

OPTISENS ODO 2000 Handbook

Sensor for dissolved oxygen measurement in water and wastewater

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 ODO 2000 sensors is the measurement of dissolved oxygen in water and waste water applications. The sensor is suitable for connection to the MAC 100 signal converter.

1.2 Certifications

CE marking

The device fulfils the statutory requirements of the following EC directives:

- EMC Directive 2014/30/EU

The manufacturer certifies successful testing of the product by applying the CE marking.

1.3 Safety instructions from the manufacturer

1.3.1 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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The collection of personal data (such as names, street addresses or e-mail addresses) in the manufacturer's documents is always on a voluntary basis whenever possible. Whenever feasible, it is always possible to make use of the offerings and services without providing any personal data.

We draw your attention to the fact that data transmission over the Internet (e.g. when communicating by e-mail) may involve gaps in security. It is not possible to protect such data completely against access by third parties.

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.

1.3.2 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.

1.3.3 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.

1.3.4 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.

1.3.5 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.

1.4 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.

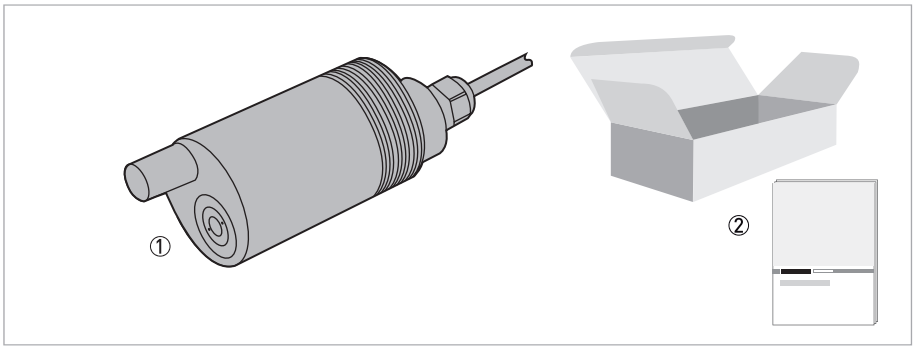


Figure 2-1: Standard scope of delivery

① Ordered sensor
② Documentation

Optional accessories

- SENSOFIT IMM 2000 - Immersion assembly

Consumables / Spare parts available

- Connector for cleaning hose
- Zero solution (sodium sulfite Na_2SO_3) for verification and calibration
- Optical disk

INFORMATION!
For further information contact your local sales office.

2.2 Device description

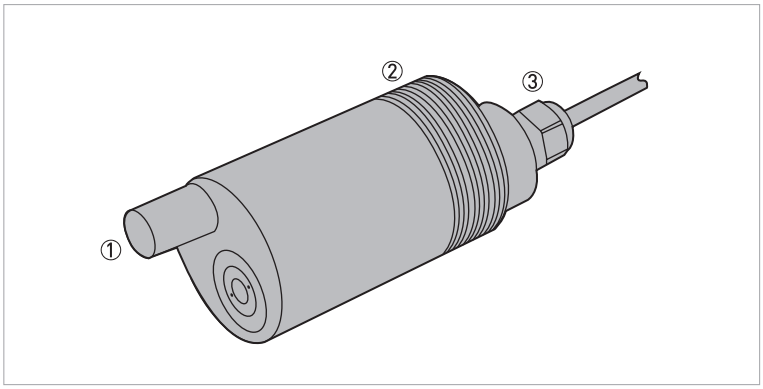


Figure 2-2: Device description

① Cleaning nozzle
② 2" NPT
③ Attached cable

2.3 Nameplate

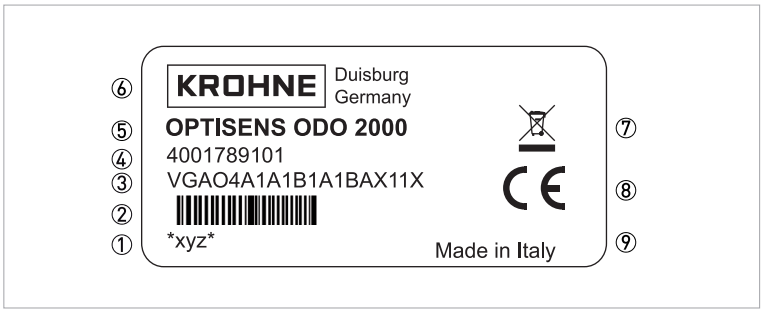


Figure 2-3: Example for a nameplate

① Serial number
② Serial number as barcode
③ Order code
④ Article number
⑤ Device name
⑥ Manufacturer
⑦ Electronic/electric device waste marking (WEEE dustbin symbol)
⑧ CE marking
⑨ Country of manufacture

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

The sensor type is specified on the label 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 General installation instructions

The sensor tip must always have full contact with water.

The mounting position of the sensor should be 25°...75° from vertical position (sensor tip pointing downwards). Non-observance might cause air bubbles or dirt/sludge to stick to the sensor tip.

For optimal positioning use an immersion assembly as shown in the following image.

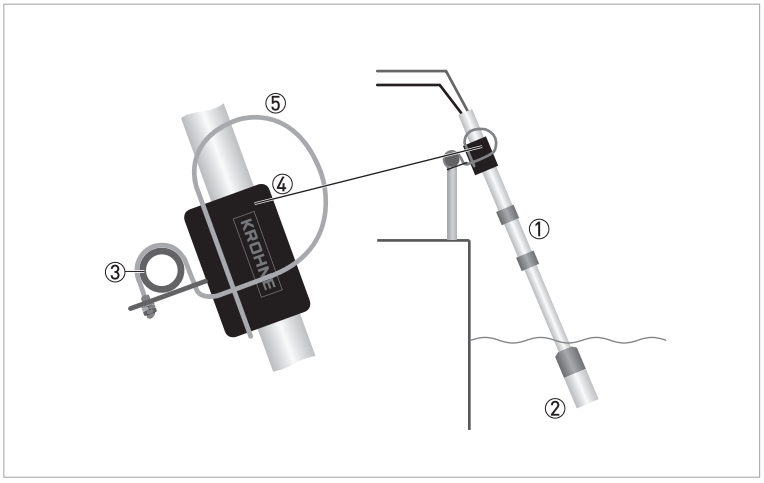


Figure 3-1: Optimal mounting position

① Immersion assembly
② Sensor holder
③ Handrail
④ Rod holder
⑤ Mounting bracket

INFORMATION!
Install the sensor in a light angle to avoid wrong measurement results due to a dirty sensor or trapped air on the sensor.

3.3 Storage and transport

- Store the device in a dry, dust-free location.
- Avoid continuous direct sunlight.
- The original packing is designed to protect the equipment. It has to be used if the device is transported or sent back to the manufacturer.

3.4 Configuration of a measuring point

The sensor has a 4...20 mA current loop and can be operated with external signal converter or without. If operated without the external converter the converter is needed as configuration and calibration tool.

A complete measuring point consists of at least two or three parts:

- Optional: A signal converter (for configuration only as calibration tool or for operation)
- OPTISENS ODO 2000 sensor (including cable)
- Immersion assembly or other adequate housing

If automatic flushing is installed, an optional solenoid valve is necessary as well.

Examples of typical measuring points are listed in the following sections.

3.5 Pre-installation requirements

CAUTION!

- *Never touch or scratch the optical disk (luminophore with black silicone cover) of the sensor.*
- *Make sure that the optical disk is clean and dust-free. If necessary, clean the optical disk as described on page 41*

CAUTION!

Do not turn the cable gland on the sensor this might cause a sensor leak and damage the electronics inside. While mounting or dismounting the sensor, the senor cable must not be fixed or trapped as this might loosen the water tight gland connection from the sensor.

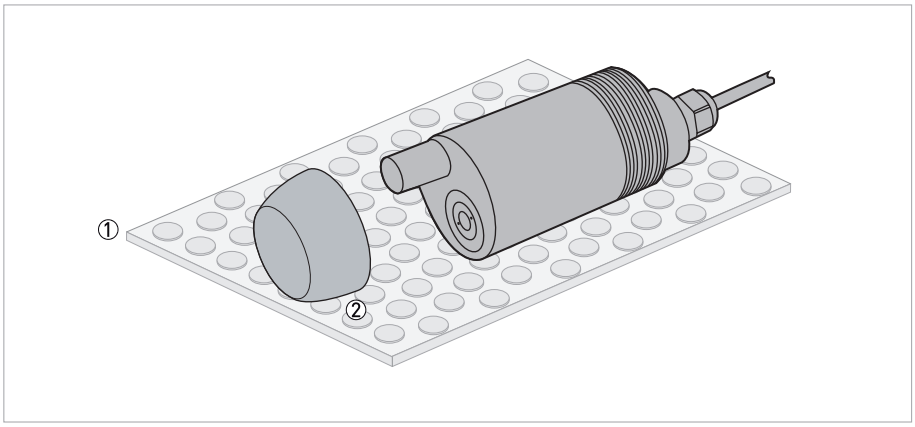


Figure 3-2: Unpacking the sensor

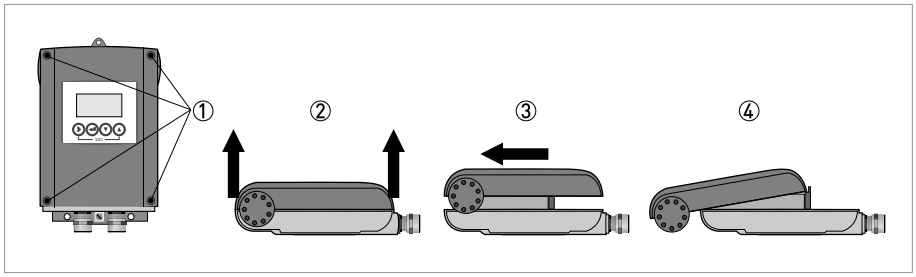
Unpacking the sensor

- Lay the sensor on a soft mat/tissue ①.
- Keep the protection cap ② in the original packaging as long as it is not required.

3.6 Opening the converter housing

INFORMATION!
Clean and grease all threads each time you open the housing. Use only resin-free and acid-free grease. Before closing the cover, ensure that the housing gasket is properly fitted, clean and undamaged.

All installation works on the electrical connections require to open the converter housing:



- Loose the four screws ① with a crosstip screwdriver.
- Lift the housing at the top and bottom at the same time ②.
- Slide the housing cover backward ③.

➲ The housing cover is guided and held by the inside hinge; you have access to the terminal compartment now (see ④ in the previous drawing and next section).

3.7 Installation procedure

The device is factory calibrated and the analog signals are set to the measurement range 0...20 mg/l (ppm). To install the device in the correct way, follow the order and the following sections and their instructions.

1. Connect the sensor to the signal converter or directly to the control system.
2. Configure the measurement range. Verify or calibrate sensor if required.
3. Mount the sensor into the immersion assembly. (For further information refer to the manual of the assembly)
4. Install the sensor into its final measuring location.

3.8 Sensor use without cleaning function

WARNING!
Without a cap on the air line connector the sample might block the cleaning drilling for later use or water might flow into a closed assembly and damage the probe due to later handling.

Before installation and immersion the sensor check the following order:

- Do not install any flexible tubing.
- Install a cap on the air line connector in order to avoid the cleaning drilling to be blocked for later use or water to flow through it into a closed assembly.

3.9 Sensor use with cleaning function

INFORMATION!
Most applications do not require the cleaning function if the sensor is installed correctly in a correct angle.

When the automatic cleaning is required the device can be equipped with a cleaning hose for air cleaning.

Before the device is installed into its final measuring location the following points must be observed

- provide hose (Ø 6.3...9.5 mm / 1/4...3/8") in suitable length
- prepare a connection for the cleaning hose
- push the hose onto the cleaning connector
- put the sensor cable and cleaning hose through the adequate extension pipe of the mounting assembly

The pressurised air is to be provided and must be clean with a max of 3 bar.

The typical cleaning time is 15 seconds and the typical cleaning frequency is 2 times/day, but this will differ from application to application.

3.10 Mounting the sensor into an assembly



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



CAUTION!
Do not turn the cable gland on the sensor this might cause a sensor leak and damage the electronics inside. While mounting or dismounting the sensor, the senor cable must not be fixed or trapped as this might loosen the water tight gland connection from the sensor.



INFORMATION!
Check the sensor on air after each manual cleaning procedure. For further information refer to Calibration with a signal converter on page 27.

For further instructions on installation into an immersion assembly refer to the assembly manual.

Use an assembly that does not fix the sensor cable or require the sensor to be screwed into the assembly. If the sensor needs to be screwed for mounting or dismounting make sure that the sensor cable is turned into the same direction.



Installing procedure

- Insert the sensor cable through the immersion assembly.
- Fasten the sensor to the tip of the assembly.
- Connect the wires either to the control system directly (only 4...20 mA) or to the MAC 100 signal converter. For further information refer to *Connecting the sensor to PC* on page 21, refer to *Connecting the sensor directly to the control system* on page 21 and refer to *Connecting the sensor cable to the signal converter* on page 19.

For removing the sensor, repeat the steps above in reverse order.

Calibrate the sensor before installing it into the assembly. For further information refer to *Calibration* on page 25

4.1 Safety instructions



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.

4.2 Connecting the power supply to the signal converter MAC 100



DANGER!
The device must be grounded in accordance with regulations in order to protect personnel against electric shocks.



DANGER!
Never install or operate the device in potentially explosive areas, it might cause an explosion that can result in fatal injuries!



CAUTION!
When connecting the power supply, always note the safety regulations of the current state of the art. Also note the following items to avoid fatal injuries, destruction or damage of the device or measuring errors:

- *De-energise the cables of the power supply before you start any installation works!*
- *Always keep the housing of the device well closed if you do not perform any installation works. The function of the housing is to protect the electronic equipment from dust and moisture.*
- *Assure that there is a fuse protection for the infeed power circuit ($I_{nom} \leq 16$ A) and a disconnecting device (switch, circuit breaker) to isolate the signal converter.*
- *Check the nameplate and assure that the power supply meets the voltage and frequency of the device. You can operate the device in the range of 100...230 VAC and 8 VA with a tolerance of -15/+10% while 240 VAC +5% is included in the tolerance range (a version with a power supply of 24 VAC/DC is in preparation). A power supply outside these specifications may destroy the device!*
- *Assure that the protective earth conductor (PE) is longer than the L- and N-conductor.*



INFORMATION!
The manufacturer has designed all creepage distances and clearances according to VDE 0110 and IEC 664 for pollution degree 2. The power supply circuits fulfil the overvoltage category III and the output circuits fulfil the overvoltage category II.

Before you start to connect the power supply cables, note the following drawing with the function of the terminals:

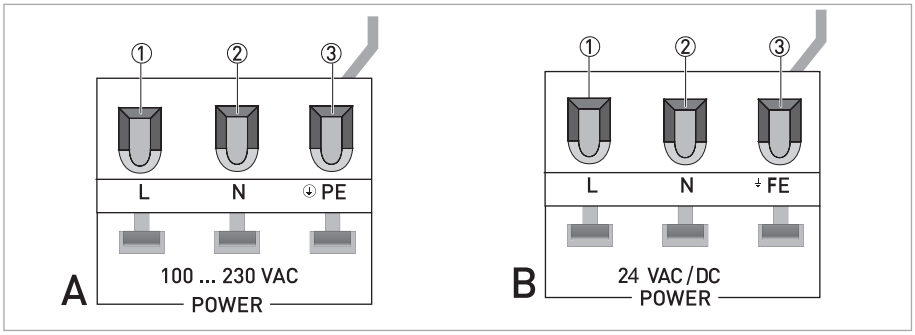
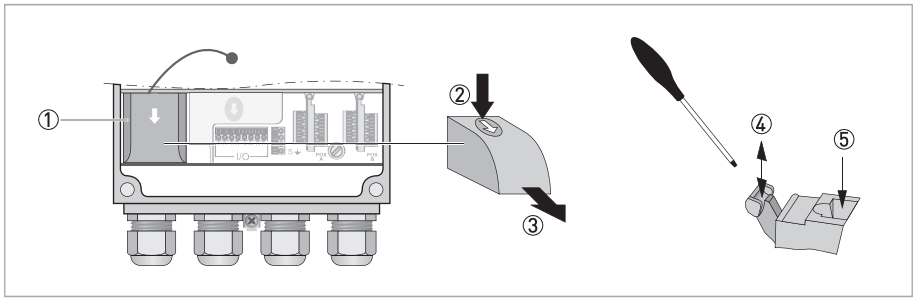


Figure 4-1: **A** - 100...230 VAC / **B**- 24 VAC/DC

① Live (L)
② Neutral (N)
③ Protective Earth (PE) or Functional Earth (FE)

Afterwards connect the power supply cables accordingly:

CAUTION!
The manufacturer strongly recommends to use a slotted screwdriver with a tip of 3.5 x 0.5 mm / 0.14 x 0.02" to push down the lever! Otherwise you could damage the lever.



- De-energise the power supply cables with the help of a disconnecting device (switch, circuit breaker)!
- Open the converter housing (refer to *Opening the converter housing* on page 14).
- Remove the cover of the power supply terminal (①) by pressing it down and pulling forwards at the same time (② and ③), be careful and do not disrupt the retaining band (it prevents the cover from getting lost)!
- Use a slotted screwdriver with a tip of 3.5 x 0.5 mm / 0.14 x 0.02" to push down the lever, connect the wires to the terminals and pull up the levers again (④ and ⑤).
- Refasten the cover of the power supply terminal, close the converter housing and tighten all screws of the housing.

4.3 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.

Connect the dissolved oxygen sensor to the MAC100 for optimal configurability and process control due to following features:

- scale selection flexibility
- digital input to hold signals during cleaning process
- easy calibration via zero point and sensitivity adjustment
- set minimum and maximum for alarm relays
- galvanic isolated 4...20 mA outputs
- error current

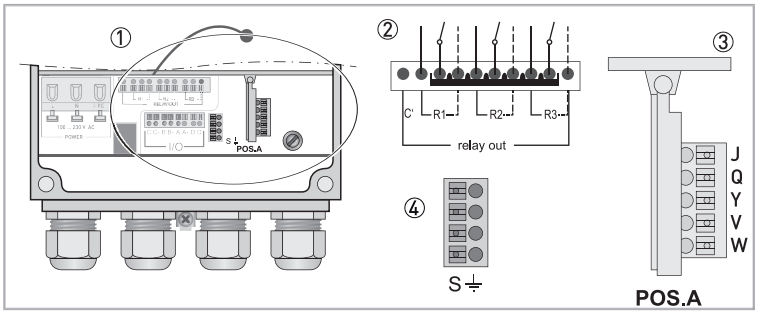


Figure 4-2: Sensor connection terminals on the signal converter MAC 100

① Sensor connection terminal
② Relays
③ Terminal block A: terminals for sensors
④ Terminal block S (protective earth)

Wire	Terminal block Pos.A
White	J
Green	Q
Yellow	Y
Grey	V
None	W
brown	not connected

Wire	Terminal S
Metal (non isolated cable)	S

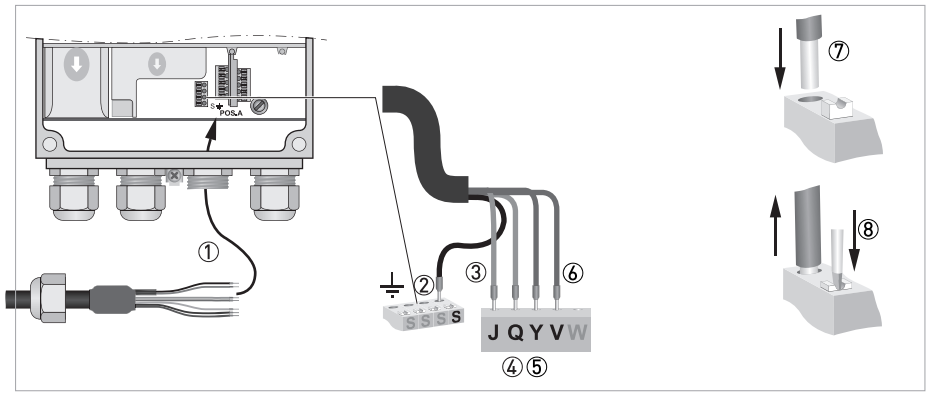


Figure 4-3: Connecting the sensor cable

The following instructions describe the connection of the sensor cable.

Connecting the sensor cable to the signal converter

- Remove the terminal cover.
- Thread the sensor cable through the middle right cable gland ①.
- Push the wires ⑦ into terminal J ③, Q ④, Y⑤, V ⑥ and S ②.
- To remove a wire, press down the white clip ⑧ on the corresponding terminal and pull the wire out.

4.4 Connecting the sensor directly to the control system



CAUTION!
Avoid cable interruptions. If necessary use adequate junction box. Keep the cable far away from power cables inside of the switch board.

The device is loop powered and can be connected directly onto the control system via any junction box.

Wire	Function
Green	+ current loop
White	- current loop
Metal	shield

The normal operation needs just the connection of the green and white wires, which are protected against accidental inversion. The shield is not connected to the probe but it must be connected to the ground.

4.5 Connecting the sensor to PC



CAUTION!
Avoid cable interruptions. If necessary use adequate junction box. Keep the cable far away from power cables inside of the switch board.

Connect the device to the converter or directly to the control system as stated in above chapters. The shield is not connected to the probe but it must be connected to the ground.

Wire	Function
Shield	not connected
Yellow	A (+) RS485
Grey	B (-) RS485
Brown	not connected
Green	+ current loop
White	- current loop / COM RS485

5.1 Menu mode structure

INFORMATION!
The following table just presents an overview. Additional levels are accessible from certain menus offering the possibility to change presets.

Measuring mode	Main menu		Submenu			Parameter	
3 or 4 pages, scrolling with ↓ or ↑	> 2.5 s ↵	**A quick setup**	> ↵	A1 language		> ↵	For further information see function tables.
				A2 Tag			
				A3 manual hold			
				A4 set clock			
				A5 reset errors			
				A6 analog outputs	> ↵ A6.1 measurement		
					A6.2 conc. absolute		
					A6.3 range		
					A6.4 time constant		
				A17 offset			
				A18 temperature offset			
				A19 product cal.			
		↓↑		↓↑			↓↑

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.
						B1.4 conc. absolute		
						Simulation menus input A; existence of the single submenus depends on the selected hardware setting in C setup / C3 I / O. To start a simulation process refer to the MAC 100 manual.		
				B3 simulation I/O		B3.6 simulation R3 To start a simulation process refer to the MAC 100 manual.		
				B4 actual values		B4.1 operating hours		
						B4.2 process input A		
						Menus which show the corresponding actual reading; existence of the single submenus depends on the hardware setting and the used sensor.		
				B5 logbooks		B5.1 status log		
						B5.2 calibration log		
				B6 information		B6.1 C number		
						B6.2 process input A		
						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	> ↵	Menus for the setup of the corresponding process input; existence of the single submenus depends on the hardware setting and the used sensor.	> ↵	For further information see function tables.
						C1.1 parameter		
						C1.27 offset		
						C1.28 temperature offset		
						C1.29 product cal.		
				C3 I/O		C3.1 hardware		
						C3.2 current out A		
						C3.3 current out B		
						C3.4 current out C		
						C3.5 control input to hold outputs		
						C3.8 current R3		
				C5 device		C5.1 device info		
						C5.2 display		
						C5.3 1 meas.page		
						C5.4 2 meas.page		
						C5.5 graphic page		
						C5.6 special functions		
						C5.7 units		
		↓↑		↓↑		↓↑		↓↑
	D service: This menu is password protected and contains functions to be used by service personnel only.							

5.2 Calibration

INFORMATION!
Insure that the sensor is clean and free from any deposits on the measurement element (optical disk). Please clean with clear water and a soft cloth as some deposits might not visible to our eye.

The calibration of the probe must satisfy this sequence:

- calibration of sensitivity in water-saturated air
- calibration of the zero point in sodium sulfite solution Na_2SO_3 (or other adequate 0 standard solution/gas)

Replace the sensing element if:

- mechanically damaged
- after the calibration procedure it does not produce the expected values

Before the sensitivity calibration it is necessary to allow the internal temperature sensor to adjust the ambient temperature. This time could be equal to 5 or 10 minutes depending of the difference between the sensor and the ambient temperature.

The sensitivity calibration is done with the sensor in water-vapor saturated air inside a dark beaker or cup with a little bit of water on the ground.

The zero point calibration is done in sodium sulfite Na_2SO_3 solution.

Optical components such as LED and photodiodes as well as the sensing element (replaceable) can have a small drift during their lifetime.

Checking and periodic calibration of the probe is always necessary to ensure the accuracy of the sensor.

5.2.1 Calibration checklist

Checklist

- Make sure that any offset is set back to zero.
- Clean the sensor with clear water and a soft tissue.
- Use a soft tissue to gently dry the optical disk (do not wipe otherwise the sunprotection might get damaged).
- Let the temperature adjust for approximate 10 minutes until the reading is stable.
- Put the sensor into a dark beaker or a cup with little bit of water and cover for sun light protection as well as to produce vapor-saturated air (optical disk has to be dry).
- Wait in measurement mode until reading is stable before starting calibration via the calibration menu.
- Go into the calibration menu of the transmitter or send command (ID+S) via RS485.
- If available enter data for air pressure, humidity and salinity. If not available use the already programmed factory settings. (In case of measuring in sea water contact the local sales office.)
- Perform sensitivity calibration successful.
- Put the sensor into a dark beaker or a cup containing sodium sulfite Na_2SO_3 (oxygen calibration solution with zero oxygen in it) and cover for sun light protection.
- Wait until the reading is stable which can take 15 to 45 minutes. The reading might underswing and go up again.
- Confirm the zero calibration on the transmitter or send command (ID+Z) via RS485.
- Zero calibration performed successful.
- The total time of the calibration if done via transmitter has to be below 60 minutes after having entered the calibration menu. In case the calibration takes over 60 minutes the sensor will jump back to factory calibration and not safe the just performed calibration. In case of unsuccessful calibration the sensor will jump back to factory calibration.
- The transmitter has an offset function which can be used in case of a small offset in zero solution after calibration.

For further details refer to *Calibration with a signal converter* on page 27 or refer to *Calibration with PC* on page 33.

5.2.2 Calibration with a signal converter



CAUTION!

- *Never touch or scratch the optical disk (luminophore with black silicone cover) of the sensor.*
- *Make sure that the optical disk is clean and dust-free. If necessary, clean the optical disk as described on page 41*

The sensor requires a 2-point calibration. The sensor is factory calibrated by means of standard solution and it is ready for use. The operator can perform the field calibration via controller by means of the sensitivity and zero point adjustment. It has to be done in the order sensitivity first and zero point calibration thereafter.



INFORMATION!

It is suggested to verify the sensor periodically and calibrate in case of need to get the requested accuracy on the specific application.

To avoid alarms on the distributed control system (DCS) 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. In this mode the calibration can be started. Activate the manual "hold function" in the first step.

Step 1: activating the 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. 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

- For re-calibration, remove the sensor from the process.
- If you calibrate a sensor, make sure that the sensor is correctly connected to the signal converter.
- Check the sensor for damages, check the optical disk for coating and rinse the sensor tip with tap water and gently clean it with a soft tissue.
- Do not touch or scratch the optical disk.
- Repeat the cleaning step twice to make sure that the sensor is clean as well from deposits we can not detect with human eye (e.g. polymer or biological film).

INFORMATION!
Use a soft tissue very gently by pressing it onto the optical disk in order to avoid scratches. Otherwise water droplets are not being removed and interfere with later calibration.

Step 3: Calibration procedure

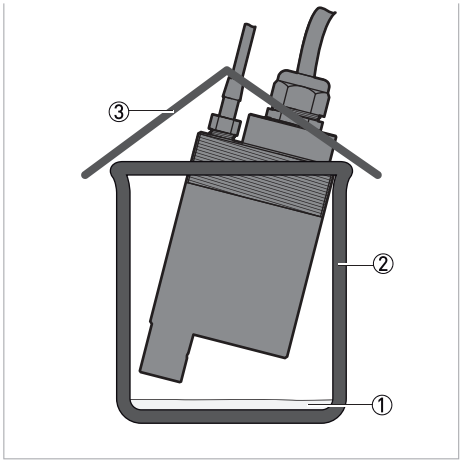


Figure 5-1: Sensitivity calibration

① Water
② Dark beaker or cup
③ Opaque cover (e.g. towel)
Sensor immersed in an angle in a dark beaker.

CAUTION!
The sensor tip has to be dry. Wait until ambient temperature is reached which can take 5 to 10 minutes.

CAUTION!
Protect the optical disk from sunlight effects to ensure correct calibration.

Sensitivity Calibration

- Position the sensor in a dark beaker or cup out of a material which has little to none light reflecting characteristics. Pour in a little bit of water so that the bottom of the cup is covered with a water film which will cause water-vapour saturated air. The sensor shall not stand vertical, but at a light angle to reduce any influences due to reflection. Cover the setup with a cloth to shut out any interfering sun light.

The probe executes automatically the following operation:

- Restore of the excitation current of the LED of 15 mA
- Reset the sensitivity and zero point
- Optical efficiency-calibration
- The sensitivity calibration

The probe readout depending on temperature at 100% air saturation

Temperature	DO concentration
15°C	100.0% saturated / 10.15 ppm
20°C	100.0% saturated / 9.17 ppm
25°C	100.0% saturated / 8.38 ppm

The values will depend of salinity, atmospheric pressure and relative humidity.

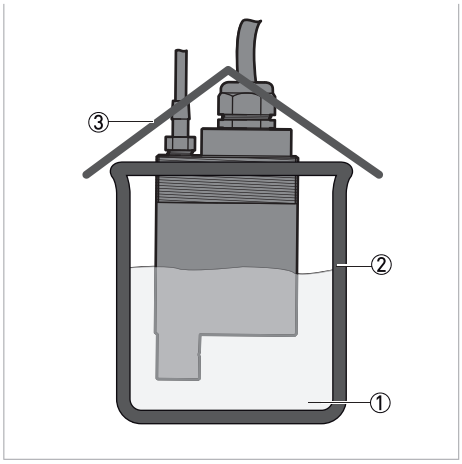


Figure 5-2: Zero point calibration

① Sodium sulfite solution
② Dark beaker or cup
③ Opaque cover (e.g. towel)

Zero point calibration

Position the sensor into a dark beaker or cup and fill it with sodium sulfite Na_2SO_3 solution. Cover the cup with a towel or similar to not have sunlight interferences.

The zero point calibration without oxygen must be carried out after sensitivity calibration.

If the calibration has not been performed successfully (error), verify if the probe has been really immersed in zero solution. Inspect the sensing element. If it is damaged, proceed to replace it and perform a new sensitivity and zero point calibration.

INFORMATION!
It will take about 15-35 minutes until the minimum value has been reached. The reading might underswing and increase a little bit before it is a stable reading near or at 0 ppm.

INFORMATION!
Overall the calibration of Sensitivity and Zero is not allowed to last longer than 60 minutes with the signal converter. If it lasts longer the instrument will jump back to factory calibration and the calibration has to be started new.

Step 4a: 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" appear. Press ▼ or ▲ until the submenu **process input A** is highlighted.

- 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" appear. Press ▼ or ▲ until the submenu **product cal.** is highlighted.

- Press **>** to enter the chosen menu.

You are on the third submenu level. In the upper line of the display "product cal." and "C1.2" appear.

The submenu **air pressure** is highlighted.
- Press ▼ or ▲ to select the air pressure in Pa.
- Press ↵ to confirm.

The submenu **humidity** is highlighted.
- Press ▼ or ▲ to select the humidity in %.
- Press ↵ to confirm.

The submenu **salinity** is highlighted.
- Press ▼ or ▲ to select the salinity in mg/L.
- Press ↵ to confirm.

The submenu **sensitivity calibration** is highlighted.
- Press ▼ or ▲ until the submenu **start the calibration** is highlighted.
- Press ↵ to start the calibration.

The actual oxygen is displayed. Please wait till the value is stable.

- Press ↵ to proceed.

There is a count down of 35 seconds for the sensitivity calibration.

The message **sensitivity calibration successful** is highlighted if the calibration was successful.
- Press ↵ to proceed with the zero point calibration.

The message **sensitivity calibration unsuccessful** is highlighted if the calibration was not successful.
- Press ▼ or ▲ to choose between repeat the calibration yes or no.

The submenu **zero point calibration** is highlighted.
- Press ↵ to start the zero point calibration.

The actual concentration is displayed. Please wait till the value is stable.

- Press ↵ to confirm.

The message **zero point calibration successful** is highlighted if the calibration was successful.
- In this case press ↵ several times to leave the calibration menu.

The message **zero point calibration unsuccessful** is highlighted if the calibration was unsuccessful.

Step 4b: 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.1" appear. Press ▼ or ▲ until the submenu **product cal.** is highlighted.
• Press **>** to enter the chosen menu.
The actual oxygen is displayed. Please wait till the value is stable.
There is a count down of 35 seconds for the sensitivity calibration.
Press ↵ to confirm the settings.

INFORMATION!

- *If "calibration successful" is highlighted, press ↵ several times to save the calibration and to return to main menu level.*
- *If an error occurs during the calibration procedure, the display shows an error message.*
- *If the calibration was not successful please start again and follow the steps mentioned in this chapter.*
- *If the calibration was unsuccessful refer to Troubleshooting on page 39*

Step 5: switching back to measurement

- Deactivate the function **manual hold** again.
- Install the sensor in the measuring location.

5.2.3 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.

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 "B5/B5.1" appears, beneath the submenu **status log** is highlighted.

Press ▼ or ▲ until the submenu **calibration log** and **B5.2** 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.

5.2.4 Calibration with PC

In addition to the calibration with converter the device can be calibrated via computer using standard RS485 communication modules and a standard terminal program (such as hyperterminal). For this matter the sensor needs to be powered with 24 VDC (9/36 VDC). Neither communication module nor terminal program are products from **KROHNE**.

Please be aware that the device is factory configured for analog mode operation. After 2 seconds from switching on, the current loop will provide 8 seconds a fixed current value depending of the selected scale. If during this 8 seconds interval digital activity is detected on the RS485 line it will switch to digital communication. Else it will remain in analog operation.

The calibration and programming via PC gives additional possibilities concerning the signal calibration and is straight forward.

5.2.5 Communication protocol

Through the RS485 it is possible to connect the probe to a PC for the data handling and the calibration and the configuration of the probe. It is necessary to use a RS485 / RS232 or RS485 / USB converter. It is possible to use the hyperterminal of a PC.

The protocol is product specific and not a standard protocol.

Standard baud rate 9600.

Transmission mode

Characters	ASCII
Bits per characters	
start bits	1
data bits	8
parity	none
stop bits	1
Errors verifying (just command A)	BCC

Commands format

2 byte for ID (01-32)
1 byte for command
n byte data to insert if required by the command
1 byte <cr> (carriage return), end of the command

The probe responds to the command with the individual ID or 00.

Do not use the ID 00 if the probe is in a network in order to avoid conflicts.



INFORMATION!
The probe do not answer if configured for different baud rate.

5.2.6 Sensor mode options

As factory setting the sensor is configured in analog operating mode (current loop 4...20 mA). This is within the programming: digital mode = 0.

Analog mode

After 8 seconds from switching the sensor on, the current will provide for 8 seconds a fixed current value depending of the selected scale:

10 mA if selected scale is in ppm as standard setting

12 mA if selected scale is in % air saturation

If during this 8 second interval no activity on the RS485 line is detected the sensor will keep the analog operating mode. If during this 8 second interval activity on the RS485 is detected the sensor will switch to digital operating mode (digital mode=1). In this mode the current value will be 10/12 mA depending of the scale and it will increase during transmission. Within the digital mode the operator is able to perform the calibration and to configure the sensor via the RS485 connection. The digital mode will be maintained until the next time the sensor is switched on.

INFORMATION!
Make sure to switch the sensor off and on if you changed the from digital mode =1 to 0 for the analog mode to become effective.

5.3 Commands for operation via RS485

Through the Help command is possible to get a list of commands implemented in the probe

5.3.1 Help

Command Format: ID + H ↵
For example, if ID = 14, type 14H ↵ or 00H ↵
By sending the command 'H' the probe responds with a list of available commands with a brief description

```
------------------------------------------------------------------------------
HELP MENU, COMMAND LIST       ODO KROHNE GmbH
------------------------------------------------------------------------------
OD8325.057 OPTICAL D.O. PROBE   Rev.fw:2.00  S/N:192225 Dye:V3FB

00H   <cr> Help menu
00A   <cr>  Acquisition
00Mx <cr> Digital mode:      0000              (0=analog mode 1=digital mode)
00Ox <cr> Analog out 4/20mA: 0000             (0=ppm 1=%sat)
00Cx <cr> Chloride salinity: 0000 x 100ppm  (0-600 x 100ppm)
00Px <cr> Atm. pressure:     0760 mmHg       (500-800mmHg)
00Ux <cr> Relative humidity: 0050 %RH        (0-100%RH)
00S   <cr> Sens. calibration: OK              (point cal 1)
00Z   <cr> Zero  calibration: OK              (point cal 2)
00Dx <cr> Last cal date:                      (max 8 characters)
00Ix  <cr> ID value:   Actual 0005 Config 0005 (01-32)
00Bx <cr> Baud rate:  Actual 0003 Config 0003 (1=2400 2=4800 3=9600 4=19200)

Type ID number or 00 before command
example, if ID=15 type 15A <cr> or 00A <cr>
Use 00A <cr> if only one probe is connected
------------------------------------------------------------------------------
```

Figure 5-3: Help menu - List of all available commands

5.3.2 Acquisition

Command Format: ID + A ↵
For example, if ID = 14, type 14A ↵ or 00A ↵

By sending the command 'A' (00A), the probe responds by sending a data record containing the code, ID, date, time, and the value of all measurements.

```
00A
OD8325-  5 0.0 01/01/01 00:00:00    82.4%sat    6.75ppm     25.3øC       000ppm
    760mmHg      50%RH          EC
```

Figure 5-4: Record format

The transmission of the measured parameter follows the format:
Measuring field - Sign of the measurement (if positive it sents one space) - Value of the measurement (6 characters – aligned on the right)

Measurement unit field – Measurement unit of the parameter (4 ch. – aligned on the left) - 1 space (ASCII 32)

± 20.00 ppm	dissolved oxygen concentration ppm
± 200.0% sat	dissolved oxygen concentration % sat
± 20.0°C	Temperature
± 60000 ppm	Chloride salinity
± 760mmHg	Atmospheric pressure
± 50% RH	relative humidity

At the end of the record the probe sends the data of the last calibration, than 2 bytes with the BCC.

XX/XX/XX	Last calibrate date
XX:	2 byte BCC

The transmission is ended with a carriage return <cr> and line feed <lf> sequence.

BCC calculation

The BCC is calculated as XOR of all bytes of the message (excluded <cr> and <lf>) and divided in 2 nibble. The 2 nibble are then transformed in ASCII codes.

5.3.3 Digital mode

Command Format: ID + M + x ↵
For example, if ID = 14, and analog out = ppm type 14M1 ↵ or 00M1 ↵

The probe can be configured for digital mode (digital mode=1) or analog 4...20 mA (digital mode=0).

5.3.4 Analog output

Command Format: ID + O + x ↵
For example, if ID = 14, and analog out = ppm type 14O1 ↵ or 00O1 ↵

The analog output 4...20 mA can be linked to the %sat or ppm scale:
Set the parameter x=0 for ppm
x=1 for the %sat scale

5.3.5 Chloride salinity

Command Format: ID + C + x ↵
For example, if ID = 14, and salinity 20000 ppm type 14C200 ↵ or 00C200 ↵

Probe response:	ID + C + x	command executed correctly
Probe response:	none	command does not run properly

To check whether the entered value was received, type the command 'A'.

5.3.6 Atmospheric pressure

Command Format: ID + P + x ↵
For example, if ID = 14, and the pressure 780mmHg, type 14P780 ↵ or 00P780 ↵

Probe response:	ID + U + x	command executed correctly
Probe response:	none	command does not run properly

To check whether the entered value was received, type the command 'A'.

5.3.7 Relative humidity

Command Format: ID + U + x ↵
For example, if ID = 14, and humidity 50%, type 14U50 ↵ or 00U50 ↵

Probe response:	ID + U + x	command executed correctly
Probe response:	none	command does not run properly

To check whether the entered value was received, type the command 'A'.

5.3.8 Sensitivity calibration

Command Format: ID + S ↵
For example, if ID = 14, type 14S ↵ or 00S ↵

Probe response:	ID + S + x	command executed correctly
Probe response:	none	command does not run properly

To check whether the entered value was received, type the command 'A'.

5.3.9 Zero point calibration

Command Format: ID + Z ↵
For example, if ID = 14, type 14Z ↵ or 00Z ↵

Probe response:	ID + Z + x	command executed correctly
Probe response:	none	command does not run properly

To check whether the entered value was received, type the command 'A'.

5.3.10 Last calibration date

Command Format: ID + D + cccccccc ↵
For example, if ID = 14, and we need to set the date 13/11/10, type 14D13/11/10 ↵ or 00D13/11/10 ↵

Probe response:	ID + D + cccccccc	command executed correctly
Probe response:	none	command does not run properly

The Command is for memorising the last calibration date.
The operator can use the 8 characters as he likes better (no syntaxes limitation).

5.3.11 ID value

Command Format: ID + I + x ↵
For example, if ID = 14, and we need to set the ID at 07, type 14I07 ↵ or 00I07 ↵

Probe response:	ID + I + x	command executed correctly
Probe response:	none	command does not run properly

The new ID will be available from the next start up of the probe.

5.3.12 Baud rate

Command Format: ID + B + x ↵
For example, if ID = 14, and we need to set the speed 2=4800 baud, type 14B2 ↵ or 00B2 ↵

Probe response:	ID + B + x	command executed correctly
Probe response:	none	command does not run properly

The new baud rate will be available from the next switching on of the probe.

5.4 Troubleshooting

Problem	Possible cause	Remedy
No values are displayed	No power supply available or sensor cable not connected	Check electrical connection
No sensor reaction	Deposits on the measurement element	Clean the optical disk (luminophore with black silicone) of the sensor very carefully with a soft cloth (do not wipe (do not wipe otherwise the sun protection will be destroyed).)
	Optical disk is damaged	Calibrate and if outside of specification, replace the optical disk
Indicated values are too high	Deposits on the optical disk	Clean the optical disk, verify and in case of need recalibrate
	Optical disk is damaged	Calibrate and if outside of specification, replace the optical disk
	No sun protection on the luminophore	Replace the optical disk
	Wrong or no offset	Program an offset if difference is very small or recalibrate sensor
Indicated values fluctuate	Entrained air/air bubbles	Move measurement location by a few centimeters or change installation angle
No connection between PC and sensor within 8 seconds	Terminal program was connected before sensor	Power up sensor and connect terminal program
Sensor does not answer via RS485 but is connected the correct way (2400/4800/9600 or 19200 bits)	Baud rate programmed wrong	Try with different baud rate

5.5 Function tables

Measurement setting	Setting options or allowed values	Default value
Possible scales	200.0 %sat, 20.00 ppm	20.00 ppm
Scale in %sat (without converter only)	0.0...200.00 %sat	
ID %sat	12 mA for 8" at power on	
Scale in ppm	0.0...20.00 ppm	
ID ppm	10 mA for 8" at power on	

Secondary parameters

Salinity (chloride)	0...600 x 100 ppm (100 ppm step)	0 ppm
Pressure	500...800 mmHg	760 mmHg
Relative humidity	0...100%	50%

Temperature

Compensation range	0.0...50.0°C	
Temperature Comp. coefficient	internal table	

Serial interface

Interface	RS485 not terminated Isolated from the sample Not isolated from the loop power supply	
Distance	1000 / 500 / 250 / 125 meter	
Baud rate	2400 / 4800 / 9600 / 19200 bits	9600 bit
Probes in network	up to 32	
Protocol	ASCII	

Power supply

Voltage	9...36 VDC	
Current	22 mA max.	

6.1 Maintenance

6.1.1 Cleaning

- Dirt deposits or trapped air on the optical disk may lead to erroneous results.
- Rinse the device thoroughly with tap water and only use a soft tissue to carefully remove deposits from the optical disk. Do not wipe, but softly press it onto the black silicone of the optical disk covering the luminophore otherwise the black silicone (sun protection) will be destroyed.
- The sensor housing may be cleaned by scrubbing it with a suitable brush. Make sure you do not touch or scratch the optical disk.

6.1.2 Recalibration

It is recommended to check the sensor in regular intervals. For this use holding it in the air or putting it into sodium sulfite Na_2SO_3 solution and verify the sensor. In case of the sensor is not reaching the expected value clean the sensor and redo the check, if the sensor still does not reach expected values do a calibration. For further information refer to *Calibration* on page 25.

INFORMATION!
The life time expectation of the sensor depends heavily on the application and if something that might scratch the optical disk or something chemical aggressive is in the water (medium) to be monitored.

6.1.3 Optical disk replacement

The optical disk is the active component which needs to be replaced in regular intervals. The timescale between replacements can be 1 to 3 years or longer. This strongly depends if damage occurs (e.g. scratches) and how aggressive the medium is.

For the exchange of the optical disk please make sure that the sensor is not connected to power and not immersed in water. Unscrew the disk with the tool provided with the new disk. Screw the new disk into the location of the old disk. Insure that the disk is screwed in all the way that no water can get into the sensor which would damage it.

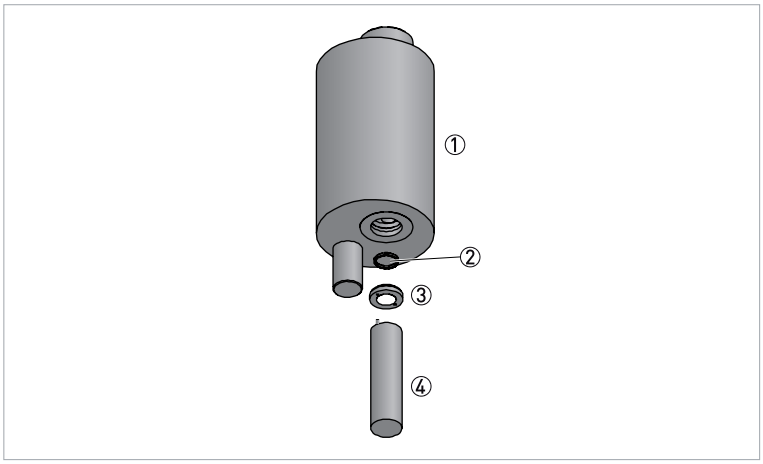


Figure 6-1: Optical disk for OPTISENS ODO 2000, including mounting tool

① Sensor body
② O-ring
③ Optical disk
④ Mounting tool

Replace the optical disk

- Insert the two rods of the tool into the two small holes of the optical disc.
- Unscrew the old optical disk counter clockwise.
- Place the new O-ring in the original position.
- Screw in the new replacement disk clock wise
- Make sure that the disk is fastened tight.

6.2 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.

6.3 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.

6.4 Returning the device to the manufacturer

6.4.1 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.*

6.4.2 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:		

6.5 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.

7.1 Measuring principle

The application of optical oxygen measurement has been studied extensively since the mid 1980s. The optical oxygen sensor contains an oxygen sensitive dye (fluorophore) that is immobilised in an oxygen permeable polymer matrix layer and in direct contact with the process media.

The fluorophore is excited by the energy-rich blue light emitted by the LED inside the sensor into an excited state. This energy can be emitted from the excited fluorophore after a short period (micro seconds) by emission of low-energy red light. In case an oxygen molecule is getting in contact with the excited fluorophore, the energy can also be transferred from the excited fluorophore in a non-radiative reaction to the oxygen. In that case the intensity of the emitted red light from the polymer matrix layer is decreased (fluorescence quenching). Consequently, the intensity of the emitted red light is decreased with increasing oxygen content. The intensity of the emitted red light is measured with a light detector. The change in intensity is used to measure the oxygen concentration in the process media. To compensate the intensity drift of the light emitting blue LED its intensity is directly measured with a second light detector.

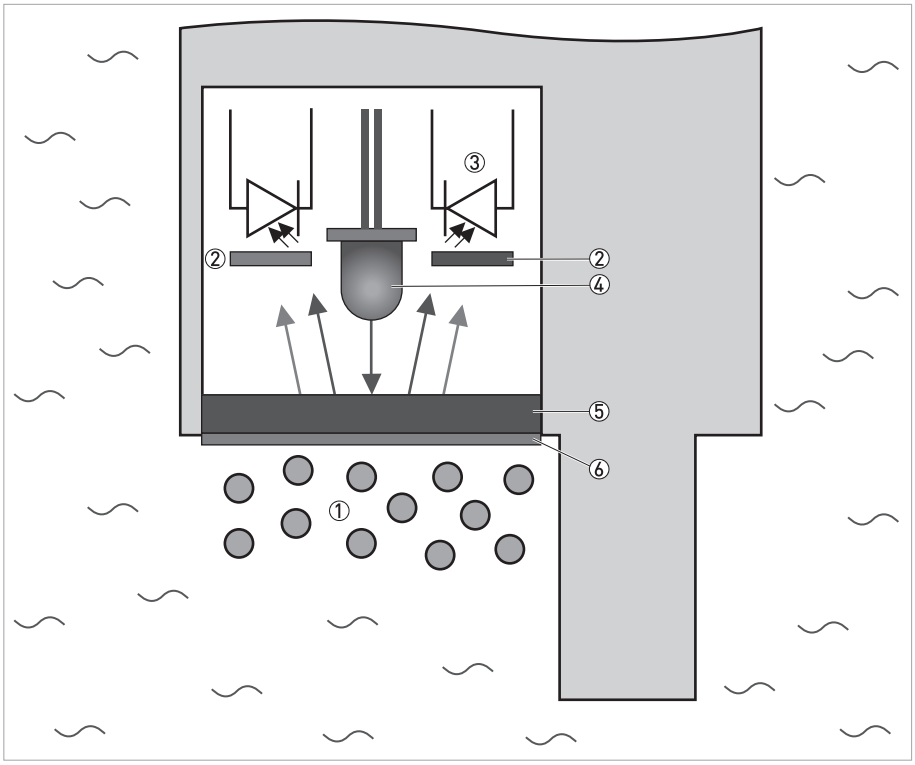


Figure 7-1: Optical measurement of dissolved oxygen

① Process media with dissolved
② Color filter
③ 2 identical light detectors
④ LED
⑤ Carrier
⑥ Fluorescent layer

7.2 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

Parameter	Dissolved Oxygen
Measuring principle	Fluorescence

Design

Measuring principle	Optical, luminophore disk
Measuring scale	0...20 mg/l (ppm)
Sensor type	Installation with MAC 100 signal converter or directly to control system via 4...20 mA
Shaft diameter	60 mm / 2.36"
Shaft length	166 mm / 6.5"
Sensor thread	2" NPT
Hose diameter	6.3...9.5 mm / 1/4...3/8"

Operating conditions

Temperature range	-5...50°C / +23...122°F
Pressure range	Max. 1 bar at 25°C / 14.5 psi at 77°F
Measuring range	0...20 mg/l (ppm)
Accuracy	± 0.1 ppm if < 1.0 %ppm / ± 1.0 %sat if < 10.0 %sat ± 0.2 ppm if > 1.0 %ppm / ± 2.0 %sat if > 10.0 %sat
Repeatability	± 0.5% of the scale
Resolution	0.01 ppm
Response time (95%)	large signal (>3% air) 95% < 40 seconds
	small signal (<3% air) 95% < 120 seconds
Measuring cycle	8 seconds
Drift	< 1% year
Relative humidity	0...95% non condensing
Air pressure cleaning	max. 3 bar / 43.51 psi
Units displayed sensor	mg/l (ppm) or %
Units displayed converter	mg/l (ppm)
Temperature sensor	Pt100

Installation conditions

Ingress conditions	IP68
Weight	Body 420 g / 0.93 lb 10 meter cable 760 g / 1.41 lb

Materials

Sensor body	PVC

Electrical connection

Cable	10 meter / 32.8 ft. 20 meter / 65.62 ft. 30 meter / 98.43 ft.
Voltage	9...36 VDC
Analog output	4...20 mA loop powered isolated
Load	600 Ohm max. at 24 VDC
Digital output	RS485

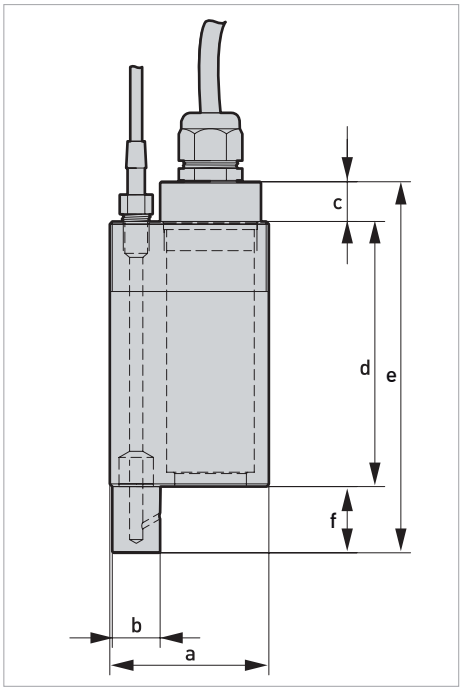
Approvals

CE

This device fulfils the statutory requirements of the EC directives. The manufacturer certifies successful testing of the product by applying the CE mark.

Electromagnetic compatibility	EMC Directive 2014/30/EU EN 61326-2-3:2013 EN 55011:2009+A1:2010

7.3 Dimensions and weight



	Dimensions [mm]	Dimensions [inch]
a	60	2,4
b	18	0,71
c	15	0,6
d	100	3,94
e	140	5,51
f	25	0,98





KROHNE – Process instrumentation and measurement solutions

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