Mo**S** - Oxygen

Manual

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1. GENERAL DESCRIPTION

The dissolved oxygen sensor is suitable for the use in monitoring systems for long-term measurement. The sensor can be used in salt water, lakes and rivers (fresh or charged water) for the measurement of dissolved oxygen. A multi-core 4-wire sea-cable is used for power supply and data acquisition.
A power supply of 12 VDC is used as current source for the sensor, Other voltages can be realised for the power supply of the sensor (on request). The signal output can be also be adapted (on request).

2. MECHANICS

The sensor consists of following parts:

- Pressure tube
- Oxygen sensor head
- Sensor cap with pressure compensation and membrane
- Cover with underwater-connector (optional with locking sleeves)
- 2 Allen screws
- Electronic board

The sensor housing is principally made of corrosion resistant materials like plastics (POM) or titanium, independently of the field of use. A pressure resistance of minimum 2000 dbar is warranted.
The connector is made of titanium and neoprene. It is screwed in the cover of the pressure tube and O-ring sealed. The locking sleeves which are generally foreseen for this type of connector are not used because the water pressure is sufficient for to hold sensor and inline-connector together.
The cover, together with the connector, is fastened to the pressure tube by two Allen screws.
The part of the sensor head installed in the housing is sealed with two O-rings in its lower part, and with one O-ring in its upper part.
The upper part of the pressure tube is glued with the sensor head for safety.

2.1. DIMENSIONS

Housing diameter 25 ± 0.3 mm
Total length 240 mm
Weight in air 260 g

2.2. SENSOR SKETCH

3. SENSOR ELECTRONICS

When the sensor is connected to an external power supply, than the continuous polarisation of the sensor is disconnected by an integrated switch.
The voltage is approx. -0,65 VDC by a consumption of approx. 1 µA.
The electronic board need no fastening inside the housing. It is directly adapted to the connector and accessible by dismounting the cover of the sensor.

4. DATA OF THE OXYGEN SENSOR:

Sensor type	: Clark-measuring cell
Housing	: Plastics (POM), Titanium
Range	: 0 - 150 % saturation
Resolution	: 0.1 % sat.
Accuracy	: 1.5 % sat.
Response time	: 900 ms (see listing)

5. MEASURING PRINCIPLE

The O_2-sensor follows the polarographic principle with two cells. The anode is formed by a silver tube within the sensor. It comprises a glass body in which a platinum wire is arranged as the cathode.
At the rounded end of the sensor a removable hood is situated by which a gas-permeable membrane is held in place. Under the hood there is a special electrolyte which makes the flow of a current between anode and cathode possible.
The anode serves as a reference by offering a constant potential for the cathode. The cathode where oxygen is reduced is separated from the sample which is to be measured by a thin layer of electrolyte and a special membrane.
The electrolyte allows a certain chemical reaction whereas the membrane is impermeable for ions and other substances. When supplied with a so-called polarisation potential an electric current flows in proportion to the O_2-concentration.
Membrane and polarisation potential are chosen in such a way that they only react with oxygen and not with nitrogen, nitrogen oxides, carbon dioxide and most gases.
In order to prevent an external polarisation, e.g. the influence of other O_2-sensors resp. their electrodes, the external electrode, in this case the anode is connected with the ground potential.
The cathode is polarised with a constant negative voltage. The sensor is independent from movement and membranes and measures a minimum of 97% of the real value. This is achieved by a very small cathode environment, the arrangement of the cathode, and a homogeneous permeable membrane which leads to a minimum consumption of oxygen.

The function of the sensor based on O_2-reduction at the cathode is described by the following formula:

$$O_2 + 2\ H_2O + 4\ e^- \rightarrow 4\ OH^-$$

Electrons for this reaction are provided by the silver/silver-chloride anode.

6. USE OF THE OXYGEN SENSOR

Oxygen electrode membranes

The oxygen sensor has been designed to give different performances depending on the membranes used. The sensor normally uses two membranes, the blue inner membrane for measurement and the red outer membrane for protection.

1. The outer protective membrane prolongs the live of the measuring membrane, limits the effect of fouling and avoids the need to stir the sample.
2. The use of the second membrane, however, significantly slows down measurement.

For samples having very low oxygen contents, or when fast reading is required, we recommend not to use the protective red membrane. In this case the Probe must be lowered at <u>0.3 m/sec at least.</u>

The following table lists four ways of membraning the oxygen sensor thus obtaining the maximum performance for any specific use of the sensor.

Pos.	Internal Membrane	External Membrane	Application	Response time (Nitrogen/Air)	Stirring Effect
1	Green	Red	Monitoring	9 sec	3%
2	Blue	Red	Monit. / Profiling	5 sec	4%
3	Green	None	Profiling	4 sec	25%
4	Blue	None	Fast Profiling	1 sec	40%.

Note: All values of the table are given for a temperature of 25°C.

7. MEMBRANE CAP AND ELECTROLYTE REPLACEMENT

Make sure before starting with measurements, that there is enough electrolyte in the sensor. Gas bubbles inside (because of evaporation of the elctrolyte) may lead to troubles when measuring.
The membrane cap and the electrolyte of the oxygen sensor have been designed to allow at least three months of continuous good function of the sensor. When the sensor is left exposed to air, the electrolyte evaporates through the membrane in a period of 2 to 3 months, depending on the ambient humidity conditions, the sensor can dry out completely.
For this reason we recommend fitting the hydration cap to the oxygen sensor whenever the sensor is not in use. The hydration cap contains a sponge in its base which must be saturated with distilled water.
Any excess water will overflow the cap during fitting. Fit or remove the cap slowly, without forcing, in order to avoid damaging of the membrane.

Note: After a period of time following fitting of the cap, the display will indicate an oxygen level very close to zero. Remember to remove the cap prior to analysis.

Membrane cap and/or electrolyte replacement are necessary when:

- A readout of over 0.2 PPM is displayed after the sensor check in the absence of oxygen.
- The oxygen sensor responds more slowly than usual or drifts.
- The membrane(s) of the cap is mechanically damaged and shows leakage, holes or stretches.
  <u>Test:</u> Connect a piece of zinc with housing ground and move it nearby the oxygen sensor.
  If the membrane has a leakage, the oxygen measurement value results in more drifting as usual.
- The oxygen sensor, filled with electrolyte, has been stored for a length of time at temperatures outside those are recommended (-10 to 40°C).

<u>Procedure:</u>

1) Unscrew and remove the old cap. Pay attention not to damage the glass tip of the sensor with any scratch or crack the sensor is unfit for use.
2) Wash the silver and glass assembly with distilled water and dry it with a lint-free paper towel. Do not touch the internal parts of the sensor with fingers. Clean the tip of the sensor with a lint-free towel.

3) In this condition, with the tip of the sensor dry and clean, there should be no current flowing between anode and cathode. The reading should be less than 0.2 PPM. The sensor should not be touched during this check. If the readout is higher, there is most likely a film of moisture still in contact with the sensor tip. Carefully dry the sensor tip. If the problem persists, the sensor has probably short circuited inside or has a scratched tip or otherwise the electronic oxygen zero of the probe is out of adjustment.
4) Take a new membrane cap and the electrolyte dispenser. Carefully fill the membrane cap. Do this in such a way that the drops are deposited directly into the bottom of the membrane thus preventing the formation of bubbles in the cap. Any bubbles should be eliminated by tapping the membrane with the index finger.
5) Slowly insert the membrane cap into the sensor body allowing any trapped air to escape.
6) Slowly screw on and securely tighten the membrane cap.
7) Wash the body of the sensor with distilled water, shake the sensor to eliminate any drops of water in contact with the membrane. If necessary dry it carefully with a lint-free paper towel.

IMPORTANT:

For maximum stability of readout it is necessary to wait 30 minutes after membrane cap and/or electrolyte replacement. This is the time required to reach a good polarisation level of the sensor. Oxygen analyses can, however, be carried out within a few minutes of membrane cap replacement provided that a calibration is performed. When necessary, substitute the electrolyte, do not "top-up".
We recommend that only ADM electrolyte is used, since its composition and pH guarantee the best performance and minimise corrosive effects in the sensor.

Membrane(s) replacement (=oxygen membrane cap)

It is possible to fit new membrane(s) into old caps using the sensor maintenance kit.
Parts needed from the maintenance kit:
- One oxygen external membrane (red) | for monitoring
- One oxygen internal membrane (blue) | purposes only
- One O-ring
- O-ring mounting tool

Procedure:

1) Remove the protection ring from the membrane cap. Remove and discard the black O-ring and the membrane(s).
2) Fit the new O-ring over the point of the conical tool and position it on the widest part of the tool.
3) Place the cap on the table with its narrow end pointing upwards.
4) Position the internal membrane (blue) on the cap. Using finger nails remove the protective square of white PVC from the back of the external membrane (red). Place the red membrane on the first (blue) membrane.
5) Place the widest part of the tool against the membrane(s). Lightly pressing the tool slide the O-ring carefully into the slot of the cap thus holding the membrane(s) in position.
6) Cut away excessive membrane with fine scissors as close as possible to the O-ring.
7) Finally replace the protective ring.

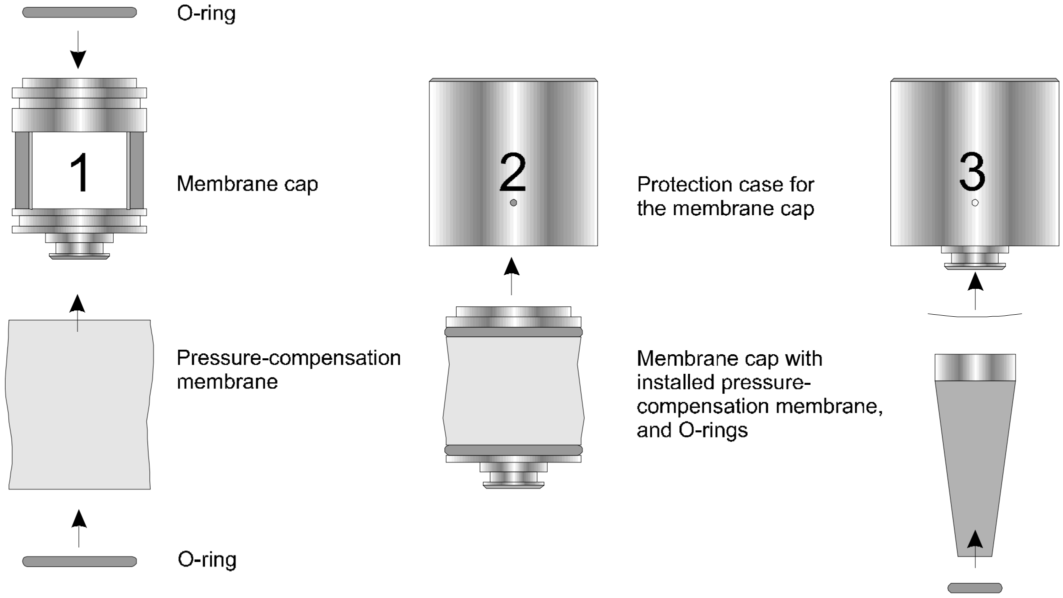
8. OXYGEN SENSOR CLEANING

If the oxygen sensor current is too low, after membrane cap replacement and cleaning the sensor tip with filter paper, it is necessary to polish the sensor tip with the abrasive paper included in the maintenance kit. It is sufficient to rub the tip lightly over the paper two or three times without applying excess pressure. Wash the sensor with tap or, if possible, distilled water to remove residues.

If the silver anode appears completely black or covered with foreign materials it is necessary to clean it with the abrasive paper. Wrap the paper around the silver body and rotate it to obtain original silver brightness.
Wash the sensor with distilled water to remove residues.
After these operations the oxygen current will be higher than normal and will drop during the first day to arrive at the normal stability level of 0.1 to 0.3 PPM/week.

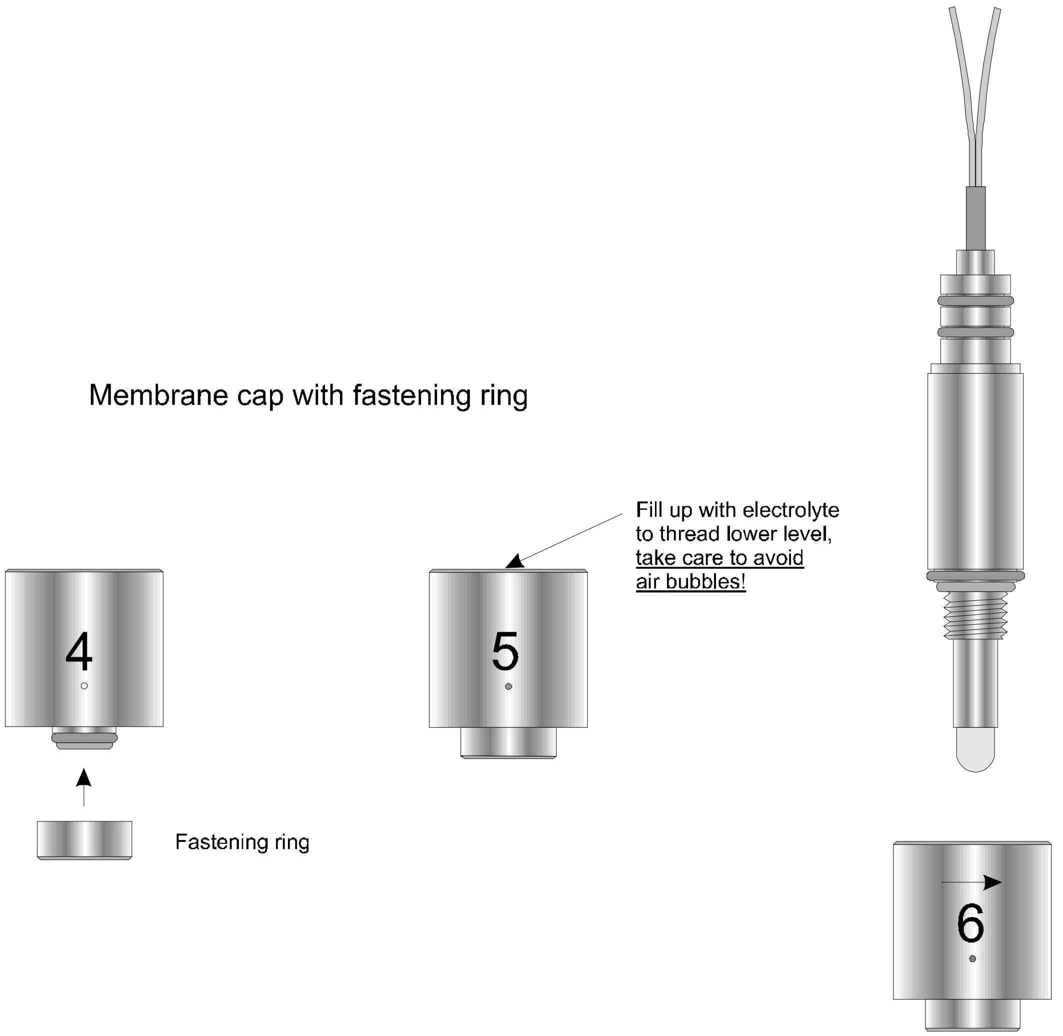
Note: Using only the green membrane and at a temperature of 20°C, the nominal sensor current (in ambient air) is 55 ±10 nano Ampere. Higher values are quite normal if the sensor has only been polarised for a short period of time or if maintenance operations have been carried out within the last 24 hours.

9. ASSEMBLING OF THE OXYGEN SENSOR HEAD



Membrane cap with fastening ring

Assembling of the oxygen sensor



10. CALCULATION OF THE OXYGEN SATURATION AND CALIBRATION PROCEDURE

10.1. MATHEMATICAL FORMULAS

Following constants are necessary for the calculation of the oxygen saturation in %:

c1	=	- 0,029	Membrane coefficient
c2	=	0,000115	Pressure compensation coefficient

O_2-Slope = $\dfrac{100}{e^{(T \times c_1)} \times O_2}$

Following variables are necessary for the calculation of the oxygen saturation in %:

O_2	=	Measuring value of the O_2 electrode (unit Volt, subtract zero voltage)
T	=	Temperature (unit degrees Celsius)

The formula is as follows:

Saturation = $O_2 \times O_2 Slope \times e^{(T \times C_1 + Pressure \times C_2)}$

Pressure dimension: dbar

If you want to change your result of “per cent oxygen saturation” into the “oxygen concentration in mg/l” please use your own standard formulas.

10.2 CALIBRATION PROCEDURE

The calibration of this sensor is possible on air (=101,7 %) or in air saturated destilled water (=100%). If you want to check the 0% value, please use a solution of 2% sodium sulfite (Na_2SO_3). Normally the zero point is very stable and there are no changes observed for a long time. So it’s enough to check only the 101,7% resp. 100% value periodically.

10.3. EXAMPLES FOR OXYGEN SATURATION CALCULATION

a) Examples for Measuring values, used in the following calculation:

Output Signal at 0% oxygen:	0,002 V
Output Signal at 100% oxygen (air):	2,5 V
Temperature (unit degrees Celsius):	25°C
Pressure (Depth) in dbar:	0
C1:	-0,029
C2:	0,000115

Results:

O_2 = 2,5 V – 0,002 V

O_2-Slope = $\dfrac{100}{e^{(T \times c_1)} \times O_2} = \dfrac{100}{e^{(25 \times -0,029_1)} \times 2,498V}$ = 82,65536 $\dfrac{\%}{V}$

Saturation = $O_2 \times O_2 - Slope \times e^{(T \times C_1 + Pressure \times C_2)}$

= 2,498 V $\times\ 82,65536 \dfrac{\%}{V} \times e^{(25 \times -0,029 + 0 \times 0,000115)}$

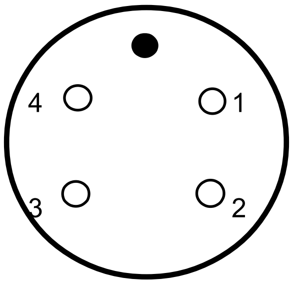
= 99,999 %

b) Now repeat the calculation for depth 2,000 m (=2,000 dbar). If your calculation is correct, the result should be 125,84% saturation.

11. SENSOR CONNECTION

The sensor connection is realised according to following sketch

SUBCONN BH-4M Ti



Pin 1 : GND power supply

Pin 2 : GND signal

Pin 3 : Signal output 0…5 V DC

Pin 4 : Power supply 9…30 V DC

Top view on the sensor connector

Note: Power supply and output signal can be modified on request.

12. REPLACEMENT OF WEAR PARTS

For the DO sensor a service kit containing several membranes and a bottle of electrolyte is available. The wear out of the membrane and the electrolyte including the adding of electrolyte due to evaporation through the membrane is not covered by the warranty and has to be paid. Please ask for a special quotation.

Please be very careful when screwing on the membrane cap again after the replacement of membranes and/or electrolyte. Screw on has to be done very slowly and only by hand until there is a slight resistance noticeable due to the contact of the integrated o-ring. If screw on is done too strong, the inner sensitive part of the sensor will be destroyed leading to the necessity of exchanging the complete sensitive part. This is not covered by the warranty repair and has to be paid in this case.