WATERPROOF
OXYGEN METER

CO-411

USER‘S MANUAL

ELMEIRON

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WATERPROOF
OXYGEN METER

CO-411

Before use please read the instruction carefully!

CONTENTS

1. EXPLOITATION NOTICES

Dear User!
We present you a device distinguished by accuracy according to the technical data and by high stability of the results. We believe that measurements will not cause you any trouble and that the meter will operate without any inconvenience. **Obtaining accurate results requires careful reading of the manual.**
Accuracy of the oxygen measurements depends on the sensor calibration and regular conservation which consist in replacing the membranes, electrolyte and cleaning the electrodes. **Neglecting these activities after some time will make measurements impossible. It is worth remembering that stabile measurement is possible only with natural or simulated water flow. Measurements in mg/l require introducing the atmospheric pressure and salinity value, which affect the measurement result.**
The essential feature of our products is their low failure frequency. However if your meter fails, our firm immediately performs its warranty repair.

We wish you a pleasant and trouble-free work with our meter.

2. CHARACTERISTICS OF THE METER

CO-411 oxygen meter belongs to the newest generation of measuring devices. The meter ensures accuracy and repeatability of readings. Two kinds of power source: battery and power adapter enable work in the field and long-lasting measurements in the laboratory. The meter's memory is independent from power supply. The meter is equipped with large LCD display, showing the oxygen concentration measurement or the temperature value and additional symbols which make working easier. Waterproof housing makes working in difficult conditions possible. Minimised size and weight make the meter very handy especially during field work.
Main features of **CO-411** are:

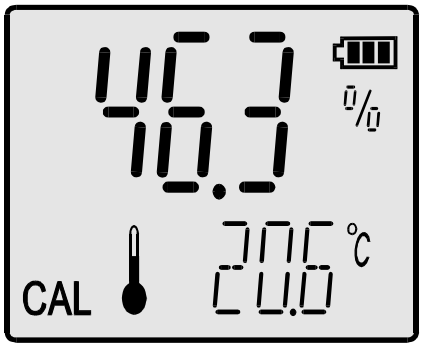
- accuracy and stability of readings;
- automatic and manual temperature compensation;
- measurement and automatic calculation of the atmospheric pressure and salinity influence on the oxygen concentration;
- one- or two-point electrode calibration;
- automatic recognition of the calibration points;
- storing of the oxygen sensor's characteristic independently from power supply;
- system protecting the meter against damages caused by connecting the battery inversely and information about the necessity of replacing the battery (🔋);
- automatic switch off function.

3. WHAT IS THE METER DESIGNED FOR

CO-411 oxygen meter is an accurate and easy-to-use meter designed for measuring oxygen dissolved in water (in % of saturation or in mg/l) and oxygen concentration in the air (in %). The meter may be also used for making accurate measurements of temperature of solutions and air in ℃.
CO-411 is used in water treatment stations, laboratories, agriculture, universities, scientific laboratories etc.
The meter is prepared to work with galvanic oxygen sensor equipped with BNC-50 connector and with Pt-1000 temperature probe with Chinch connector.

4. THE OUTSIDE VIEW

On the front wall of the meter there is an LCD placed (Pic.1), on which, depending on the user's choice, the oxygen concentration readout in % or mg/l is displayed. The way of choosing the unit is described in the point 6.1. Simultaneously with the result a measured temperature value in ^{o}C is displayed. Symbols of units are displayed next to the result. In case of disconnecting the temperature probe the meter switches to the manual temperature compensation mode (the symbol disappears). The battery condition is signalised with the symbol. The keyboard placed under the display is used for switching the meter on and off, choosing the measuring function, calibration and entering parameters.



Pic. 1.

The **CAL** symbol on the left side of the display informs that the meter is in calibration mode.

The keyboard (Pic. 2) placed under the display is used for switching the meter on and off, choosing the measuring function, calibration, entering the parameters and storing the results in the memory.

The keyboard has the following keys:

- turning the meter on and off;

- pressing shortly enters the unit choosing mode (with the  button), holding returns to the measurement mode;

- holding in the measurement mode enters the calibration mode (the ***CAL*** symbol displayed), pressing shortly in this mode records the reading in the calibration point;

 , 

- buttons used for entering parameters.

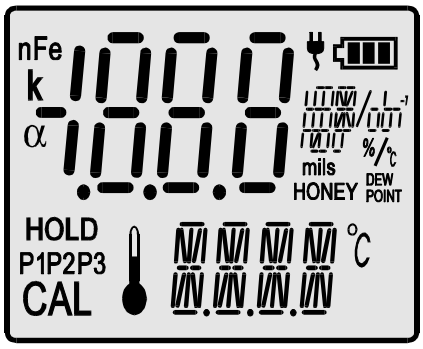
In the upper wall of the meter there are inputs placed with the symbols given below:

F - the **BNC-50** input for connecting the DO sensor;
t - the **Chinch** input for connecting the temperature probe;
P - the power adapter input.

Pic. 2.

5. SWITCHING THE METER ON AND OFF

The meter is switched on by pressing the ON/OFF button. The meter tests the memory and the display on which all symbols are displayed after switching it on (Pic.3).



Pic.3

If the test ends successfully, after about 1.5 s the meter switches automatically to the measuring mode, in which it was switched off. If a HLP sign is displayed, it means that the meter has lost the factory settings and requires service repair. If after 1,5 s all symbols are continuously displayed, it informs that the calibration parameters of the sensor have been lost.

After pressing the CAL button the meter adopts standard characteristic and enters the measuring mode. It will be necessary to calibrate the oxygen sensor.

The meter is switched off by pressing the ON/OFF button. In case of working on batteries, in order to save them, the meter switches automatically off after 10 minutes of non-use. This function is automatically deactivated when working with power adapter.

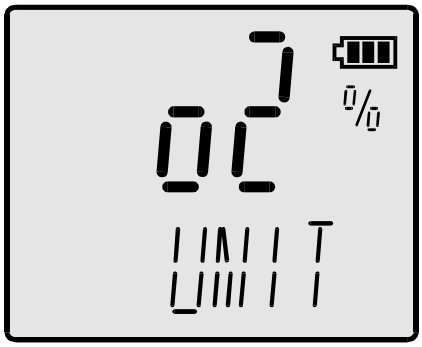
6. PREPARATION TO WORK

Before starting work:
- connect the power adapter plug to the **P** input, if work with the power adapter is planned;
- to BNC-50 input **F** connect the DO sensor;
- in case of using the temperature probe, connect it to the Chinch temperature input **t**;
- switch the meter on by pressing the ON/OFF button.

6.1. Choosing the measurement function and unit

The reading for the oxygen concentration in water may be displayed in % or in mg/l. In case of measurement of the oxygen concentration in air the reading may be displayed in % only.
To choose the unit:

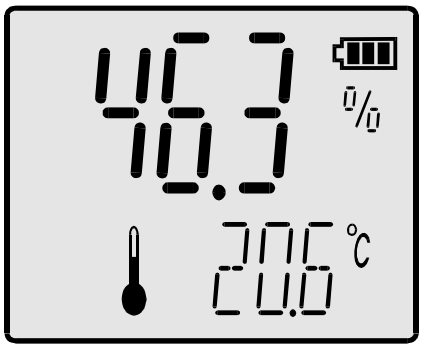
- in the measurement mode press the FUNCTION button, the lower row of the display shows the UNIT symbol and the upper row the oC symbol and the chosen unit (Pic. 4);
- ith the ↗ button, next to the oC symbol, choose:
  - % - measurement of the oxygen concentration in water in %;
  - mg/L - measurement of the oxygen concentration in water in mg/l;
  - air % - measurement of the percentage concentration of the oxygen in air;
- press and hold the FUNCTION button to return to the measurement mode.



Pic. 4

6.2. Choosing the kind of temperature compensation

The meter switches to the automatic temperature compensation mode automatically after connecting the temperature probe. Next to the reading the symbol will apear. The measurement will be compensated to the value of temperature measured by the probe
Disconnecting the temperature probe switches the meter to the manual temperature compensation mode (the symbol disappears) and the value of the temperature introduced in the way described below will be adopted for compensation.



Pic. 5

6.2.1. Entering the temperature value for manual temperature compensation

To introduce the temperature value for manual temperature compensation:

- disconnect the temperature probe (the symbol disappears);
- with the , buttons enter the requested temperature value.

7. BASIC INFORMATION ABOUT THE OXYGEN MEASUREMENT

Measurement of oxygen dissolved in water solutions is performed with use of the oxygen sensor. The basic element of the sensor is a Teflon semi-permeable membrane, which enables penetration of oxygen contained in the measured solution, into the electrolyte – inside of the sensor. The sensor generates a cell, which voltage depends on the oxygen content in the electrolyte.

The meter enables measurement in % of oxygen saturation and in **mg/l**. Calculation of the mg/l value is based on the saturation measurement in % and the temperature measurement. During mg/l measurements, the values of salinity and atmospheric pressure should be additionally introduced. The saturation measurement in % does not depend on these factors.

The quality of the oxygen sensor has a major effect on the measurement accuracy. Complications arising during measurements are caused mainly (98%) by the sensor, not the device. In many cases problems result from negligence of basic maintaining activities of the sensor from the user's side. It is worth remembering that during measurement the sensor absorbs oxygen from the environment of the membrane.

The sensor's manufacturers recommend in their instructions the minimal flow-rate of the tested water, assuring a stable result. If that requirement is not complied **the result will regularly decrease.** During measurements in stagnant solutions the flow can be partly simulated by keeping the sensor in motion with a suitable speed. In laboratory conditions, i.e. performing measurements in a vessel, the flow can be forced with a magnetic stirrer. However, when measuring low O_2 saturation, intensive stirring can cause increase of oxygen content in the tested solution. Transferring water samples to the laboratory can alter their O_2 concentration. The best results can be achieved **only in conditions recommended by the manufacturer of the sensor in the operation manual.**

Long-lasting storage of the sensor without performing any measurements (more than 1 months) requires removing of the electrolyte. After this period the container must be filled with a fresh electrolyte and the sensor stored in distilled water for about 24 hours.

Accurate measurement result is determined by the condition of the membrane. The membrane must be free of any cracks (appearing of electrolyte-drops or white spots when dry). Before measurement the sensor should be activated by storing it in distilled water for about 15 minutes. Strongly polluted wastewater after some time causes clogging of the membrane, which is recognised by inability to calibrate the device at 100% oxygen content (the calibration range becomes too narrow). In both cases the membrane should be replaced according to the manufacturer's instructions. When replacing the membrane and replenishing the electrolyte it is important to pay attention if there are no air bubbles in the container beneath the membrane, because otherwise the measurements will be falsified. In such case the container should be twisted off and the bubbles removed by tapping it against the table, next the electrolite should be refilled again and the sensor assembled.
Depending on thickness of the membrane, awaiting time for a stable result is about 1 - 1,5 min. Accuracy of the measurement is connected with the temperature of calibration and measurement. The greater the difference of these temperatures, the greater the measurement error. For measurements of concentration in the range 30 ÷ 80%, it is sufficient to make one-point calibration in 100% oxygen concentration. For measurements in solutions with low oxygen content (about a few %) calibration should be also made in 0% solution. Clean water contains about 60 ÷ 80% oxygen. Waste water and chemical solutions are in general less saturated with oxygen but liquids with forced aeration are much more saturated than clean water. When performing accurate measurements, the sensor's manufacturers recommend carrying out calibration just before the measurement since after some time the sensor's parameters are changing. Even the best oxygen sensors have so-called drift about ±1%/24 h.

8. THE OXYGEN SENSOR

The meter co-operates with galvanic oxygen sensor of ±2% accuracy, provided that the measurement is made in the same temperature as calibration. The accuracy of measurement decreases together with growing of the difference between the temperature of calibration and temperature of measurement. It is <4% when the difference is ±5℃ and increases up to 6% when the difference is ±10℃. The membrane of the s ensor should be replaced if it has been mechanically damaged or in case of inability of calibrating the device. The necessary procedures are given in the instruction of the sensor's manufacturer.
Before starting work please read the information given in the chapter 7 carefully.

9. ENTERING THE OXYGEN METER PARAMETERS

9.1. The salinity influence compensation

Salinity of the solution decreases the oxygen solubility in water and has to be taken into consideration during measurements in mg/l. **Change of salinity in 1 g/l changes the oxygen saturation in about 0.5%.** The meter enables entering the salinity value in g/l and counts the change of oxygen saturation in mg/l.

9.1.1. Introducing the salinity value

The salinity value may be determined on the basis of known conductivity of the measured solution. Table 1 gives the real dependence between salinity and conductivity counted in NaCl. In order to enter the salinity value:

- measure conductivity of the solution with any conductivity meter and read the salinity value from the table;
- in the oxygen measuring mode press the 

button, in the lower row of the LCD the SAL (salinity) sign will be displayed and in the upper row - the salinity value introduced previously;
- with the  ,  buttons enter the salinity value read from the table 1 into the upper row of the LCD;
- enter the oxygen measuring mode by pressing the 

button.

Measurement in % of saturation does not require entering the salinity value.

mS/cm	g/l	mS/cm	g/l	mS/cm	g/l
1	0.49	28	16.87	55	34.34
2	1.00	29	17.52	56	34.99
3	1.52	30	18.17	57	35.64
4	2.08	31	18.82	58	36.28
5	2.63	32	19.46	59	36.93
6	3.19	33	20.11	60	37.58
7	3.74	34	20.76	61	38.23
8	4.29	35	21.41	62	38.87
9	4.85	36	22.05	63	39.52
10	5.40	37	22.70	64	40.17
11	6.00	38	23.35	65	40.81
12	6.61	39	23.99	66	41.46
13	7.21	40	24.64	67	42.11
14	7.83	41	25.29	68	42.75
15	8.45	42	25.93	69	43.40
16	9.07	43	26.58	70	44.05
17	9.70	44	27.23	71	44.70
18	10.35	45	27.87	72	45.34
19	11.01	46	28.52	73	45.99
20	11.66	47	29.17	74	46.64
21	12.31	48	29.82	75	47.28
22	12.96	49	30.46	76	47.93
23	13.61	50	31.11	77	48.58
24	14.26	51	31.76	78	49.22
25	14.91	52	32.40	79	49.87
26	15.56	53	33.05	80	50.63
27	16.22	54	33.70		

Table 1. Determining the salinity in g/l NaCl on the basis of conductivity in mS/cm (at the temperature 25^{o}C).

9.2. Atmospheric pressure influence compensation

The concentration of oxygen saturated in water determined in mg/l depends directly on the atmospheric pressure value, which means that 10% pressure change causes also 10% oxygen saturation change. If the atmospheric pressure value differs significantly from 1013 hPa, it should be calculated into the measurement. The meter enables introducing of the atmospheric pressure value and calculates it into changes in the oxygen concentration.

9.2.1. Introducing the atmpspheric pressure value

In order to introduce the atmospheric pressure value:

- measure the atmospheric pressure in hPa;
- in the temperature measuring mode press the 

button until a PRES symbol appears in the lower row and the upper row shows the previously introduced atmospheric pressure value;
- introduce currently measured atmospheric pressure value with the 
, 
buttons;
- pass to the measuring mode pressing the 

button.

Measurement in % of saturation does not require entering the atmospheric pressure value.

10. CALIBRATION OF THE OXYGEN SENSOR

In order to eliminate the measurement error arising from the individual characteristic of the sensor its calibration should be carried out. This procedure should be performed always before using new sensor, after replacing the membrane or in case of high measurement accuracy requirements. Sensors have so-called “signal drift” associated with the interval between calibration and measurement. Longer interval decreases the measurement accuracy. Calibration is also recommended if the temperature of the tested solution differs significantly from the temperature in which the sensor was calibrated, because then an additional error arises. **In such case it is recommended to prepare calibration solutions of at least approximate temperature to the predicted temperature of the tested solutions.**

If it is impossible to calibrate the device, the membrane of the sensor should be replaced according to the manufacturer’s instruction. This situation usually takes place when the membrane is strongly polluted or ruptured (sometimes almost invisibly). After replacing the membrane the sensor should be conditioned in water for 24 hours.

Applied oxygen sensors require 1- or 2-point calibration in standard solutions. The meter has two values of the calibration points recorded: P1=0% and P2=100%. 2 point calibration is carried out in **0% of oxygen concentration solution** (i.e. **saturated** sodium sulphide) and calibration in 100% of oxygen saturation is made in the air. **In such case the membrane has to be immersed in distilled water for a few minutes before calibration.** It is assumed that O_2 content in the air corresponds to 100% of saturation, what enables simplified calibration to be carried out.

1 point calibration is made only for 100% of oxygen saturation.

In case of measurement of oxygen content in air let the fresh air in into the room. Usually, 1-point calibration in air is sufficient, as the zero point of the meter is at its resolution level.

In order to calibrate the meter:

- press and hold the CAL button until the CAL symbol appeares on the display, the current calibration parameters will be deleted. If the measurement was made in mg/l, the meter changes the unit to % automatically;
- put an activated oxygen sensor to the vessel containing 0% solution (saturated sodium sulphite solution);
- when the readout stabilises, the P1 symbol appears (the first calibration point), press the CAL button. The readout will blink, what informs about memorising the calibration value, next the corrected measurement value (0%) will appear on the display;
- take the sensor out, **wash it accurately in distilled water** and leave it on the air;
- when the reaout stabilises, the P2 symbol appears (the second calibration point), press the CAL button. The readout will blink, what informs about memorising the calibration value, next the corrected measurement value (100%) will appear on the display.

If after pressing the CAL button the meter cannot detect the value of the sample solution (0% or 100%), an Err sign displays for a moment in the place of CAL. In such case it is necessary to check the condition of the membrane and applied solutions.

Quitting the calibration mode by pressing the button automatically restores the unit chosen before entering the calibration mode.

10.1. Restoring the manufacturer's settings of the sensor

Entering the calibration mode and exiting it not making calibration in at list one point deletes the characteristic stored until now and restores the standard characteristic.

11. MEASUREMENT OF OXYGEN CONCENTRATION IN WATER

Before starting the oxygen concentration measurement the meter should be prepared for work (chapter 6) and the oxygen sensor calibrated (chapter 10). The measurement in **%** of saturation does not require additional measurements of the temperature, salinity or atmospheric pressure. **However, frequent measurements in mg/l depend on these factors.** This influence is corrected automatically by the device, which takes into consideration the temperature value measured by the sensor or - in case of manual compensation - the value entered by the user. The oxygen sensor is equipped with an additional system compensating the temperature influence on the membrane. Because of limited accuracy of this compensation the highest accuracy can be achieved by calibrating the sensor at the same temperature at which the measurement will be carried out. **The measurement error increases together with the difference between the calibration and measurement temperatures and results from characteristic features of the sensor, not the device.** For applied sensor this error is equal ±3% at ±10^{0}C temperature difference. If higher accuracy is required, the interval from the last calibration must be additionally taken into consideration (signal drift). If the atmospheric pressure is about 1013 hPa and the salinity of the tested solution is insignificant, the measurement can be started without entering these values (0.00 g/l and 1013 hPa should be entered as default values). **Before making accurate measurements, the salt content in the tested solution should be determined.** The easiest way to determine salinity is conductivity measurement with conversion to NaCl. The salinity value is introduced according to the chapter 9.1. The current value of the atmospheric pressure should be introduced according to the section 9.2.

11.1. Measurement with automatic temperature compensation

In order to make measurement with automatic temperature compensation:
- connect the temperature probe with the meter;
- insert the oxygen and temperature probes to the measured solution;
- turn the meter on with 

button;
- choose the unit according to the chapter 6.1;
- in case of measurements in **mg/l** enter the salinity and the atmospheric pressure value (section 9.1 and 9.2);
- check or simulate the flow of the measured solution;
- wait till stabilisation of the result about 1 min and check the reading.

Caution: exceeding the temperature compensation range is signalised by blinking reading and the  symbol.

11.2. Measurement with manual temperature compensation

In order to make measurement with manual temperature compensation:
- disconnect the temperature probe from the meter;
- turn the meter on by pressing the 

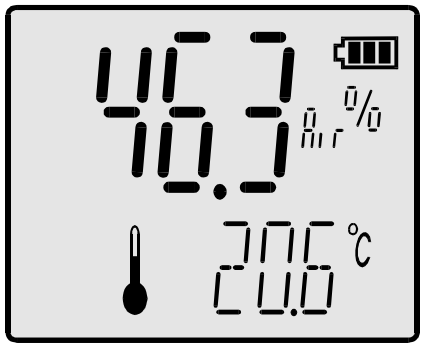
button;
- choose the unit according to the chapter 6.1;
- in case of measurements in **mg/l** enter the atmospheric pressure and the salinity value (section 9.1 and 9.2);
- insert the oxygen sensor to the measured solution;
- using thermometer measure the temperature of the solution;
- in the measurement mode, with the  ,  buttons, enter the temperature value of the measured solution;
- check or simulate the flow of the measured solution;
- after stabilisation check the reading.

Caution: in case of measurements in solutions with low salinity check, according to the chapter 9.1, weather the introduced salinity value is equal 0.00 g/l.

12. MEASUREMENT OF OXYGEN CONTENT IN AIR

Before starting the oxygen content measurement, the meter should be prepared for work (chapter 6) and the oxygen sensor calibrated (chapter 10). The oxygen content measurement does not require additional measurements of temperature, salinity and atmospheric pressure.

In order to make measurement:
- connect the oxygen sensor to the **O2** connector (Pic. 2.);
- leave the oxygen sensor in the air;
- switch the meter on with the FUNCTION button;
- choose the measurement function with the FUNCTION button;
- choose the unit according to the chapter 6.1;
- wait until the reading stabilises and check it (Pic. 6).



Pic. 6

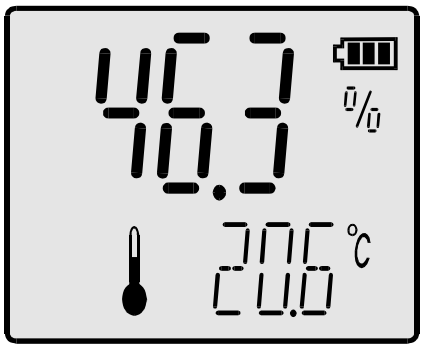
Note: during the measurement of the oxygen content in air next to the reading the air % symbol is displayed (to differenciate it from the measurement of the percentage of the oxygen concentration in water).

13. TEMPERATURE MEASUREMENT

The temperature measurement is made in the following way:

- connect the temperature probe to the Chinch connector;
- switch the meter on by pressing the ON/OFF button;
- put the temperature probe to the measured solution;
- wait till the value stabilises and check the reading.

The meter cooperates with the Pt-1000 probe. Depending on its class the accuracy of the measurement changes.



Pic. 7

CAUTION: disappearing of the symbol informs about break in the circuit of the temperature probe. The meter displays the value of the temperature entered by the user for manual compensation.
Blinking -50℃ value while making measurement at po sitive temperature informs about short circuit in the temperature probe.

14. READOUT OF THE SOFTWARE VERSION NUMBER

In order to check the software version number turn the meter off and next, holding the FUNCTION button, turn the meter on by pressing the ON/OFF button. Instead of the display test, the screen as in the picture below will appear (Pic. 8). In the upper row the software version will appear and in the lower row a type of internal power supply, to which the meter has been adjusted:

Accu - internally powered by two rechargeable R6/AA batteries;
bAtt - internally powered by two standard R6/AA batteries.

Rys. 8

After about 1.5 s. the meter enters the measurement mode.

15. POWER SOURCE AND CHANGING THE BATTERY

The meter is powered by 9V battery or 12V stabilised power adapter. The adapter should be joined with the connector **P (**Pic.2). Connecting the power adapter disconnects the battery and is signalised by the symbol.
The level of filling the symbol informs about the battery condition. Blinking symbol informs, that the battery should be changed. In order to do this, it is necessary to undo two screws in the lower wall of the meter, pull out the whole wall and replace the battery.
The next thing is to put the new battery into the meter and mount the wall.
The wall has a sealing ring on the edge. While closing the meter, it is very important to pay attention if the ring is put inside the housing in the whole perimeter. Next, do the screws till the moment of resistance (not too hard). Leaving the wall improperly screwed may cause the meter's inundation. This kind of failure is not repaired under the warranty conditions.

16. EQUIPMENT

The standard equipment for the meter is:

1. Oxygen sensor;
2. Pt-1000B temperature probe (standard);
3. Plastic container for the meter and probe;
4. Users manual with warranty.

The additional equipment available for this meter is:
1. 12V/100mA power adapter;
2. Pt-1000 1/3B temperature probe with higher accuracy.

17. TECHNICAL DATA

OXYGEN MEASUREMENT:

Range	Accuracy
0 ÷ 199.9 %	0.1 %
0 ÷ 19.99 mg/l	0.01 mg/l

Accuracy of the measurement:

Measurement temerature	Accuracy (±1 digit)
equal to the calibration temperature	±2 %
±5 ^{o}C than the calibration temperature	±4 %
±10 ^{o}C than the calibration temperature	±6 %

Temperature compensation range: 0.0 ÷ 40.0 ^{o}C
Salinity compensation range: 0.0 ÷ 50.0 g/l
Atmospheric pressure compensation range: 800 ÷ 1100 hPa
Probe calibration:
two-point 0% and 100% O_2
one-point in 100%O_2
Oxygen sensor: membrane, galvanic

TEMPERATURE MEASUREMENT:

Range	Resolution	Accuracy* (±1 digit)
- 50.0 ÷ 199.9 ^{o}C	0.1 ^{o}C	±0.1 ^{o}C

* accuracy of the meter. Final accuracy of the measurement depends on the accuracy of applied PT-1000 probe

Temperature probe: platinum resistor Pt-1000
Accuracy of the probe in range 0 ÷ 100 ^{0}C:
for Pt-1000B resistor: ±0.8 ^{0}C
for Pt-1000$^{1}/_{3}$B resistor: ±0.3 ^{0}C

OTHER:

WORKING TEMPERATURE: -5 ÷ 45 ^{o}C
POWER: 9V battery 6F22
12V stabilised power adapter
POWER CONSUMPTION: 27 mW
DISPLAY: LCD 55 x 45 mm
DIMENSIONS: 149 x 82 x 22 mm
WEIGHT: 220 g

W A R R A N T Y

The ELMETRON company ensures a 24-month warranty for the **CO-411** oxygen meter number:

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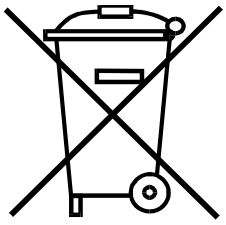
In case of damage the producer will repair the meter within 14 days from the day of delivery.
The warranty doesn't cover the damages caused by usage not in conformity with the user's manual, using wrong power adapter, mechanical damages and damages caused by repairs made by unauthorised persons.

The oxygen sensor and the temperature probe have a 1-year warranty of the producer.

NOTICE: Before sending the meter to us please contact the firm by phone or email.
When sending the meter, the oxygen sensor, the temperature probe and the power adapter should be also included.

Date of production.....
Date of sale.....
Date of warranty expiry.....



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