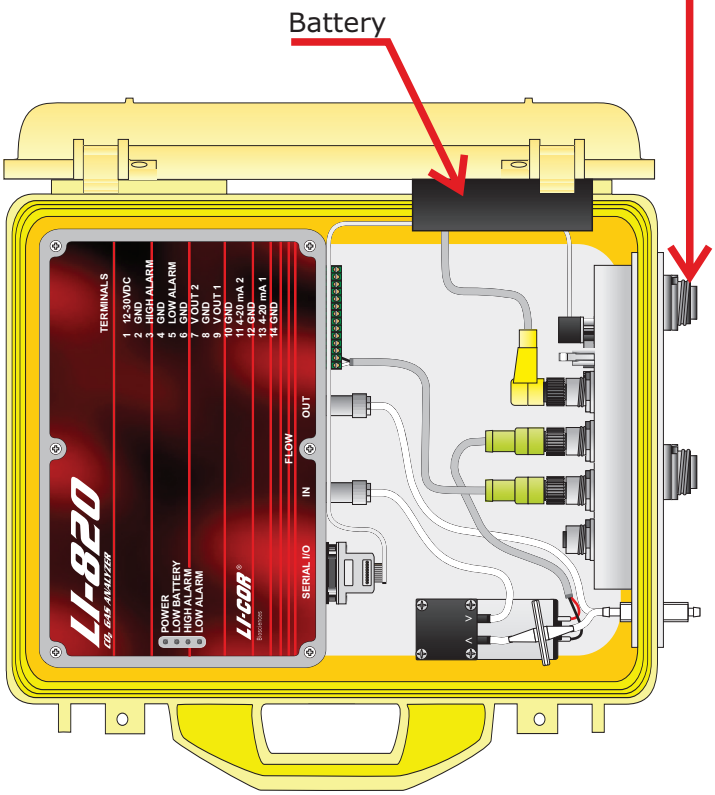
Battery specifications
Type : WS14-4 Ni-MH Sealed maintenance-free
Nominal voltage 14.4 Volts
Nominal capacity 4.0 A/h
Nominal battery duration 4 hours
CAUTION
avoid short circuit
do not charge in a sealed container
Charging instruction:
Charge the batteries after every use.

Battery mechanical specifications:
Size: 110 x 90 x 55 mm
Mass: 1100 grams

Connectors: male panel 4 pin: Battery inlet



Pin1 : +14.4 Volts
Pin2: +14.4 Volts
Pin3: Battery Temp-Sensor
Pin4: Ground



The battery

Battery charger

Model GENIUS 1000/12

Input 100-250 VAC , 50/60 Hz

OutPut 1,1 A : Charging time ~ 4 hours

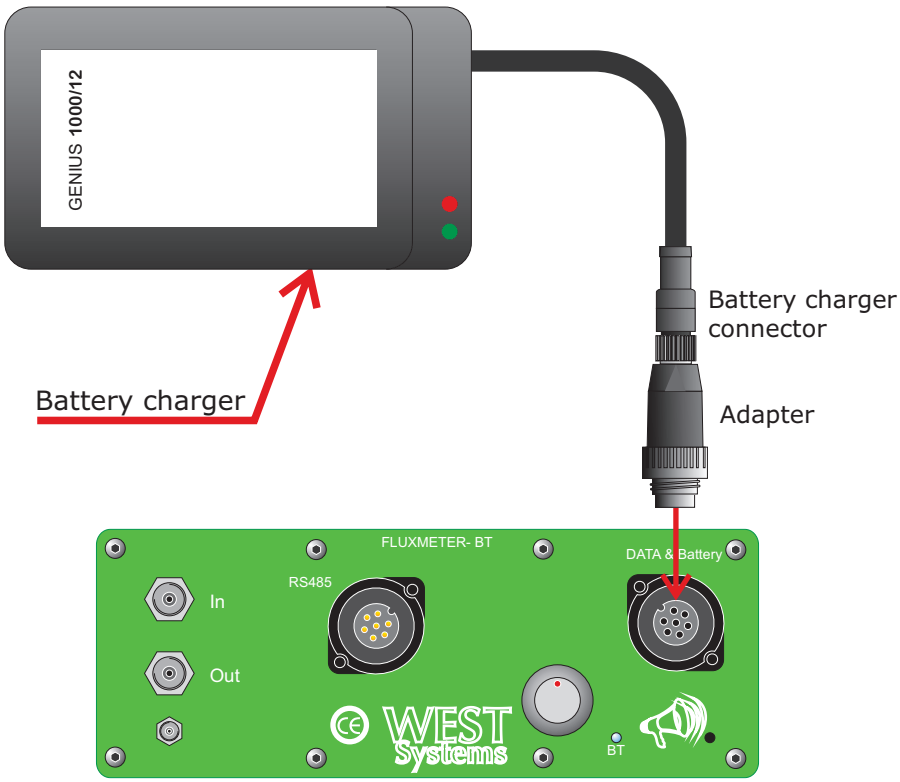
GREEN LED light: Power ON.

YELLOW/RED LED:
YELLOW light on: Charging the battery.
YELLOW light off: Battery charged.
RED light: Replace battery.

To recharge the spare battery connect the battery charger to the battery and wait that the yellow led light switch off.

The recharge the battery inside the instrument connect the battery-charger to the adapter and connect it to the "Data and battery" connector on the green panel of the instrument.

ATTENTION: Please do not turn on when the instrument is charging with the adapter.

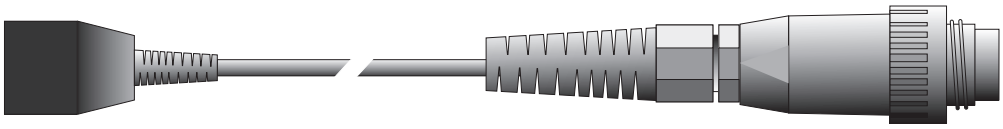


Cables

Palmtop charger cable

USB type A Female connector

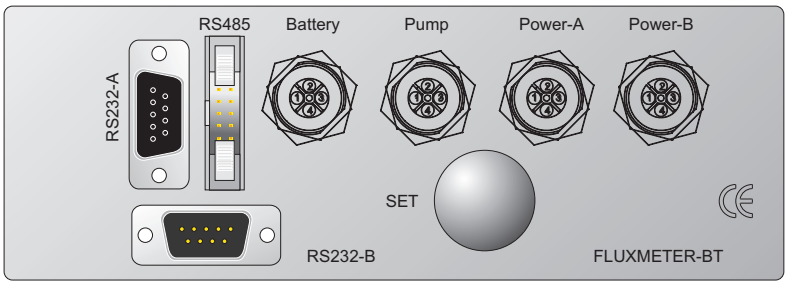
Amphenol 6+T Female connector



The cable have to be connected to the RS485 port of the external connection panel.

The cable have a power supply of 5 Vdc , 500 mA.

CS-D0023_01 Board panel



SENSORS POWER SUPPLY female panel connector
POWER-A POWER-B connectors

PIN 2 : 14.4 Volt - to PIN 1 of Detectors Terminals
PIN 4 : Ground - to PIN 2 Detectors LI800 Terminals

PUMP POWER SUPPLY female panel connector

PIN 1 : 12.0 Volt to positive pole of Pump
PIN 4 : Ground to negative pole of Pump

BATTERY IN male panel connector

PIN 1 : 14.4 Volt to battery
PIN 3 : Battery Temp. Sensor
PIN 4 : Ground

RS232-A female panel connector: LICOR LI820/840 port
Connect here the Licor LI820/840 using a pin-to-pin male/female cable

RS232-B male panel connector: External BT
Connect here an optional emergency Bluetooth device,
to be used in case of fault of the internal BT.

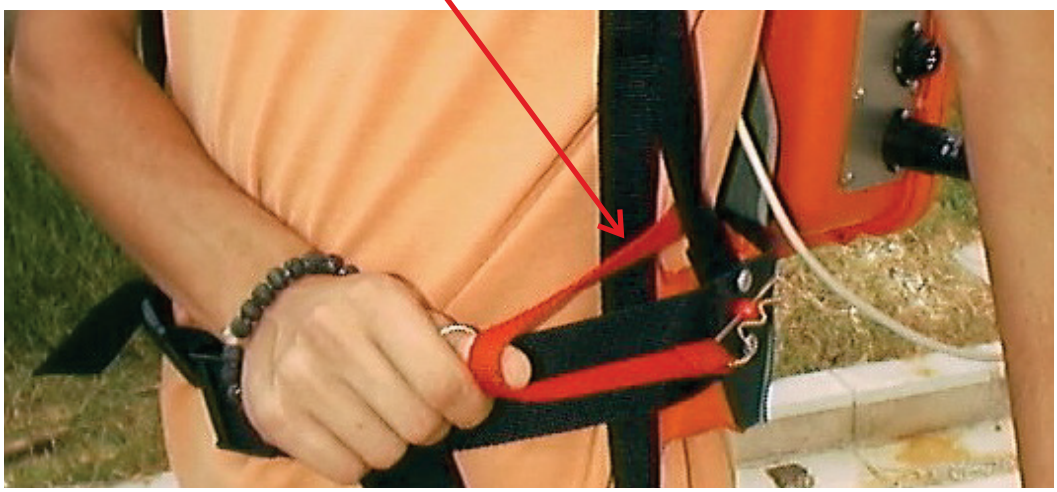
RS485 male IDC panel connector:

DB9 PIN	IDC PIN	Function
1	1	GND
2	3	14.4V
3	5	GND
4	7	RS485 B
5	9	RS485 A
6	2	GND
7	4	14.4 V
8	6	GND
9	8	RS485 B

The backpack

Backpack assembly.
Assemble the Fluxmeter on the backback using the screw on the internal side of backpack

Safety hints
If you need to free your self from the backpack and the instrument pull the red belt.



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Calibration of the flux meter

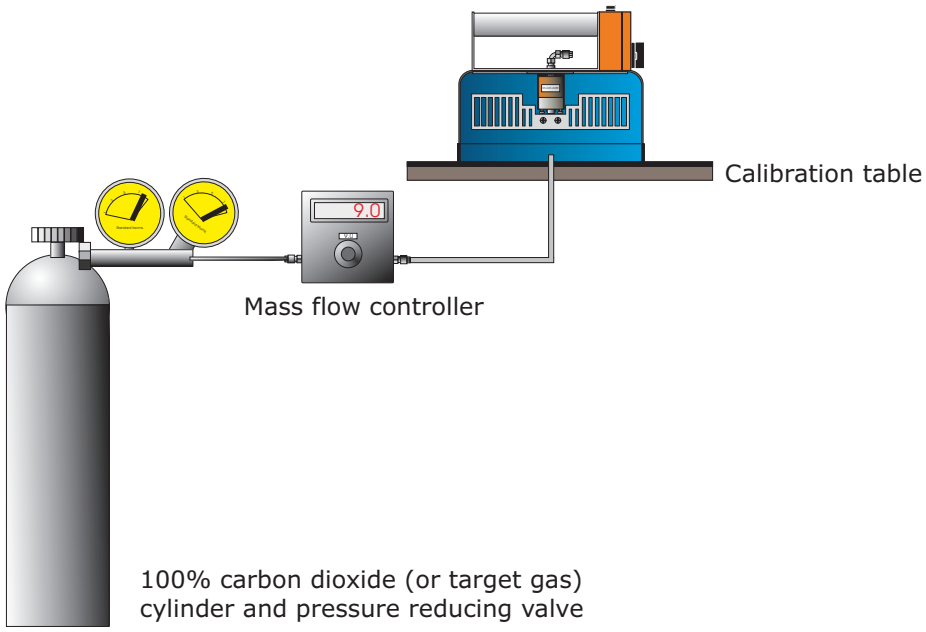
Fluxmeter calibration

Here is reported the procedure followed by WEST Systems to check the fluxmeter calibration.

How to verify the fluxmeter calibration

The calibration described refers to carbon dioxide calibration, for other gases, like methane or hydrogen sulphide, the same procedure has been followed.

Sketch of calibration device



CO_2 fluxes from soil are simulated by injecting a known flow of gas into the accumulation chamber. The interface between the accumulation chamber and the calibration table is built to minimize the gas leakage.

The apparatus is schematized in figure 1.

For flux between 0.5 and 300 moles/(m^2day) the injected flux is controlled and measured with a precision mass flow controller. This MFC, calibrated for CO_2, is electronically stabilized (Accuracy 1%).

Calibration of the flux meter

Fluxmeter calibration

For fluxes between 300 moles/(m^2day) and 700 moles/ (m^2day) the injected flux is controlled by means of a mechanical flow reducer and measured using a bubble flowmeter (Accuracy 3%) before and after the flux measurement with the accumulation chamber.

Two series of measure were performed for flux of 300 moles/(m^2day) to evaluate the coherence between the two different methods of flow measurement.

A thermometer and barometer were utilized to measure the barometric pressure and the air temperature during the experiment in order to select the correct accumulation chamber conversion factor.
A flow meter is utilized to measure the pumping flow during the experiment.
During all the measures a 100% CO_2 flow was utilized.
The same procudure was utilized to check the instrumental response to methane / Hydrogen Sulfide.

Calibration of the flux meter

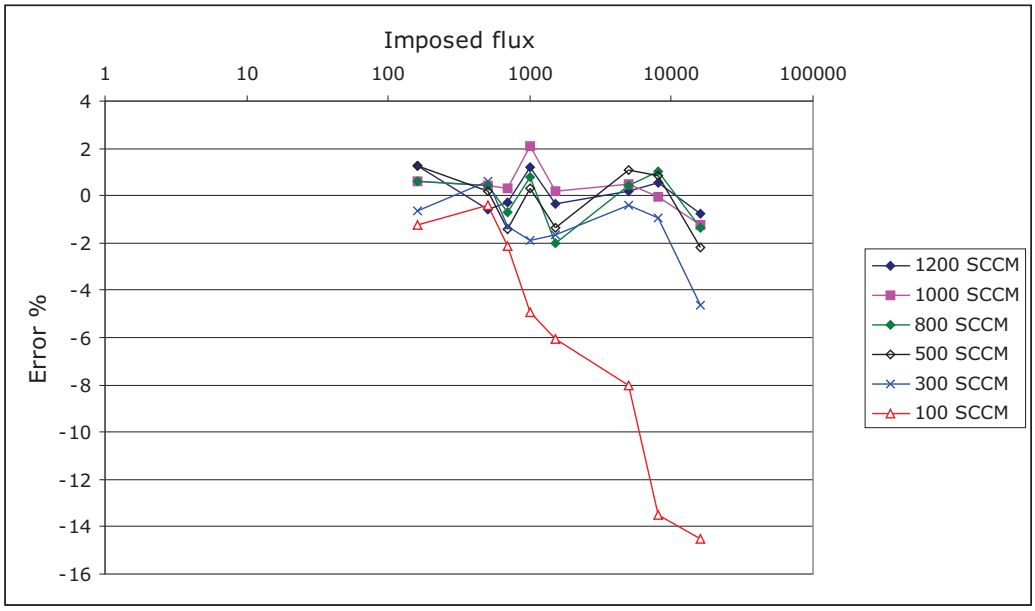
The influence of pumping flow

Influence of pumping efficiency on the flux measurement results:

We have carried out some sets of measures utilizing the same injected flux but with different pumping flow from the accumulation chamber to the detector.

The pumping flow was changed by means of a mechanical flow reducer and measured with a Microbridge Mass Airflow sensor (Accuracy 2%).

We have not noted a significant variation of the measures except when the pumping flow is less than 200 SCCM.



In the diagram the plot of the measurement error versus the imposed flux of carbon dioxide (expressed in grams per square meter per day) at different pumping flow rates is shown.

In order to avoid unwanted variation of pumping flow due to power supply the pump is supplied at 12 V DC with a stabilized voltage regulator.

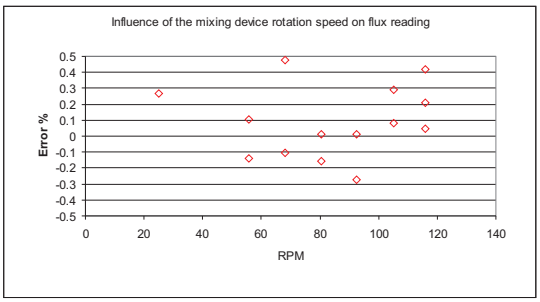
The pumping flow , after the power supply stabilization, is 1000 SCCM ± 20%. The efficiency of pump can vary due to dust or moisture in the pump body. Periodic maintenance is necessary.

Calibration of the flux meter

The influence of mixing device

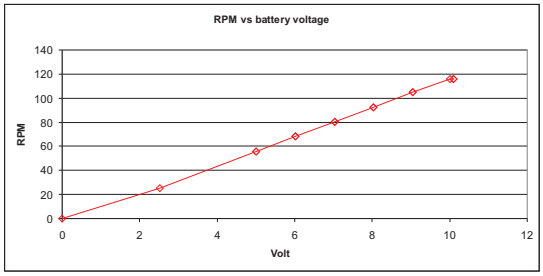
The mixing device was suspected, by some researcher, to affect the accuracy of the flux measurement.
In our experience the precision of the measurements was noteably reduced without a mixing device present.
In the two plots below the measurements at various regimes of mixing device rotation are reported.

Influence of the mixing device rotation speed



In the plot the measured flux vs the mixing device rotation speed.

Battery status vs RPM.



In the plot the mixing device RPM (Rotation per minute) vs power supply voltage. The normal range for the battery voltage is between 9.6 V (new battery) and 6 Volt (discharged battery)

Pneumatic connections

The tubes

Four types of tube are used to realize the gas sampling line:

- RILSAN tube 6 mm external diameter 4 mm internal diameter;
- SILICON tube 8 mm external diameter 3.3 mm internal diameter;
- SILICON 12.5 mm external diameter 4.3 mm internal diameter;
- Tygon 13.5 mm external diameter 8 mm internal diameter.

The filters

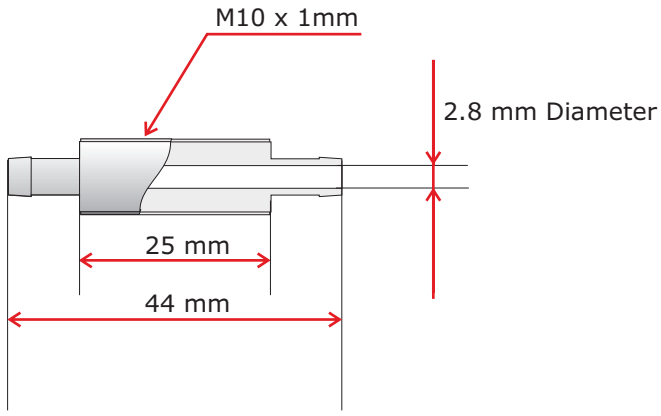
Two types of filters are used to protect the gas sampling line:

- 25 mm diameter 0.22μm PTFE membrane Cole-Palmer 2915-20 or equivalent;
- 50 mm diameter 0.45μm PTFE membrane Cole-Palmer 2915-30 or equivalent.

The PTFE membrane filters are permeable to gases and water vapour and are impermeable to liquid water and dust particles. The use of the filters protects the gas detectors and the other pneumatic parts. Please check the status of the filters very often.

The fittings

WEST Systems Tube fitting for RILSAN 6x4 and Silicon tubes

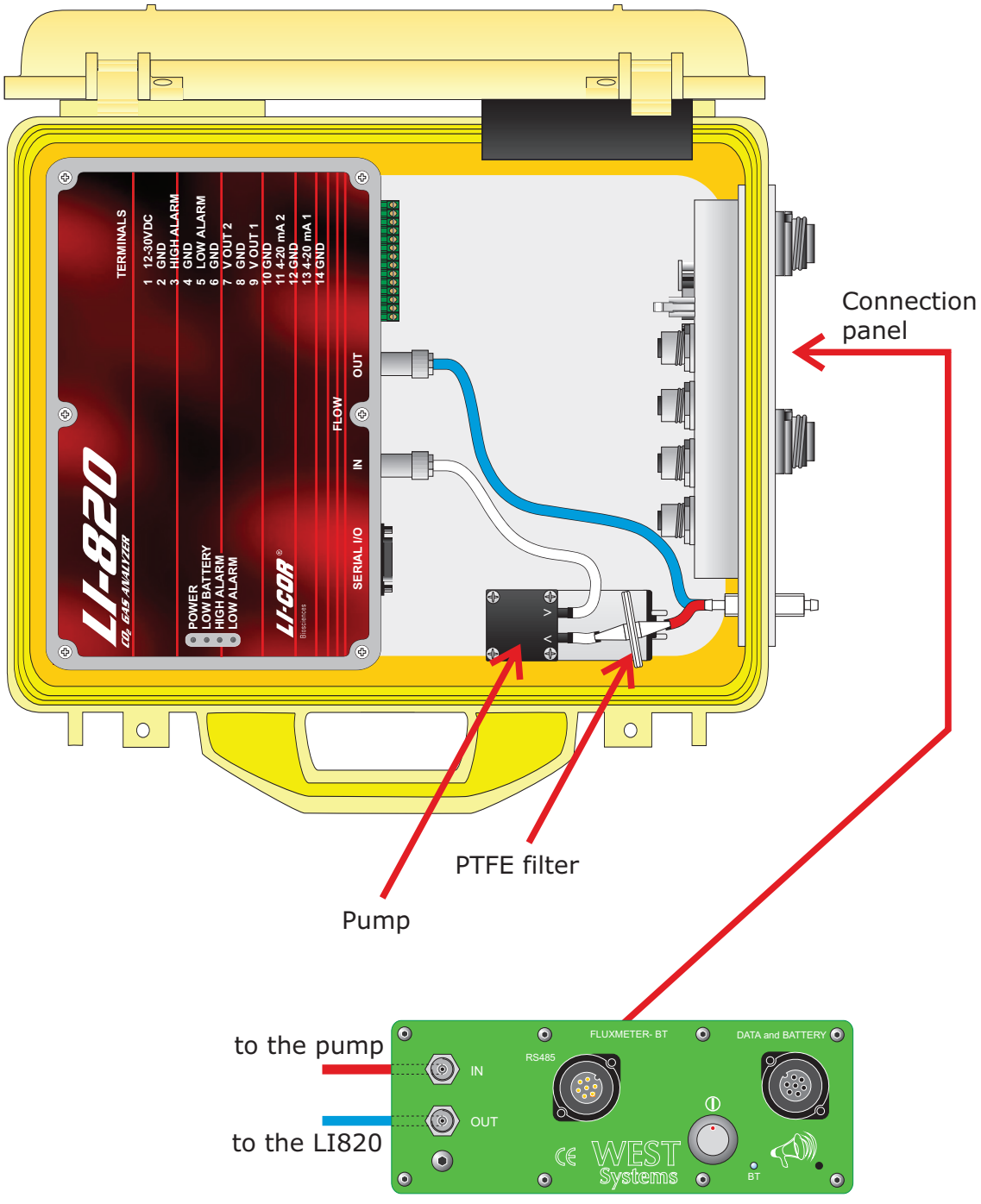


Material : Chromed brass

The gas sampling line is assembled with 1/8" gas cylindrical or conical thread fittings. The sealing is guaranteed by (r) Loctite 542 dope.

Pneumatic connections

Inside the fluxmeter

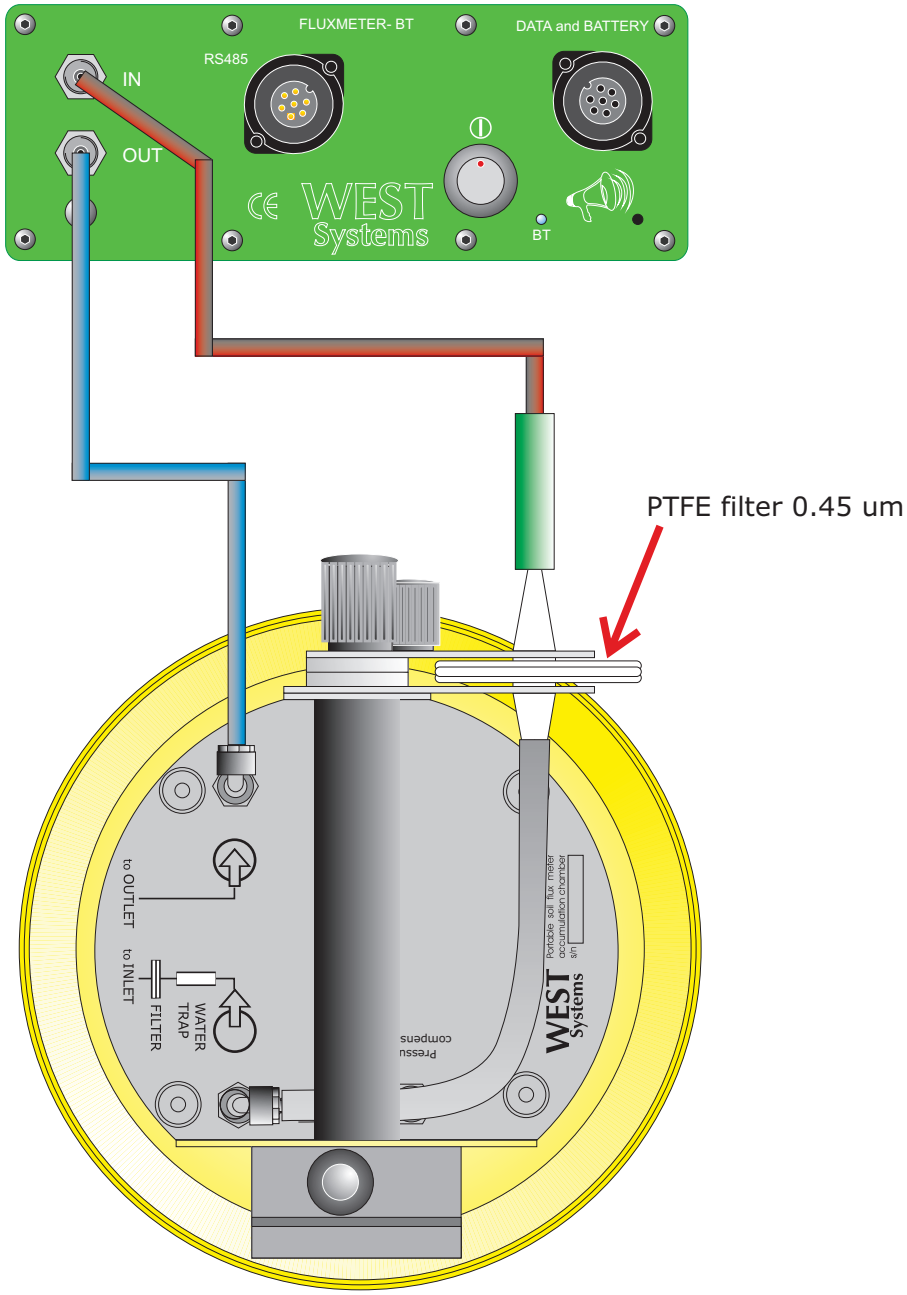


Tubing legend

- C-Flex or silicon tube 6 mm external diameter 3.3 mm internal diameter;

Pneumatic connections

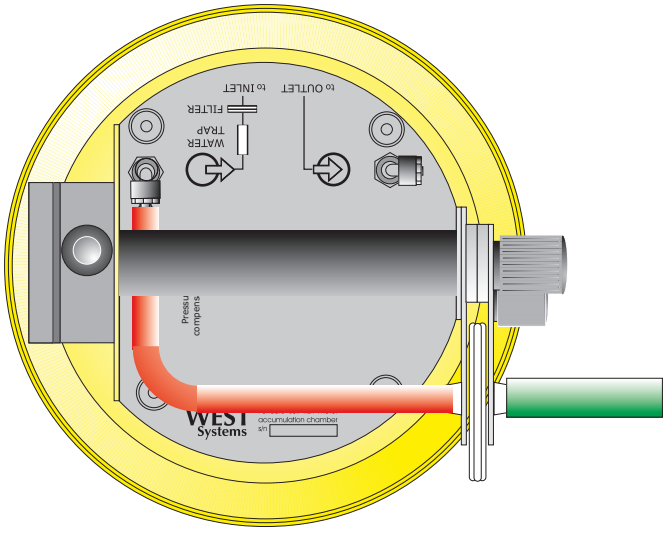
Accumulation chamber connections



Tubing legend

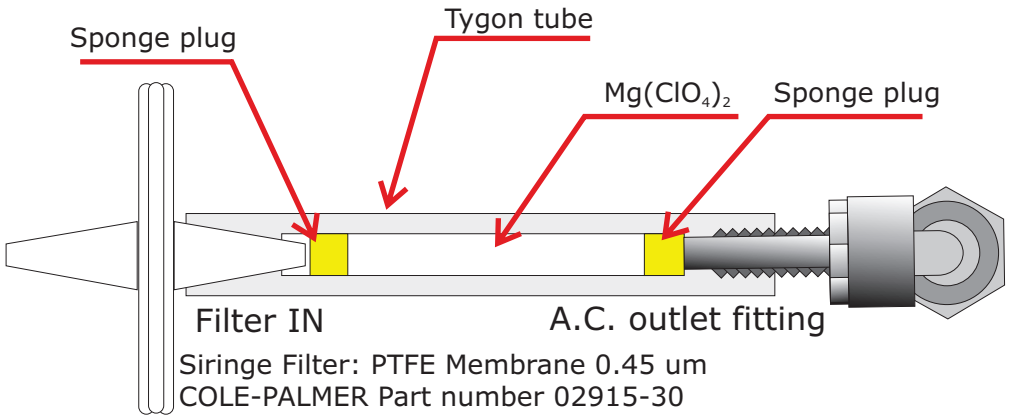
- RILSAN tube 6 mm external diameter 4 mm internal diameter BLUE color;
- RILSAN tube 6 mm external diameter 4 mm internal diameter RED color;
- SILICON 12.5 mm external diameter 4.3 mm internal diameter;

Pneumatic connections



Tubing legend

- Tygon 13.5 mm external diameter 8 mm internal diameter;
- SILICON 12.5 mm external diameter 4.3 mm internal diameter;



Siringe Filter: PTFE Membrane 0.45 um
COLE-PALMER Part number 02915-30

! For the usage of water trap see the warning of page 5.3.

Troubleshooting

In most cases the problems are related to the battery charge status and to the serial data communications between palmtop and instrument.

The palmtop and its serial cable are the most fragile components of your instrument.

A) Power supply related problems

The FluxMeter does not turn On:
The LED light on the On/Off button do not become green:

- The battery pack is plugged to the instrument?
- The battery pack is charged?

Hints

- A charged battery's voltage must be more than 14.4 Volts.
- NiMH batteries can be recharged in any charge status. They do not have "memory effect".
- The LED light on the power button is flashing green/red: This means that the battery charge status is LOW.

B) Basic communication problems

Message: Connection failed / not connected
Fluxmanager cannot communicate with the instrument:

- The selected communication port is not the correct one;
- The bluetooth of the palmtop is OFF;
- The instrument is OFF;
- The distance between the instrument and the palmtop exceed the bluetooth range.

Please see Appendix P

Message: Fluxmeter not found
Fluxmanager can communicate with remote bluetooth but not with the the instrument:

- Reset the palmtop by pressing the reset button in the palmtop bottom.
- Switch off the instrument, wait 10 seconds and turn on it again.
- Restart with the connection procedure (see Appendix P).

Troubleshooting

Please report all problems that you encounter in using this device to us. This will help us to improve our instrument as well as customer support.

e-mail to: g.virgili@westsystems.com

Software FluxRevision

FluxRevision is the software that allows to quickly elaborate a large number of files created by FluxManager. Note: FluxRevision runs on Microsoft Windows operating systems; the Microsoft .NET framework is required on the machine.

There are two ways to download the FluxManager files from the PDA to a personal computer:

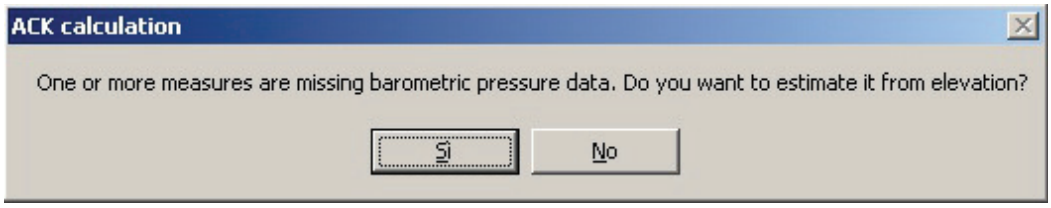
- Copy the files from the location *\My Documents\FluxManagerFiles* to the storage card (SD or MicroSD card) and plug the memory card to a PC (using a card reader).
- Install on the PC the software Microsoft Activesync (the installer is on the CD furnished with the PDA, or it can be freely downloaded from the Microsoft website). Then plug the PDA to the PC with the USB cable. The ActiveSync window will appear and will allow to navigate into the PDA directories. Go to the path *\My Documents\FluxManagerFiles* and copy the files to the PC.

Once you have the files in the PC, start the FluxRevision application. In the first instance you'll be ask to select the folder where you have the files to be examinated. The folder you select will be proposed the next time you start the software. Select the folder and press *OK*. If there are valid files, the application will start to parse the data.

To estimate the flux from the slope of the regression line, the application will need to know the following parameters (see chapter 4 for details):

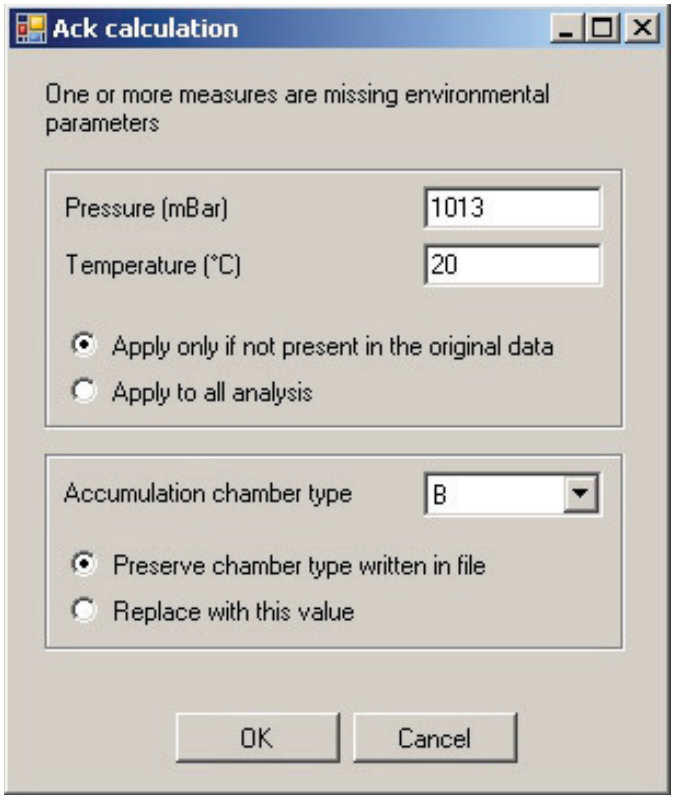
- Air temperature
- Barometric pressure
- Volume of the accumulation chamber

If the barometric pressure is missing (because you don't have a pressure probe inside the fluxmeter and you didn't manually inserted the value in the FluxManager saving window), but the fluxmeter of the PDA is equipped with a GPS antenna, FluxRevision can estimate the pressure from the elevation (of course this calculation can't be as accurate as having a sensor).

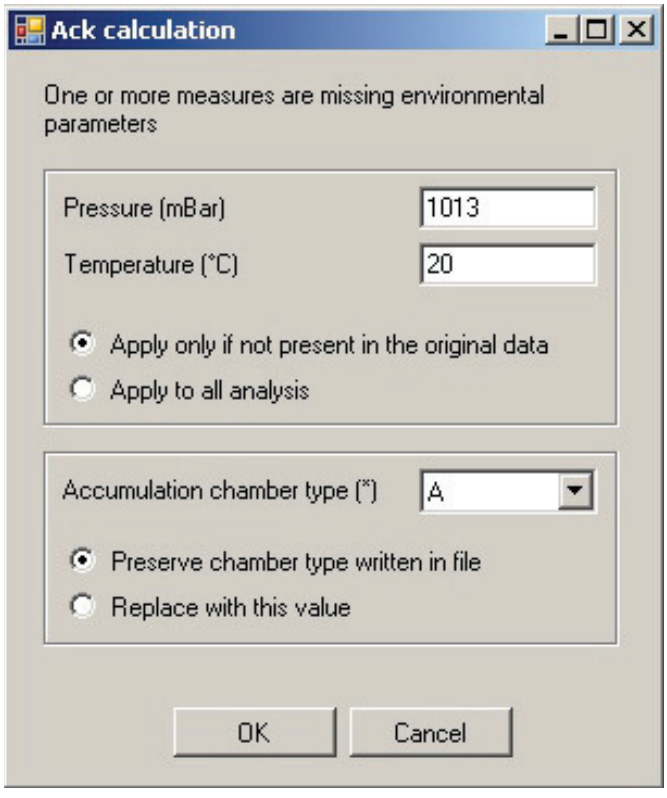


If some files are missing environmental parameters, you'll see the window appear.

Software FluxRevision



The volume of the accumulation chamber is obtained with the type of chamber (A, B or C) that you inserted in the FluxManager software. Check that the information about the chamber type (A in the illustration) is correct: the displayed type is the one obtained from the files. If the files present more than one chamber types, an asterisk will signal this. For example if you select a folder with some file with accumulation chamber A and some with type B, you will see a window like this:



Software FluxRevision

To set the barometric pressure or the temperature in the measures that are missing this parameter, replace the default values (1013 mBar and 20°C) and press OK. If the "Apply to all analysis" box is checked, the parameters in the measures that already had them will be overwritten.

Once all the files are parsed, you'll see the measures in the list of the left.

Folder: The folder that contains the measure files.

Curve: You can choose the currently displayed gas specie. Changing the specie has the effect to display the ErrQ and the Flux on the list. So the filter and the sorting of the list will refer to the selected specie.

Filter Records: This box allows filtering the measures in the list. The measures excluded from the filter will however be present in the report file.

Never revised: Checking this box, the list will contain only the measures that have never been revised (with no revision date).

ErrQ and **Flux**: Entering a value in these 2 boxes will exclude the measures with Flux or Errq higher or lower than the inserted threshold. Pressing the >= button will invert the sign.

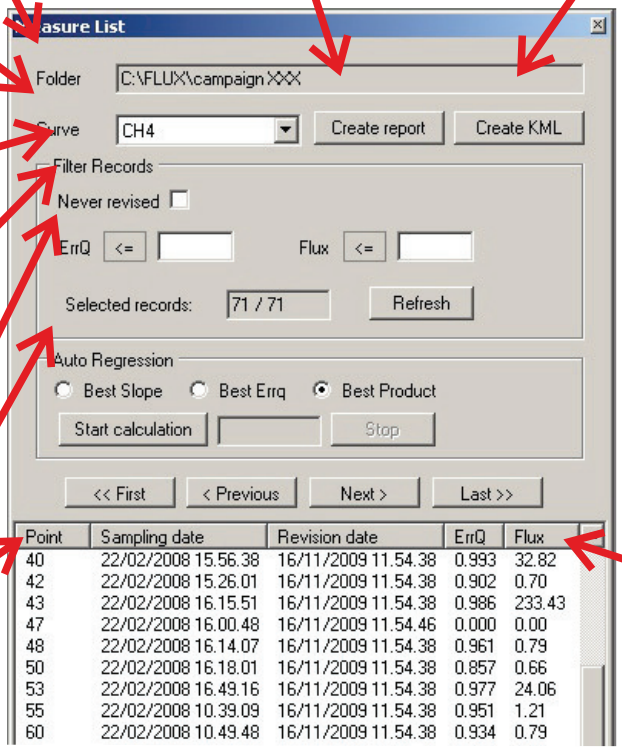
Auto Regression: this will automatically determine the best time interval to calculate the linear regression, according to the following algorithms:

- Best Slope: the interval which determines the highest slope is chosen.
- Best Errq: the interval which determines the highest Errq is chosen.
- Best Product: the algorithm looks for a good compromise between the 2 previous parameters.

First..Last: Navigates the measure list. You can sort the measures by clicking on the column header.

Create report: Allows to create the report file. See the paragraph for details.

Create KML: If the files contain GPS data, will be generated a KML file, just to have a quick representation of the spatial distribution of measure points. The file can be opened with software like Google Earth.



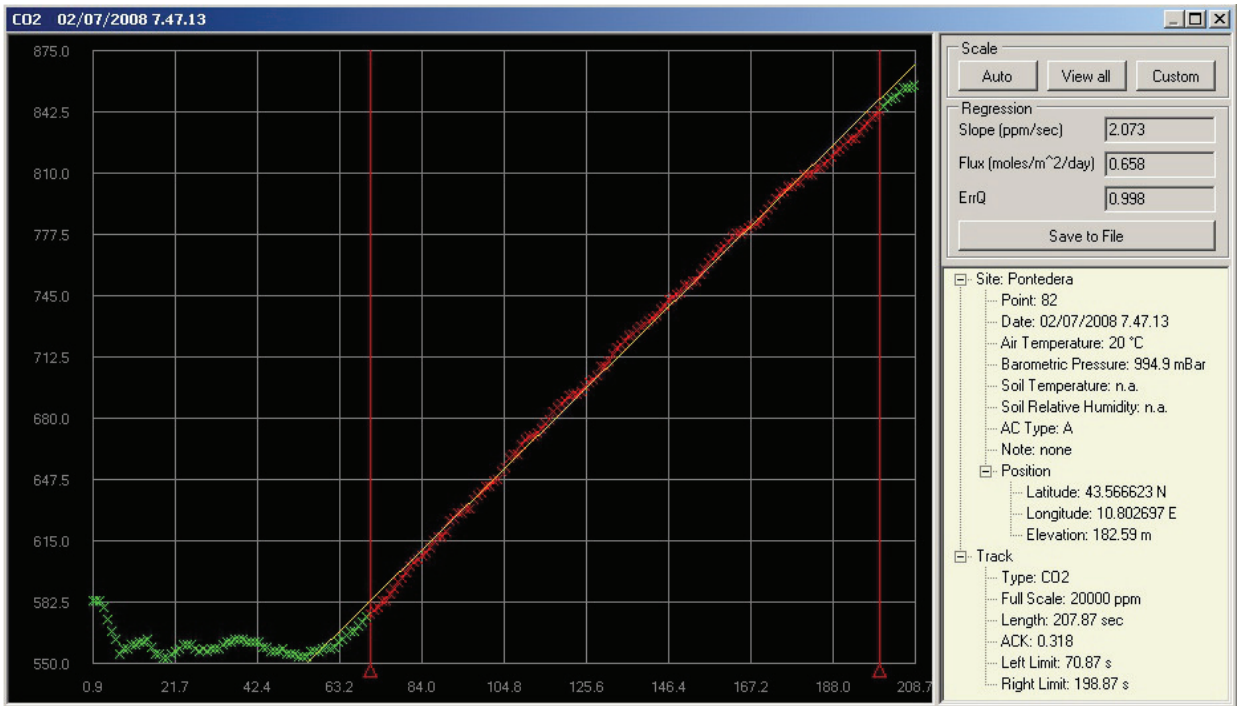
Point: it's the value you inserted in the "Point" field in the FluxManager saving window. By default it's numerical and auto incremental but you can insert also words.
Sampling date: it's the date and the time the measure was performed. Warning: this information is taken from the PDA clock so check it before to start the analysis' sequence.
Revision date: it's the date and time the measure was edited (with FluxRevision) by modifying left and right limits of flux interpolation and then modifying the value of the flux.
ErrQ: it's the value referred to the currently displayed gas specie. For example select Errq <= 0.9 to evaluate if there are curves with a bad linear interpolation.
Flux: it's the value referred to the currently displayed gas specie.

Software FluxRevision

Selecting an item in the list or pressing one of the navigate buttons, the flux curves are displayed. Like in FluxManager, are displayed the graphs of the sensors with TRACK=ON. They are usually the gas sensors.
The window is composed by 3 panels:

- The graph: time vs. concentration (or whatever measure unit is). Clicking with the middle mouse button, the X and Y value will be shown. Clicking with the right mouse buttons, it will be possible to export the plot as a JPEG image file, or to perform an automatic regression (in the same way as the *Auto Regressio*n work, but only for this file).
- The control panel, composed by *Scale* panel and *Regression* panel.
- The information box, which contains additional information about the measure point.

The scale panel allows to scale the Y axis of the plot. The *Custom* button permits to view only concentration interval. Then press the Auto or View All to restore the whole range.



The red points are used to calculate the interpolation line (and so, the flux), the green ones are ignored. To modify the interpolation time interval, move the left and right limits with the mouse left button. As you leave the button, the line is automatically recomputed and drawn: you will see the labels *Slope*, *Flux*, *ErrQ*, *Left Limit*, *Right limit* change. As you decide the interval is correct, click the *Save to File* button.

Warning: By saving, the file of that measure will be updated, and the interval you chose in the PDA with FluxManager will be overwritten.

You will see also the field *Revision date* in the list will be updated with the current time.

Report file

The report file is a table where each row corresponds to a measure point. The number of the columns is variable, since the 3 red fields are repeated for every sensor with TRACK=ON. The fields are the following:

- DATE
- TIME
- SITE
- POINT
- LONGITUDE
- LATITUDE
- UTM ZONE
- UTM LONGITUDE
- UTM LATITUDE
- ELEVATION
- NOTE
- PRESSURE (Hpa)
- AIR TEMPERATURE (°C)
- SOIL TEMPERATURE (°C)
- SOIL RELATIVE HUMIDITY (%)
- ACCUMULATION CHAMBER
- ACK
- SLOPE [ppm/s]
- FLUX [mol/mq/day]
- ERRQ
- FILENAME

The report file is a text file, the fields are separated by the TAB character, so the file can be easily opened with applications such as Microsoft Excel or OpenOffice Calc.

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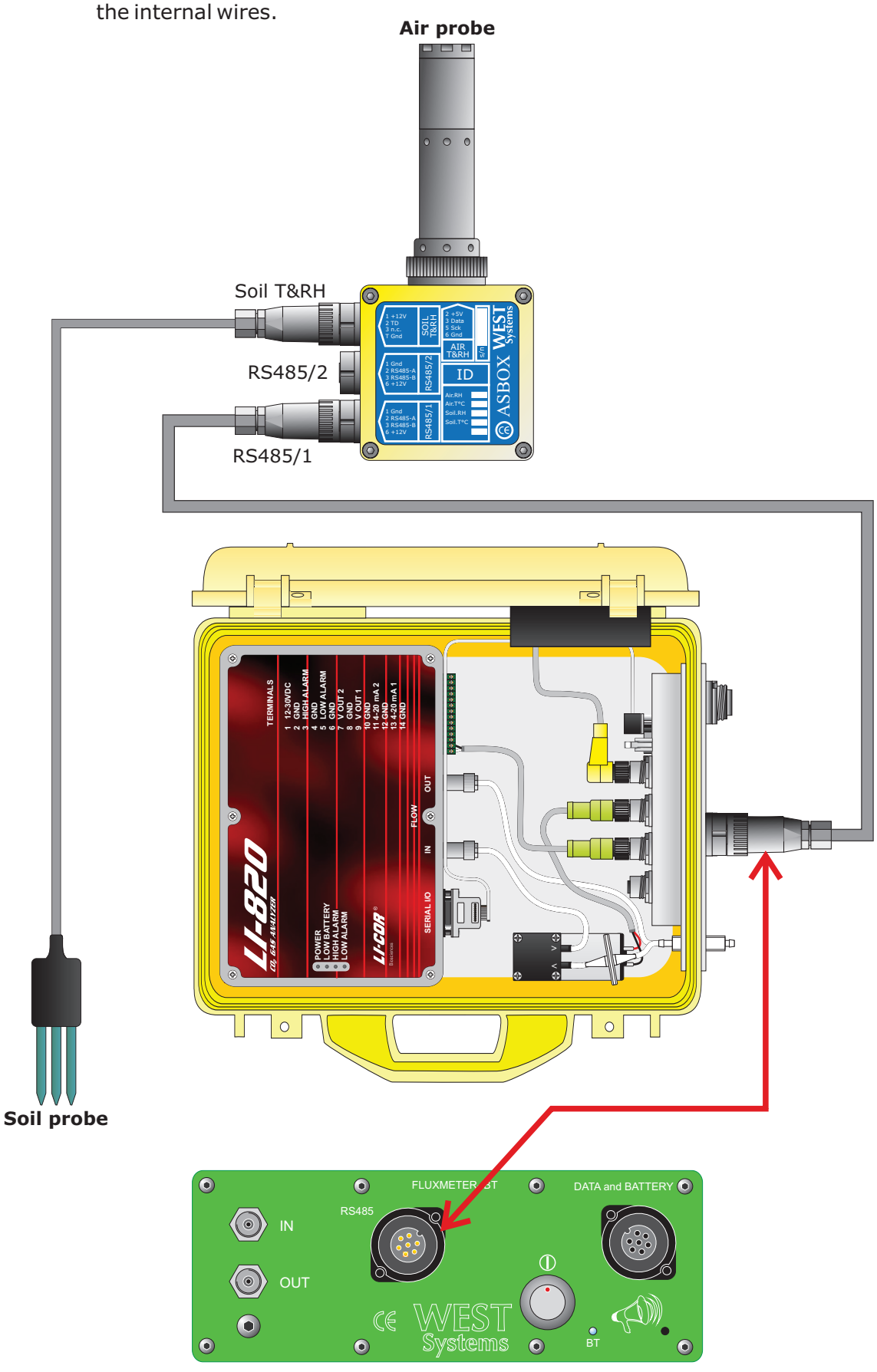
Air-Soil Box

Installation

The design below shows the connections of air and soil probes.
The soil probe needs to be completely covered by soil (not just the fork).
When removing the soil probe, do not pull it by the cable: this could break the internal wires.



RS485 Configuration

Sensor	Conf	RS485 ID
Soil Relative Humidity	0xA0	0x14
Soil Temperature	0xB0	0x15
Air Relative Humidity	0xDA	0xA4
Air Temperature	0xD9	0xA5

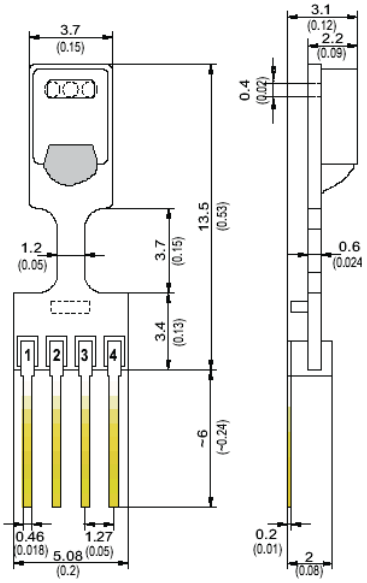
Soil temperature and volumetric water content gauge

Sensor Specifications

Soil temperature
Range: -40 to +50°C
Resolution: 0.1 °C
Accuracy: ±1°C

Soil relative humidity
Range: 0-100% (volumetric water content)
Accuracy: ±3%

Silicon Air Temperature and relative humidity gauge

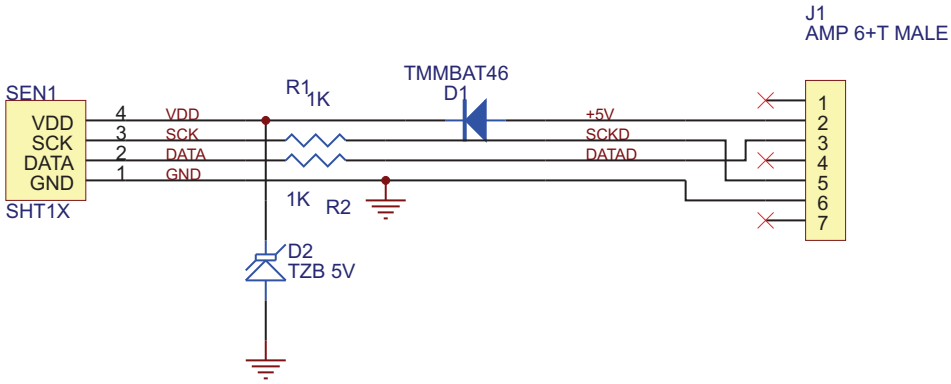


Sensor specifications

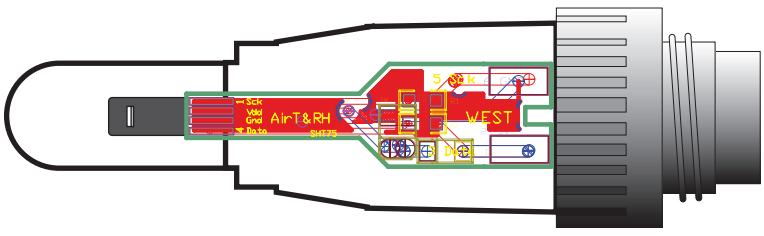
Two sensors for relative humidity & temperature:

- Measurement range: 0-100% RH
- Absol. RH accuracy: +/- 2% RH (10...90% RH)
- Repeatability RH: +/- 0.1% RH
- Temp. accuracy: +/- 0.4°C (5...40 °C)
- Calibrated & digital output
- Fast response time < 3 sec.

Probe schematics



Probe Layout (actual size)

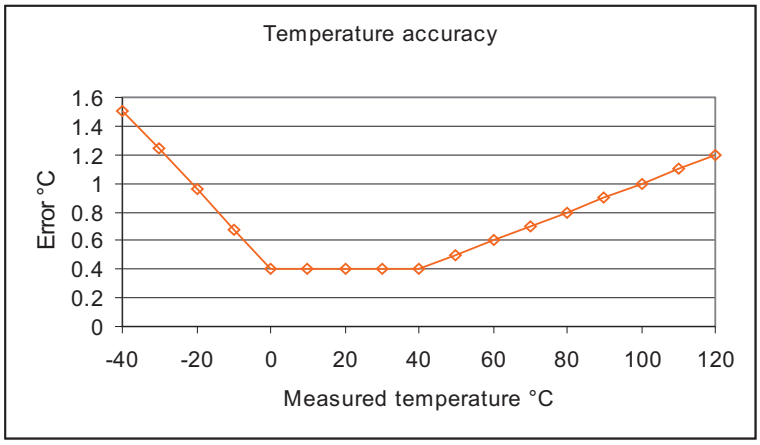


Amphenol 6T male

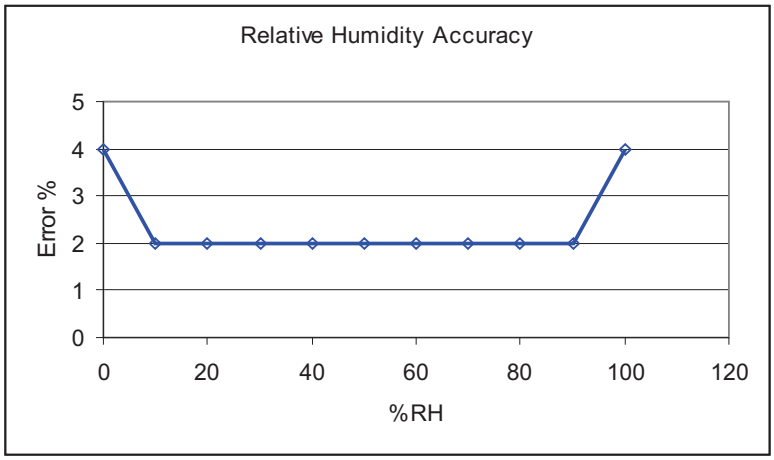
Air-Soil Box

Silicon Air Temperature and relative humidity gauge

Air Temperature accuracy Vs. temperature



Relative Humidity accuracy Vs. RH%



Glossary of terms

Activesynch: Communication software, furnished with the palmtop, that allows the communications between the palmtop and the desktop computers via docking cradle and USB connection.

AcK : Conversion factor between the native unit of instrument (ppm/sec) and the user unit (Normally moles/squaremeter/day)

CF Compact Flash memory card: Non volatile memory card that is used to store programs or data. The card can be used to share the data between the palmtop and your personal computer. An adapter might be necessary to use the card on you personal computer.

Docking Cradle: desktop base used to connect the palmtop to a personal computer via USB using MS ActiveSynch (See the palmtop manual).

ErreQ, r^2, sr: The quality factor of the regression. A value of ErreQ higher than 0.9 means that the regression quality is very good.

Filter: PTFE membrane syringe filter.

LICOR,LI820,LI8x0 LI800, GasHound : A carbon dioxide detector.

LPM : Flow unit, Liter per minute

PDA, PalmTop : The Compaq iPAQ or Hewleet Packard Pocket PC palmtop computer.

p.p.m. : Gas concentration in parts per million per volume.

PTFE : Polytetrafluorethylene or (r) TEFLON, inert plastic that do not suffer chemical attacks.

SCCM : Flow unit, Standard cubic centimeter per minute.

SD Secure digital memory card : A non volatile memory card (see CF compact flash and appendix A).

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If you'd like to have your paper(s) reported here please send us the paper abstract and we'll include it in the next releases. Thanks.

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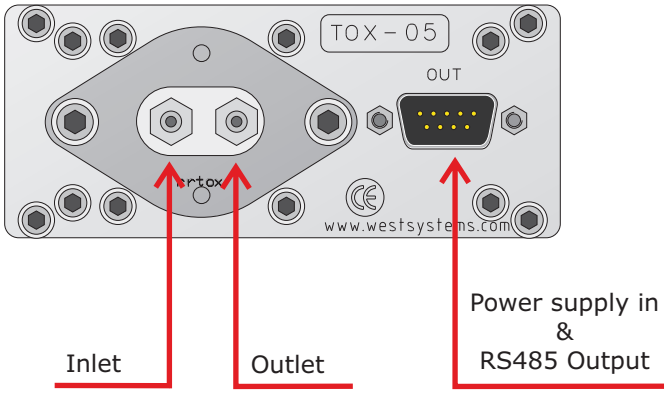
Hydrogen Sulfide (H_2S) Detector



Pin	Signal
1	Gnd
2	+VDC
3	Gnd
4	RS485-B
5	RS485-A
6	Gnd
7	+12V
8	Gnd
9	RS485-B

Legenda
Gnd: Ground reference for power supply and RS485
+VDC: 10-28 Volts Power supply input
RS485-A: Digital signal output A
RS485-B: Digital signal output B

Sensor specifications
Ambient conditions:
Air temperature -30°C to 50 °C
Air pressure 800 hPa to 1200 hPa
Air RH 15% ... 90% non condensating.
Expected sensor life > 24 months.
Chemical cell order code: WEST H2S-BH
Detector order code: WEST TOX-05-H2S-BH
Factory calibration : 20 ppm
RMS Noise < 0.02 ppm
Zero Offset < ±0.05 ppm
Max Overrange 200 ppm

The chemical cell reaction is:

$$H_2S + 2O_2 = H_2SO_4$$

the gas sample specific consuption is very low:

2.5×10^{-10} moles/sec per ppm

Due to this consuption the H2S flux is methodically understimated by a -10% with the accumulation chamber A and by a -5% when using the accumulation chamber B. Then we advise to use the accumulation chamber B except when the flux is very very low.

Hydrogen Sulfide (H_2S) Detector

Cross sensitivity tables

Unfortunately the hydrogen sulfide detector is affected by cross sensitivity with several gas species: In the table below these cross sensitivity are reported:

		Test @ ppm	Reading ppm
SO_2	Sulfur Dioxide	20	< 2
NO	Nytrogen monoxide	50	< 1.5
NO_2	Nytrogen dioxide	10	< -3
Cl_2	Chlorine	10	< -2.5
H_2	Hydrogen	400	< 1
C_2H_4	Ethylene	400	< 0.4
CO	Carbon monoxide	400	< 4
NH_3	Ammonia	20	< 0.02

Example: if the detector is exposed to a 20 ppm concentration of sulfur dioxide the reading can reach a maximum of 10 ppm.
The reading is negative when exposed to chlorine or nytrogen dioxide.

Hydrogen Sulfide (H_2S) Detector

Hydrogen sulfide detector calibration dates:

Date:		By:	
Standard gas mixture:	ppm	Zero:	ppm
Barometric pressure	HPa	Air T.	°C

Date:		By:	
Standard gas mixture:	ppm	Zero:	ppm
Barometric pressure	HPa	Air T.	°C

Date:		By:	
Standard gas mixture:	ppm	Zero:	ppm
Barometric pressure	HPa	Air T.	°C

Date:		By:	
Standard gas mixture:	ppm	Zero:	ppm
Barometric pressure	HPa	Air T.	°C

Date:		By:	
Standard gas mixture:	ppm	Zero:	ppm
Barometric pressure	HPa	Air T.	°C

Date:		By:	
Standard gas mixture:	ppm	Zero:	ppm
Barometric pressure	HPa	Air T.	°C

Date:		By:	
Standard gas mixture:	ppm	Zero:	ppm
Barometric pressure	HPa	Air T.	°C

Hydrogen Sulfide (H_2S) Detector

Calibration

As explained previously in Chapter 4 the flux measurement is proportional to the slope of the concentration curve versus time. The proportionality factor depends on the volume/surface ratio of the accumulation chamber used for the measurement, as well as, the barometric pressure and air temperature at the moment of making the measurement.

The most important aspect to understand is that the flux is proportional to the gradient of concentration over time: ppm/second.

This aspect allows us to simplify the control of the response of the gas sensors utilised.

Each time a measurement campaign is initiated the instrumental response of the gas sensors must be verified and, if necessary, their calibration fine tuned.

To simplify the explanation see the following example:

Calibration control example:

Before verifying the calibration turn on the instrument and leave it on for a minimum of 20 minutes to stabilise the temperature of the detector.

Step1: Verifying the zero:

Inject a flow (1 liter per minute) of nitrogen, or synthetic air, into the instrument and on the palmtop screen read the concentration of carbon dioxide. Obviously, it is important that the injected mixture not contain Hydrogen Sulpide. In the absence of a standard mixture with these caracteristics you can intake atmospheric air, as long as it is outside the area of abnormal emissions.

The method for injecting standard gas mixtures is explained in detail in the following pages.

Step2: Verification of the span:

Inject a standard mixture containing approximately 20 ppm of H_2S and check the response of the instrument.

Let's suppose that the check performed gave the following results:

Injecting a mixture at zero concentration of H_2S the detector returns a reading of 0.2 ppm.

Injecting a mixture containing a 20 ppm concentration H_2S the detector returns a reading of 19.7 ppm.

At a variation of concentration set at 20 ppm the instrument has a slightly different response: 19.5 ppm (=19.7 - 0.2 ppm). The evaluation error is of about 0.5 ppm, which in percentage points over the span corresponds to 2.5% less.

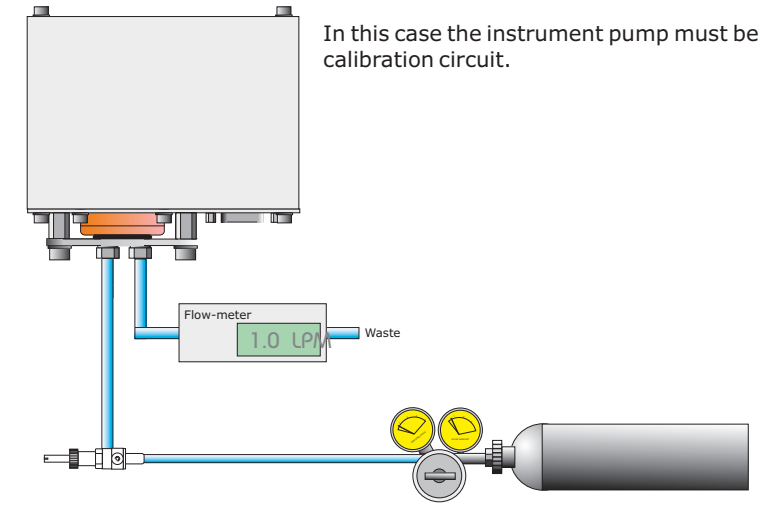
The error in evaluating the increment in concentration manifests as a systematic error in the evaluation of flux and, therefore, must be corrected by calibrating the instruments when it is too high (> 5%).

Hydrogen Sulfide (H_2S) Detector

Step 1 : Calibrating the Zero

Option A)

Inject a flow (approximately 1 liter per minute) of nitrogen, or synthetic air, into the instrument using a Mass Flow Controller or a needle type flow regulator and a flow meter following the scheme below.

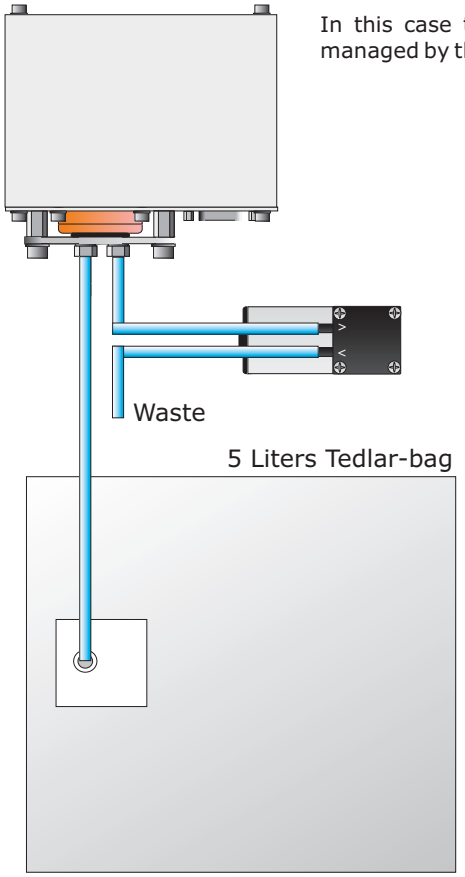


Needle-type Flow regulator
or
Mass flow controller

In this case the instrument pump must be disconnected from the calibration circuit.

Option B) Preferred

Fill the 5 liters Tedlar-bag with nitrogen, or synthetic air and connect it to the instrument:



In this case the instrument pump is connected and will be managed by the Calibra.exe calibration software.

Hydrogen Sulfide (H_2S) Detector

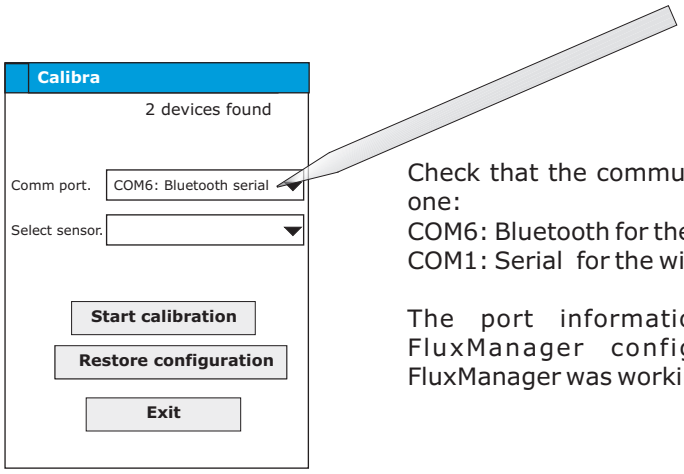
Step 1 : Calibrating the Zero

To calibrate the detector you need :

- A cylinder with nitrogen or UPP air (Mixture of 79% of N2 and 21% of oxigen);
- A cylinder with 15 / 20 ppm of H2S in nitrogen or UPP air;
- A 5 (10) liters TEDLAR bag;
- Warm up the instrument for a 30 minutes period before to start calibration.

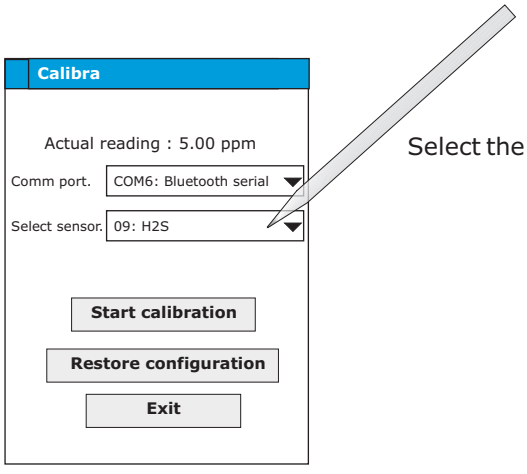
Open the calibration software supplied with the instrument: **Calibra**

Calibra reads the instrument configuration made by FluxManager, then before to run Calibra be sure that FluxManager recognized the correct configuration of instrument.

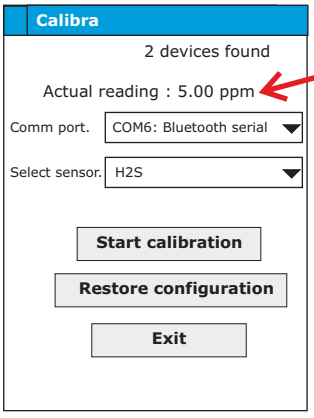


Check that the communication port is the correct one:
COM6: Bluetooth for the wireless connection
COM1: Serial for the wired connection.

The port information is taken from the FluxManager configuration file, then if FluxManager was working also Calibra has to work.

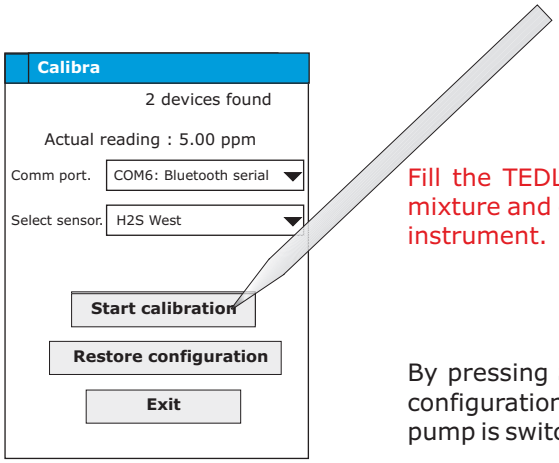


Select the H2S detector: **09: H2S**



Once selected the sensor you want to calibrate you can see the actual reading.

Step 2 : Calibrating the Span

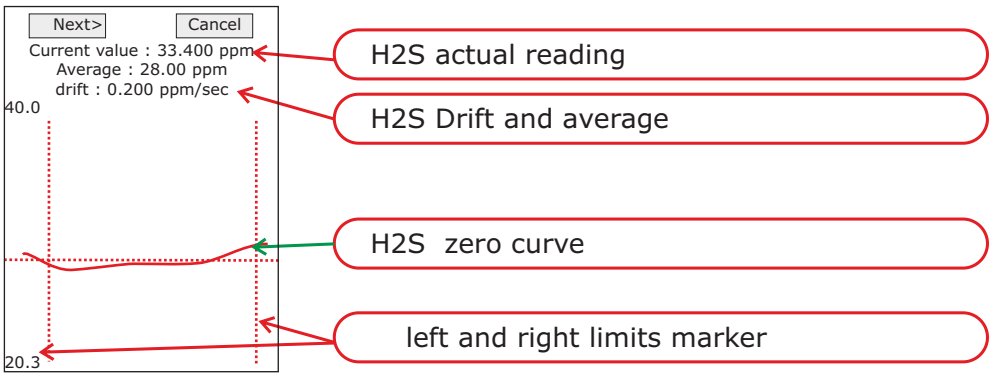


Fill the TEDLAR bag with the H2S free gas mixture and connect it to the inlet port of the instrument.

By pressing **Start Calibration** the detector configuration is reset to default value and the pump is switched on.

By pressing **Start Calibration** Calibra asks the current calibration values to the detector and store it in a file. These saved values can be used to restore the current calibration if something worog will happen.

Now the gas mixture is injected into the detector and the concentration readings are shown in the botton part of the screen.
The goal is to wait the stabilization of reading and then to select an interval where the readings are stable.



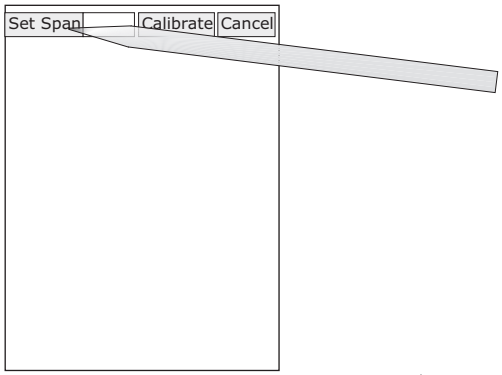
Once selected an interval you can read the average value and the drift in the interval. The average value of the selected interval will be used to calibrate the detector. The drift value will give you an idea of "readings stabilization". The drift value must be close to zero as possible.

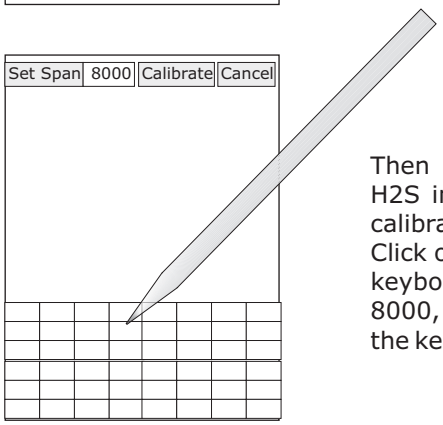
Once ready press the "NEXT>" button to proceed with calibration.

Hydrogen Sulfide (H_2S) Detector

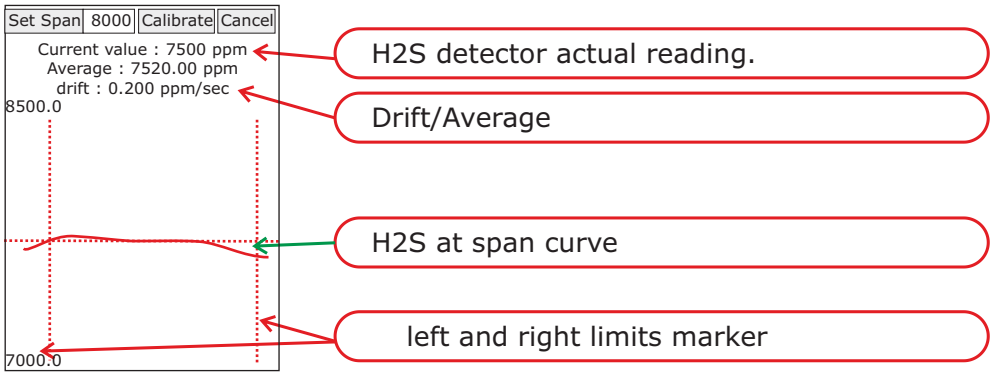
Step 2 : Calibrating the Span

Now connect the TEDLAR bag filled with the standard gas mixture (8000 ppm of H2S , in the example) to the instrument.
Also here the goal is to wait the stabilization of reading and then to select an interval where the readings are stable.





Then you've to enter the exact concentration of H2S in the gas mixture you'd like to use for the calibration: for instance 8000 ppm.
Click on the "SetSpan" label and, using the virtual keyboard, enter the value , expressed in ppm : 8000, once finished click again "SetSpan" to hide the keyboard.

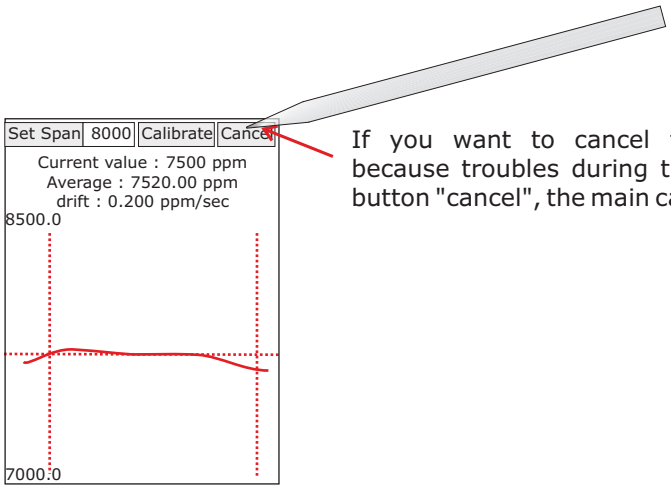


Once selected an interval you can read the average value and the drift in the interval. The average value of the selected interval will be used to calibrate the detector. The drift value will give you an idea of "readings stabilization". The drift value must be close to zero as possible.

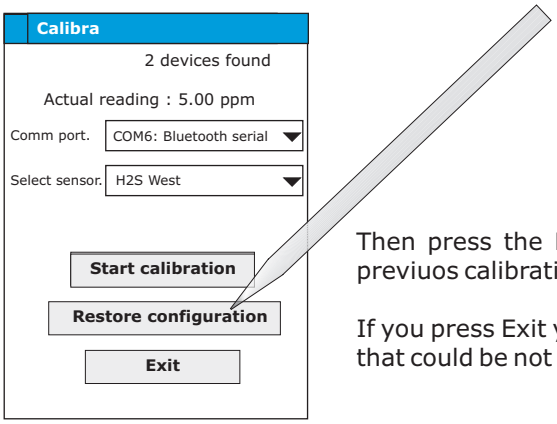
Step 2 : Calibrating the Span

Now, if you press **calibrate** the detector will be calibrated with the new parameters.

If you want to abort the operation press the **Cancel** button:



If you want to cancel the current calibration, because troubles during the procedure, press the button "cancel", the main calibra screen will appear.

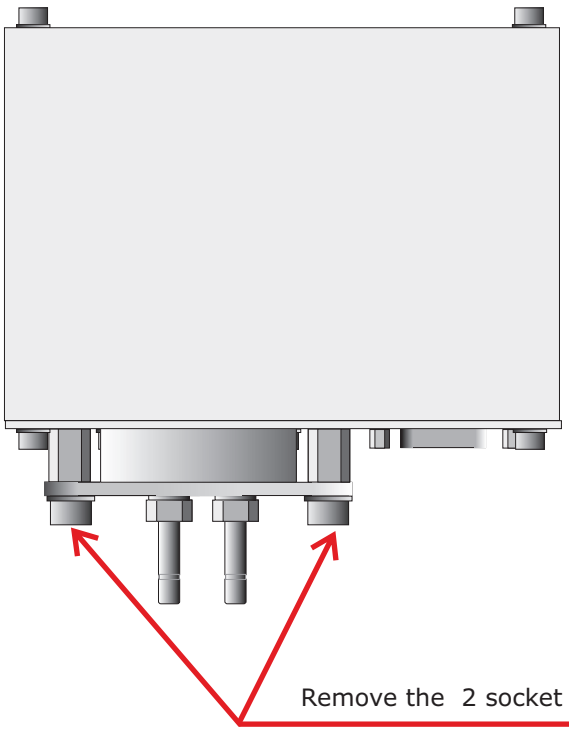


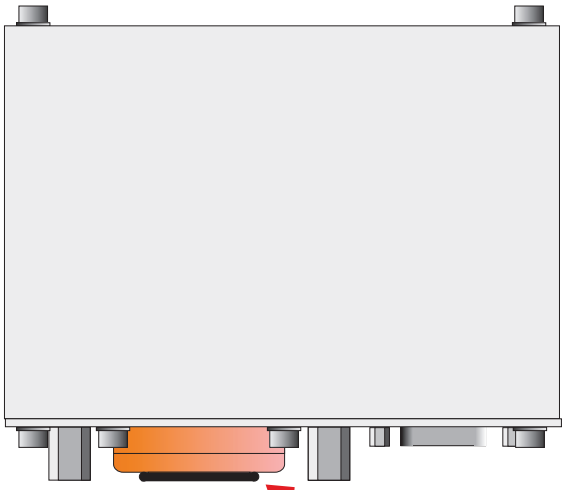
Then press the Restore configuration to reset the previuos calibration.

If you press Exit you'll use the "standard calibration" that could be not so accurate.

Hydrogen Sulfide (H_2S) Detector

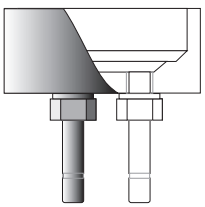
Replacing the sensor head





Now proceed following the instruction from step 1 to step 4.

(Step 4) Remove the O-ring gasket



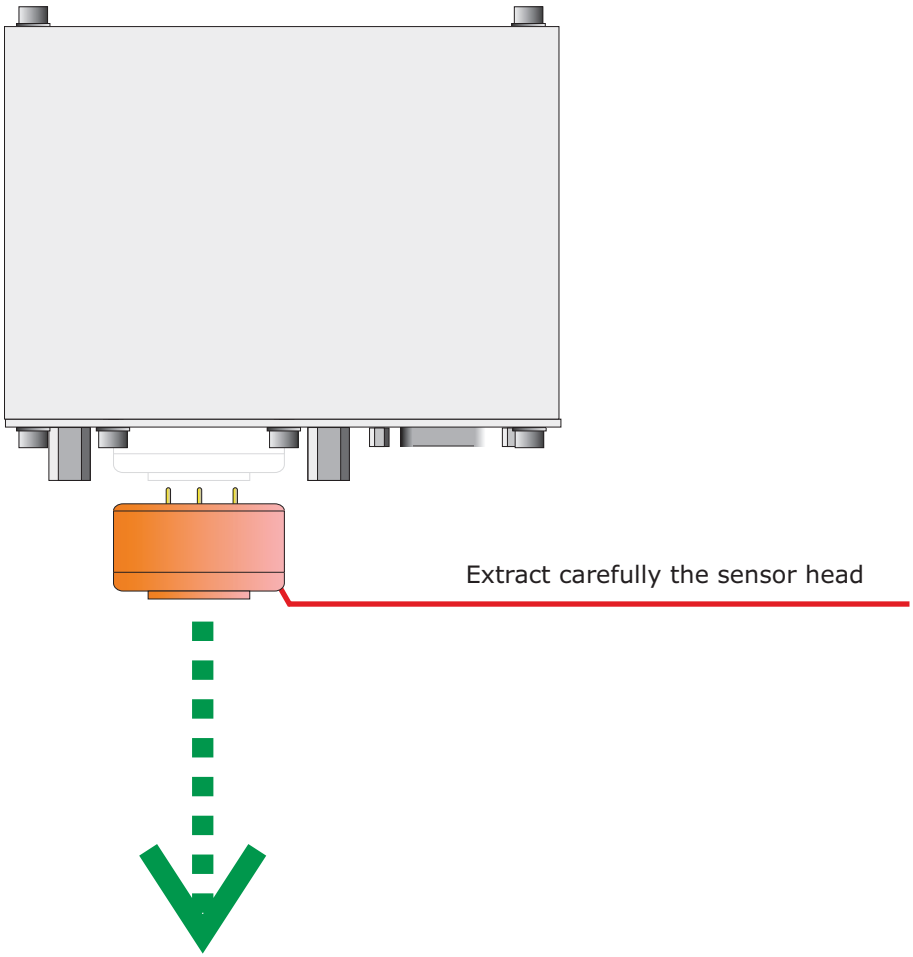
(Step 3) remove the online adapter

(Step 2) remove the flange

(Step 1) remove the socket head screws

Hydrogen Sulfide (H_2S) Detector

Replacing the sensor head

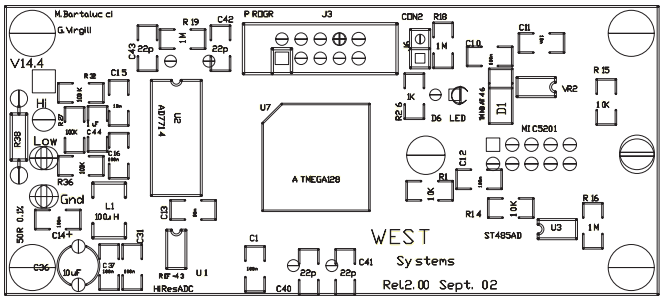


Now install the new sensor head (WS-H2S-BH Head) and re-assemble the detector. Please check the O-Ring status and check the sealing of the sensor head/on line adapter.

After changing the head you have to re-calibrate the detector.

Hydrogen Sulfide (H_2S) Detector

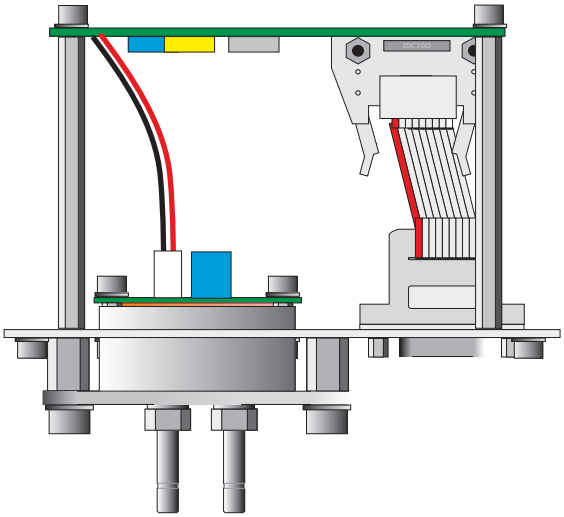
WS6B11 HiResolution ADC Converter



The WS6B11 is a high resolution analog to digital converter with the following specifications:

Resolution 20 bit @ 1 Hz;
Repeatibility 0.01% of Full Scale value;
Accuracy 0.025% of Full Scale value;
Full Scale value 20 mA;
Protocol WS6B11 with CheckSum enabled;
Configuration Type (Conf) D0
Interface RS485 @ 9600 bit/sec, none parity, 8 bit data, 1 bit stop;
RS485 Address 01;

Power supply 12-18 Volts DC 30 mA.
Sampling frequency 1 Hz



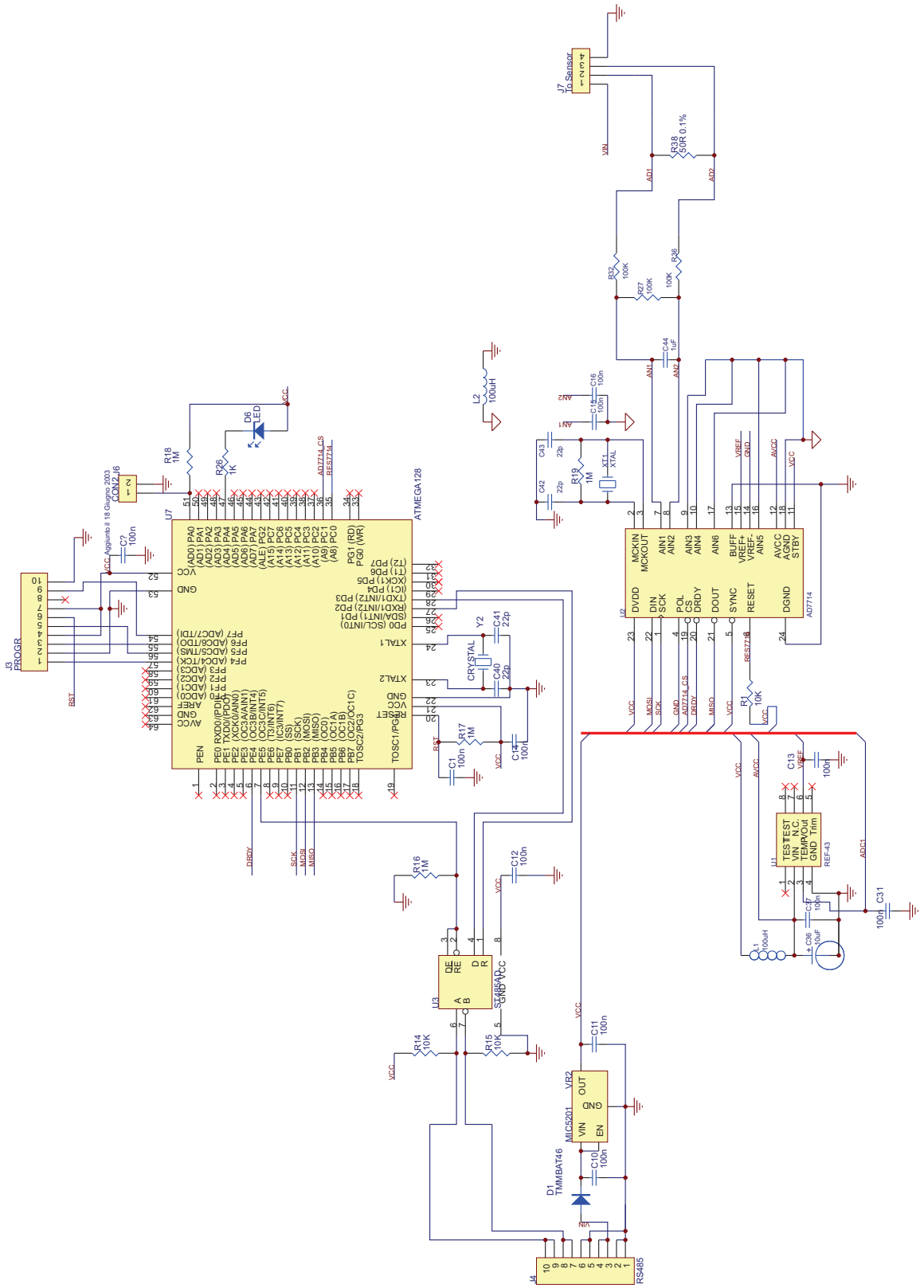
The WS6B11 Must be set as:

Conf: D0;
Configuration PINS OPEN;
RS485 ID : By default 01 HEX;

The 4-20 mA configuration must be done while in Conf: 06;
The calibration software must be SetSensorH2S.exe

Hydrogen Sulfide (H_2S) Detector

WS6B11 HiResolution ADC Converter



Hydrogen Sulfide (H_2S) Detector

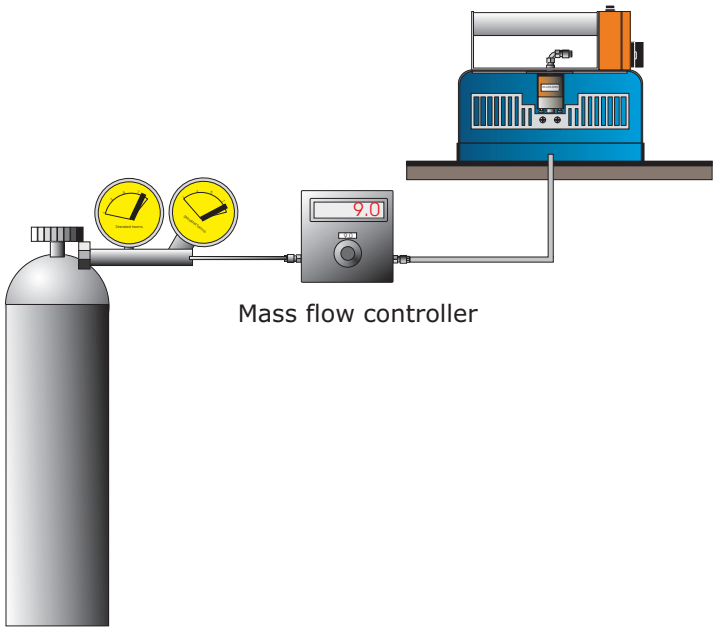
Flux and concentration calibration results

H_2S fluxes from soil are simulated by injecting a known flow of gas into the accumulation chamber. The interface between the accumulation chamber and the calibration table is built to minimize the gas leakage.
For flux between 0.0002 and 0.02 moles/(m^2day) the injected flux is controlled and measured with a precision mass flow controller. This MFC is electronically stabilized (Accuracy 3%).

For fluxes between 0.06 moles/m^2/day and 0.6 moles/m^2/day the injected flux is controlled by means of a mechanical flow reducer and measured using a bubble flowmeter (Accuracy 3%) before and after the flux measurement with the accumulation chamber.

A thermometer and barometer were utilized to measure the barometric pressure and the air temperature during the experiment in order to select the correct accumulation chamber conversion factor.

The same procudure was utilized to check the instrumental response to Carbon Dioxide.



Mass flow controller

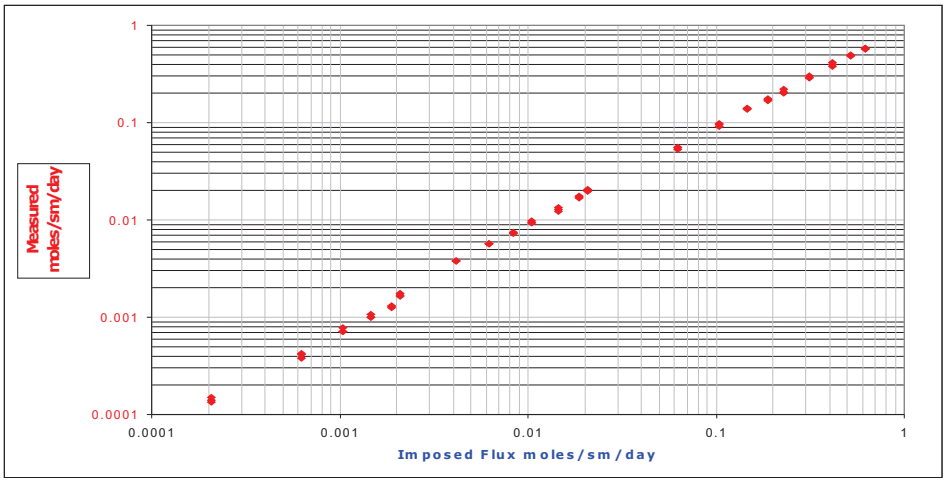
Standard mixture of hydrogen sulfide/carbon dioxide/nitrogen cylinder and pressure reducing valve

Hydrogen Sulfide (H_2S) Detector

Flux and concentration calibration results

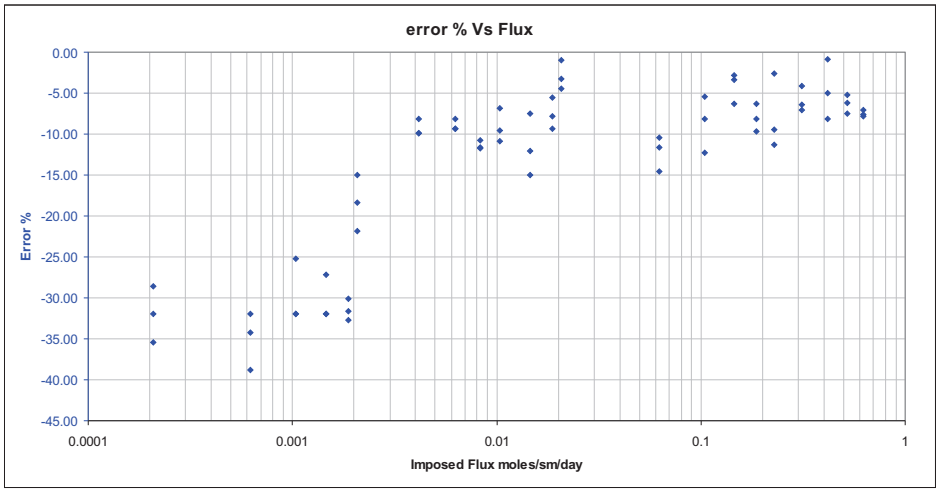
The simulated flux experiment was done using the accumulation chamber B that's more accurate for the hydrogen sulfide measurement.
Room temperature : Betwenn 20.2 and 21.4 °C
Air relative humidity 52-54%
Barometric pressure between 1013.1 and 1013.8 HPa
Accumulation Chamber B constant at 1013 and 20°C 0.707 (moles/sm/day)/(ppm/sec)

For each imposed flux 3 measurement was done to show the repeatibility.



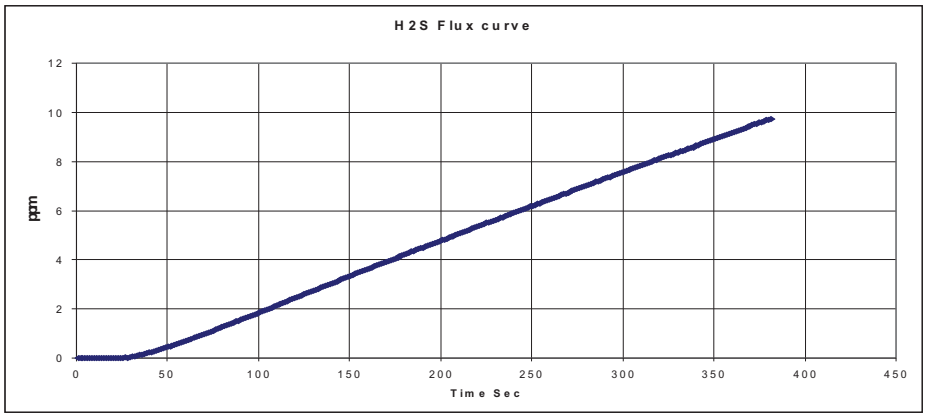
Errors plot

In the plot below the error evaluating flux vs flux are shown



A flux curve

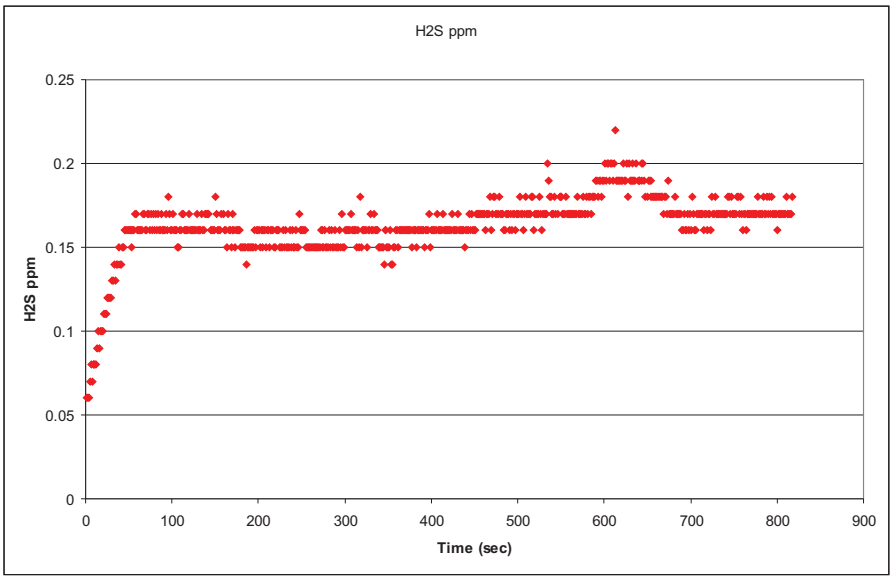
In the plot below a typical hydrogen sulfide flux curve: the slope is 0.028 ppm/sec and the flux is 0.019 moles/sm/day



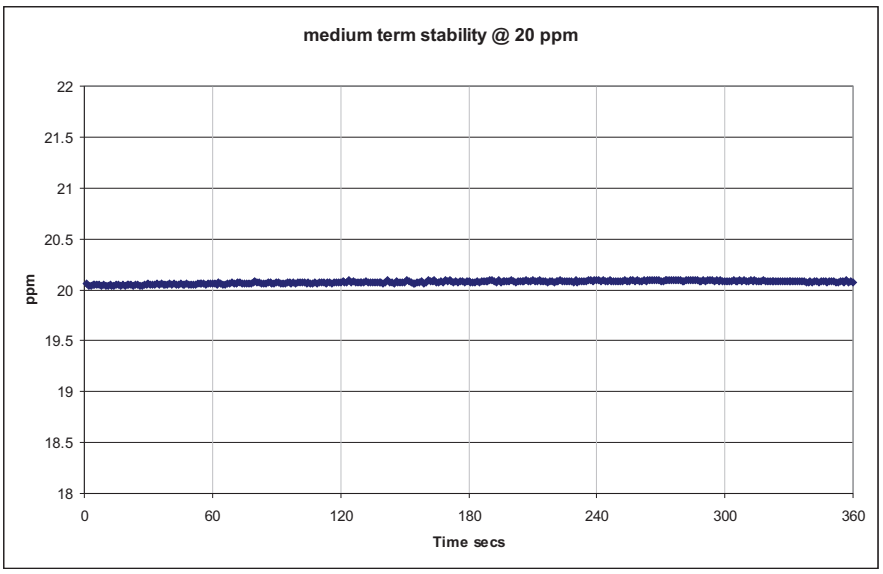
Hydrogen Sulfide (H_2S) Detector

Flux and concentration calibration results

In the plot below the "base line" of the hydrogen sulfide detector output is reported. The initial drift is due to the sensor temperature adjustement when the pump is switched on. The injected gas mixture was the laboratory air.



In the plot below the stability of the hydrogen sulfide detector output is reported. The injected gas mixture at 1 liter per minute was 20 ppm of H_2S in nitrogen.



LI820 CO2 Detector

General discussion

The subjects regarding calibration of your portable instrument for the measurement of diffuse flux will be discussed in this chapter.

As explained previously in Chapter 4 the flux measurement is proportional to the slope of the concentration curve versus time. The proportionality factor depends on the volume/surface ratio of the accumulation chamber used for the measurement, as well as, the barometric pressure and air temperature at the moment of making the measurement.

The most important aspect to understand is that the flux is proportional to the gradient of concentration over time: ppm/second.

This aspect allows us to simplify the control of the response of the gas sensors utilised.

Each time a measurement campaign is initiated the instrumental response of the gas sensors must be verified and, if necessary, their calibration fine tuned.

To simplify the explanation see the following example:

Calibration of LICOR

Before verifying the calibration turn on the instrument and leave it on for a minimum of 20 minutes to stabilise the temperature of the detectors.

Step1: Verifying the zero:

Inject a flow of nitrogen, or synthetic air, into the instrument and on the palmtop screen read the concentration of carbon dioxide. Obviously, it is important that the injected mixture not contain carbon dioxide. In the absence of a standard mixture with these caracteristics you can intake atmospheric air, as long as it is outside the area of abnormal emissions, and taking into consideration a standard value of 350 ppm for carbon dioxide.

The method for injecting standard gas mixtures is explained in detail in the following pages.

Step2: Verification of the span:

Inject a standard mixture containing approximately 1% (10,000 ppm) of carbon dioxide and check the response of the instrument.

Let's suppose that the check performed gave the following results:

Injecting a mixture at zero concentration of carbon dioxide the CO2 detector returns a reading of 10 ppm.

Injecting a mixture containing a 10,000 ppm concentration of carbon dioxide the CO2 detector returns a reading of 9940 ppm.

At a variation of concentration set at 10,000 ppm the instrument has a slightly different response: 9930 ppm (=9940-10 ppm). The evaluation error is of about 70 ppm, which in percentage points over the span corresponds to 0.6% less

The error in evaluating the increment in concentration manifests as a systematic error in the evaluation of flux and, therefore, must be corrected by calibrating the instruments when it is too high (> 5%).

LI820 CO2 Detector

When you need to calibrate the LICOR LI820/LI800

The LICOR is a very stable detector, the pressure compensation and the thermal stabilization features allows the instrument to maintain it calibration for long periods. The calibration is necessary if you decide to change the optical path or to clean it. In any case we advise calibrating it only if necessary.

What you need to calibrate the LICOR LI820/LI800

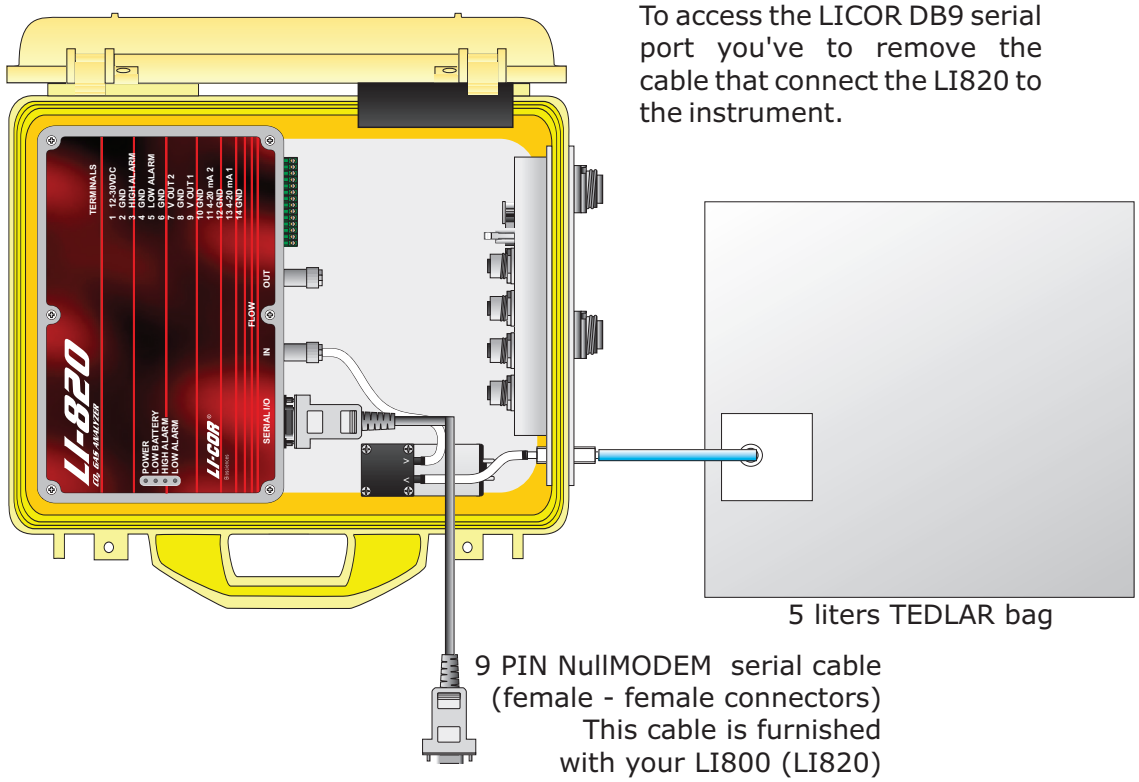
- A personal computer running MS Windows 9x, or NT4.0 or Windows 2000 or XP;
- A null modem cable, furnished with the LICOR LI8x0;
- A cylinder of nitrogen or synthetic UPP Air, or a SODA LIME trap or a DRAGER PIPE to trap the carbon dioxide.
- A cylinder of standard mixture of 1% of carbon dioxide in air (or nitrogen); The CO2 concentration has to be minimum the 50% of the full scale vale of LI8x0 and maximum the 95% of this value. If the full scale value is 2% by volume of CO2 the concentration of standard must be in the range from 1% up to 1.9% of CO2;
- A flow meter able to measure up to 2000 cubic centimeter per minute (not strictly necessary);
- A screwdriver and a hexagonal wrench to access the DB9 connector.

Connect the RS232 serial cable to a free serial port of your computer.

Run the LICOR windows software (Furnished with the LICOR sensor) on your personal computer.

Flow the gas mixture into the LICOR , not exceeding 1000 SCCM (Standard Cubic Centimeter per minute)

Follow the instruction of LICOR handbook to calibrate the zero and the span of your detector:
LI800 (page 3 to 11 of the LI800 handbook)
LI820 Page 3.24 of the LI820 handbook



To access the LICOR DB9 serial port you've to remove the cable that connect the LI820 to the instrument.

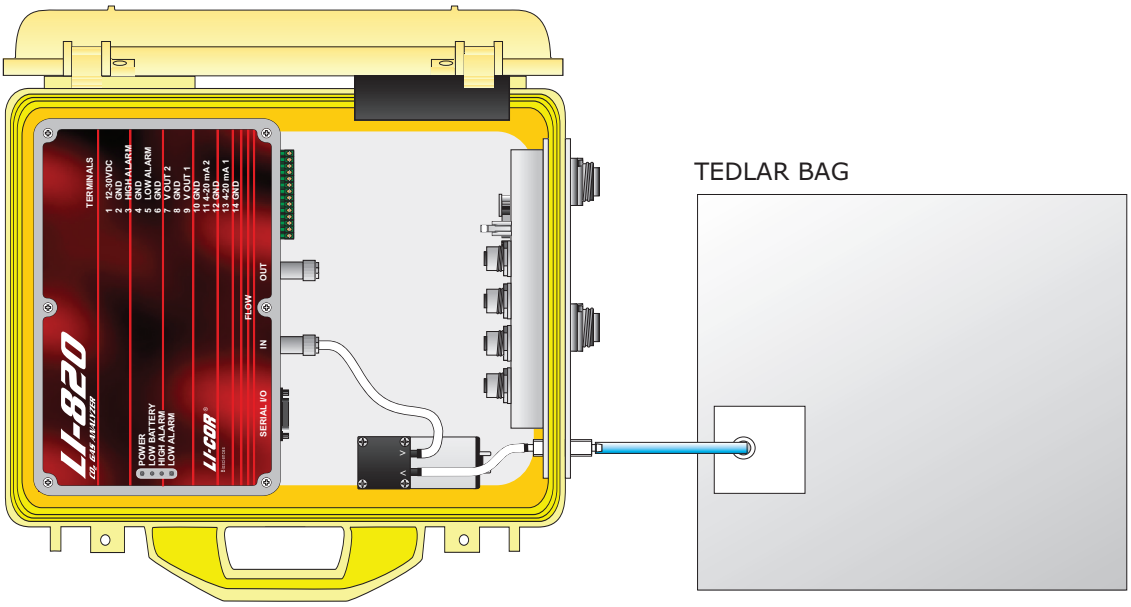
5 liters TEDLAR bag

9 PIN NullMODEM serial cable (female - female connectors) This cable is furnished with your LI800 (LI820)

To the RS232 port of your computer

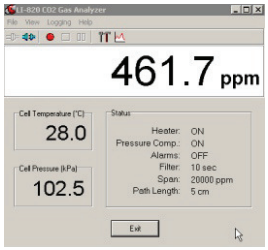
Once ready reassemble the instrument.

LI820 CO2 Detector

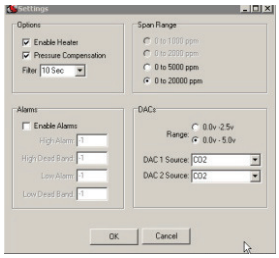


To apply the gas mixture to the LI820 fill and connect a TEDLAR BAG to the inlet port; then to turn on the pump START a measurement with FluxManager.

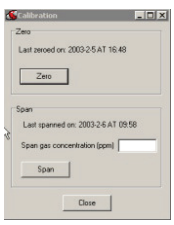
The LI800/820 settings.



In the figure at the left the main screen of the LI820 configuration / checking software.



Selecting [View][Settings] you access to the configuration screen.
Enable heater must be checked
Pressure compensation must be checked
The Span range (Thas the Full scale of LICOR) for the normal use is set to 20,000 ppm (2%). If you want to increase the low flux measurement accuracy you can set the Span range to 5,000 ppm (0.5%). With the FS set at 5000 ppm the capability of measuring high flux will be reduced to a maximum of 100 moles per square meter per day.



Selecting [View][Calibration] you access to the calibration screen.
Calibrate for first the zero and then the span.

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WS-HC Methane Detector

WS-HC Hydrocarbon Flux measurement:
The HydroCarbon detector is based on a double beam infrared spectrometer able to detect methane, hexane , propane and other molecules with HC linkages. The instrument comes calibrated for the methane. *The instrument requires a frequent **zero base-line** calibration that will be done using atmospheric air. The calibration requires 20 second*.

Detector specifications:

Accuracy 5%

Repeatibility 2%

Resolution 22 ppm (Methane equivalent)

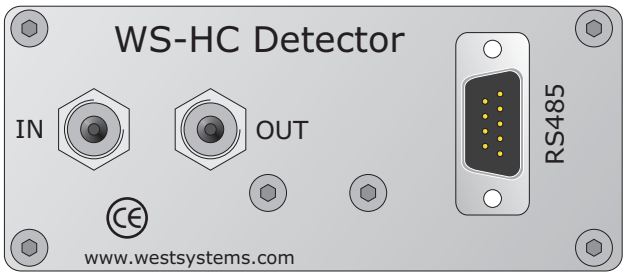
Full scale range is 10000 ppm of methane.

Detection limit 60 ppm.

Methane flux measurement range from 0.2 to 300 moles/m^2 per day (accumulation chamber A or C) and from 0.2 to 600 moles/m^2 per day (accumulation chamber B).
The precision depends on the measured flux:

```
range 0.2 - 10    moles/ m² per day ±25%
       10 - 600   moles/ m² per day ±10%
```

The measurement of very low fluxes (< 0.2 moles/m^2 per day) is possible but the error will increase due to the low detector sensitivity.



RS485 Connector	**DB9 Male panel**
Pin 1	**Gnd**
Pin 2	**+Power supply**
Pin 3	**Gnd**
Pin 4	**RS485 B**
Pin 5	**RS485 A**
Pin 6	**Gnd**
Pin 7	**+Power supply**
Pin 8	**Gnd**
Pin 9	**RS485 B**

The gas fittings can be used with rilsan 6x4 mm tubes or silicon 5x3.2 tubes. Please respect inlet and outlet ports.

WS-HC Methane Detector

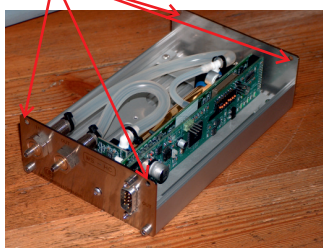
WS-HC detector / Set of baseline

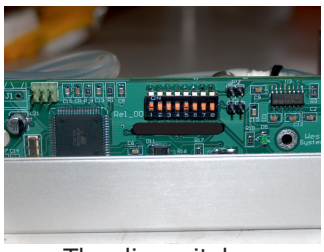
The WS_HC detector requires a frequent baseline correction: From FluxManager start a measurement taking the accumualtion chamber far from the soil in order to sample atmospheric air instead of soil gas.
Select the {Tools} {Set zero} menu voice and wait for 15-20 seconds. During this period the WS-HC will not send any concentration data. Once finished the base line (then the readings) of WS-HC will be zero and the instrument will be ready to work.

WS-HC detector / technical informations

To access the DIP switches

remove the 4 hexagonal screw and then remove the cover

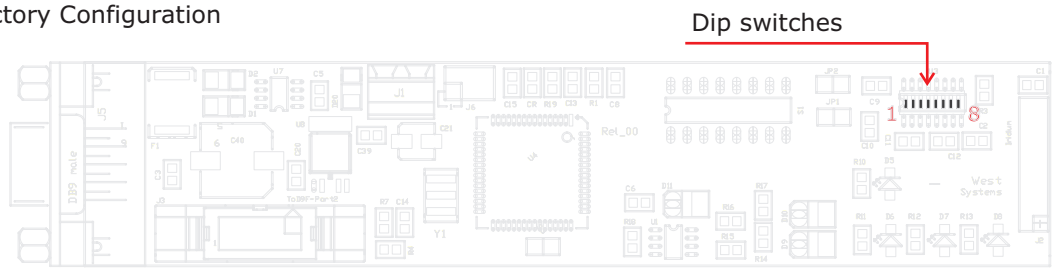




The dip switch
1 ON = Address base
5 ON = Temperature active

Re-assemble the cover.

Factory Configuration



Factory Configuration

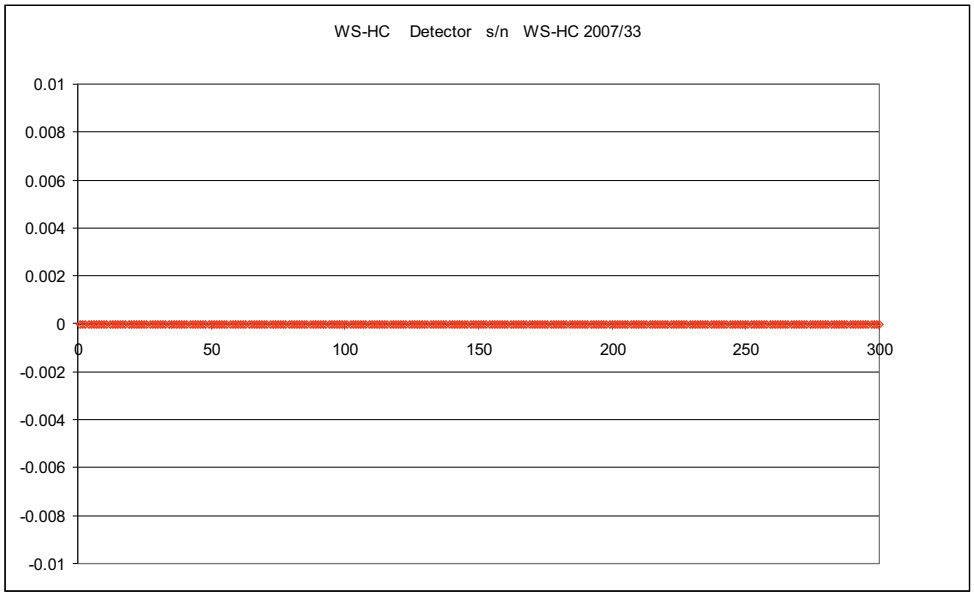
Description	Conf	Unit	Sw1 On	Sw1 Off
Methane	E6	ppm	**01**	0A
Temperature	E9	°C	**02**	0B

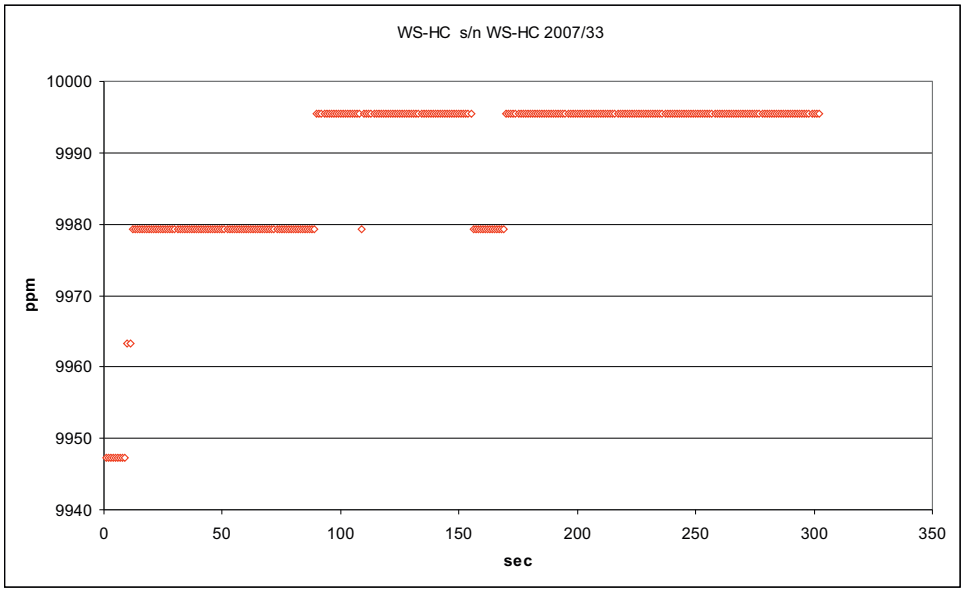
DIP switch settings

DIP	Enable	Default
SW1	Base Address	**On**
SW2	Reserved	**Off**
SW3	Reserved	**Off**
SW4	Reserved	**Off**
SW5	Temperature On/Off	**On**
SW6	Reserved	**Off**
SW7	Reserved	**Off**
SW8	Reserved	**Off**

WS-HC detector

The WS-HC readings are very stable: here is reported the record of 300 seconds while injecting UPP air or nitrogen at 1 liter per minute flow rate.



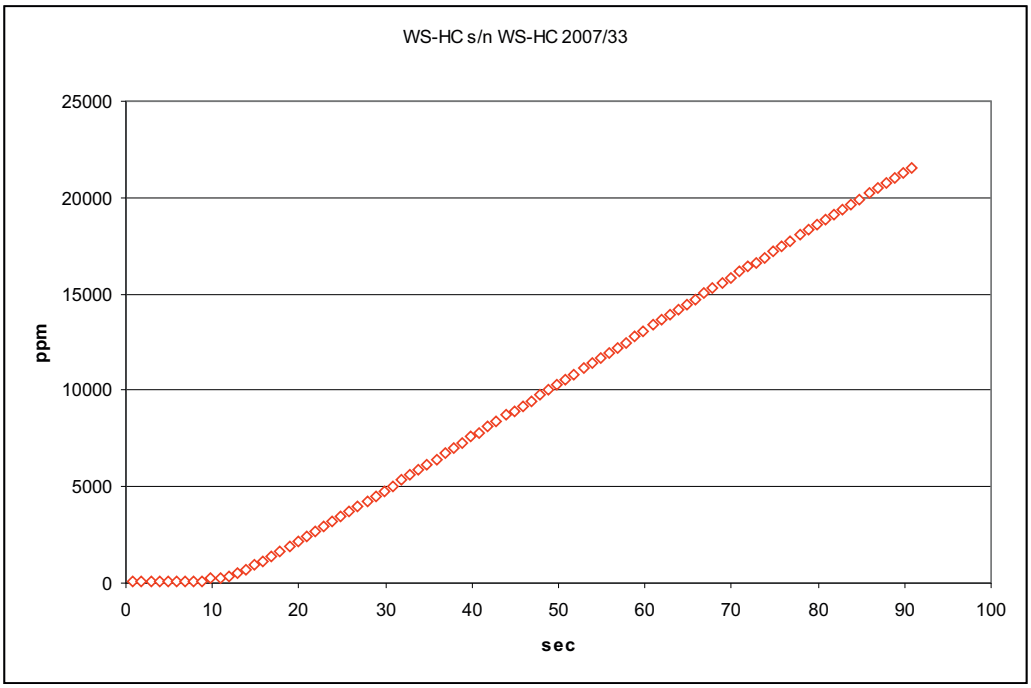


Here is reported the record of 300 seconds while injecting a standard mixture of 10000 ppm of methane in nitrogen at 1 liter per minute flow rate. The readings drift is 0.086 ppm/sec. The average value is 9975 ppm and the error is -0.25%.

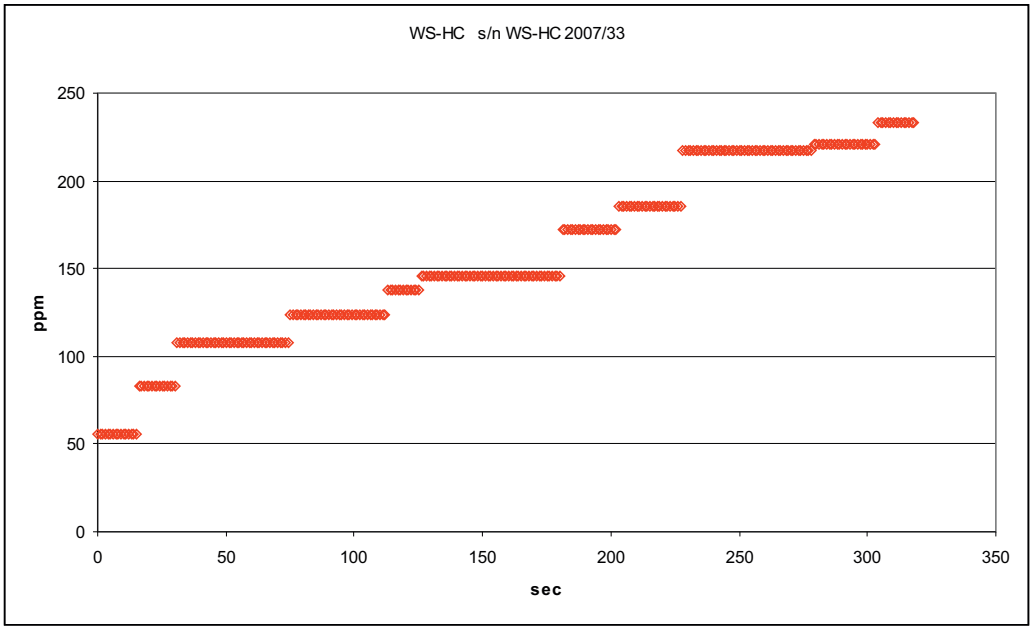
The drift is the most important parameter to control while measuring flux. Since it's not possible to distinguish between a drift, due to thermal and electrical instability of the detector, and a real variation of concentration due to the flux the drift of detector reduce the precision while measuring flux.

The drift of 0.086ppm/sec (at 1013 and 26°C) correspond to a 0.03 moles/m^2 per day value of flux.

WS-HC Methane Detector



In the plot a typical methane flux curve: the flux is about 80 moles/m^2/day.



In the plot the typical curve at very low flux: 0.18 moles/m^2/day.

WS-HC Methane Detector

Calibration of the methane detector

General discussion

The subjects regarding calibration of your portable instrument for the measurement of diffuse flux will be discussed in this chapter.

As explained previously in Chapter 4 the flux measurement is proportional to the slope of the concentration curve versus time. The proportionality factor depends on the volume/surface ratio of the accumulation chamber used for the measurement, as well as, the barometric pressure and air temperature at the moment of the measurement.

The most important aspect to understand is that the flux is proportional to the gradient of concentration over time: ppm/second.

This aspect allows us to simplify the control of the response of the gas sensors utilised.

Each time a measurement campaign is initiated the instrumental response of the gas sensors must be verified and, if necessary, their calibration fine tuned.

To simplify the explanation see the following example:

Calibration control example:

Before verifying the calibration turn on the instrument and leave it on for a minimum of 20 minutes to stabilise the temperature of the detectors.

Step1: Verifying the zero:

Inject a flow of nitrogen, or synthetic air, into the instrument and on the palmtop screen read the concentration. Obviously, it is important that the injected mixture do not contain methane. In the absence of a standard mixture with these characteristics you can intake atmospheric air, as long as it is outside the area of abnormal emissions, and taking into consideration that you can have few ppm of methane in air.

The method for injecting standard gas mixtures is explained in detail in the following pages.

The WS/HC requires a frequent set of base line, then before to proceed is necessary to start the measurement in order to turn on the pump, then wait that the reading is stable and then set the base line by selecting *Tools Set zero* menu voice *of* fluxmanager. As shown in the previous chapter the WS-HC base line is very stable and after the Set Zero procedure the methane reading will be zero.

Step2: Verification of the span:

Inject a standard mixture containing approximately methane in the range from 7000 up to 10000 ppm and check the response of the instrument.

Let's suppose that the check performed gave the following results:

Injecting a mixture at zero concentration of CH_4 the detector returns a reading of 0 ppm.

Injecting a mixture containing a 10,000 ppm concentration of CH_4 detector returns a reading of 9930 ppm.

At a variation of concentration set at 10,000 ppm the instrument has a slightly different response: 9930 ppm . The evaluation error is of about 70 ppm, which in percentage points over the span corresponds to 0.6% less

The error in evaluating the increment in concentration manifests as a systematic error in the evaluation of flux and, therefore, must be corrected by calibrating the instruments when it is too high (> 5%).

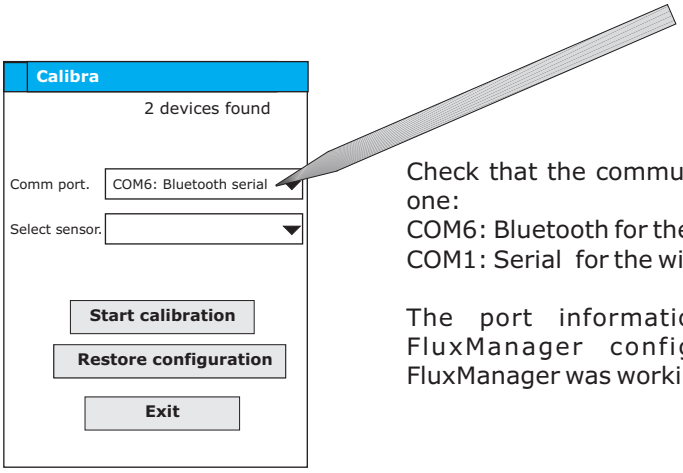
WS-HC Methane Detector

Calibration of the methane detector

To calibrate the detector you need :
- A cylinder with nitrogen or methane free air UPP;
- A cylinder with 7500 / 10000 ppm of methane in nitrogen or UPP air;
- A 5 liters TEDLAR bag;
- Warm up the instrument for a 30 minutes period before to start calibration.

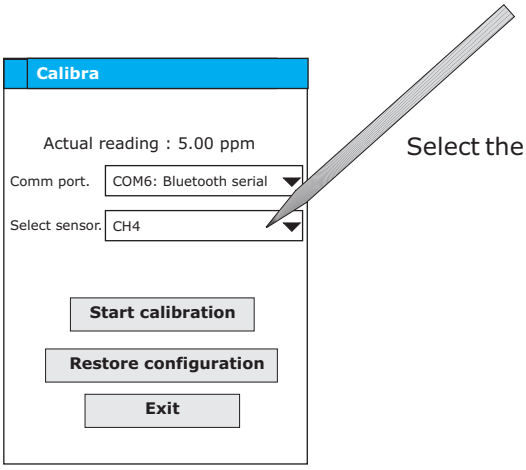
Open the calibration software supplied with the instrument: **Calibra**

Calibra reads the instrument configuration made by FluxManager, then before to run Calibra be sure that FluxManager reconnized the correct configuration of instrument.



Check that the communication port is the correct one:
COM6: Bluetooth for the wireless connection
COM1: Serial for the wired connection.

The port information is taken from the FluxManager configuration file, then if FluxManager was working also Calibra has to work.

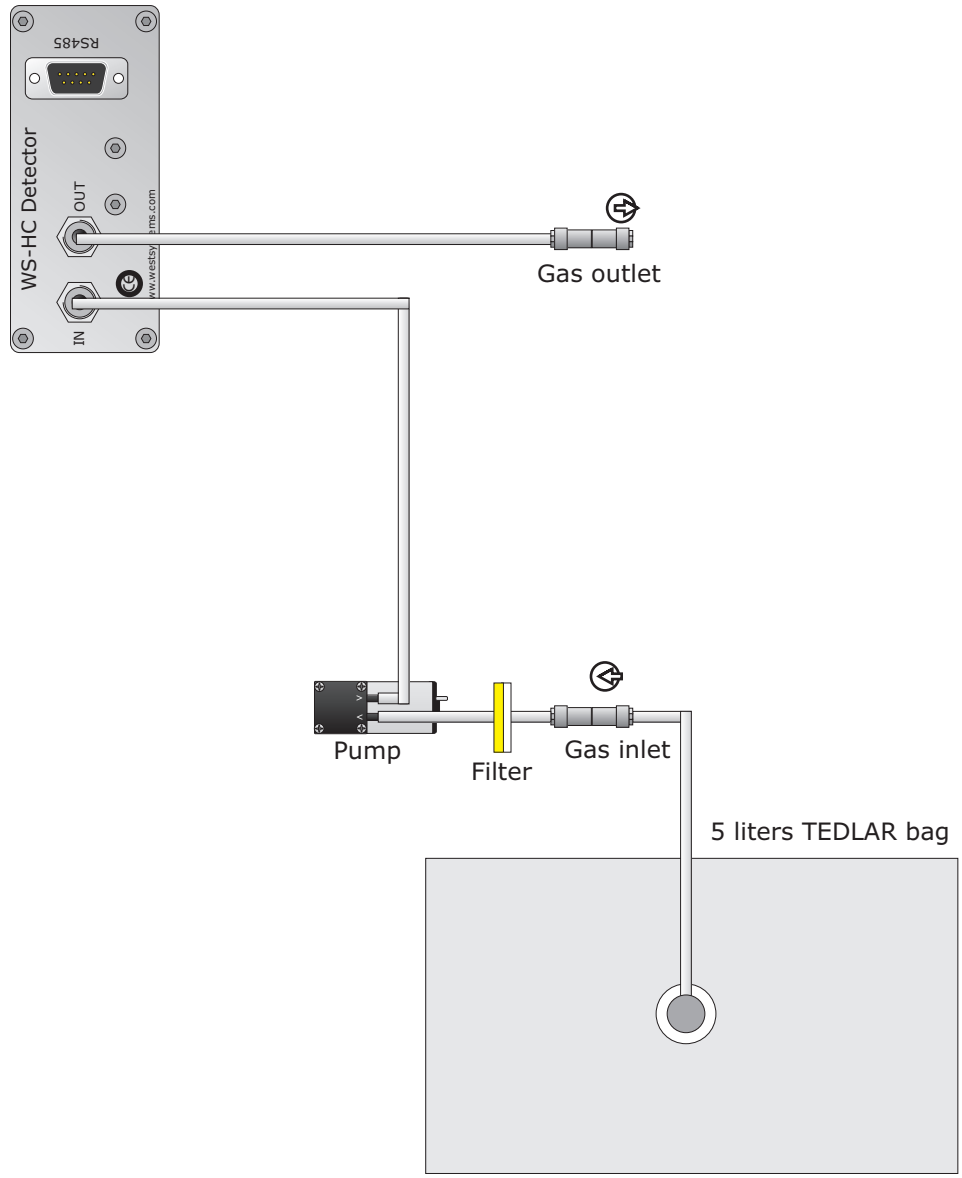


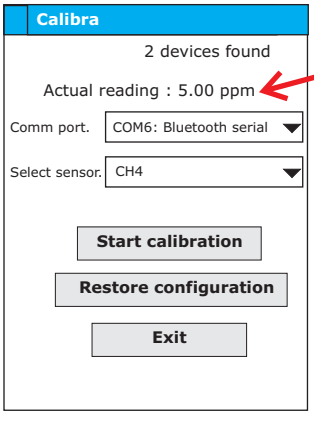
Select the methane detector: **CH4**

WS-HC Methane Detector

Calibration of the methane detector

Here following the pneumatic connections while calibrating.

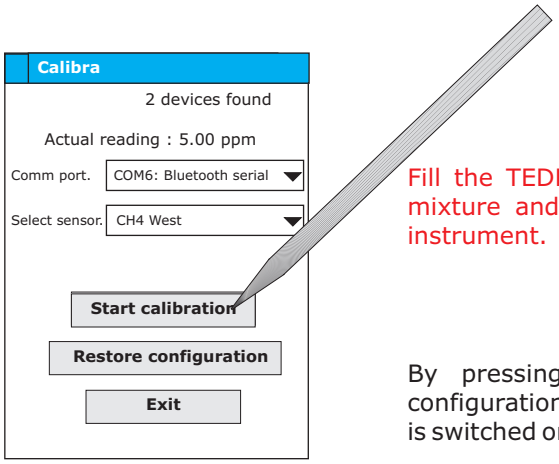




Once selected the sensor you want to calibrate you can see the actual reading.

WS-HC Methane Detector

Calibration of the methane detector

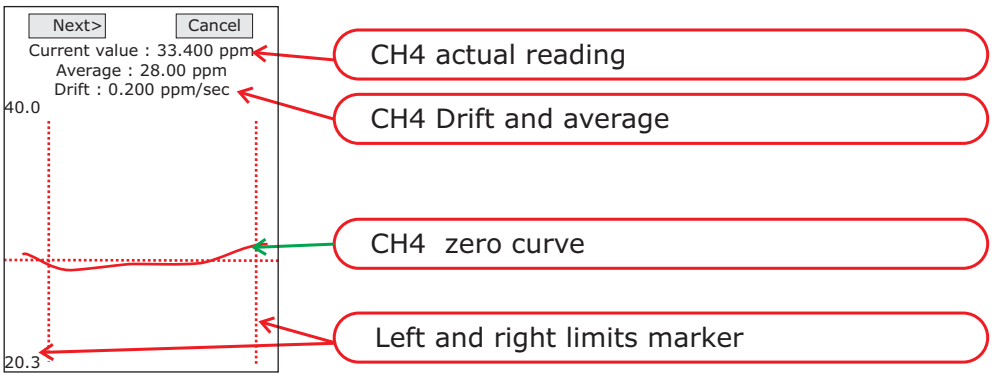


Fill the TEDLAR bag with the methane free gas mixture and connect it to the inlet port of the instrument.

By pressing **Start Calibration** the detector configuration is reset to default value and the pump is switched on.

By pressing **Start Calibration** Calibra asks the current calibration values to the detector and store it in a file. These saved values can be used to restore the current calibration if something worog will happen.

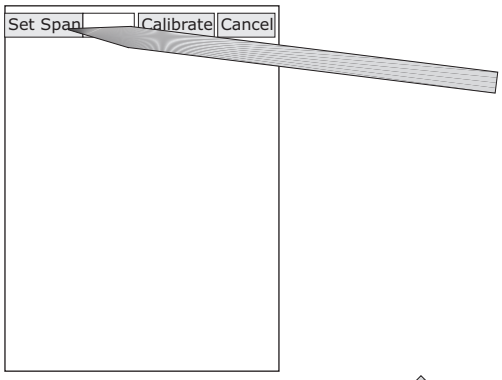
Now the gas mixture is injected into the detector and the concentration readings are shown in the botton part of the screen.
The goal is to wait the stabilization of reading and then to select an interval where the readings are stable.

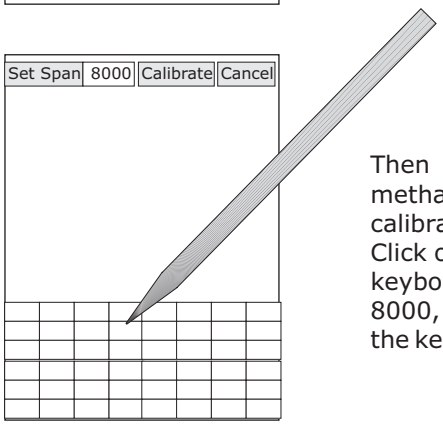


Once selected an interval you can read the average value and the drift in the interval. The average value of the selected interval will be used to calibrate the detector. The drift value will give you an idea of "readings stabilization". The drift value must be close to zero as possible.

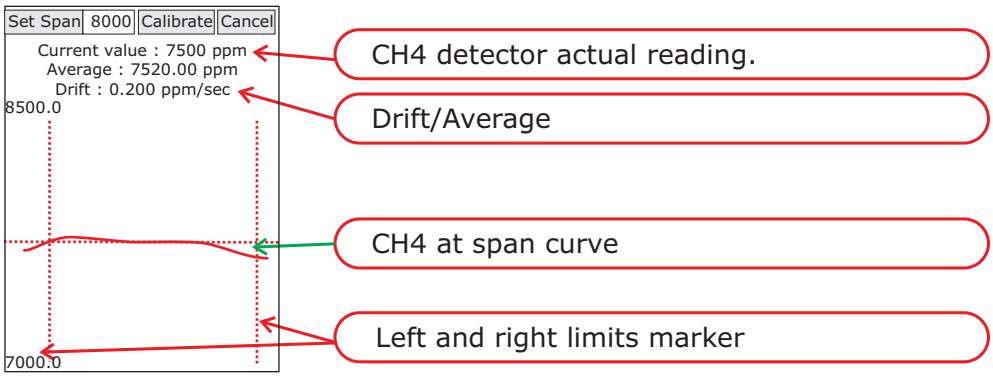
Once ready press the "NEXT>" button to proceed with calibration.

Now connect the TEDLAR bag filled with the standard gas mixture (8000 ppm of CH4 , in the example) to the instrument.
Also here the goal is to wait the stabilization of reading and then to select an interval where the readings are stable.





Then you've to enter the exact concentration of methane in the gas mixture you'd like to use for the calibration: for instance 8000 ppm.
Click on the "SetSpan" label and, using the virtual keyboard, enter the value , expressed in ppm : 8000, once finished click again "SetSpan" to hide the keyboard.



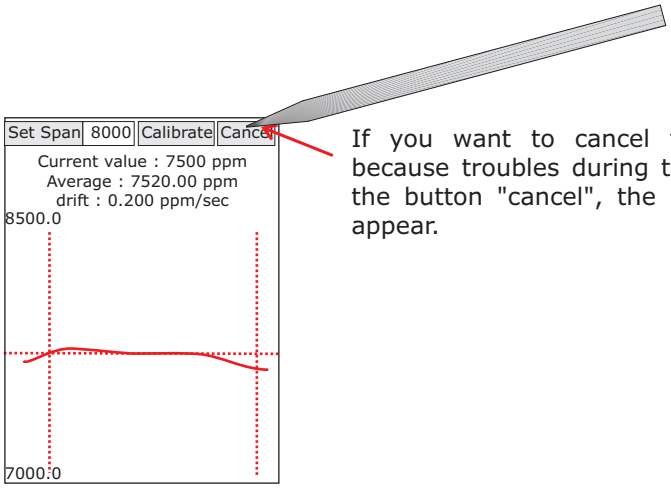
Once selected an interval you can read the average value and the drift in the interval. The average value of the selected interval will be used to calibrate the detector. The drift value will give you an idea of "readings stabilization". The drift value must be close to zero as possible.

WS-HC Methane Detector

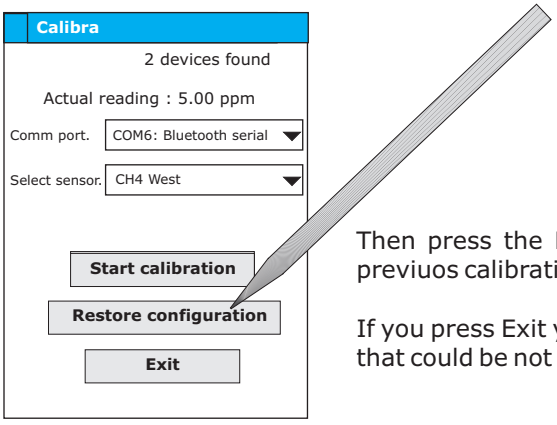
Calibration of the methane detector

Now, if you press **calibrate** the detector will be calibrated with the new parameters.

If you want to abort the operation press the **Cancel** button:



If you want to cancel the current calibration, because troubles during the procedure or.., press the button "cancel", the main calibra screen will appear.

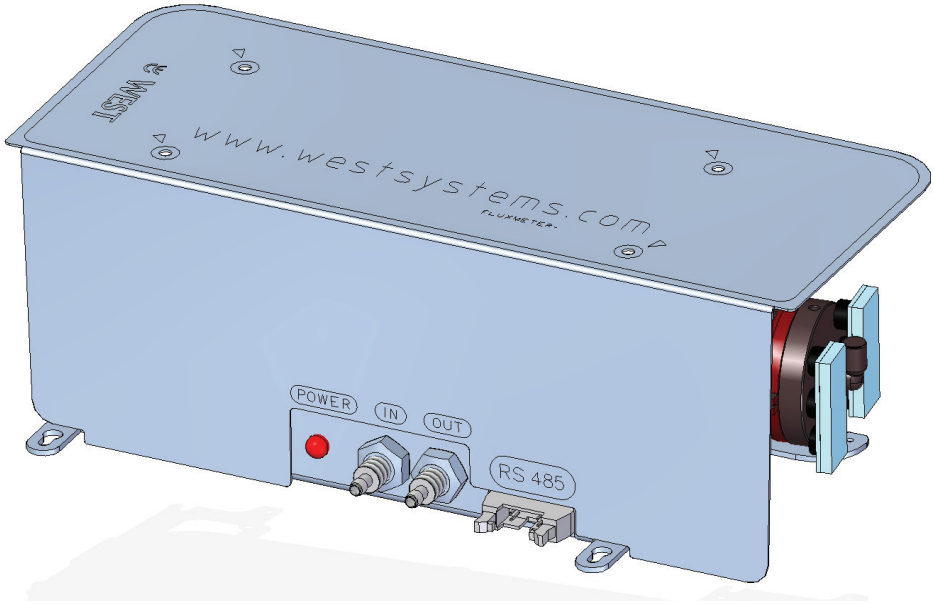


Then press the Restore configuration to reset the previuos calibration.

If you press Exit you'll use the "standard calibration" that could be not so accurate.

WS-CH4-TLD Methane Detector

WS-CH4-TLD Methane Flux measurement:
The detector is based on a TLD (tunable laser diode) coupled with a multipass cell. The Tunable Diode Laser Absorption Spectroscopy detection method is based on the principle of absorption of the light by a medium which is described by the Beer Lambert law.
The operational wavelength of the laser diode is 1650nm. The signal is then optimized by adding a multipass optical cell, which allows increasing the pathlength in the gas.



The IN and OUT gas fittings can be used with rilsan 6x4 mm tubes or silicon 5x3.2 tubes. Please respect inlet and outlet ports.

! Always make sure that a filter (porosity 0.20 µm or less) is applied between the inlet on the fluxmeter and the inlet of WS-CH4-TLD detector. If water, dust, dirt or any other polluting substance comes inside the cell, it will alter the behaviour of the mirrors. In the best case, it will be necessary to send the instrument to West Systems for a cleaning, which is a long and expensive procedure.
Never open the protective case of the WS-CH4-TLD. Some components like the optical fiber could be damaged if touched or moved.

The RS485 cable provides both power supply and communication

RS485 Connector

Pin 1	Gnd
Pin 2	Gnd
Pin 3	+Power supply
Pin 4	+Power supply
Pin 5	Gnd
Pin 6	Gnd
Pin 7	RS485 B
Pin 8	RS485 B
Pin 9	RS485 A
Pin 10	Rs485 A

WS-CH4-TLD Methane Detector

Detector specifications:

Resolution: 0.1 ppm

Concentration measurement range: from 0.1 ppm to 10% vol*

Accuracy: ±10%

Operating temperature: -10°C...+45°C

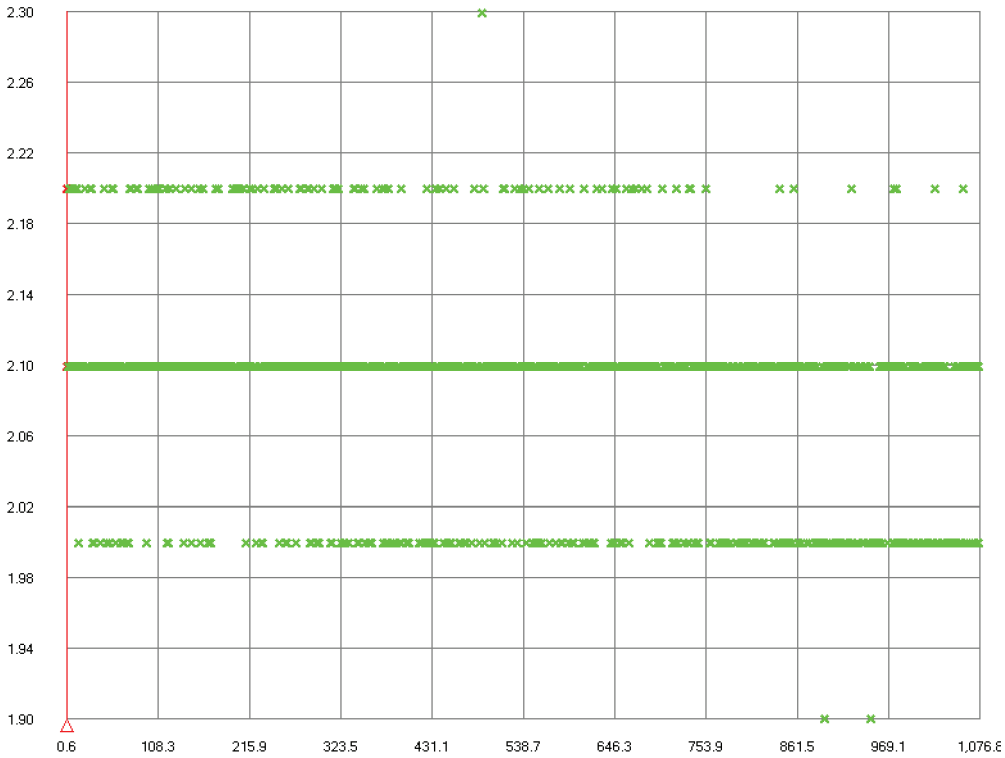
Selectivity to methane

Flux Measurement range: from 1 to 900,000 millimoles/m2 per day

Range	Unit	Precision
0-1000	mmoles/m^2 per day	±25%
1000 – 150,000	mmoles/m^2 per day	±10%
150,000 – 900,000	mmoles/m^2 per day	±20%

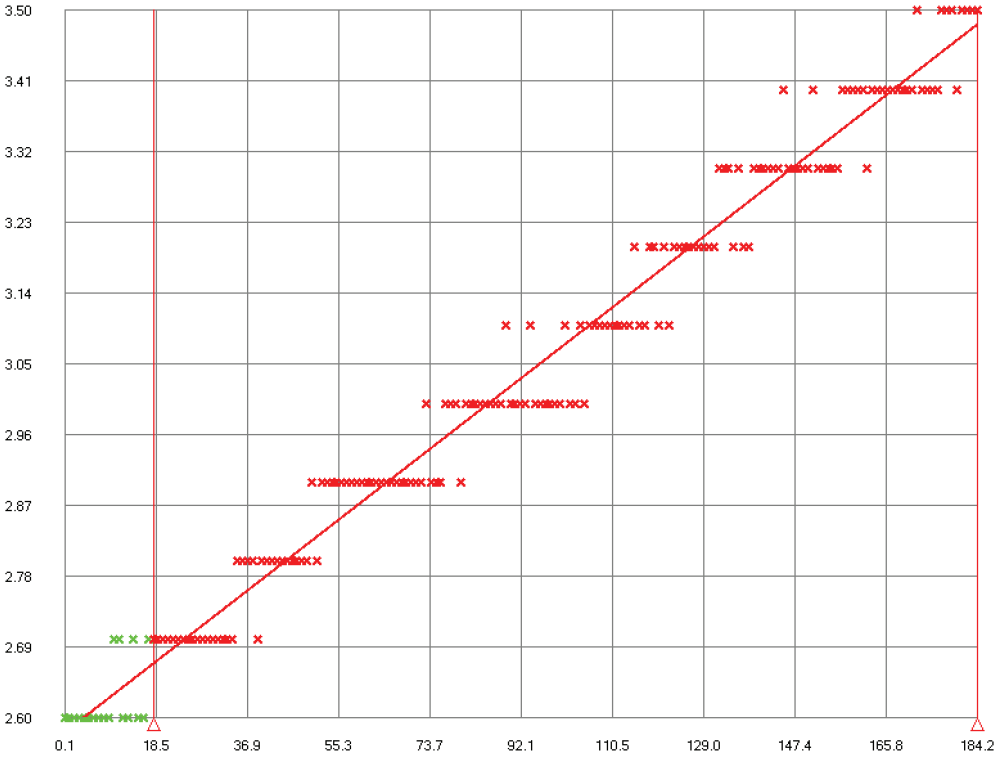
Start-up time
The methane detector is ready to measure in less than a minute.
During the warm-up time, the shown methane concentration is 0.

The following plot (ppm vs. seconds) shows a stability test while injecting atmospheric air for about 1,000 seconds.

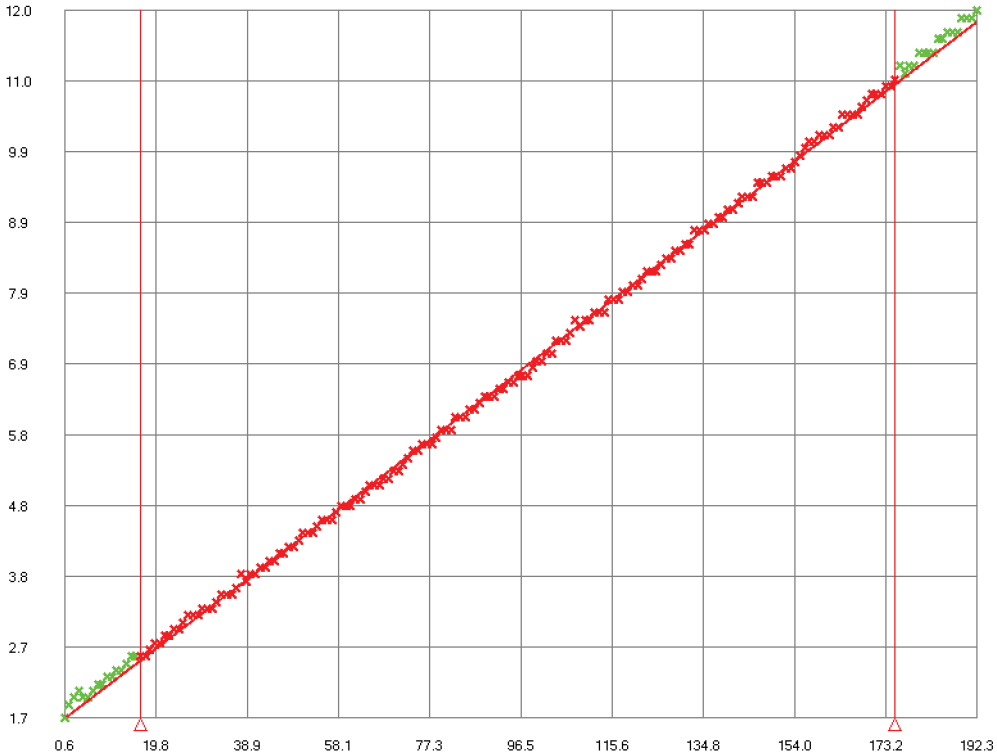


*The detector is actually able to measure concentration up to 100% vol, which is not purpose of soil emission measurement.

The plot (ppm vs. seconds) shows an accumulation curve while measuring a flux of 1.7 mmoles/m2 per day



The plot (ppm vs. seconds) shows an accumulation curve while measuring a flux of 18 mmoles/m2 per day

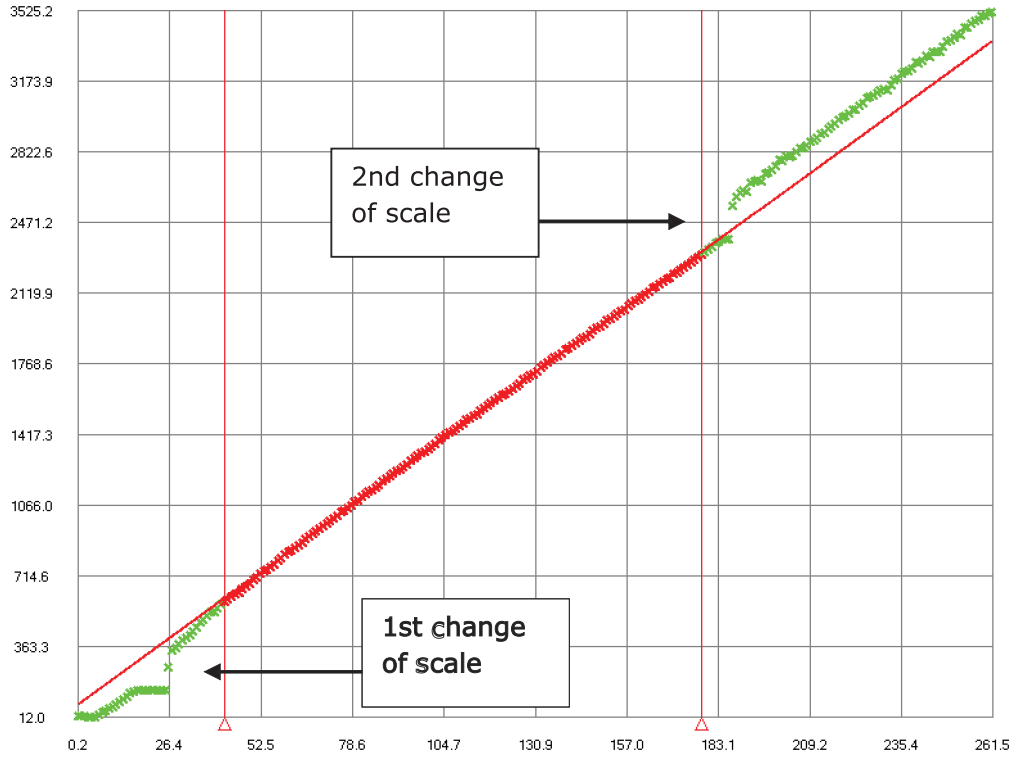


WS-CH4-TLD Methane Detector

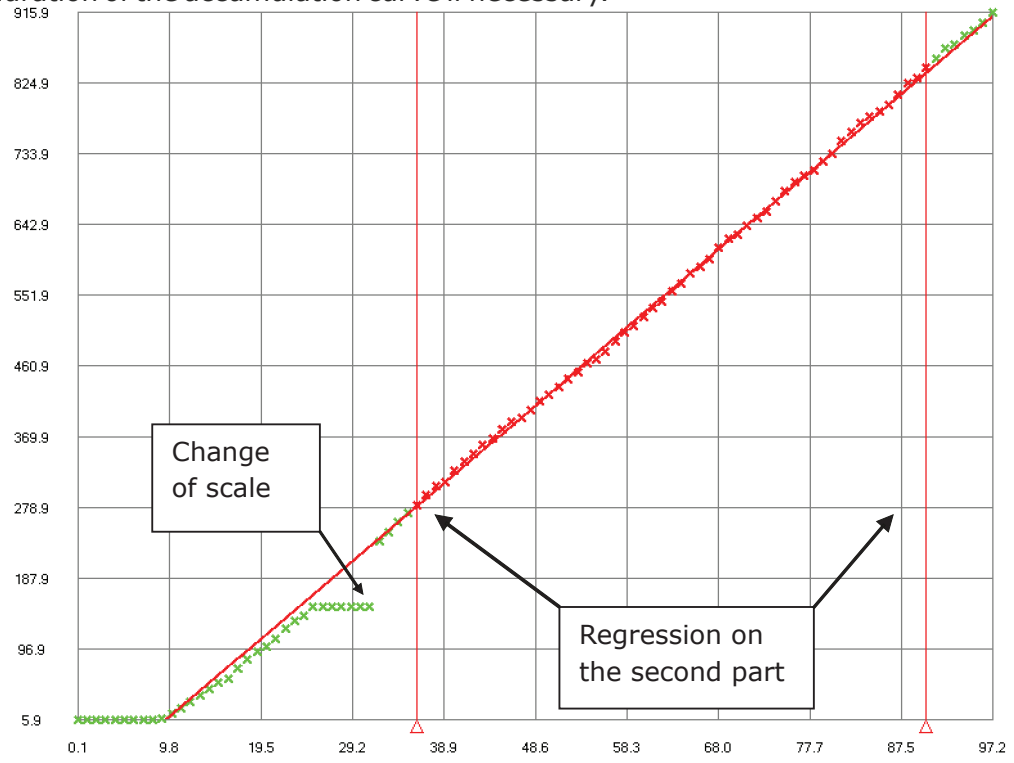
In order to guarantee the measuring of CH4 concentration in a wide range (0-100% vol),the sensor needs to apply different settings on the laser diode.This adaptations produce a gap of a few seconds during which a valid concentration value is not available.

Computing flux

The sensor presents a first change of scale around 140-150 ppm and a second change around 2300-2400 ppm. During a change of scale, the value remains constant for about 10 seconds.



If you cross that threshold during the accumulation curve, please apply the interpolation on the second part of the curve. Do not include the ten-seconds gap into the linear regression in order to prevent measure errors. Extend the duration of the accumulation curve if necessary.



Calibration of the methane detector

General discussion

The subjects regarding calibration of your portable instrument for the measurement of diffuse flux will be discussed in this chapter.

As explained previously in Chapter 4 the flux measurement is proportional to the slope of the concentration curve versus time. The proportionality factor depends on the volume/surface ratio of the accumulation chamber used for the measurement, as well as the barometric pressure and air temperature at the moment of the measurement.

The most important aspect to understand is that the flux is proportional to the gradient of concentration over time: ppm/second.

This aspect allows us to simplify the control of the response of the used gas sensors.

Each time a measurement campaign is initiated the instrumental response of the gas sensors must be verified. If the error is not acceptable, the instrument has to be sent to West Systems for calibration.

To simplify the explanation see the following example:

Calibration control example:

Before verifying the calibration turn on the instrument and leave it on for a minimum of 5 minutes to stabilise the temperature of the detectors.

In order to injext a mixture into the detector, we suggest filling a gas sampling bag (e.g. Tedlar bag) from the cylinder and then let the pump of the fluxmeter flow the gas inside the detectors. In this way, it's possible to recreate a scenario as mush as possible similar to the on field measurement.

Step1: Verifying the zero:

Inject a flow of nitrogen, or synthetic air, into the instrument and read the concentration on the palmtop screen. Obviously, it is important that the injected mixture doesn't contain methane.

The method for injecting standard gas mixtures is explained in detail in the following pages.

Step2: Verification of the span:

Inject a standard mixture containing methane in a concentration possibly close to the values you reach when measurering maximum fluxes (example 10,000 ppm).

Let's suppose that the performed test gave the following results:

Injecting a mixture at zero concentration of CH the detector returns a reading of 0 ppm.

Injecting a mixture containing a 10,000 ppm concentration of CH detector returns a reading of 9930 ppm.

At a variation of concentration set at 10,000 ppm the instrument has a slightly different response: 9930 ppm. The evaluation error is of about 70 ppm, which in percentage points over the span corresponds to -0.6%

The error in evaluating the increment in concentration manifests as a systematic error in the evaluation of flux and, therefore, must be corrected by calibrating the instruments when it is too high (> 5%).

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The palmtop

West Systems provides the station with a palmtop. To know the model of the palmtop please see the list of the package's components in chapter 1. For more information about the palmtop please read the palmtop's handbook equipped.

West Systems also provides a memory card with a preinstalled copy of FluxManager. We advise using this card as a backup copy of FluxManager and buy another card to store and transfer the data.

The PDA has a memory card slot, so West Systems provides an SD adapter thus you can plug the memory card into the adapter and then the adapter into the card reader of a PC and copy the FluxManager files.

If the battery of the PDA is down, you can recharge it with the fluxmeter battery. West Systems furnishes a cable for connecting the RS485 port on the fluxmeter external panel to the male USB A-type connector of the PDA USB cable (see page 5.10 for the cable's specification). When this cable is connected you can continue your field work while the PDA is recharging.

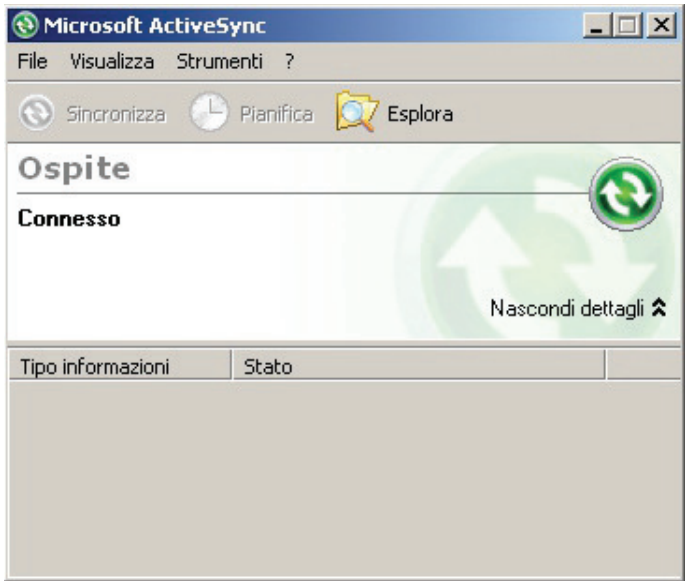
FluxManager installation

The FluxManager software is furnished by West Systems on two different supports:

- On the West Systems software CD.
- On the SD memory card.

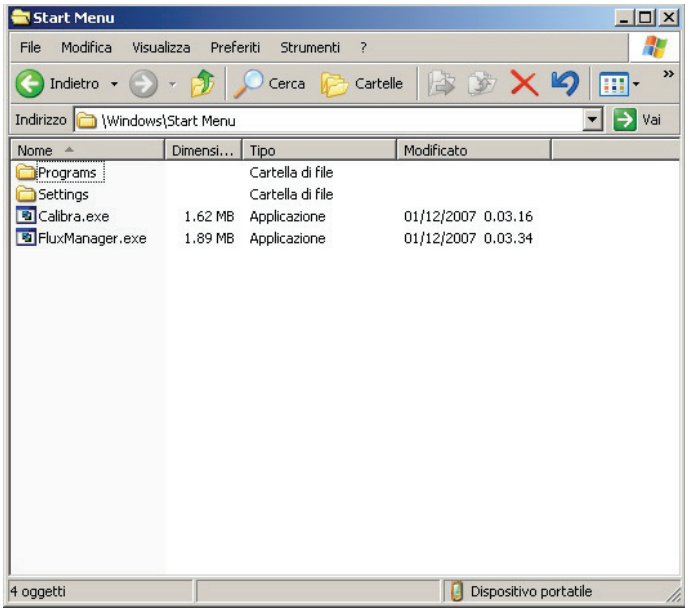
PC based installation

1- Connect the PDA to your computer using the USB cable. If Microsoft Activesync is installed, its window will appear:



2- Pressing the *Explore* button, Activesync will allow to navigate into the PDA directories.

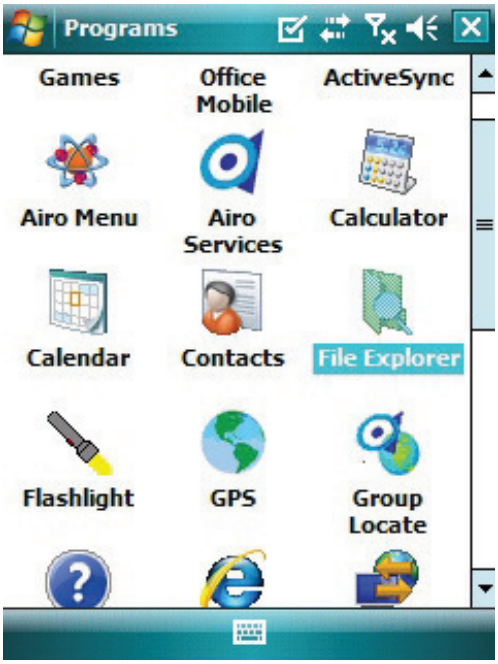
3- Navigate to the path *\Windows\Start Menu* and copy here the two files calibra.exe and FluxManager.exe from the software CD. From now on the executables files you just copied will appear when pressing the Start Menu of the PDA. The PDA furnished by West Systems has already the two files installed.



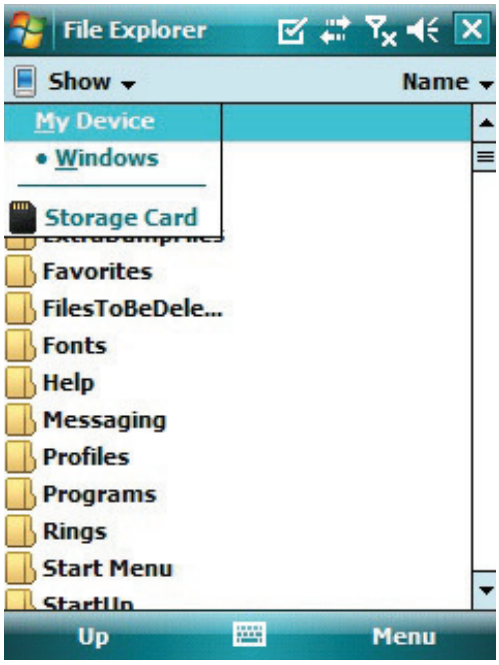
FluxManager installation

Storage card based installation

1- Insert the SD card into the SD slot of the palmtop.
2- On the PDA: press the Start button and then Programs. Run File Explorer.

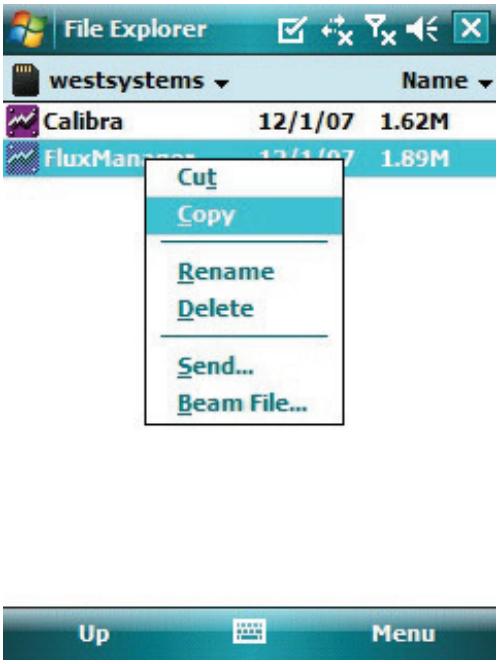


3- Navigate to Storage card.

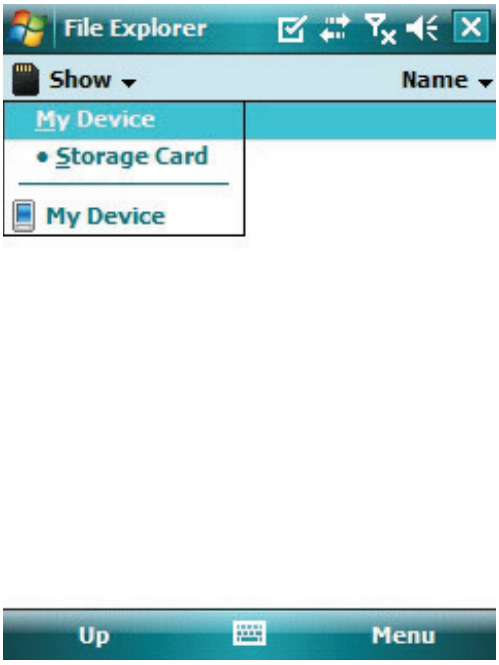


FluxManager installation

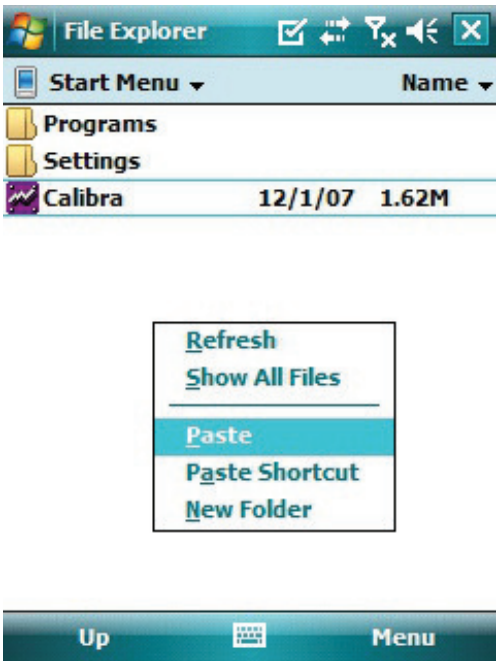
4- Copy FluxManager.exe by holding the stylus on the file for few seconds.



5- Navigate to My Device, then to the path *Windows**Start Menu*



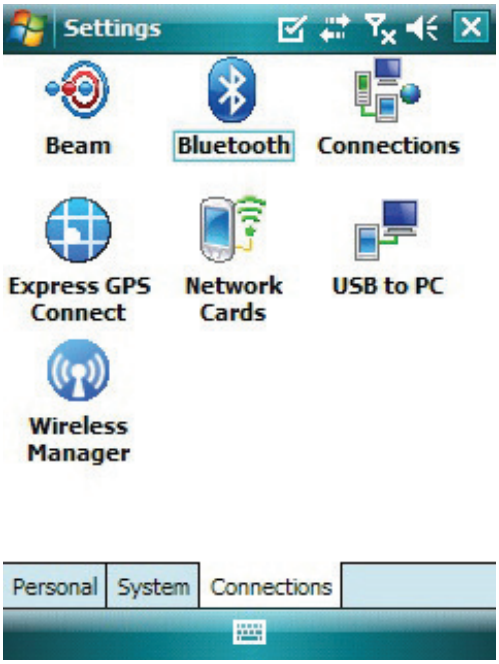
6- Hold the stylus in the white area and as the popup appears press *Paste*. From now on the executables files you just copied will appear when pressing the Start Menu of the PDA.



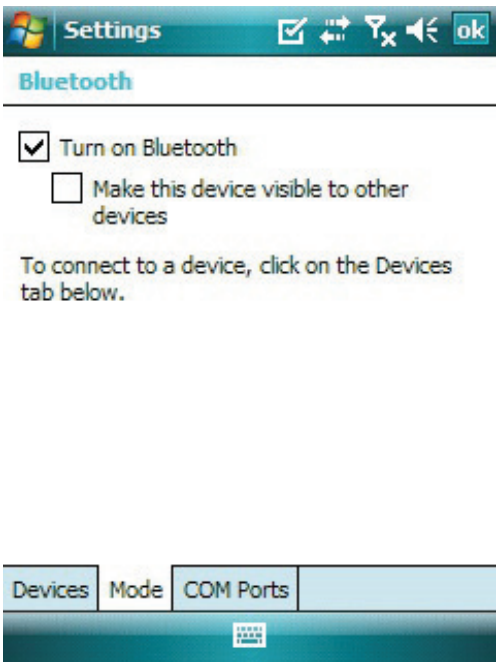
Bluetooth communication

The Bluetooth connection system allows the wireless management of the portable fluxmeter. A Bluetooth RS232 adapter is embedded into the fluxmeter and connected to the palmtop via radio. The operating range is up to 10 meters.
To setup the communication between the PDA and the fluxmeter:

1- Switch on the fluxmeter.
2- Switch on the palmtop. Once the Windows Mobile main page displays, press *Start* and select *Settings*. Go to *Connections* tab and select *Bluetooth*.



Make sure Bluetooth is active.

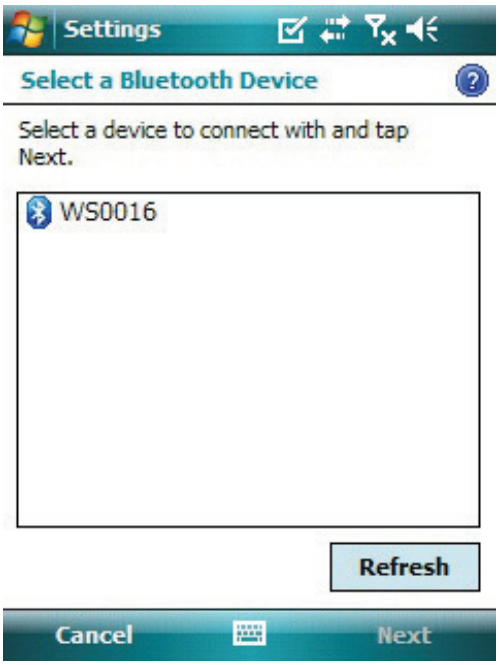


Bluetooth communication

3- Go to *Devices* tab and check if there is an item with the serial number of your fluxmeter (e.g. WS0001).

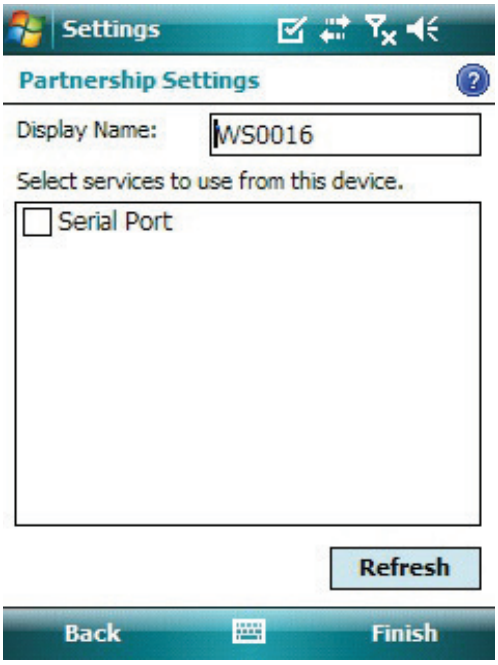
If it's displayed, go forward to point 4. If it's not (like in the picture), click *Add new device…* to start a Bluetooth search.

Click on the serial number of the instrument you want to add and click *Next*.



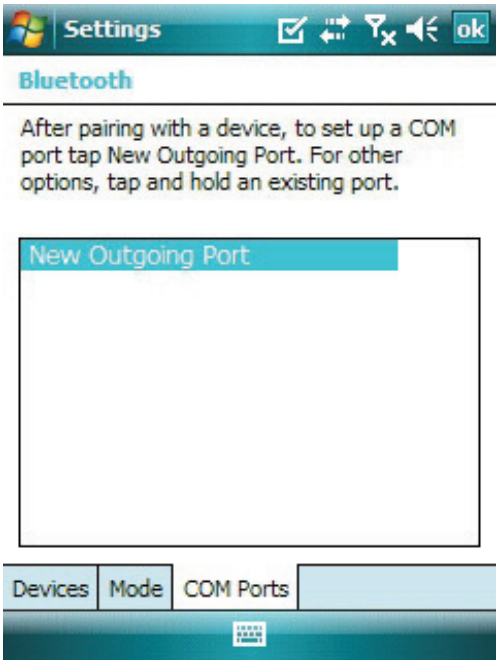
Bluetooth communication

Enter the passkey "1234" and click *Next*, then *Finish*.

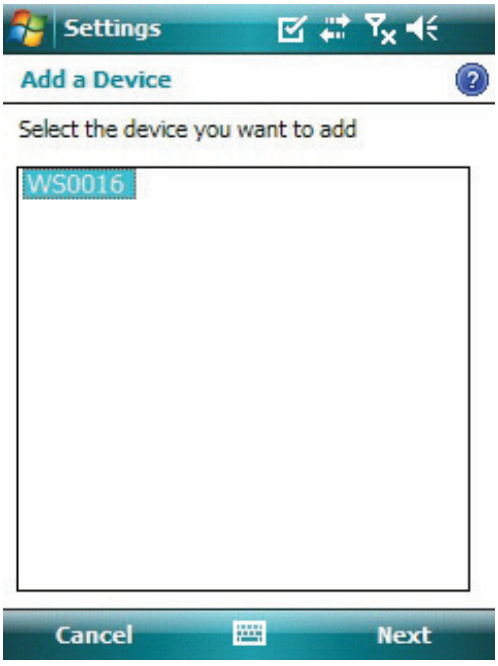


Now the instrument is in the list.

4- Go to the *COM Ports* tab and click *New Outgoing Port*.

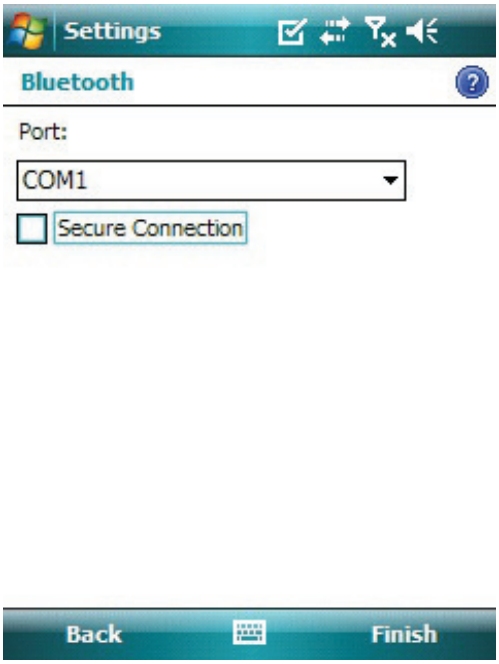


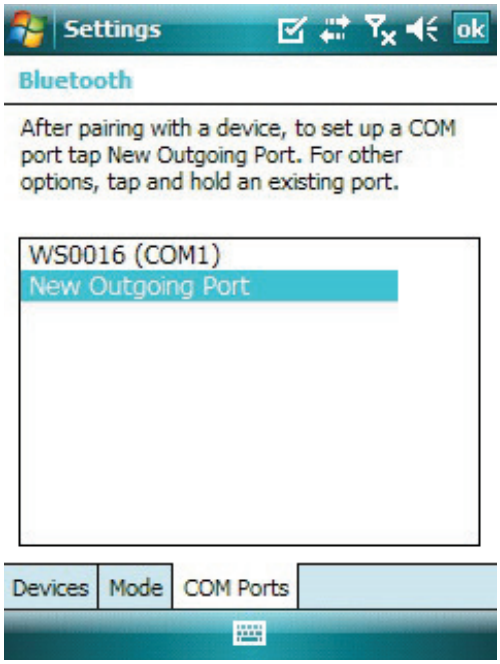
Select the device by comparing the serial number and click *Next*.



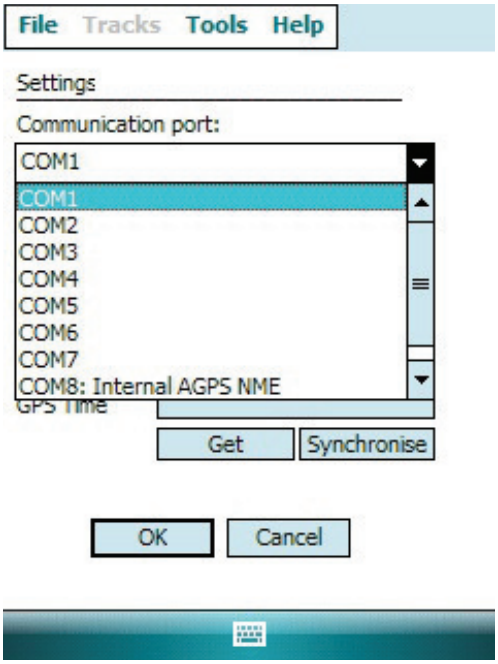
Bluetooth communication

Uncheck *Secure Connection* and select a port (e.g. COM1). Click *Finish*.





5- Now you can start FluxManager. Click *Tools* and then *Settings* and select the port you entered in the previous point (e.g. COM1).



Bluetooth communication

Now you're ready to perform a measurement. The PDA has an integrated GPS that you won't have to configure, FluxManager will recognize it.

West Systems provides a SD with a preinstalled copy of FluxManager. We advise using this card as a backup copy of FluxManager and buy another card to store and transfer the data.

The PDA has a memory card slot, so West Systems provides an SD adapter thus you can plug the memory card into the adapter and then the adapter into the card reader of a PC and copy the FluxManager files.

For more information about the palmtop please read the palmtop's handbook equipped.

Bluetooth communication

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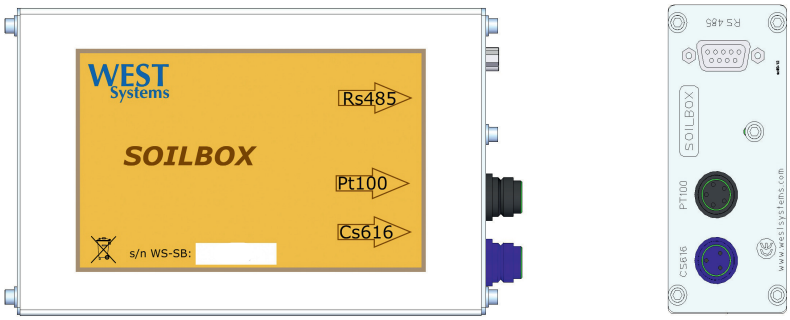
Soil Box

General description

The Soil.box is an hardware/software interface that convert the signal of Soil Temperature and of the Soil Water Content TDR CS616 sensor to a digital format compatible with the DF1A soilflux station.

The output of the Soil.box is a RS485 with the standard WEST Systems pin out. Since the SoilBox is designed to be the last device in the bus the RS485 line is terminated with a 120 Ohm embedded resistor.



Connections:

- RS485 --> IN A
- CS616 --> IN-B
- Pt100 --> OUT

Addresses

Description	LCD	Conf	Unit	LS	FS	ID0	ID1	ID2	ID3
Water Content %	TDR	A0	%	0	100	**1**	5	9	0D
Water C. Pulse	TDR RAW	A1	uSec	15	35	**2**	6	0A	0E
Soil temperature	6B13	22	°C	0	200	**3**	7	0B	0F
PT100 Resistance	6B13 R.	A2	Ohm			**4**	8	0C	10

Where:
LCD is the caption that the station display when the channel is selected.
Conf. Is the channel type
Unit is the measure unit.
LS is the minimum reading
FS is the maximum reading

The RED highlighted is the default set.
ID0 .. **ID3** are the base RS485 address of the device that you can set following the next table:

DIP SW	SW5	SW6	SW7	Addr 0
ID0	0	0	0	01
ID1	0	0	1	05
ID2	0	1	0	09
ID3	0	1	1	13

Dip SW 8 :Reserved for calibration / no actual function.

Please note that the soilbox is designed to works only with the CS616 CS water content TDR probe. The obsolete CS615 can not be used.

Please follow the instructions on the RS485 Expansion chapter of the station Handbook to configure the station.

SoilBox

Connectors pinout

Soil Temperature Pt100 Connections

Panel 3+T female connector

```
Pin 1:     Red 1
Pin 2:     Red 2
Pin 3:    White 1
Pin T:    White 2
```

If you're using a old Pt100 probe , supplied with the Rs485 HUB check that the pin T is connected to the White 2 wire of the Pt100 probe. If NOT please modify the Pt100 connection. A simple bridge between pin 3 and pin T can be enough , also if this simple solution can reduce the temperature measurement accuracy.

CS616 Connections

Panel 6+T female connector

```
Pin 1: Orange (Ignition)
Pin 2: Red (Power supply)
Pin 3: Green (Signal)
Pin 4: Black + Screen (Ground)
```

RS485 Connections

Panel 6+T male connector

```
Pin 1: Gnd   Black
Pin 2: A     Yellow
Pin 3: B     Green
Pin 6: +V12  Red
```

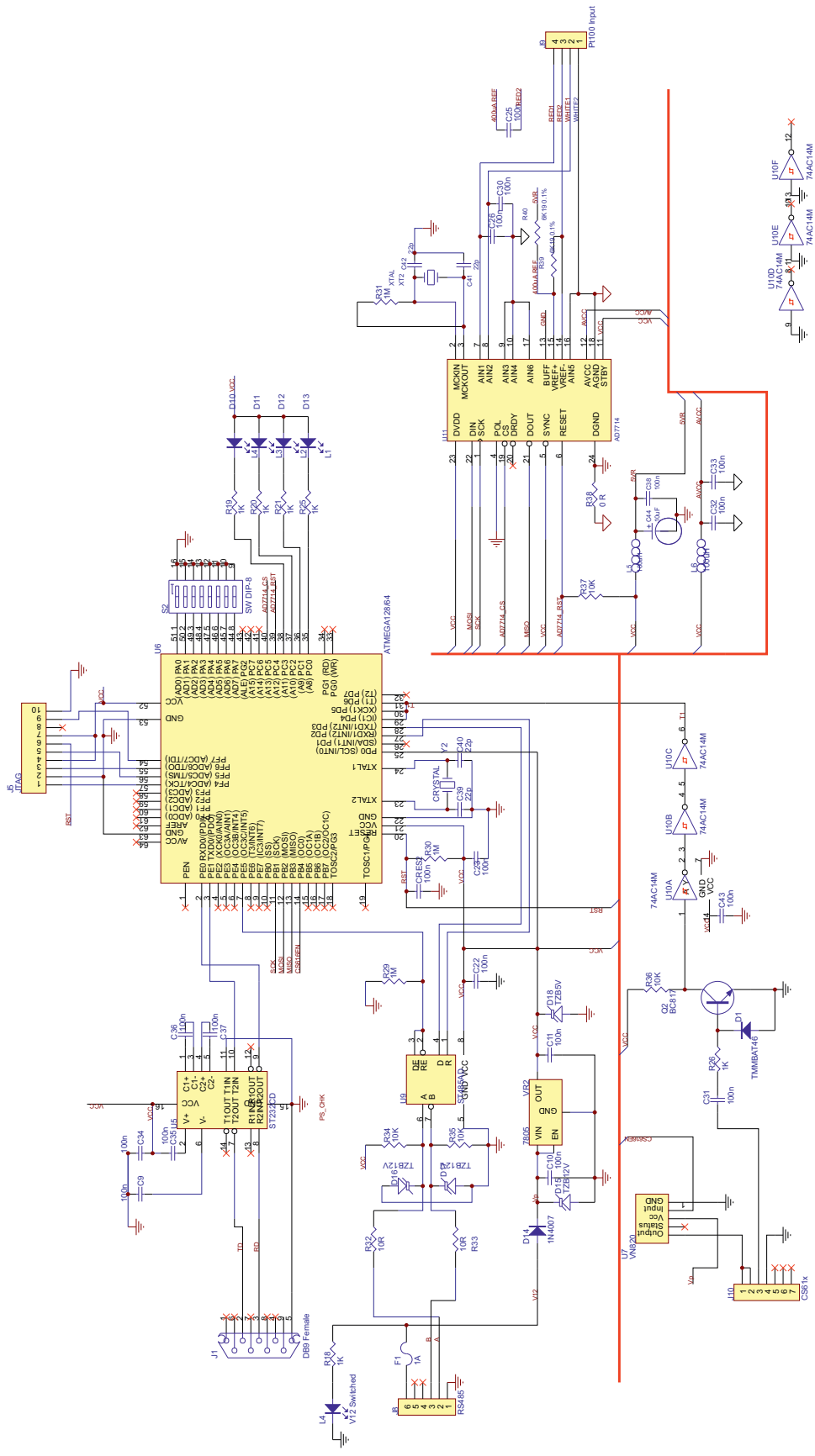
DIP switch settings

DIP SW	Enable/Disable	Factory Default
SW1	TDR	1
SW2	TDR RAW	1
SW3	6B13	1
SW4	6B13 R.	1

DIP SW	Enable/Disable	Factory Default
SW5	ID Set 0	0
SW6	ID Set 1	0
SW7	ID Set 2	0
SW8	Calibration	0

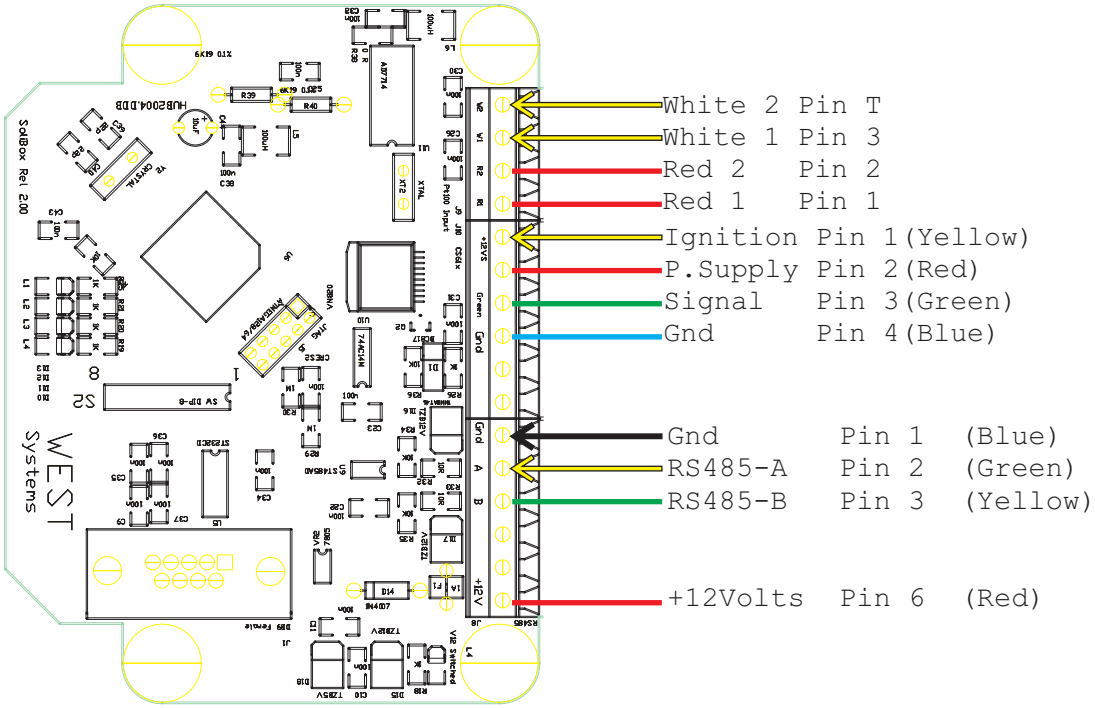
See page S.1

Schematic



SoilBox

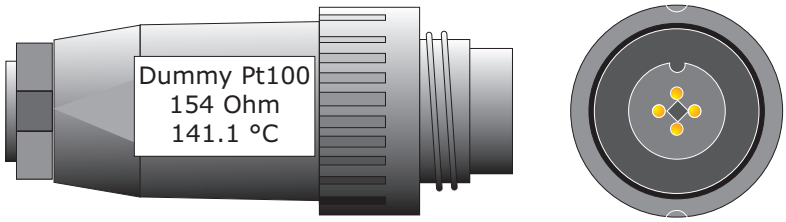
PCB Layout



Testing temperature channel

Connect the dummy Pt100 probe , you can ask with no charge to WEST Systems, to the soil box and check that the 6B13 channel reading is equal to the reading reported on the label attached to the dummy probe. The Dummy probe resistance has a tolerance of 1/1000 of the value reported on the label. The temperature reading error must be less than 0.5°C

WEST Systems provide a 100 Ohm (Zero degree Celsius) and a 154 Ohm (141.1°C) dummy probes.



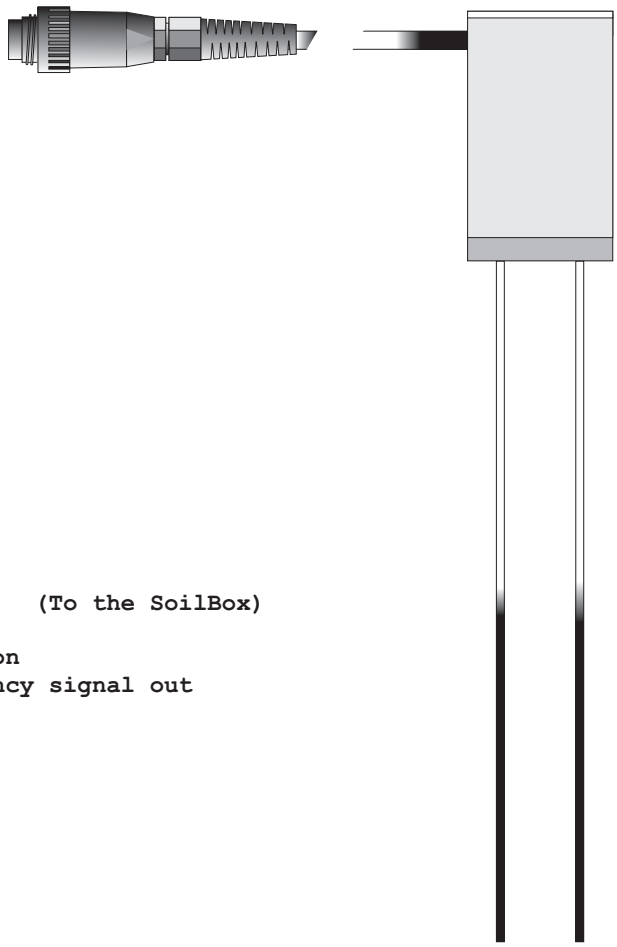
To check the soil pt100 probe use a calibrated termocouple or pt100 (better) portable gauge and compare the reading with the station one. A 1.6°C tollerance must be acceptedt if you use a K termocouple, a 0.5°C tollerance is normal if you use a Pt100 probe.

SoilBox

Soil water

Manufatcurer : Campbell Scientific
Ordering code : CS616 / CS615 (Out of stock)
Water content
Range 5-50 %
Accuracy 3%

The CS616 (CS615) Water Content Reflectometer measures the volumetric water content of porous media using time-domain measurement methods.
The Water Content Reflectometer consists of two stainless steel rods connected to a printed circuit board. A shielded four-conductor cable is connected to the circuit board to supply power, enable the probe, and monitor the pulse output. The circuit board is encapsulated in epoxy. The probe rods can be inserted from the surface or the probe can be buried at any orientation to the surface.
The CS616 (CS615) response is dependent on the dielectric constant of the material surrounding the probe rods. Water is the principal contributor to the dielectric constant value, but the solid constituents such as quartz, clay and organic matter also affect the measurement. The same calibration of volumetric water content to probe output signal period may not apply to all soils. Accuracy can be optimized by using calibrations derived for a specific soil. Accuracy of ± 2.0% over the entire water content range and for a wide range of soil types is routinely obtained in our laboratory. Applying the general calibrations from the operating manual provides accuracy of ± 3.0%.

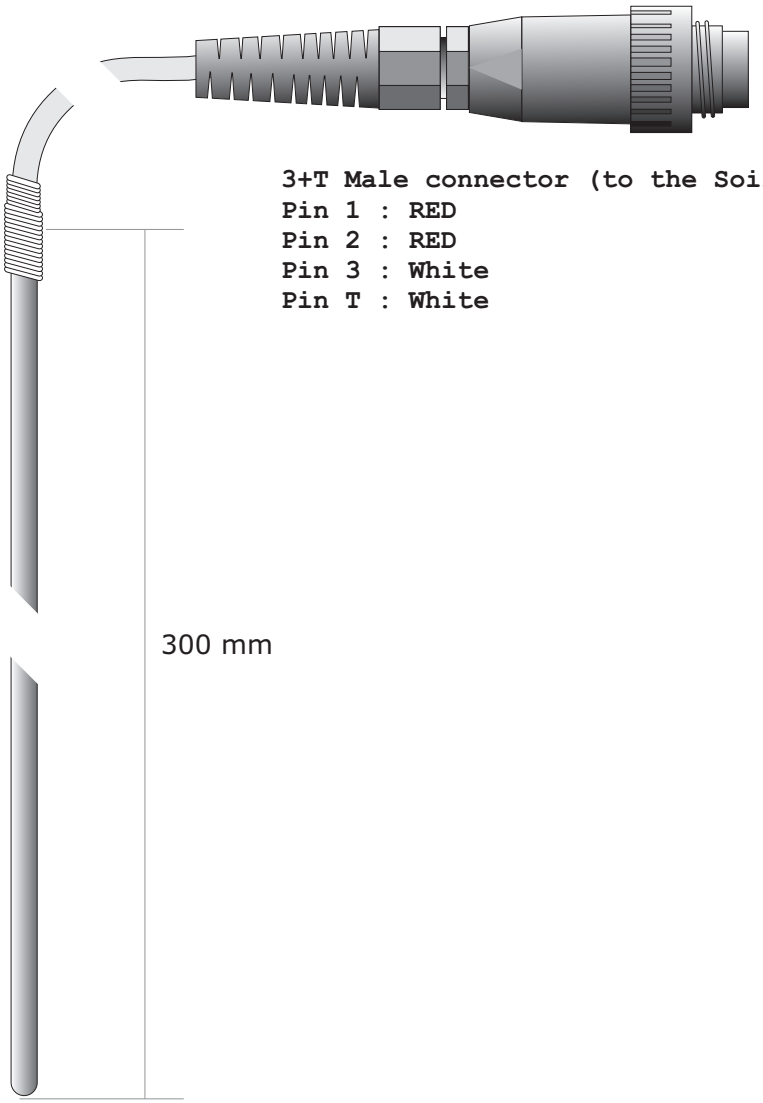


6+T Male cable connector (To the SoilBox)
Pin 1 : Red +12 Volt
Pin 2 : Orange Ignition
Pin 3 : Green Frequency signal out
Pin 4 : Black+Sh. Ground
Pin 5 : n.c.
Pin 6 : n.c.
Pin T : n.c.

SoilBox

Soil temperature

Manufatcurer : RS
Ordering code :RS 321-6090
Type : Pt100 DIN IEC 751 Class B 4 wires
Range 0 to 200 °C
Max operating temperature 200°C
Accuracy 0.3°C
Probe length 300 mm
Probe diameter 6 mm
Cable length 3 Meter
Cable PTFE and silicon insulated



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Portable flux meter handbook
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