

**WATERPROOF  
MULTIFUNCTION  
METER  
CX-401**

**USER'S MANUAL**

**WATERPROOF  
MULTIFUNCTION METER  
CX-401**

Before use please read the instruction carefully!

## TABLE OF CONTENT

### I. Introduction

1. Exploitation notices	4
2. The characteristic of the meter	5
3. What is the meter designed for	6
4. Outside view	7
5. Switching the meter on and off	10
6. Preparation to work	11
6.1. Choosing the kind of temperature compensation	11
6.2. Changing the resolution of the measurement	12

### II. pH measurement

7. Preparation of the pH electrode	14
8. Calibration of the pH electrode	15
8.1. Introducing the pH values of the buffer solutions	17
8.2. Automatic change of the pH value of buffer solution	19
8.3. The actions during calibration	21
8.4. Calibration with automatic temperature compensation	24
8.5. Calibration with manual temperature compensation	26
9. Changing the electrode and checking it's condition	26
9.1. Checking the electrode's condition	26
10. pH measurement	27
10.1. Measurement with automatic temperature compensation	27
10.2. Measurement with manual temperature compensation	28
11. Notices about the temperature compensation and interpretation of the results	29

### III. Conductivity and salinity measurement

12. Basic information about the conductivity measurement	32
13. Preparation to work	33
13.1. Choosing the unit	34
13.2. Entering the $W_{TDS}$ coefficient	35
14. Choice and maintenance of the conductivity cell	36
14.1. The cell choice	36
14.2. The conductivity cell maintenance	37
15. Calibration	38
15.1. Calibration without the sample solution	38
15.2. Calibration with use of sample solution	39
16. The simplified way of determining the $\alpha$ coefficient	41
17. Entering the $\alpha$ coefficient value	42
18. The conductivity measurement	43
18.1. The measurement without temperature compensation	43
18.2. The measurement with temperature compensation	44
18.3. The measurement with manual temperature compensation	45

19.	Salinity and TDS measurement	46
19.1.	Salinity measurement with conversion to NaCl or KCl content	47
19.2.	Determining the $W_{TDS}$ coefficient	48
19.3.	The measurement of salinity with conversion to TDS	48

#### **IV. Oxygen concentration measurement**

20.	Basic information about dissolved oxygen measurement	50
21.	The oxygen sensor	52
22.	Entering the parameters	52
22.1.	Changing the number of probe	52
22.2.	Changing the unit	53
22.3.	Salinity influence compensation	53
22.4.	Automatic compens. of the atmospheric pressure influence	56
23.	Calibration of the oxygen probe	57
24.	Oxygen concentration measurement	59
24.1.	Measurement with automatic temperature compensation	60
24.2.	Measurement with manual temperature compensation	60

#### **V. Atmospheric pressure measurement**

25.	Atmospheric pressure measurement	62
-----	----------------------------------	----

#### **VI. ORP (mV) and temperature measurement**

26.	ORP (voltage) measurement	64
27.	Temperature measurement	64

#### **VII. Other**

28.	Clock, date, auto switch off function	66
28.1.	Time display	66
28.2.	Date display	66
28.3.	Auto off function	66
28.4.	Checking the battery condition	67
28.5.	Setting the time and date	67
29.	Storage and readout of the results	68
29.1.	Storing or printing	68
29.2.	Parameters of storing and reading from the memory	68
29.3.	Storing the single measurements in the memory	70
29.4.	Storing the measuring series	70
29.5.	Reviewing of the results	71
29.6.	Deleting the stored results	71
30.	Printouts on the printer	72
30.1.	Printout of the result – single or serial	72
30.2.	Printout of the results stored in the memory	73
31.	Power source and changing the battery	73
32.	Co-operation with the PC	74
34.	Technical data	75
33.	Equipment	78

## **I. Introduction**

## 1. EXPLOITATION NOTICES

Dear User!

We present you a device distinguished by accuracy according to the technical data and by a high stability of the displayed results. We believe that the measurements will not cause you any trouble and that the meter will operate without any inconvenience. **Wide range of additional functions requires careful reading of the manual in other case some of the features may stay unused or using the meter may cause you a troubles.**

The employing of good-quality electrodes cells and probes and their replacing after a suitable time ensures obtaining of high measuring parameters. We want to call your attention to the fact, that this equipment has a much shorter working life than the meter. Typical symptoms of an improper operation of the electrode are deterioration of final result stability, it's flowing as well as a higher measuring error. **Part of the users has problems, arising from employing electrodes not being preconditioned before the measurement or making the measurements without removing the shielding ring from the liquid junction or taking measurements with a plugged junction.** To avoid this situation it is necessary to choose the proper kind of electrode for solutions which are going to be measured ex. special electrodes for the sewage, liquids with deposits, meat cheese etc. Therefore, if you observe improper operation of the device, please take control measurements with another electrode or check the used electrode with another pH-meter. **Generally the deterioration of the meter work is caused by the electrode and not by the meter.**

In case of conductivity measurements it is important to choose the cell with right constant K value for the measuring range. Wrong selection may cause larger error occur, similar situation occurs during measurements with automatic temperature compensation with incorrectly introduced  $\alpha$  coefficient.

Accuracy of the dissolved oxygen measurements depends on the sensor calibration and regular maintenance which consist in replacing the membranes, electrolyte and cleaning the electrodes. **Lack of correct maintaining of the sensor after some time will make measurements impossible. Please turn your attention to the fact that stabile measurement is possible only with simulated or natural measured water flow.**

The essential feature of our products is their low failure frequency. However if your meter will fail, our firm immediately performs its warranty repair.

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

## 2. THE CHARACTERISTICS OF THE METER

The multifunction meter **CX-401** belongs to the newest generation of measuring devices which offer wide range of additional functions. The meter ensures high accuracy and repeatability of the readings. Two kinds of power source: battery and power adapter enable work in field and long-lasting measurements in the laboratory. The newest generation electronic elements used in the meter made it's memory independent to power supply and have ensured very low power consumption what greatly increases the operation time on 1 battery. The meter is equipped with large custom LCD display, which enables simultaneous observing of the measured function, temperature value and additional symbols which make working easier. Waterproof housing makes working in difficult conditions possible. Small size and weight make the meter very handy especially during the field work.

Main features of the **CX-401** are:

- high accuracy and stability of the reading;
- automatic and manual temperature compensation;
- pH electrode calibration in 1 to 5 points;
- automatic recognition of pH buffers and standards;
- imposed values of standard solutions with possibility of changing their value;
- option of automatic introduction of temperature correction on the value of pH buffer solutions (NIST norm);
- information about the condition of the pH electrode;
- storing of three characteristics of electrodes in each function;
- wide range of conductivity measurement with 6 automatically switched subranges (autorange);
- counting the conductivity to salinity in NaCl or KCl according to real dependence to conductivity;
- possibility of introducing the TDS coefficient;
- calibration of the conductivity cell by introducing the constant K or on sample solutions;
- function of determining the constant K of cell;
- automatic compensation of the salinity influence on the oxygen measurement using the conductivity measurement function;
- measurement and automatic compensation of the atmospheric pressure influence on the dissolved oxygen concentration;
- internal datalogger for 200 measurements with time date and temperature;
- taking series of measurements with set time interval;
- RS-232 output
- possibility of printing the measurement results or values stored in the memory on standard printer with use of interface;
- Information about the battery condition;
- automatic switch off function after time set by the user;

### 3. WHAT IS THE METER DESIGNED FOR

Waterproof multifunction meter **CX-401** is precise and easy to use meter designed for hydrogen ion concentration measurements in pH units, Oxidation Reduction Potential (mV) conductivity, in  $\mu\text{S}/\text{cm}$  or  $\text{mS}/\text{cm}$ , dissolved oxygen in water in % of saturation or  $\text{mg}/\text{l}$  and atmospheric pressure measurement in hPa. The meter may be also used for accurate temperature measurement of solutions and air in  $^{\circ}\text{C}$ .

The conductivity measurement result may be also displayed in concentration units ( $\text{g}/\text{l}$  or %) counted to NaCl, KCl or TDS. Waterproof housing enables work in difficult weather conditions or in humid environment.

Multifunction **CX-401** meter is being used in food, chemical, pharmaceutical and energetical industries, in water treatment stations, laboratories, agriculture, universities, scientific laboratories etc.

The meter is prepared to work with all types of combination pH electrodes and conductivity cells, with wide constant K range, equipped with BNC-50 connector. It is possible to connect the meter with two electrodes (pH measuring and reference) by special adapter offered as additional equipment. **CX-401** cooperates with Pt-1000 temperature probe with Chinch connector.

The meter may collect up to 200 measurements taken as single or series of measurements with set time interval. RS-232 output enables connecting the meter with a PC for sending the data or through special EI-401 interface with standard printer, what enables printing the data collected in the memory or current results of the measurement.

In case of necessity of collecting series longer than 200 results it is possible to use special software offered by our company.

**Caution:** interface EI-401, which enables connecting the meter with standard printer and special software for collecting series of measurements on a PC is offered as additional equipment.

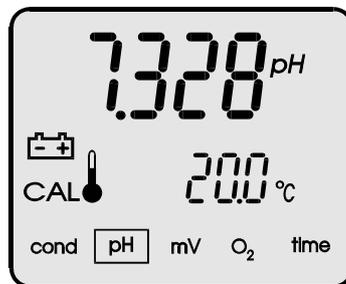
#### 4. OUTSIDE VIEW.

On the front wall of the meter there is a LCD display (pic. 1) on which depending on the chosen function following symbols are displayed:

- result of the conductivity or salinity measurement;
- result of the pH measurement in pH units;
- result of the mV measurement in mV;
- result of the oxygen measurement in % or mg/l
- time and date.

Choosing the function by  button is signalled by displayed frame round the right symbol in the lower part of the display: **cond** (conductivity), **pH**, **mV**, **O<sub>2</sub>** or **time**.

Simultaneously with the result a measured temperature value is displayed in °C. Symbols of the units are displayed by the results. In the oxygen measurement mode there is possibility of reading the atmospheric pressure value.



Pic. 1.

Beside the temperature value a  symbol for automatic temperature compensation is displayed or  for manual. **CAL** symbol on the left side of the display informs that the meter is in calibration mode.

After pressing the  button all parameters introduced by the user are displayed and also the value of atmospheric pressure measurement (in oxygen measurement function). If the battery should be changed a  symbol is displayed.

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, printing and storing the results in the memory.

The keyboard has the keys as follows:

-  - to change the function, and switch the meter on, off.
-  - short pressing in MODE/P.CAL mode enables choosing points of calibration to change their value.  
- longer pressing of this button enters the calibration mode (*CAL* symbol displayed). Short pressing in this mode confirms the calibration result.
-  - after pressing this button the result is stored, the measuring series starts or printing begins.  
- after longer pressing of this button the stored results reviewing is possible.
-  - chooses the entered parameter.
-  ,  - buttons used for entering the parameters

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

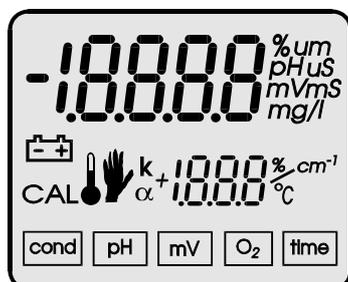
- F** - **BNC-50** connector for connecting the combination pH electrode, Redox electrode or the oxygen probe
- F1** - **BNC-50** for connecting the conductivity cell
- t** - **Chinch** input to connect the temperature probe
- RS** - **RS-232** input for connecting with PC or printer
- P** - Power adapter input **9V**



Pic. 2.

### 5. SWITCHING THE METER ON AND OFF

The meter is switched on by pressing the  button. The meter tests the memory and display on which all symbols are displayed.



Pic. 3

If the test was successful, after about 1.5 s the meter switches it self automatically to the measuring mode, in which it was switched off. If a *HELP* sign will be displayed it means that the meter has lost the factory settings and requires the service repair. If after the 1,5 s all symbols will be continuously displayed it informs that the calibration parameters of electrodes or cells were lost.

After pressing the  button the meter will take standard characteristics:

- shift = 0 pH, characteristic slope = 100% for pH electrode;
- constant  $K = 1.000 \text{ cm}^{-1}$  for conductivity cell;
- shift = 0%  $\text{O}_2$ , characteristic slope = 100%  $\text{O}_2$  for oxygen sensor.

And will enter the measuring mode. It will be necessary to calibrate the conductivity cell, pH and oxygen electrodes.

The meter is switched off by pressing and longer holding of the  button till displaying of the  $\square^{\text{FF}}$  symbol. In case of working on the batteries to save them the meter switches it self automatically off after the time set by the user from last pressing of any button. Way of introducing the time is described in the paragraph number 21. This function is switched off for the time of calibration, taking the series of measurements, printing the memory content and work with the power adapter.

## 6. PREPARATION TO WORK

Before starting the work one should:

- join the power adapter plug to the **P** input, if work with the power adapter is planned;
- to BNC-50 input **F** join the ready to work combination pH electrode, redox electrode or the dissolved oxygen sensor;
- to BNC-50 input **F1** join the conductivity cell;
- in case of using the temperature probe it should be connected with the chinch temperature input **t**;
- In case of printing or work with PC join the interface EI-401 or cable CP-4XX – PC with **RS** input
- switch the meter on by pressing the  button.

**CAUTION:** during pH measurements the conductivity cell has to be disconnected from the meter or removed from the measured solution in which the pH electrode is immersed.

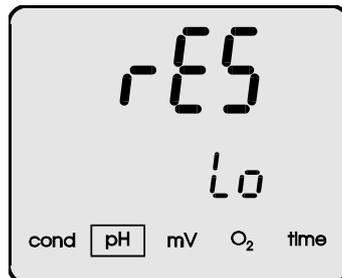
### 6.1. Choosing the kind of temperature compensation

The meter switches it self to the automatic temperature compensation mode automatically after joining the temperature probe, after disconnecting it the meter enters the manual temperature compensation mode. In ATC mode near the displayed temperature a  symbol appears. Manual temperature compensation is indicated by  symbol near the value entered by the user, it may be changed using  or  keys.

## 6.2. Changing the resolution of the measurements

The measurement results may be displayed with chosen resolution. To change it one should:

- in the measuring mode press the  button, a rES (resolution) sign will be displayed. (Pic. 4)
- Using keys  or  one may choose:
  - Lo - (low) resolution of the measurement;
  - Hi - (high) resolution of the measurement.



Pic. 4

For the pH measurement:

- Lo - resolution of the measurement 0.01 pH;
- Hi - resolution of the measurement 0.001 pH.

For the conductivity measurement:

- Lo - resolution of the measurement 3½ digits;
- Hi - resolution of the measurement 4½ digits.

For the oxygen measurement:

- Lo - resolution of the measurement 1% or 0,1mg/l;
- Hi - resolution of the measurement 0.1% or 0.01 mg/l.

Return to the measurement mode by pressing  button.

## **II. pH measurement**

## 7. PREPARATION OF THE pH ELECTRODE

The electrode should be prepared to work according to the producer instructions. If the instructions weren't given please follow the steps:

- new electrode should be put into distilled water or in saturated KCl solution for about 5 hours;
- Before starting the measurements protecting rings (if used in this kind of electrode) should be removed. The ring placed on the junction – lower part of the electrode should be moved up along the electrode's body and the upper, which protects the KCl refilling hole, down along the body.

**Removing the lower ring is essential, in other case the electrode won't measure.**

Upper ring should be removed during measurements of high temperature solutions or to protect the junction during measurements in solutions with deposits or oils;

- during measurements in laboratory it is advisable to use an electrode holder;
- after every measurement the electrode should be washed in distilled water;
- excess of liquid on the electrode should be removed by gentle touching the glass with a tissue paper;
- after work the electrode should be stored in one of the above given solutions. The protecting rings should be moved on the junction and upper hole;
- in case of long breaks between the measurements the electrode should be stored, after drying, in the packaging;
- after taking the electrode of the package the eventual deposit should be removed using water;
- before using the electrode it should be placed in distilled water for about 2 hours;
- if the construction of the electrode enables refilling the electrolyte, it should be controlled and refilled periodically by the upper hole in the electrode's body (usually as the electrolyte a KCl solution is used).

**CAUTION:** storing of the electrode in distilled water shortens it's life time and may cause shifting of the zero point.

## 8. CALIBRATION OF THE pH ELECTRODE

Before starting the measurement with new electrode, after long-lasting using, or before making measurements which require higher accuracy the electrode connected with the meter should be calibrated. Results of measurements done without calibration will have a great error. The calibration is done on the buffer solutions. It depends on comparing pH value of the buffer solutions with the value displayed by the meter and next automatic introduction of correction which is taken into consideration during measurements. The calibration should be periodically repeated because during work the parameters of the electrode are changing what influences the accuracy. The frequency of this procedure depends on the demanded accuracy, number of the measurements carried out, conditions in which the electrode was used, temperature and value of the measured solutions. When the highest accuracy is required it is recommended to use sample solutions with certificates. In technical usage buffer solutions are used with lower accuracy but mostly with total values ex. 2.00 pH; 4.00 pH etc. In this manual to make it easier a buffer solution name was used for both buffer and sample solutions. For accurate measurements it is necessary to use fresh good quality buffers.

The first action taken before the calibration is entering the values of used pH buffer solutions to the meter's memory. This should be done before the first calibration and repeated in case of changing the used buffers to other values.

During the calibration after immersing the pH electrode and temperature probe the meter automatically detects the value of the used buffer, if it was earlier stored in the meter's memory.

There is possibility of calibration in minimum 1 buffer solution and maximum in 5. The more points of calibration is used the higher is the accuracy in the whole measuring range.

Calibration in one buffer solution can't ensure high accuracy. If only one buffer solution is used its value should be close to the forecasted value of measured solution. If the required accuracy isn't very high and the measurements will be done in the whole range the one point calibration should be done with buffer solution close to 7.00 pH. Thanks this the so called zero electrode shift will be eliminated. In other points a standard characteristic will be taken from the meter's memory. This characteristic corresponds with theoretical efficiency of the pH electrode

If measurements are done both in acids and alkalis and the measurements are not done at the ends of measuring range it is enough to calibrate the electrodes in 3 buffer solutions with values in range given in table 2 – calibration points 2, 3 and 4. In case of accurate measurements in the whole range it is recommended to calibrate the electrode in all 5 points given in the table. IN **CX-401** characteristic of the electrodes is approximated linearly between the calibration points.

**Starting the calibration under one of the electrode numbers does not remove the set buffer values, but irreparably removes the electrode characteristic stored under this number.**

**There is no possibility of calibrating only one point, leaving the rest of data from the last calibration.**

**CX-401** enables independent storing of 3 characteristics of pH electrodes. This feature is especially useful when fast replacing of the electrodes is necessary or when it was broken. Those electrodes should be earlier calibrated and brought into memory under following symbols  $E1$ ,  $E2$ ,  $E3$ .

The order of using the buffer solutions is freely chosen.  
The user may choose two independent ways of action:

1. enter the value of pH buffer solutions depending on the actually used buffers, in the range given for each point of calibration;
2. use the values of pH sample solutions entered to the memory by the manufacturer. Those values are in conformity with the NIST norm. This type of calibration switches on the automatic correction introduction connected with the change of sample solution along with temperature changes.

Choosing the second option makes the calibration much easier. The user doesn't need to warm up or cool down the sample solutions to the temperature given by the user. This option includes some simplifications and when very high accuracy is required it shouldn't be used. The meter stores independently 5 values of the buffers for each of the calibration modes described above.

#### 8.1. Introducing the pH values of buffer solutions.

Values of the buffer solutions set by the producer in the meter's memory are given in the table 1.

Point of Calibration	Resolution 0,001	Resolution 0,01
1	1,675	1,68
2	4,002	4,00
3	6,881	6,88
4	9,225	9,22
5	12,627	12,63

Table 1

If the values of used buffer solutions are different than the given above the user may change the set values.

Range of possible changes is given in the table 2. There is possibility to introduce the values of buffer solutions with two or three decimal places.

**The meter doesn't allow for introducing pH values in ranges other than those given in the table 2.**

Table 2.

Calibration point	Range
1	0,800 ÷ 2,100
2	3,900 ÷ 4,100
3	6,800 ÷ 7,100
4	8,900 ÷ 9,400
5	11,500÷ 14,000

**The values of pH buffer solutions entered by the users are stored in the meter's memory till their changing to others.**

Some of the sample solutions made according to norms may differ between on the third decimal place. In very accurate measurements the user may not use the mode with values of sample solutions according to NIST, but the mode which enables changing the values of stored buffers. Before calibration one has to change them to the accurate value of used sample.

The range of introducing the pH values of the buffer solutions in the individual points of calibration is quite wide what enables to use buffer solutions with values which differ from the ones set by the producer. For example buffers with value 2,00 pH; 7,00 pH; 9,00 pH; and 12,00 pH may be used. In every case the introduced buffer solution will be automatically recognised by the meter.

Together with the temperature change value of the pH buffer solution changes. The producers often give the values of the solutions in few temperatures. This data may be used and the meter may be calibrated in other temperature than 20 °C, by introducing to the meters memory value of the buffer which responds to the chosen temperature.

#### **8.2. Automatic change of the pH value of buffer solution.**

In this mode 5 constant sample solution values, according to NIST, are used. **In the meter's memory a table with dependence between the temperature and pH values for this 5 sample solutions is stored.** This dependence is showed in the table 3. Those values are taken into consideration when the calibration is done in other temperatures. Values between the points are approximated linearly.

The highest accuracy may be obtained only when the pH values of the buffer solutions are identical as in the table.

If there are some differences between the values given in the table and values given by the producer of buffer solutions, one should judge weather the error which will occur during calibration with automatic correction of the value won't be to big. If yes one should resign from using this option.

The range of the temperatures, taken into consideration during introducing the correction, is 0 to 60 °C, and can't be exceeded.

Table 3.

Temp. °C	Kind of buffer solution				
	1 oxalate	2 phthalate	3 phosphate	4 di-sodium tetraborate	5 calcium hydroxide
0	1.666	4.003	6.984	9.464	13.423
5	1.668	3.999	6.951	9.395	13.207
10	1.670	3.998	6.923	9.332	13.003
15	1.672	3.999	6.900	9.276	12.810
<b>20</b>	<b>1.675</b>	<b>4.002</b>	<b>6.881</b>	<b>9.225</b>	<b>12.627</b>
25	1.679	4.008	6.865	9.180	12.454
30	1.683	4.015	6.853	9.139	12.289
35	1.688	4.024	6.844	9.102	12.133
40	1.694	4.030	6.838	9.063	11.984
45	1.700	4.047	6.834	9.038	11.841
50	1.707	4.060	6.833	9.011	11.705
55	1.715	4.075	6.834	8.985	11.574
60	1.723	4.091	6.836	8.962	11.449

### 8.3. The actions during calibration

One should:

- a. Choose the resolution with which the buffer solution value will be introduced. Depending on the fact whether the buffer solutions have the pH value given with 2 or 3 decimal places one should choose the right resolution.

Using  button choose the pH function, next press the  button a  $r\text{-}\overline{E5}$  (resolution) sign will be displayed.

Using  or  buttons choose:

$\overline{L0}$  - (low) resolution of the measurement 0.01 pH;

$\overline{Hi}$  - (high) resolution of the measurement 0.001 pH.

- b. Choose the electrode number under which the parameters of calibration will be stored.

Press the  button, then using  or  buttons choose the electrode number (symbols  $\overline{EL1}$ ,  $\overline{EL2}$ ,  $\overline{EL3}$ ), under this number the calibration results will be stored. Above the electrode number following signs will be displayed:

$\overline{CLR}$  - under this number there is no characteristic stored and producers values are provided.

$\overline{SET}$  - under this number there are values of last calibration stored.

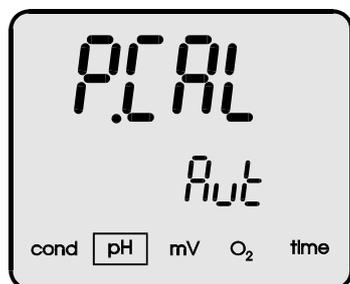
$\overline{BAD}$  - the last calibration showed that the electrode is losing its efficiency and in short time its calibration won't be possible

- c. Choose or block the function of automatic correction of the change of pH value of buffer solution with the temperature.

To do so one should press the  button than a  $\overline{PCAL}$  symbol (points of calibration) will be displayed, (pic. 5) next using  or  buttons choose:

$\text{Aut}$  – automatic change of the stored pH value of the buffer solution by its temperature change according to table 3.

$\text{USt}$  – setting the value of the buffer solution in the range given in table 3.



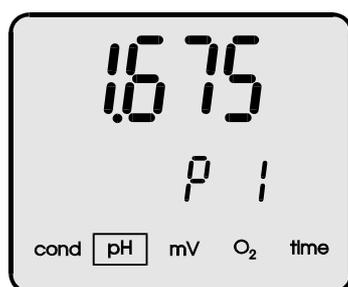
Pic. 5

After choosing the  $\text{Aut}$  symbol one should press the  button and start the calibration in buffer solutions according to point e and chapter 8.4.

After choosing the  $\text{USt}$  act according to the point d.

d. After choosing the  $\text{USt}$  (user setting) symbol one should start checking and eventually changing the stored values of calibration points. To do so one should press the  button. In the lower row a  $\text{pH}$  symbol will be displayed, point one of calibration, and in the upper row value of the buffer. (pic. 6) If one uses buffer solution with value a bit different than this displayed one, using  or  buttons bring the displayed value to the value of used buffer solution.

Range of changes for each calibration points is given in the table 2.



Pic. 6.

To pass to the second point of calibration press the **CAL** button in the lower row a **P2**, symbol will be displayed (point 2) and in the upper row the stored in this point value of buffer solution. When checking or changing the value in the next steps please follow the instructions given above.

After the end of introducing the pH values of buffer solutions using the **MODE** button return to the choosing the calibration points mode (**Aut / USt.**) or by next pressing the **FUNCTION** enter the pH measuring mode.

During next calibrations if the values of the previously used buffer solutions haven't changed the actions described in this point may be omitted.

- e. Prepare the electrode for work acting according to it's producer instructions, than mark it with the number chosen in the meter (symbols **EL 1**, **EL 2**, **EL 3**).
- connect the prepared combination electrode and temperature probe to the right connectors (**F** and **t**) in the meter (pic. 2);
  - if the function of automatic correction of the influence of temperature on pH value of the buffer solution isn't used measure the temperature of the buffer solutions and bring it to the temperature given by it's producer, so to reach the value set in the meters memory. The order of using the buffer solutions may be chosen freely.

After choosing the number of electrode according to the point b, press the  button and start the calibration on the buffer solutions.

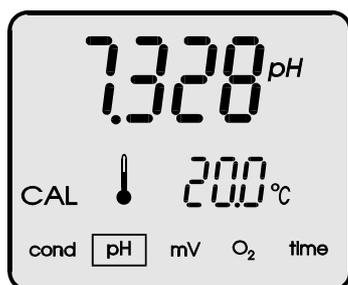
Under each of the three numbers of electrode one may calibrate next electrodes in pH buffers with different values, after earlier setting those values and storing them under the chosen number.

**If the used buffer solution has identical value as this displayed, or this buffer isn't used the value should be left without changing. The meter takes under the consideration only the detected, during calibration, values of buffer solutions.**

#### 8.4 Calibration with automatic temperature compensation

After preparing the meter to the calibration it is necessary in pH function to:

- press and hold the  button till the appearance of the **CAL** (pic. 7) symbol on the display; **the old parameters of calibration are deleted;**
- put the electrode and the temperature probe to the buffer solution, wait till stabilisation of the result. The result may be different than pH value of the buffer solution.

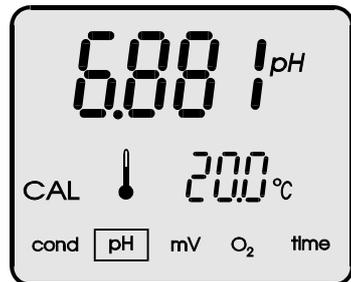


Pic. 7.

After stabilisation of the result press the  button.

In this moment the result will blink what will inform about storing the calibration result, in this same time in the upper row the corrected value of measurement will be displayed – it will be equal the value of used buffer solution (pic. 8).

If the function of automatic correction of the temperature influence on pH value of the buffer solution is used, this value will be considered in the displayed value of the buffer solution. If by accident someone will use buffer solution different than those set for the calibration the meter won't be able to detect this value and  $E_{err}$  sign will be displayed. In this case it is necessary to check the value of the buffer solution or the electrode which may be broken or clogged.



Pic. 8.

- c. one may finish the calibration at this moment by pressing the  button or continue the calibration in other buffer solutions, by washing the electrode and temperature probe before every immersing in the buffer and acting according to the point b.

After calibrating one electrode it is possible to calibrate two others, choosing the two remaining symbols according to point 8.3.b.

**If after choosing the electrode number and entering the calibration mode one will exit without making the calibration the earlier stored characteristic will be deleted and a standard characteristic will be adapted.**

### 8.5. Calibration with manual temperature compensation

To start the calibration with manual temperature compensation one has to disconnect the temperature probe. Disconnecting the temperature probe switches the meter to manual compensation. On the display the entered value of the temperature is displayed, not the measured one. The  ,  buttons will be unblocked and using them one may enter the value of the solution temperature. This value is displayed in the lower row of numbers on the display. Next thing is to join the pH electrode with the meter and act according to points a ÷ c. of the previous section. It is important to remember that in case of manual temperature compensation the temperature value entered by the user is taken under consideration.

**Caution:** simultaneous pressing of both  and  buttons sets the temperature to 20 °C.

## 9. CHANGING THE ELECTRODE AND CHECKING IT'S CONDITION

If in the memory of the meter there is more than one electrode characteristic one may change the electrode without the calibration. This feature is very useful especially when using different kinds of electrodes (for sewage, and clear water etc.) or during measurements in the field, in case of breaking the electrode. One has to connect the earlier calibrated electrode marked with the number and choose the right number of characteristic from the memory according to the steps given in section 8.3.b ( $E_L 1$ ,  $E_L 2$ ,  $E_L 3$  symbols)  
After this one may start the measurements.

### 9.1. Checking the electrode's condition

Checking the electrode condition is possible only if the calibration was done. To do so in the pH mode the  button should be pressed and number of calibrated electrode should be chosen. If above the number a  $b^Rd$  symbol will be displayed this informs that the electrode has lost its efficiency and in short time its calibration won't be possible. It is necessary to prepare a new electrode.

## 10. pH MEASUREMENT

Before starting the measurement one has to prepare the meter for work (chapter 6) and pH electrode (chapter 7). Good condition of the electrode is the main condition of correct measurements. If the electrode was calibrated and is joined with the meter it is advisable to check whether the number of the electrode is this same as the number of the characteristic chosen from the memory. If not, the number should be changed according to section 8.3.b and the resolution of measurement should be chosen according to the chapter 6.2.

### 10.1. Measurement with automatic temperature compensation

During measurements with automatic temperature compensation, the meter cooperates with the temperature probe and measures the temperature of the solution simultaneously with the pH measurement and takes it into consideration during compensation.

In case of measurement with automatic temperature compensation one should:

- join the temperature probe and the combination pH electrode to the right connectors on the meter **F and t** (pic.2), symbol  will be displayed;
- if the electrode wasn't calibrated or was already used for some time it is advisable to calibrate it. (chapter 8);
- insert the electrode and the temperature probe to the measured solution. During measurements in vessels one should not touch the bottom and the walls with the electrode. Best way is to use an electrode stand;
- Turn the meter on by pressing the  button;
- using  button choose the pH measurement function.
- After the stabilisation read the result

**Accurate laboratory measurements require using of electromagnetic stirrers.**

**NOTICE:** exceeding of the measuring range is indicated by blinking of the digits on the display.

## 10.2 Measurements with manual temperature compensation

Disconnecting the temperature probe from the meter switches the meter to the manual temperature compensation mode (symbol  is displayed).

Measurement with manual temperature compensation is similar to the measurement with ATC, the difference is that using ,  buttons one enters the temperature measured with other thermometer. This value is displayed under the pH value and is taken into consideration during the compensation.

The manual compensation may be used during stable conditions ex. during pH measurements in the laboratory, especially when a thermostat is used, or when the temperature probe was damaged.

During the measurement with manual temperature compensation one should:

- insert the pH electrode to the vessel with the measured solution, if the electrode wasn't calibrated or already was used for a long time the calibration should be done (chapter 8). During measurements in a vessel one shouldn't touch the bottom and the walls with the electrode. The best way is to use an electrode stand;
- using a laboratory thermometer measure the temperature;
- turn the meter on using the  button;
- using the  button choose the pH function;
- with ,  buttons enter the value of measured temperature;
- wait till the stabilisation of the value and read the result.

**Caution:** simultaneous pressing of  and  buttons sets the temperature value to 20 °C

## 11. NOTICES ABOUT THE TEMPERATURE COMPENSATION AND INTERPRETATION OF pH MEASUREMENT RESULTS

The **CX-401** meter has a manual and automatic temperature compensation, what enables eliminating errors which result from changes of the electrode characteristics under the influence of temperature changes. To explain the role of the temperature compensation it is important to remind that pH meter is an mV meter which displays voltage counted to pH unit. In constant temperature for one pH unit a constant mV value is changed. In temperature of 20 °C it is 58,168 mV. The value of mV on one pH unit **changes together with the temperature**, what is taken into consideration in the formula for “k coefficient” of the pH electrode.

$$k=0.198422 T$$

**Taking this change into consideration during measurement is called temperature compensation, which is connected with change of the electrode efficiency and not with the change of the measured solution caused by temperature change.**

Changes of the pH values of some solutions with the temperature are very small and others big ex. pure water.

When comparing solutions, which change their values together with the temperature change, it should be done in this same temperature.

Sometimes it happens that results of measurement in this same solution in stable temperature are different. When analysing such a situation it is important to take following factors into consideration:

- differences may occur because of poor quality electrode;
- The result was treated as stabilised to fast (medium class electrode needs about 40 seconds to full stabilisation);
- the measured solution may not be homogeneous and lack of magnetic stirrer doesn't allow for obtaining similar results;
- During measurements in sewage some chemical reactions, which change the result, may occur;

Very small differences may be caused by the meters accuracy. The **CX-401** accuracy is  $\pm 0.002$  pH,  $\pm 1$  digit, what practically means that in extreme situation results of 2 measurements may differ for 0.005 pH and this will be an acceptable error, because 1 measurement will be made with  $-0.002$  pH error and second with  $+0.002$  pH.  $\pm 1$  digit information explains difference caused by rounding up of the result on the last visible place on LCD (discretisation error).

If after making a two point calibration in pH buffers 7.00 pH and 4.00 pH (acidic conditions), the results are checked in 9.00 pH (alkali conditions), in some cases the result may be 8.90 pH or 9.10 pH. This may occur when the electrode has unsymmetrical characteristic. Making a 3 point calibration with alkali, neutral and acidic buffers may prevent from such errors. Sometimes the measurement results are unstable, the quality of the electrode has the crucial influence. **In most cases the reason for slow drifting of the result, it's instability or prolonging the time of stabilisation is the clogged junction, broken electrode or contaminated membrane.**

Often it happens when wrong kind of electrode was chosen for the kind of measured solution.

Leaving the electrode for few hours in the distilled water or placing it in water with detergent may eliminate this symptoms, especially if the measurements were done in solutions with deposits, fats or oils. The electrode which for a long time wasn't used may have the junction clogged by KCl crystals, what may be removed by placing the electrode in distilled water. Heavily contaminated electrode may be cleaned in chloroform and deposits of iron in 2N HCl. The electrode life may be prolonged by storing it in KCl solution. Depending on the kind of measured solution or substance proper kind of electrode should be chosen. They differ one from another with shape, membranes look, kind of junction and body. Electrodes for heavily polluted sewage is different than this for clean water or for meats or soil. It should fulfil the following conditions:

- a. it must be easy to wash, so an electrode with plastic unremovable housing shouldn't be used. Deposits, fats and chemical compound will precipitate on the junction what will disable the measurement or falsify the results;
- b. shape of the membrane should enable easy washing. For measurements in sewage the best shape of membrane is a cylinder shape;
- c. junction in the electrode for sewage has more holes what enables easy flow of the electrolyte and makes clogging difficult;
- d. during measurement of sewage or liquids with deposits with electrode which shape enables refilling of the electrolyte the hole for refilling should be opened to use the difference of pressures to clean the junction.

### **III. Conductivity and salinity measurement**

## 12. BASIC INFORMATION ABOUT THE CONDUCTIVITY MEASUREMENT

The conductivity measurement is based on applying a voltage with proper frequency between two electrodes and measuring it. In the **CX-401** the frequency depends on the measuring range and may vary from 100 Hz up to 10 kHz. Depending on the kind of the measured liquid, its concentration and the temperature, the voltage flow is easier or harder. The conductivity result indirectly informs about the salts concentration in the measured liquid. The greater is the salt concentration the bigger is the conductivity (KCl, NaCl) This dependence doesn't concern all of the solutions. In some cases after exceeding some salinity value the conductivity starts decreasing. The temperature has also a great influence on the results of a conductivity measurement which increases together with the temperature growth. The measured conductivity may be displayed as salinity in g/l of NaCl or KCl assuming that the measured liquid includes homogeneous salt.

The electrode's surface and the distance between them have decisive influence on the so called constant K value of the cell. This value has a great influence on the accuracy of the measurement. Depending on the measured conductivity value cells with constant  $K = 0,1 \text{ cm}^{-1}$  up to  $10 \text{ cm}^{-1}$  are used. During the measurement the meter multiplies the measured value by the constant K introduced to the meters memory and displays the result in units of **conductivity** ( $\mu\text{S}/\text{cm}$  or  $\text{mS}/\text{cm}$ ). By the result a shortened symbol of the unit is displayed ( $\mu\text{S}$  or  $\text{mS}$ ). The conductivity is changing together with temperature and salts concentration. To make the comparing of the results possible the measured value is counted by the meter to the value which responds to measurement in  $25 \text{ }^\circ\text{C}$ . Measurement in this temperature is most accurate. In other temperatures there is so called temperature compensation used, this means that there are some counting made by the meter which take the actual measured temperature and  $\alpha$  coefficient under the consideration. This coefficient describes how much will the result change when the temperature will change for  $1 \text{ }^\circ\text{C}$ . The  $\alpha$  coefficient in this meter may be changed in range  $0 \div 10.00\% / \text{ }^\circ\text{C}$ . The value of this coefficient is introduced to the memory by the user. For NaCl in temperatures close to  $25 \text{ }^\circ\text{C}$  it is  $2\% / \text{ }^\circ\text{C}$ . Ex. in case of measurements in  $30 \text{ }^\circ\text{C}$  the result changes  $5 \times 2\% = 10\%$ . The counting is done automatically and takes the introduced by the user value of the  $\alpha$  coefficient into consideration. The value of this coefficient may be found in the literature or may be approximated by the user.

The conductivity, despite the electronic precision, should always be treated as burdened with some error, which depends on the error of conductivity cell (it's linearity), temperature and first of all depending on the  $\alpha$  coefficient during measurements in temperatures different than 25 °C.

### 13. PREPARATION TO WORK

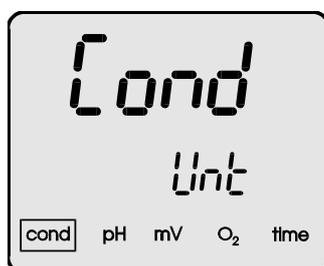
Before the calibration and measurements it is necessary to make all activities described in the chapter 6. Additionally according to the chapter below it is necessary to choose the unit in which we will make the calibration and measurement.

#### 13.1. Choosing the unit

The result of the measurement may be displayed in units of conductivity and salinity. The salinity may be counted to NaCl, KCl or TDS content. The result may be displayed in **% of weight concentration** or in **g/l**. To choose the unit one has to:

- in the conductivity measuring mode press the  button till displaying in the lower row on LCD a *Unit* (unit) symbol;
- with buttons  ,  choose in the upper row on LCD sign:

*Cond* - measurement in units of conductivity (pic. 9);



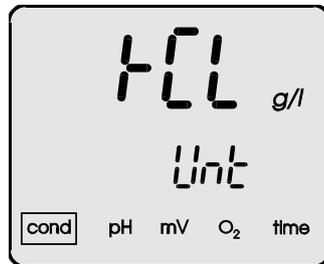
Pic. 9.

*NaCl* - measurement result counted to NaCl in **g/l**  
(pic. 10);



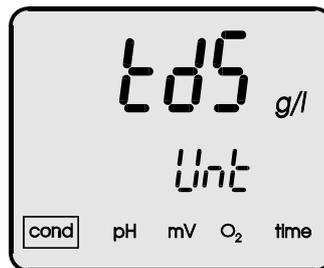
Pic. 10.

*KCl* - measurement result counted to KCl in **g/l** (pic. 11);



Pic. 11.

*t<sub>d5</sub>* - measurement result counted to TDS in **g/l**  
(pic. 12).



Pic. 12.

In case of salinity measurement (ppt, ‰ or tds), short pressing of the **CAL** button chooses displaying the result in % of weight concentration or g/l. By the symbol with name of the salt a % or **g/l** symbol will be displayed.

- by pressing the **FUNCTION** enter the measuring mode.

The result of measurement in % of weight concentration may be counted to value in **ppm** according to dependence:

1% of weight concentration (C) = 10 000 ppm = 10 ppt

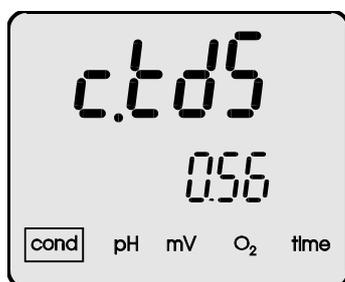
Resolution of measurement in % of weight concentration is 0.001% or 10 ppm.

### 13.2. Entering the $W_{TDS}$ coefficient

In case of measurement of salinity with conversion to TDS it is necessary to introduce the  $W_{TDS}$  coefficient.

One should follow the steps:

- in the conductivity measuring mode few times press the **MODE** button till moment of displaying in the upper row on LCD a **ctds** symbol – TDS coefficient (pic. 13);
- with **←** , **→** buttons enter the correct value of the TDS coefficient;
- enter the measuring mode by pressing the **FUNCTION** button.



Pic. 13.

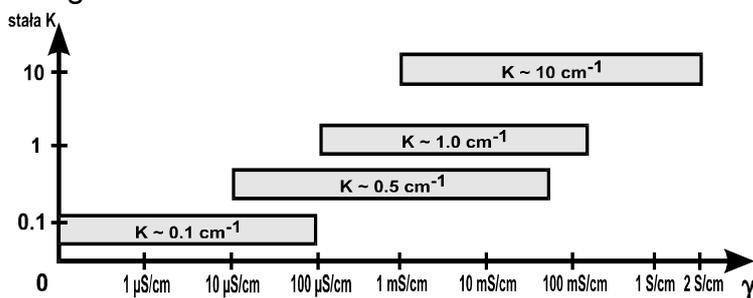
The way of determining the  $W_{TDS}$  coefficient is described in section 18.2.

## 14. CHOICE AND MAINTENANCE OF THE CONDUCTIVITY CELL

### 14.1. The cell choice

The conductivity measuring range in **CX-401** meter is 0 – 1999 mS/cm. The meter co-operates with conductivity cells with constant  $K = 0.010 \div 19.99 \text{ cm}^{-1}$  and BNC-50 connector. Depending on the required measuring range it is necessary to choose the right cell with constant  $K$  which enables receiving correct results. Beyond the range the cell loses its linearity and the results have greater error. Accurate measurements in the whole range are possible with use of 3 different conductivity cells.

Depending on the expected measuring range one may choose the correct cell using the chart below.



Pic. 14. Dependence between the measuring range and constant  $K$  of the used conductivity cells.

The cell with constant  $K \approx 0,1 \text{ cm}^{-1}$  should be used for measurements of ultra pure and redistilled water. Those waters after contact with air very quickly change their conductivity, so their pouring into vessels for measurement with dip cell (immersing) may cause errors. For accurate measurements it is necessary to use flow through probe with build in temperature probe, what enables measurement of water which flows directly from the container.

#### 14.2. The conductivity cell maintenance

To receive stable results it is advised to store the cell for few hours before the measurement in water, especially this is required in case of distilled water measurements.

The conductivity probe maintenance mainly consists of accurate washing the inside of the measuring cell with distilled water. **It is forbidden** to clean the platinum electrodes mechanically, because the platinum layer may be rub of, what will result in decreasing the accuracy, may cause lowering the stability and change the constant K.

Measurements of liquids with oils and heavy sediments content may cause platinum contamination, make the measurement impossible and irreparably damage the electrodes. In case of fat content in the measured liquids it is possible to clean the electrodes by immersing the cell in acetone, chloroform, fourhydrofuran or detergent.

Some norms propose universal liquid for cleaning the cells. This is mixture of equal parts of isopropyl alcohol, ethyl ether and hydrocholic acid, diluted with water in 1:1 ratio.

The conductivity probe with broken measuring cell can't be used for further measurements because the constant K is greatly changed, the result is unstable and the influence of placing the cell in measuring vessel greatly changes the result.

## 15. CALIBRATION

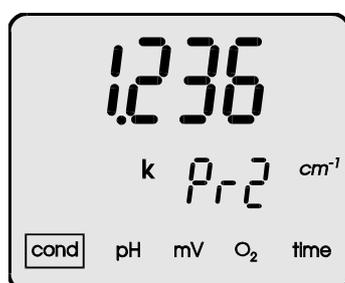
The calibration is done to prepare the meter for cooperation with the used conductivity probe, this is the essential condition for obtaining accurate results. The calibration may be done without the sample solution (by entering to the meter's memory known value of the constant K of cell) or with use of standard solution with known conductivity. Constant K of the conductivity cell may change as reaction to contamination of the electrodes, that's why periodically it is necessary to check the meters indications on the sample solution and eventually repeat the calibration. When using three cells it is possible to store their characteristics under the  $\rho_{r1}$ ,  $\rho_{r2}$ ,  $\rho_{r3}$  symbols.

### 15.1. Calibration without the sample solution

The meter has the possibility of calibration without the use of sample solution. To make this calibration it is necessary to know the constant K of the conductivity probe. This value may be given by the cell producer or may be determined using the **CX-401** meter after making the calibration in the sample solution.

To make the calibration one should:

- in the measuring mode press the **MODE** button till displaying the screen with the value of constant K (pic. 15).
- with **←**, **→** buttons (symbols  $\rho_{r1}$ ,  $\rho_{r2}$ ,  $\rho_{r3}$ ) choose the number of cell;
- press the **CAL** button on the display a **CAL** symbol will be displayed;
- with **←**, **→** buttons enter the value of constant K;
- press the **MODE** button and return to the mode of choosing the number of cell or enter the measuring mode by pressing the **FUNCTION** button.



Pic. 15.

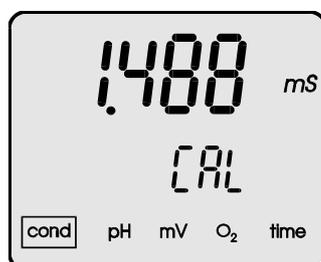
## 15.2. Calibration with use of sample solution

The meter enables one point calibration in the freely chosen sample solution. To decrease the error it is recommended to use solutions with value close to the forecasted value of measurement. It is required to use high quality sample solutions. The calibration is done in the actually chosen unit (subchapter 13.1).

### 15.2.1. Entering the value of sample solution

To enter the value of sample solution one should:

- choose the unit according to point 12.1;
- in the conductivity measuring mode press the **MODE** button till appearing a **CAL** symbol in the lower row on LCD (pic. 16);
- with **←**, **→** buttons enter, in the upper row on LCD, the value of sample solution;
- enter the measuring mode by pressing the **FUNCTION** button.



Pic. 16.

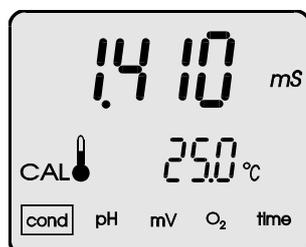
### 15.2.2. Calibration with automatic temperature compensation

What to do:

- enter the value of sample solution (point 15.2.1);
- connect the conductivity cell and temperature probe;
- immerse both probes in the sample solution, hold the conductivity cell at least 1 cm away from the bottom and walls of the vessel. The measuring cell should be completely filled with the measured solution, there shouldn't be any air bubbles and the electrodes should be evenly moistened\*;
- measure the temperature of solution and bring it to 25 °C;
- press and hold the **CAL** button till appearing a **CAL** symbol on the display (pic. 17).

\* - air bubbles may be removed by moving the immersed cell. To make the moistening of the electrodes easier it is recommended to immerse the cell in distilled water with washing-up liquid, and than wash it in distilled water.

- wait till the stabilisation of the value and press the **CAL** button. Pulsating of the results informs about storing in the memory. If  $\text{Err}$  symbol will be displayed it is necessary to check the introduced value of the sample solution.
- exit the calibration mode by pressing the **FUNCTION** button.



Pic. 17.

The meter is calibrated and ready for the measurement.

### 15.2.3. Calibration with manual temperature compensation

To calibrate the meter it is necessary to:

- turn the meter on with the **FUNCTION** button;
- choose the measurement of conductivity (subchapter 13.1);
- disconnect the temperature probe and simultaneously press the  $\leftarrow$ ,  $\rightarrow$  buttons. In lower row of LCD a 25 °C value will appear;
- introduce the value of the sample solution (chapter 15.2.1);
- immerse the conductivity cell in the sample solution and hold it at least 1cm away from the bottom and walls of the vessel. The measuring cell should be completely filled with the sample solution and shouldn't include any air bubbles, the electrode's surface should be evenly moistened\*;
- with lab thermometer measure the temperature of the sample solution and bring it to 25 °C;
- press and hold the **CAL** button till the **CAL** symbol (pic. 17) will appear on the display.
- wait till stabilisation of the result and press the **CAL** button. Pulsating of the result informs about storing it. If  $\text{Err}$  sign will be displayed it is necessary to check the entered value of sample solution.
- exit the calibration mode by pressing the **FUNCTION** button.

The meter is calibrated and ready to work.

\* - air bubbles may be removed by moving the immersed cell. To make the moistening of the electrodes easier it is recommended to immerse the cell in distilled water with washing-up liquid, and than wash it in distilled water.

### 16. THE SIMPLIFIED WAY OF DETERMINING THE $\alpha$ COEFFICIENT

The knowledge of  $\alpha$  coefficient has a crucial significance during measurements in temperatures different than 25 °C.

This coefficient is changing together with the temperature and concentration. Below we are giving values of  $\alpha$  coefficient in 25 °C for few compounds with determined weight concentration.

Table 4.

substance	Weight Concentr.	$\alpha$ coefficient
HCl	10 %	1.56
KCl	10 %	1.88
H <sub>2</sub> SO <sub>4</sub>	50 %	1.93
NaCl	10%	2.14
HF	1.5 %	7.20
HNO <sub>3</sub>	31 %	1.39

In the table 5 there are rough values of  $\alpha$  coefficient for KCl and NaCl depending on the temperature and concentration of the measured liquid.

Table 5.

temp. °C	$\alpha$ coefficient			
	KCl solution			Saturat ed NaCl
	0,01M	0,1M	1,0M	
5	2,68	2,68	2,39	2,77
10	2,45	2,36	2,20	2,53
15	2,27	2,19	2,04	2,38
20	2,11	2,06	1,89	2,21
25	1,91	1,86	1,75	2,03
30	1,80	1,77	-	1,91

In practice the  $\alpha$  coefficient may be determined with simplification that on the value of this coefficient greater influence has the temperature change than changes in the composition of the salts and their concentration (what shows the data in table 5).

To determine the coefficient one should:

1. Take the solution, which conductivity will be measured in temperatures different than 25 °C
2. Bring the solution in the lab to 25 °C and measure it's conductivity ( $G_{25}$ ).
3. Change the temperature to other determined value ex. 20 °C.
4. Turn the meter to manual temperature compensation by disconnecting the temperature probe from the meter.

5. Enter with the keyboard temperature value 25 °C.
6. Again measure the conductivity of the solution (ex. in 20 °C) This value will be different than in 25 °C ( $G_{T_x}$ ).
7. Determine the  $\alpha$  coefficient using the formula:

$$\alpha = [ (G_{25} - G_{T_x}) / \{G_{25} (25 - T_x)\} ] \times 100(\%/ \text{ } )$$

where:  $T_x$  - value of the changed temperature in °C

$G_{25}$  - conductivity measured in 25 °C.

$G_{T_x}$  - conductivity measured in temperature  $T_x$

**This same should be done reducing the temperature to ex. 15, 10 and 5 °C, taking down the counted values of  $\alpha$  coefficient. This same may be done raising the temperature of the sample.**

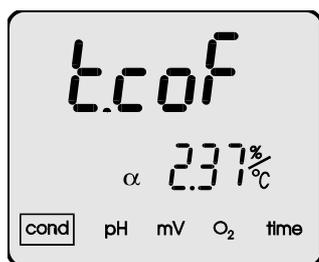
During measurements in temperatures different than 25 °C, before starting measurement, it is necessary to introduce the received  $\alpha$  coefficient for the existing temperature.

#### 17. ENTERING THE $\alpha$ COEFFICIENT VALUE

The  $\alpha$  coefficient range in **CX-401** is 0 ÷ 10.00 % with accuracy of regulation 0.01 % / °C. For the measurements it is possible to adopt the most often used temperature coefficient  $\alpha = 2 \% / \text{ } ^\circ\text{C}$  or in case of higher accuracy requirements determine the kind of measured solution and choose for it the correct value of this coefficient.

To introduce the  $\alpha$  coefficient one should:

- in the conductivity measuring mode press the **MODE** button till displaying the screen with value of the  $\alpha$  coefficient (pic. 18). A **t.cof** (temperature coefficient  $\alpha$ ) symbol will be displayed;
- with **←** , **→** buttons enter the value of the coefficient .
- return to the measuring mode by pressing the **FUNCTION** button.



Pic. 18.

The measurement result will be counted with use of the introduced temperature coefficient  $\alpha$ .

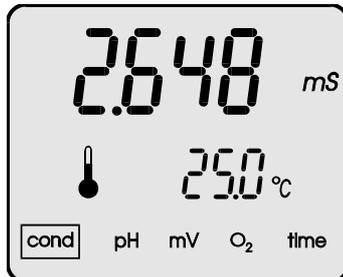
## 18. THE CONDUCTIVITY MEASUREMENT

### 18.1. The conductivity measurement without temperature compensation

An accurate conductivity measurement should be done without the temperature compensation. The measured solution should be brought to temperature of 25 °C. During the control it is possible to use the temperature probe. In case of work without temperature probe it is necessary to introduce the temperature value with ↶ , ↷ buttons.

One should:

- connect the conductivity and temperature probes to the right connectors **F1** and **t** (pic. 2);
- turn the meter on with  button.
- choose the conductivity measurement and the unit (point 13.1);
- if the conductivity cell wasn't calibrated earlier make the calibration according to chapter 15;
- Place both probes in the measured solution, the conductivity cell can't touch the walls and bottom. The measuring cell should be completely filled with the sample solution and shouldn't include any air bubbles, the electrode's surface should be evenly moistened\*;
- bring the temperature of the measured solution to 25 °C.
- read the result after it's stabilisation (pic. 19).



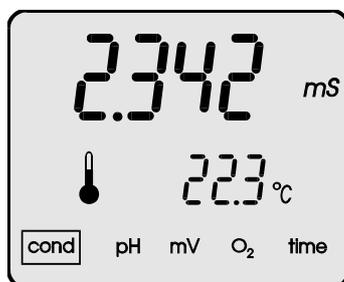
Pic. 19.

- \* - air bubbles may be removed by moving the immersed cell. To make the moistening of the electrodes easier it is recommended to immerse the cell in distilled water with washing-up liquid, and then wash it in distilled water.

## 18.2. Conductivity measurement with automatic temperature compensation

In case of measurement with automatic temperature compensation one should:

- connect the conductivity and temperature probes to the right connectors **F1** and **t** (pic. 2);
- turn the meter on with  button.
- choose the conductivity measurement and the unit (point 13.1);
- if the conductivity cell wasn't calibrated earlier make the calibration according to chapter 15;
- control or change the value of the temperature coefficient  $\alpha$ ;
- Place both probes in the measured solution, the conductivity cell can't touch the walls and bottom. The measuring cell should be completely filled with the sample solution and shouldn't include any air bubbles, the electrode's surface should be evenly moistened\*;
- wait till the stabilisation and read the result (pic. 20).



Pic. 20.

**Notice:** in case of exceeding the value of temperature taken during compensation into consideration the result starts blinking although the conductivity measuring range wasn't exceeded.

If near the value a  symbol is displayed instead of  it informs that the temperature probe is broken or inaccurately connected.

\* - air bubbles may be removed by moving the immersed cell. To make the moistening of the electrodes easier it is recommended to immerse the cell in distilled water with washing-up liquid, and than wash it in distilled water.

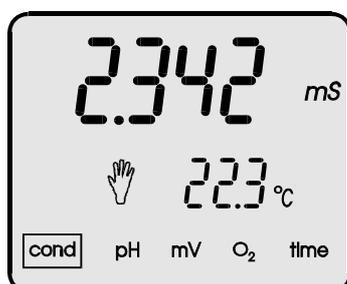
### 18.3. Conductivity measurement with manual temperature compensation

The measurement with manual temperature compensation may be done in stable work conditions, ex. during measurements in laboratory, especially with use of thermostat, or in case of the temperature probe damage. Disconnecting the temperature probe switches the meter to manual temperature compensation.

In case of measurement with manual temperature compensation one should:

- connect the conductivity probe to the **F1** connector (pic. 2);
- turn the meter on with  button.
- choose the conductivity measurement and the unit (point 13.1);
- if the conductivity cell wasn't calibrated earlier make the calibration according to chapter 15;
- control or change the value of the temperature coefficient  $\alpha$ ;
- Place the probe in the measured solution, the conductivity cell can't touch the walls and bottom. The measuring cell should be completely filled with the sample solution and shouldn't include any air bubbles, the electrode's surface should be evenly moistened\*;
- measure the temperature of the solution and introduce it's value with the  ,  buttons.
- after the stabilisation read the result (pic. 21).

**Notice:** simultaneous pressing of  and  buttons sets the temperature to 25 °C.



Pic. 21.

\* - air bubbles may be removed by moving the immersed cell. To make the moistening of the electrodes easier it is recommended to immerse the cell in distilled water with washing-up liquid, and then wash it in distilled water.

### 19. SALINITY AND TDS MEASUREMENT

Salts and minerals dissolved in natural water influence the conductivity, which in principle is proportional to the quantity of dissolved substances. This dependence enables, after some calculations, to determine the salinity of the measured solution in concentration units (g/l or %), or determine the TDS (Total Dissolved Solids). The received values are always approximated and the final accuracy depends on the way of making the calculations, concentration of the measured solution and its temperature. In most salinity meters a simplification is used, that dependence between the conductivity and salinity in the solution is linear in the whole measuring range. Usually a 0.5 coefficient is used, the conductivity result in mS/cm is multiplied by this coefficient and the result of salinity in g/l is received, ex. if the conductivity value is 2 mS/cm the salinity is 1g/l. In reality the dependence between the conductivity and salinity isn't linear the conversion coefficient is changing together with the concentration and temperature. The table 6 shows the dependence between conductivity and real salinity of NaCl solution in temperature 25 °C and values of salinity counted for constant coefficient 0.5. This comparison shows that for greater concentrations using the constant coefficient introduces large error.

Table 6.

Conductivity (mS/cm)	Real salinity (g/l)	Salinity (g/l) Counted for coefficient = 0.5	Error (%) by using the coefficient = 0.5
1.00	0.495	0.500	0.01
2.00	1.006	1.000	0.60
4.00	1.976	2.000	1.21
10.00	5.400	5.000	7.40
30.00	18.174	15.000	17.46

**In CX-401 microcontroller takes into consideration the real dependence between the conductivity and salinity what greatly lowers the error. There is possibility of counting the salinity in NaCl or KCl, because the dependence for this two salts is a bit different.**

The results will be more accurate for homogeneous solutions (NaCl, KCl). Determining the concentration of salts mixture with unknown composition in most cases is counted to NaCl. To check the usefulness of water for home or industrial use usually determining of TDS is used. To use the conductivity measurement for determining the TDS it is necessary to specify the  $W_{TDS}$  coefficient, which introduced to the meter's memory enables automatic conversion. To determine the  $W_{TDS}$  coefficient it is necessary to specify the weight of dissolved substances. The laboratory method of determining the dissolved solids content consists in taking a given volume of the water, evaporating the filtered sample, drying it to constant weight in temperatures  $103 \pm 105^{\circ}\text{C}$ , weighting and counting in volume ratio ( $\text{mg}/\text{dm}^3$ ). The received weight is lower than total dry mass in water because besides the dissolved solids there can be also substances which were not dissolved which are removed by filtering before evaporating. Using the conductivity measurement it is possible to determine the Total Dissolved Solids. It is assumed that the salt's composition in the taken samples is not changing significantly.

#### **19.1. Salinity measurement with conversion to NaCl or KCl content**

The measurement of salinity with conversion to NaCl or KCl content should be done as follows:

- choose the salinity measurement with conversion to NaCl or KCl content according to chapter 13.1;
- choose the unit (g/l or %);
- then act as during the conductivity measurement (chapter 18);
- after stabilisation read the result.

### 19.2. Determining the $W_{TDS}$ coefficient

For salinity measurement with conversion to TDS content it is necessary to determine the  $W_{TDS}$  coefficient and enter it to the meter's memory. To do so it is necessary to make the conductivity measurement of the tested water with exactly given volume or weight. In traditional way determine the Total Dissolved Solids in this water and than count the coefficient according to the below given formulas.

1. If the result is to be displayed in g/l:

$$W_{TDS} = TDS /$$

where:

$W_{TDS}$  - TDS coefficient

TDS – Total Dissolved Solids in g/l;

$\gamma$  - conductivity of the sample in mS/cm;

Caution: the TDS value should be counted to volume of sample equal to 1l.

2. If the result is to be displayed in % of weight concentration:

$$W_{TDS} = TDS /$$

where:

$W_{TDS}$  - TDS coefficient

TDS – Total Dissolved Solids in g/kg;

$\gamma$  -conductivity of the sample in mS/cm;

Caution: the TDS value should be counted to weight of the sample equal 1kg.

### 19.3. The measurement of salinity with conversion to TDS

The measurement of salinity with conversion to TDS should be done as follows :

- according to chapter 13.1 introduce the  $W_{TDS}$  coefficient;
- choose the measurement of salinity with conversion to TDS and the displayed unit (g/l or %);
- than act as during conductivity measurement (chapter 18).
- after stabilisation read the result in chosen units (g/l or %)

#### **IV. Dissolved oxygen measurement**

## 20. BASIC INFORMATION ABOUT DISSOLVED OXYGEN MEASUREMENT

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

The meter enables measurement in % of oxygen saturation and **mg/l**. The calculation of the mg/l value is based on the saturation measurement in % and the temperature measurement. When requiring high accuracy during mg/l measurements, the values of salinity and atmospheric pressure must be additionally introduced. The saturation measurement in % does not depend on these factors.

**The quality of the oxygen sensor has a decisive effect on the measurement accuracy. The troubles arising during the measurements are caused mainly (98%) by the sensor, yet not by the device. In many cases the troubles result from lack of basic maintenance of the sensor from the user's side.** It must be remembered, that during the measurement the sensor takes 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 the measurements in a vessel, the flow can be forced with a magnetic stirrer. Although it must be kept in mind that when measuring low O<sub>2</sub> saturation intensive stirring can cause an increase of oxygen content in the tested solution. Taking water samples and transferring them to the laboratory can alter the O<sub>2</sub> concentration in the samples. The best results can be achieved **only in conditions, which are recommended by the manufacturer of the sensor in the operation manual.**

Long-lasting storing of the sensor without performing of measurements (above 1 month) 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.

A correct measurement is determined by the good condition of the membrane. The membrane must be free of any cracks (appearing of electrolyte-drops or white spots when dry). Before the measurement the electrode should be activated by storing in distilled water for about 15 minutes. Strongly polluted wastewater causes after some time clogging of the membrane. This is revealed by the impossibility of calibrating of 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 weather there are no air bubbles in the container beneath of the membrane, because otherwise the measurements will be false. In that case the twisting of the sensor should be repeated after refilling the electrolyte. In order to obtain a stable result there must be some awaiting time before making the reading. According to the sensor's manufacturers that is about 1-1,5 min, depending on the thickness of the membrane. The accuracy of the measurement is connected with the temperatures of calibration and measurement. The greater the difference of these temperatures, the greater the measurement error. The used sensors require a two-point calibration in a zero O<sub>2</sub> saturated solution and an optional solution (most often a 100% - saturated one). 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. 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. Wide measuring range in multifunction meter **CX-401** enables measurements of waters which are permeated with oxygen. This situation occurs when in the water plants are blooming and growing, in this moment during the photosynthesis process large quantities of oxygen are produced.

## 21. THE OXYGEN SENSOR

The meter may co-operate with galvanic oxygen sensor. Conventionally it co-operates with the sensor made by ELSENT with accuracy of  $\pm 1\%$ , if the measurement is done in this same temperature as the calibration. The accuracy of measurement decreases together with growing of the difference between the temperature of calibration and temperature of measurement. It is  $<3\%$  when the difference is  $\pm 5^{\circ}\text{C}$  and  $5\%$  when the difference is  $\pm 10^{\circ}\text{C}$ . **In case of using another sensor the device requires its adaptation by the manufacturer.**

It must be remembered that the membrane of the sensor should be replaced if it is mechanically damaged or if the device cannot be calibrated. The necessary procedures are given in the instruction of the probe's manufacturer.

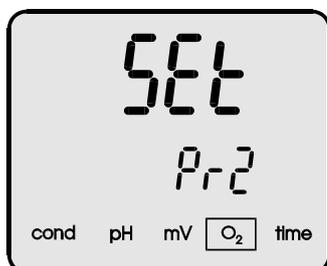
**Before starting the work please read carefully the information given in chapter 20.**

## 22. ENTERING THE PARAMETERS

### 22.1. Changing the number of probe

The meter may store calibration characteristics of 3 DO probes. Before the calibration or measurement it is necessary to choose the required number of probe. It is done as follows:

- in the measuring mode press the **MODE** button till appearing in the lower row of LCD **P-1**, **P-2** or **P-3** symbol (pic. 22).
- with **←**, **→** buttons choose the required number of probe
- enter the measuring mode by pressing the **FUNCTION** button



Pic. 22.

The symbol above the probe's number informs:

**Clr** - under this number there is no characteristic stored and manufacturers settings are applied.

**Set** -

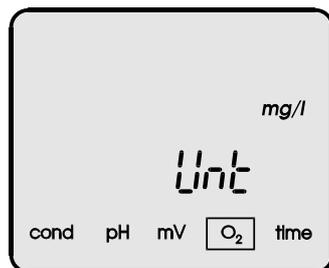
calibration results stored.

under this number there are the

## 22.2. Changing the unit

The measurement result may be displayed in % of the oxygen saturation or in **mg/l**. To choose the unit one should:

- in the oxygen measuring mode press the **MODE** button till displaying in the lower row of LCD **Unit** (unit) sign;
- with **←** , **→** buttons choose in the upper row the symbol:  
**%** - measurement in % of oxygen saturation  
**mg/l** – measurement in mg/l (pic. 23).



Pic. 23.

- return to the measuring mode by pressing the **FUNCTION** button.

## 22.3. Salinity influence compensation

Salinity of the solution decreases the oxygen solubility in water and requires taking into consideration during measurements in mg/l. **1 g/l change of salinity changes the oxygen saturation for about 5%**. The meter enables entering the salinity value in g/l and counts the change of oxygen saturation in mg/l.

### **22.3.1. Automatic introduction of salinity value**

The meter enables automatic introduction of measured solution salinity. To use this feature one should:

- by pressing the  button enter the conductivity measuring function;
- measure the salinity of solution in NaCl (accurate description in chapter 19.1);
- after stabilisation of the salinity result enter the oxygen measuring mode by pressing the  button;
- press the  button till moment of displaying in the lower LCD row a *SAL* (salinity) symbol;
- shortly press the  button in the upper LCD row automatically the value of measured salinity in g/l will be provided. If after pressing the button a *ERR* (error) sign will be displayed and next the old value of salinity it informs that during the conductivity measurement the unit wasn't changed for g/l of NaCl;
- return to the measuring mode by pressing the  button.

### **22.3.2. Manual entering of the salinity value**

The salinity value may be determined on the basis of known conductivity of the measured solution. The table 7 gives the real dependence between the salinity and conductivity counted in NaCl. To enter the salinity value one should:

- with any conductivity meter measure the conductivity of the solution and from the table 7 read the salinity value;
- in the oxygen measuring mode press the  button till displaying in the lower LCD row *SAL* (salinity) sign;
- with  ,  buttons enter in the upper LCD row the salinity value read from the table 7;
- enter the oxygen measuring mode by pressing the  button.

**Measurement in % of saturation doesn't require entering the salinity value**

mS/c m	g/l	mS/c m	g/l	mS/c m	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		

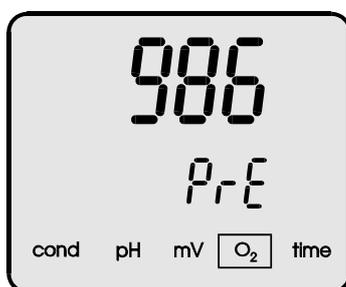
Table 7. Determining the salinity in g/l NaCl on the basis of conductivity in mS/cm (in temperature 25°C).

#### 22.4. Automatic compensation of the atmospheric pressure influence

The value of oxygen saturated in water determined in mg/l depends directly on the atmospheric pressure value, this means that 10% pressure change causes oxygen saturation change for 10%. The meter ensures automatic compensation thanks build in atmospheric pressure sensor. This influence is automatically counted during measurements in mg/l.

There is possibility of reading the atmospheric pressure value:

- in the oxygen measuring mode press the **MODE** button till moment of appearing in the lower LCD row  $P_rE$  (pressure) sign (pic. 24);
- in the upper row a value of atmospheric pressure will be displayed in hPa;



Pic. 24.

- enter the oxygen measuring mode by pressing the **FUNCTION** button.

**During the oxygen measurement in % of saturation the atmospheric pressure has no influence.**

### 23. CALIBRATION OF THE OXYGEN PROBE

In order to eliminate the measurement error arising from the individual characteristic of the sensor a calibration of the device should be carried out. This procedure should be performed always before operation with a new sensor, after replacing the membrane or for special requirements concerning the measurement accuracy. The probes have a so-called "signal drift" associated with the interval between the calibration and measurement. A longer interval decreases the measurement accuracy. The calibration is also recommended if the temperature of the tested solution differs greatly from the temperature in which the probe was calibrated, because then an additional error arises. **In this case calibration solutions should be used, which temperature is almost the same as the predicted temperature of the tested solutions.**

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

The used oxygen sensors require one or two point calibration in standard solutions. During two point calibration a solution **with 0% oxygen saturation** is used (solution of  $\text{Na}_2\text{SO}_3$ ) and second with **100% oxygen saturation**. It can be prepared by aeration of water for more than ten minutes. When using this solution it should flow or be stirred. The method of preparing both solutions is described in detail in the users manual for the oxygen sensor. A simplified calibration for 100%  $\text{O}_2$  saturation can be carried out in the air, without immersing the sensor in water. **Before that the membrane must be wetted with water for several minutes.**

It is assumed that the  $\text{O}_2$  content in the air corresponds to 100%- saturation, what enables a simplified calibration to be carried out.

The one point calibration is done only in the solution with 100% oxygen saturation.

**Starting the calibration under the chosen sensor number deletes the characteristic stored in memory under this number.**

**If after choosing the sensors number and entering the calibration mode one will exit this mode the stored characteristic will be deleted and standard characteristic will be applied.**

To calibrate the meter one should:

- place the sensor in the vessel with 0% saturation solution;
- choose the saturation in % measurement according to chapter 21.2;
- press and hold the  button till appearing in the left lower corner of display a **CAL** symbol;
- after the stabilisation of result press the  button.

The result will pulsate what informs about storing the value of calibration at this same time in the upper row of LCD a corrected value of the measurement (0%) will be displayed.

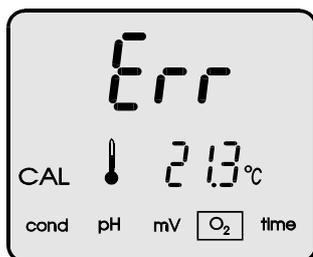
Take the sensor out, **wash it accurately in distilled water** and put it into 100% oxygen saturated solution ensuring the liquid flow or leave it on the air.

- after the stabilisation of the result press the  button.

The result will pulsate, what informs about storing the calibration data at this same time in the upper LCD row corrected value of the measurement will be displayed (100%).

- enter the measuring mode by pressing the  button.

If after pressing the  button the meter can't detect the value of the sample solution (0% or 100%), in the place of result for a moment an **Err** sign will be displayed (pic. 25). In this case it is necessary to check the condition of the membrane and the used solutions.



Pic. 25.

## 24. OXYGEN CONCENTRATION MEASUREMENT

Before starting the oxygen concentration measurement the meter should be prepared for work (chapter 6) and the oxygen sensor calibrated (chapter 23). As mentioned the measurement in % saturation does not require additional measurements associated with the temperature, salinity and atmospheric pressure. **Although the measurement in mg/l, used more frequently, depends on those factors.** This influence is corrected automatically by the device, taking into the consideration the temperature value measured by the sensor or in case of manual compensation value entered by the user. The oxygen sensor is equipped with an additional system compensating the temperature influence on the membrane. Because of the 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 with the increase of the difference between the calibration and measurement temperatures and results from characteristic features of the sensor but not from the device.** For the applied sensor (ELSENT) this error is about < 3% at a  $\pm 5^{\circ}\text{C}$  temperature difference and increases to 5% at a  $\pm 10^{\circ}\text{C}$  temperature difference.

If a higher accuracy is required the interval from the last calibration must be additionally taken into consideration (signal drift). If the salinity of the tested solution is very small, the measurement can be started without entering its value (value 0.00 g/l should be entered). **However accurate measurements should be preceded by the determination of the salt content in the tested solution.** The salinity of the solution can be determined simply by measuring the electric conductivity using the conductivity meter. The easiest way to determine the salinity is conductivity measurement with conversion to NaCl. The salinity value is introduced according to chapter 22.3.

#### 24.1. Measurement with automatic temperature compensation

To make the measurement with automatic temperature compensation one should:

- connect the temperature probe with the meter;
- insert the oxygen and temperature probes to the measured solution;
- turn the meter on with  button;
- with  button choose the oxygen measuring function;
- choose the unit according to chapter 22.2;
- by accurate measurements in **mg/l** enter the salinity value (chapter 22.3);
- check or simulate the flow of the measured solution;
- wait till stabilisation of the result about 1 ÷ 1.5 min (depends on the probe) and read the result.

#### 24.2. Measurement with manual temperature compensation

To make the measurement with manual temperature compensation one should:

- disconnect the temperature probe from the meter;
- turn the meter on by pressing the  button;
- with  button choose the oxygen measuring mode;
- choose the unit according to the chapter 22.2;
- by accurate measurements in **mg/l** enter the salinity value (chapter 22.3);
- insert the oxygen sensor to the measured solution;
- using thermometer measure the temperature of the solution;
- with  ,  buttons enter in the lower row of LCD value of temperature of the measured solution;
- check or simulate the flow of the measured solution;
- after the stabilisation read the result.

During series of measurements it is recommended to check and correct the introduced value of solution temperature.

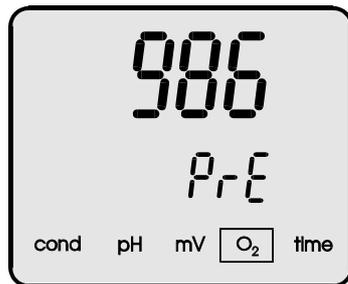
**Caution:** in case of measurements in solutions with low salinity check according to the chapter 22.3, whether the introduced salinity value is 0.00 g/l.

## **V. Atmospheric pressure measurement**

## 25. ATMOSPHERIC PRESSURE MEASUREMENT

The meter enables atmospheric pressure measurement. To read it's value one should:

- turn the meter on by pressing the **FUNCTION** button;
- with **FUNCTION** button choose the oxygen concentration mode (**O<sub>2</sub>**);
- press the **MODE** button till moment of displaying in the lower row of LCD the **PrE** (pressure) sign;
- in the upper row the value of the pressure in hPa will be displayed (pic. 26);



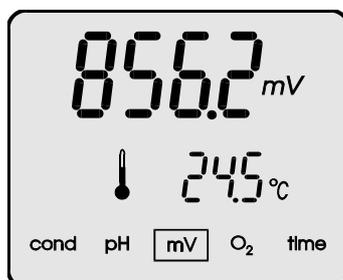
Pic. 26.

- return to the measuring mode by pressing the **FUNCTION** button.

## **VI. ORP and temperature measurement**

## 26. ORP (VOLTAGE) MEASUREMENT

Multifunction meter **CX-401** is accurate mV meter (Oxidation Reduction Potential). The measurement may be done with special redox electrode or during titration. The result may be checked after choosing the mV mode with  button (pic. 27).



Pic. 27.

## 27. TEMPERATURE MEASUREMENT

The temperature measurement is done as follows:

- to the Chinch connector connect the temperature probe;
- by pressing the  button switch the meter on;
- put the temperature probe to the measured solution;
- wait till the stabilisation of the value and read the lower row of numbers.

The meter co-operates with the PT-1000 probe. Depending on its class the accuracy of the measurement changes.

**NOTICE:** break in the circuit of the temperature probe switches the meter to the manual temperature compensation mode. It is signalled by changing the  symbol to  symbol. On the display the value of the temperature entered by the user is displayed.

Blinking -50°C value during measurement in positive temperatures informs about short circuit in the temperature probe.

## **VII. Other**

## 28. CLOCK, DATE, AUTO SWITCH OFF FUNCTION

After choosing the **time** mode with  button the meter will display the actual time. By pressing the  button one may display the date, auto off time and battery condition.

### 28.1. Time display

The hour is displayed in two rows. In the upper one the hour and minutes are displayed and in the lower one seconds. The way of changing the hours is described below. There is no way to set the seconds, they are deleted after pressing the  button.

### 28.2. Date display

The date is displayed as follows: Month – Day – Year. (pic. 28) In the upper row the month and day are displayed and in the lower the year, in two digits form (year 2000 = 00, year 2001 = 01 etc)

Pic. 28

### 28.3. Auto off function

About choosing the auto off function informs a *Auto-OFF* symbol. In the lower row the time of switching off in minutes is displayed (the time is counted from the last pressing of any button). The value is changed by  or  buttons

If after choosing the time 1 minute one will press the , button a --- symbol will be displayed instead of numbers. This will deactivate the auto off function. Exit from this function is after pressing the  button.

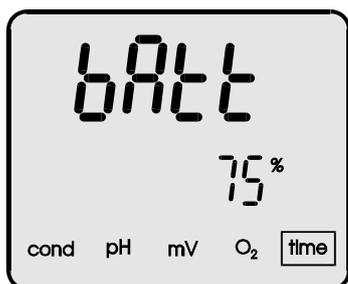
The auto off function is active only during work on battery. This function is also switched off for the time of calibration, time of making a series of measurements, printing the memory content and work with power adapter.

#### 28.4. Checking the battery condition

Disconnect the power adapter, enter the **time** function and press the **MODE** button till moment of displaying in the upper row a **bAtt** symbol (pic. 29). In the lower row the condition of battery described in % will be displayed:

- 100% the battery is full
- 0% the battery should be replaced

In case of using the power adapter instead of the **bAtt** symbol a **SUPP** symbol will be displayed and value 100%.



Pic. 29.

Pressing the **FUNCTION** button returns the meter to the time mode.

#### 28.5. Setting the time and date

The setting mode of the actually displayed parameter one enters by pressing and holding the **CAL** button. The position which we are going to change starts blinking, the value is changed with **←** or **→** buttons. The pulsating position is chosen by short pressing of the **CAL** button. After pressing the **FUNCTION** button the setting mode is being left.

## 29. STORAGE AND READOUT OF THE RESULTS

### 29.1. Storing or printing

The meter enables storing, readout or printing of 200 results of actually measured function. The results are stored in EEPROM memory, which is non-volatile, so the data isn't lost even after complete lack of power. There is also possibility to printout on request the result of measurement which is being done at this moment. For printing an Interface EI-401 (Elmetron) is required. Before starting the work it is necessary to choose the storing or printing function and determine the way of displaying the result.

### 29.2. Parameters of storing and reading from the memory

The parameters are changed in the readout mode. It may be entered from every measuring function by pressing and holding the  button, until on the display the number of last stored result will be displayed. This number is displayed on turns with the stored result.

Before starting the storing one has to choose the kind of results collecting: on request or as series, and also the way of displaying the result.

Next pressing of the  button shows screens with following functions which may be changed:

- a.  $SEr$  - taking or printing series or single results.



Pic.30

With  or  button choose in lower row  $\sigma n$  or  $\sigma FF$  symbols. (pic. 30)  
Choosing  $\sigma n$  activates automatic storing of the results and  $\sigma FF$  single, after every pressing of  button

b.  $Int$  - time interval during series taking (pic.31).



Pic. 31.

Value of the time interval is displayed in the upper row of digits, and the informative symbol  $Int$  in the lower row.

Buttons  and  are used to set the chosen time in minutes and seconds.  
The shortest time is 1 second and the longest 60 minutes. Holding the buttons make changing quicker. (repetition).

In case of choosing the  $SEr$  parameter to  $\sigma FF$  setting the interval isn't necessary.

c.  $Prt$  - printing - yes or no.

With   buttons one has to choose  $\sigma n$  when the results should be printed, or  $\sigma FF$ , when they should be stored in the memory.

d.  $All$  - Way of displaying the stored results.

$\sigma n$  - successively number of sample, result, time and date of storing the result.

$\sigma FF$  - successively number of sample and result

Changing with   buttons.

Return to the results readout display after pressing  button.

Exit from the readout mode after pressing of the  button.

### 29.3. Storing the single measurements in the memory

If according to previous section storing of single results was chosen, every pressing of  button stores the measured result. The results are stored as the next ones after the last stored. If someone was checking the earlier stored results and didn't return to the last one the results won't be deleted and the value will be stored after the last measurement. If the user wants to store the result from the chosen number first he has to delete the results (as described in the point 29.6) and next start storing the results by pressing the  button. During storing the results the number of result will be displayed for a moment.

If after pressing the  button instead of number an *End* sign will be displayed it informs that the maximal number of results was stored.

### 29.4. Storing the measuring series

There is possibility to store series of measurements up to 200 measurements. To do so one has to :

- choose the way of collecting the measurements (p. 29.2a);
- enter the time interval (p. 29.2b)
- delete the stored results starting from the chosen one (p. 29.6);
- exit the setting mode by pressing the  button.
- Return to the measuring mode by pressing the  button.
- with  button choose the function which results one wants to store.
- with  button start taking the series. The measurements will be stored starting from the first free number.

**Taking the series is signalled by blinking frame round the symbol of function which results are stored.**

Before each storing of the result the number of measurement will be displayed for a moment. The taking of the series may be stopped by pressing  or  button or by filling the memory. If taking the series was stopped earlier than 200 number one may start to take the next series till the end of memory.

### 29.5. Reviewing of the results

Reviewing of the stored results is started from the measuring mode, by pressing and holding the  button until the number of last stored result on turns with its value will be showed.

Every pressing of the  or  button shows the next or previous number and result with time and date if **ALL function was chosen** (p. 29.2.d.).

In this mode the buttons   work with repetition and after longer holding the numbers change very quickly till stopping on the highest or lowest number.

The reviewing mode may be left by pressing the  button.

### 29.6. Deleting the stored results

To delete the stored results one has to:

- press and hold the  button
- with buttons  or  set the number of measurement from which we want do delete the memory;
- press the  button what will delete the stored results from the chosen one till the end of the memory. On the display in the place of results there will be -- sign displayed what confirms the deleting.
- to exit the reviewing mode press the  button.

In case of using all 200 numbers of memory more results won't be stored. To store new results it is necessary to delete the old ones acting as it was described above. If one wants to clear all the memory the deleting should be started from the first number.

### 30. PRINTOUTS ON THE PRINTERS

In upper wall of the meter there is a RS-232 input which enables joining the meter with printer. To connect a printer with Centronics connector it is necessary to use an adapter EI - 401 which is offered as additional equipment. The adapter is connected with the meter by the RS-232 connector (pic.2) and with the printer by standard cable. There is possibility to print the measured value, or the results stored in the memory. If the printer is equipped with serial RS-232 input a special cable 4XX-PC, offered as additional equipment, is required.

#### 30.1. Printout of the result – single or serial

To print the result of the current measurement one should:

- connect the printer with the meter as described above
- switch the meter on;
- set the printout parameter  $Prt$  to  $on$  (chapter 29.2.c);
- choose the printout form (chapter 29.2.d) and way of printing – single or serial printouts (chapter 29.2.a);
- turn the printer on;
- if the single kind of taking measurements was chosen, every pressing of the  button will cause printing the actually measured value temperature and number;
- if taking the series of measurements was chosen, after pressing the  button printing of actually measured value, temperature and number of measurement with chosen time interval will be started.

If the parameter  $PtL$  was set to  $on$  together with the value of actually measured result and temperature the date and hour will be printed.

Printing of the series may be stopped by pressing the  or  button. There are no limits in number of printed results.

### 30.2. Printout of the results stored in the memory

To print the results stored in the memory:

- join the printer with the meter using the RS-Centronics adapter (as described on the beginning of the chapter);
- switch the meter and printer on;
- choose the printout format (point 29.2.d) and way of printing – serial or single (point 29.2.a)
- enter the results viewing mode (point 29.5), with buttons ,  set the number of measurement from which the printing should be started. Pressing the  starts printing.

The results of measurements with numbers will be printed.

In case of setting the  $\xi r$  parameter to *on* all results from the set one to the end of memory will be printed, in case of setting the  $\xi r$  parameter to *off* only the result stored under the chosen number will be printed.

In case of setting the  $RLL$  parameter to *on*, together with the result of measured function and temperature the hour and date will be printed.

### 31. POWER SOURCE AND CHANGING THE BATTERY

The meter is 9V battery or stabilised power adapter powered. The adapter should be joined with the **P** connector (pic.2) The battery is necessary to keep the clock going. Joining the power adapter disconnects the battery.

The battery condition may be checked according to chapter 28.4. Displaying the  symbol informs that the battery should be changed. To do this it is necessary to unscrew the 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 battery back into the meter and mount the wall. The special shape of the wall disables wrong mounting, only in one position it is possible to put the wall on.

The wall on the edge has a sealing ring. It is very important to pay attention, during closing the meter, if the ring on the whole edge was put inside the housing. If it is correct screw the screws till feeling the resistance (not too hard). Leaving the wall not correctly screwed causes losing the waterproofness and may cause that water will get into the meter and will destroy it. This kind of failure is not repaired on the warranty conditions.

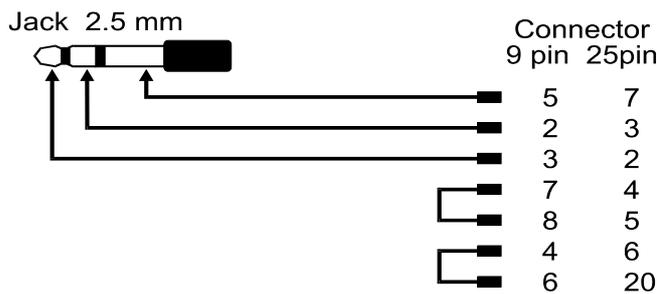
### 32. CO-OPERATION WITH THE PC

Connecting the meter with a PC enables storing data directly on the computer, what eliminates the limitation to 200 results. The PC should be equipped with serial RS-232 connector (typically COM2) configured for 9600 b/s, 8 bit, 1 even bit, 1 stop bit, lack of steering the transmission.

On the picture 2 there is the way of joining the meter with the computer showed. On the right side of the picture there is the way of joining the cables with the 9 or 25 pin plug with relevant pin numbers.

For the transmission a special software prepared by our company may be ordered or residential Windows program - HyperTerminal (in menu Accessories / Communication). If it isn't there it should be installed from the Windows installation CD. The program should be configured with option „direct connection with port...COMx“. After setting the option *Port* to *00* after pressing the  button transmission of the currently measured value and temperature to the PC will start in the format which depends of the chosen parameters *SEr*, *int* and *ALL*.

On the pic. 32 a scheme of connecting the meter with a PC is showed. On the right side of the picture way of connecting from the side of computer for 9 and 25 pin connector with the correct numbers of pins. (Cable 4XX-PC available as



option)

Pic. 32.

**Caution:** the meter and PC should be switched on after connecting the cable.

### 33. TECHNICAL DATA

#### pH measurement:

range	resolution	Accuracy (±1 digit)
-2.000 ÷ 16.000 pH	0.001 / 0.01 pH	±0.002 pH

INPUT IMPEDANCE:  $10^{12} \Omega$   
TEMPERATURE COMPENSATION: manual/automatic  
RANGE OF COMPENSATION: -5.0 ÷ 110.0 °C  
pH ELECTRODE CALIBRATION: automatic,  
in 1 ÷ 5 points

#### RANGE OF RECOGNITION AND ENTERING OF THE pH BUFFER SOLUTIONS

Calibration point	Range
1	0,800 ÷ 2,100
2	3,900 ÷ 4,100
3	6,800 ÷ 7,100
4	8,900 ÷ 9,400
5	11,500 ÷ 14,000

AUTOMATIC CHANGE OF THE pH BUFFER VALUE TOGETHER WITH THE TEMPERATURE CHANGE,  
FOR SAMPLES CONSISTENT WITH NIST (table page 19) IN RANGE 0 ÷ 60 °C  
THERMAL STABILITY OF ZERO: 0.001 pH/ °C

#### mV measurement:

ranges	resolution	Accuracy (±1 digit)
-1000 ÷ 1000 mV	0.1 mV	±0.1 mV

INPUT IMPEDANCE:  $10^{12} \Omega$

**CONDUCTIVITY MEASUREMENT:**

ranges	resolution	Accuracy (±1 digit)	Frequency
0.000 ÷ 19.999 µS/cm	0.001 / 0.01 µS/cm	±0.1 %	100 Hz
20.00 ÷ 199.99 µS/cm	0.01 / 0.1 µS/cm	±0.1 %	1 kHz
200.0 ÷ 1999.9 µS/cm	0.1 / 1 µS/cm	±0.1 %	2 kHz
2.000 ÷ 19.999 mS/cm	0.001 / 0.01 mS/cm	±0.1 %	5 kHz
20.00 ÷ 199.99 mS/cm	0.01 / 0.1 mS/cm	±0.25 %	10 kHz
200.0 ÷ 1999.9 mS/cm	0.1 / 1 mS/cm	±0.25 %	10 kHz

\* Accuracy given for the end value of the range.

Ranges of frequency changes were given for constant K = 1. For other values of the constant K the values will change proportionally to changes of this constant.

TEMPERATURE COMPENSATION: manual/automatic  
 COMPENSATION RANGE: -5.0 ÷ 70.0 °C  
 CONSTANT K RANGE: 0.010 ÷ 19.999 cm<sup>-1</sup>  
 α COEFFICIENT RANGE: 0.00 ÷ 10.00 %/ °C  
 TDS COEFFICIENT RANGE: 0.20 ÷ 1.00  
 MEASURING RANGE KCl: 0 ÷ 200 g/l  
 MEASURING RANGE NaCl: 0 ÷ 250 g/l  
 PROBE CALIBRATION: one point  
 1. by entering the constant K of the probe  
 2. using the calibration solution

**OXYGEN METER:**

range	Resolution	Accuracy
0 ÷ 400.0 %	0.1 %	Of probe* ±1 digit
0 ÷ 60.00 mg/l	0.01 mg/l	Of probe* ±1 digit

TEMPERATURE COMPENSATION RANGE: 0.0 ÷ 40.0 °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<sub>2</sub>  
 One point in 100%O<sub>2</sub>  
 Oxygen probe: membrane, galvanic

\* Accuracy given in the "oxygen Probe" section (page 52).



### 34. EQUIPMENT

The standard equipment for the CX-400 meter is:

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

The additional equipment available for this meter is:

1. Combined pH electrode (glass membrane);
2. Conductivity cell;
3. Power adapter 9V;
4. Adapter EI-401 for connecting the printer with Centronics connector;
5. 4XX-PC cable;
6. Software for collecting large number of data on the PC;
7. Adapter for connecting measuring end reference electrode in place of combined one;
8. Temperature probe Pt-1000 1/3B with higher accuracy;
9. Conductivity cells for different conductivity ranges;
10. Ion selective electrodes;
11. ORP measuring electrodes;
12. Dissolved oxygen sensor.

## WARRANTY

The "ELMETRON" company ensures a 24 months warranty for the multifunction meter CX-401 number:

.....

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 users manual, using wrong power adapter, mechanical damages and damages caused by repairs made by unauthorised persons.

**The pH electrode, conductivity cell, oxygen sensor have the warranty of the producer.**

**NOTICE:** Before sending the meter to us please contact the firm by phone or email.

When sending the meter, the used electrode, conductivity cell, oxygen sensor, temperature probe and power adapter should be also included.

Date of production.....

Date of sale.....

Date of warranty expiry.....