



OPTISENS PH 8100 Handbook

pH sensor

The documentation is only complete when used in combination with the relevant documentation for the signal converter.

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1.1 Intended use

**CAUTION!**

Responsibility for the use of the measuring devices with regard to suitability, intended use and corrosion resistance of the used materials against the measured fluid lies solely with the operator.

**INFORMATION!**

The manufacturer is not liable for any damage resulting from improper use or use for other than the intended purpose.

The intended use of OPTISENS PH 8100 sensor is the measurement of pH in water liquids. The sensor is suitable for connection to the MAC 100 signal converter.

1.2 Safety instructions from the manufacturer

1.2.1 Copyright and data protection

The contents of this document have been created with great care. Nevertheless, we provide no guarantee that the contents are correct, complete or up-to-date.

The contents and works in this document are subject to copyright. Contributions from third parties are identified as such. Reproduction, processing, dissemination and any type of use beyond what is permitted under copyright requires written authorisation from the respective author and/or the manufacturer.

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We hereby expressly prohibit the use of the contact data published as part of our duty to publish an imprint for the purpose of sending us any advertising or informational materials that we have not expressly requested.

1.2.2 Disclaimer

The manufacturer will not be liable for any damage of any kind by using its product, including, but not limited to direct, indirect or incidental and consequential damages.

This disclaimer does not apply in case the manufacturer has acted on purpose or with gross negligence. In the event any applicable law does not allow such limitations on implied warranties or the exclusion of limitation of certain damages, you may, if such law applies to you, not be subject to some or all of the above disclaimer, exclusions or limitations.

Any product purchased from the manufacturer is warranted in accordance with the relevant product documentation and our Terms and Conditions of Sale.

The manufacturer reserves the right to alter the content of its documents, including this disclaimer in any way, at any time, for any reason, without prior notification, and will not be liable in any way for possible consequences of such changes.

1.2.3 Product liability and warranty

The operator shall bear responsibility for the suitability of the device for the specific purpose. The manufacturer accepts no liability for the consequences of misuse by the operator. Improper installation or operation of the devices (systems) will cause the warranty to be void. The respective "Standard Terms and Conditions" which form the basis for the sales contract shall also apply.

1.2.4 Information concerning the documentation

To prevent any injury to the user or damage to the device it is essential that you read the information in this document and observe applicable national standards, safety requirements and accident prevention regulations.

If this document is not in your native language and if you have any problems understanding the text, we advise you to contact your local office for assistance. The manufacturer can not accept responsibility for any damage or injury caused by misunderstanding of the information in this document.

This document is provided to help you establish operating conditions, which will permit safe and efficient use of this device. Special considerations and precautions are also described in the document, which appear in the form of icons as shown below.

1.2.5 Warnings and symbols used

Safety warnings are indicated by the following symbols.



DANGER!

This warning refers to the immediate danger when working with electricity.



DANGER!

This warning refers to the immediate danger of burns caused by heat or hot surfaces.



DANGER!

This warning refers to the immediate danger when using this device in a hazardous atmosphere.



DANGER!

These warnings must be observed without fail. Even partial disregard of this warning can lead to serious health problems and even death. There is also the risk of seriously damaging the device or parts of the operator's plant.



WARNING!

Disregarding this safety warning, even if only in part, poses the risk of serious health problems. There is also the risk of damaging the device or parts of the operator's plant.



CAUTION!

Disregarding these instructions can result in damage to the device or to parts of the operator's plant.



INFORMATION!

These instructions contain important information for the handling of the device.



LEGAL NOTICE!

This note contains information on statutory directives and standards.



• **HANDLING**

This symbol designates all instructions for actions to be carried out by the operator in the specified sequence.

➡ **RESULT**

This symbol refers to all important consequences of the previous actions.

1.3 Safety instructions for the operator



WARNING!

*In general, devices from the manufacturer may only be installed, commissioned, operated and maintained by properly trained and authorized personnel.
This document is provided to help you establish operating conditions, which will permit safe and efficient use of this device.*

2.1 Scope of delivery

**INFORMATION!**

Inspect the packaging carefully for damages or signs of rough handling. Report damage to the carrier and to the local office of the manufacturer.

**INFORMATION!**

Do a check of the packing list to make sure that you have all the elements given in the order.

**INFORMATION!**

Look at the device nameplate to ensure that the device is delivered according to your order. Check for the correct supply voltage printed on the nameplate.



Figure 2-1: Standard scope of delivery

- ① Ordered sensor
- ② Documentation

Optional accessories

- SENSOFIT FLOW 1000 - flow-through holder
- SENSOFIT IMM 1000 - immersion holder
- SENSOFIT INS 1000 - insertion screw in adapter
- SENSOFIT RET 1000/2000 - retractable holder (in preparation)
- Cable pH/ORP-W VP 8.0 with temp. wire 5 m / 16.5 ft
- Cable pH/ORP-W VP 8.0 with temp. wire 10 m / 33 ft

Consumables/Spare parts available

- 250 ml pH buffer solutions pH4/pH7
- OPTISENS PH 8100 sensor

**INFORMATION!**

For further Information ask your local sales office.

2.2 Device description

2.2.1 pH sensor

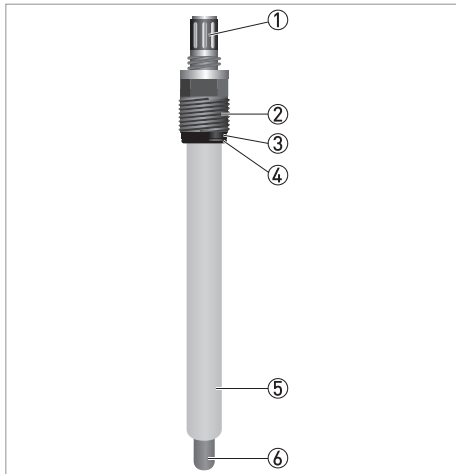


Figure 2-2: Sensor type

- ① Cable connector VP 8.0
- ② PG 13.5 thread
- ③ Washer
- ④ O-ring
- ⑤ Glass
- ⑥ pH sensitive glass

The OPTISENS PH 8100 is manufactured using a pH sensitive special glass which can be used in almost all standard water applications due to its wide measuring range.

The pH sensors are available with different diaphragms:

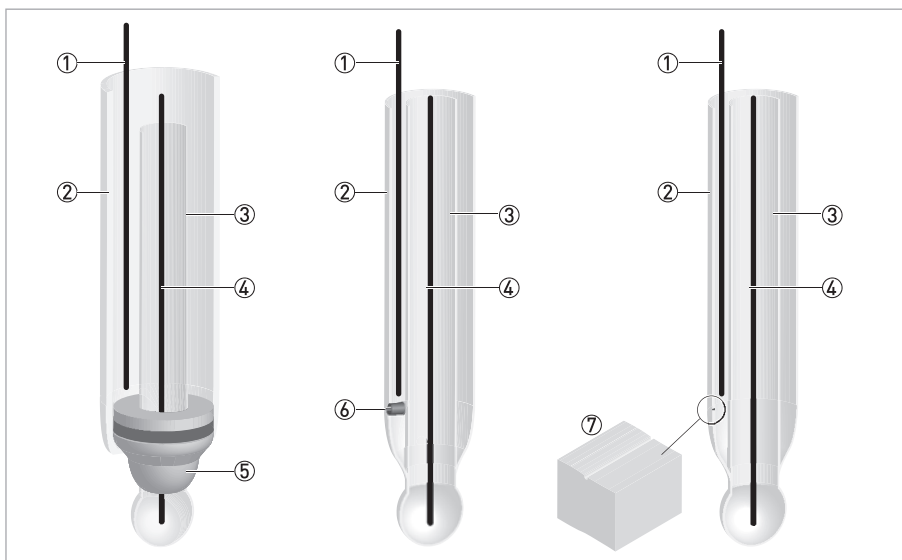


Figure 2-3: Diaphragm types

- ① Reference electrode
- ② KCl solution
- ③ Inner pH 7 buffer solution
- ④ Measuring electrode
- ⑤ PTFE diaphragm
- ⑥ Ceramic diaphragm
- ⑦ Open diaphragm

pH sensor with open diaphragm and Pt100

open diaphragm (microscopically small hole in the glass); integrated Pt100 temperature measurement; suitable for cooling water, wastewater and chemical industry applications.

pH sensor with ceramic diaphragm

Ceramic diaphragm; suitable for drinking water and pool industry applications.

pH sensor with PTFE diaphragm

Dirt-repellent teflon diaphragm; suitable for wastewater, surface water and process water applications.

2.3 Nameplate



INFORMATION!

Prüfen Sie anhand des Typenschildes, ob das gelieferte Gerät Ihrer Bestellung entspricht.

The sensor type is specified on the labelling of the sensor package and on the sensor itself.

3.1 General notes on installation

**INFORMATION!**

Inspect the packaging carefully for damages or signs of rough handling. Report damage to the carrier and to the local office of the manufacturer.

**INFORMATION!**

Do a check of the packing list to make sure that you have all the elements given in the order.

**INFORMATION!**

Look at the device nameplate to ensure that the device is delivered according to your order. Check for the correct supply voltage printed on the nameplate.

3.2 Storage and transport

**CAUTION!**

Do not store the sensor tip dry. This will shorten lifetime considerably.

Always store the pH sensor tip wet in a 3 molar KCl solution when not in use. Saltless water must be avoided since this would leak the KCl ions. The original packing in which the sensor tip was delivered contains a plastic tube with KCl solution and therefore is suitable for storage and transport (see following drawing).

- Since the pH sensor is made out of glass it is very fragile. Avoid shocks of any kind.
- Do not touch or scratch the pH sensitive glass tip of the sensor.
- Store the sensor in its original packaging in a dry, dust-free location. Keep it away from dirt. If necessary, clean it as described on page 37.

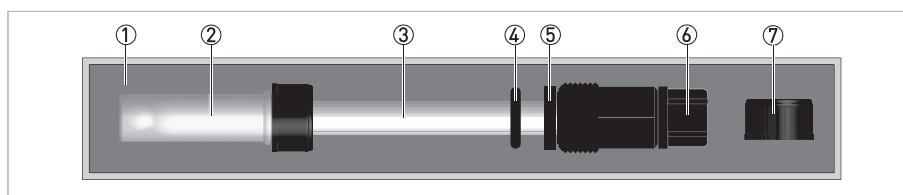


Figure 3-1: sensor in its original packaging

- ① Padding
- ② Plastic tube filled with 3 molar KCl solution
- ③ sensor
- ④ O-ring
- ⑤ Washer
- ⑥ Protective cap over electrical connector
- ⑦ Sealing cap without hole to seal plastic tube ② when sensor is in use



Storing the sensor in the provided plastic tube

- Screw the sealing cap off the plastic tube. Keep it in the original packaging.
- If there is not enough KCl solution in the plastic tube, fill it up with 3 molar KCl solution.
- Insert the sensor tip through the hole in the storage cap (see drawing on page 13).
- Carefully push the O-ring delivered with the storage cap on the sensor so that the cap sits over the O-ring.
- Insert the sensor tip into the plastic tube until it is fully covered with KCl solution.
- Tighten the cap.
- Store the sensor in its original packaging.

3.3 Installation procedure

Because a new pH sensor needs to be calibrated before it is installed into its final measuring location, it is important to follow the installation order:

1. Unpack the sensor.
2. Connect the sensor to the signal converter.
3. Calibrate the sensor.
4. Install the sensor into its final measuring location.

The required steps are explained in the following sections.

3.4 Pre-installation requirements



CAUTION!

- Do not drop the device! Handle the device with care!
- Never touch or scratch the pH membrane glass of the sensor.
- Store the sensor in its original packaging in a dry, dust-free location. Keep it away from dirt. If necessary, clean it. See cleaning procedure on page 37.
- Do not make any mechanical modifications to the sensor (electrodes shortened, drilled, bent or scratched). This can result in the loss of proper functionality, as well as the rights under the device warranty.
- The sensor must be suitable for the temperature, pressure and medium conditions which are specified (including chemical resistance).

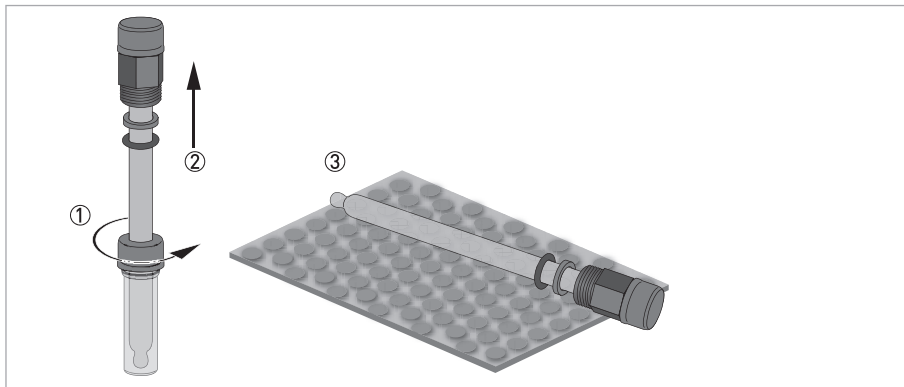


Figure 3-2: Handling the sensor



Unpacking the sensor

- Loosen the storage cap which is screwed or/and pushed on to the plastic tube ①.
- Gently pull the sensor out of the plastic tube ②.
- Lay the sensor on a soft mat/tissue ③.

3.5 Safety instructions



DANGER!

For devices used in hazardous areas, additional safety notes apply; please refer to the Ex documentation.



DANGER!

All work on the electrical connections may only be carried out with the power disconnected.



DANGER!

Observe the national regulations for electrical installations!



WARNING!

Observe without fail the local occupational health and safety regulations. Any work done on the electrical components of the measuring device may only be carried out by properly trained specialists.

**INFORMATION!**

Look at the device nameplate to ensure that the device is delivered according to your order.

3.5.1 Connecting the sensor cable to the signal converter

**DANGER!**

All work on the electrical connections may only be carried out with the power disconnected. Take note of the voltage data on the nameplate!

**INFORMATION!**

Look at the device nameplate to ensure that the device is delivered according to your order. Check for the correct supply voltage printed on the nameplate.

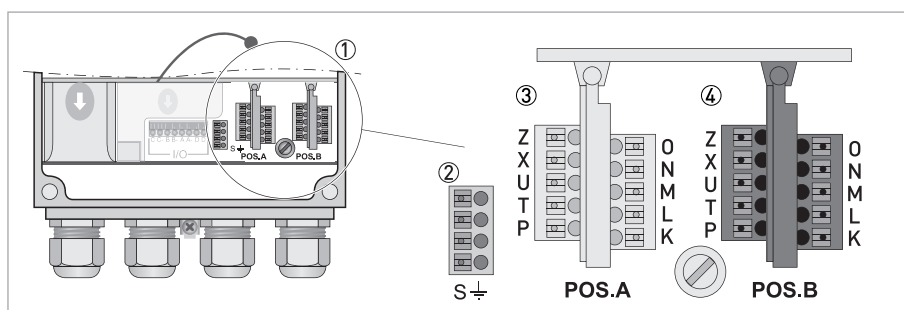


Figure 3-3: Sensor connection terminals on the MAC 100 dual channel version

- ① Sensor connection terminals
- ② Terminal block S (protective earth)
- ③ Terminal block Pos.A: terminal for sensor and temperature
- ④ Terminal block Pos.B: terminal for sensor and temperature

The pH sensors are available with integrated Pt100 temperature sensor. The pH sensors with integrated temperature sensor use a VP 8.0 cable.

When ordering the one channel version, only the interface "Pos.A" is populated. In the version with two channels the interfaces "Pos.A" and "Pos.B" are populated.

Wire	Terminal block Pos.A/B
OPTISENS PH 8100 with VP 8.0 cable (with integrated Pt100/1000)	
Inner coax shield (black)	N (ref.)
Coax core (transparent)	O (pH)
Sense (3-wire connection Pt100/Pt1000)	U
Pt100 (white)	P
Pt100 (green)	X
Outer shield (green-yellow)	S

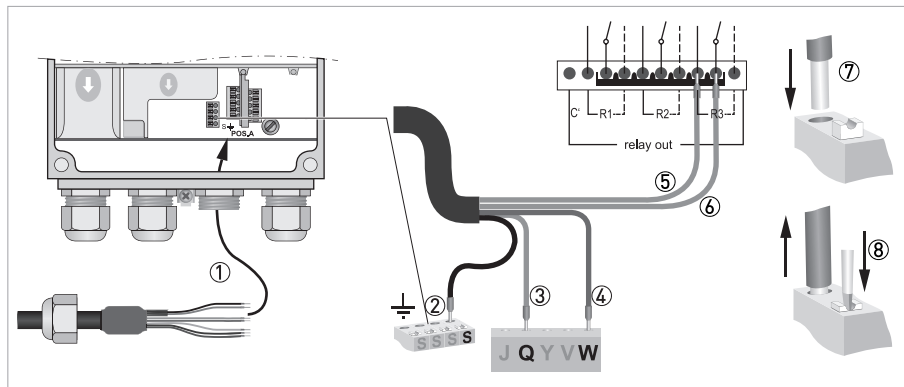


Figure 3-4: Connecting the sensor cable

The following instructions describe the connection of the different sensor cables.



Connecting the sensor cable to the signal converter

- Thread the sensor cable through the outer right cable gland ①.
- Push the coax shield ④ into terminal N ② and the coax core into terminal O ③.
- To remove a cable, press down the white clip ⑤ on the corresponding terminal and pull the cable out ⑥.

3.5.2 Connecting the external temperature sensor

Connect an external Pt100 or Pt1000 sensor to terminal block Pos.A/B of the signal converter according to the following drawings:

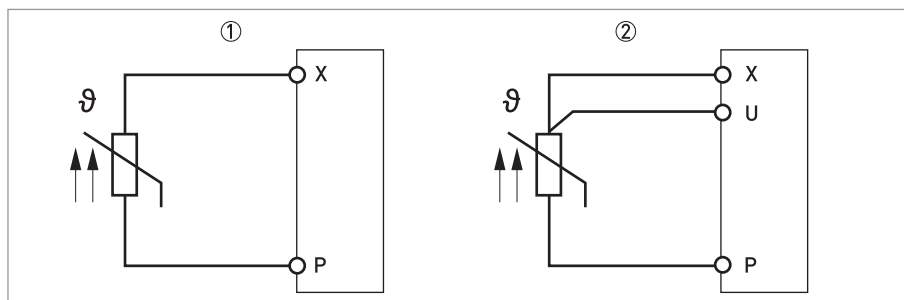


Figure 3-5: Connection of an external Pt100/1000 temperature sensor to the signal converter (2-wire connection)

- ① 2-wire connection
② 3-wire connection

3.5.3 Connecting the cable to the sensor

**CAUTION!**

Moisture on the sensor connector must be avoided! Moisture may cause a short-circuit and a malfunction of the sensor!

If moisture has entered the connector dry it with air (e.g. hot air gun).

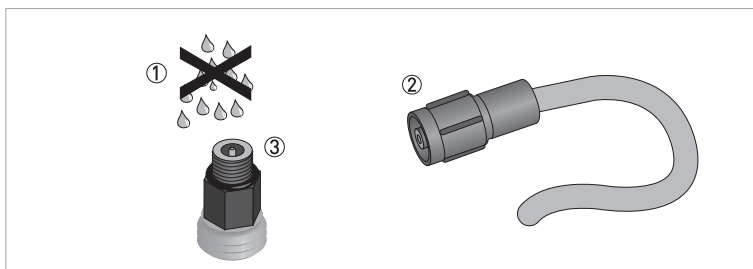


Figure 3-6: Connecting the cable to the sensor

**Connecting the cable to the sensor**

- Ensure that the cable and the sensor connector are absolutely dry ①.
- Screw the cable connector ② on to the sensor connector ③ and tighten it by hand.

3.6 Calibrating the sensor

Before the sensor is installed, it has to be calibrated. Proceed as described on page 26. Then continue with the installation procedure.

3.7 Installing the sensor

3.7.1 General installation instructions

The sensor tip must always have full contact with the measuring medium.

The mounting position of the sensor should not deviate more than 75° from vertical position (sensor tip pointing downwards). Doing otherwise might cause internal air bubbles to float into the sensor tip. This would interrupt the electrical contact between the inner buffer solution and the glass surface.

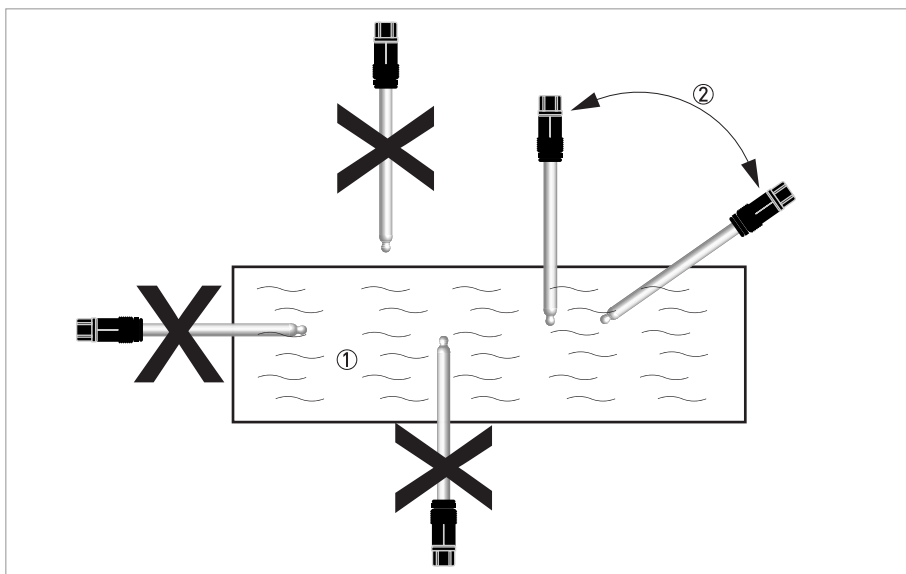


Figure 3-7: Installation requirements

- ① Measuring medium
- ② Maximum deviation of 75° from vertical position

3.7.2 Mounting to a flow-through assembly

**WARNING!**

Ensure that the pipe is without pressure before installing or removing a sensor!

**INFORMATION!**

The flow-through assembly is an optional accessory and not part of the standard scope of delivery. It has to be installed horizontally in pump or sample lines or directly in the process.

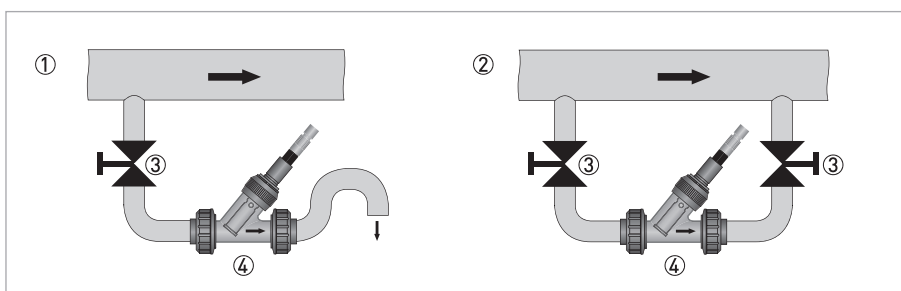


Figure 3-8: Possible mounting positions of the flow-through assembly

- ① Mounting in an outlet pipe
- ② Mounting in a bypass pipe
- ③ Valve
- ④ Flow-through assembly

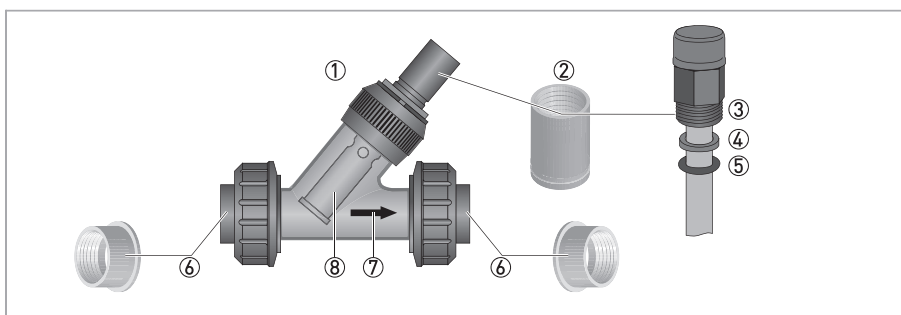


Figure 3-9: Installing the sensor into the flow-through assembly

- ① Flow-through assembly
- ② Female thread
- ③ Sensor thread
- ④ Washer
- ⑤ O-ring
- ⑥ Process connection
- ⑦ Flow direction
- ⑧ Protective cage

**Installing a new sensor**

- Make sure that the O-ring ⑤ and the washer ④ on the sensor are assembled in the sequence indicated in the drawing.
- Screw the sensor into the female thread ② of the flow-through assembly ①. Tighten the sensor by hand.
- If you have not yet established the electrical connection to the signal converter, leave the protective cap on the sensor until you establish the electrical connection.

3.8 Installing an external temperature sensor

Since the slope of the pH sensor is temperature-dependent, a temperature compensation makes sense if the temperature of your measuring medium varies.

If the pH sensor does not have an integrated Pt100/1000 temperature sensor, you should use an external temperature sensor. There are various different possibilities of adding an external temperature sensor to your pH measurement installation. They can not be explain in detail in this document. Nevertheless, you should follow the general guidelines.

General guidelines for external temperature sensor installation

- The temperature sensor should be calibrated using a reference thermometer. For further information refer to *Temperature compensation* on page 26.
- The temperature should be measured close to the pH sensor in the same medium to avoid temperature differences. For example, surface water may have a different temperature than deeper water.

Suitable external temperature sensors are

- Pt100 in 2-wire or 3-wire connection
- Pt1000 in 2-wire or 3-wire connection

3.9 Examples of a typical measuring point

The following examples each show the signal converter, a sensor with or without integrated temperature measurement, and the flow-through or immersion assembly.

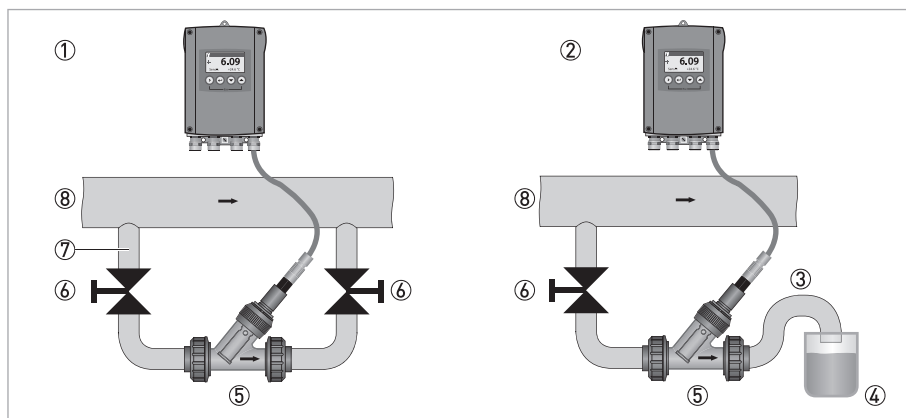


Figure 3-10: Measuring point using the flow-through assembly

- ① Bypass measurement
- ② Outlet measurement
- ③ Elbow pipe
- ④ Sample vial
- ⑤ Flow-through assembly with sensor
- ⑥ Shut-off valve
- ⑦ Bypass pipe
- ⑧ Main pipe

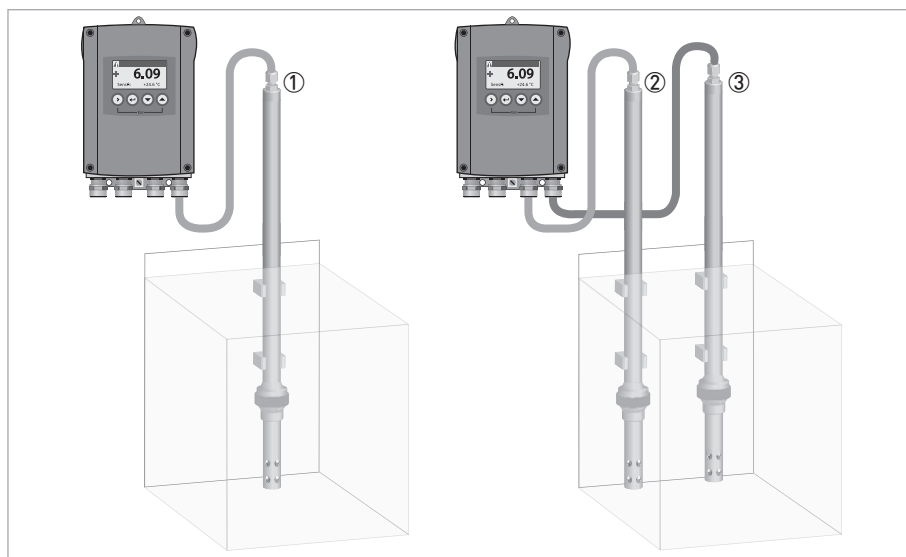


Figure 3-11: Measuring point using the immersion assembly

- ① pH and temperature on single channel instrument
- ② pH or pH and temperature
- ③ pH and temperature

4.1 Menu mode structure



INFORMATION!

The following table just presents an overview. When programming the device, always consult the function tables additionally as they contain further information!

Measuring mode	Main menu	Submenu			Parameter
3 or 4 pages, scrolling with ↓ or ↑	> 2.5 s ↵	A quick setup	> ↵ A9.1 temp.comp.	> ↵ A9 pH cal. A process input A pH calibration (for dual channel version; refer to pH/ORP sensor documentation for further information)	> ↵ For further information see function tables.
			A12.1 start calib. ORP	A12 ORP calibration B Only if switched to ORP! process input B ORP calibration (for dual channel version; refer to pH/ORP sensor documentation for further information)	
			A13.1 temp.comp.	A13 pH cal. B process input B pH calibration (for dual channel version; refer to pH/ORP sensor documentation for further information)	

Measuring mode	Main menu		Submenu				Parameter	
3 or 4 pages, scrolling with ↓ or ↑	> 2.5 s ↩	B test	> ↩	B1 sim.process inp.A	> ↩	B1.1 temperature	> ↩	For further information see function tables.
						B1.5 ORP Only if switched to ORP! (for dual channel version; refer to pH/ORP sensor documentation for further information)		
						B1.7 pH (for dual channel version; refer to pH/ORP sensor documentation for further information)		
				B2 sim.process inp.B		B 2.1 temperature		
						B2.5 ORP Only if switched to ORP! (for dual channel version; refer to pH/ORP sensor documentation for further information)		
						B2.7 pH (for dual channel version; refer to pH/ORP sensor manual for further information)		
				B3 simulation I/O		B3.1 current out A		
						B3.2 current out B		
						B3.3 current out C		
						B3.6 simulation R3		
				B4 actual values		B4.1 operating hours		
						B4.2 process input A		
						B4.2.1 temperature		
						B4.2.2 pH/ORP		
						B4.2.9 CPU temp. (depends on V number)		
						B4.2.11 electrode current		
						B4.3 process input B		
						B4.3.1 temperature		
						B4.3.2 pH/ORP		
						B4.3.9 CPU temp. (depends on V number)		
						B4.3.11 electrode current		
				B5 logbooks		B5.1 status log		
						B5.2 calibration log		
				B6 information		B6.1 C number		
						B6.2 process input A		
						B6.3 process input B		
						B6.4 SW.REV.MS		
						B6.5 SW.REV.UIS		
						B6.6 Electronic Revision ER		
	↓↑		↓↑		↓↑		↓↑	

Measuring mode	Main menu	Submenu			Parameter
3 or 4 pages, scrolling with ↓ or ↑	> 2.5 s ↩	C setup	> ↩ C1 process input A	> ↩ C1.1 parameter (pH/ORP)	> ↩ For further information see function tables.
				C1.7 inner buffer (only pH)	
				C1.8 zero point	
				C1.9 slope	
				C1.10 calibration buffers	
				C1.14 time constant	
				C1.15 temperature	
				C1.16 ORP cal.	
				C1.17 pH cal.	
			C2 process input B (for dual channel version; refer to pH/ORP sensor manual for further information)	C2.1 parameter (pH/ORP)	
				C2.7 inner buffer (only pH)	
				C2.8 zero point	
				C2.9 slope	
				C2.10 calibration buffers	
				C2.14 time constant	
				C2.15 temperature	
				C2.16 ORP cal.	
				C2.17 pH cal.	
		↓↑	↓↑	↓↑	↓↑

4.2 Function tables

4.2.1 Menu A, quick setup



INFORMATION!

Note that the appearance of some sub-menus depends on the hardware setting and the used sensor(s). Also only the sensor relevant menus and submenus are shown here in detail. For all other menu functions refer to the MAC 100 signal converter manual.

A7, ORP cal. A / A12 ORP cal. B

For single or dual channel version: Settings for sensor verification

4.2.2 Menu B, test

**INFORMATION!**

Note that the appearance of some sub-menus depends on the hardware setting and the used sensor(s). Also only the sensor relevant menus and sub-menus are shown here in detail. For all other menu functions refer to the MAC 100 signal converter manual.

The procedure to start the simulation process is the same for all functions:



- Choose the function with the help of ↓ or ↑ and press ↵.
- ➡ You see the two options "set value" (opens the editor to enter the simulation value) and "break" (exits the menu without simulation).
- Choose the desired option with the help of ↑ or ↓ and press ↵.
- ➡ If you chose "set value", the device asks "start simulation" and offers the options "no" (exits the menu without simulation) or "yes" (starts the simulation finally).
- Choose the desired option with the help of ↑ or ↓ and press ↵.
- ➡ If you chose "yes", the simulation starts.

B1,sim.process inp.A

B2,sim.process inp.B

Menu point	Designation / function	Settings / descriptions
B1.1 B2.1	temperature	In this menu the temperature can be simulated.
B1.5 B2.5	ORP	In this menu the relative concentration of ORP can be simulated.

B4, actual values

Menu point	Designation / function	Settings / descriptions
This menu groups several functions which allow to display the corresponding actual reading. The shown measurements are depending on the device configuration.		
B4.1	operating hours	This menu shows the operating time of the devices in hours.
B4.2	process input A	In this menu the measurements from process input A can be read.
B4.3	process input B	In this menu the measurements from process input B can be read.

4.2.3 Menu C, setup

**INFORMATION!**

The signal converter has a dual process input, A and B. Each process input has an own submenu in this main menu. Process input A is always present, i.e. there is always a board in the interface "Pos.A" in the connection area. The interface of process input B only has a board with the dual channel signal converter. Be aware that the definition which kind of measurement a process input can do is defined when ordering the device. The configuration cannot be changed later.

**INFORMATION!**

Note that the appearance of some submenus depends on the hardware setting and the used sensor(s).

C1, process input A**C2, process input B**

Menu point	Designation / function	Settings / descriptions
Process input A and B can be either a sensor 1 or a sensor 2. Further information about the type of sensor 1 or 2 please refer to MAC 100 manual "Sensor input combinations". Process input A is always present, process Input B can be present. Note: The exchange of a sensors 1 with a sensor 2, or vice versa, can only be done by the manufacturer! Depending on the sensor which is connected to a slot A or B the menu changes.		
C1.1 C2.1	parameter pH parameter ORP	This menu item is for selecting the probe which is connected to process input A/B. The entries of this selection depends on the chosen device configuration. The device configuration is customer specific and set during production.
C1.8 C2.8	zero point	This menu item shows the actual zero point to the calibrated pH/ORP sensor.
C1.9 C2.9	slope	This menu item shows the actual slope point to the calibrated pH/ORP sensor.
C1.16 C2.16	ORP cal.	Menu item for calibrating the ORP sensor.
C1.16.1 C2.16.1	prepare calibration	View actual ORP value.
C1.16.2 C2.16.2	ref. value ORP	Enter the reference value of the probe in mV.
C1.16.3 C2.16.3	start calibration?	Start calibration procedure.
C1.16.4 C2.16.4	stored value	View stored value of calibration.

4.3 Calibration

4.3.1 Temperature compensation

There are three basic options for temperature compensation:

- **automatic:** the signal converter will automatically compensate temperature influences using the information of a Pt100 or Pt1000 temperature sensor.
- **manual:** the signal converter will compensate temperature influences using a manually entered value; this option only makes sense if the temperature of the measured medium is quite constant.
- **off:** temperature compensation is disabled.



INFORMATION!

If you choose no compensation, the measured pH value will most likely deviate from the actual pH value. The reason is that the pH value of a specific medium varies depending on the temperature of the medium.

The menu for the type of temperature compensation offers the following options:

- **Pt1000:** choose this option if there is an external Pt1000 temperature sensor connected to the signal converter.
- **Pt100:** choose this option if the sensor has an integrated Pt100 temperature measurement or if there is an external Pt100 temperature sensor connected to the signal converter.
- **manual:** choose this option if there is no integrated or external temperature sensor connected to the signal converter.
- **process input A:** choose this option if there is a temperature sensor connected to input A of the signal converter.



INFORMATION!

In the basic configuration the setting of the temperature compensation is Pt100. If you use a pH sensor without Pt100/1000 than select the temperature compensation "manual" and enter the value. Otherwise an error will be displayed.

After starting-up the signal converter, the measuring screen appears. This is the standard screen which is displayed automatically in the normal operating mode. If you are in this mode and you want to adjust the temperature compensation, you have to perform the following steps:

Step 1: activating the temperature compensation for measurement

- Press > for more than 2.5 seconds, then release the button. You are on the main menu level. In the upper line of the display "A" appears, beneath the main menu quick setup is highlighted. - Press ▼ or ▲ until the main menu setup is highlighted.	
MAIN MENU A quick setup B test > C setup D service Press > to enter the chosen menu.	
You are on the first submenu level. In the upper line of the display "setup" and "c1" appears, beneath the submenu process input A is highlighted. - Press ▼ or ▲ to select process input A or process input B. Choose process input A or B where ever pH is configured. - Press > to enter the chosen menu.	
You are on the second submenu level. The submenu parameter is highlighted. Press > to enter the chosen menu.	
You are on the third submenu level. In the upper line of the display "parameters" appears. - Press ▼ or ▲ to select pH. - Press ↵ to confirm the entered value.	
You are on the second submenu level. The submenu parameter is highlighted. - Press ▼ or ▲ to select temperature. - Press > to enter the chosen menu.	
You are on the third submenu level. In the upper line of the display "temperature" and "C1.15.1" or "C2.15.1" appears, beneath the option probe is highlighted. - Press ▼ or ▲ to select temp.comp. - Press > to enter the chosen menu.	
You are on the fourth submenu level. In the upper line of the display "temp.comp" appears. Now you can setup the temperature compensation. - Press ▼ or ▲ to choose between automatic or off. - Press ↵ to confirm the entered value.	
You are on the third submenu level. If you have chosen the option automatic, you can select the type of temperature compensation now. - Press ▼ or ▲ to choose probe. - Press > to enter the chosen menu.	
You are on the fourth submenu level. Press ▼ or ▲ to choose between Pt100, Pt1000, manual or process input A. - Press ↵ to confirm the entered value. - Press ↵ several time until you reach the measuring mode again. Choose yes to safe and confirm your selection.	



INFORMATION!

When ordering the dual channel version, the interface "Pos A" and "Pos B" are populated. A separate temperature sensor has to be connected to "Pos A" and configured on **process input A**. To connect a sensor with integrated Pt100/Pt1000, the integrated temperature sensor has to be connected on the same terminal block as the sensor.

Step 2: Configure /adjust the temperature sensor

Step 2a: probe Pt100/1000	
Read the currently measured temperature of the Pt100/1000 temperature sensor from the measurement screen and write it down. Measure the temperature with a reference thermometer and check if it deviates from the temperature measured by the Pt100/1000. - Press > for more than 2.5 seconds, then release the button. You are on the main menu level. In the upper line of the display "A" appears, beneath the main menu setup is highlighted. - Press ▼ or ▲ until the main menu setup is highlighted.	
	MAIN MENU A quick setup B test > C setup D service Press > to enter the chosen menu.
	You are on the first submenu level. In the upper line of the display "setup" and "c1" appears, beneath the submenu process input A is highlighted. Choose process input A or B where ever pH is configured. - Press ▼ or ▲ to select process input A or process input B. - Press > to enter the chosen menu process input A/B.
	You are on the second submenu level. Press ▲ or ▼ until the submenu temperature is highlighted. Press > to enter the chosen menu. The submenu probe is highlighted.
	- Press ▼ or ▲ until the submenu Pt100/1000 is highlighted. - Press ↵ to enter the chosen menu.



- If necessary, enter the temperature correction in Kelvin so that the signal converter shows the same temperature as the reference thermometer. Press **↵** to confirm the entered value. The temperature sensor has been adjusted.

Step 2b: probe manual			
Measure the temperature of the measuring medium. • Press > for more than 2.5 seconds, then release the button. You are on the main menu level. In the upper line of the display "A" appears, beneath the main menu setup is highlighted. • Press ▼ or ▲ until the main menu setup is highlighted.			
MAIN MENU			
A quick setup B test > C setup D service			
• Press > to enter the chosen menu.			
You are on the first submenu level. In the upper line of the display "setup" and "c1" appears, beneath the submenu process input A is highlighted. Choose process input A or B where ever pH is configured.			
• Press ▼ or ▲ to select process input A or process input B .			
• Press > to enter the chosen menu process input A/B .			
You are on the second submenu level. Press ▲ or ▼ until the submenu temperature is highlighted.			
• Press > to enter the chosen menu. The submenu probe is highlighted.			
• Press ▼ or ▲ until the submenu manual is highlighted. • Press ↵ to enter the chosen menu.			



- Enter the measured temperature. Press ↵ to confirm the entered value. The manually measured temperature will now be used for temperature compensation.



- Step 2c: **probe process input A**
 The temperature sensor connected to input A of the signal converter is used for temperature compensation.
 The temperature sensor **probe process input A** has to configured in submenu **process input A**.
 If you use a Pt100/1000 follow the instruction in step 2.1. If you use manually entered value, follow the instruction in step 2.2.

4.3.2 Calibrating pH measurement

A pH calibration is necessary in regular intervals or when installing a new pH sensor.

In an intact sensor, the optimal slope is 59 mV for each pH unit and the optimal zero point is 0 mV at pH 7. The slope should at least have a value between 50...65 mV per pH unit. Re-calibrate the sensor if the slope does not approximate those limits.

The pH sensor ages, the slope gets flatter and the zero error increases. When one or both of these values exceed certain limits, the signal converter displays a message indicating that the sensor has to be exchanged.



CAUTION!

- *Never touch or scratch the pH sensitive glass tip of the sensor.*
- *Make sure that the glass tip is clean and dust-free. If necessary, clean the tip as described refer to *Cleaning* on page 37.*



CAUTION!

Moisture on the sensor connector must be avoided! Moisture may cause a short-circuit and a malfunction of the sensor!

If moisture has entered the connector dry it with air (e.g. hot air gun).

To avoid alarms on the process control system when temporarily removing the sensor (i.e. for maintenance), the signal converter has a hold function. This function "freezes" all outputs (i.e. the display and the current outputs) of the last measured value.



INFORMATION!

As an indication that the manual hold function is active, the "warning sign" in the upper left corner of the display appears. Meanwhile the status messages show "checks in progress". For more details about how to select the manual hold function refer to the signal converter manual.

After starting-up the signal converter, the measuring screen appears. This is the standard screen which is displayed automatically in the normal operating mode. If you are in this mode and you want to initiate a calibration, you have to activate the manual hold function in the first step.

Step 1: activating the manual hold function

- Press > for more than 2.5 seconds, then release the button. You are on the main menu level. In the upper line of the display "A" appears, beneath the main menu quick setup is highlighted. - Press ▼ or ▲ until the main menu quick setup is highlighted.	
MAIN MENU	
> A quick setup B test C setup D service	
Press > to enter the chosen menu.	
You are on the first submenu level. In the upper line of the display "quick setup" and "A1" appears, beneath the submenu language is highlighted.	
- Press ▼ or ▲ until the submenu manual hold is highlighted. - Press > to enter the chosen menu.	
You are on the second submenu level. In the upper line of the display "manual hold" appears, beneath the option off is highlighted	
Press ▼ or ▲ to choose the option "on"	
Press ↵ to confirm the entered value.	



- You have activated the manual hold function. To go to the next step and prepare the calibration procedure. You have to return to the measuring mode.
- Press **↵** until you reach the measuring mode again



Step 2: preparing the calibration procedure

- If you re-calibrate an existing sensor, remove the sensor from its respective assembly (for further information refer to *Mounting to a flow-through assembly* on page 18 or refer to *Calibrating pH measurement* on page 30).
- If you calibrate a new sensor, make sure that the sensor is correctly connected to the signal converter.
- Check the sensor for damages, check the diaphragm for coating and rinse the sensor tip with tap water and gently swipe it with a soft tissue.
- Provide two buffer solutions with the same known temperature: pH 4 and pH 7.

After activating the manual hold function and the preparative measures, you can get access to the calibration procedure from the measuring mode in two different ways. Either you go via the main menu **setup** (step 3a) or via the main menu **quick setup** (step 3b).

Step 3a: accessing the calibration menu via the main menu **setup**

- Press > for more than 2.5 seconds, then release the button. You are on the main menu level. In the upper line of the display "A" appears, beneath the main menu quick setup is highlighted. - Press ▼ or ▲ until the main menu setup is highlighted.	
MAIN MENU A quick setup B test > C setup D service	
Press > to enter the chosen menu.	
You are on the first submenu level. In the upper line of the display "setup" and "c1" appears, beneath the submenu process input A is highlighted.	
Press ▼ or ▲ to select process input A or process input B is highlighted. Choose process input A or B where ever pH is configured.	
Press > to enter the chosen menu.	
You are on the second submenu level. In the upper line of the display "process input A" and "C1.1" appears, beneath the submenu parameter is highlighted.	
Press ▼ or ▲ until the submenu pH cal. is highlighted.	
Press > to enter the chosen menu.	



- You can start the calibration procedure now as described in "Step 4".

Step 3b: accessing the calibration menu via the main menu **quick setup**

Press > for more than 2.5 seconds, then release the button. You are on the main menu level. In the upper line of the display "A" appears, beneath the main menu quick setup is highlighted.	
MAIN MENU > A quick setup B test C setup D service	
Press > to enter the chosen menu.	
You are on the first submenu level. In the upper line of the display "quick setup" and "a" appears, beneath the submenu language is highlighted.	
Press ▼ or ▲ until the submenu pH cal. A or B is highlighted, wherever pH is configured	
Press > to enter the chosen menu.	



- You can start the calibration procedure now as described in "Step 4".



Figure 4-1: Calibration procedure



Step 4: calibration procedure

- After choosing the submenu **pH cal.** (step 3a) or **pH cal. A or B** (step 3b) in the previous steps, continue by pressing **>**.
- ➡ The signal converter demands to choose the kind of temperature compensation for the calibration. You have the options "off", "automatic" and "manual" (for detailed information refer to *Temperature compensation* on page 26). Please select the same kind of temperature compensation for the calibration as for the measurement.
- If you chose "automatic", just press **↵**. If you chose "manual", first enter the temperature of the buffer solutions using **▼** or **▲** and then press **↵**.
- ➡ On the screen the message **calib. buffer 1** appears.
- Submerge the sensor tip into the pH 7 buffer solution ①.
- ➡ The currently measured value is shown on the display.
- Wait until a steady value is displayed, then press **↵**.
- Press **↵** to finally start the calibration procedure.
- ➡ The message **pH 1 set value** and the pH value of the first buffer solution are displayed on the screen.
- Press **↵** to confirm the settings.
- After 25 seconds the calibration step is completed and **calib. buffer 2** appears. Otherwise, if the shown value deviates from the buffer solution, enter the correct value using **▼** or **▲**.
- Press **↵** to confirm the entered value.
- ➡ On the screen the message **calib. buffer 2** appears.
- Rinse the sensor tip with tap water ② and clean it with a soft tissue.
- Submerge the sensor tip into the pH 4 buffer solution ③.
- ➡ The currently measured value is shown on the display.
- Wait until a steady value is displayed.
- Press **↵** to continue the calibration procedure.
- ➡ The message **pH 2 set value** and the pH value of the second buffer solution are displayed on the screen.
- Press **↵** to confirm the setting.
- After 25 seconds the calibration step is completed. Otherwise, if the shown value deviates from the buffer solution, enter the correct value using **▼** or **▲**.
- Press **↵** to confirm the entered value.
- ➡ The zero point of the sensor is displayed (should be near 0 mV in an intact sensor).

- Press **↵** to confirm.
- ➡ The slope of the sensor is displayed (should be near 59 mV in an intact sensor).
- Press **↵** to confirm.
- ➡ The message **store cal. value?** is displayed on the screen. The signal converter asks if the new calibration values should be stored.
- Choose **yes** to store the calibration values. Choose **no** to discard the results.
- Press **↵** to confirm.
- ➡ Prior returning to the measuring display, you are asked if the configuration should be stored.
- Choose **yes** using **▼** or **▲** to store the new calibration values.
- ➡ You have completed the pH calibration.
- If you want to return to the measuring mode, press **↵** several times until you reach this mode.

**INFORMATION!**

*If an error occurs during the calibration procedure, the display shows an error message.
Possible causes for an error are:*

- *Slope too flat.*
- *Wrong buffer solution.*
- *Wrong electrical connection.*
- *Moisture in the sensor connector.*

**Step 5: re-installing the sensor**

- After the calibration procedure, rinse the sensor with tap water.
- Reinstall the sensor into its assembly, refer to *Installing the sensor* on page 17.

**Step 6: switching back to measurement**

- Deactivate the function "manual hold" again.

4.3.3 Calibration log



INFORMATION!

In order to show the history of the calibrations, the signal converter has a calibration logbook function. Up to 64 entries of the calibration history are stored including date and time.

Accessing the calibration log

- Press > for more than 2.5 seconds, then release the button. You are on the main menu level. In the upper line of the display "A" appears, beneath the main menu **quick setup** is highlighted.
- Press ▼ or ▲ until the main menu **test** is highlighted.

MAIN MENU A quick setup > B test C setup D service	
Press > to enter the chosen menu.	
	You are on the first submenu level. In the upper line of the display "test" and "B1" appears, beneath the submenu sim.process input A is highlighted.
	Press ▲ or ▼ until the submenu logbooks is highlighted.
	Press > to enter the chosen menu.
	You are on the second submenu level. In the upper line of the display "logbooks" and "B1" appears, beneath the submenu status log is highlighted.
	Press ▼ or ▲ until the submenu calibration log is highlighted.
	Press > to enter the chosen menu.



- You are on the data level and you see the calibration history. With the help of ▼ or ▲ you can scroll through the different entries.
- If you want to return to the measuring mode press ↵ several times until you reach this mode.

4.4 Troubleshooting

Problem	Possible cause	Remedy
The pH sensor does not deliver a signal.	Mechanical damage of the glass bulb, e.g. small cracks. This will shortcut the ion exchange and deliver a pH7 reading.	Exchange sensor.
	Moisture inside the sensor connector. This will shortcut the signal between pH glass half cell and reference half cell and deliver a reading of pH7.	Clean the connector (sensor/cable) with pure water and dry with air (e.g. hair blower).
The pH sensor delivers an unstable signal.	The diaphragm in the reference half cell does not provide good contact to the process medium due to drying up or coatings.	• Clean the diaphragm with hot soap or acid using a soft tissue (details on page 37). • Submerge sensor in water and increase the temperature to 50...60°C / 122...140°F. • Submerge sensor in 3 molar KCl solution at ambient temperature. The decrease in temperature will cause the reference half cell to suck in KCl solution through the diaphragm and regenerate the diaphragms functionality.

5.1 Maintenance

5.1.1 Cleaning

**INFORMATION!**

Recalibrate the sensor after each manual cleaning procedure.



- Slight dirt residues or dust: Rinse the sensor tip with demineralised water and clean it with a soft tissue.
- Oily and greasy coatings: Remove with a warm soap solution and rinse with demineralised water.
- Hardness deposits or metal hydroxide deposits: Soak the sensor tip including diaphragm in 10% citric acid or hypochloric acid for a couple of minutes and rinse the complete glass shaft of the sensor with demineralised water.
- Biological fouling: Soak the sensor tip including diaphragm in 10% pepsin solution for minimum 3 hours and afterwards rinse the complete glass shaft of sensor with demineralised water.

5.1.2 Aging and re-calibration

During operation, but already during storage, pH sensors age due to poisoning effects of the inner buffer system. Therefore it is important to re-calibrate the sensors in regular intervals as described.

Aging effects pH sensors:

- **Decrease of slope** due to abrasion, drying, corrosion of glass bulb coating and leaching: The slope should be $> 50 \text{ mV/pH}$. An optimal value is 59 mV/pH at $25^\circ\text{C} / 77^\circ\text{F}$. When the slope drops below 50 mV/pH , an error message is displayed and the sensor has to be exchanged. The slope of the sensor is displayed after each calibration procedure.
- **Shift of zero point** due to leaching / contamination of reference half cell or increased resistance between glass bulb and reference half cell: The zero point should lie between $-58 \dots +58 \text{ mV}$ at pH 7. An optimal value is 0 mV at pH 7. The zero point of the sensor is displayed after each calibration procedure.

The following figure shows the aging effects

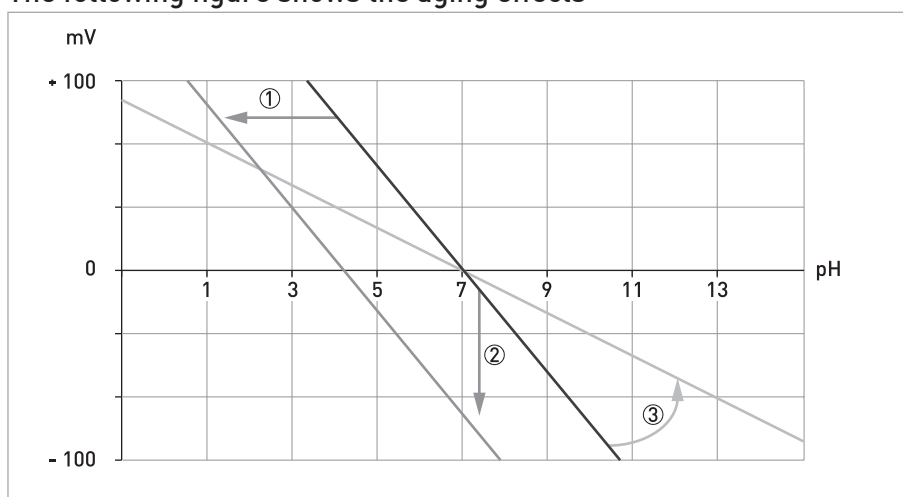


Figure 5-1: Aging effects of sensor

- ① Horizontal shift of slope
- ② Vertical shift of slope
- ③ Decrease of slope



INFORMATION!

The life time of a pH sensor can lie anywhere between 6 weeks and 2 years. The life time expectation depends heavily on the application. The right choice of the sensor type is very important.

5.2 Spare parts availability

The manufacturer adheres to the basic principle that functionally adequate spare parts for each device or each important accessory part will be kept available for a period of 3 years after delivery of the last production run for the device.

This regulation only applies to spare parts which are subject to wear and tear under normal operating conditions.

5.3 Availability of services

The manufacturer offers a range of services to support the customer after expiration of the warranty. These include repair, maintenance, technical support and training.

**INFORMATION!**

For more precise information, please contact your local sales office.

5.4 Returning the device to the manufacturer

5.4.1 General information

This device has been carefully manufactured and tested. If installed and operated in accordance with these operating instructions, it will rarely present any problems.

**CAUTION!**

Should you nevertheless need to return a device for inspection or repair, please pay strict attention to the following points:

- *Due to statutory regulations on environmental protection and safeguarding the health and safety of the personnel, the manufacturer may only handle, test and repair returned devices that have been in contact with products without risk to personnel and environment.*
- *This means that the manufacturer can only service this device if it is accompanied by the following certificate (see next section) confirming that the device is safe to handle.*

**CAUTION!**

If the device has been operated with toxic, caustic, radioactive, flammable or water-endangering products, you are kindly requested:

- *to check and ensure, if necessary by rinsing or neutralising, that all cavities are free from such dangerous substances,*
- *to enclose a certificate with the device confirming that is safe to handle and stating the product used.*

5.4.2 Form (for copying) to accompany a returned device



CAUTION!

To avoid any risk for our service personnel, this form has to be accessible from outside of the packaging with the returned device.

Company:		Address:	
Department:		Name:	
Tel. no.:		Fax no. and/or Email address:	
Manufacturer's order no. or serial no.:			
The device has been operated with the following medium:			
This medium is:	☐	radioactive	
	☐	water-hazardous	
	☐	toxic	
	☐	caustic	
	☐	flammable	
	☐	We checked that all cavities in the device are free from such substances.	
	☐	We have flushed out and neutralized all cavities in the device.	
We hereby confirm that there is no risk to persons or the environment through any residual media contained in the device when it is returned.			
Date:		Signature:	
Stamp:			

5.5 Disposal



CAUTION!

Disposal must be carried out in accordance with legislation applicable in your country.

Separate collection of WEEE (Waste Electrical and Electronic Equipment) in the European Union:



According to the directive 2012/19/EU, the monitoring and control instruments marked with the WEEE symbol and reaching their end-of-life **must not be disposed of with other waste**. The user must dispose of the WEEE to a designated collection point for the recycling of WEEE or send them back to our local organisation or authorised representative.

6.1 Measuring principle

6.1.1 pH measurement

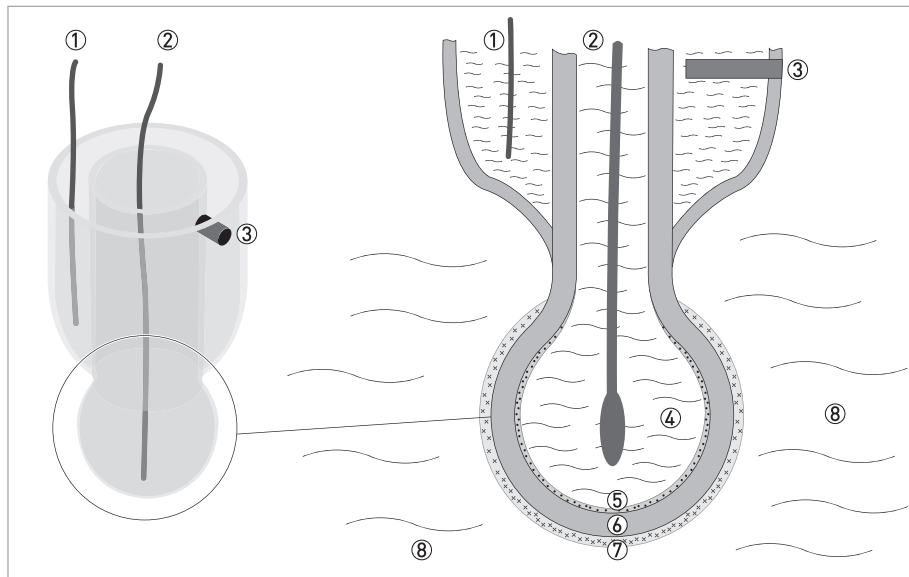


Figure 6-1: Measuring principle for pH measurement

- ① Reference electrode
- ② Measuring electrode
- ③ Diaphragm in contact with KCl solution and measuring medium
- ④ Inner pH 7 buffer solution
- ⑤ Surface potential on the inside (contact with buffer solution)
- ⑥ pH sensitive glass (membrane glass)
- ⑦ Surface potential on the outside (contact with measuring medium)
- ⑧ Measuring medium

The measuring principle of a pH sensor is based on a membrane glass (pH sensitive glass). When the membrane glass gets into contact with a liquid, a thin layer of hydrated gel develops on the surface, enabling an ion exchange between the glass surface and the liquid. The so-called Nernst potential builds up on the glass surface. If both sides of the glass are in contact with liquids, a voltage may be detected between the two surface potentials. The voltage correlates to the difference in H^+ ion concentration and thus to the difference of pH values in both liquids.

The pH sensor contains an internal buffer solution with a known pH value. If the pH value of the measuring medium on the outside of the sensor is equal to the pH value of the inner buffer, the resulting voltage is 0 V.

If the pH value of the medium differs from the internal pH value, a voltage between the internal and the external layer can be measured. From the resulting voltage, the pH difference of the two liquids can be calculated.

The voltage is measured using a measuring electrode and a reference electrode; both are built into the sensor. The measuring electrode is in contact with the known buffer solution in the pH sensitive glass bulb. The reference electrode is immersed into a saturated solution of potassium chloride (KCl). The KCl solution itself is in electrical contact with the measuring medium by means of a diaphragm. The diaphragm prevents the measuring medium from penetrating into the reference system but still allows electrical contact with the measuring medium.

The voltage change of a pH sensor at 25°C / 77°F is around 59 mV for each pH unit. This is also called the slope of the pH sensor. The slope is temperature dependent and decreases over life time of the sensor.

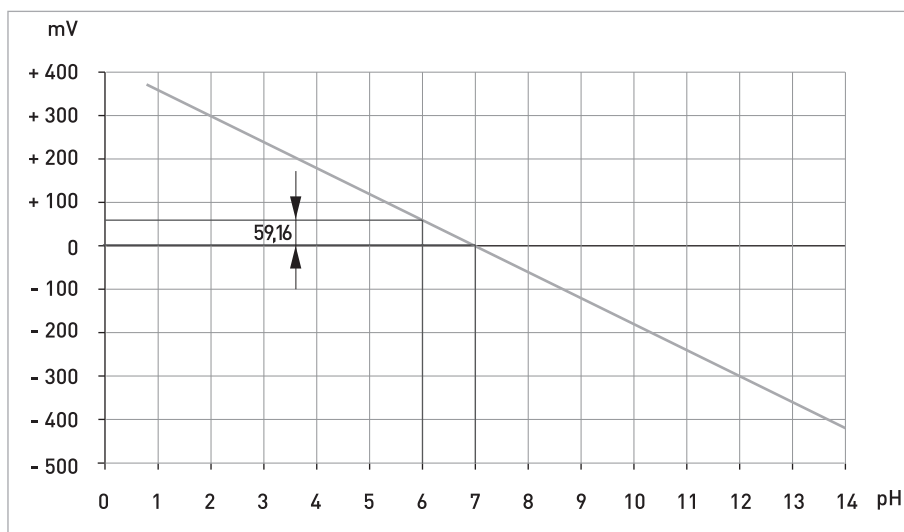


Figure 6-2: Optimal slope at 25°C / 77°F

To compensate for the temperature dependency of the pH measurement, the temperature of the medium can be measured and automatically compensated in the signal converter.

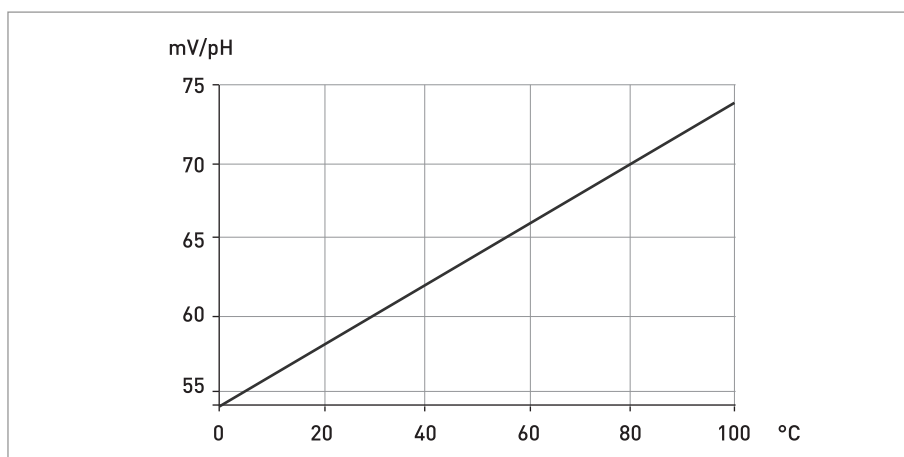


Figure 6-3: Temperature dependency of the Nernst Factor (theoretical slope of a pH sensor)

6.2 Technical data



INFORMATION!

- The following data is provided for general applications. If you require data that is more relevant to your specific application, please contact us or your local sales office.
- Additional information (certificates, special tools, software,...) and complete product documentation can be downloaded free of charge from the website (Downloadcenter).

Measuring system

Measuring principle	Potentiometric
Measuring range	0...14 pH

Design

Construction	Glass sensor
Shaft diameter	12 mm / 0.47"
Length	120 mm / 4.72"
Process connection	PG 13.5
Temperature sensor	Pt100
Sensor cap	VP 8.0
Type of diaphragm	2 x open

Measuring accuracy

Reference conditions	Medium: water
	Temperature: 20°C / 68°F
	Pressure: 1 bar / 14.5 psi (absolute)
Maximum measuring error	pH: 0.2% full scale
	Temperature : 1.0% full scale
Repeatability	0.2% full scale
Resolution	0.1 (or 0.01 in extended mode)
Long-term stability	24 hours: tested within accuracy definition
Temperature drift	Tested within accuracy definition
Cable length variation	Tested within accuracy definition

Operating conditions

Temperature range	0...+130°C / +32...+266°F
Max. operating pressure	10 bar / 145 psi (absolute)
Minimum conductivity	> 2 µS/cm

Installation conditions

Process connection	PG 13.5
Immersion holder	SENSOFIT IMM 1000
Flow-through holder	SENSOFIT FLOW 1000
Insertion screw-in adapter	SENSOFIT INS 1000
Retractable holder	SENSOFIT RET 1000/2000 (in preparation)

Materials

Sensor shaft	Glass
Measuring electrode	H Glass
Inner buffer	pH 7.0
Reference electrolyte	Polisolve Plus
Diaphragm	2 x open
Gasket	EPDM

Electrical connection

Connector	VP 8.0
Cable	Cable PH/ORP-W VP 8.0
Cable length	5 m / 16.4 ft or 10 m / 32.8 ft

**INFORMATION!**

For further information contact your local sales office.

6.3 Dimensions

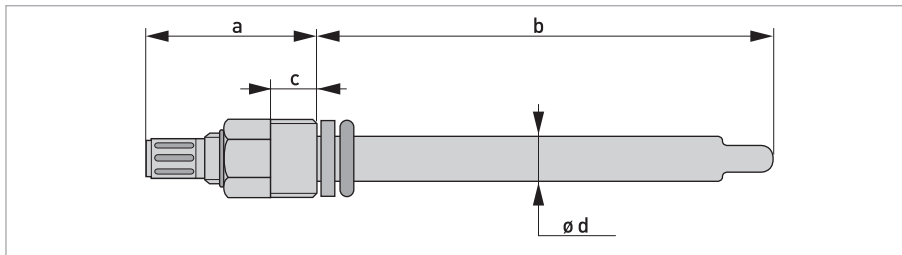


Figure 6-4: Dimension of OPTISENS PH 8100

	Dimensions [mm]	Dimensions [inch]
a	52	2.0
b	120	4.7
c	12	0.5
d	Ø 12	Ø 0.5

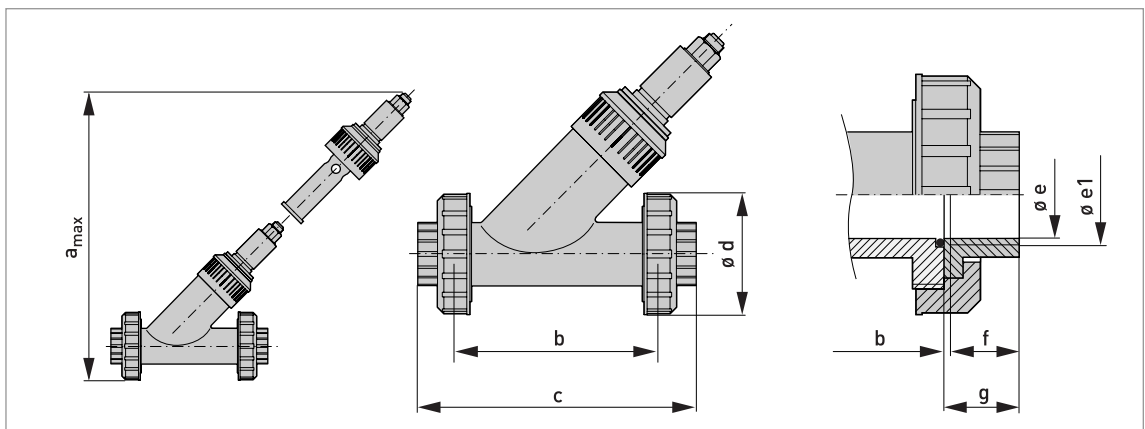


Figure 6-5: Dimensions SENSOFIT FLOW 1000

	Dimensions [mm]	Dimensions [inch]
a _{max}	165	6.5
b	142.5	5.61
c	178.5	7.03
d	Ø 75	Ø 2.95
e	Ø 21	Ø 0.83
e1	G1	G1
f	19.1	0.75
g	22	0.87

7.1 pH as a function of mV

The pH-value is the negative decadative logarithm of the hydrogen ion concentration, and it is directly related to the proportion of hydrogen ions H^+ to hydroxide ions OH^- in the media. The pH-sensor measures excess or deficit of the hydrogen ions and gives a proportional millivolt signal as output. The signal is 59.16 mV per 1 pH at 25°C / 77°F. In clean water there is a total balance between hydrogen ions and hydroxide ions, the output from the electrode is 0.0 mV and pH is 7. The millivolt signal is measured by the pH sensor and the corresponding pH value is calculated in the signal converter.

mV	pH	H^+ ions [mol/l]	OH^- ions [mol/l]	Example
414	0	1	0.00000000000001	Sulfuric acid
355	1	0.1	0.00000000000001	
296	2	0.01	0.00000000000001	Coca Cola
237	3	0.001	0.00000000000001	Vinegar
177	4	0.0001	0.00000000000001	Orange juice
118	5	0.00001	0.00000000000001	
59	6	0.000001	0.00000000000001	Milk
0	7	0.0000001	0.00000001	Clean water
-59	8	0.00000001	0.0000001	Sea water
-118	9	0.000000001	0.000001	
-177	10	0.0000000001	0.00001	
-237	11	0.00000000001	0.0001	
-296	12	0.000000000001	0.01	
-355	13	0.00000000000001	0.1	
-414	14	0.000000000000001	1	Sodium hydroxide

7.2 pH temperature dependency

The output from a pH sensor varies with the temperature in a predictable way. The size of the variation depends on both the temperature and the pH being measured.

°C	°F	pH	pH	pH	pH	pH	pH	pH	pH	pH	pH	pH	pH
5	41	2.30	3.24	4.18	5.12	6.06	7.00	8.06	9.12	10.18	11.24	12.30	13.36
15	59	2.15	3.12	4.09	5.06	6.03	7.00	8.03	9.06	10.09	11.12	12.15	13.18
25	77	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00
35	95	1.85	2.88	3.91	4.94	5.97	7.00	7.97	8.94	9.91	10.88	11.85	12.82
45	113	1.70	2.76	3.82	4.88	5.94	7.00	7.94	8.88	9.82	10.76	11.70	12.64
55	131	1.55	2.64	3.73	4.82	5.91	7.00	7.91	8.82	9.73	10.64	11.55	12.46
65	149	1.40	2.52	3.64	4.76	5.88	7.00	7.88	8.76	9.64	10.52	11.40	12.28
75	167	1.25	2.40	3.55	4.70	5.85	7.00	7.85	8.70	9.55	10.40	11.25	12.10
85	185	1.10	2.28	3.46	4.64	5.82	7.00	7.82	8.64	9.46	10.28	11.10	11.92
95	203	0.95	2.16	3.37	4.58	5.79	7.00	7.79	8.58	9.37	10.16	10.95	11.74

At pH 7 and 25°C / 77°F the temperature error is zero. If temperature or pH changes the temperature error is calculated using the following formula:

0.03 pH difference / pH or 0.03 pH difference / K



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