WATERPROOF
MULTIFUNCTION
METER

CX-401

USER'S MANUAL

ELMETRON

USER’S MANUAL

WATERPROOF
MULTIFUNCTION METER

CX-401

Before use please read the instructions carefully!

CONTENTS

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 would not cause you any trouble and that the meter would 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 be troublesome.**
Using electrodes of good quality and replacing them after a suitable time ensures obtaining high measuring accuracy. It is worth remembering that electrodes have much shorter life time than the meter. Deterioration of the result stability and increase of the measuring error are typical symptoms of an improper work of the electrode. **Some problems users have may arise from using pH electrodes not being conditioned before the measurement, making measurements not having removed the shielding ring from the liquid junction, with contaminated membrane or plugged junction, making measurements not taking the membrane cap off.** To avoid such situations it is necessary to choose a proper kind of electrode for solutions which are going to be measured, e.g., sewage, liquids with deposits, meat, cheese etc. Therefore, if you observe improper operation of the device, please take control measurements with another electrode. **In most cases deterioration of the meter's work is caused by the electrode and not by the meter itself.**
In case of conductivity measurements it is important to choose the cell with a K constant value suitable for the measuring range. Improper selection may cause larger error occurrence, what may also happen during measurements with automatic temperature compensation with an inappropriate α coefficient introduced.
Accuracy of the dissolved oxygen measurements depends on the sensor's calibration and regular conservation which consists in replacing the membranes, electrolyte and cleaning the electrodes. **Neglecting these activities after some time would make measurements impossible. Please turn your attention to the fact that stabile measurement is possible only with natural or simulated water flow.**
The essential feature of our products is their low failure frequency. However, in case of the meter's failure, our firm provides its immediate repair under the warranty conditions.
We wish you a pleasant and trouble-free work with our meter.

2. CHARACTERISTICS OF THE METER

CX-401 multifunction meter belongs to the newest generation of measuring devices. It offers wide range of additional functions. The meter ensures high accuracy and repeatability of readings. Two kinds of power source: the rechargeable battery and the power adapter, enable work in field and long-lasting measurements in the laboratory. The meter's memory is independent from power supply. The meter is equipped with a large backlit custom LCD display, enabling observing simultaneously: the measured function, the temperature value and additional symbols which make working easier. Waterproof housing makes working in difficult conditions possible. Minimised size and weight make the meter very handy especially during field work.

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

- high accuracy and stability of readings;
- automatic and manual temperature compensation;
- pH electrode calibration in 1 to 5 points;
- automatic recognition of pH buffers and standards;
- factory set values of buffer solutions with possibility of changing their value by the user;
- option of automatic introduction of temperature influence on the value of pH buffer solutions (NIST norm);
- information about the pH electrode condition;
- storing of the date and calibration characteristics of three electrodes (sensors) in each function;
- possibility of introducing the time of calibration validity and signalling its expiry;
- wide range of conductivity measurement with 6 automatically switched subranges (autorange);
- converting the conductivity to salinity in NaCl or KCl (g/l or %) according to actual dependence to conductivity;
- converting conductivity to TDS (g/l or %) with possibility of introducing the TDS coefficient;
- measurement of resistivity in Ωcm;
- temperature compensation for measurements in natural, pure and ultra pure water;
- calibration of the conductivity cell by introducing the K constant or in 1 to 5 standard solutions;
- function of determining K constant of the cell;
- compensation of the salinity influence on the oxygen measurement with use of the salinity measured by the meter;
- measurement and automatic compensation of the atmospheric pressure influence on the oxygen measurement;
- signalising of the reading stabilisation (READY);
- holding the reading on the display (HOLD);
- storing measurement results with time, date and temperature, taken as single or series of measurements with set time interval;

- possibility to create the last calibration report or readout of last 10 calibration data of each measuring function in the data transmission software;
- microUSB output for connecting with PC and charging the rechargeable batteries;
- large LCD backlit display with brightness control;
- real time clock with date;
- automatic switch off after time set by the user.

3. WHAT IS THE METER DESIGNED FOR

CX-401 multifunction meter is a precise and easy-to-use meter designed for measurements of hydrogen ion concentration in pH units, redox potential (mV), conductivity of solutions in in S/cm, resistivity in Ωcm, concentration of oxygen dissolved in water in % or mg/l, oxygen saturation in air in % and atmospheric pressure measurement in hPa. The meter can be also used for accurate measurements of the temperature of solutions and air in ℃.

For measurements in pure and ultra pure water suitable temperature compensation may be chosen.

The conductivity reading can be displayed in S/cm or in concentration units (g/l or %) counted to NaCl, KCl or TDS. Waterproof housing enables work in difficult weather conditions or in humid environment.

CX-401 is used in food, chemical, pharmaceutical and power 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 K constant range, equipped with the BNC-50 connector. It is possible to connect the meter with two electrodes (pH measuring and reference) by special adapter offered as an additional equipment. **CX-401** cooperates with Pt-1000 temperature probe with the Chinch connector.

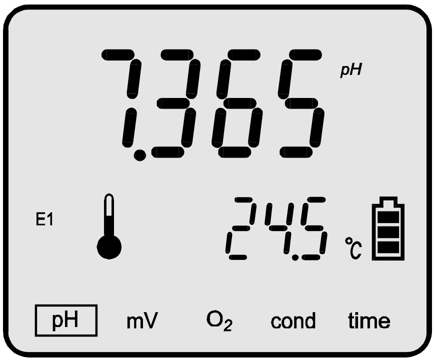
The meter may store measurement results taken as single or series of measurements with set time interval. The USB interface enables sending the stored results. When the collected series exceed the memory capacity, it is possible to use included software.

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

Choosing the function by the FUNCTION button is signalised by the frame displayed around the symbol of the chosen function in the lower part of the display: **cond** (conductivity), **pH**, **mV, O_2** or **time.** Simultaneously with the result a measured temperature value in °C is displayed. Symbols of units are displayed next to the results. In the dissolved oxygen measurement mode readout of the air pressure is possible.



Pic. 1.

Next to the temperature value the 🌡 symbol for automatic temperature compensation or the ✋ symbol for manual compensation is displayed. The ***CAL*** symbol on the left informs that the meter is in the calibration mode.
The number of the chosen electrode is displayed on the left (E1, E2, E3). It informs which of the characteristics would be taken into consideration during all calculations. Blinking symbol of the electrode number informs that its characteristic was deleted, the calibration validity has expired (point 6.6) or that the last calibration indicated that the pH electrode had lost its efficiency.
The number of detected calibration point is displayed during calibration process between the upper and the lower row of digits (P1, P2, P3, P4, P5).
In the MODE mode all parameters set by the user and the value of the air pressure measurement (for the O_2 measuring mode) are displayed. The rechargeable battery condition is signalised by the 🔋 symbol.

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

The keyboard is equipped with the following keys:

FUNCTION - pressing shortly switches the meter on, enables changing the function, pressing and holding switches the meter off.

CAL - pressing and holding enters the calibration mode (***CAL*** symbol displayed). Pressing shortly in this mode confirms the calibration result.

MEM - pressing shortly holds the reading on the display, records the reading or starts the measuring series.
- pressing and holding this button enters reviewing the stored readings.

MODE - chooses the entered parameter.

↙, ↗ - buttons used for entering the parameters.

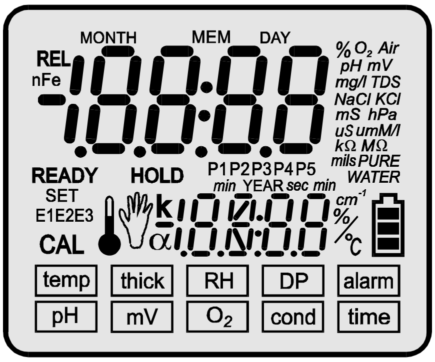
In the upper wall of the meter inputs are placed with the symbols given below:
pH - the **BNC-50** input for connecting the combination pH electrode or the redox electrode;
t - the **Chinch** input for connecting the temperature probe;
O2 - the **BNC-50** input for connecting the oxygen sensor;
USB - micro**USB** input for connecting the power adapter or with the PC;
Cond - the **BNC-50** input for the conductivity cell.


pH
t
O2
USB
Cond
ELMETRON
7.365
pH
E1
CAL
24.5
°C
pH
mV
O₂
cond
time
MEM
CAL
FUNCTION
MODE
multifunction meter CX-401
waterproof

Pic. 2.

5. SWITCHING THE METER ON AND OFF

After switching it on with the FUNCTION button, the meter tests the memory and the display on which all symbols are displayed (Pic. 3).



Pic. 3.

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

After pressing CAL the meter adopts standard characteristics:

- offset = 0 pH, slope = 100% for the pH electrode;
- K constant = 1.000 cm^{-1} for the conductivity cell;
- offset = 0% O_2, slope = 100% O_2 for the oxygen sensor

and enters the measuring mode. It is necessary to calibrate the conductivity cell the pH electrode and the oxygen sensor.

The meter is switched off by pressing and holding the FUNCTION button until the OFF symbol displays. When the meter is powered by the rechargeable batteries only, it switches automatically off after the time of non-use set by the user (description in the chapter 29.4). This function is deactivated during calibration, while collecting series of measurements and working with the power adapter.

6. PREPARATION TO WORK

Before starting work:

- connect prepared combination pH electrode or redox electrode to the **pH** (BNC-50) input;
- connect oxygen sensor to the **O2** (BNC-50) input;
- connect conductivity cell to the **Cond** (BNC-50) input;
- in case of using the temperature probe connect it to the **t** (Chinch) temperature input;
- in case of working with a PC connect a suitable cable to the **microUSB** input
- switch the meter on by pressing the FUNCTION button.

The pH electrode is isolated from the conductivity cell, therefore during the pH and the conductivity measurements both electrode and cell may be immersed in the same solution simultaneously.

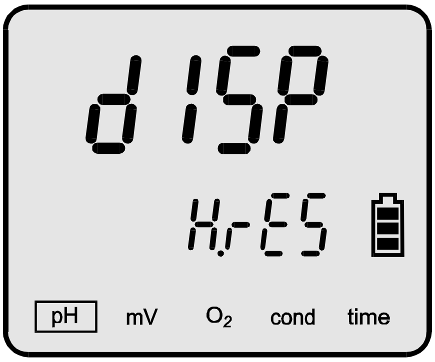
6.1. Choosing the kind of the temperature compensation

The meter switches to the automatic or manual temperature compensation mode itself. Connecting the temperature probe switches the automatic temperature compensation on. Next to the measured value the 🌡 symbol is displayed. After disconnecting the probe the meter enters the manual temperature compensation mode. In place of the 🌡 symbol the ✋ is displayed, at the same time the buttons ↙ , ↗ are being unlocked and changing the temperature with their use is possible.

6.2. Changing the measurement resolution

The measurement results can be displayed with a chosen resolution. Setting the resolution:

- in the measuring mode press the MODE button, the dISP (display) symbol will appear, Pic. 4.
- with the ↙ , ↗ buttons choose:
  - L.RES - low resolution;
  - H.RES - high resolution.



Pic. 4.

For the pH measurement:
L.RES - 0.01 pH resolution;
H.RES - 0.001 pH resolution.

For the conductivity measurement:
L.RES - 3½ digit resolution;
H.RES - 4½ digit resolution.

For the O_2 concentration measurement:
L.RES - 1% or 0.1mg/l resolution;
H.RES - 0.1% or 0.01 mg/l.

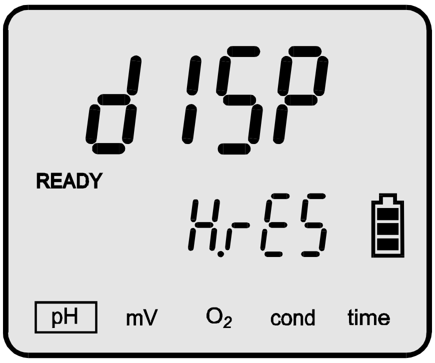
For the mV measurement:
L.RES - 1 mV resolution;
H.RES - 0.1 mV resolution.

Return to the measuring mode by pressing the FUNCTION button.

6.3. Switchnig the stabilised reading signalisation on and off

The meter may signalise that the reading has stabilised. To switch the signalisation on and off:

- in the measuring mode press the MODE button, the dISP (display);
- press the CAL button shortly, the **READY** symbol will appear (Pic. 5.), the signalisation is switched on. After pressing the CAL button once again the READY symbol disappears and switches the signalisation off.



Pic. 5.

After switching the signalisation on each reading stabilisation will be signalised with and **READY** symbol and sound signal – if the second has been activated (section 29.5). If the value changes and exceeds the stabilised reading range, the **READY** symbol will disappear.

Return to the measuring mode by pressing the FUNCTION button.

6.4. Changing the electrode number

If there has been more than one electrode's characteristic stored in the meter's memory, it is possible to replace the electrodes without the need of calibration. This option is quite useful in case of working in the field. It is necessary to connect the electrode calibrated earlier and choose its number given during calibration.

In order to do so, in the measuring mode:

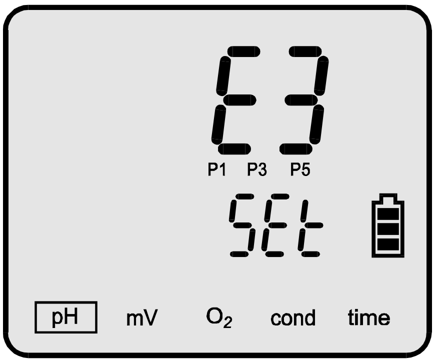
- press the MODE button until the E1, E2 or E3 symbol displays in the upper row of the display, than using the ↙ , ↗ buttons choose the number under which the calibration data will be stored (Pic. 6). Below the electrode number one of the following symbols will be displayed:

  CLr - under this number there is no characteristic stored and the factory values are provided. In the measuring mode the electrode number will be blinking.

  SEt - under this the last calibration data are stored.

  bAd - the last calibration indicated that the electrode is loosing its efficiency and in a short time its calibration may not be possible (for the pH function only). In the measuring mode the electrode number will be blinking.

Additionally the points in which the electrode has been calibrated are shown under its number.



Pic. 6.

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

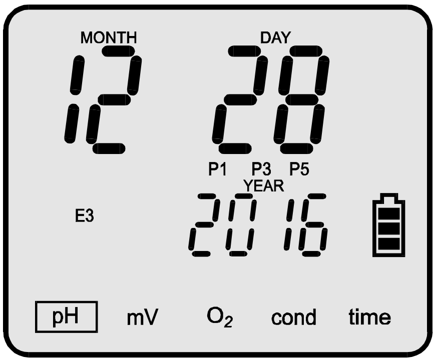
Note: while changing the electrode remember about choosing the relevant electrode number in the meter.

6.5. Readout of the last calibration date

The meter remembers the dates of calibration of all electrodes, cells and sensors in every measuring function. Before starting work it is possible to check the date of the last calibration.
In order to do so, in the measuring mode:

- press the MODE button until the electrode number displays in the upper row of the display (E 1, E2 or E3 symbol);
- using the ↙ , ↗ buttons choose the electrode number that is to be checked and press the CAL button shortly. The date of the last calibration will be displayed in the following format: month – day and the year will be displayed below (Pic. 7). On the left side of the display the electrode number is shown.

Blinking date informs about expiration of the electrode's calibration validity. Introducing the calibration time is described in the point 6.6.



Pic. 7.

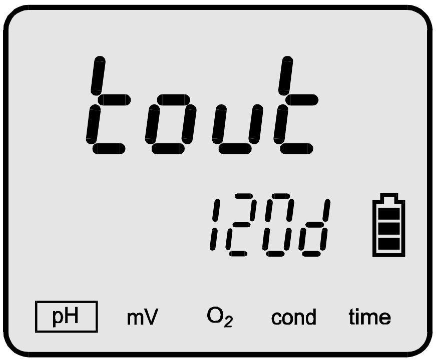
The meter memorises the date during calibration. If the date in the meter's clock is changed after calibration, the date of calibration validity expiration will be faulty signalised. It is important to set the current date before calibration.

Return to the readout of the electrode number mode by pressing the MODE button, and to the measuring mode by pressing the FUNCTION button.

6.6. Setting the time of calibration validity

The meter remembers the time of calibration validity separately for three electrodes, cells or sensors. After this time has been exceeded, the meter signals on the display with blinking electrode number (E1, E2 or E3 symbols) that the calibration for this electrode is necessary.
To enter the time validity of the calibration in the measuring mode:

- press the MODE until the tout (timeout, Pic. 8) symbol displays in the upper row of the display. The number of days to the next calibration will be displayed below;
- using the ↙ , ↗ buttons enter the required quantity of days to the next calibration. After choosing time of one day and pressing the ↙ button, instead of digital values the --- symbol appears what deactivates the calibration validity expiry controlling function.



Pic. 8.

Return to the measuring mode by pressing the FUNCTION button.

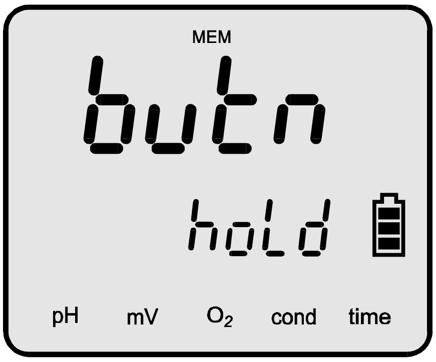
6.7. Defining the MEM button functions

The MEM button may function in three ways:

1. record single readings;
2. start collecting measurement series;
3. hold the reading on the display.

To define the function:

- in the measuring mode press and hold the MEM button until the **MEM** symbol and the number of the last recored reading is displayed;
- press the MODE button, the butn symbol will appear and below the last set parameter will be displayed (Pic. 9.). With the ↙ , ↗ buttons choose:
  - onE - each time the MEM button will be pressed, the current measurement readout will be recorded;
  - SEr - pressing the MEM button will activate collecting measuring series;
  - hoLd - pressing the MEM button in the measuring mode holds the reading on the display until any button wil be pressed;
- return to the measuring mode by pressing the FUNCTION button.



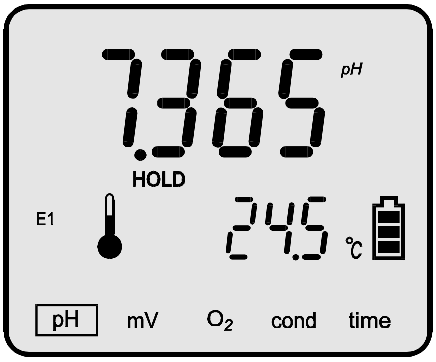
Pic. 9.

Note: activating the HOLD function automatically blocks the possibility of manual and automatic recording of readings.

6.8. Holding the reading on the display

The user may hold the reading on the display by pressing the MEM button. Before activating the HOLD function the MEM button function has to be defined according to the previous subchapter.

Pressing the MEM button will hold the reading on the display. Below the reading the HOLD symbol will be displayed (Pic. 10).
To deactivate this function and return to the measuring mode, press any button.



Pic. 10

Note: **the HOLD function cannot be activated in the calibration mode.**

II. pH MEASUREMENT

7. PREPARATION OF THE pH ELECTRODE

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

- new electrode should be put into saturated KCl solution for about 5 hours;
- before starting measurements, the protecting rings (if used in this kind of electrode) should be removed. The ring placed on the junction - the lower part of the electrode - should be removed upward the electrode's body and the upper, which protects the KCl refilling hole, downward the body. **Removing the lower ring is essential, in other case the electrode will not measure.** The upper ring should be removed during measurements of high temperature solutions or to protect the junction during measurements in solutions with deposits or oils. Sometimes instead of a ring a cork is used;
- during measurements in laboratory it is advisable to use an electrode holder;
- after every measurement the electrode should be washed in distilled water;
- excess liquid on the electrode should be removed by gentle touching the glass with a tissue paper;
- after work the electrode should be stored in the saturated KCl solution. The protecting rings should be put on the junction and upper hole;
- in case of long breaks between measurements the electrode should be stored dry in the packaging;
- after taking the electrode out of the package the eventual deposit should be removed with use of water;
- before using it after a long break, the electrode should be placed in saturated KCl solution for about 1 hour;
- if the electrode construction enables refilling the electrolyte, it should be controlled and refilled periodically by the upper hole in the electrode's body (usually as the electrolyte KCl solution is used).
- If the electrode is equipped with a small container (bottle) put on its end, the bottle should be taken off before measurements by unscrewing the nut gently and taking the bottle down the electrode's body. After the measurements the bottle should be put on again. Such electrodes are not equipped with the protective ring on the junction. It is necessary to control the level of the saturated KCl solution in the bottle and fill it up if necessary.

Note: storing the electrode in distilled water shortens its lifetime and may increase measurement error.

8. CALIBRATION

Before starting measurement with new electrode or before making measurements which require high accuracy, the electrode connected to the meter should be calibrated.

Calibration is performed in buffer or standard solutions with accurately determined value and consists in comparing pH value of the standard with the value displayed by the meter and automatic introduction of the correction into the meter's memory. The correction is calculated during next measurements. Calibration should be periodically repeated because the parameters of the electrode in use are changing what influences the accuracy. The frequency of this procedure depends on the required accuracy, number of the measurements carried out, conditions in which the electrode is used, temperature and pH value of the measured solutions.

CX-401 enables storing characteristics of 3 calibrated pH electrodes marked by different symbols (E1, E2 or E3). This feature is especially useful when it is necessary to change the electrode quickly or replace a broken one.

The meter enables entering the calibration validity expiry date. In case of using this option, calibration should be performed when the symbol of the electrode in use (E1, E2 or E3) is blinking.

For accurate calibration, enter the pH values of the applied solutions to the meter's memory. During calibration, after immersing the pH electrode and the temperature probe, the meter will detect the value of the buffer automatically.

When the highest accuracy is required, it is recommended to use certified standard solutions. The most frequently used are buffer solutions having total values i.e. 2.00 pH, 4.00 pH etc, with a composition specified by the manufacturer. Usually, they are also of high accuracy.

For accurate measurements it is necessary to use fresh solutions of good quality. The pH value of standard and buffer solutions is influenced by temperature changes.

The solutions contain the manufacturer's specifications of the pH values corresponding to the particular temperature.

In case of an accurate calibration the value of the solution recorded in the memory has to be the same as the value of this solution at the temperature in which the calibration is performed. Blinking of the electrode's symbol when the calibration process is finished
informs that the electrode is no longer efficient and should be replaced in a short time (description in the chapter 9).

Calibration performed in one solution does not guarantee high accuracy. If only one solution is used, its value should be close to the anticipated value of the measured solution. If the required accuracy is not very high and the measurements will be made in the whole pH range, 1 point calibration should be performed with use of standard or buffer solution of value close to 7.00 pH. Thanks to this, the zero offset of the electrode will be eliminated and in other points a standard characteristic slope will be adopted.

If measurements are made both in acids and alkalis and not at the extremes of pH range, it is enough to calibrate the electrodes in 3 buffer solutions with values in range given in the table 2 – calibration points 2, 3 and 4. In case of performing accurate measurements in the whole measuring range it is recommended to calibrate the electrode in all 5 points, additionally taking into consideration the solutions' pH values given in points 1 and 5 in the table. In **CX-401** the characteristics of the electrodes are approximated linearly between the calibration points. **Entering the calibration mode irreparably erases the electrode's characteristic stored under the chosen electrode number. There is no possibility to perform calibration only in one point without changing the rest of the data from the last calibration.**

Blinking of the electrode's number informs about its characteristic erase, its calibration validity expiry or that it is no longer efficient. In the calibration mode the number of the recognised calibration point is displayed between the upper and the lower row (P1, P2, P3, P4, P5).

8.1. Calibration with use of standard and buffer solutions

Before starting the calibration process prepare the meter according to the chapter 6 and choose whether it shall be performed with use of standards or in buffer solutions. Calibration may be performed in two ways:

1. **Enter the values of currently used pH buffers and calibrate the electrode with use of these buffers.**

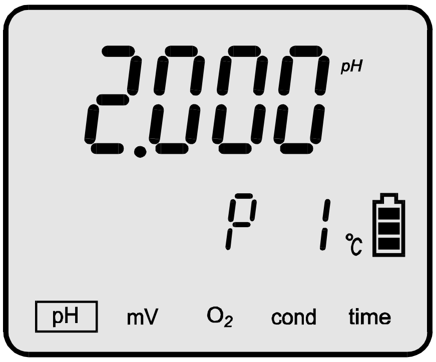
2. **Use the pH standard solutions values entered to the memory by the manufacturer, NIST norm compliant. Choosing the calibration in standards activates the function of automatic correction considering the influence of temperature changes on the standard solution value, what eliminates the necessity of rising or lowering the solutions temperature or entering the pH standards values corresponding with their temperature.**

8.2. Entering the buffers’ values into the meter’s memory

If the method of calibration in buffers has been chosen and the pH values entered by the manufacturer are used, there is no necessity to change them. However, it should be verified whether the values correspond to those of applied buffers. Different buffers’ values should be introduced to the meter’s memory before calibration.
To introduce:

- in the pH measuring mode press the MODE button a few times until the P.CAL symbol (points of calibration) displays at the upper row and using the ↙ , ↗ buttons choose buFF symbol at the lower row (calibration in buffers);

press the CAL button. At the lower row P 1 symbol (the first buffer solution) displays and at the upper row – the value of the pH buffer (Pic. 11.). In case of using buffer solution of a different value than displayed one, change the displayed value with use of the ↙ , ↗ buttons.



Pic. 11.

- to pass to the second point of calibration, press the CAL button, in the lower row P2 symbol will be displayed. The value of the buffer solution stored for this point will be displayed in the upper row;
- check or set the values of the next calibration points following the instructions given above;
- having set all the needed values, enter the pH measuring mode by pressing the FUNCTION button.

Each of the calibration points has a different range for entering the pH buffers' values. This limitation enables the meter to recognise the buffer solutions automatically. Table 1 contains the manufacturer's settings of the values of pH buffer solutions used for calibration, which may be changed according to the ranges given in this table. The range of introducing these changes is wide for each of the calibration points, what enables using buffer solutions of pH values differing significantly from these set by the manufacturer. In every case the meter will automatically detect the introduced solution.

Table 1

Calibration point	Factory value	Range of changes
1	2,000	0,800 ÷ 2,100
2	4,000	3,900 ÷ 4,100
3	7,000	6,800 ÷ 7,100
4	9,000	8,900 ÷ 10,200
5	12,000	11,800÷ 14,000

The meter recognises only the pH buffers values detected during calibration. The pH values stored in unused calibration points do not affect the calibration results.

During next calibrations there is no need to perform the actions described above, unless the buffer solutions are changed to buffers of different values. The pH values introduced to the meter's memory by the user are stored in non-volatile memory.

The manufacturer gives information about the pH values of the solutions at different temperatures. This data may be useful for calibrating the electrode in temperature other than 20 °C by introducing the value of the buffer corresponding to its value in this temperature to the meter's memory.

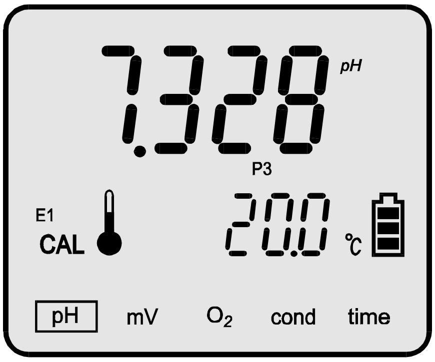
There is no possibility to enter pH values in ranges other than those given in the table 1.

8.3. Calibration in buffer solutions

After preparing the electrode, calibration in buffer solutions may be started. The buffers may be applied in any order.

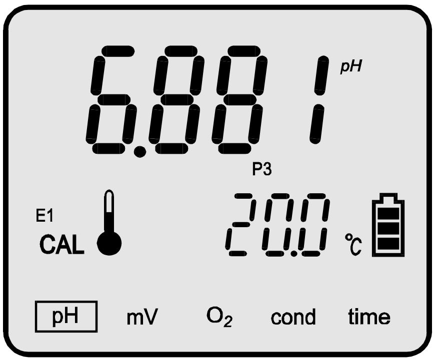
To calibrate:

a. choose the resolution for entering the pH buffer value according to the section 6.2;
b. choose the electrode number (E 1, E2, E3), under which the results of calibration will be stored according to the section 6.4 and mark the electrode with this number;
c. in the pH measuring mode press the MODE button until the P.CAL symbol displays in the upper row of the display and with use of the ↙ , ↗ buttons choose the buFF option from the lower row;
d. return to the measuring mode pressing the FUNCTION button;
e. connect the combination pH electrode prepared earlier and the temperature probe to the **pH** and **t** connectors respectively (Pic. 2);
f. put the electrode and the temperature probe into the buffer, do not touch the walls of the vessel – it is advisable to use an electrode holder;
g. bring the temperature of the buffers to the value corresponding to the buffers' values stored by the meter;
h. press and hold the CAL button until the **CAL** symbol appears on the display. **This deletes the previous parameters of calibration;** below the pH value the **P** symbol with the recognised buffer number appears (Pic. 12.);
i. wait till the result stabilises on the display (in most cases the result slightly differs from the buffer's value).



Pic. 12.

When the value stabilises, press the CAL button. The result will blink, what informs that the calibration value has been recorded in the meter‘s memory; simultaneously, the corrected readout equal to the buffer‘s value will be displayed in the upper row (Pic. 13.). If the reading is still different than the buffers value, wait until it stabilises and press the CAL button again.



Pic. 13.

The meter will record the correction. If the meter cannot recognise the buffer, the Err symbol will be displayed. In this case it is necessary to check the value of the buffer solution or the electrode which may be broken.
The meter calculates only the pH buffers values detected during calibration. The values entered earlier into the memory do not affect the results.
After finishing calibration in the first buffer rinse the electrode and the temperature probe with distilled water and start calibration process in the next buffers, acting according to the procedures given in point i and when the calibration process is finished, escape the calibration mode by pressing the FUNCTION button.

When one electrode is calibrated, it is possible to calibrate two another electrodes, choosing the remaining electrode numbers.

After choosing the electrode number, entering the calibration mode and escaping it without making calibration, the stored characteristic will be erased and the standard characteristic will be adopted.

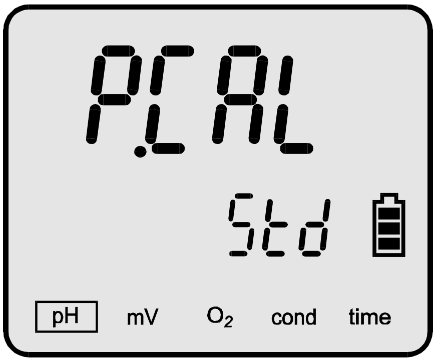
8.4. Calibration with use of NIST compliant standard solutions

Calibration in standards is performed with use of 5 pH standards values, with chemical composition compliant with NIST. **The meter's memory stores a table with a dependence between the temperature and pH values for these standard solutions.** This dependence is shown in the table 2.
If the standard solution differs from the value given in the table 2 on the third decimal place, it is possible to make a slight correction of the manufacturer's settings (see the description below).
After the temperature probe is put into the pH standard, its temperature is measured and on such basis the pH value corresponding to this temperature is displayed automatically. There is no need of lowering or rising the standard solutions temperature.

To perform calibration in standards:

a. choose the resolution with which the calibration will be performed according to the section 6.2;
b. choose the electrode number (E1, E2, E3) under which the results of calibration will be stored according to the section 6.4 and mark the electrode with this number;
c. in the pH measuring mode press the MODE button until the P.CAL symbol is displayed in the upper row and with the ↙, ↗ buttons choose the Std (calibration in standards) option in the lower row, Pic. 14.;
d. return to the measuring mode pressing the FUNCTION button;
e. connect the prepared combination pH electrode and the temperature probe to the **pH** and **t** connectors respectively (Pic. 2);
f. put the pH electrode and the temperature probe into the standard, do not touch the walls of the vessel – it is advisable to use an electrode holder;
g. press and hold the CAL button until the **CAL** symbol appears on the display. The meter will enter the calibration mode. **This deletes the previous parameters of calibration,** the **P** symbol a with a number of the recognised standard is displayed;
h. wait till the reading stabilises on the display (in most cases it may slightly differ from the pH standard's value) and press the CAL button. The result will blink and the value equal to the standard's value will be displayed. The correction will be recorded by the meter. If the readout is still different than the standard's value, wait until it stabilises and press the CAL button again.

At this point the calibration may be finished by pressing the FUNCTION button or continued in other standard solutions. After each measurement rinse the electrode and the temperature probe with distilled water in another standard and dry them with a tissue paper as described in the point h.



Pic. 14.

The meter calculates only the pH buffers values detected during calibration. The values entered earlier into the memory do not affect the calibration results.
The range of the temperatures taken into consideration for automatic calculations is 0 ÷ 60 ^{O}C and should not be exceeded.

Table 2

Temp. ^{0}C	Type of standard solution				
	1 oxalate	2 phthalate	3 phosphate	4 di-sodium tetraborate	5 calcium hydroxide
0	1.666	4.000	6.984	9.464	13.423
5	1.668	3.998	6.951	9.395	13.207
10	1.670	3.997	6.923	9.332	13.003
15	1.672	3.998	6.900	9.276	12.810
20	**1.675**	**4.001**	**6.881**	**9.225**	**12.627**
25	1.679	4.005	6.865	9.180	12.454
30	1.683	4.011	6.853	9.139	12.289
35	1.688	4.018	6.844	9.102	12.133
40	1.694	4.027	6.838	9.063	11.984
45	1.700	4.038	6.834	9.038	11.841
50	1.707	4.050	6.833	9.011	11.705
55	1.715	4.064	6.834	8.985	11.574
60	1.723	4.080	6.836	8.962	11.449

The values between the points given in the table are approximated linearly by the meter.

The values of standard solutions prepared according to the norm may differ from its values at the third decimal place. In case of very accurate measurements it is possible to make a correction of the factory settings and introduce the value given by the standard’s producer. The meter enables changing the standard value differing in range of ±0.010 pH from the table values for 20 ^{0}C (Table 2). The procedure of introducing changes in standard values is the same as for entering the buffers‘ values. In case of differences greater than ±0.010 pH it is recommended to perform calibration in buffers which enables entering a freely chosen solution value to the meter‘s memory.

When the electrode is calibrated, it is possible to calibrate two another electrodes, choosing the remaining electrode numbers.

After choosing the electrode number, entering the calibration mode and escaping it without performing calibration, the stored characteristic will be erased and the standard characteristic will be adopted.

8.5. Calibration with manual temperature compensation

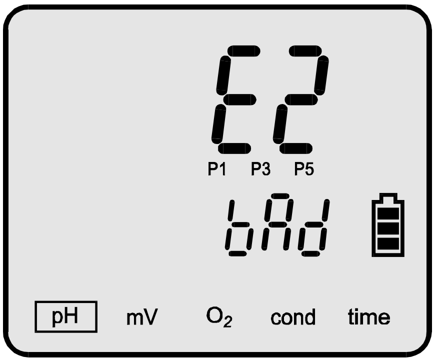
In order to start calibration with manual temperature compensation, disconnect the temperature probe, what switches the meter to manual compensation. The display shows the temperature value introduced by the user, not the one measured with the probe. The ↙, ↗ buttons are unlocked to enter the temperature of the solution. This value is displayed in the lower row of numbers on the display. Next, connect the pH electrode to the meter and act according to the description from the previous section.

Note: pressing both ↙, ↗ buttons simultaneously sets the temperature to 20 ^{0}C.

9. CHECKING THE ELECTRODE CONDITION

After pH electrode calibration the meter calculates its parameters: offset in pH units and slope defined also as efficiency in percents.
The electrode offset may be defined in pH or mV units.
An ideal electrode immersed in the 7.00 pH buffer before calibration should indicate 7.00 pH which equals 0.00 mV. If the reading is different, it informs that the electrode has an offset, which may be reduced by calibration. The information about the offset in mV may be obtained by converting the reading in pH. At 20 ^{0}C each pH unit corresponds to 58,168 mV. If the electrode has 0,2 pH offset, multiply it by 58,168 mV to obtain the electrode potential value in mV (SEM – Standard Error of Measurement). In the given example it will be equal 11,634 mV.
The SEM parameter may be also checked by immersing the electrode in 7.00 pH buffer and switching the meter to measurement in mV.

Blinking of the electrode symbol (E 1, E2, E3) after calibration informs that the electrode has lost its efficiency and that in a short time its calibration will not be possible. After entering the mode of the electrode's number changing bAd symbol is displayed below the electrode number (Pic. 15.).
Należy przygotować nową elektrodę.



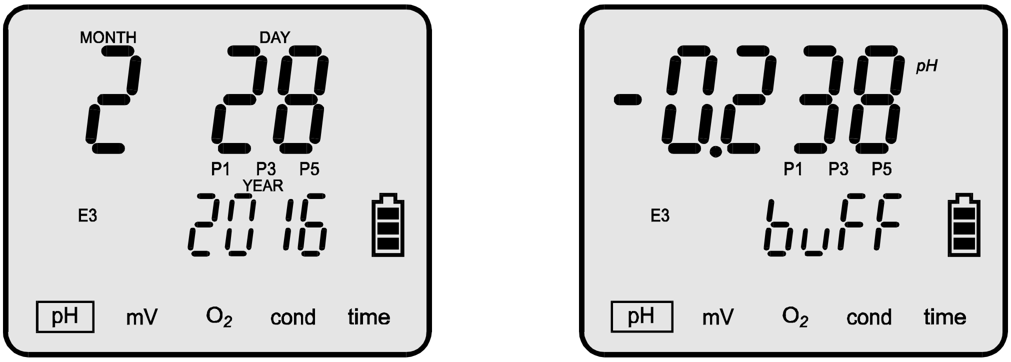
Pic. 15.

9.1. Readout of the electrode parameters after calibration

When the pH electrode has been calibrated, it is possible to check its parameters: zero offset and slope, in the pH measurement mode.
To check:

- press the MODE button until the electrode number shows at the upper part of the display (E 1, E2 or E3 symbol);
- with the ↙ , ↗ buttons choose the number of the electrode that is to be checked and press the CAL button shortly. The last calibration date will be displayed in the following format: month – day – year (below, Pic. 16A);

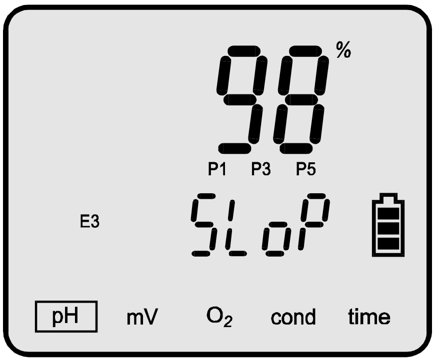
press the CAL button again, a buFF symbol will be displayed in the lower row, the zero offset will be visible in the upper row of the display (Pic. 16B);



A B

Pic. 16

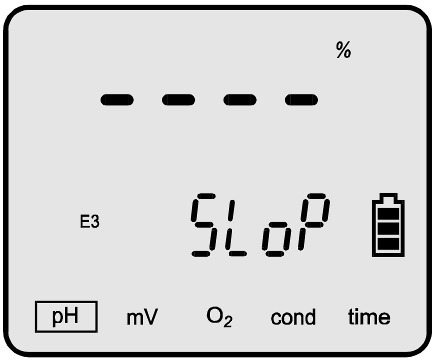
- press the CAL button once again, the lower row will display the SLoP symbol, and the upper row – the percentage of the electrode condition (Pic. 17);



Pic. 17

The electrode‘s calibration points are displayed between the upper and the lower row.

After the electrode characeristic has been deleted (entering the calibration mode and escaping it without performing calibration at any point) the meter takes into consideration an ideal electrode‘s characteristics and its actual parameters are unknown. In such case, in the electrode parameters readout mode, lines are displayed instead of numbers. 1 point calibration enables indicating only the zero offset of the electrode. Instead of the slope value lines are displayed (Pic. 18).



Pic. 18

Back to the electrode number readout by pressing the MODE button, and to the measuring mode by pressing the FUNCTION button.

10. pH MEASUREMENT

Before starting measurement the meter and the pH electrode have to be prepared for work (chapter 6 and 7 respectively). Good condition of the electrode is the main condition of correct measurements. If the electrode was calibrated, choose its number in the meter according to the section 6.4 and required measurement resolution according to the section 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 calculates the temperature influence to the result.

In case of measurement with automatic temperature compensation:

- turn the meter on by pressing the FUNCTION button;
- using the FUNCTION button choose the pH measurement function;
- join the temperature probe and the combination pH electrode to the **pH** and **t** connectors respectively (Pic. 2), the 🌡 symbol will be displayed;
- if the electrode was not calibrated or has already been in use for a quite long period, it is advisable to calibrate it (chapter 8);
- insert the electrode and the temperature probe to the measured solution. During measurements in vessels do not touch the bottom and the walls with the electrode. It is advisable to use an electrode stand;
- after the stabilisation read the result.

Accurate laboratory measurements require using of magnetic stirrer.

Note: exceeding the measuring range is signalised blinking digits on the display. Exceeding the automatic temperature compensation range is signalised with blinking digits and the 🌡 symbol.

10.2 Measurement with manual temperature compensation

Disconnecting the temperature probe switches the meter to the manual temperature compensation mode (the ✋symbol is displayed).
Measurement with manual temperature compensation is similar to the measurement with ATC, the difference is that the buffer's temperature is measured with a laboratory thermometer and entered by the ↙ , ↗ buttons. This value is displayed below the pH value and is calculated for compensation.
Manual compensation may be used in stable conditions, e.g. during pH measurements in the laboratory, especially when a thermostat is used, or when the temperature probe was damaged.
In case of measurement with manual temperature compensation:

- turn the meter on by pressing the FUNCTION button;
- using the FUNCTION button choose the pH measurement function;
- insert the electrode and the temperature probe to the measured solution. If the electrode was not calibrated or has already been in use for a quite long period, it is advisable to calibrate it (chapter 8). During measurements in vessels do not touch the bottom and the walls with the electrode. It is advisable to use an electrode stand;
- measure the temperature of the solution with use of a laboratory thermometer;
- with the ↙ , ↗ buttons enter the value of measured temperature;
- wait till the value stabilises and read the result.

Note: pressing both ↙ , ↗ buttons simultaneously sets the temperature to 20 ^{0}C.

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

CX-401 meter has a possibility of manual and automatic temperature compensation, what enables eliminating errors which result from affecting the electrode characteristics by the temperature changes. The pH meter is a mV meter which displays voltage counted to pH unit. In a constant temperature there is a constant mV value per one pH unit. In 20 ^{0}C it is 58,168 mV. The value of mV per one pH unit **changes together with the temperature,** what is taken into consideration in the formula for “k coefficient” of the pH electrode:

$$\mathbf{k = 0.198423\ T}$$

Calculating this change into measurement result is called temperature compensation. It is connected with a change of the electrode efficiency and not with a change of the pH value of the measured solution caused by the temperature change.

Changes of the pH values with the temperature in the majority of solutions are rather slight, however in e.g. pure water they tend to be significant.

Comparing values of solutions that tend to be affected by the temperature change should be done in the same temperature. Sometimes the results of measurements in the same solution in stable temperature are different. These are possible reasons of such situations:

- differences occur because of poor quality of the electrode;
- the result is treated as stabilised too soon (medium quality electrode needs about 40 seconds to full stabilisation);
- the measured solution is not homogeneous and lack of magnetic stirrer does not allow for obtaining similar results;
- during measurements in sewage some chemical reactions, which change the result, may occur.

The final measurement error is dependent mainly on the electrode’s quality, the temperature measurement error, the quality of the buffers applied for calibration and accuracy while performing procedures connected with calibration as well as measurements. The meter may cause minor differences.

The accuracy of the meter totals to ±0.002 pH, ±1 digit, what practically means that difference between results of measurements made by 2 meters in the same standard may come to 0.005 pH. Such error is acceptable because one measurement will be made with -0.002 pH error and the second with +0.002 pH error. ±1 digit information explains the difference caused by rounding up of the result on the last visible place on the LCD.

When the meter is calibrated in two points, in buffers 7.00 pH and 4.00 pH (acidic solutions), and the measurement accuracy is checked in 9.00 pH (alkali solution), in some cases the result may amount to 8.90 pH or 9.10 pH. This may occur when the electrode has unsymmetrical characteristic. Making a three-point calibration with alkaline, neutral and acidic buffers may prevent from such errors. Sometimes the measurement readings are unstable and in such cases the quality of the electrode has crucial meaning. **Slow drifting of the result, its unstability or prolonging time of stabilisation in most cases results from clogged junction, broken electrode or contaminated membrane.** It happens frequently as a result of irrelevant kind of electrode chosen for the kind of measured solution. Storing the electrode in distilled water for several hours or placing it in water with detergent may eliminate such problems, especially if the measurements were made in solutions with deposits, fats or oils. The electrode may be also cleaned with use of a special cleaning solution. In certain cases removing the deposit from the junction is impossible. Such electrode has to be replaced. The electrode that hasn't been in use for a long time may have the junction clogged by KCl crystals, what can be removed by placing the electrode in distilled water. If it does not take effect, the thiourea solution in saline acid can be used. Heavily contaminated electrode is cleaned in chloroform and deposits of iron in 2N HCl. Storing it in KCl solution can prolong the electrode life. Depending on the kind of measured solution or substance, proper kind of electrode should be chosen. They differ one from another with shape, look, kind of junction and body. Using unsuitable electrodes may cause their damage and make measurements impossible.

III. CONDUCTIVITY AND SALINITY MEASUREMENT

12. BASIC INFORMATION ABOUT THE CONDUCTIVITY MEASUREMENT

The conductivity measurement is based on applying electric current with a proper voltage and frequency to the measured solution. In **CX-401** the voltage comes to several dozens of mV and the frequency depends on the measuring range and may vary from 100 Hz up to 10 kHz. The electric current value is dependent on the kind of the measured liquid, its concentration and temperature. The conductivity result indirectly informs about the salt concentration in the measured liquid – when it increases, the conductivity rises (KCl, NaCl). However, after overdrawing certain salinity value the conductivity starts decreasing. The value of a conductivity measurement also increases together with the temperature. Measured conductivity can be displayed as salinity in g/l of NaCl or KCl assuming that the measured liquid includes homogeneous salt. The content of the salt dissolved in water may be also approximated with use of the TDS coefficient. The electrodes' surface and the distance between them determine the cell's K constant value. During measurement the meter multiplies the measured value by the K constant introduced to the meter's memory and displays the result in units of **conductivity** (µS/cm or mS/cm). The unit symbol in abbreviated form (µS or mS) is displayed next to the reading. Conductivity changes along with temperature and salts concentration. In order to enable comparison of the results, the measured value is counted by the meter to the value which corresponds to measurement at reference temperature (it is usually the temperature 25°C). Measurement at reference temperature is the most accurate. At other temperatures the temperature compensation is used, which means that the meter calculates the influence of the temperature and the α coefficient on the result (this value should be entered by the user before making measurement, section 13.3). This coefficient describes how much (in %) the result changes with 1^0C of the temperature change. The α coefficient may be introduced into the meter in $0 \div 10.00\% / {}^0$C range unless non-linear temperature compensation for ultra pure water has been chosen. For NaCl at temperatures close to 25 ^{0}C it amounts to 2% / ^{0}C, e.g. in case of measurements at 30 ^{0}C the result change totals to 5x2%=10%. For ultra pure water these changes are even greater.

Calculation is made automatically and takes into consideration the value of the α coefficient introduced by the user. This value can be found in appropriate resources or approximated by the user (chapter 19).

The conductivity measurement should always be treated as burdened with a certain error, which depends on the conductivity cell (its linearity) and temperature. When measurements are not made in the reference temperature, the error is dependent mainly on the α coefficient, which is affected by the temperature and concentration changes.

13. ENTERING THE CONDUCTIVITY MEASUREMENT PARAMETERS

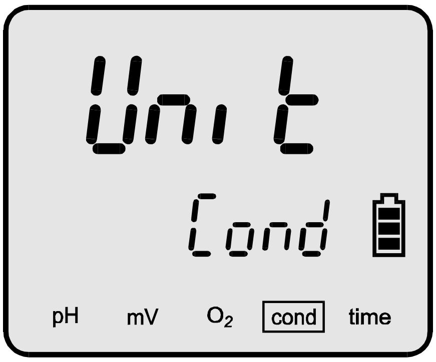
Before starting calibration and measurements it is necessary to perform all activities described in the chapter 6. Additionally, according to the chapter below, it is necessary to choose the unit in which the calibration and measurement are going to be made.

13.1. Choosing the unit

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

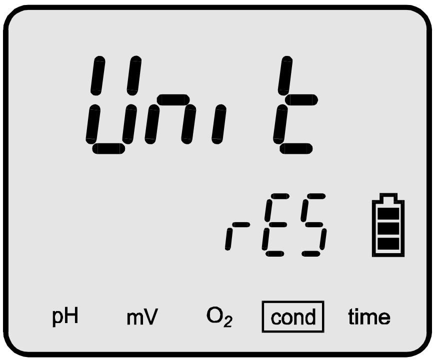
- in the conductivity measuring mode press the MODE button till the Unit (unit) symbol displays in the lower row on the LCD;
- with the ↙ , ↗ buttons choose in the lower row on the LCD:

Cond - measurement in conductivity units (Pic. 19.);



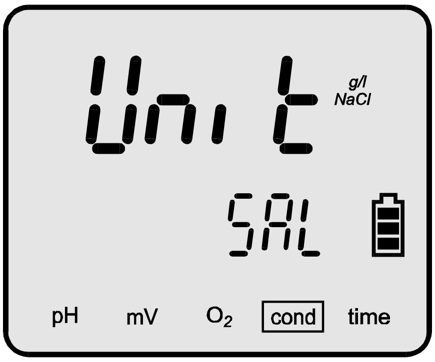
Pic. 19.

RES - measurement in resistivity units (Pic. 20);



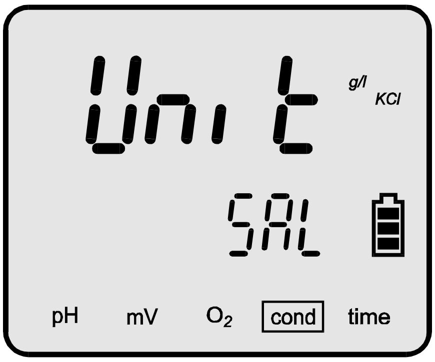
Pic. 20

SAL NaCl - result counted to NaCl in **g/l** (Pic. 21);



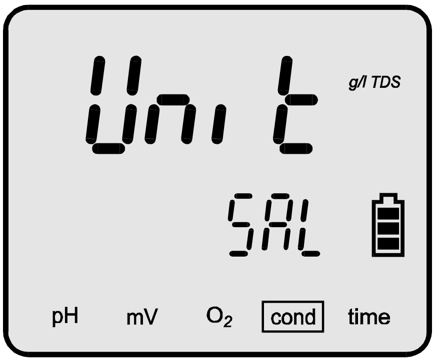
Pic. 21.

SAL KCl - result counted to KCl in **g/l** (Pic. 22);



Pic. 22.

SAL TDS- result counted to TDS in **g/l** (Pic. 23).



Pic. 23.

In case of the salinity measurement (**NaCl**, **KCl** or **TDS**), short press of the CAL button chooses displaying the result in % of weight concentration or g/l. Next to the Unit symbol the **%** or **g/l** symbol will be displayed.

- enter the measuring mode by pressing the FUNCTION button.

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

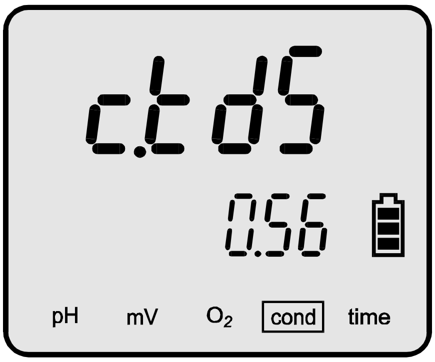
1% of weight concentration (C) = 10 000 ppm = 10 ppt

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:

- in the conversity measuring mode press the MODE button a few times till a c.tdS symbol (TDS coefficient) displays in the upper row on the LCD (Pic. 24);
- with the ↙ , ↗ buttons enter the correct value of the TDS coefficient;
- enter the measuring mode by pressing the FUNCTION button



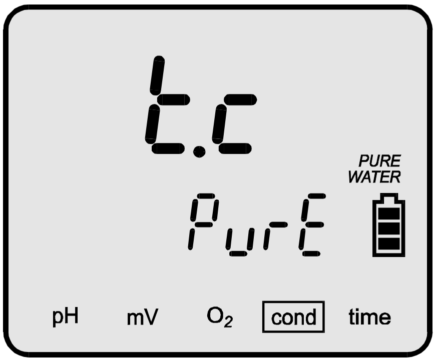
Pic. 24.

The way of determining the W_{TDS} coefficient is described in the section 17.2.

13.3. Choosing the type of the temperature compensation

In case of measurements in Cond and RES unit, depending on the type of measured solutions, it is possible to choose the most suitable way of compensating the conductivity changes in the temperature measurement function.
To choose:

- in the conductivity measuring mode press the MODE button until the display with types of temperature compensation displays (Pic. 25). The t.c symbol will appear (temperature compensation), and below the parameter chosen earlier will be displayed;
- With the ↙, ↗ buttons choose:
  - Lin - linear compensation with calculation of the entered α coefficient value;
  - nLin - non-linear compensation for natural water, on the right side of the display the **WATER** symbol will be displayed;
  - PurE - non-linear compensation for ultra pure water, on the right side of the display the **PURE WATER** symbol will be displayed;
  - NACL - non-linear compensation for ultra pure water with traces of neutral salt, on the right side of the display the **PURE WATER** symbol will be displayed;
  - HCL - non-linear compensation for ultra pure water with traces of acid, on the right side of the display the **PURE WATER** symbol will be displayed;
  - nAOH - non-linear compensation for ultra pure water with traces of alkalines, on the right side of the display the **PURE WATER** symbol will be displayed;
- return to the measuring mode by pressing the FUNCTION button



Pic. 25.

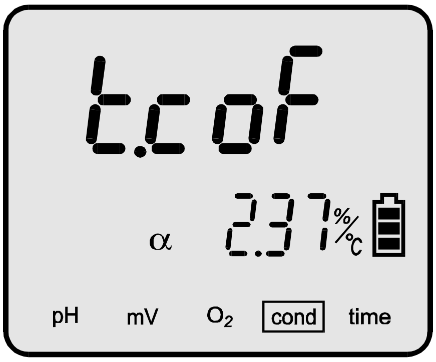
In case of measurements in the SAL unit with conversion to NaCl, KCl or TDS the t.c menu does not appear. Only linear compensation is possible.
The exact description for the natural and ultra pure water is given in the chapter 18.

13.4. Entering the α coefficient value

When the measurement is made in Cond and RES unit and the Lin (compenstion) has been chosen or in case of measurements with conversion to SAL (salinity), the α coefficient value may be entered. The range is 0 ÷ 10.00 % / ^{0}C with possibility of setting every 0.01 % / ^{0}C. For regular measurements it is advisable to adopt the most often used temperature coefficient α = 2 % / ^{0}C. In case of higher accuracy requirements it is necessary to determine the kind of measured solution and adjust the value of the coefficient.

To introduce the α coefficient:

- in the coductivity measuring mode press the MODE button until the α coefficient value displays (Pic. 26.). The tcoF (temperature coefficient) symbol will appear;
- with the ↙ , ↗ buttons enter the coefficient value.
- return to the measuring mode by pressing the FUNCTION button.



Pic. 26.

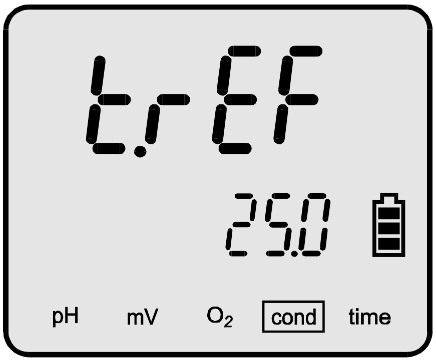
The result will be calculated with use of the introduced α temperature coefficient.

Simplified way of determining the α coefficient is described in the section 19.

13.5. Entering the reference temperature value

When the measurement is made in Cond and RES unit and the Lin (compenstion) has been chosen, the reference temperature value may be entered. The range is 10.0 ÷ 40.0 ^{0}C with possibility of setting every 0.1 ^{0}C. The most frequent value is 25 ^{0}C.
To enter the reference temperature:

- in the coductivity measuring mode press the MODE button until the reference temperature value displays (Pic. 27). The t.rEF (reference temperature) symbol will appear;
- with the ↙ , ↗ buttons enter the reference temperature value.
- return to the measuring mode by pressing the FUNCTION button.



Pic. 27.

The result will be calculated with use of the introduced reference temperature.

Note: pressing both ↙ , ↗ buttons simultaneously sets the temperature to 25 ^{0}C.

14. MAINTENANCE OF THE CONDUCTIVITY CELL

The recommended conductivity cell with a range 0 ÷ 500 mS/cm is sufficient for measurements in almost every type of liquids in maximal concentration. Metal electrodes are easy to clean and plastic body ensures higher durability.

In case of using platinum cells the electrodes **must not be cleaned mechanically**, because it results in rubbing off the platinum layer, what can cause decreasing of accuracy, lowering of stability and changing of the K constant. Measurements of liquids with oils and heavy sediment content may cause platinum contamination, make the measurement impossible and irreparably damage the electrodes.

To obtain stable readings it is advisable to soak the cell for an hour before the measurement. It is especially important in case of measurements in distilled water.

Maintenance of the cell consists in accurate rinsing the measuring cell with distilled water.

In case of fat content in the measured liquids it is possible to clean the electrodes by immersing the cell in acetone, chloroform, tetrahydrofuran or detergent.

Broken glass cell cannot be used due to significant K constant change, unstable readings and increase of the dependence of the result on the position of the cell in the measuring vessel. To obtain correct measurement results, the cell should be immersed in such a way for the solution to fill it up and not to include any air bubbles. The best way is to immerse the cell, make a few vertical moves and thus to remove air bubbles through holes in the upper part of the cell. If the air bubbles are difficult to remove, it is advisable to immerse the cell in a water – washing up liquid mixture, what lowers the surface tension and disables air bubbles to stick to the surface of the cell walls or electrodes. Next, wash the cell accurately with distilled water.

15. CALIBRATION

A characteristic feature of every conductivity cell is its K constant. Before displaying the reading the value is multiplied by the K constant value. The value of the K constant depends on the size of the electrodes' surface and the distance between them. If the user keeps the cell clean, the K constant is not changing. However, it is likely to change in case of contamination of the surface of the electrodes.
Calibration consists in introducing the K constant value cell given by the manufacturer (recommended)) or with use of standard solution with known conductivity – in order to determine the K constant. The meter enables calibration in 5 standard solutions. In practice, it is sufficient to calibrate in one solution of the value close to the anticipated measurement values.

The cell manufacturer precisely determines the K constant and using this value will be the most reliable. In case of the user's calibration it is necessary to apply fresh, accurately prepared standard solution, accurately thermostatic at 25^{0}C. When these conditions are not kept, the calibration will be burdened with error.

When using three cells, it is possible to store their characteristics under the C1, C2 or C3 symbol.

Entering the calibration mode irreversibly erases the K constant of the cell stored under the chosen cell number.

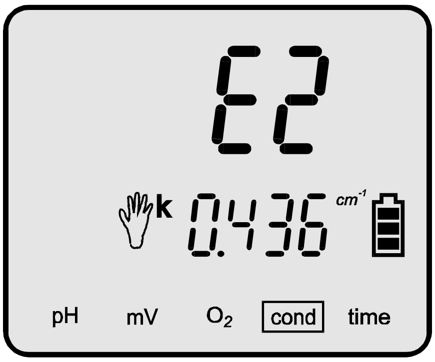
After choosing the cell number, entering the calibration mode and escaping it without making calibration, the stored K constant will be erased and the K constant = 1 cm^{-1} will be adopted. The erased characteristic is signalised by the meter with red colour of the cell number on the measuring screen.

15.1. Calibration without standard solution

The meter has a possibility of calibration without use of standard solution. In case of such calibration it is necessary to know the K constant of the conductivity cell. This value may be given by the manufacturer of the cell or may be determined using **CX-401** meter after calibration in standard solution.

To calibrate:

- in the measuring mode press the MODE button until the screen with the cell number (E1, E2, E3) and the K constant value displays (Pic. 28.). The ✋ symbol next to the K constant value corresponds to entering thew K constant manually. If calibration in standard solutions has been made earlier, than in the place of K constant value lines will be displayed;
- with the ↙ , ↗ buttons choose the cell number (E1, E2, E3);
- press and hold the CAL button, until the ***CAL*** symbol appears on the display;
- with the ↙ , ↗ buttons enter the K constant value;
- press the MODE button and return to the mode of choosing the cell number or enter the measuring mode by pressing the FUNCTION button.



Pic. 28.

15.2. Calibration with use of standard solutions

Calibration is made in order to determine the K constant of the cell. The meter enables 5-point calibration in standard solutions of freely chosen value. In case of 1-point calibration it is advisable to use a standard of value close to the anticipated value of the measured solution. Calibration requires high-quality standard solutions to be used. Calibration is made in currently chosen measurement unit (section 13.1).

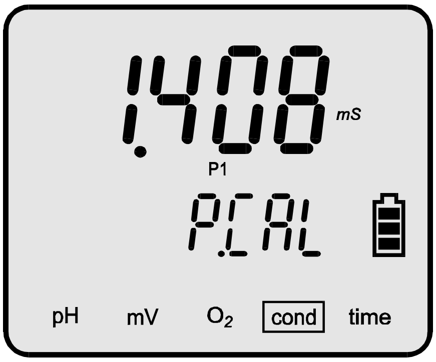
It is necessary to comply with the principles given below to obtain the exact results of calibration:

1. In case of calibration in more than one point first use the standard of the lowest conductivity value and finish with the solution of the highest conductivity value.
2. The temperature of the standard solution should be equal to the reference temperature (most often it is 25 ^{0}C), it is advisable to use a thermostat.
3. New, unused standard solution should be applied.
4. The cell and its electrodes should be clean and devoid of bubble of air.
5. The cell should be placed in an electrode holder.

15.2.1. Entering the standard solution values

In order to enter the values of the standard solutions:

- choose the unit according to the section 13.1;
- in the conductivity measuring mode press the MODE button till the P.CAL symbol appears in the lower row on the LCD (Pic. 29);
- with the CAL button, choose the point **P1** .... **P5**, of which value is to be entered;
- with the ↙ , ↗ buttons enter the value of the standard solution in the upper row on the LCD;
- with the CAL button choose next points or enter the measurintg mode by pressing the FUNCTION button.



Pic. 29.

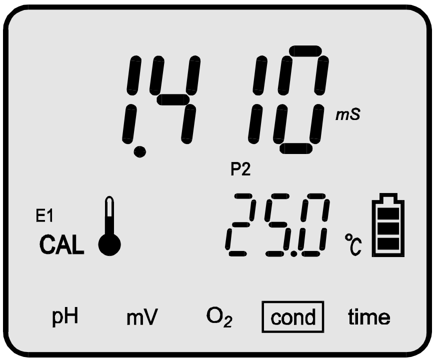
15.2.2. Calibration with automatic temperature compensation

It is necessary to:

- enter the value of standard solution (point 13.1);
- connect the conductivity cell and the temperature probe;
- immerse both of them in the first standard solution, hold the conductivity cell at least 1 cm away from the bottom and the walls of the vessel. The measuring cell should be filled up with the measured solution, there should not be any air bubbles and the electrodes should be evenly moistened*;
- measure the temperature of the solution and bring it to the **introduced value of reference temperature**;
- press and hold the CAL button until the ***CAL*** symbol appears on the display (Pic. 30).
- with the MODE button choose the calibration point corresponding to the standard solution value, the point number (P1...P5) and the value entered for this point will apear for a moment;
- wait till the value stabilises and press the CAL button. Blinking reading informs about recording it in the memory. If the Err symbol displays, it is necessary to check the introduced value of the standard solution;
- immerse the conductivity cell and the temperature probe in the next solution and with the MODE button choose its value to calibrate in the next points

or

- exit the calibration mode by pressing the FUNCTION button.



Pic. 30.

The meter is calibrated and ready to work.

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

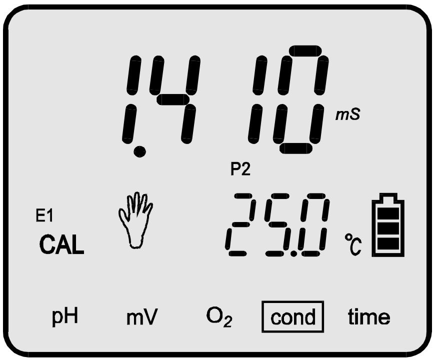
15.2.3. Calibration with manual temperature compensation

It is necessary to:

- turn the meter on with the FUNCTION button;
- choose the conductivity measuring mode (section 13.1);
- disconnect the temperature probe and press the ↙ , ↗ buttons simultaneously. In the lower line of LCD an introduced reference temperature value will appear (section 13.5);
- enter the value of the standard solutions (point 15.2.1);
- immerse the conductivity cell in the first standard solution and hold it at least 1 cm away from the bottom and walls of the vessel. The measuring cell should be filled up with the standard solution and should not include any air bubbles, the electrode's surface should be evenly moistened*;
- measure the temperature of the standard solution with a laboratory thermometer and adjust it to the set reference temperature;
- press and hold the CAL button until the ***CAL*** symbol appears (Pic. 31).
- with the MODE button choose the calibration point corresponding to the standard solution value, the point number (P1...P5) and the value entered for this point will apear for a moment;
- wait till the value stabilises and press the CAL button. Blinking reading informs about recording it in the memory. If the Err symbol displays, it is necessary to check the entered value of the standard solution;
- immerse the conductivity cell and the temperature probe in the next solution and with the MODE button choose its value to calibrate in the next points

or

- exit the calibration mode by pressing the FUNCTION button.



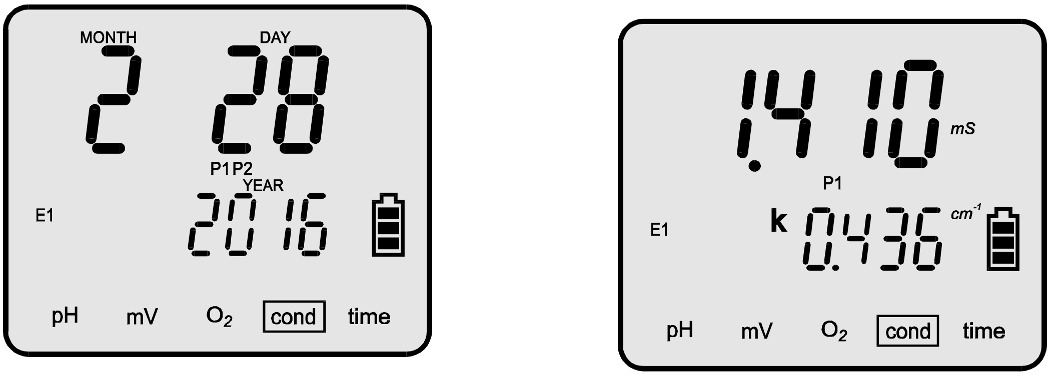
Pic. 31

The meter is calibrated and ready to work.

15.2.4. Readout of the K constant

When calibration in standards is finished, it is possible to check the K constant in each of the calibration points.
To do so:

- in the conductivity measuring mode press the MODE button until the cell number displays (E1, E2, E3). In the place of the K constant value the lines will be displayed. Between the upper and the lower line the points are shown, in which the cell was calibrated. If the K constant value appears below the cell number, it informs that it has been entered manually (without using standards);
- pressing shortly the CAL button enables checking the calibration date (Pic. 32A), then the calibration point value (at the top of the LCD) and the K constant value (at the bottom of the LCD) for all the calibration points (Pic. 32B);
- return to the cell number choosing mode pressing the MODE button or enter the measuring mode by pressing the FUNCTION button.



A B

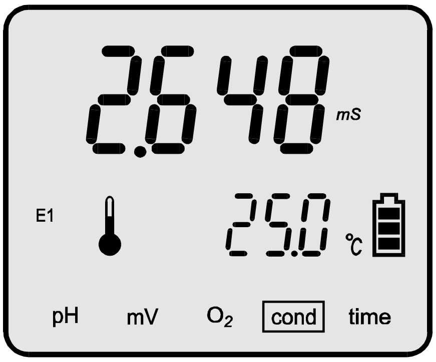
Pic. 32

16. CONDUCTIVITY MEASUREMENT

16.1. Measurement without the temperature compensation

An accurate conductivity measurement should be made without the temperature compensation. The measured solution should be adjusted to the reference temperature value introduced earlier, using the temperature measuring function in the meter. In case of working without the temperature probe it is necessary to introduce the temperature value with the ↙ , ↗ buttons.

To make measurement:
- connect the conductivity cell and the temperature probe to the **Cond** and **t** connectors respectively (Pic. 2);
- switch the meter on with the FUNCTION button;
- choose the conductivity measuring mode and the unit (section 13.1);
- if the conductivity cell was not calibrated, calibrate it according to the chapter 15;
- immerse the conductivity cell and the temperature probe in the standard solution and hold the conductivity cell at least 1 cm away from the bottom and walls of the vessel. The measuring cell should be filled up with the standard solution and should not include any air bubbles, the electrode's surface should be evenly moistened*;
- adjust the temperature of the measured solution to the reference temperature;
- after stabilisation check the reading (Pic. 33).



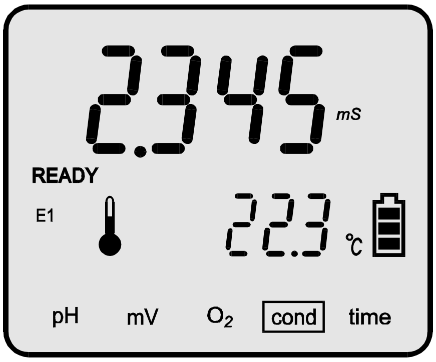
Pic. 33.

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

16.2. Measurement with automatic temperature compensation

In order to make a measurement with automatic temperature compensation:

- connect the conductivity cell and the temperature probe to the connectors **Cond** and **t** respectively (Pic. 2);
- switch the meter on with the FUNCTION button;
- choose the conductivity measuring mode and the unit (section 13.1);
- if the conductivity cell was not calibrated, calibrate it according to the chapter 15;
- check or change the value of the reference temperature and the α coefficient;
- immerse the conductivity cell and the temperature probe in the standard solution and hold the conductivity cell at least 1 cm away from the bottom and walls of the vessel. The measuring cell should be filled up with the standard solution and should not include any air bubbles, the electrode's surface should be evenly moistened*;
- after stabilisation check the reading (Pic. 34).



Pic. 34.

Note: in case of exceeding the range of temperature compensation the result starts blinking even though the conductivity measuring range has not been exceeded.

Displaying of the ✋ symbol instead of 🌡 next to the value informs that the temperature probe is broken.

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

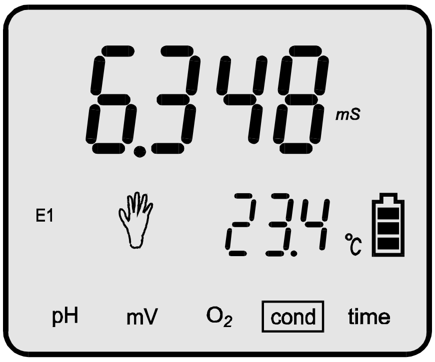
16.3. Measurement with manual temperature compensation

Measurement with manual temperature compensation may be made in stable work conditions, e.g., during measurements in laboratory, especially with use of thermostat, or in case of the temperature probe damage. Disconnecting of the temperature probe switches the meter to manual temperature compensation.

In case of measurement with manual temperature compensation:

- connect the conductivity cell to the **Cond** connector (Pic. 2);
- disconnect the temperature probe;
- switch the meter on with the FUNCTION button;
- choose the conductivity measuring unit (section 13.1);
- if the conductivity cell was not calibrated, calibrate it according to the chapter 15);
- check or change the value of the reference temperature and the α coefficient;
- immerse the conductivity cell in the standard solution and hold it at least 1 cm away from the bottom and walls of the vessel. The measuring cell should be filled up with the standard solution and should not include any air bubbles, the electrode’s surface should be evenly moistened*;
- measure the temperature of the solution with a laboratory thermometer and enter the value with the ↙ , ↗ buttons;
- after stabilisation check the reading (Pic. 35).

Note: pressing the ↙ , ↗ buttons simultaneously sets the temperature to the reference temperature value.



Pic. 35.

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

17. SALINITY AND TOTAL DISSOLVED SOLIDS 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 to determine, after certain calculations, salinity of the measured solution in concentration units (g/l or %), or to determine the TDS (Total Dissolved Solids). The received values are always approximate and the total accuracy depends on the way of making calculations, concentration of the measured solution and its temperature. In most salinity meters a simplification is used, that dependence between 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 is received in g/l, e.g., if the conductivity value is 2 mS/cm the salinity is 1g/l. In practice the dependence between conductivity and salinity is not linear and the conversion coefficient is changing together with the concentration and temperature. Table 3 shows the dependence between conductivity and real salinity of NaCl solution in temperature 25 ^{0}C and values of salinity counted for constant coefficient 0.5. This comparison shows that using a constant coefficient for greater concentrations introduces significant error.

Table 3

Conductivity (mS/cm)	Salinity (g/l)	Salinity (g/l) calculated for coef. = 0.5	Error (%) for coef. = 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 bases calculations on actual dependence between conductivity and salinity what greatly reduces the error. There is a possibility of counting the salinity in NaCl or KCl, because the dependence for these two salts is slightly different.

The results are more accurate for homogeneous solutions (NaCl, KCl). Concentration of salts mixture with unknown composition in most cases is counted to NaCl. The usefulness of water for home or industry is usually checked by determining TDS. In order to use the conductivity readout for determining the TDS it is necessary to specify the W_{TDS} coefficient, which enables automatic conversion after having introduced it to the meter's memory. 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 water, evaporating the filtered sample, drying it to constant weight in temperature $103\div105^0$C, weighting and counting in volume ratio (mg/dm^3). The received weight is lower than total dry mass in water because apart from the dissolved solids it contains also undissolved substances that are removed by filtering before evaporating. It is possible to determine the approximate Total Dissolved Solids content using the conductivity readout on the assumption that the salt's composition in the taken samples has not been changing significantly.

17.1. Salinity measurement with conversion to NaCl or KCl

The measurement of salinity with conversion to NaCl or KCl content is made in the following way:

- choose the salinity measurement with conversion to NaCl or KCl content according to the section 13.1;
- choose the unit (g/l or %);
- then act as during the conductivity measurement (chapter 16);
- after stabilisation check the reading.

17.2. Determining the W_{TDS} coefficient

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

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

$$W_{TDS} = \frac{TDS}{\gamma}$$

where:

W_{TDS} - TDS coefficient
TDS - Total Dissolved Solids in g/l;
γ - conductivity of the sample in mS/cm;

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

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

$$W_{TDS} = \frac{TDS}{\gamma}$$

where:

W_{TDS} - TDS coefficient
TDS - Total Dissolved Solids in g/kg;
γ - conductivity of the sample in mS/cm;

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

17.3. The salinity measurement with conversion to TDS

The measurement of salinity with conversion to TDS should be made in the following way:

- determine the W_{TDS} coefficient according to the section 17.2;
- enter the W_{TDS} coefficient according to the section 13.2;
- choose the salinity measurement with conversion to TDS and the displayed unit (g/l or %);
- than act as during conductivity measurement.
- after stabilisation check the reading.

18. NOTICES ABOUT TEMPERATURE COMPENSATION

18.1. Natural water

The meter enables reduction of the temperature compensation error in case of measurements in natural water with conductivity in range 60 µS/cm ÷ 1 mS/cm. Natural water is the surface water and the ground water. Compensation may be applied in the temperature range 0 ÷ 37 ºC. The coefficient values for natural water have been entered to the meter‘s memory and are calculated in counting process. After choosing non-linear compensation (nLin) from the menu the meter will calculate the relevant parameters.

18.2. Ultra pure water

The most accurate conductivity readings will be obtained in the reference temperature without temperature compensation. In case of measurements in ultra pure water with conductivity up to 10 µS/cm proceeded with temperature compensation, the measurement accuracy has been improved with use of a special function in the meter which enables automatic detection of the most suitable α coefficient depending on temperature of the measured solution.

A distinction has been made among four types of ultra pure water (UPW):
UPW - ultra pure water without contamination (C=0.055µS/cm at 25.0ºC).
UPW $_{\mathrm{NaCl}}$ - ultra pure water with traces of neutral ions (e.g. NaCl);
UPW $_{\mathrm{HCl}}$ - ultra pure water with traces of acidic ions (e.g. HCl);
UPW $_{\mathrm{NaOH}}$ - ultra pure water with traces of alkaline ions (e.g. NaoH).
Trace contamination usually appears as a result of water filtration and depends on types of applied filters.
Temperature changes cause the α coeffcient changes. The most significant change appears in case of water without trace contamination.
The table below describes the changes.

In case of water with conductivity C=0.5µS/cm at 25 ºC the α coefficient values at other temperature are as follows:

	T=26.0ºC		T=50.0ºC		T=69.9ºC	
	conductivity	α coef.	conductivity	α coef.	conductivity	α coef.
UPW	0.532µS/cm	5.81%	1.50µS/cm	8.55%	3.20µS/cm	11.96%
UPW NaCl	0.512µS/cm	2.07%	0.77µS/cm	2.15%	1.00µS/cm	2.20%
UPW HCl	0.508µS/cm	1.47%	0.67µS/cm	1.41%	0.81µS/cm	1.36%
UPW NaOH	0.512µS/cm	1.83%	0.72µS/cm	1.72%	0.88µS/cm	1.68%

In case of ultra pure water without trace contamination it is possible to compensate to the chosen reference temperature. For water with trace contamination compensation is calculated for 25 ºC.
The user has to determine the type of contamination in the measured water and choose the relevant option which will enable to calculate conductivity for the reference temperature.
In case of measurements in ideally clear water, the PurE compensation has to be chosen from the menu.
If water contains trace contamination (it is the most frequent case), knowing the type of contamination (acidic, alkaline or neutral) enables to choose relevant compensation option. If we know that water is not ideally clear but we do not know the type of contamination, the best solution is to choose compensation for contamination with neutral salts - nACL **PURE WATER .**

Ultra pure water is a strong solvent. When it is exposed to air even for a short time, its conductivity changes to about 2 ÷ 3µS/cm as a result of dissolution of CO_2 in it. Therefore, measurements in open vessels may result in additional error.
Using the same cell for measurements in both salty and ultra pure water may also cause erroneous readings. It is crutial to carefully and accurately rinse the cell. Sistematically rising measurement values may signalise that the cell was not cleaned sufficiently and the remains of chemical compounds from the cell infiltrate into the measured water. It is advisable to use a separate cell for measurements in ultra pure water.
In order to improve accuracy, it is advisable to use a flow cell connected in the by-pass outflow of the ultra pure water. The materials used in the supply circuit should not be soluble in water. In case of making pH measurements in the same circuit, the pH electrode should be placed as the second one, behind the conductivity cell.
The cell has to be accuratelly rinsed, especially before first measurements. It may last even 24h to rinse the cell with flowing ultra pure water until the cell is clean.

19. SIMPLIFIED WAY OF DETERMINING THE α COEFFICIENT

The knowledge of α coefficient has a crucial significance during measurements in temperatures different than the reference temperature.
This coefficient is changing together with the temperature and concentration.
Table 4 contains values of α coefficient in 25 ^{O}C for a few compounds with determined weight concentration.

Table 4

compound	**Weight concentration**	**α coefficient**
HCl	10 %	1.56
KCl	10 %	1.88
H_2SO_4	50 %	1.93
NaCl	10%	2.14
HF	1.5 %	7.20
HNO_3	31 %	1.39

Table 5 contains rough values of α coefficient for KCl and NaCl depending on the temperature and concentration of the measured liquid.

Table 5

temp. `^{0}C	**α temperature coefficient**			
	KCl solution			**saturated 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

Use the value of the α coefficient determined for the reference temperature to which the meter calculates the result**.**

It may be assumed that the α coefficient is constant in the range ±5 ^{0}C from the reference temperature.

For more significant differences between the measurement and reference temperatures the value of the α coefficient may be determined according to the description below:

1. Adjust the temperature of the measured solution to the reference temperature (**T_R**) and measure its conductivity (**G_{TR}**).
2. Change the solution temperature **T_X** to the value in which the measurement is going to be made.
3. Turn the meter to manual temperature compensation by disconnecting the temperature probe.
4. Enter the value of reference temperature **T_R** with the keyboard.
5. Measure the conductivity of the solution again. This value will be different than in **T_R** temperature (**G_{Tx}**).
6. Determine the α coefficient using the following formula:

$$\alpha = \frac{G_{TR} - G_{TX}}{G_{TR}\,(T_R - T_X)} \times 100\ (\%/^0C)$$

where:

T_R - reference temperature in ^{0}C
T_x - changed temperature in ^{0}C
G_{TR} - conductivity at T_R reference temperature
G_{Tx} - conductivity at T_x temperature

Now, the α coefficient is determined for the reference temperature T_R and the measurement temperature T_x.

In case of measurements at temperatures different than the reference temperature it is necessary to introduce the calculated α coefficient value for the measurement temperature.

In case when the T_R reference temperature is equal to 25°C the formula is:

$$\alpha = \frac{G_{25} - G_{Tx}}{G_{25}\,(25 - T_X)} \times 100\ (\%/^0C)$$

where:

T_x - value of the changed temperature in ^{0}C
G_{25} - conductivity measured in **25 ^{0}C**.
G_{Tx} - conductivity measured in temperature T_x

IV. OXYGEN CONCENTRATION MEASUREMENT

20. BASIC INFORMATION ABOUT OXYGEN MEASUREMENT

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

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

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

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

Long-lasting storage of the sensor without performing any measurements (more than 2 months) requires removing of the electrolyte. After this period the container must be filled with a fresh electrolyte and the sensor stored in distilled water for about 24 hours.

Accurate measurement result is determined by the condition of the membrane. The membrane must be free of any cracks (appearing of electrolyte-drops or white spots when dry). Before measurement the sensor should be activated by storing in distilled water for about 15 minutes. Strongly polluted wastewater after some time causes clogging of the membrane, which is recognised by inability to calibrate the device at 100% oxygen content (the calibration range becomes too narrow). In both cases the membrane should be replaced according to the manufacturer's instructions. When replacing the membrane and replenishing the electrolyte it is important to pay attention if there are no air bubbles in the container beneath the membrane, because otherwise the measurements would be falsified. In such case the container should be twisted off and the bubbles removed by tapping it against the table, next the electrolite should be refilled and the sensor assembled.

Depending on thickness of the membrane, awaiting time for a stable result is about 1 - 1,5 min. Accuracy of the measurement is connected with the temperature of calibration and measurement. The greater the difference of these temperatures, the greater the measurement error. For measurements of concentration in the range 30 ÷ 80%, it is sufficient to make one-point calibration in 100% oxygen concentration. For measurements in solutions with low oxygen content (about a few %) the calibration should be also made in 0% solution. Clean water contains about 60 ÷ 80% oxygen. Waste water and chemical solutions are in general less saturated with oxygen but liquids with forced aeration are much more saturated than clean water. When performing accurate measurements, the sensor's manufacturers recommend carrying out calibration just before the measurement since after some time the sensor's parameters are changing. Even the best oxygen sensors have so-called drift about ±1%/24 h. Wide measuring range in **CX-401** multifunction meter enables making measurements in water permeated with oxygen, i.e. with blooming and growing plants, where during the photosynthesis process large quantities of oxygen are produced.

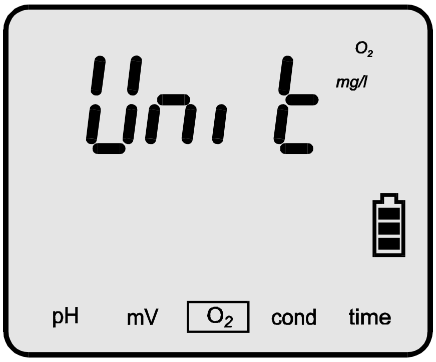
21. ENTERING THE OXYGEN MEASUREMENT PARAMETERS

21.1. Changing the unit

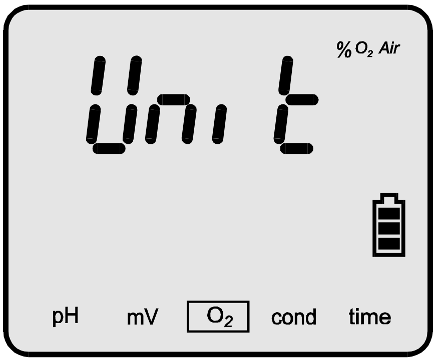
The measurement result can be displayed in % of the oxygen saturation or in **mg/l**. In case of measurements of ocygen saturation in air the reading can be displayed only in **%**.
To choose the unit:

- in the oxygen measuring mode press the MODE button until the Unit (unit) symbol displays in the upper row of the LCD;
- with the ↙ , ↗ buttons choose:

% O_2 - measurement of oxygen concentration in water in **%**;
mg/l O_2 - measurement of oxygen concentration in water in **mg/l** (Pic. 36);
% O_2 Air - measurement of percentage saturation of oxygen in air (Pic. 37).



Pic. 36.



Pic. 37

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

21.2. The salinity influence compensation

Salinity of the solution influences the oxygen solubility in water and has to be taken into consideration in case of measurements in mg/l. **1 g/l of salinity change causes about 0.5% of the oxygen concentration change.** The meter enables entering the salinity value in g/l and counts the change of the oxygen concentration in mg/l.

21.2.1. Automatic introduction of the salinity value

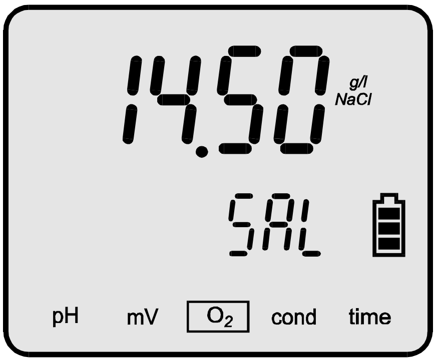
The meter enables automatic introduction of measured solution salinity. In order to do it:

- enter the conductivity measuring function by pressing the FUNCTION button;
- measure salinity of the solution in g/l unit with conversion to NaCl (accurate description in the section 17.1);
- after stabilisation of the salinity result enter the oxygen measuring mode by pressing the FUNCTION button;
- press the MODE button until the SAL (salinity) symbol displays in the lower row of the LCD;
- press the CAL button shortly; In the upper row of the LCD the value of the measured salinity in g/l will be displayed automatically. If after pressing the button an Err (error) symbol and next the previous value of salinity is displayed it informs that during the conductivity measurement the unit has not been changed for g/l of NaCl;
- return to the measuring mode by pressing the FUNCTION button.

21.2.2. Manual introduction of the salinity value

The salinity value can be determined on the basis of known conductivity of the measured solution. Table 6 shows the real dependence between salinity and conductivity counted in NaCl. In order to enter the salinity value:

- measure conductivity of the solution with any conductivity meter and read the salinity value from the table;
- in the oxygen measuring mode press and hold the MODE button until the SAL (salinity) symbol displays in the lower row of the LCD, Pic. 38;
- with the ↙ , ↗ buttons in the upper row of the LCD enter the salinity value read from the table;
- return to the oxygen measuring mode by pressing the FUNCTION button.



Pic. 38

Measurement in % does not require entering the salinity value.

Note: pressing the ↙ , ↗ buttons simultaneously sets the salinity value to 0.00 g/l NaCl.

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

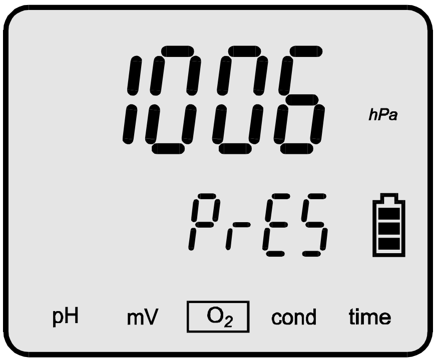
Table 6. Determining the salinity in g/l NaCl on the basis of conductivity in mS/cm (at 25°C).

21.3. Automatic compensation of the atmospheric pressure influence

The concentration of oxygen dissolved in water determined in mg/l depends directly on the atmospheric pressure value, which means that 10% pressure change causes also 10% oxygen saturation change. The meter enables automatic compensation with use of build-in atmospheric pressure sensor. This influence is automatically counted during measurements in **mg/l**.

There is a possibility of reading the atmospheric pressure value:

- in the oxygen measuring mode press the MODE button until the PrES (pressure) symbol appears in the lower row of the LCD, Pic. 39;
- the value of atmospheric pressure in hPa will appear in the upper row;



Pic. 39.

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

In case of measurement in % the atmospheric pressure does not influence the result.

22. CALIBRATION OF THE OXYGEN SENSOR

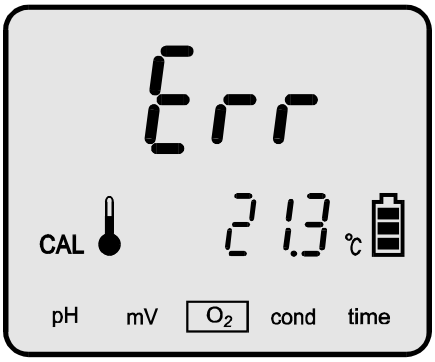
The meter cooperates with a galvanic membrane sensor of our production with measurement accuracy equal ±1%, provided that the measurement is performed at the same temperature as calibration. The bigger the difference in the measurement and calibration temperature, the lower the accuracy. It is <3% when the temperature difference is ±5 ^{0}C and 5% for the difference ±10 ^{0}C. The calibration is performed to eliminate the measurement error arising from the individual characteristic of the sensor and should be repeated always before measurement with new sensor, after replacing the membrane or in case of high measurement accuracy requirements. Characteristic feature of sensors is a „signal drift“, which means that the longer interval between calibration and measurement, the lower measurement accuracy. Calibration is also recommended if temperature of the tested solution differs significantly from temperature in which the probe was calibrated, because then an additional error arises. **In such case it is recommended to prepare calibration solutions having approximate temperature to the predicted temperature of the tested solutions.**
If it is impossible to calibrate the device, the membrane of the sensor should be replaced according to the manufacturer’s instruction. This situation usually takes place if the membrane is strongly polluted or ruptured (sometimes almost invisibly). After replacing the membrane the sensor should be conditioned in water for 24 hours. Applied oxygen sensors require 1- or 2-point calibration in standard solutions. The meter has two values of the calibration points recorded: P1=0% and P2=100% (or 20.9**% Air**). During calibration in **0%** oxygen concentration solution (e.g. **saturated** sodium sulphite) its flow has to be provided by making round moves with the sensor. Calibration of the 100% point is made in the air, **after accurate washing the remains of 0% solution from the sensor with distilled water**. It is assumed that O_2 content in the air corresponds to 100% of saturation, what enables simplified calibration to be carried out.
1 point calibration is made only for 100% of oxygen concentration after a few minutes of soaking the sensor in distilled water.
In case of measurement of oxygen content in air let the fresh air in into the room. Usually, 1-point calibration in air is sufficient, as the zero point of the meter is at its resolution level.

Entering the calibration mode under the chosen sensor number erases the characteristic stored in the memory under this number

To calibrate:

- place the sensor in the vessel with 0% saturation solution (saturated sodium sulphite solution);
- press and hold the CAL button till the moment of appearing the ***CAL*** symbol in the bottom left corner of the display, the meter will enter the calibration mode and automatically change the unit to % (if it was previously set to measurement in **mg/l O_2**);
- when the reading stabilises, press the CAL button. The reading will blink, what will inform about recording the calibration value; at the same time the corrected reading (0%) will be displayed in the upper row of the LCD;
- take the sensor out, **rinse it accurately with distilled water** and leave it in the air;
- when the reading stabilises, press the CAL button. The reading will blink, what will inform about recording the calibration value; at the same time the corrected reading (100%) will be displayed in the upper row of the LCD;
- return to the measuring mode by pressing the FUNCTION button.

If after pressing the CAL button the meter is unable to detect the value of the standard solution (0% or 100%), an Err symbol displays for a moment instead of the reading (Pic. 40). In such case it is necessary to check the condition of the membrane in the sensor.



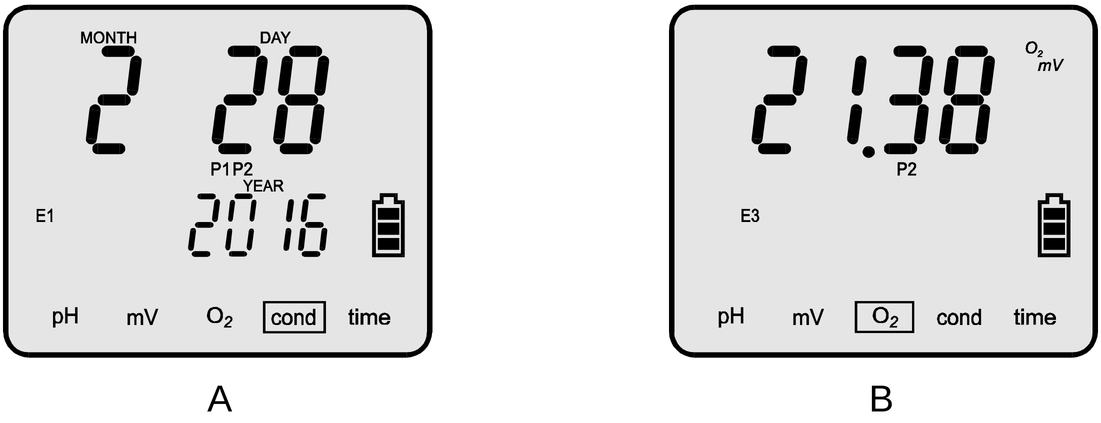
Pic. 40.

In case of choosing the sensor number, entering the calibration mode and escaping it without making calibration, the stored characteristic will be erased and a standard characteristic will be adopted.

22.1. Readout of the sensor parameters after calibration

When the pH electrode has been calibrated, it is possible to check its parameters: mV potential in the calibration points.
To check, in the oxygen measuring mode:

- press the MODE button until the sensor number shows at the upper part of the display (E1, E2 or E3 symbol);
- with the ↙ , ↗ buttons choose the number of the electrode that is to be checked and press the CAL button shortly. The last calibration date will be displayed in the following format: month – day – year (below), Pic. 41A. Between the upper and the lower row the points in which the sensor is calibrated are displayed;
- press the CAL button again, the reading in the P1 point will be visible in the upper row of the display;
- press the CAL button once again, the reading in the P2 point will be visible in the upper row of the display (Pic. 41B);



A

B

Pic. 41

Return to the electrode number readout by pressing the MODE button, and to the measuring mode by pressing the FUNCTION button.

23. MEASUREMENT OF DISSOLVED OXYGEN CONCENTRATION IN WATER

Before starting the oxygen concentration measurement the meter should be prepared for work (chapter 6) and the oxygen sensor calibrated (chapter 22). The measurement in **%** of saturation does not require additional measurements of the temperature, salinity or atmospheric pressure. **However, measurements in mg/l, which are more frequent, depend on these factors.** This influence is corrected automatically by the device, which takes into consideration the temperature value measured by the sensor or - in case of manual compensation - the value entered by the user. The oxygen sensor is equipped with an additional system compensating the temperature influence on the membrane. Because of limited accuracy of this compensation the highest accuracy can be achieved by calibrating the sensor at the same temperature at which the measurement will be carried out. **The measurement error increases together with the difference between the calibration and measurement temperatures and results from characteristic features of the sensor, not the device.** For the applied sensor this error is equal about < 3% at $\pm 5^0$C temperature difference and increases to 5% at a $\pm 10^0$C temperature difference.

If higher accuracy is required, the interval from the last calibration must be additionally taken into consideration (signal drift). If the salinity of the tested solution is insignificant, the measurement can be started without entering its value (value 0.00 g/l should be entered). **Before making accurate measurements, the salt content in the tested solution should be determined.** The easiest way to determine salinity is conductivity measurement with conversion to NaCl. The salinity value is introduced according to the section 21.2.

23.1. Measurement with automatic temperature compensation

In order to make measurement with automatic temperature compensation:
- connect the oxygen sensor and the temperature probe to the **O2** and **t** connectors respectively (Pic. 2), the 🌡 symbol will appear;
- immerse the oxygen sensor and the temperature probe in the measured solution;
- switch the meter on with the FUNCTION button;
- choose the measuring function with the FUNCTION button;
- choose the unit according to the section 21.1;
- in case of accurate measurements in **mg/l** enter the salinity value (section 21.2);
- check or simulate flow of the measured solution;
- wait about 1 min until the reading stabilises and check it.

23.2. Measurement with manual temperature compensation

In order to make measurement with manual temperature compensation:
- disconnect the temperature probe;
- switch the meter on with the FUNCTION button;
- choose the measuring function with the FUNCTION button;
- choose the unit according to the section 21.1;
- in case of accurate measurements in **mg/l** enter the salinity value (section 21.2);
- immerse the oxygen sensor in the measured solution;
- measure the temperature of the solution with a laboratory thermometer;
- with the ↙ , ↗ buttons enter the temperature value of the measured solution into the lower row of the LCD (pressing of both ↙ , ↗ buttons simultaneously sets the temperature to 20°C);
- check or simulate flow of the measured solution;
- check the reading when it stabilises.

In case of measurement series it is possible to adjust the temperature compensation each time the temperature of the solution changes.

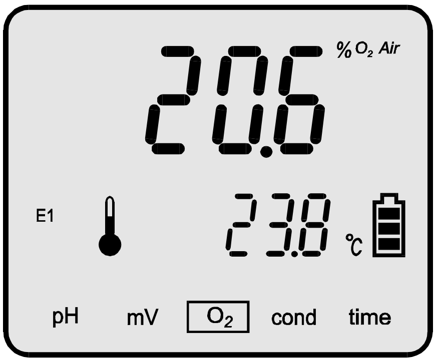
Uwaga: in case of measurements in solutions with low salinity, check according to the section 21.2 if the introduced salinity value is equal 0.00 g/l.

24. MEASUREMENT OF OXYGEN SATURATION IN AIR

Before starting the oxygen saturation measurement, the meter should be prepared for work (chapter 6) and the oxygen sensor calibrated (chapter 22). The oxygen saturation measurement does not require additional measurements of temperature, salinity and atmospheric pressure.

In order to make measurement:

- connect the oxygen sensor to the **O2** connector (Pic. 2);
- leave the oxygen sensor in the air;
- switch the meter on with the FUNCTION button;
- choose the measuring function with the FUNCTION button;
- choose the unit according to the section 21.1;
- check the reading when it stabilises (Pic. 42).



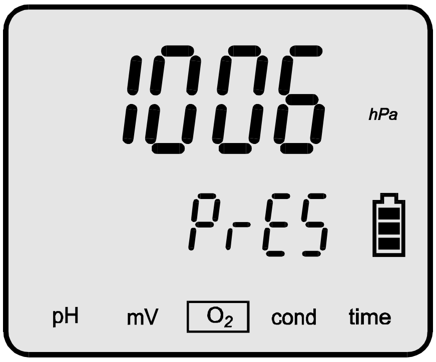
Pic. 42

V. ATMOSPHERIC PRESSURE MEASUREMENT

25. ATMOSPHERIC PRESSURE MEASUREMENT

The meter enables atmospheric pressure measurement. In order to read its value:

- turn the meter on by pressing the FUNCTION button;
- with the FUNCTION button choose the oxygen measuring mode (**O_2**);
- press the MODE button until the PrES (pressure) symbol dispalys in the lower row of the LCD;
- in the upper row the value of the pressure in hPa will be displayed (Pic. 43);



Pic. 43.

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

VI. REDOX POTENTIAL AND TEMPERATURE MEASUREMENT

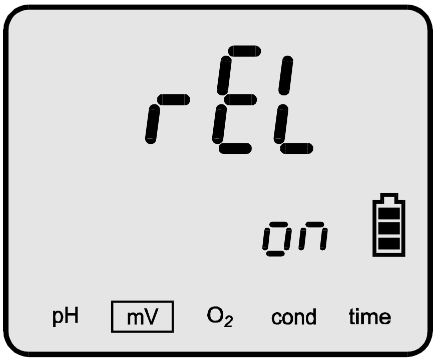
26. ENTERING THE POTENTIAL MEASUREMENT PARAMETERS

Before starting measurement choose the mode of measurement and, if necessary, enter the potential offset value.

26.1. Choosing the mode of measurement

The meter may display an absolute or relative potential reading. To choose the required mode of measurement:

- in the redox potential measuring mode press the MODE button until the rEL (relative) symbol will be displayed in the upper row;
- with the ↙ , ↗ buttons choose in the lower row:
  - on - the relative measurement is on, the difference betwen the measurement value and entered reference potential value will be displayed;
  - oFF - the relative measurement is off, the absolute potential measurement value will be displayed.
- return to the measuring mode by pressing the FUNCTION button.

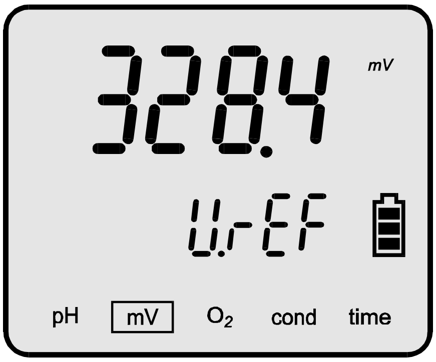


Pic. 44.

26.2. Entering the reference potential value

After choosing the mode of displaying the relative potential reading enter the reference potential value. To enter:

- in the redox potential measuring mode press the MODE button until in the upper row the U.rEF (reference potential) symbol will be displayed (Pic. 45.);
- with the ↙ , ↗ buttons enter the reference potential value or press the CAL button, the meter will substitute the value which was measured at the moment of pressing the MODE button;
- return to the measuring mode by pressing the FUNCTION button.



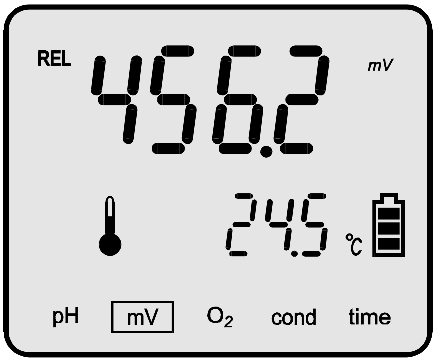
Pic. 45.

If the relative measurement has not been chosen (section 26.1), the reference potential screen will not appear.

Note: pressing the ↙ , ↗ buttons simultaneously sets the reference potential value to 0.0 mV.

27. REDOX POTENTIAL MEASUREMENT

CX-401 multifunction meter is an accurate redox potential meter. The measurement can be made with a special redox electrode or during titration. The reading may be checked after choosing the mV mode with the FUNCTION button. In case of switching the relative measurement mode on the REL symbol will be displayed on the left side of reading (Pic. 46).



Pic. 46.

28. TEMPERATURE MEASUREMENT

The temperature measurement is made in the following way:

- switch the meter on by pressing the FUNCTION button;
- connect the temperature probe to the Chinch connector, the 🌡 symbol will be displayed;
- put the temperature probe to the measured solution;
- wait till the value in the lower row stabilises and check the reading.

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

NOTE: break in the circuit of the temperature probe switches the meter to the manual temperature compensation mode. It is signalised by changing of the 🌡 symbol to the ✋ symbol. The value of the temperature entered by the user is shown.

Blinking -50℃ value while making measurement in positive temperature informs about short circuit in the temperature probe.

VII. OTHER

29. CLOCK WITH DATE

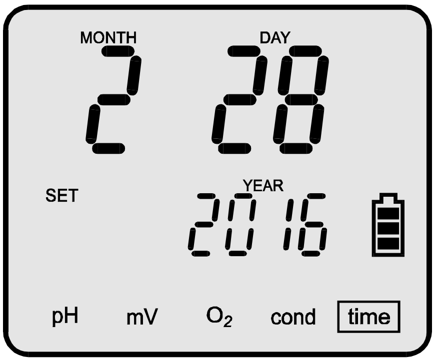
After choosing the **time** mode with the FUNCTION button the meter will display the current time. Pressing of the MODE button displays interchangeably: date, automatic switch off time, sound settings, backlight mode, software version number, serial number, date of production and date of manufacturer‘s calibration.

29.1. Clock

The time is displayed in two rows on the display. In the upper one hours and minutes are displayed and the lower one displays seconds. The way of setting time is displayed below.

29.2. Date

The date is displayed in the Month – Day – Year system (Pic. 47). In the upper row current month and day are displayed and in the lower row - current year.



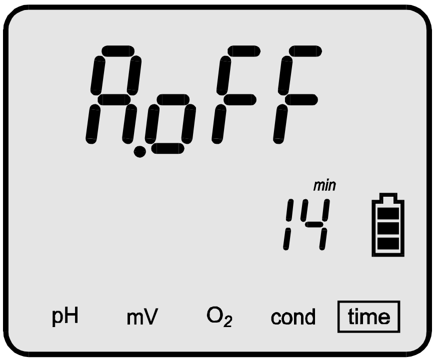
Pic. 47.

29.3. Setting time and date

Enter the mode of setting currently displayed parameter (hour or date) by pressing and holding the CAL button until the **SET** symbol will be displayed. The position, which is to be changed with the ↙ , ↗ buttons, starts blinking. To set the next position, press the CAL button shortly. The seconds are not settable, they reset after the setting mode has been left. Press the FUNCTION button to return to the **time** mode.

29.4. Auto switch off function

In order to choose the screen of setting the auto switch off function, the **time mode** press the MODE button until the AoFF (Auto OFF) symbol displays (Pic. 48). The lower row displays the time of switching off in minutes (the time is counted from the last press of any button). The value is changed with ↙, ↗ buttons. If after choosing 1 minute the button ↙ is pressed, instead of numbers the --- symbol displays. The auto off function is deactivated. Return to the **time** mode after pressing the FUNCTION button.



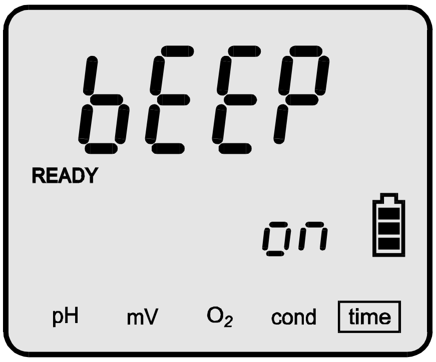
Pic. 48.

The auto switch off function is active only in case of working on the rechargeable battery. This function is deactivated during calibration, collecting series of measurements and in case of working with the USB power adapter.

29.5. Switching the sound on and off

The meter may signalise pressing each button and the stabilised reading with a sound. This function may be also deactivated by the user.
To do so:

- in the **time** function press the MODE button until the bEEP symbol appears in the upper row (Rys. 49);
- with the ↙ , ↗ buttons choose in the lower row:
  - oFF - sound signalisation off;
  - on - button sound signalisation on;
  - READY on - button and stabilised reading sound signalisation on.



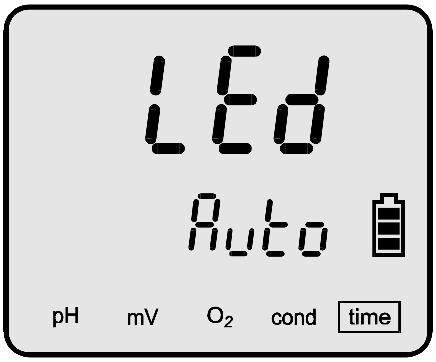
Rys. 49

Return to the **time** mode by pressing the FUNCTION button.

29.6. The LCD backlight mode

In the **time** mode press the MODE button till the LEd sign displays in the upper row of the LCD (Pic. 50). In the lower row the oFF, Auto or on parameter will be displayed.

- oFF - the backlight is switched off;
- Auto - the mode of automatic switching on of the backlight for 30 seconds (in the calibration mode 5 minutes) after pressing of any button;
- on - the backlight is always on.

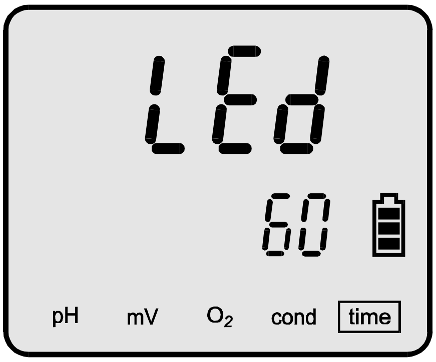


Pic. 50.

With the ↙ , ↗ buttons choose the backlight mode.
Return to the **time** mode after pressing the FUNCTION button.

29.7. The brightness control

Controling brightness of the backlight is especially important during the field work. Setting the brightness to 50% makes the work time on one set of batteries two times longer, with brightness which is sufficient for work.
While choosing the backlight mode (section 29.6) it is possible to control brightness (only for the Auto and on mode) by pressing the CAL button shortly. Instead of Auto or on parameter the value of brightness in % displays. With ↙ , ↗ buttons it is possible to set the brightness value from 10 ÷ 100%, with every 10%.



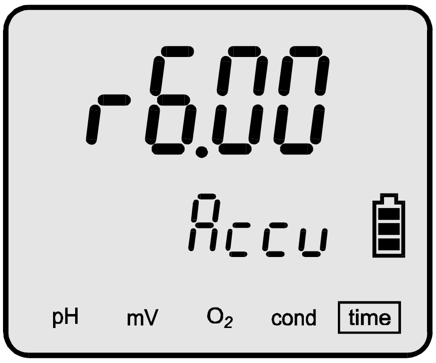
Pic. 51

With the ↙ , ↗ buttons choose the backlight mode.
Return to the **time** mode after pressing the FUNCTION button.

29.8. Readout of the software version number, date of production and date of manufacturer‘s calibration

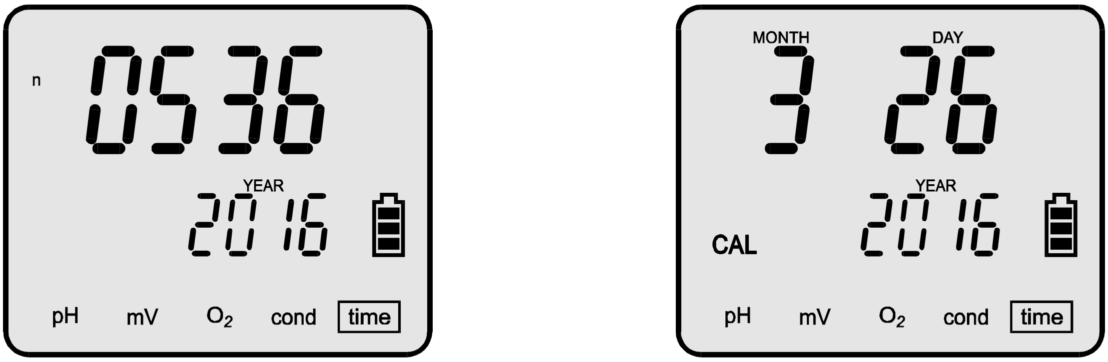
In the **time** function press the MODE button till there is a screen displayed, as in the picture below (Pic. 52). The upper row displays the software version number and the lower row shows the kind of internal power source to which the meter is prepared:

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



Pic. 52.

Pressing shortly the CAL button, check: serial number with date of production (Pic. 53A) and manufacturer‘s calibration date (Pic. 53B).



A B

Pic. 53

Return to the **time** mode after pressing the FUNCTION button.

30. STORING AND READOUT OF THE RESULTS

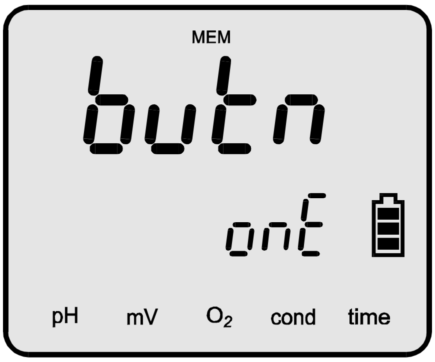
The meter enables storing of 4000 results of the currently measured function. The results are stored in EEPROM memory, which is non-volatile, therefore the data isn't lost even after complete lack of power. Before starting work it is necessary to choose the parameters of storing or readout of the stored results.

30.1. Parameters of storage and readout from the memory

The parameters are changed in the readout mode, which is entered from every measuring function by pressing and holding the MEM button, until the number of the most recently recorded readings shows. This number is displayed on turns with the stored reading.
Before recording, choose the way of collecting readings: on request or automatically in series, and also the way of displaying the reading.

Each press of the MODE button displays screens with the following parameters which may be changed:

a. butn - defining the MEM button functions (Pic. 54).



Pic. 54

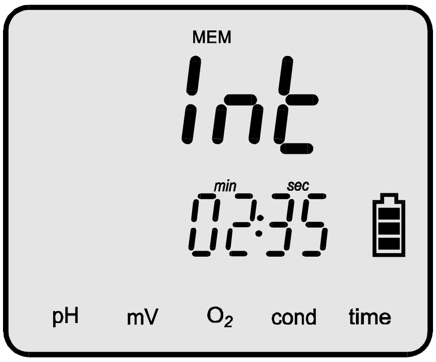
With the ↙ , ↗ buttons choose from the lower row:

onE - each press of the MEM button results in recording the current reading in the memory;

SEr - pressing the MEM button starts collecting the measuring series;

hold - pressing the MEM button in the measuring mode holds the reading until any button will be pressed;

b. Int - the interval between measurements when collecting series (Pic. 55).



Pic. 55

The Int symbol is displayed in the upper row and the time in the lower row. With the ↙ , ↗ buttons set the time in minutes and seconds.
The shortest time is 1 second, the longest - 60 minutes. Holding the button increases the change rate (repetition).
In case of setting the butn parameter to onE or hoLd the Int position does not appear.

c. ALL - the way of displaying the stored readings:

on - successively: number of the reading, the reading, time and date of recording the reading;

oFF - successively: number of the reading and the reading.

Change with the ↙ , ↗ buttons.

Return to the results readout display after pressing the MEM button.

Exit the readout mode after pressing the FUNCTION button.

30.2. Recording single readings

If recording single readings has been chosen according to the previous section, every press of the MEM button records a reading. The newest reading is recorded under the number after the last one. In case of checking the readings stored earlier and not returning to the last one, the readings will not be deleted and the value will be stored under the first empty position. In case of storing the reading beginning with the chosen number, first delete the readings starting from this particular number (as described in the section 30.5), and start collecting readings by pressing the MEM button.
While recording a reading, its number will be displayed for a moment.
If after pressing the MEM button instead of a number the End symbol is displayed, it informs that the maximal number of readings has been reached.

30.3. Collecting measuring series

There is a possibility to store series of measurements in the meter's memory. It is necessary to:
- choose the way of collecting the results serially (point 30.1.a);
- enter the time interval (point 30.1.b);
- delete stored readings starting from the chosen one (section 30.5);
- return to the measuring mode by pressing the FUNCTION button;
- with the FUNCTION button choose the function which readings are going to be stored;
- with the MEM button start collecting series. The measurements will be stored starting from the first free number.

Collecting series is signalised by blinking frame around the symbol of function of which results are being stored.

Each time the reading is recorded, its number displayed for a moment. Collecting series may be stopped by pressing the FUNCTION or the MEM button or by filling up the memory. If the series is not filling the memory totally, collecting the next series may be started until the end of the memory capacity.

30.4. Reviewing the readings

Reviewing stored readings is started in the measuring mode by pressing and holding the MEM button until the number of the last stored result displays on turns with its value.

Every press of the ↙ or ↗ button shows the next or the previous number and the result with time and date depending on which parameter of the ALL function has been chosen (description point 30.1.c).

In this mode the ↙ , ↗ buttons function with repetition and after holding them the numbers are changing with increasing rate till they stop at the highest or lowest number.

The reviewing mode is left by pressing the FUNCTION button.

30.5. Deleting stored readings

In order to delete stored readings:

- press and hold the MEM button;
- with the ↙ , ↗ buttons set the number from which deleting process is to be started;
- press and hold the CAL button; it will delete results from the chosen one to the last one stored. Instead of readings there will be the --- symbol displayed, what confirms deleting;
- to exit the reviewing mode press the FUNCTION button.

In case of filling up the memory capacity, further readings will not be stored. To store new readings it is necessary to delete the previous ones acting as it is described above. In case of deleting all the readings from the memory, it should be started from the first number.

31. CALIBRATION REPORT

During calibration process in each of the measurement functions the meter creates a calibration report, which includes information about calibration points, measurement results in this points and calculated parameters as: efficiency and offset of the pH electrode and K constant of the conductivity cell. The calibration time and date is also recorded in the memory. Apart from the last calibration report the meter stores data of 10 last calibrations in each of the measurement functions. The reports may be transmitted to a PC with use of the data transmission software and there they may be reviewed, edited or recorded on a hard drive. There is no possibility to read the report in the meter. All the process is described below.

32. COOPERATION WITH A PC

Connecting the meter with a PC enables storing the data directly on the computer, what makes possible number of samples to store unlimited. It is also possible to review collected series stored in the meter‘s memory and the user‘s calibration reports. A PC should be equipped with USB connector. For data transmission, use a special software of our production. After inserting the CD to a drive the installation program will start automatically. It is necessary to follow the given instructions.

In the upper wall of the meter the **microUSB** connector is placed for connecting it with the PC by USB.
After connecting, turn on the meter and the PC and launch the transmission software. In the SETUP / PORT menu choose USB. Next, choose the mode of cooperation with the meter. Choose among the following options:

- **“Collect series”** is used for collecting results of a current measurement. After choosing this option a window with the result of a current measurement displays. Only the elements which are marked in the field “Send” will be collected and stored. It is necessary to set the number of measurements which are to be stored and intervals between the storage processes. On the basis of this data the software will count the time of collecting the whole series. The series are stored in temporary file. In case of lack of power the collected data will be stored in a file “NoNamexx”. The collecting is started by pressing the “Collect” button.

- **“Download data from memory”** enables sending the chosen part or whole of the data stored in the meter’s memory to a file. In option “Collect” we mark the data we want to be sent. The transfer is started by pressing the button “Download”.

- "**Download calibration data**" only for the meters equipped with the calibration data memory (GLP). Choose measuring function in the meter to collect its report. In case of multifunction meters of the 460, 600 and 700 series it will be the main function.

  In this option choose:

"**Factory data**"	-	downloads the meter‘s data: name, serial number calibration date;
"**Last calibration**"	-	downloads only the last calibration in a chosen measuring function;
"**History of calibration**"	-	downloads all the stored calibrations in a chosen measurement function. The first downloaded calibration will be the most recent one.

After choosing an option and pressing the "Start" button the data are downloaded.

33. POWER, REPLACING THE RECHARGEABLE BATTERY

The meter is powered by two R6 rechargeable batteries or by **USB** power adapter with stabilised valtage 5V, which has to be conneccted to the **microUSB** connector (pic. 2). The rechargeable batteries are necessary to keep the clock working. The 🔋 symbol in the lower right corner of the LCD informs about efficiency of the rechargeable batteries. Blinking ▯ symbol informs that it is necessary to charge the batteries. When the voltage falls below the minimal value the meter switches off. Connecting the power adapter starts the process of charging the batteries, it is signalised by blinking elements in the 🔋 symbol. When this symbol starts lighting continuously, it informs that the battery is fully charged. During the charging process the meter can normally work. In order to replace the batteries, it is necessary to undo two screws in the lower wall of the meter, pull out the container with batteries and replace them, paying attention to insert the batteries properly. Next, put the new batteries into the meter and mount the wall. The wall has a sealing ring on the edge. While closing the meter, it is very important to pay attention if the ring is put inside the housing in the whole perimeter. Next, do the screws till the moment of resistance (not too hard). Leaving the wall improperly screwed may cause the meter’s inundation, which is not repaired under the warranty conditions.

34. 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} Ω
Temperature compensation:	manual/automatic
Compensation range:	-5.0 ÷ 110.0 °C
pH electrode calibration:	automatic, in 1 ÷ 5 points
pH electrode calibration range:	
Offset:	±0.7 pH
Efficiency:	85 % ÷ 105 %
Thermal stability of zero:	0.001 pH/ °C

Range of recognition and entering 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 ÷ 10,200
5	11,800÷ 14,000

Automatic change of the pH buffer’s value resulting from the temperature change for standards consistent with NIST (section 8.4) in range 0 ÷ 60 °C

mV MEASUREMENT:

range	resolution	accuracy (±1 digit)
-1999.9 ÷ 1999.9 mV	0.1 / 1 mV	±0.1 mV

Input impedance:	>10^{12} Ω
Relative measurement range:	±1999.9mV

CONDUCTIVITY MEASUREMENT:

ranges	resolution	accuracy[1] (±1 digit)	frequency[2]
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

[1] - accuracy corresponds to the end value of the range.

[2] - frequency changes range corresponds to the K constant = 1. For other K constant values the range will change proportionally to the changes of this constant.

Temperature compensation:	manual/automatic
Compensation range:	-5.0 ÷ 70.0 ^{0}C
K constant range:	0.010 ÷ 19.999 cm^{-1}
α coefficient range:	0.00 ÷ 10.00 %/ ^{0}C
TDS coefficient range:	0.20 ÷ 1.00
Measuring range for conversion to KCl:	0 ÷ 239 g/l
Measuring range for conversion to NaCl:	0 ÷ 296 g/l
Measuring accuracy for conversion to TDS:	1.0 %*
Measuring accuracy for conversion to KCl:	2.0 %
Measuring accuracy for conversion to NaCl:	2.0 %
Resistivity measuring range:	0.500 Ωcm ÷ 200 MΩcm
Resistivity measuring accuracy:	2.0 %

Cell calibration:

1. by entering the K constant of the cell
2. with use of max. 5 calibration solutions

* - for correct TDS coefficient value

MEASUREMENT OF OXYGEN CONCENTRATION IN WATER:

range	resolution	accuracy
0 ÷ 600.0 %	0.1 %	sensor's* ±1 digit
0 ÷ 60.00 mg/l	0.01 mg/l	sensor's* ±1 digit

* - accuracy of the sensor given in the chapter "Calibration of the oxygen sensor".

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

MEASUREMENT OF OXYGEN SATURATION IN AIR:

range	resolution	accuracy
0 ÷ 100.0 %	0.1 %	sensor‘s* ±1 cyfra

* - accuracy of the sensor given in the chapter "Calibration of the oxygen sensor“.

Sensor calibration:	
two-point	in 0% and 20.9% O_2
or one-point	in 20.9%O_2
Oxygen sensor:	membrane, galvanic

ATMOSPHERIC PRESSURE MEASUREMENT:

range	resolution	accuracy (±1 digit)
800 ÷ 1100 hPa	1 hPa	±2 hPa

Pressure sensor	HP03S

TEMPERATURE MEASUREMENT:

range	resolution	accuracy* (±1 digit)
- 50.0 ÷ 199.9 ^{0}C	0.1 ^{0}C	±0.1 ^{0}C

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

Temperature probe	Pt-1000 platinum resistor

Accuracy of the probe in the range 0 ÷ 100 ^{0}C:

with the Pt1000B resistor	±0.8 ^{0}C
with the Pt1000A resistor	±0.35 ^{0}C

OTHER:

Memory capacity:	4000 readings
Operating temperature:	-5 do 45 ^{0}C
Power:	2 x AA NiMH rechargeable battery 5V/1000mA USB adapter
Power consumption:	
0% backlight	70 mW
100% backlight	180 mW
battery charging	max. 2.4 W
Display:	LCD 55 x 45 mm
Dimensions:	149 x 82 x 22 mm
Weight:	260 g (with rechargeable batteries)

35. EQUIPMENT

The standard set includes:

1. Pt1000B temperature probe (standard).
2. Plastic container for the meter, electrode and temperature probe.
3. 5V/1000mA USB power adapter.
4. USB A – microB cable.
5. Data transmission software.
6. Manual with warranty.

Additional equipment:

1. Combination pH electrode (glass membrane).
2. Conductivity cell.
3. Oxygen sensor.
4. Adapter for connecting measuring and reference electrode in place of the combination electrode.
5. Pt1000A temperature probe of higher accuracy.
6. Ion selective electrodes.
7. Redox potential electrodes.

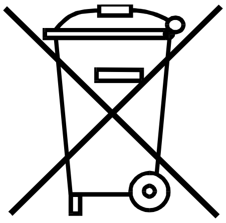
WARRANTY

The “ELMETRON” company provides 24 months of warranty for
CX-401 multifunction meter serial no. ....
In case of breakdown the manufacturer will repair the device within 14 days from the delivery date. The warranty does not cover breakdown caused by usage not in conformity with the manual, use of inappropriate power adapter, mechanical damage and breakdown caused by servicing or alterations made by unathorised individuals.
<u>Conductivity cell, oxygen sensor and pH electrode are equipped with separate warranties.</u>

Note: Before sending the meter for servicing contact us by phone or email.
<u>Always include applied pH electrode, conductivity cell, oxygen sensor, temperature probe, warranty with the date of sale and power adapter.</u>

We also provide after warranty repair service.

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



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