



**VP** INSTRUMENTS

# ***VPFlowScope* (dP) Manual**

**VPFlowScope and VPFlowScope dP  
Firmware 1.15.1  
With VPStudio 2.0.0**



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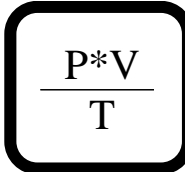
## WARNING – READ THIS FIRST



Congratulations! You have bought a state of the art insertion mass flow meter from VPInstruments! The *VPFlowScope* and *VPFlowMate* are versatile and easy to use and can be very powerful tools to monitor compressed air consumption. However, there are a few important issues you need to know before using these kind of instruments. Please also see the instruction manual before use!



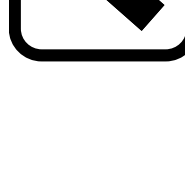
**Insertion probes can be dangerous!** Please familiarize yourself with the forces on the probe under pressurized conditions and ALWAYS use the safety chain or an additional safety belt when installing the instrument. Respect the local guidelines and regulations for working with pressurized equipment.



**Gas flow through pipes follows certain physical laws.** These physical laws have serious consequences for the installation requirements. Familiarize yourself with these laws to make sure that the product is installed correctly. Always make sure that upstream length, downstream length, flow, pressure, temperature and humidity ranges are within specifications.



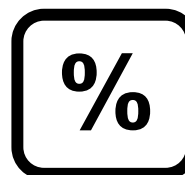
**Precision instruments need maintenance.** Check your flow meter regularly and make sure it remains clean. When polluted, gently clean the sensor using demineralised water or a light cleaning solvent.



**Precision instruments need regular re-calibration.** The *VPFlowMate* and *VPFlowScope* are guaranteed for 24 months when used in clean, filtered, oil free and dry compressed air. When any of these conditions is not met, the re-calibration interval may become shorter than 24 months. VPInstruments offers service contracts which cover a one year re-calibration, firmware upgrades and minor repairs.



**Not intended for fiscal metering or billing.** The *VPFlowMate* and *VPFlowScope* are not intended for fiscal metering, as they can be shifted or turned during operation. VPInstruments recommends using in-line flow meters or a special welded fixture for these applications. Laws on fiscal metering and billing may vary per country or state.



**Do not overestimate the results.** The practical measurement uncertainty of an insertion probe is +/- 5%. Do not expect less than 5% measurement uncertainty from any insertion-based measurement as this is physically impossible due to the nature of turbulent pipe flows. Our products are not intended to be used as a single means to determine compressor capacity. Products are subject to improvement. VPInstruments offers software and firmware releases. Please visit [www.vpinstruments.com/downloads](http://www.vpinstruments.com/downloads) for details.



**Feedback leads to product improvement.** Please share your experience with us, as we are continuously improving our products in our commitment to quality, reliability and ease of use.

Keep the above mentioned issues in mind and we are confident that you will enjoy using our products over their complete lifetime.

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# 1. Introduction

Congratulations! We thank you for your order and the confidence in our company. You purchased the most easy to use compressed air measurement tool in the world. With the *VPFlowScope (dP)*, you can monitor and record flow, pressure, temperature, and total air consumption, simultaneously.



Installation is very easy. In chapter 4 the plug and play installation/usage is explained. You find information on the display of the *VPFlowScope (dP)* in chapter 5. Chapter 6 shows the extended usage of the software program VPStudio. Other installations, using 4..20mA and Modbus outputs, can be found in chapter 7. Please read first the basic installation in chapter 4 carefully. Finally chapter 9 shows how you can service and maintain your *VPFlowScope (dP)* best.

It is advised to get familiar with the *VPFlowScope (dP)* and its functionalities before using it in the field, so you fully benefit from this tool. We advise to hook up the *VPFlowScope (dP)* first and see how the display works and where you can find the different features.

Check the packaging box for any inconsistencies. Should there be any shipping damage, notify the local carrier. At the same time a report should be submitted to Van Putten Instruments BV, PO BOX 151, 2600 AD DELFT, The Netherlands.

## 2. VPFlowScope vs. VPFlowScope dP

The difference between the *VPFlowScope* and the *VPFlowScope dP* is in the sensor module. The technology is different and therefore the specifications and the applications of the instruments are different. The accessories, like the display and VPStudio software, are the same and can be interchanged. See the table below with the biggest differences. For more specifications on both instruments, see chapter 10.

	<b>VPFlowScope</b> 	<b>VPFlowScope dP</b> 
Technology	Thermal mass flow principle	Differential pressure technology
Flow range	0,5...150 m <sub>n</sub> /sec (1,7..492 sfps)	20..200 m <sub>n</sub> /sec (65..650 sfps)
Temperature range	0..60°C (extended 80°C) (32..140°F (extended 32..176°F))	-40..+150°C (no icing) (-40..+302°F)
Pressure range	0..16 bar <b>GAGE</b> (0...232 psi <b>gauge</b> )	0..10 bar <b>ABSOLUTE</b> (0..145 psi <b>absolute</b> ) Refer to product label
Advantage	Thermal mass flow technology has a high rangeability; thus with the same sensor you can measure very low flows and high flows.	The differential pressure technology is over 100 years old and has been proven as an accurate measurement. This technology is less sensitive for dirt and water.
Humidity	0..95% (no condensation)	100% condensation (no icing)
Air quality	Measure in dry and clean air only! Always after the dryer and filter.	Measurement in both dry and saturated air.
Examples of usage	Leakage management, point-of-use measurement, efficiency monitoring for complete compressor system, air allocation per department.	Directly down stream the compressor, to measure the flow output of the compressor.

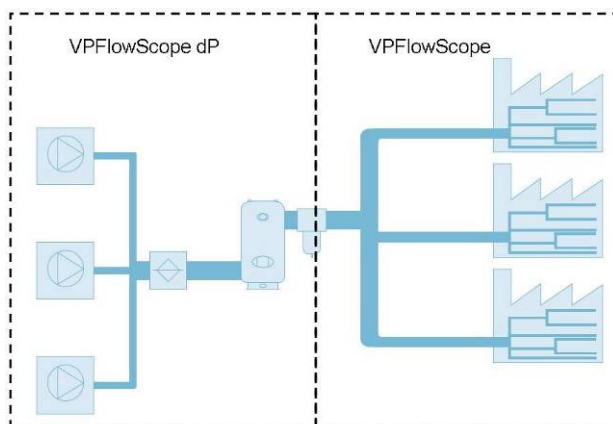
\* Specifications can change. Always check the label of your *VPFlowScope* (dP)

### Usage VPFlowScope vs. VPFlowScope dP

Always check with each sensor the specifications;

- Flow range (both maximum and minimum flow),
- Inner pipe diameter,
- Pressure range,
- Temperature range,
- Humidity

In general, you can use our instruments in all applications that stay within the specifications of the instruments. The intended usage of instruments are as shown in the picture aside:

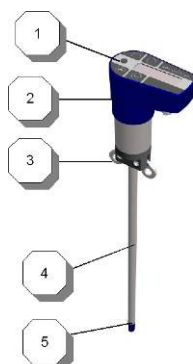




### 3. Product overview

#### 3.1 VPFlowScope and VPFlowScope dP with display and data logger

The VPFlowScope (dP) measures mass flow, temperature and pressure simultaneously. The LCD display provides real time information. With the built-in data logger, you can make recordings for a certain period of time.



##### Description

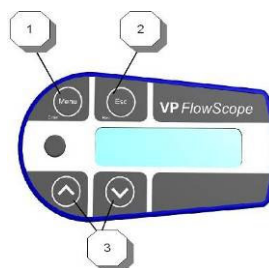
1. Fixation screw
2. Display module: with data logger memory
3. Sensor module: contains the flow, pressure and temperature sensor.
4. Probe shaft (0,5")
5. Multi sensor

##### Display module:

The keypad provides access to the VPFlowScope's most used functions. For advanced functions, the VPStudio configuration software is used.

The three line display is equipped with an automatic back light.

In the menu all functions are controlled as follows:



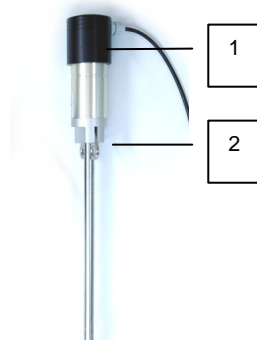
##### Description

1. Menu / Enter button
2. Escape/ Record button
3. Up/ Down arrows

Menu	To go to the display menu
Enter	To enter values or move cursor to right
Esc	Up one level or move cursor to left. Stop data logging
Rec	When you are not in the menu, press 'Rec' to start data logging
Down arrow	Move down in the menu or lower value
Up arrow	Move up in the menu or higher value

#### 3.2 VPFlowScope (dP) with connector cap

The VPFlowScope (dP) can also be delivered with a connector cap. Read out is only via the 4..20mA or RS485 outputs. See chapter 7.



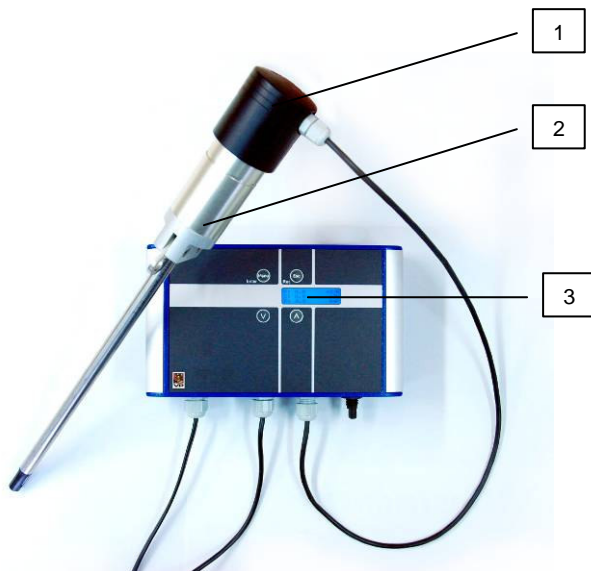
##### Description

1. Connector cap with M12 connector.
2. VPFlowScope (dP) sensor module.

### 3.3 VPFlowScope (dP) with VPFlowTerminal

The VPFlowTerminal features a pre-mounted connector cap for the VPFlowScope (dP) sensor module. The keypad for data configuration, connection to the VPStudio software and the optional data logger, are all located in the VPFlowTerminal. All communications go via the VPFlowTerminal.

The display and keypad are the same as on the VPFlowScope display, see previous page to handle the display keypad. For further usage of the VPFlowTerminal, we refer you to the VPFlowTerminal user manual.



#### Description

1. Connector cap pre-mounted to VPFlowTerminal via 10m (32.8ft) cable.
2. VPFlowScope (dP) sensor module.
3. VPFlowTerminal with display and keypad

## 4. Getting started; Step by step with VPFlowScope (dP) start kit

In this chapter the usage of the VPFlowScope and VPFlowScope dP start kit step by step. This includes the installation and use with the interface split box and RS485-USB converter.

The VPFlowScope (dP) can also be delivered with a cable with open wires, with a connector cap or with a VPFlowTerminal. See the next chapters for this usage.



### **VPFlowScope**

Dry and clean air only! Make sure you are measuring behind a dryer and filter.

### **VPFlowScope dP:**

Saturated and dirty air. The VPFlowScope dP can also be used for clean and dry air. Check both minimum and maximum flow range.

### 4.1 Step 1: Put together the VPFlowScope (dP)

Connect the display to the VPFlowScope (dP) sensor module. Make sure that the display slides completely over the O-ring seal. Apply some O-ring grease if required. Gently fix the screw on top of the display (see picture).

### 4.2 Step 2: Install the VPFlowScope (dP) in the pipe

First select the right installation point. The installation point is crucial for the right measurements. Sources of error can be: installation effects, unknown flow profiles, swirls, pressure and temperature effects, humidity effects, oscillations in the flow. To ensure the highest possible accuracy of flow measurement, the installation and piping instructions must be followed carefully. Therefore read this paragraph carefully.

#### **Take into account:**

- Choose a site which is accessible, which allows ease of wiring and maintenance, and which allows you to still read and access the display if possible.
- Meet the specifications of the VPFlowScope (dP). When the specifications are not met, for instance the pressure or temperature level is too high; this will cause inaccurate flow measurement and can even damage your flow meter.
- Do not apply mechanical stress on the sensor head.

#### **Avoid:**

- Excessive heat, check the temperature range of your VPFlowScope (dP).
- Potential water damage on the outside. Avoid areas of high humidity and avoid dripping. Be aware that the VPFlowScope (dP) is not watertight, it is only splash proof. Avoid also corrosive atmosphere where possible.
- Condensation Use only the VPFlowScope dP.
- Corrosive atmosphere where possible.
- Electrical problems (high voltage/ high power).
- Mechanical vibration and danger (walking bridges, fork lift trucks).
- Any source of potential error.



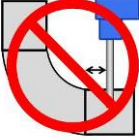
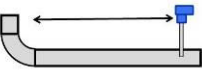
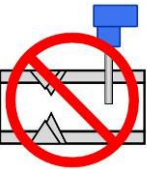
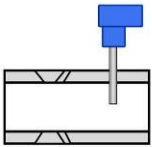
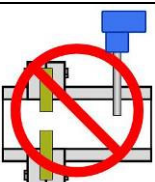
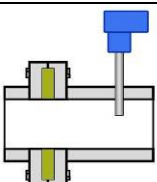

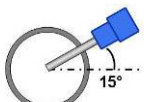
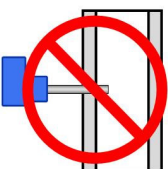
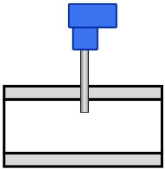
**Warning:** These devices are only for use with air, nitrogen and other non hazardous, or non combustible gases. The maximum working pressure is 16 bar (232 psi) for the VPFlowScope and 10 bar (145 psi) for the VPFlowScope dP. Different pressure ratings are indicated on the product.

## Pipe size

Recommended minimum pipe diameter: 2"

Exception *VPFlowScope* (thermal sensor only!): from 1" and up. Be aware though that the field accuracy is approximately 10%, since installation errors have a bigger effect on the measurement accuracy.

## Piping guidelines

DONT'S	DO'S
	 <p>Like any flow meter, the <i>VPFlowScope</i> (dP) requires a minimum up- and downstream piping. The immediate up- and downstream piping must be of sufficient length, straight and free of obstructions. Check the piping table on the next page for details!</p>
	 <p>Weld beads on the internal wall of the pipe before or after the <i>VPFlowScope</i> (dP), should be ground flush with the pipe wall before the meter is installed.</p>
	 <p>Proper style and proper size gaskets should always be used when installing the <i>VPFlowScope</i> (dP).</p>
	 <p>It is advised to install the <i>VPFlowScope</i> (dP) probe of least at an angle of 15° upwards. This to prevent the built-up of water in or around the sensor or the connection tee. Water will have effect on the measuring results.</p>
	 <p><i>VPFLOWSCOPE</i> DP only: Do not install in vertical piping, since the sensor can be clogged with water. Install preferably in horizontal piping. The <i>VPFlowScope</i> (thermal mass sensor) can be installed in vertical piping.</p>

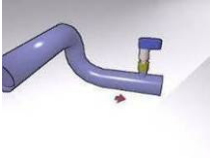
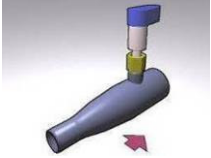
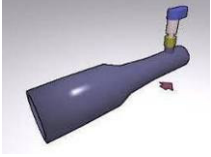
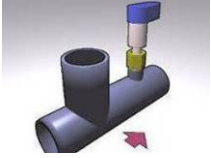
## Piping table

**General rule:** At least 20 times the pipe diameter upstream and at least 5 times the pipe diameter downstream, to avoid any distortion of the flow profile.

For some exceptions the upstream length needs to be longer, or can be shorter. Check the piping table below for your application.



If possible, you can always choose a longer upstream length, as these are minimum values. The up- and downstream lengths are used industry wide as guidelines, and will never be a guarantee for obtaining the "true value". So always be careful and try to build up your own experience from practical measurements.

Upstream object	Description	Minimal length
	Double elbow These objects cause swirl and unequal flow profiles.	40 *D
	Diameter change (small >> big) Diameter changes can be abrupt or sloped. These changes may cause jet shaped flow profiles, which result in a high reading.	40*D
	Diameter change (big >> small) These objects have a positive effect. They flatten the flow profile.	10 *D
	Closed or open branch. These objects generate vortices and flow profile disturbance.	30*D

See also to the ISO 14511:2001 ("Measurement of fluid flow in closed conduits- Thermal mass flow meters") international standard.



#### Communication with end-user

Sometimes you cannot meet all the installation guidelines and you have to install in non-perfect conditions. In some cases: a measurement with higher uncertainty is better than no measurement at all. Communicate this with your end-user, so they can take this uncertainty into account.

#### Prepare the installation

The VPFlowScope (dP) can be inserted through a welding tap with internal 1/2 inch thread or through a hot tap saddle (see pictures). A hot tap saddle can be installed under pressurized conditions, so there is no need to shut down production.



Use a ball valve to insert and retract the VPFlowScope (dP) when you want. Use a 1/2 inch full bore ball valve or a 3/4 inch ball valve. The VPI hot tap drill has a 1" drill size. In that case, place a 1" ball valve and use, after drilling, a reducer to go back to 1/2" for the compression fitting.

The line on the VPFlowScope (dP) insertion probe indicates when it is safe to close the ball valve, when retracting the VPFlowScope (dP) from your system. This is for a standard ball valve, check first with your ball valve if this also applies for your application.

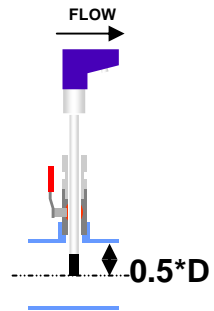


## The installation

### Insertion depth

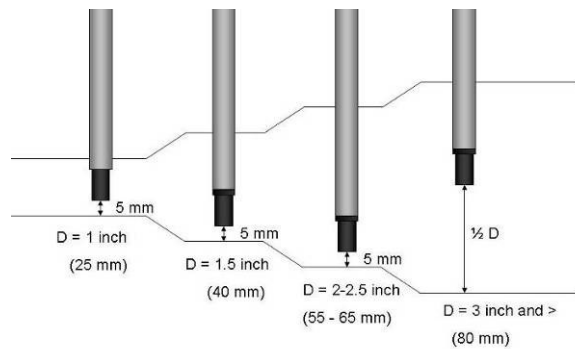
Generally the insertion depth of the VPFlowScope (dP) is 0.5 times the inner pipe diameter, where the bottom of the sensor must be in the middle of the pipe (see picture).

The VPFlowScope (dP) is shaped to make alignment with the flow direction easy. Alignment "by the eye" is sufficient. See also the technical drawing in appendix A for right installation.



### Exception VPFlowScope (thermal sensor only!)

Between pipe sizes of 1" and 2": be aware that the field accuracy is +/- 10%; installation errors are bigger. The insertion depth between DN25 and DN65 is also different. The VPFlowScope has to be inserted almost completely or else the temperature sensor of the VPFlowScope itself is outside the flow path. See picture on the right.



### SAFETY FIRST: START WITH MOUNTING THE SAFETY LINE!

The VPFlowScope (dP) is mounted with a 1/2 inch compression fitting. The probe is sealed with a Teflon ferrule instead of a stainless steel ferrule. Teflon may become slippery. The safety line will keep the sensor secure when it accidentally moves out of the compression fitting.

NEVER over-tight the fitting, because it might damage the sensor tube.



1. Insert the compression fitting in the welding tap. Use Teflon tape or liquid sealant.



2. Keep the ball valve closed!



3. Insert the VPFlowScope(dP) probe.



4. Mount the safety line. Hook the safety line up in the ring of the VPFlowScope (dP). For extra safety, you can add a luggage strap (like for suitcases).

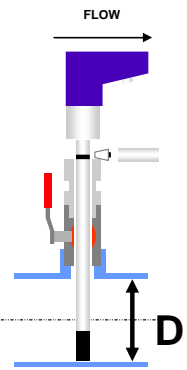




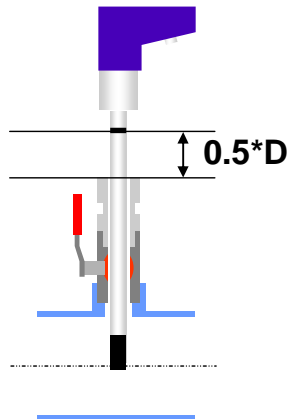
5. Place a mark on the probe, to identify the place where it is safe to close the ball valve when retrieving the VPFlowScope (dP).



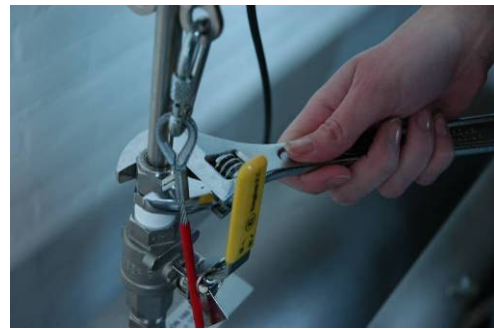
6. Open the ball valve and slowly push the VPFlowScope (dP) probe completely in.



7. Push the probe in till it hits the bottom of the pipe. Now place another mark on the probe.



8. Retrieve the probe half the pipe diameter. Adjust the safety line (and strap) to keep the VPFlowScope (dP) in place. Keep in mind to align the VPFlowScope (dP) with the flow direction.



9. Gently tighten the compression fitting. Do not over tighten to prevent damage to the probe. Pull the probe to check if the compression fitting is tight enough.



10. Now your VPFlowScope (dP) is installed.

### 4.3 Step 3: Connecting the cables

Connect the VPFlowScope (dP) via the interface split box to the 12V adapter. (See Appendix B for Electrical guidelines.)

Immediately after start up you see the firmware version in the display. One more step is required for configuration. The VPFlowScope (dP) needs to know the inner tube diameter to display volumetric flow values.

Programming the inner tube diameter in the display:

1. Menu > settings >> tube diameter.
2. Use up and down arrow to change the digit.  
Use enter/escape to move the cursor right or left.
3. Press enter.

The tube diameter can also be entered by the software, see next chapter.

#### Display defaults:

The display shows real-time information:

- Mass flow:  $m_f$ /sec
- Pressure: bar  
VPFlowScope: bar **GAUGE**  
VPFlowScope dP: bar **ABSOLUTE**
- Temperature: degrees Celsius.



Other units like sfps, scfm, psi, are available. Change these units in the display. Press Menu >> Settings >> Display. Use the up and down arrows to go through the list. Press Enter to select per line the right unit.

Now your VPFlowScope (dP) is completely installed and ready for use.

### 4.4 Step 4A: Real-time read out with the VPStudio software

#### Step 4A.1: Install VPStudio software

Click vpstudio.msi on the CD ROM and follow installation steps. All necessary drivers for later on can be found in the program folder of VPStudio (dP) on your computer, subfolder 'Drivers'.

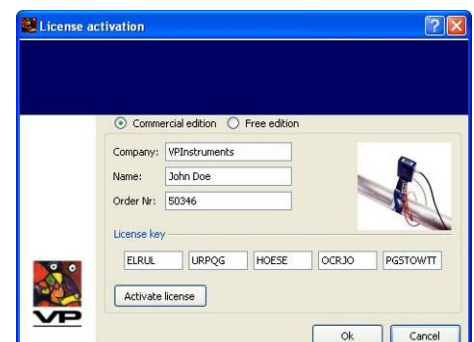
#### Step 4A.2 Install the RS485-USB driver

See picture to connect the RS485-USB converter. Inserting the RS485-USB converter in your PC, the computer will recognize it and will install the driver. You can also find the driver files on the CD ROM, which is delivered with the USB converter. Note: every time you put the USB converter in a different port, the computer needs to install the driver again.

Open VPStudio.

#### Step 4A.3 License key

First time you open it: the license activation screen will appear. Find the license key with your order. It is capital sensitive. Enter your license key and Activate. Click OK if it was successful.





### Free edition

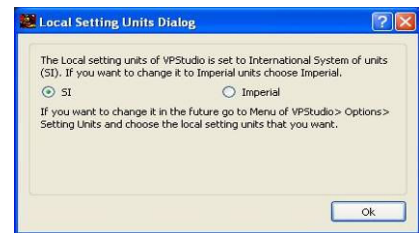
The Free Edition is available to configure the basic settings of your VPFlowScope (dP), like the pipe diameter. Select “Free edition”, click “Activate License” and you can use the VPStudio- Free edition.

To change the license key go to Menu – Help – License Manager.

### Step 4A.4 Set units

First time you open VPStudio: The local setting Units Dialog appears. Choose here which units you prefer. Click OK.

You can always change the units in the menu of VPStudio: Options > Setting Units.

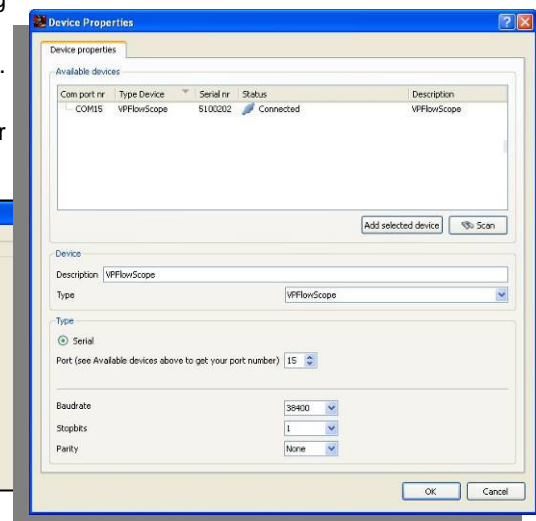


### Step 4A.5: VPStudio > Add new device

First: create your VPFlowScope (dP) in VPStudio. Click right mouse button in the explorer field and click 'New device'.

The 'Add New Device' window appears.

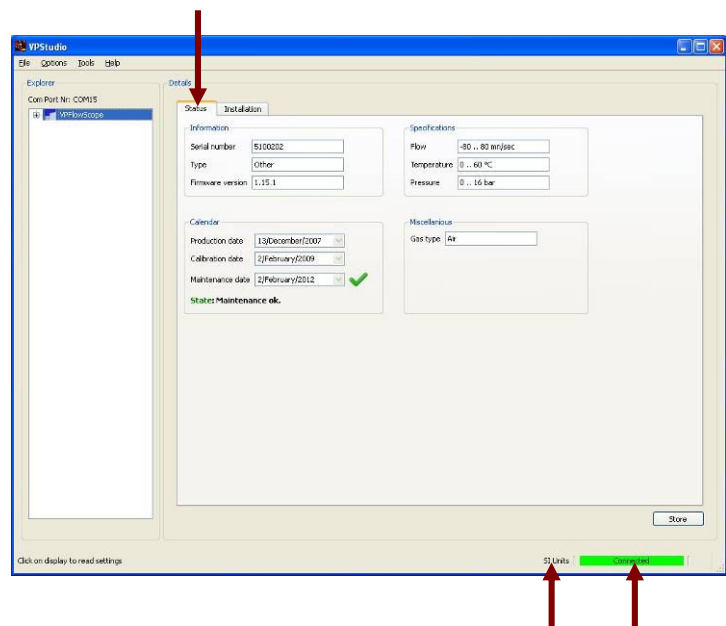
- Press “Scan” button to show all possible connections on your PC. In the ‘Available Devices’ column, search for the VPFlowScope you want to connect (here COM15).
- Select the VPFlowScope and click “Add selected device”.
- Write in the ‘Description’ field a name of your choosing (VPFlowScope here).
- All other parameters will be pre-configured automatically. Type: VPFlowScope. Serial port: Number of port: here 15.
- Press OK. The VPFlowScope is added in the explorer field.



- See you connection status: right below corner. When it is disconnected: check if the VPFlowScope is wired and connected correctly.

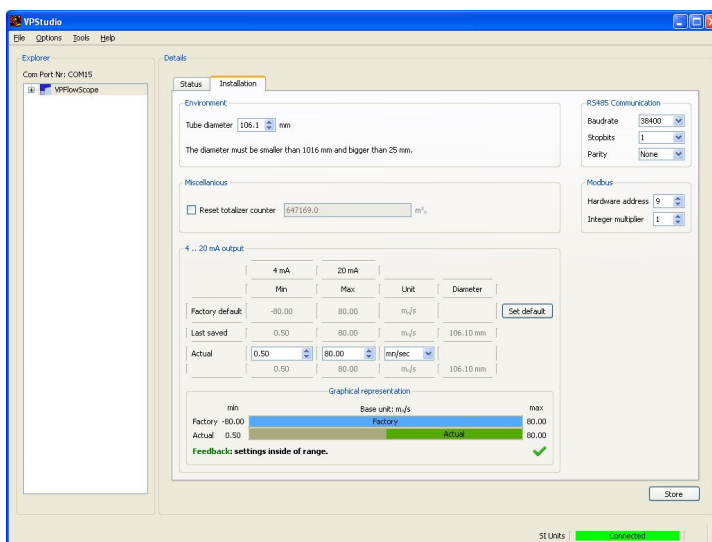
- See the units right blow corner: SI Units here.

- In details: Status tab: you should see the specifications of your flow meter: the serial number, last calibration date, advised service date, etc.



The installation tab: configure here the VPFlowScope (dP) sensor module, e.g. enter the tube diameter.

Always click on 'Store' in the right corner below to store the configurations in the VPFlowScope. 'Store' also synchronizes the clock of the VPFlowScope to your PC.

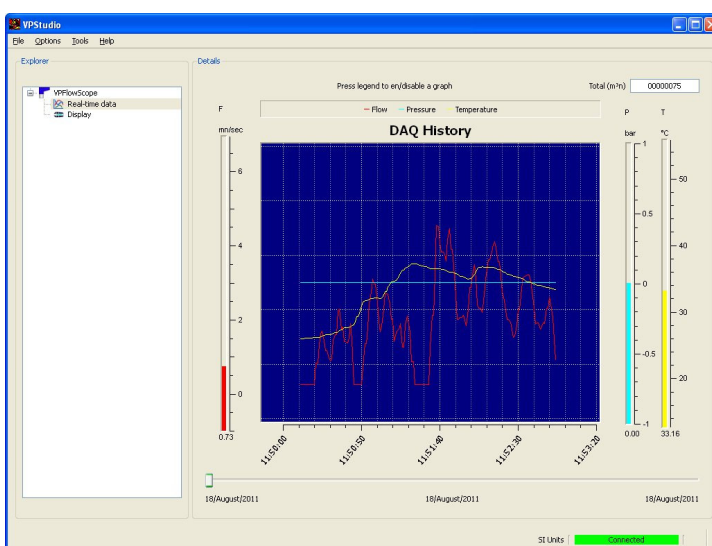


#### Step 4A.6: VPStudio real time information

- Open the VPFlowScope folder in the explorer field by clicking the + in front of your VPFlowScope.
- Click on 'Real-time data'.
- Move the mouse over the graph and press right mouse button --> 'Acquire', to start acquisition. Status turns yellow when communicating with your flow meter.

The sample rate is fixed and is 1 sample/sec (every second a measurement is taken).

During real time measurement; the right mouse button gives you access to graph functions and data export function. See chapter VPStudio.

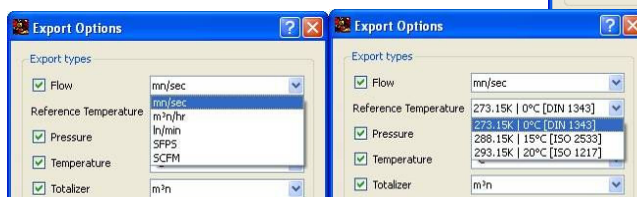
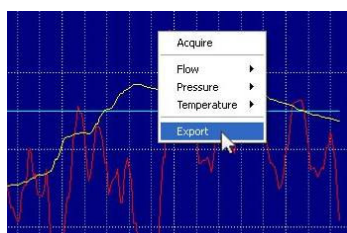
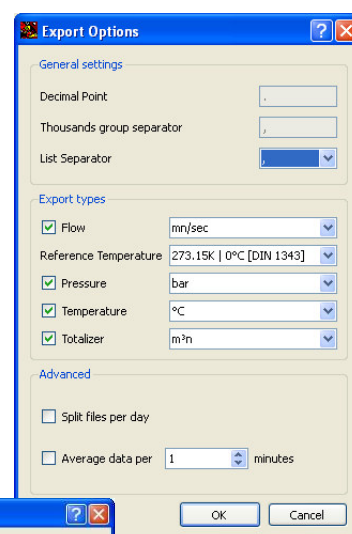


#### Step 4A.7 Export data to csv.file

The real time data can be exported to a csv.file at any moment for further data processing.

- Click right mouse button in the details field, click 'Export'.
- Choose a name and a place for your export file, click OK.
- The 'Export Options' dialog appears. Choose which data to export and how:
  - General settings: You can change the delimiter for the CSV file here to match you country residual settings.
  - Export: select which parameters with which units you want to export
  - Advance: When you have a lot of measurement data; split files per day and/or average the data to make it manageable.

See appendix D how to generate graphics with Excel.



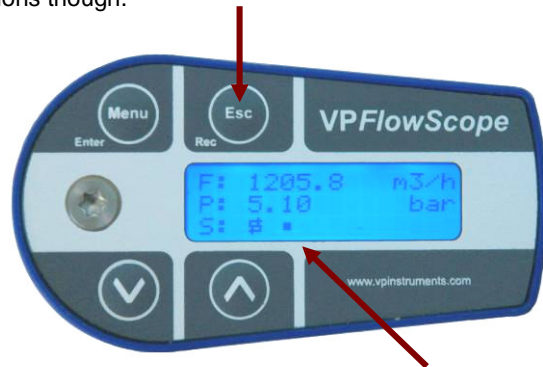
## 4.5 Step 4B: Log and read out data log sessions

The data logger of the VPFlowScope (dp) is located in the display. The display interchangeable between VPFlowScope (dP) sensor modules. Check the firmware versions though.

### Step 4B.1: Data logging

You can start logging right-a-way. It is useful to synchronize the date and time with your PC (Store data via VPStudio).

- Press 'Rec' (Esc) on the keypad,
- Press Enter to confirm
- and the VPFlowScope (dP) starts recording.



**Feedback:** The third line is alternating between the recording state (S) and a chosen parameter. The recording mode is shown by a blinking dot (see picture on the right).

The data logger contains 500,000 points. Default setting: recording once per 5 seconds. Change the interval settings with VPStudio. See chapter 6.

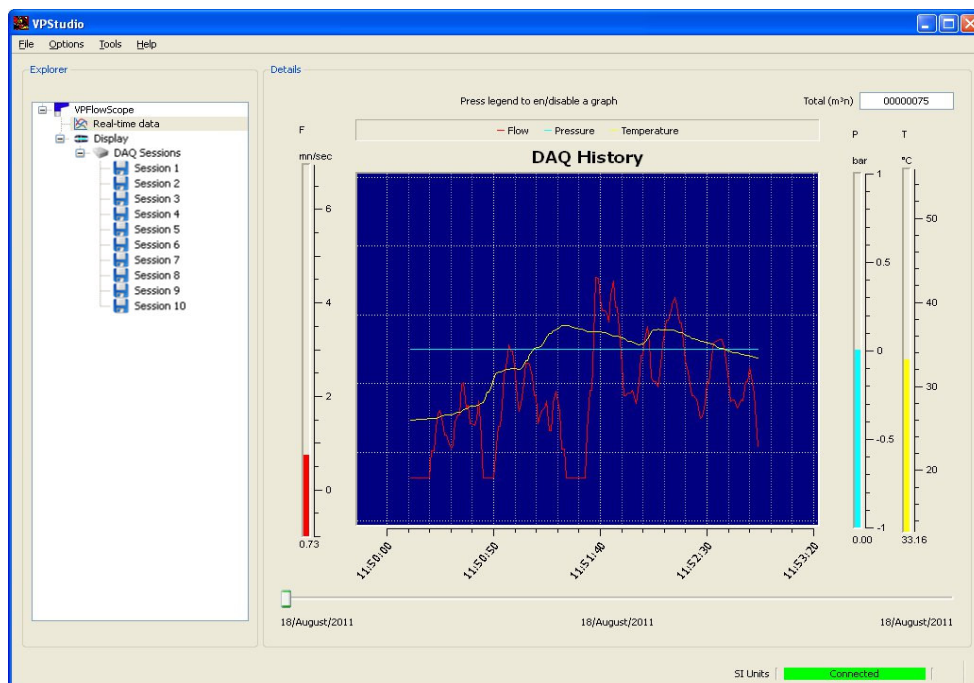
Stop recording by 'Esc' (Rec) and confirm. The blinking dot disappears. Read out you logged DAQ session with VPStudio.

### Step 4B.2: Read out log file

Connect the VPFlowScope (dP) to VPStudio (See steps 4A.1 to 4A.5). Fold out completely the explorer tree. Your log sessions appear. Select the session you want to read out, move the mouse over the graph and press right mouse button 'Acquire', to start acquisition. The time to acquire all data depends on the amount of logged data; it can vary between seconds and a couple of minutes.

As with real time information, you can change the graph lay out with right mouse click. To export the file, click right mouse and export. See step 4A.7. on the previous page.

**Deleting** your DAQ Sessions can be done using the keypads on the display. Go to Menu > DAQ Sessions >> Delete all sessions.



## 5. Display

In the display you can set some basic configurations.

### Controls

In the menu all functions are controlled as follows:






Menu	To go to the display menu
Enter	To enter values or move cursor to right
Esc	Up one level or move cursor to left
Rec	When you are not in the menu, press Rec to start data logging
Down arrow	Move down in the menu or lower value
Up arrow	Move up in the menu or higher value

**Note:** During recording, some functions of the menu are disabled!

### Menu structure and functionalities

<u>Menu level</u>	<u>Display text</u>	<u>Description</u>
1. Settings	>> 1.Tube diameter	Change tube diameter
	>> 2.Display >>> Choose parameter for display line 1, line 2 and line 3	Change display parameters Choose line 1, line 2, line 3 Parameters available:
		Flow F: <div><div>- mn/sec</div><div>- m3n/hr</div><div>- ln/min</div><div>- SCFM</div><div>- m3n/min</div><div>- sfps</div></div>
		Pressure P: <div><div>- bar</div><div>- psi</div></div>
		Temperature T: <div><div>- degC</div><div>- degF</div></div>
		Totalizer : <div><div>- m3n</div><div>- SCF</div></div>
	>> 3.Date & time	Change sensor date and time Change sensor address
2. Profiles	>> Activate	Disabled
3. DAQ sessions	>> New session	Start new recording
	>> Delete all	Deletes all recordings
4. Advanced	>> Reset	Resets the display

## Display feedback

<u>Display status description</u>	<u>Icon</u>
Sensor module is connected	
Sensor module is not connected.	
Recording mode	
Out of range of the specification	
Service required	

## Flow direction

Flow direction is an extra feature for the *VPFlowScope* (thermal sensor only). The flow direction is visible in the display.

- The backwards flow is shown with a minus before the amount, e.g. -347 m<sup>3</sup><sub>n</sub>/hr.
- In the totalizer: by adding and retracting flow depending on the flow direction.

## Power failure and your data logging

When there is a power failure, the *VPFlowScope* continues data logging after re-stating the power. The data after the power failure will be stored in a separate DAQ session.

## 6. VPStudio Software

For the basic settings and functionalities, please also read chapter 4.

### 6.1 General

At initial use, your *VPFlowScope* (dP) needs to be added in VPStudio in the explorer field (step 4A.5). You can install more than one *VPFlowScope* (dP) in VPStudio; each one has to be connected with an individual RS485-USB converter to your computer. You can read out only one at a time.

#### Internal clock synchronization

When you 'Store' settings via VPStudio, the internal clock of the *VPFlowScope* (dP) synchronizes with the clock of the computer. It is important that you are not in the menu of the display of the *VPFlowScope* (dp).

#### Menu of VPStudio

- Units: Go to Options > Setting Units to change the units between SI and Imperial.
- License Manager: Go to Help > License manager. To adapt or change the license key of your VPStudio.
- Index: This user manual

#### SI Units and Imperial Units

For *VPFlowScopes* (dP) with a firmware version lower than 1.0.15, you can only read out data in SI Units.

### 6.2 Connection VPStudio - VPFlowScope

See the connection status with your *VPFlowScope* in the right corner below.

#### Refresh

Refresh the connection with your *VPFlowScope* (dp) by right mouse click in the explorer field and click "Refresh". VPStudio actively seeks connection with the *VPFlowScope*.



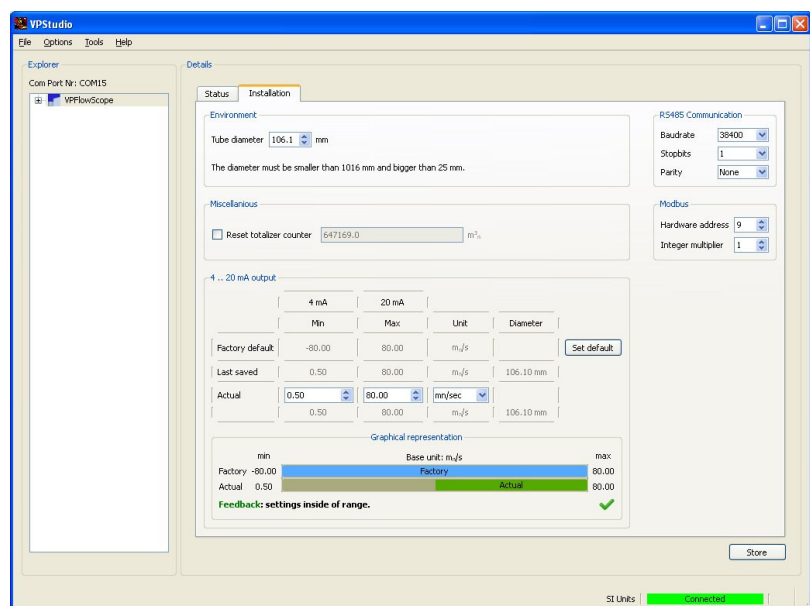
### 6.3 VPFlowScope settings and basic configurations

Click on your *VPFlowScope* in the explorer

Status tab shows specifications of your *VPFlowScope*, like:

- Serial number,
- Firmware version
- Gas type.
- Important: you can see when your *VPFlowScope* was produced, last calibrated and when it needs maintenance.

In the installation tab you can configure your *VPFlowScope* ( See picture).





## Environment

Configure the inner pipe diameter. Press 'Store'.

## Miscellaneous

Reset the totalizer counter, by selecting the box and press 'Store'.

## 4..20mA output

The 4..20 mA output can be used to connect the *VPFlowScope* to a control or central supervision system.

Default setting: m<sup>3</sup>/sec: 0..100% of flow range. You can change this range and type of output. In the pull down menu, you can choose flow, pressure, temperature related units.

Changing to volumetric units, the programmed diameter is calculated in the settings. So change the diameter first, then the analogue settings. *VPStudio* provides feedback while you are changing the settings. Use "set default" to go back to the factory default.

	4 mA	20 mA	Unit	Diameter
Factory default	0.00	80.00	m <sup>3</sup> /s	
Last saved	0.50	80.00	m <sup>3</sup> /s	25.00 mm
Actual	0.50	80.00	m <sup>3</sup> /s	25.00 mm

Graphical representation

min Base unit: m<sup>3</sup>/s max

Factory 0.00 Factory 80.00

Actual 0.50 Actual 80.00

Feedback: settings inside of range. ✓

## Flow direction option in 4..20mA

Default setting: -100% to +100% of flow range. You can change this to your liking. See examples in appendix E.

## RS485 communication

The *VPFlowScope* supports Modbus RTU. Take the *VPFlowScope* of the Modbus network when you need to configure it, as other devices will interfere with *VPStudio* commands. See 6.2 for usage and command settings.

Only change the settings in *VPStudio* when the *VPFlowScope* (d) is mounted in a slower network.

Hardware address: Modbus address, between 1 and 250. Each *VPFlowScope* in the same network needs to have a different address.

Integer multiplier: this multiplier is used for the integer registers only (see Modbus table). Divide the output by this number to get the real, floating point value. Adapt the value when the actual reading is a very small number, or when an extra digit resolution is needed.

Example:

flow = 32.3 m/sec

multiplier = 10

modbus output on register 16: 323. Divide by ten to get 32.3

multiplier =1

flow =32.3

modbus output on register 16: 32

RS485 Communication

Baudrate 38400

Stopbits 1

Parity None

Modbus

Hardware address 9

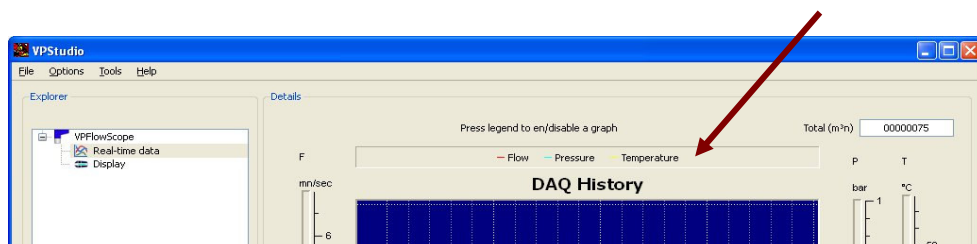
Integer multiplier 1

## Store

Click 'Store' to save the configurations in your *VPFlowScope*. 'Store' action also synchronizes the clock of your *VPFlowScope* to your PC.

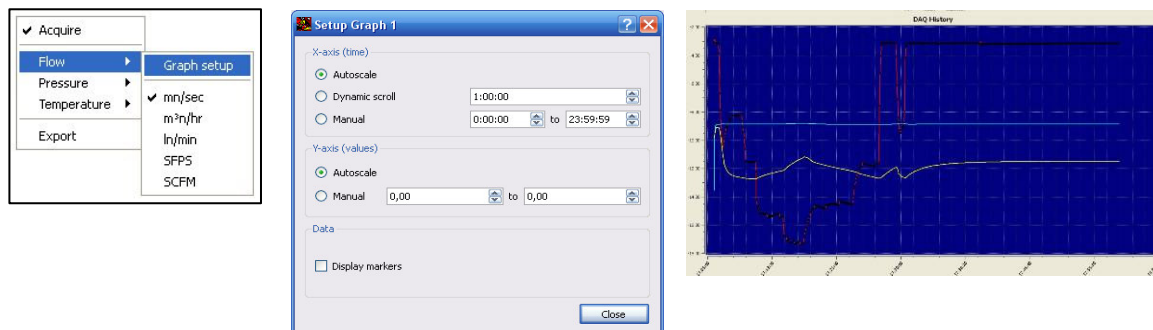
## Graph settings

All parameters are standard displayed in one graph. Select the parameter you want to disable above your graph (see arrow).



The settings of the graphs in both 'Real time data' and 'Display' > 'DAQ sessions' are automatically: the graphs will auto scale according to the data. Change the lay out to a more suitable manner when desired. During data acquisition, press right mouse button to find the menu for graph settings and the export function.

You can fix the axis manually and you can display markers. Here flow is set in m<sup>3</sup>n/hr and next you can see the flow graph with markers.



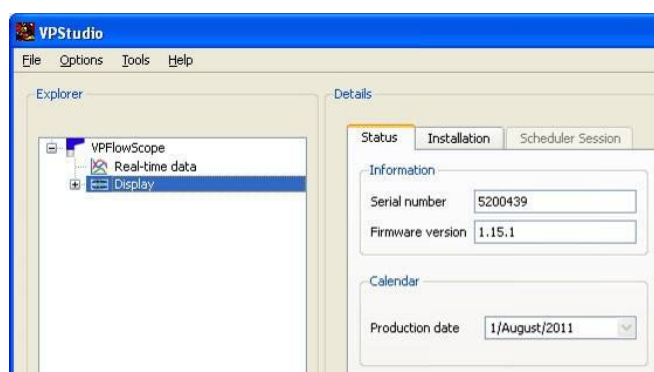
## 6.4 Display and data logger settings

Select 'Display' to see and configure the display and data logger. I

Status tab: see firmware version and production date.

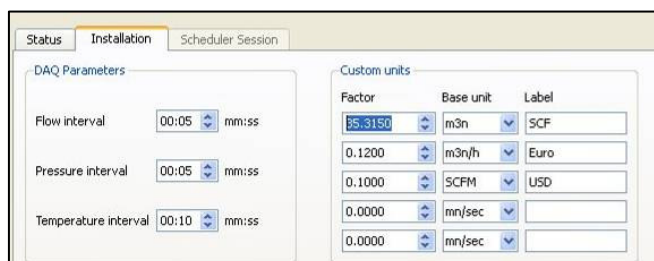
Installation tab:

- Set interval of the three parameters for the DAQ log session; for flow, pressure and temperature. The numbers correspond with "minutes : seconds".



The measurements are real time measurements at that moment (snapshots) and not an average over the interval.

In 'Custom units' you can create your own unit. In the picture we have created e.g. Euro and USD. As example we stated that every m<sup>3</sup>/hr costs 0.12 Euro and a SCFM costs 0.1 USD (these are not real numbers). Custom units are only visible real time in the display itself.



When you store data in the display, the display is temporarily not available.

VPFlowScope logging capacity :		
Interval	Days	Months
1 sec	2	
5 sec	9	
10 sec	19	
30 sec	58	2
60 sec	116	3
5 min	580	>12

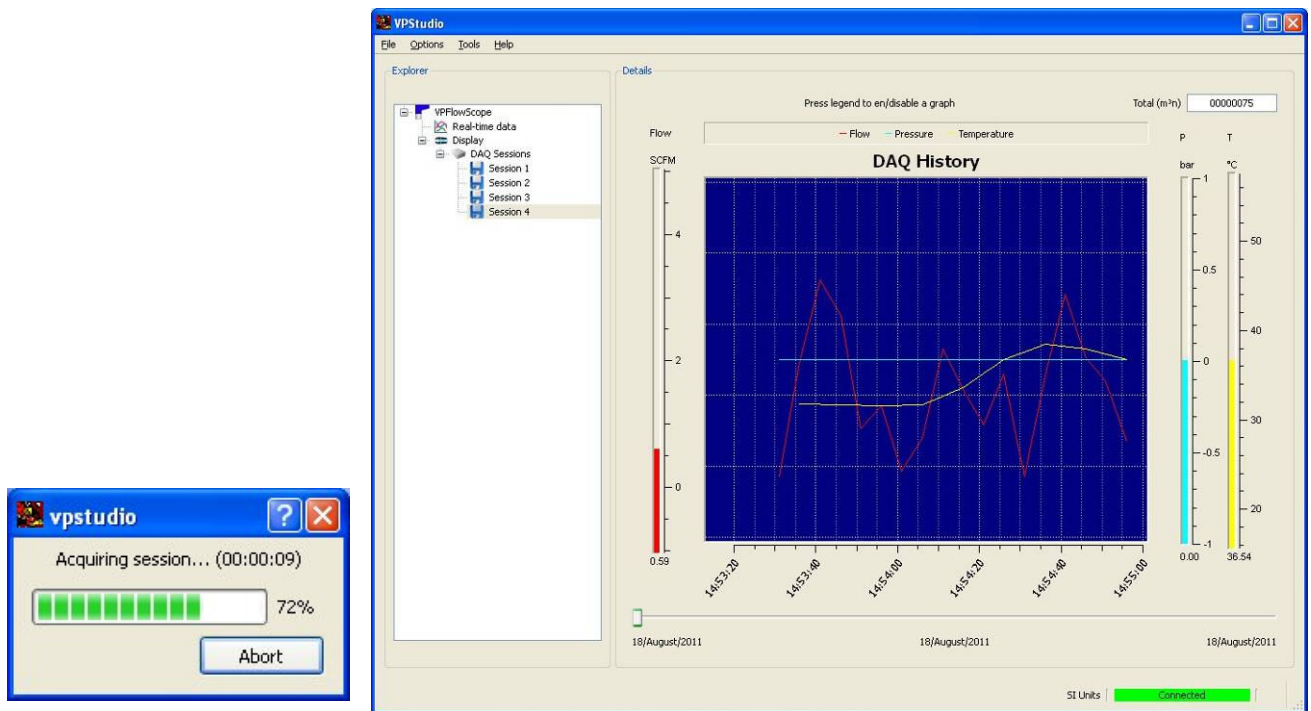


When acquiring real-time information and DAQ sessions in VPStudio, the three parameters are always displayed in the original (SI) units.



## Reading out data logger

See chapter 4.5. Select your session and acquire the retrieved data by clicking right-mouse-button when you hover the mouse over the graph "Acquire". VPStudio gives feedback on how long it takes to read in the data. You can change the graph settings and export the data, as with 'Real-time data' (see chapter 6.3).

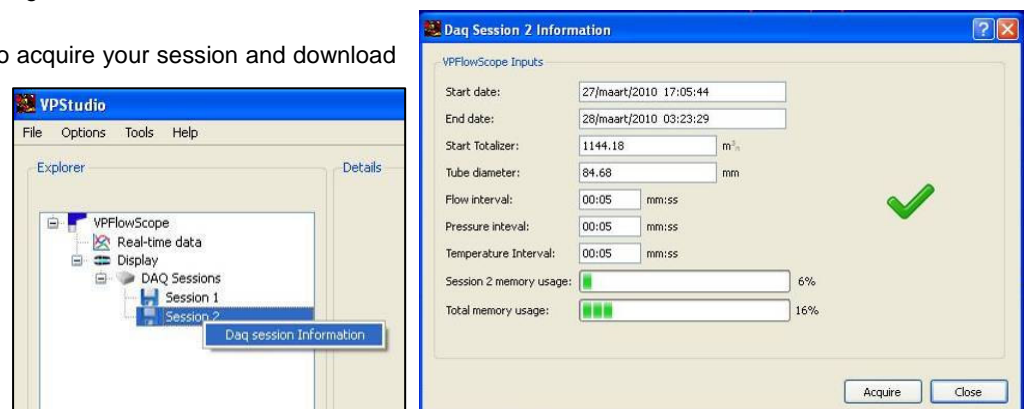


Be sure you have all DAQ sessions in csv.file with the right units. The csv.file does not e.g. store a pipe diameter. So make sure you have it in volume flow (e.g. m<sup>3</sup>n/hr or SCFM) rather than in velocity.

## Details DAQ sessions

Click right mouse button on the session in the explorer to go to DAQ session information. Here you will see information about the session, like start date, tube diameter and the intervals. The memory usage of the session and the total memory usage can also be found here..

From here you can also acquire your session and download it.

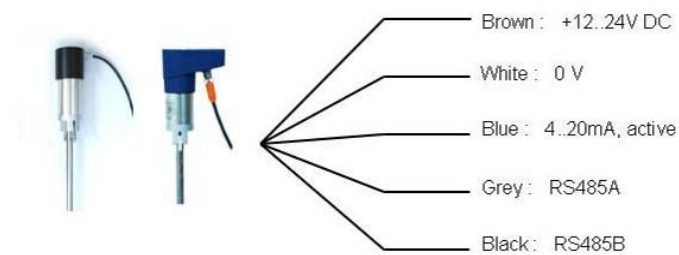


## Deleting DAQ session

You can only delete your DAQ session in the display itself, by using the keypad. Go to menu> DAQ sessions >> Delete all. Press Enter and delete all DAQ sessions. You can not delete just one session.

## 7. Electrical connections

The *VPFlowScope* (dP) provides a 4..20 mA output and a RS485 output. All signals are present in the M12 connector, this is for the *VPFlowScope* (dP) display as for the connector cap.



Tip: Use a shielded cable of good quality. Connect shield to safety ground on one point.

Pin description of the display module connector: see appendix G.

### 7.1. Using the 4..20 mA output

The 4..20mA output is an active, non- isolated linearized output.

#### Hardware requirements:

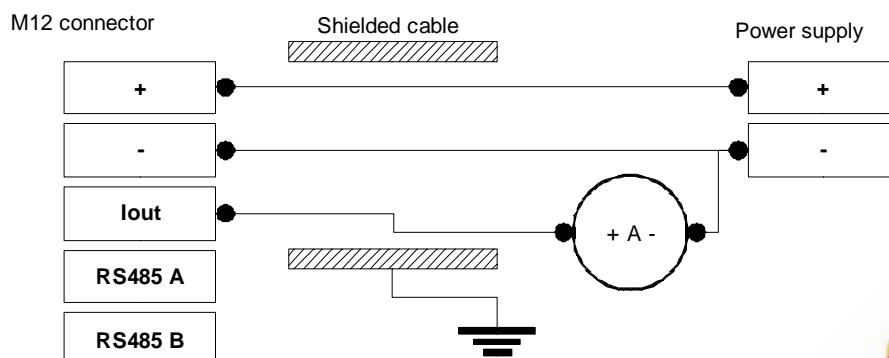
- *VPFlowScope* (dP)
- Cable, M12, 5 or 10 m (16.4 or 32.8ft)
- Read out device (multimeter, plc, centralized data acquisition)



Be aware that you need the interface box with power supply and USB-RS485 converter to configure the *VPFlowScope* (dP) with *VPStudio*.

#### Electrical scheme:

The current meter is placed in between the current output and the power supply ground. You can also use a digital multimeter to test the current output.



4..20mA Factory default: 0..100% of the flow range in normalized velocity. With *VPStudio* you can select which parameter you want to read out: flow, pressure or temperature, and the corresponding unit. See chapter 6 for more information.

You can hook up the 4..20mA output to an existing control or central supervision system for read out or you can use e.g. a digital multi meter to test the current output locally. See tips and tricks for the 4..20mA connection in appendix E.

## 7.2 Using Modbus

### 7.2.1. Introduction to Modbus

For new users, a complete introduction on the Modbus standard can be found on [www.modbus.org](http://www.modbus.org). See the document Modbus\_over\_serial\_line\_V1\_02.pdf, which can be downloaded from their website. We strongly recommend to download and read this information carefully.



For the 32 bit holding registers, the multiplication factor needs to be programmed via VPStudio. You need VPStudio 1.19.0 or higher to perform this action. The default factor is 100, but with older, upgraded units, the factor will be 0, resulting in no output.

### 7.2.2 Holding registers (firmware revision 1.15.0 and up)

The actual measurement data is placed in holding registers. To read out data, you will need to use the corresponding holding register.

dec	HEX	Description	Type
16	0x10	Flow in $m_n$ /sec	32-bit integer (x10)
17	0x11	Flow in $m_n^3$ /hr	32-bit integer (x10)
18	0x12	Flow in $l_n$ /min	32-bit integer (x10)
19	0x11	Flow in scfm	32-bit integer (x10)
20	0x14	Flow in $m_n^3$ /min	32-bit integer (x10)
21	0x10	Flow in sfps	32-bit integer (x10)
32	0x20	Pressure in bar	32-bit integer (x10)
33	0x21	Pressure in psi	32-bit integer (x10)
64	0x40	Temperature in degC	32-bit integer (x10)
65	0x41	Temperature in degF	32-bit integer (x10)
128	0x80	Totalizer in $m_n^3$	32-bit integer (x10)

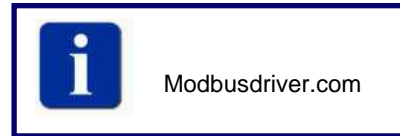
dec	HEX	Description	Type
24	0x18	Flow in $m_n$ /sec	Floating point
25	0x19	Flow in $m_n^3$ /hr	Floating point
26	0x1A	Flow in $l_n$ /min	Floating point
27	0x1B	Flow in scfm	Floating point
28	0x1C	Flow in $m_n^3$ /min	Floating point
29	0x1D	Flow in sfps	Floating point
40	0x28	Pressure in bar	Floating point
41	0x29	Pressure in psi	Floating point
72	0x48	Temperature in degC	Floating point
73	0x49	Temperature in degF	Floating point
136	0x88	Totalizer in $m_n^3$	Floating point

### 7.2.3 Basic use: First steps

You can practice or try out the *VPFlowScope* (dP) Modbus commands with your PC, using the *VPFlowScope* (dP) start kit: You can use the free Modbus demonstration program *Modpoll.exe*. This program is ideal to test the Modbus-RTU compliant command set of the *VPFlowScope* (dP). You can download this program from the internet. Use a search engine to find it.

Hardware requirements:

- *VPFlowScope* (dP)
- Split box + power supply
- USB to RS485 converter



#### Instructions

1. Connect everything as described in Chapter 4,
2. Open *VPStudio* and change the Modbus address if desired,
3. Close *VPStudio*,
4. Open a command prompt via the start menu of your pc,
5. Start: execute program >> type cmd and press enter,
6. Go to the directory where you have placed *modpoll.exe*.

#### Basic command syntax, using modpoll:

`modpoll -a [address] -r [register number] -t [data type] -b [baudrate] -p [parity] [COM Port]`

type `modpoll -h` for help.

**Examples:** The following examples can be tried out to test the Modbus communication.

##### read flow value

```
modpoll -a 9 -r 19 -t 4 -b 38400 -p none COM3
```

>>Answer (example): 1167

Divide by 100: Flow = 11.67 cfm

##### read pressure value

```
modpoll -a 9 -r 33 -t 4 -b 38400 -p none COM3
```

>>Answer (example): 733

Divide by 100: Pressure = 7.33 bar

##### read temperature value

```
modpoll -a 9 -r 65 -t 4 -b 38400 -p none COM3
```

##### read totalizer

```
modpoll -a 9 -r 129 -t 4 -b 38400 -p none COM3
```

**Set multiplier to 100 for these examples:**

##### Floating point example:

Read flow in mn/sec, from floating point register:

modpoll -m rtu -a9 -r26 -t 4:float -b38400 -p none COM9

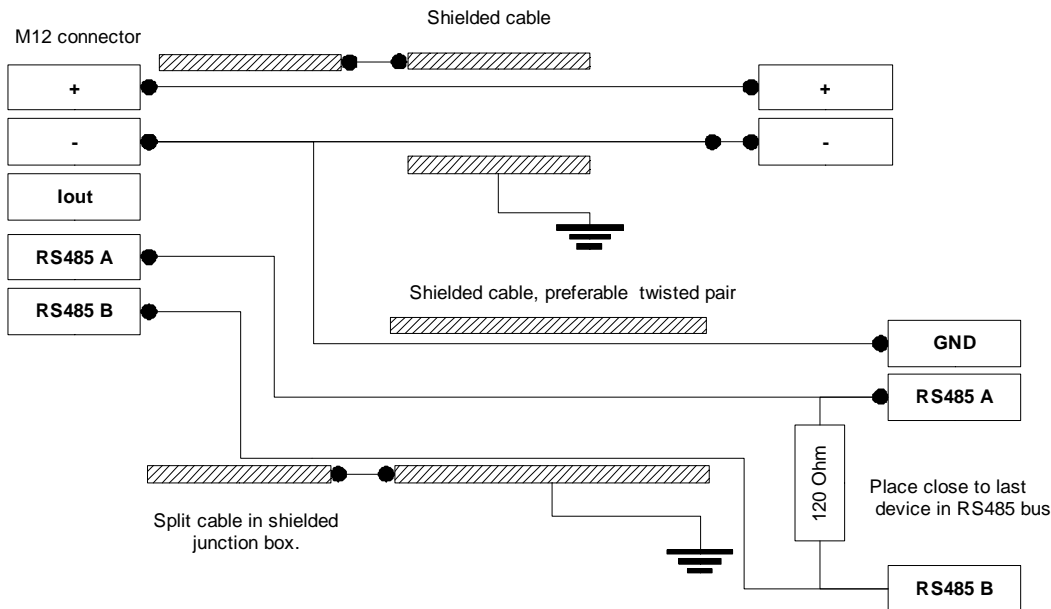
Answer: 76.811389

#### 7.2.4. Advanced use: Do it yourself one on one connection

For a one-to-one connection with a PLC or a different type of RS485 converter, please see the wiring scheme below. When short wiring is used, a termination resistor is not needed. For longer wires (>10m), please read RS485 related literature, which is referred to in chapter 7.2.5. The ground (common) should be connected to the readout device, so you will need three wires to establish the connection.



There is some confusion about "A" and "B" in the RS485 standard. If you experience communication problems, you should swap the A and B wire to see if this is the cause.



#### 7.2.5. Advanced use: RS485 Networks



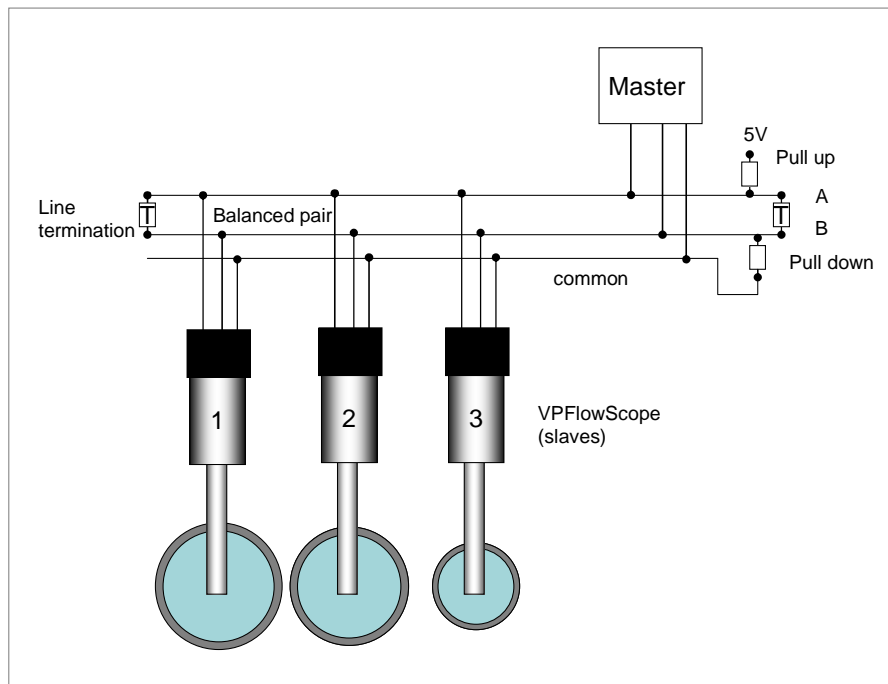
For longer distances and network connections, in- depth knowledge about RS485/RS422 networks is needed. Please familiarize yourself with the RS485 standard.

Useful literature links:

[www.modbus.org](http://www.modbus.org) for information about networking multiple sensors on a bus.

[www.bb-elec.com](http://www.bb-elec.com), a manufacturer of RS485 converters which provides extensive user manuals and application notes about RS485 networks.

After you have studied the Modbus and the RS485 standard, you can start making your first network. See an example network with three VPFlowScopes and one master below. You see pull down, pull up and termination resistors. These resistors need to be calculated. Refer to the RS485 related literature for details.



## 8. VPFlowScope (dP) with Connector Cap

The VPFlowScope (dP) with connector cap can be used when you do not need a display and/or data logger on the VPFlowScope (dP) itself. Examples of usage are when there is a central monitoring system like VPVision or when there is a direct RS485 connection with a central control system.

The VPFlowScope (dP) can only be read out via the outputs: RS485 or 4..20mA. See the previous chapter how to connect and read out the outputs.

Be aware that you do need a display, interface box kit and VPStudio to for instance:

- Configure a pipe diameter in the flow meter (to have volume flow)
- Set the 4..20mA output to a different parameter (e.g. in m<sup>3</sup>n/hr)
- Configure a ModBuss address. Default is address 9. When you have several flow meters in your network, each one should have a different address.



## 9. Service

The VPFlowScope (dP) needs regular maintenance to ensure that the product is functioning properly. Especially when the product is used for mobile air audits, we recommend inspecting the instrument before and after every audit to ensure that the product has not been damaged. For precision measurement equipment such as the VPFlowScope (dP), a proper maintenance program is key to reliable measurement results and a long product lifetime.



**WARNING:** As with all pressure systems, do not attempt any service or maintenance when there is ANY pressure in the product. Service can only be carried out by trained, experienced professionals. Wrong service may result in leakage, damage to the product, serious injury or death. When in doubt, contact your local dealer for assistance.

### 9.1 Cleaning the VPFlowScope thermal mass flow sensor

The sensor can be gently cleaned using cleaning alcohol or an ultrasonic cleaning bath that is aluminium friendly detergent. Make sure that no alcohol remains in the pressure sensor hole! Damaged sensor modules need to be returned for re-calibration or exchange.



### 9.2 Cleaning the VPFlowScope dP sensor

The VPFlowScope dP sensor is tolerant to dirt and water drops. However when water drops or dirt block the pressure tubes that go to the pressure sensors, you can clean it yourself by you can taking apart the sensor completely and service this.

The transmitter is separated from the sensor probe. Inside there are filters that are easy to exchange. When you have a dirty application it is recommend to regularly check and exchanges these filters. When you do air audits, you might consider to exchange them for each new measurement, so you are guaranteed of the quality of the VPFlowScope dP.

When you send back the flow meter for recalibration. You only have to send back the sensor housing, so the package is small.

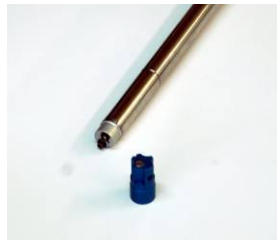


Sensor housing



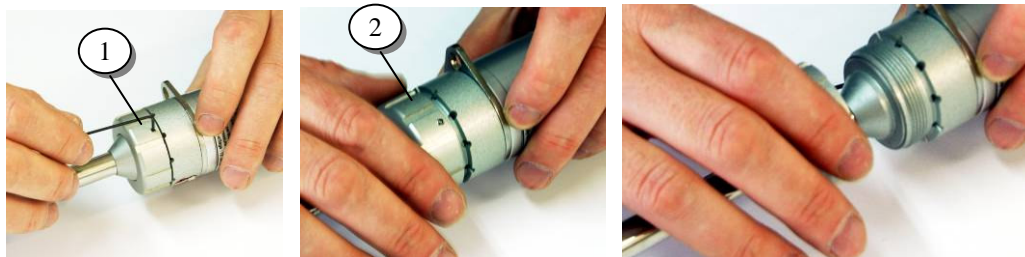
To clean the VPFlowScope dP sensor, please follow the following steps:

**Step 1:** Unscrew the blue sensor tip with a small screw driver. You can leave the two rubbers during cleaning. They only need to be taken off and exchanged when they are damaged.





**Step 2:** Unscrew the safety locking screw (1). This locking screw prevents movement of the main fixation ring, so the VPFlowScope dP cannot be accidentally opened when pressurized. When the safety screw is removed, you can turn the fixation ring (2) and remove it.



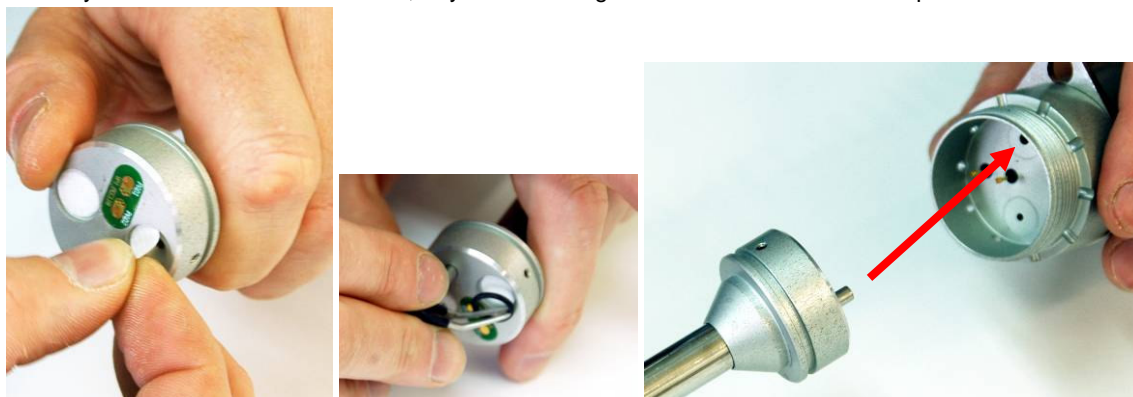
**Step 3:** Take the sensor probe out of the sensor housing. You can see the filters. The pins are for the temperature sensor. The temperature sensor is the only sensor being inside the sensor. Do not worry, this is built-in and will not be a problem when cleaning.



**Step 4:** Use tweezers to remove the o-rings and the filters. To clean you can purge the pressure sensor tubes with e.g. compressed air, water or soap.



**Step 5:** Put new filters on. They are stickered on one side. It is important to centrare the filter-stickers and to tighten them around. Put the rubbers back in place and assemble back the flow meter. Be careful: there is only one way to assemble back the sensor, or you will damage the filter! Be careful for the pin on the sensor side.





**Step 6:** Do not forget to tighten the locking screw. Perform a pressure test to make sure it is pressure tight. And your flow meter is ready for usage again! It is as new!

When any part is damaged; each part can be ordered separately. Contact the VPInstruments sales team for this.

### **9.3 Software and firmware updates**

News on software and firmware updates can be found on [www.vpinstruments.com](http://www.vpinstruments.com), or are provided by your local re-seller. The *VPFlowScope* (dP) sensor can be updated via the RS485 port. For updating the firmware of the display, a special RS232 cable is needed. Instructions on the update procedure can be found in a separate instruction leaflet, which is distributed together with the upgrade kit. Upgrading is only possible for authorized people, at own risk.

### **9.4 Recalibration**

To keep your *VPFlowScope* (dP) in best shape, it needs recalibration. The recommended recalibration date can be found in *VPStudio*, when you read out your *VPFlowScope* (dP). Keep close eye on this date. We advice annual recalibration.

### **9.5 Service Subscriptions**

VPInstruments offers several Service Subscriptions. Enrolling in the Service Subscription Program helps you get the most out of your measurement equipment. We keep your equipment in excellent shape, as we offer an annual re-calibration on our state of the art calibration equipment. With the latest software releases and expert technical support, you will save time and money. We offer the following programs:

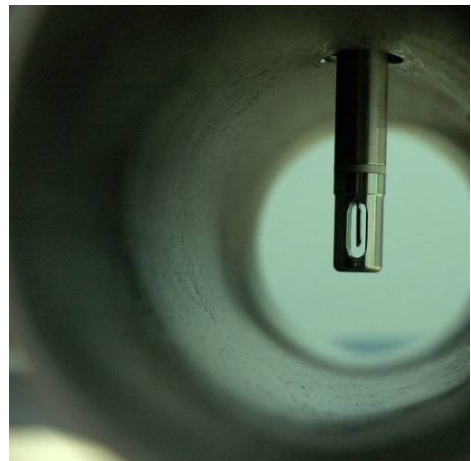
- Standard Service Subscription; annual re-calibration of your flow meter and up to 5 years warranty extension.
- Full Service Subscription; annual exchange of your flow meter. No service time! Have a fully calibrated flow meter 24/7, 365 days a week!

Improved software performance, innovative new product features, and technical support helps keep you focused on what matters most for your company.

#### **Benefits**

- Annual calibrated and cleaned instruments
- Warranty extension
- Software- and firmware updates
- Live support and e-mail support by our skilled technicians

Consult your sales agent for information about our service program.





## 10. Specifications





**Please always check the label of your product for the specifications.**

Specifications are subject to change as we are continuously improving our products.  
Please contact us to obtain the latest specification sheet.

	<b>VPFlowScope</b> (thermal mass flow sensor) 	<b>VPFlowScope dP</b> 
<b><u>Flow sensor</u></b>		
Flow ranges:	0.5...150 m <sub>n</sub> /sec. See ID-label on your VPFlowScope.(1.7...492 spfs)	20..200m <sub>n</sub> /sec. See ID-label on your VPFlowScope (dP). (65...650 sfps)
Accuracy:	2% of reading under calibration conditions Recommended pipe diameter: 40mm (1.5 inch) and up (see app. A)	
Reference conditions:	0°C, 1013.25 mbar - DIN1343. (32°F, 14.65 psi)	
Analogue output default	0.5...150 m <sub>n</sub> /sec. See ID-label on your VPFlowScope.(1.7...492 spfs)	20..200m <sub>n</sub> /sec. See ID-label on your VPFlowScope (dP). (65...650 sfps)
Gases :	Compressed air, nitrogen, inert gases, 95% non condensing gases	Wet compressed air, Dry compressed air, Nitrogen and Inert gases.
Gas temperature	0....60°C (extended 0..80°C) See ID label 32..140°F (extended 32..176°F)	-40....+150 °C. Ice should be avoided! -40..+302 °F

<b><u>Pressure sensor</u></b>		
Range:	0...16 bar gauge (0...232 psi gauge)	0...10 bar absolute (0..145 psi abs) 0..16 bar gauge See product ID label
Accuracy:	+/- 1.5% FSS (0...60°C) (32..140°F)	

<b><u>Temperature sensor</u></b>		
Range:	0....60°C (32...140°F) Extended possibility: 0..80°C (32..176°F)	-40....+150 °C. Ice should be avoided! -40..+302 °F
Accuracy:	+/- 1°(from 10 m <sub>n</sub> /sec and up) (At zero flow conditions, temperature reading increases due to self-heating by the flow sensor)	

	<b>VPFlowScope</b> (thermal mass flow sensor) 	<b>VPFlowScope dP</b> 
<u>Data outputs</u>		
Digital:	RS485, MODBUS RTU protocol	
Analogue:	4..20 mA output, selectable via software to indicate flow, pressure or temperature	

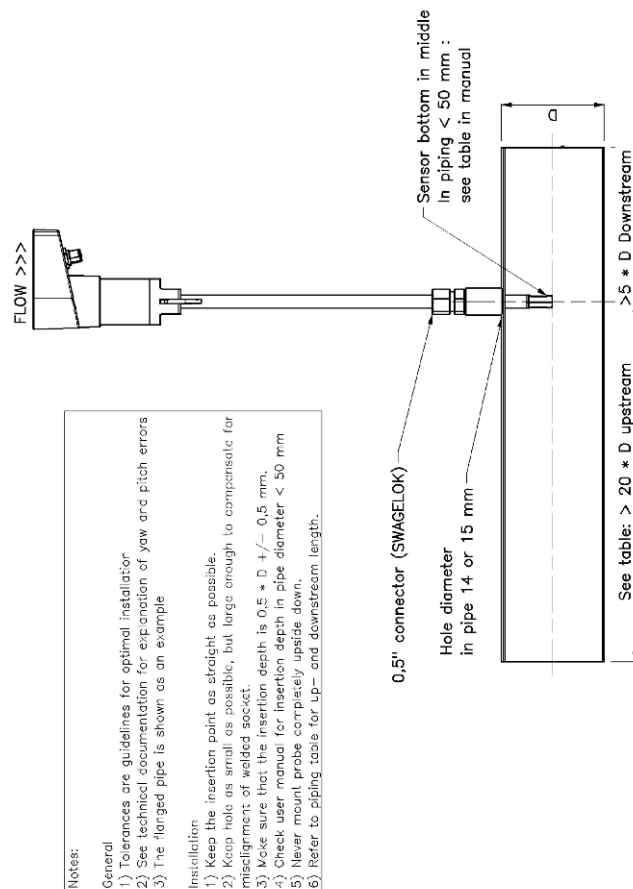
<u>Display / data logger</u>	
Technology:	Liquid Crystal (LCD)
Back light:	Blue, with auto power save
Data logger:	500,000 points

<u>Mechanical</u>		
Probe length:	400 mm (15 inch); other lengths on request	400 mm (15 inch)
Probe diameter:	12,7 mm (0.5 inch)	
Process connection:	Compression fitting, 0,5 inch, NPT thread	
Pressure rating	PN10, PN20: See product label	
Protection grade	IP52 when mated to display module IP63 when mated to connector cap	
Wetted materials	Alu, SS316, epoxy	

<u>Electrical</u> (See appendix B)	
Connection type:	M12, 5 pole
Power supply:	12...24 VDC +/- 10% Class 2 (UL)
UL/ CUL:	14 AZ, Industrial Control Equipment
CE:	EN 61326-1, EN 50082-1

<u>Environment</u>		
Environmental conditions:	Ambient	
Storage temperature:	0...60°C (32...140°F)	
Storage humidity:	10 - 95%. Avoid condensation at all times.	100%. Avoid icing. Clean before usage.

## Appendix A: Installation overview



## Appendix B: Electrical installation

The *VPFlowScope* complies with the CE requirements as stated in the CE declaration. CE compliance can only be achieved when grounding and shielding directions are followed and proper cables and connector assemblies are used.

**Electrical connection guidelines- UL 508 Listing for USA & Canada (Check label to see if product is UL marked)**

The *VPFlowScope* is intended to be used with a Class 2 power source or Class 2 transformer in accordance with UL1310 or UL1585. As an alternative a LVLC (Low Voltage Limited Current) power source, with the following properties can be used:

The device shall be used with a suitable isolating source such that the maximum open circuit voltage potential available to the product is not more than 24 V DC and the current is limited to a value not exceeding 8 amperes measured after 1 minute of operation;



A fuse in accordance with the UL248 series and rated max 4A, shall be installed in the 24V DC power supply to the device? In order to limit the available current.

#### Electrical connection guidelines: general remarks

Make sure that the following conditions are met:

For portable, non-critical applications, a switched mode 12 V DC, 1A power adapter may be used. Switched mode power supplies that are of poor quality, might affect the accuracy.

## Appendix C: Mass flow and volume flow

#### Definition of mass flow

Mass flow rate is the mass of substance which passes through a given surface per unit time. Its unit is mass divided by time. This means: kilogram per second in SI units, and slug per second or pound per second in US customary units.

Mass flow rate can be calculated from the density of the substance, the cross sectional area through which the substance is flowing, and its velocity relative to the area of interest:

$$\dot{m} = \rho \cdot v \cdot A \quad \text{where: } \dot{m} = \text{mass flow rate} \\ \rho = \text{density} \\ v = \text{velocity} \\ A = \text{flow area}$$

#### Definition of a Normal cubic meter (m<sup>3</sup><sub>n</sub>)

A normal cubic meter is used to relate mass flow to a volumetric unit. A normal cubic meter is the volume of 1 m<sup>3</sup> of air at temperature of 0°C and pressure of 1013,25 mbar abs. The mass of 1 m<sup>3</sup><sub>n</sub> of air is 1293 gram.

The normal cubic meter is officially indicated with a subscript “n” behind the volumetric unit. The indication Nm is not correct.

Other common normal conditions:

- 20°C reference (FAD): See ISO 1217
- 15° reference: See DIN 1533

#### VPFlowScope (dP) and mass flow

The VPFlowScope (dP) insertion probe is calibrated in **normal meters per second (m<sub>n</sub>/sec)**. A normal meter per second is a meter per second under the same reference conditions as a normal cubic meter. This enables you to use the VPFlowScope (dP) in various pipe diameters. The VPFlowScope (dP) only needs to know the inner tube diameter to calculate the mass flow rate.

## C.1 Working principle of the VPFlowScope (thermal mass flow)

The VPFlowScope's thermal sensor measures mass flow. The sensor response signal is directly related to the mass flow rate and can be described by the following formula:

$$V_{out} = k * \rho * v * (T_s - T_g)$$

$V_{out}$  = output voltage

$k$  = sensor (geometrical) constant

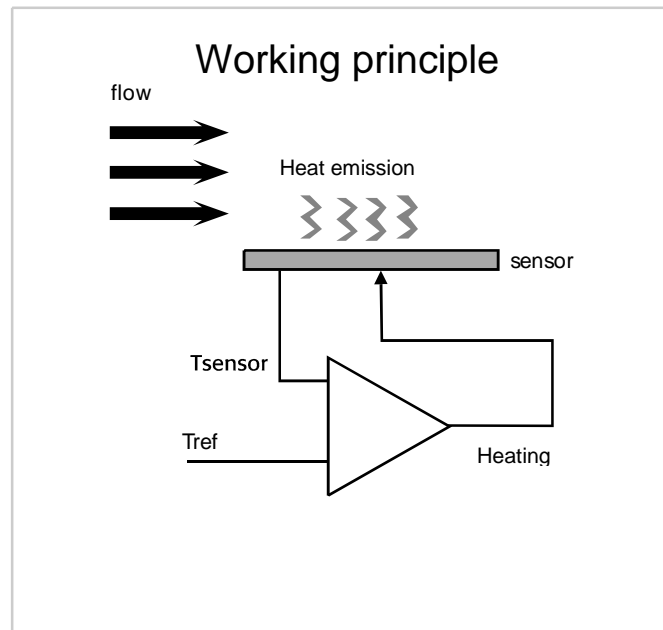
$\rho$  = thermal conductivity of the gas

$v$  = density of the gas

$v$  = actual velocity in m / sec

$T_s$  = sensor temperature

$T_g$  = gas temperature

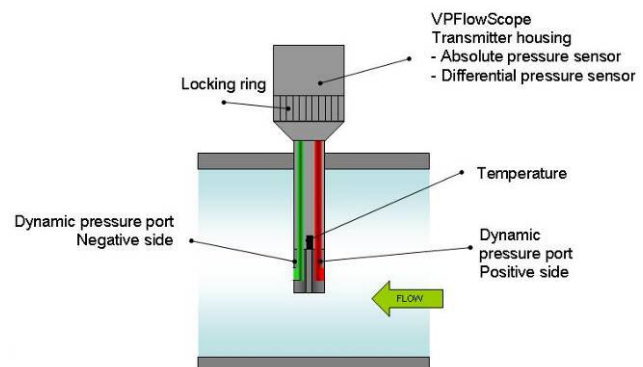


## C2. Working principle of the VPFlowScope dP

The VPFlowScope dP has a different working principle, although outputs are the same. The VPFlowScope dP also generates output in mass flow, pressure and temperature.

The VPFlowScope dP features two digital pressure sensors. One sensor measures the *dynamic pressure* generated by the airflow. The other sensor measures the *static pressure*. A temperature sensor is used for compensation.

The three sensors combined give a direct mass flow readout, similar to ISO 1217 compliant compressor test equipment.



### Differential pressure principle

The first differential pressure velocity meter was invented around 1732, by Henri Pitot.

A moving fluid causes a pressure differential, which can be calculated with the Bernoulli Equation.

$$P = K * \rho * V^2$$

where

$K$  = geometric constant, depending on the shape and size of the probe

$\rho$  = density (kg/m<sup>3</sup>)

$V$  = flow velocity (m/s)

### Dynamic Pressure

The second term -  $\frac{1}{2} \rho v^2$  - is called the dynamic pressure. The dynamic pressure is measured by the VPFlowScope dP's differential pressure sensor.

### Density calculation

The density,  $\rho$ , can be calculated for any gas, if the gas type, static pressure and temperature are known. One normal cubic meter of gas has a known density. The density then calculated, using the **Boyle Gay-Lusac equation**.

$$\text{Ideal gas law: } \rho = \rho(o) * P / P(o) * T(o) / (T(o) + T)$$

### Static pressure

P is the static pressure. It is static relative to the moving fluid. The static pressure is measured by the VPFlowScope dP's static pressure sensor.

P(o) is the reference pressure (1013.25 mbar)

T(o) is the reference temperature (273 deg C)

### Calculating the normalized velocity

By combining everything together, the VPFlowScope dP calculates normalized velocity, which results in a direct mass flow readout when multiplied by the area of the pipe.

$$Q[\text{m}^3/\text{hr}] = 3600 * V * P / P(o) * T(o) / (T(o) + T)$$



#### DP versus thermal mass flow.

One very important thing to be aware of: Differential pressure based sensors have a totally different principle compared to thermal flow sensors. Thermal sensors have a square-root relation to mass flow, while differential pressure sensors have a quadratic relation. This means that thermal sensors have an excellent sensitivity at low velocities, where differential pressure sensors have an excellent sensitivity at very high velocities.

## C3. Pipe diameter vs. flow range

Insertion mass flow meters can be used in various pipe sizes. This is a great advantage, as you can use one probe for many applications and installation is very easy. The VPFlowScope can be used from 1 inch and up. The VPFlowScope dP can be used from 2" and up.

See below two tables for most common diameters, in which you can see the maximum range of the VPFlowScope and the VPFlowScope dP. In the table we also stated the expected measurement uncertainty. This uncertainty applies for the ideal installation conditions. Note that in small tubes the installation becomes more critical and therefore, the measurement uncertainty is higher. In very large tubes, the flow profile is less predictable and it also depends on the tube roughness. In these cases, the measurement uncertainty is also higher than under calibration conditions.

VPFlowScope (thermal mass flow) 0.5..150 m <sup>3</sup> /sec (1.7..492 sfps)					
Diameter	Flow range in m <sup>3</sup> /hr, rounded down to 5 m <sup>3</sup> /hr		Flow range in scfm, rounded down to 5 scfm		Field measurement uncertainty
mm	Min flow	Max flow	Min flow	Max flow	
25 (1")	1	265	0.5	160	10%
40 (1.5")	2	680	1	400	5%
55 (2")	4	1,247	2	755	5%
80 (3")	9	2,715	5	1,595	2%
100 (4")	14	4,240	8	2,495	2%
160 (6")	35	10,855	20	6,390	5%
200 (8")	55	16,965	30	9,985	5%
250 (10")	85	26,505	50	15,600	5%



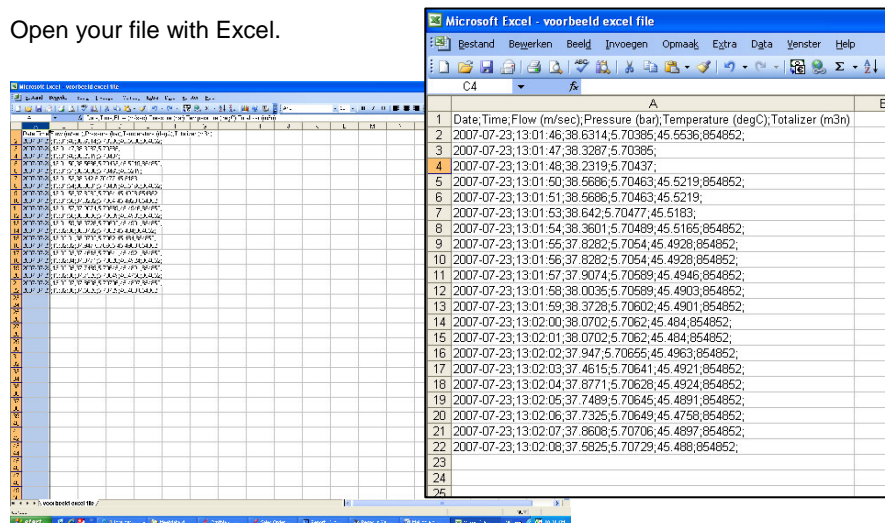


VPFlowScope dP (differential pressure) 20..200 m <sub>n</sub> /sec (65..650 sfps)					
Diameter	Flow range in m <sup>3</sup> <sub>n</sub> /hr, rounded down to 5 m <sup>3</sup> <sub>n</sub> /hr		Flow range in scfm, rounded down to 5 scfm		Field measurement uncertainty
mm	Min flow	Max flow	Min flow	Max flow	
25 (1")	DO NOT USE		DO NOT USE		10%
40 (1.5")	DO NOT USE		DO NOT USE		5%
55 (2")	170	1,710	100	1,005	5%
80 (3")	360	3,620	215	2,130	2%
100 (4")	565	5,655	330	3,330	2%
160 (6")	1,445	14,475	850	8,520	5%
200 (8")	2,260	22,620	1,330	13,315	5%
250 (10")	3,535	35,340	2,080	20,800	5%



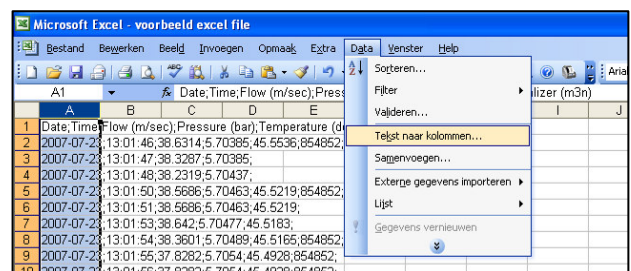
## Appendix D: Basic graphs in Excel

Open your file with Excel.

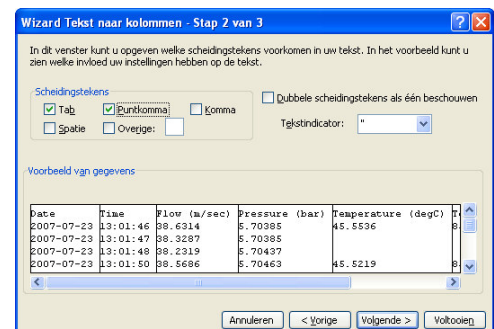
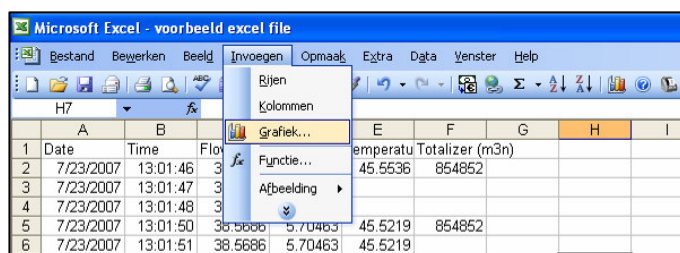


To convert the data to different columns, select the first column, as seen above and select in the menu bar 'Data' 'Text to columns'.

A wizard appears, select 'Separated' and click 'Next'. Subsequently select 'Semicolon' and click 'Finish' (see picture below). Now the data is divided over columns.



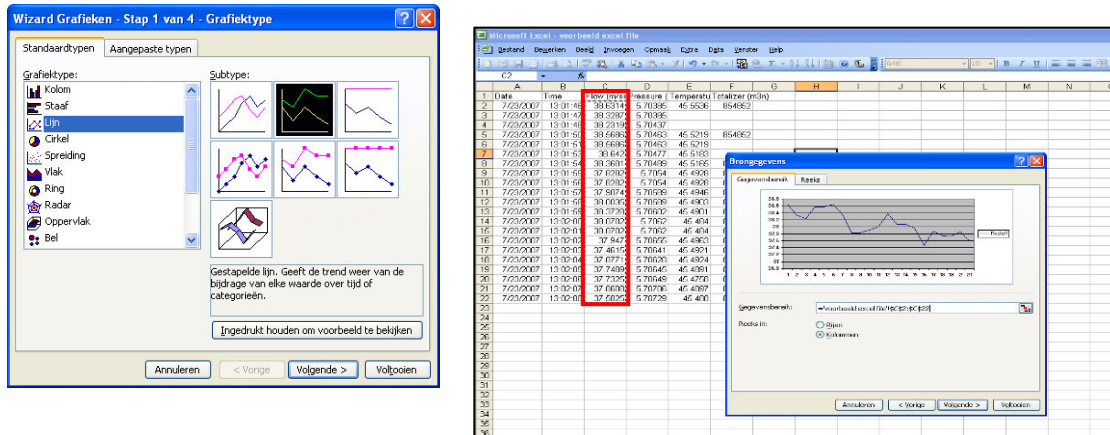
Select in the menu bar 'Add' 'Graphic'.





The wizard for making a graphic appears. First select the type of graphic you'd like. I am choosing a smooth line graphic:

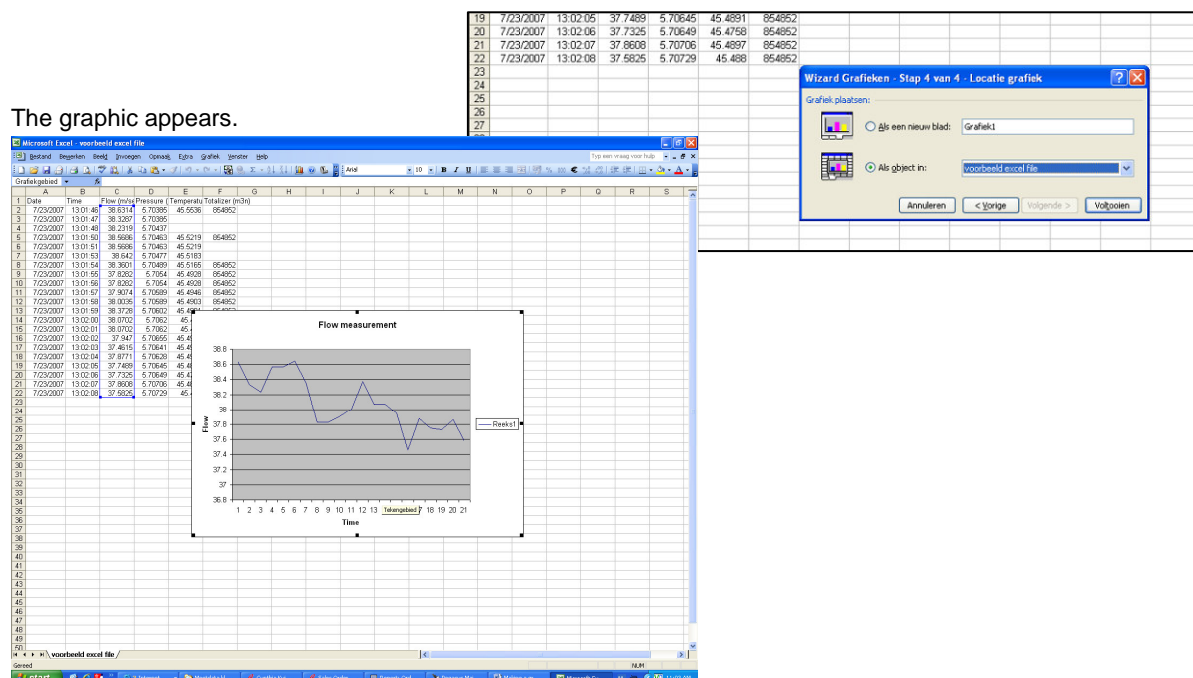
Click "next". Now select the data you want to see in the graph:



Go to the second tab to give the graph a name or to add more graphs in the same graphic. Click 'Next'. Move through the different tabs to e.g. name the total graphic and the axes. You can also change the axes, legend, etc. They can be useful to make the graphic clearer and better readable. Click "next"

Choose where you want to place your graphic, in the current tab or in a new tab and click "complete".

The graphic appears.



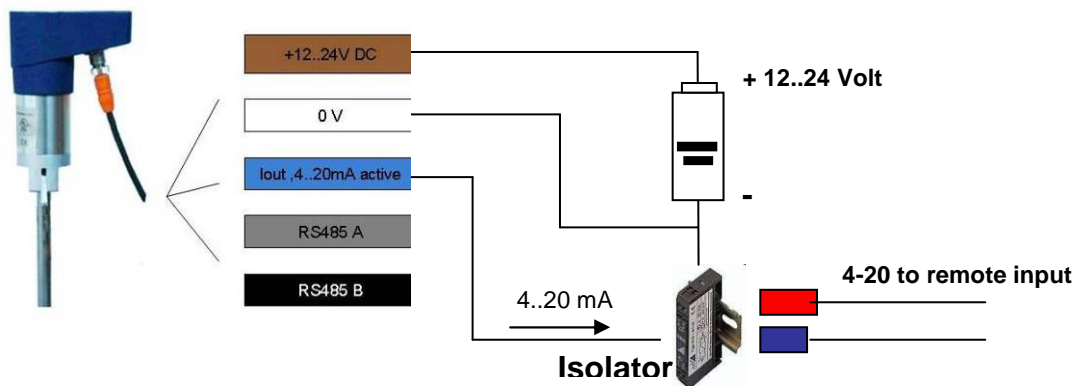
You can adjust the lay out of the graphic, like colour or size, by clicking on the different features. To change the range of the axes, place your mouse on an axis and click right mouse button.

You can use the graphics in your reports.

## Appendix E: Extra tips for electrical connection and 4..20mA

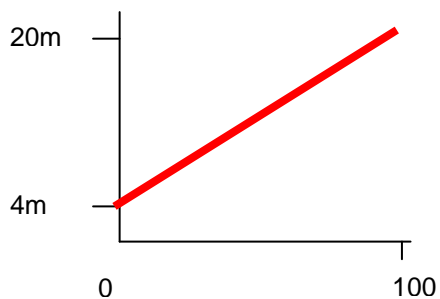
This appendix describes extra option for the output of the *VPFlowScope*.

### Isolate the current output

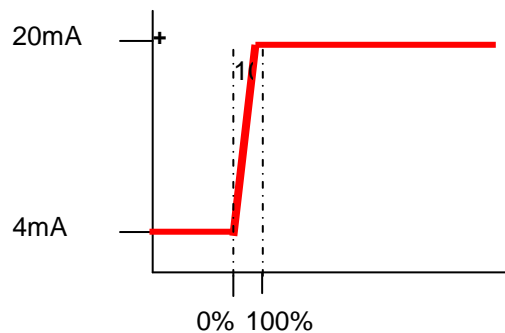


### 4..20mA Setting possibilities

Default setting: Flow from 0..100%



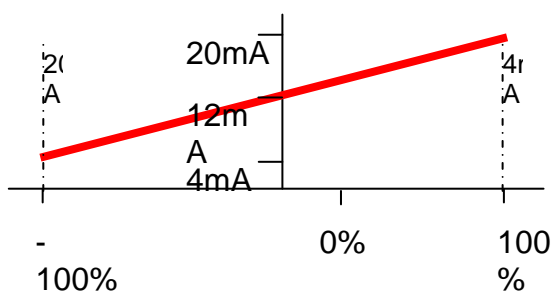
Switch configuration:



### Showing flow direction in 4..20mA options

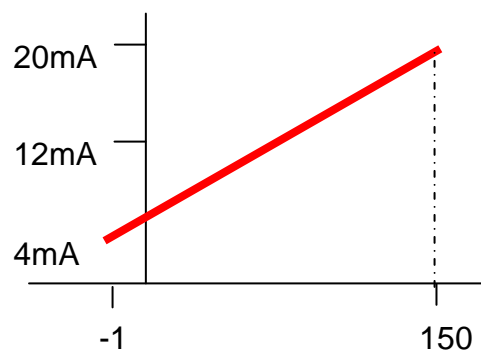
#### Fully bi-directional

4 mA = -100 % = -150 m/sec  
20 mA = +100% = 150 m/sec



#### Semi bi-directional

4 mA = -1 m/sec (just to see backflow)  
20 mA = 150 m/sec



## Appendix F: Display connector M12 & Connector cap M12

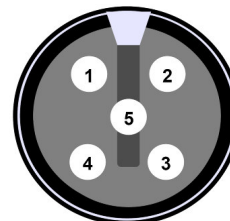
Display connector and connector cap share identical pinout.



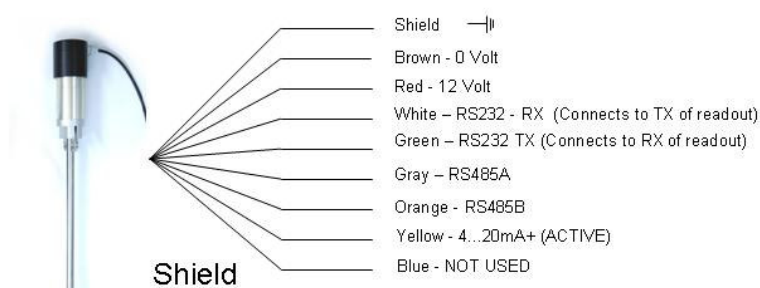
View on the display module connector (M12 female)

### Pin description

- 1 = + 12..24V DC
- 2 = - (0 Volt)
- 3 = I out (4..20 mA active)
- 4 = RS485 A
- 5 = RS485 B



## Appendix G: Cable color codes VPFlowTerminal



## Appendix H: standard pipe sizes and their inner pipe diameter

				SCH5		SCH 10s/10		SCH 30		SCH 40S/40		SCH 80s/80	
NPS (inch)	DN	OD (inch)	OD (mm)	ID (inch)	ID (mm)	ID (inch)	ID (mm)	ID (inch)	ID (mm)	ID (inch)	ID (mm)	ID (inch)	ID (mm)
2	50	2.375	60.33	2.245	57.028	2.157	54.792	2.125	53.98	2.067	52.506	1.939	49.256
2.5	66	2.875	73.02	2.709	68.804	2.635	66.924	2.499	63.47	2.469	62.708	2.323	59
3	80	3.5	88.9	3.334	84.684	3.26	82.804	3.124	79.35	3.068	77.928	2.9	73.66
3.5	90	4	101.6	3.834	97.384	3.76	95.504	3.624	92.05	3.548	90.12	3.364	85.446
4	100	4.5	114.3	4.334	110.084	4.26	108.204	4.124	104.75	4.026	102.26	3.826	97.18
5	125	5.56	141.40	5.345	135.762	5.295	134.492			5.047	128.194	4.813	122.25
6	150	6.625	168.27	6.407	162.732	6.357	161.462			6.065	154.046	5.761	146.324
8	200	8.625	219.08	8.407	213.542	8.329	211.562	8.071	205.008	7.981	202.722	7.625	193.68
9		9.625	244.48										
10	250	10.75	273.05										
12	300	12.75	323.85										
14	350	14	355.6										

NPS = Normalized Pipe size  
 DN = Nominal diameter  
 OD = Outer Diameter  
 ID = Inner Diameter