WATERPROOF MULTIFUNCTION METER

CX-461

USER'S MANUAL

ELMETRON

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WATERPROOF
MULTIFUNCTION METER

CX-461

Read the instructions carefully before use

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 lifespan 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.** To avoid such situations it is necessary to choose a kind of electrode suitable 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 a pleasant and trouble-free work with our meter.

2. CHARACTERISTICS OF THE METER

CX-461 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, which can display readouts of four different measurement functions simultaneously. Thanks to its touchscreen keyboard the operation of the meter is very comfortable. Waterproof housing enables working in difficult conditions. Minimised size and weight facilitate field work. The most important features of **CX-461** are:

- high accuracy and stability;
- automatic and manual temperature compensation;
- 1 - 5 point pH electrode calibration;
- automatic recognition of pH buffers and standards;
- default values of buffer solutions which may be changed by the user;
- possibility of automatic introduction of temperature influence on the value of pH buffer solutions (NIST norm);
- information about the pH electrode condition;
- storing of the calibration date and parameters of three electrodes (sensors) in each function;
- wide range of conductivity measurement with seven automatically switched subranges (autorange);
- converting conductivity to salinity in NaCl or KCl according to actual dependence to conductivity;
- converting conductivity into TDS (g/l or %) with possibility of introducing the TDS coefficient;
- calibration of the conductivity cell by introducing the K constant or on standard solutions;
- possibility of determining K constant of the conductivity cell;
- automatic compensation of the salinity influence on the oxygen measurement using the salinity value measured by the meter;
- measurement and automatic compensation of the atmospheric pressure influence on the dissolved oxygen concentration;
- possibility of introducing the date of calibration validity termination and signalling its expiry;
- storing measurement results with time, date and temperature, taken as single or series of measurements with set time interval;
- RS-232 output (USB with additional adapter);
- large LCD backlit display with brightness control and touchscreen;
- real time clock with date;
- automatic switch off after time set by the user.

3. THE METER'S USE

CX-461 waterproof multifunction meter is a precise and easy-to-use meter designed for measuring: hydrogen ion concentration in pH units, redox potential (mV), conductivity in μS/cm or mS/cm, oxygen dissolved in water in % of saturation or mg/l, oxygen content in air in %, atmospheric pressure in hPa and accurate air and solutions temperature in ^{0}C, ^{0}F or K.
The conductivity measurement result can be displayed in concentration units (g/l or %) counted to NaCl, KCl or TDS (total dissolved solids). Waterproof housing enables work in difficult weather conditions or in humid environment.
CX-461 multifunction meter is used in food, chemical, pharmaceutical and power industries, in water treatment stations, laboratories, agriculture, universities, scientific laboratories etc.
The meter is adjusted 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-461** 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 RS-232 output enables connecting the meter with a PC for sending the recorded data or the current results of the measurement. There is a possibility of connecting the meter with a PC using a special RS-232/USB converter. When the series to be collected exceeds the memory capacity, it is possible to use a special software offered by our firm.

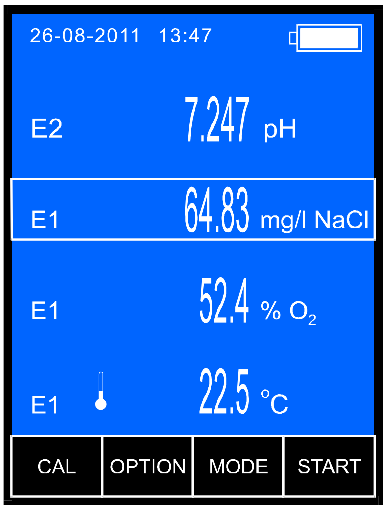
Caution: the RS-232/USB converter and the special software for collecting series of measurements on a PC are offered as an additional equipment.

4. THE OUTSIDE VIEW

On the front wall of the meter there is a graphic LCD placed (Pic. 1), which can display four measurement functions readouts chosen from among the following:

- conductivity or salinity;
- pH measurement in pH units;
- mV measurement in mV;
- oxygen concentration in % or mg/l;
- atmospheric pressure
- temperature.

At the top of the LCD the current time and date are displayed.
Choosing particular functions is described in the chapter 31.1. Symbols of the units are displayed next to the readout.



Pic. 1.

The automatic temperature compensation is signalised by the symbol, the manual compensation – by the symbol (next to the temperature readout). Number of the chosen electrode is displayed on the left. (**E1**, **E2** lub **E3**). It informs, which of the recorded characteristics will be taken into consideration during all calculations. Red colour of the electrode number informs about erased characteristic, yellow – calibration validity date expiry, or the electrode efficiency loss detected during the last calibration. The parameter screen of each function displays all parameters entered by the user. The rechargeable battery condition is signalised by the symbol.

The button (Pic. 2) placed below the display is used for switching the meter on and off.
In the upper wall of the meter connectors 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 to connect the temperature probe;
O2 - the **BNC-50** input for connecting the dissolved oxygen sensor;
PC - the **RS-232** input for connecting with a PC;
Cond - the **BNC-50** input for the conductivity cell;

In the bottom wall of the meter the **P** input is placed for connecting the power adapter.

Pic. 2.

5. THE METER‘S MAINTENANCE

The meter is equipped with a graphic touchscreen. The maintenance consists in pressing particular keys and windows which appear on the screen. Grey captions in the windows and keys inform that these elements are not active in this particular operating mode. Particular keys, connected with the measurement function (i.e. **CAL** or **MODE**) become active after selecting the chosen function. To select, press the screen in a freely chosen spot of the chosen function. Around this spot a frame will display. To deselect, press the spot again. If the chosen function has a possibility of calibration, the **CAL** key becomes active. If it has additional parameters, the **MODE** key also becomes active. The **CAL** key is the only key in the meter that responds exclusively to a long press (about 2 sec.). It prevents from accidental erase of the electrode (sensor, cell) calibration data.

Change parameters or their values by pressing the active window.
The following situations are possible:

- lack of response when pressing the window or key that are not active;
- immediate change visible in the window;
- displaying table with options;
- displaying numerical kayboard for entering numerical values. After entering the value press OK key to confirm or ESC to annul. The meter suggests the minimal and maximal value of the chosen parameter (**MIN:** and **MAX:**).

Entering wrong value, attempt of calibration when the meter doesn‘t recognise the standard or attempt to turn the meter off when series collecting proceeds are signalised by a triple warning sound, irrespective of the chosen sound settings.

Turn the meter on and off with one mechanical ON/OFF button. When a measurement series is collected, the ON/OFF button is not active until the process of collecting ends or is stopped.

6. SWITCHING THE METER ON AND OFF

After switching the meter on with the button, the memory test proceeds. If the test ends successfully, the meter enters the measurement screen with settings entered before switching it off previously. In case of detecting the manufacturer's calibration data loss, the following information will appear:

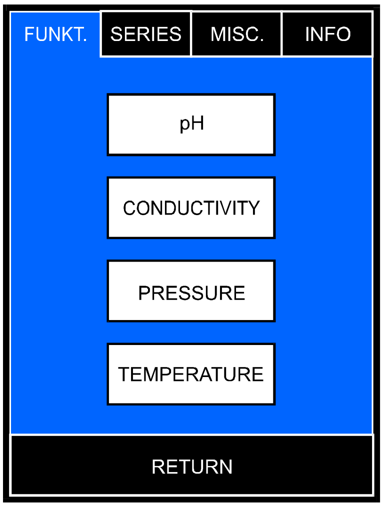
Pressing the button accepts standard manufacturer's calibration parameters and enters the measurement screen. Such situation will be repeating each time the meter is switched on and requires sending the meter to the manufacturer for servicing.
In case of the user's data loss (i.e. the pH electrode characteristic), the following information will appear:

Pressing the button accepts and records in the memory standard pH electrode characteristic and enters the measurement screen. In such case, calibration of the pH electrode is necessary. Repeating of the situation after switching the meter on again informs about the EEPROM memory malfunction and requires sending the meter to the manufacturer for servicing.

Switch the meter off by pressing the button. If the meter is powered only by the rechargeable battery, it turns off after the time of non-use set by the user (description in the chapter 31.3). This function is deactivated during calibration, while collecting series of measurements and working with the power adapter.

6.1. Choosing the measurement function

To choose the measurement fuction to be displayed, on the measurement screen press the **OPTION** button, the options screen will display with the **FUNCTIONS** tab open containing the previously set configuration (Pic. 3A).



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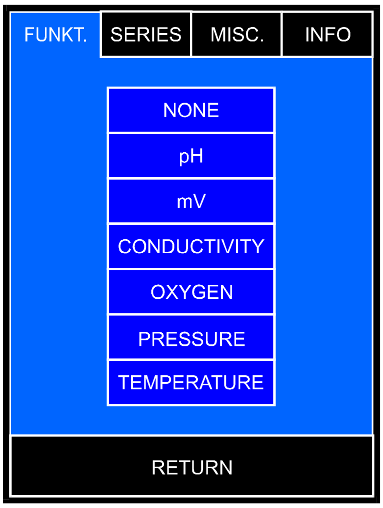


B

Pic. 3

After pressing the window with a chosen function a table will display with all the measurement finctions (Pic. 3B). After selecting the chosen function the meter returns to the function choosing screen with the new configuration. Choosing the function which has been already selected in another window automatically sets the status to **NONE** in this window.

Return to the measurement screen by pressing the **RETURN** button.

7. PREPARATION TO WORK

Before starting measurements:

- connect the power adapter plug to the **P** input, if work with the power adapter is planned;
- connect the combination pH electrode or the redox electrode to the **pH** (BNC-50) input;
- connect the DO sensor to the **O2** (BNC-50) input;
- connect the suitable conductivity cell to the **Cond** (BNC-50) input;
- in case of using the temperature probe it should be connected to the **t** (Chinch) temperature input;
- in case of working with a PC connect the 4XX-PC cable with the **PC** input
- switch the meter on by pressing the button.

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

7.1. 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 readout the symbol is displayed. After disconnecting the probe the meter enters the manual temperature compensation mode. Instead of the symbol the is displayed. In case of the manual temperature compensation the temperature value is set on the temperature measurement parameters screen (point 29.5).

II. pH MEASUREMENT

8. PREPARATION OF THE PH ELECTRODE

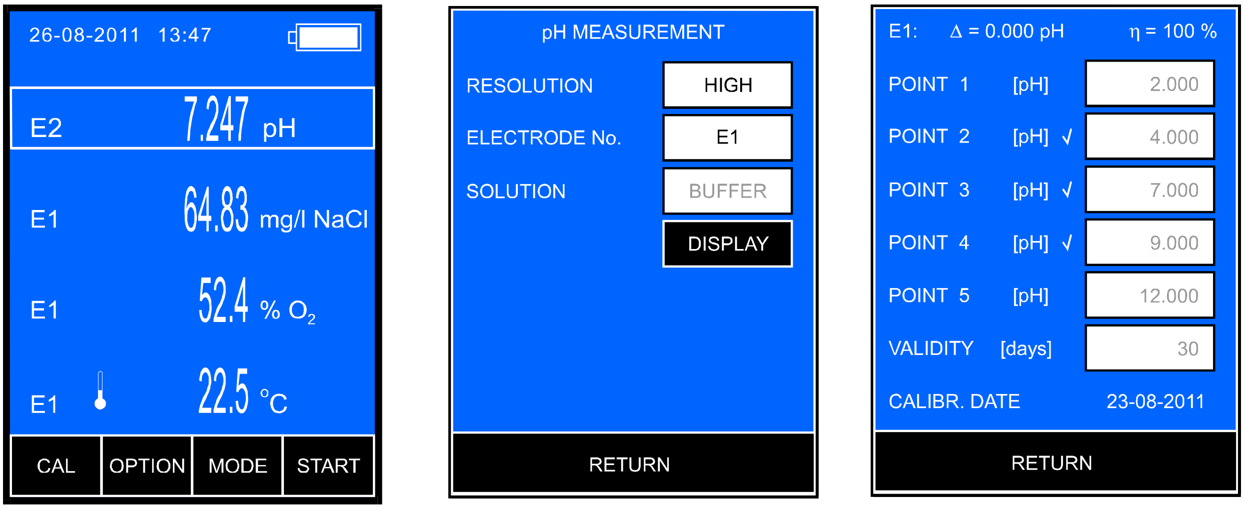
The electrode should be prepared to work according to the producer's instructions. If the instructions weren't given please act accordingly to the following steps:

- 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 would 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.

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

9. SETTING THE PH MEASUREMENT PARAMETERS

Enter the pH measurement parameters setting screen by pressing the pH measurement readout (a frame displays on it - Pic. 4A), and next the **MODE** button. The screen (Pic. 4B) enables choosing the resolution, electrode number, checking the solution type and - after pressing the **DISPLAY** button - (Pic. 4C) calibration points and validity time (these parameters are entered in the calibration mode only).



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Pic. 4

When the parameters are set, return to the measurement screen by pressing the **RETURN** button.

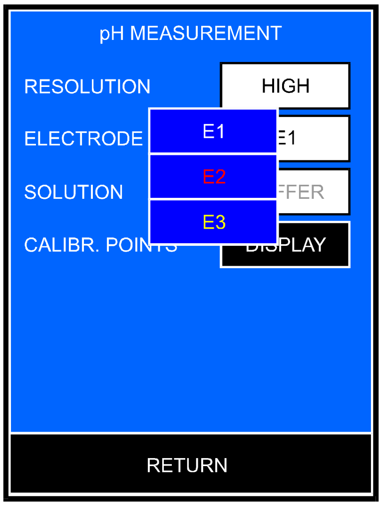
9.1. Resolution

The reading can be displayed with low or high resolution. By pressing the **RESOLUTION** window, choose:

- LOW - 0.01 pH measurement resolution;
- HIGH - 0.001 pH measurement resolution.

9.2. Electrode number

If the meter stores more than one electrode's characteristic, the electrodes may be replaced without calibration. This option is very useful for field work. After pressing the **ELECTRODE NUMBER** window the table with electrode numbers appears (Pic. 5). Choose one of the characteristics stored under **E1**, **E2** or **E3** number.



Pic. 5

The number's colour informs about the electrode's condition:

white - electrode efficient, calibration valid;

yellow - electrode efficiency loss detected during the last calibration or the calibration validity date expired (see the chapter 11);

red - characteristic erase, the electrode calibration necessary.

In the Pic. 5, the **E1** electrode is efficient, the **E2** electrode has the characteristic erased and the **E3** electrode lost its efficiency or the calibration validity date expired.

9.3. Calibration solution

Choose one of two types of the calibration solutions:

BUFFER - calibration with manually entered buffers‘ values;
STANDARD - calibration with automatic correction of the standards‘ values.

Calibration in buffers and standards is described in detail in the chapter 10.
Calibration solution values are stored for each of the three electrodes separately and may be changed only in the calibration mode (point 10.2).

9.4. Calibration points and date

After pressing the DISPLAY button the following parameters are displayed (Pic. 4C): the electrode condition, calibration points, validity time and date of the last calibration. Markers next to the calibration points windows inform that the last calibration was performed in these particular solutions. All the pararmeters‘ values are stored separately for each of the three electrodes. The calibration points may be changed only after entering the calibration mode (point 10.2).

9.5. Calibration validity date

The meter stores the calibration validity time for each of the three electrodes separately. Expiry of this date is signalised with yellow electrode number. To set the calibration validity expiry date, press the **VALIDITY** window, the numerical keyboard will appear to enter the number of days and confirm with the OK button.

10. CALIBRATION

Before starting measurement with a new electrode or before making measurements which require high accuracy, the electrode connected to the meter should be calibrated. Results of measurements made without calibration will be burdened with a significant error. Calibration is performed in the buffer or standard solutions. It consists in comparing pH value of the standard solutions with the reading displayed by the meter and automatic correction which is taken into consideration during the 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 was used, temperature and value of the measured solutions.

CX-461 enables storing characteristics of three calibrated pH electrodes separately, recorded under different numbers (**E1**, **E2** or **E3**). This feature is very useful when it is necessary to change the electrode quickly or to replace a broken one.

The meter enables entering the calibration validity expiry date for each of the electrodes separately. If this option is active, the calibration should be performed when the applied electrode number (**E1**, **E2** or **E3**) turns yellow.

For obtaining optimal calibration results, the pH values of the applied solutions should be entered to the meter’s memory by the user. During calibration, after putting the pH electrode and the temperature probe into solution, the meter detects its pH value automatically. When the highest accuracy is required, it is recommended to use certified standard solutions. However, the most often used are buffer solutions of total values i.e. 2.00 pH, 4.00 pH etc, with a composition specified by the manufacturer. They are also of quite high accuracy.

For accurate measurements it is necessary to use fresh solutions of good quality.

The temperature changes have a great influence on the pH value of standards and buffer solutions. The manufacturers usually specify the pH values of a solution in a specific temperature. During accurate calibration the stored solution value has to be the same as the value of this solution in the temperature in which the calibration is performed. If the electrode number turns yellow after the calibration is finished, it informs that the electrode lost its efficiency and will have to be replaced soon. An additional information is shown on the electrode calibration points screen (description in the chapter 11).

Calibration with use of one solution doesn't ensure 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 isn't very high and the measurements are made in the whole range, 1-point calibration should be performed with use of solution close to 7.00 pH. It enables to avoid an error resulting from so called zero offset of the electrode. In other points the meter adopts standard characteristic recorded in memory.
If measurements are made both in acids and alkalis and not at the ends of measuring range it is enough to calibrate the electrodes in 3 standard solutions with values in range given in the table 2 – calibration points 2, 3 and 4. In case of accurate measurements in a full range it is recommended to calibrate the electrode in each of the 5 points given in the table. The solutions may be used randomly. In **CX-461** the electrode characteristic is approximated linearly between the calibration points.
Entering the calibration mode erases the electrode's characteristic stored under the chosen number.
There is no possibility to calibrate the electrode only in one point with the rest of the data from the last calibration unchanged.
The characteristic erase is signalised by red colour of the electrode numer.

10.1. Calibration in buffer or standard solutions

Before starting the calibration process, prepare the meter according to the chapter 6 and decide whether the calibration will be performed with use of buffer or standard solutions.

The calibration may be performed in two following methods:

1. **Entering the values of currently used pH buffers to the meter's memory; calibration is performed in these buffers.**
2. **Using the pH standard solutions values entered to the memory by the manufacturer (NIST norm conformity). Choosing this type of calibration automatically enables correction connected with the temperature influence on the standard's value. As a result, there is no need to adjust the standard's temperature or to enter the standards' pH values corresponding with different temperature values.**

10.2. Entering the buffers' values into the meter's memory

If the calibration with use of buffers has been chosen and the pH values set by the manufacturer are used, there is no need to change them. However, it should be verified whether the values correspond to those of applied buffers. Different buffers' values should be entered to the meter's memory before calibration.

To enter:

- according to the point 9.2 choose the number of electrode (**E1**, **E2** or **E3**), for which the points of calibration are to be changed;
- enter the calibration mode: select the pH mesurement on the measurement screen, press and hold the CAL button until the background turns red (Pic. 6A). The previous characteristic is erased;
- press the MODE button, the pH mesurement parameters screen will appear (Pic. 6B);
- press the **SOLUTION** window and choose **BUFFER**;
- press the SET button, the screen with calibration points will appear (Pic. 6C);
- select the window with a point to be changed, a numerical keyboard will appear to enter the value and confirm with the OK button.
- return to the measurement screen in calibration mode by double press of the RETURN button and calibrate the electrode in the chosen points or escape the calibration mode by pressing the RETURN button again;

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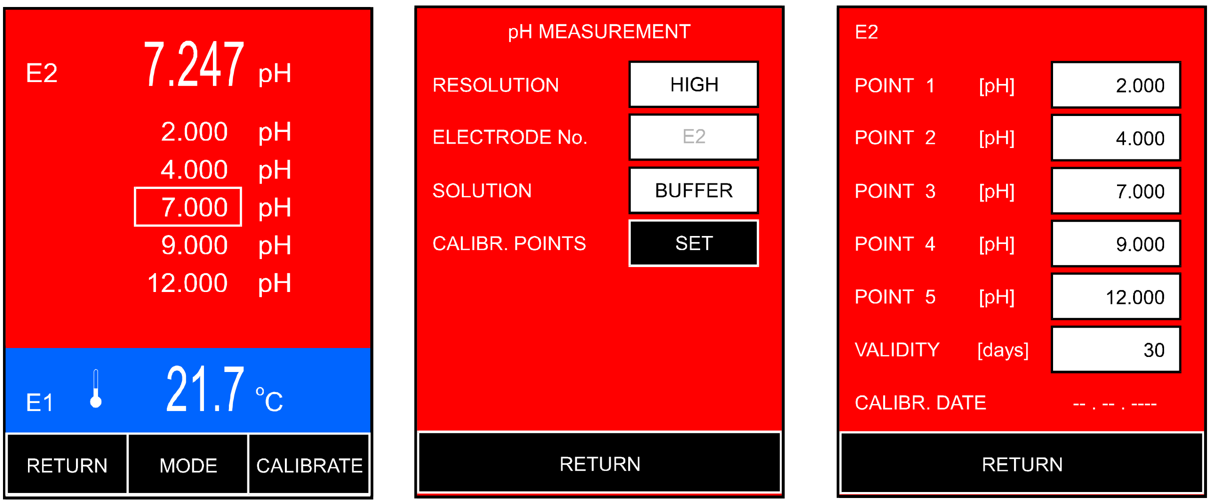


Pic. 6

Different calibration points have their own ranges of pH buffers values to enter. This limitation enables automatic detection of the buffer solutions by the meter. Table 1 contains the manufacturer's settings of the pH buffer solutions values used for calibration. They can be changed according to the ranges given in this table. The range for each of the calibration points is wide, what enables to use buffer solutions with values differing from those set by the manufacturer even to a large extent. In every case the introduced buffer solution will be automatically detected by the meter. There is a possibility to introduce values of buffer solutions with two or three decimal places, depending on the chosen resolution.

Table 1.

Calibration point	Manufacturer's value	Range
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 takes into account only the 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, provided that the previously used buffer solutions haven't been changed. The pH values introduced to the meter's memory by the user are stored in non-volatile memory.

The manufacturer gives an information about solutions values at different temperatures. This data may be useful for calibrating the electrode at temperature different than 20 ^{o}C by entering the buffer value suitable at the current temperature to the meter's memory according to the point 10.2. In such case there is no need to adjust the solutions temperature.

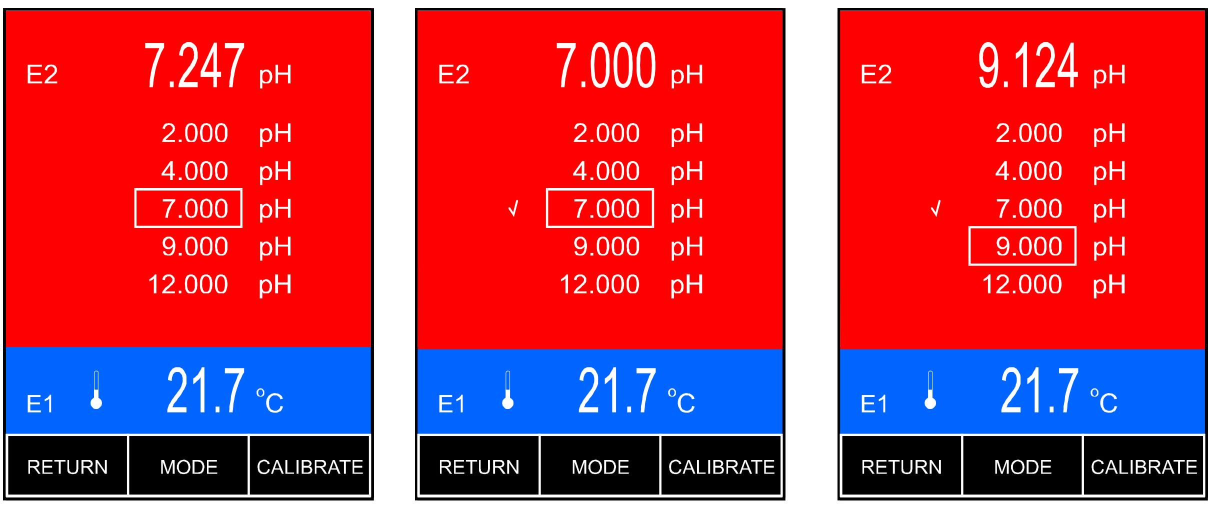
Attempt to enter pH values beyond the ranges given in the table 1 will not be accepted by the meter.

10.3. Calibration in buffer solutions

When the electrode is prepared for measurement, start calibration in buffer solutions. The buffers may be applied randomly.
To start calibration:

- choose the electrode number (**E1**, **E2** or **E3)** according to the point 9.2 and mark the electrode with this number;
- connect the pH electrode and temperature probe to the **pH** and **t** connector respectively (Pic. 2);
- enter the calibration mode: on the measurement screen mark pH, press and hold the **CAL** button until the background turns red (Pic. 7.A). The previous electrode characteristic is erased;
- press the **MODE** button, the pH measurement parameters screen will appear;
- press the **SOLUTION.** window, choose **BUFFER**;
- check and, if necessary, enter the calibration points values according to the point 10.2;
- put the pH electrode and temperature probe into the solution; do not touch the vessel‘s walls and bottom. It is advisable to use an electrode holder. The meter will mark the detected buffer‘s value with frame;
- wait until the reading stabilises (it will be probably slightly different than the calibration point value).

When the reading stabilises, press the **CALIBRATE** button. Next to the detected buffer value the marking will appear, what informs that the calibration value has been recorded. Simultaneously, the measurement value will be adjusted to the detected buffer value (Pic. 7.B). If the reading is still different than the solution value, wait until the reading stabilises and press the **CALIBRATE** button again.



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Pic. 7.

If the meter doesn‘t detect the buffer‘s value, it will signalise the error after pressing the **CALIBRATE** button with a tripple warning sound. In such case check the solution value or the electrode which may be broken.
Only the pH buffers values detected during calibration are calculated, the other values recorded earlier do not influence the readout.
After finishing calibration in the first buffer rinse the electrode and temperature probe in distilled water and start calibration in next buffers repeating the last point of the activities described above.
When the electrode is calibrated, two other electrodes may be calibrated and marked with the other electrode numbers according to the point 9.2.

10.4. Calibration with use of standard solutions

In this mode 5 constant standard solutions values, according to NIST norm, are used. **The meter’s memory stores a table with a dependence between the temperature and pH values for these 5 sample solutions.** This dependence is shown in the table 2. In particular cases the standard solution differs from the values given in the table 2 in the third decimal place. For very accurate measurements it is possible to make a slight correction of the manufacturer’s settings (description below).
After putting the temperature probe into the pH standard its temperature is measured and the pH value corresponding to this temperature is suggested automatically. There is no need to adjust the standard solutions temperature.
To perform calibration in standards:

- choose the electrode number (**E1**, **E2** or **E3)** according to the point 9.2 and mark the electrode with this number;
- connect the pH electrode and temperature probe to the **pH** and **t** connector respectively (Pic. 2);
- enter the calibration mode: on the measurement screen mark pH, press and hold the **CAL** button until the background turns red (Pic. 7.A). The previous electrode characteristic is erased;
- press the **MODE** button, the pH measurement parameters screen will appear;
- press the **SOLUTION.** window, choose **BUFFER**;
- check and, if necessary, enter the calibration points values according to the point 10.2;
- put the pH electrode and temperature probe into the solution; do not touch the vessel‘s walls and bottom. It is advisable to use an electrode holder. The meter will mark the detected buffer‘s value with frame;
- wait until the reading stabilises (it will be probably slightly different than the calibration point value).

When the reading stabilises, press the **CALIBRATE** button. Next to the detected buffer value the marking will appear, what informs that the calibration value has been recorded. Simultaneously, the measurement value will be adjusted

to the detected buffer value. If the reading is still different than the solution value, wait until the reading stabilises and press the CALIBRATE button again.
If the meter doesn‘t detect the buffer‘s value, it will signalise the error after pressing the CALIBRATE button with a tripple warning sound.
At this point the calibration may be finished by pressing the RETURN button or continued in other standards. After finishing measurement in each standard rinse the electrode and temperature probe with distilled water and dry them with tissue paper.
Only the pH buffers values detected during calibration are calculated, the other values recorded earlier do not influence the readout.
The temperature range taken into consideration while introducing correction is 0 – 60 ^{o}C and should not be exceeded during calibration.

Table 2.

Temp. ^{0}C	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.
In particular cases, the values of standards prepared according to the norm may differ from the norm at the third decimal place. If such slight difference is unacceptable it is possible to make a correction and enter the value given by the standard's manufacturer. The meter enables changing the standard's value differing in ±0.010 pH from the table values at 20 ^{0}C. Changing of the standard's values proceeds identically as in case of changing the buffer's values (point 10.2). In case of differences greater than ±0.010 pH it is recommended to comply to the buffer calibration procedure, which enables entering freely chosen solution value into the meters memory.

In case of 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. The characteristic erase is signalised with red colour of the electrode number on the measurement screen.

10.4.1. Calibration with manual temperature compensation

In case of the temperature probe breakdown, calibration with manual temperature compensation may be proceeded. To start this calibration, disconnect the temperature probe. It switches the meter to manual compensation. Next to the entered (not measured) temperature value instead of the symbol the symbol will appear. Entering the temperature value for the manual compensation is described in the point 29.5. Than act identically as in case of calibration with automatic temperature compensation, excluding the temperature probe connection.

11. CHECKING THE ELECTRODE CONDITION

When the electrode is calibrated, its condition may be checked. To check, enter the calibration points screen according to description in the point 9.4. The top of the screen (Pic. 4C) displays the electrode number and two parameters, determined duting the last calibration: Δ (zero offset in pH) and η (condition in %).
Yellow colour of the electrode number signalises:

- electrode condition loss, if the zero and condition parameter are displayed in yellow;
- calibration validity date expiry if the last calibration date is also displayed in yellow.

In case of 1 point calibration, only the zero offset parameter is displayed.

12. PH MEASUREMENT

Before starting measurement the meter and the pH electrode have to be prepared for work (chapters 7 and 8 respectively). Good condition of the electrode is crucial for correct readings. If the electrode is calibrated, choose its number according to the section 9.2 and the measurement resolution according to the section 9.1.

12.1. 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 pH and calculates its influence to the pH reading.

In case of measurement with automatic temperature compensation:

- turn the meter on by pressing the ON/OFF button;
- connect the temperature probe and the combination pH electrode to the **pH** and **t** connectors respectively (Pic. 2), the symbol will be displayed;
- immerse the electrode and the temperature probe in the measured solution. During measurements in vessels don't touch the bottom and the walls with the electrode. It is advisable to use an electrode stand;
- after stabilisation read the result.

Accurate laboratory measurements require using of a magnetic stirrer.

NOTICE: exceeding the measurement range is signalised with red colour of the displayed pH value; exceeding the temperature compensation range – with yellow colour.

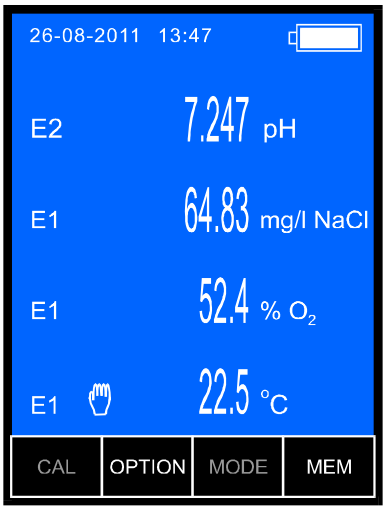
12.2. Measurement with manual temperature compensation

Disconnecting the temperature probe from the meter switches the meter to the manual temperature compensation mode. Next to the entered (not measured) temperature value, instead of the symbol, the symbol displays (Pic.). The procedure of measurement with manual temperature compensation is similar to that of measurement with ATC. The difference is in entering the solution temperature value (description – point 29.5). This value is displayed in place of the measured temperature and is compensated.

Manual compensation may be used in stable conditions, i.e. during laboratory pH measurements, especially with use of thermostat, or in case of the temperature probe breakage.

In case of measurement with manual temperature compensation:

- turn the meter on with the button;
- insert the pH electrode into the vessel with the measured solution; if the electrode is not calibrated or has already been in use for a long period of time, perform a calibration (chapter 10). During measurements in a vessel don't touch its bottom and walls with the electrode. It is advisable to use an electrode stand;
- measure the temperature of the solution with use of a laboratory thermometer and enter the value according to the point 29.5;
- wait till the value stabilises and read the result.



Pic. 8

13. NOTICES ABOUT THE TEMPERATURE COMPENSATION AND INTERPRETATION OF THE PH MEASUREMENT RESULTS

CX-461 multifunction meter enables manual and automatic temperature compensation, what eliminates errors resulting from the electrode characteristics being affected by the temperature changes. The pH meter is a mV meter which displays voltage counted to pH unit. At constant temperature there is a constant mV value per one pH unit - 58,168 mV for 20 ^{0}C. The value of mV per one pH unit **is influenced by the temperature changes,** what is calculated 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 not connected with influence of the temperature change on pH value of the measured solution but with changes in the electrode efficiency. Generally, such changes are rather slight, however in certain solutions, e.g. pure water, they tend to be significant.
In case of measurements in solutions which tend to be greatly affected by the temperature change, the results should be compared at the same temperature. In particular cases the successive readings obtained in one solution at stable temperature may be different. These are possible reasons of such situation:
- differences occur because of poor quality of the electrode;
- the reading is treated as stabilised too soon (medium class electrode needs about 40 seconds to full stabilisation);
- the measured solution is not homogeneous and lack of stirrer doesn’t allow for obtaining similar results;
- in case of 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. Minor differences may be caused by the meter.

The accuracy of the meter totals to ±0.002 pH, ±1 digit. In practice, it means that difference between results of measurements made with use of 2 meters in the same solution 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 further possible difference caused by rounding up of the result on the last visible place on the screen (discretisation error).
Performing two point calibration in 7.00 pH and 4.00 pH buffers (acidic solutions), and checking the measurement accuracy in 9.00 pH (alkali solution) in some cases results with reading equal 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. The electrode quality has a crucial meaning for the measurement readings stability. **Slow drift of the reading, its unstability or prolonged time of stabilisation in most cases result from clogged junction, broken electrode or contaminated membrane.** It happens as a result of unsuitable kind of electrode chosen for the 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. A typical electrode which is not 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 should be cleaned with chloroform and deposits of iron in 2N HCl. Storing in KCl solution may prolong the electrode life. Depending on the kind of measured solution or substance, suitable kind of electrode should be chosen. They differ one from another with shape, membrane’s look, kind of junction and body. Using unsuitable electrodes may cause their damage and make measurements impossible.

III. CONDUCTIVITY AND SALINITY MEASUREMENT

14. BASIC INFORMATION ABOUT CONDUCTIVITY MEASUREMENT

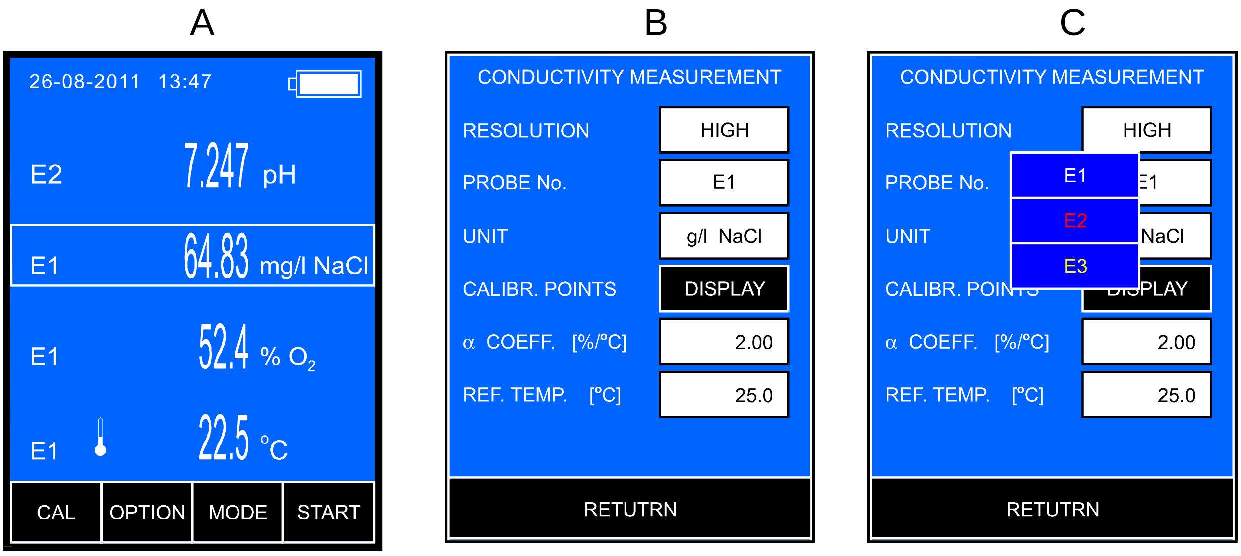
The conductivity measurement consists in applying electric current with a suitable voltage and frequency to the measured solution. In **CX-461** the voltage comes to several dozens of mV and the frequency depends on the measuring range and may vary from 100 Hz to 10 kHz. After immersing the conductivity cell into the solution the current flow between its electrodes starts. The electric current flow is dependent on the kind of the measured liquid, its concentration and temperature. The conductivity readout indirectly informs about the salt concentration in the measured liquid – the higher salt concentration, the higher conductivity (KCl, NaCl). However, this dependence doesn't concern all of the solutions. In particular cases, after overdrawing certain salinity value the conductivity starts decreasing. The temperature also has a great influence on conductivity readout, which becomes higher as the temperature rises. Measured conductivity can be displayed as salinity in g/l of NaCl or KCl assuming that the measured liquid includes homogeneous salt. It is also possible to determine approximately the concentration of salt dissolved in water with use of TDS coefficient (point 19.3).

The electrodes surface and the distance between them have a crucial influence on the cell's K constant. This constant affects the measurement accuracy to the high extent. Depending on the conductivity range, cells with K constant = 0.010 cm^{-1} up to 20.000 cm^{-1} are used. 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). Conductivity changes simultaneously with temperature and salts concentration. In order to enable comparison of the results, the measured value is calculated by the meter to the value which corresponds to measurement at reference temperature (usually 25°C). Measurement at reference temperature is the most accurate. At different temperature the temperature compensation is used, which means that the meter calculates the influence of the temperature and α coefficient, which should be entered by the user before making measurement (point 15.6). This coefficient describes the percentage of the result changes in case of 1^{0}C of the temperature change. The α coefficient may be entered into the meter in 0 ÷ 10.00% / ^{o}C range. For NaCl at temperatures about 25 ^{0}C it amounts to 2%/ ^{0}C, and in case of measurements e.g. at 30 ^{0}C the result change totals to 5x2%=10%.

The calculation is automatic in compliance with the α coefficient introduced by the user. This value can be found in professional literature or approximated by the user (chapter 20).
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.

15. ENTERING THE CONDUCTIVITY PARAMETERS

Before starting calibration and measurements it is necessary to perform all activities described in the chapter 7. Additionally, according to the chapter below, it is necessary to choose the unit in which the calibration and measurement are going to be made.
The parameters screen is entered by pressing the conductivity readout (a frame will display around it – Pic. 9A), and next the **MODE** button. This screen (Pic. 9B) enables choosing resolution, the cell number, unit, checking the calibration point and date, entering the calibration validity time, α coefficient, reference temperaure and TDS coefficient.



Pic. 9

When the parameters are entered, return to the measurement screen by pressing the **RETURN** button.

15.1. Resolution

The reading may be displayed with low or high resolution.
By pressing the **RESOLUTION** window, choose:

- LOW - 3½ digit measurement resolution;
- HIGH - 4½ digit measurement resolution.

15.2. Cell number

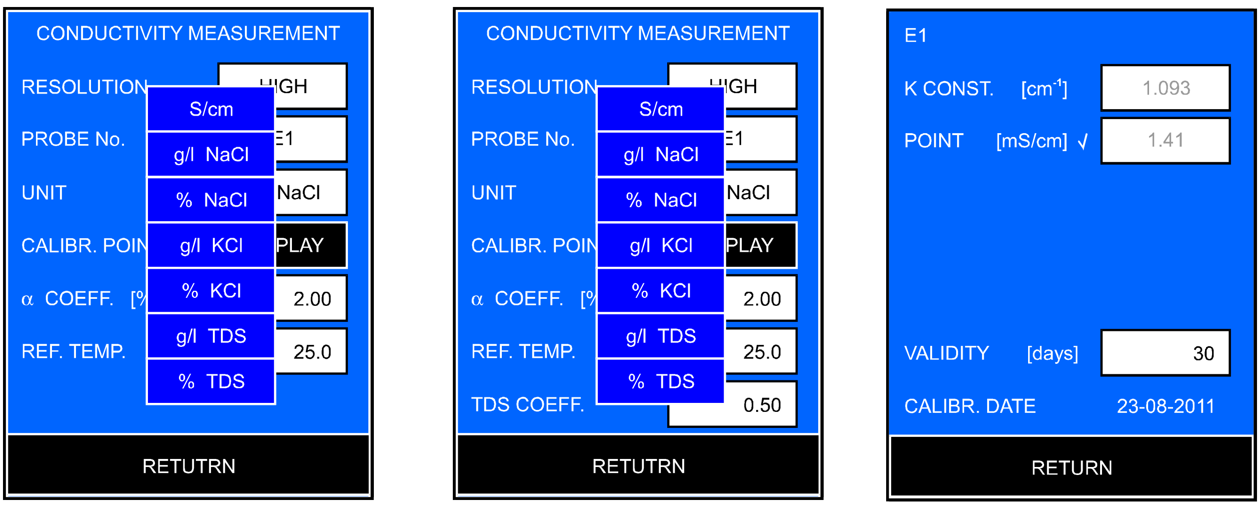
If the meter stores more than one cell characteristic, the cell may be replaced without calibration. This option is very useful in case of using different types of cells, i.e. for sewage, clear water etc. After pressing the **PROBE NO** window the table with electrode numbers appears (Pic. 9C) Choose one of the characteristics stored under **E1**, **E2** or **E3** number. The number's colour informs about the cell's condition:

white - cell calibrated;
yellow - the calibration validity date expired;
red - K constant erase (default value K = 1.000 $cm^{-1)}$, the cell calibration necessary.

15.3. Choosing the unit

The reading may be 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, press the **UNIT** window. The screen for choosing the unit will appear (Pic. 10A).

A B C



Pic. 10

Choose the unit by pressing the relevant window. In case of the salinity measurement with conversion to **TDS** an additional window will appear for enterin the TDS coefficient (Pic. 10B).

The reading in w % of the weight concentration can be counted to the value in **ppm** according to the following proportion:
1% of the weight concentration (C) = 10 000 ppm = 10 ppt.
The measurement resolution in % of the weight concentration is equal 0.001% or 10 ppm.

15.4. Calibration points and date

Pressing the **DISPLAY** button opens a screen (Pic. 10C) which displays calibration points, K constant, calibration validity time and the last calibration date. The marker next to the calibration point or K constant window informs whether the calibration was performed with use of solution or by entering the K constant. Each parameter is stored separately for each of three cells. The calibration point and K constant value may be changed only in the calibration mode (point 17.1 and point 17.2.1).

15.5. Calibration validity time

The meter stores the calibration validity time separately for each of the three cells. Exceeding this time is signalised with yellow cell number. To enter the calibration validity time, press the **VALIDITY** window, numerical keyboard will appear to enter and confirm the number of days.

15.6. Entering the α coefficient

The α coefficient range in **CX-461** is 0 ÷ 10.00 % / ^{0}C with accuracy 0.01 % / ^{0}C. Generally for measurements, the most frequently applied temperature compensation coefficient is equal α = 2 % / ^{0}C. In case of higher accuracy requirements the kind of solution should be determined and the relevant coefficient value entered.
To enter the α coefficient press the „**α COEF.**“ window, numerical keyboard will appear to enter the value and confirm with the **OK** button.

The measurement result will be counted with use of the entered α temperature coefficient.

Simplified way of determining the α coefficient is described in the chapter 20.

Notice: changing the unit in the temperature measurement function will automatically convert the α coefficient into this unit.

15.7. Entering the reference temperature

The range of the reference temperature is 10.0 ÷ 40.0 ^{O}C with accuracy 0.1 ^{O}C. The most frequently applied value is 25 ^{O}C.
To enter the reference temperature value, press the „**REF. TEMP.**“ window, numerical keyboard will appear to enter the value and confirm with the **OK** button.

The measurement result will be counted with use of the entered reference temperature.

Notice: changing the unit in the temperature measurement function will automatically convert the reference temperature into this unit.

15.8. Entering the W_{TDS} coefficient

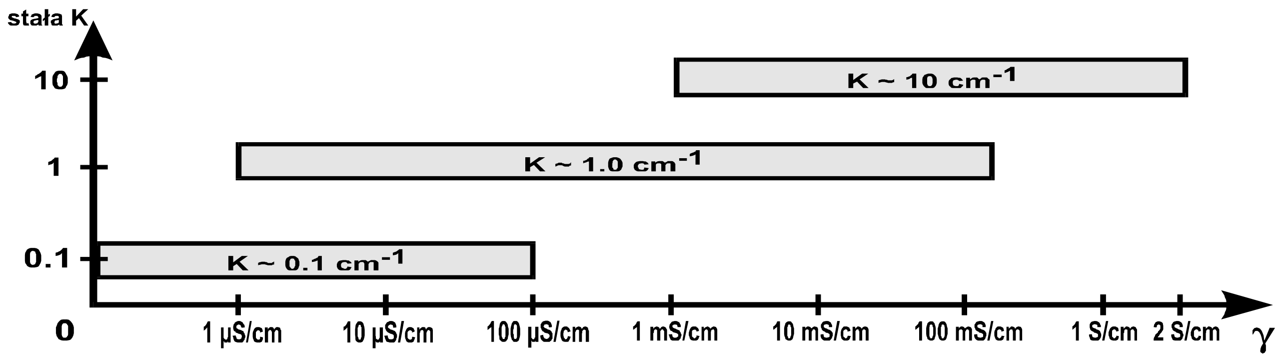
In case of choosing salinity measurement with covertion to TDS content the **TDS COEF.** window will appear (Pic. 10C). Enter the W_{TDS} coefficient value in it. To enter, press the **TDS COEF.** window, numerical keyboard will appear to enter the value and confirm with the **OK** button.

Determining the W_{TDS} coefficient is decribed in the section 19.2.

16. CHOOSING AND MAINTAINING THE CONDUCTIVITY CELL

16.1. Choosing the cell

The measurement range in **CX-461** is 0 to 2000 mS/cm. The meter cooperates with conductivity cells with K constant = 0.010 ÷ 20.00 cm^{-1}, and BNC-50 connector. Depending on the required measuring range it is necessary to choose the cell with a K constant which enables receiving correct results. **Beyond its range the cell looses linearity and the results are burdened with an increasing error.** Accurate measurements in the whole range are possible when using 3 different conductivity cells.
Depending on the expected measuring range the relevant cell may be chosen with use of the chart below.



Pic. 11. The dependence between the measuring range and K constant of applied conductivity cells.

Sandard meter‘s equipment includes the cell with K constant = 1.
The cell with K constant ≈ 0,1 cm^{-1} should be used for measurements in ultra pure and redistilled water, which changes conductivity after contact with air very quickly, therefore pouring it into vessels for measurement with use of submersible cell may cause errors. For accurate measurements of such low concentration it is necessary to use flow-through cell with built-in temperature probe, what enables measurement in water flowing directly from the container.
Cells with K constant = 10 are used for liquids with conductivity higher then 100 mS/cm.

16.2. Maintenance of the cell

In order to receive stable results it is advisable to soak the cell for a few hours before measurement, especially in case of measurements in distilled water.

Maintenance of the conductivity cell consists mainly in washing the inside of the measuring cell accurately with distilled water. The platinum electrodes **must not be cleaned mechanically**, because this results in rubbing off the platinum layer, what can cause decreasing of accuracy, lowering of stability and changing of the K constant.

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

Appropriate norms suggest using a special liquid for cleaning the cells. This is a mixture of equal parts of isopropyl alcohol, ethyl ether and hydrocholic acid diluted with water in 1:1 proportion.

Breaking of the measuring cell hinders any further measurements due to significant change of the K constant, unstable results and increase of the dependence of the result on the position of the cell in the measuring vessel.

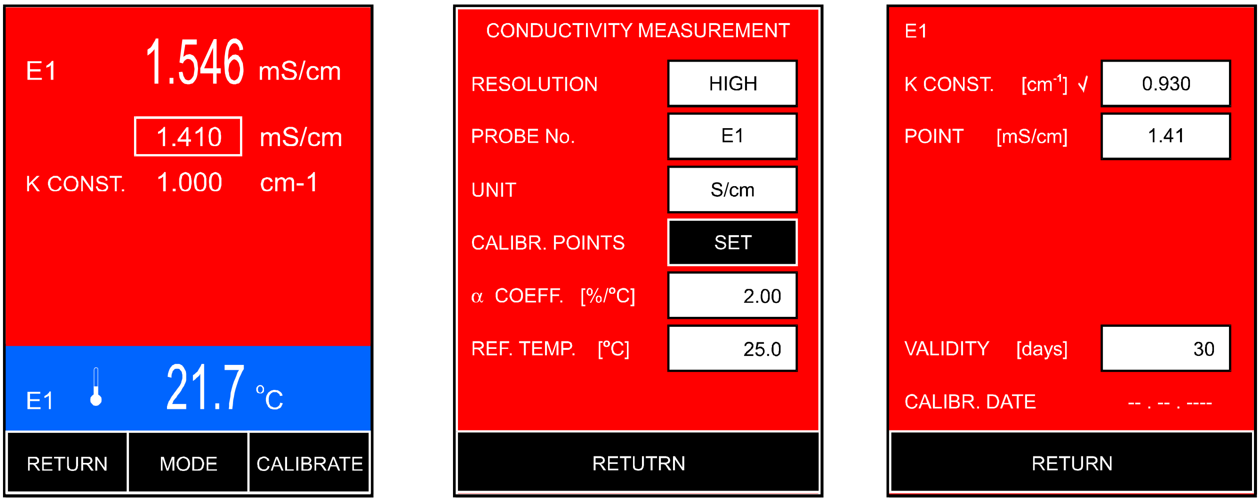
The cell should be immersed in such a way for the solution to fill it up and not to include any air bubbles (single bubbles or silver coating). It is essential for obtaining accurate results of measurements. The best way is to immerse the cell, make a few vertical moves and thus to remove air bubbles through holes in the upper part of the cell. If the air bubbles appear each time after the cell has been immersed and they 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.

17. CALIBRATION

K constant is a characteristic feature of every conductivity cell. In case of each measurement, the readout is multiplied by the K constant, which depends on the size of the electrodes' surface and the distance between them. If the user keeps the cell clean, the K constant will not change. However, if the electrodes' surface is contaminated, the K constant will change.
Calibration consists in entering the K constant in the meter's memory and is essential for obtaining accurate results. It may be performed without standard solution, by entering the K constant of the cell basing on the information provided by the manufacturer (recommended) or with use of standard solution with known conductivity – in order to determine the K constant. Calibration may be performed only in S/cm and after entering the calibration mode the meter automatically switches to this unit.
The K constant is precisely determined by the cell manufacturer 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 with accurately adjusted temperature 25^{0}C. Otherwise, calibration will be burdened with error.
When using three cells, it is possible to store their characteristics under **E1**, **E2** and **E3** symbols.

17.1. Calibration without standard solution

The meter has a possibility of calibration without use of sample 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 cell manufacturer or may be determined with use of **CX-461** meter. The meter has to be calibrated in the standard solution.
To calibrate:
- choose the cell number (**E1**, **E2** or **E3)** according to the point 15.2;
- enter the calibration mode: on the measurement screen select the conductivity measurement, press and hold the **CAL** button until the background changes its colour to red, the meter will automatically change the unit to S/cm (Pic. 12.A). Adopted K constant is equal 1.000cm^{-1};
- press the **MODE** button, the conductivity measurement screen will display (Pic. 12.B);
- press the **SET** button, the screen with K constant will display;
- press the **K CONST.** window, numerical keyboard will appear to enter the value and confirm with the **OK** button. In the window the entered K constant will appear and a marker next to it (Pic. 12.C);
- return to the measurement screen by double press on the **RETURN** button.



A B C

Pic. 12.

17.2. Calibration with use of standard solution

The meter enables 1-point calibration in a freely chosen standard solution. To decrease the error it is recommended to use solutions with a value close to the expected conductivity of the measured solution. It is required to use sample solutions of high quality.

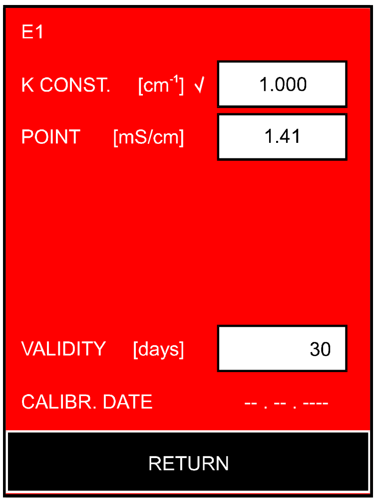
To obtain accurate results of calibration, comply to the following principles:

1. The temperature of the standard solution should be equal to the reference temperature (the most frequently it is 25 ^{0}C).
2. New, unused standard solution should be applied.
3. The calibrated cell and its electrodes should be clean and devoid of air bubbles.
4. The electrode holder should be used.

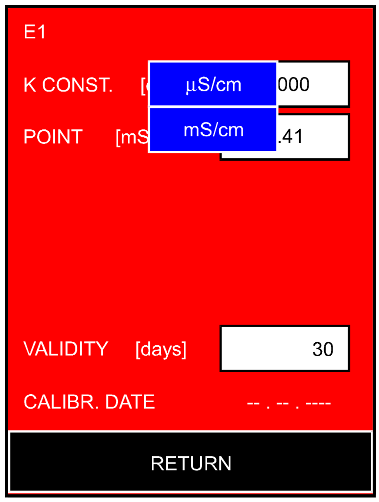
17.2.1. Entering the standard solution value

To enter the standard solution value:

- choose the cell number (**E1**, **E2** or **E3)**, according to the point 15.2;
- enter the calibration mode: on the measurement screen select the conductivity measurement, press and hold the **CAL** button until the background changes its colour to red, the meter will automatically change the unit to S/cm (Pic. 12.A). Adopted K constant is equal 1.000cm^{-1};
- press the **MODE** button, the conductivity measurement screen will display (Pic. 12.B);
- press the **SET** button, the screen with a previous calibration point will display (Pic. 13.A);
- press the window with the point value, a window for choosing the unit will appear (Pic. 13.B);
- choose the unit, numerical keyboard will appear to enter the value and confirm with the **OK** button.
- in the calibration mode enter the measurement screen by pressing the **RETURN** button, or escape the calibration mode by pressing the **RETURN** button once again .



A



B

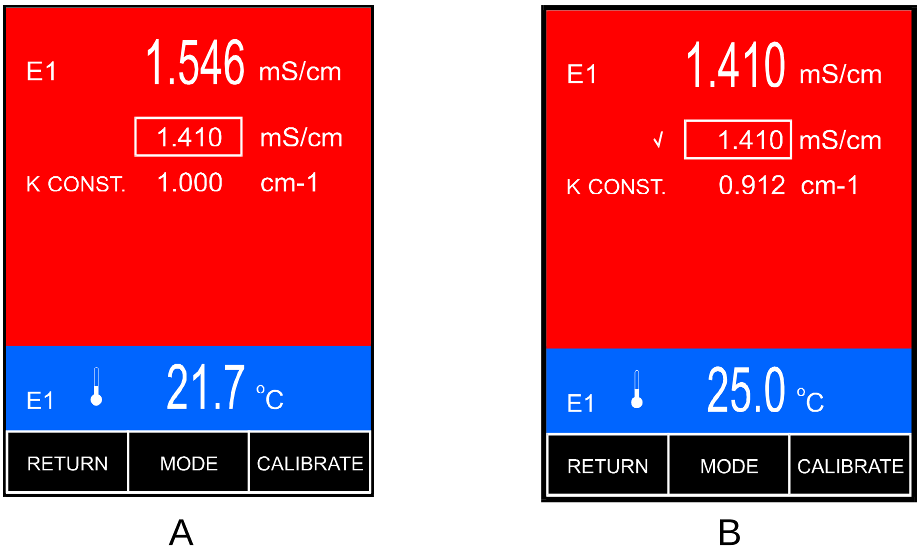
Pic. 13.

17.2.2. Calibration with automatic temperature compensation

Follow the instructions:

- connect the conductivity cell and the temperature probe;
- enter the calibration mode: on the measurement screen select the conductivity measurement, press and hold the **CAL** button until the background changes its colour to red, the meter will automatically change the unit to S/cm (Pic. 14.A). Adopted K constant is equal 1.000cm^{-1};
- check and, if necessary, adjust the standard solution value (point 17.2.1);
- immerse the conductivity cell and the temperature probe in the standard, hold the conductivity cell at least 1 cm away from the bottom and walls of the vessel. Make sure, that the measuring cell is filled up with the sample solution and does not include any air bubbles, and the electrode's surface is evenly moistened. Around the calibration point displays a frame, which informs about recognising the standard by the meter;

When the reading stabilises, press the **CALIBRATE** button. Next to the calibration point a mark appears, what informs about recording the calibration value. At the same time, the reading will be adjusted to the recognised standard value (Pic. 14.B). If the difference between the reading and the standard is significant, wait until the reading stabilises and press the **CALIBRATE** button again. Slight differences may occur as a result of inaccuracies in K constant calcuation. If the meter does not recognise the standard, it will signalise the error with a tripple warning sound after pressing the **CALIBRATE** button.



Pic. 14.

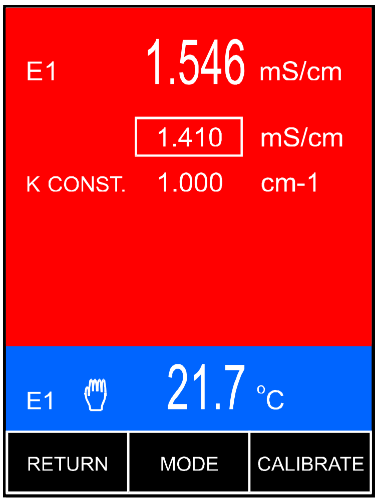
Escape the calibration mode by pressing the **RETURN** button. The meter is calibrated and ready for performing measurement.

17.2.3. Calibration with manual temperature compensation

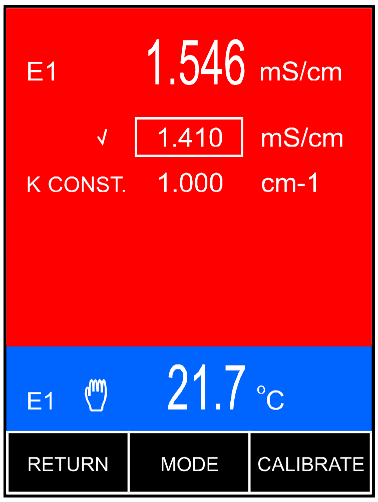
To calibrate the meter:

- disconnect the temperature probe, enter the temperature measurement parameters screen and enter the value equal to the reference temperature into the **MANUAL TEMP.** window;
- enter the calibration mode: select the conductivity measurement on the measurement screen, press and hold the **CAL** button until the background changes colour into red, the meter will automatically change the unit into S/cm (Pic. 15A). Adopted K constant is equal 1.000cm^{-1};
- check and, if necessary, adjust the standard solution value (point 17.2.1);
- measure the temperature of the solution with a laboratory thermometer and enter it according with the point 29.5;
- immerse the conductivity cell in the standard solution and hold it at least 1cm away from the bottom and walls of the vessel. Make sure, that the measuring cell is filled up with the sample solution and does not include any air bubbles, and the electrode's surface is evenly moistened. Around the calibration point displays a frame, which informs, which informs about recognising the standard by the meter;

When the reading stabilises, press the **CALIBRATE** button. Next to the calibration point a mark appears, what informs about recording the calibration value. At the same time, the reading will be adjusted to the recognised standard value (Pic. 15B). If the difference between the reading and the standard is significant, wait until the reading stabilises and press the **CALIBRATE** button again. Slight differences may occur as a result of inaccuracies in K constant calcuation. If the meter does not recognise the standard, it will signalise the error with a tripple warning sound after pressing the **CALIBRATE** button.



A



B

Pic. 15

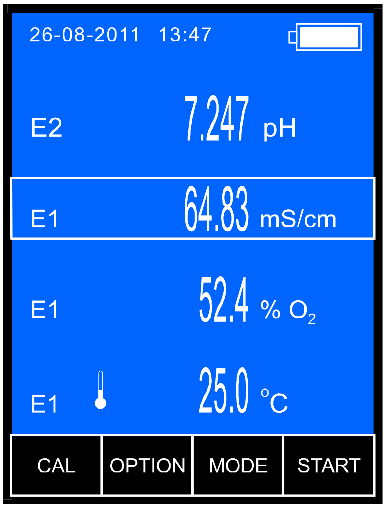
The meter is calibrated and ready for performing measurement.

18. CONDUCTIVITY MEASUREMENT

18.1. Measurement without temperature compensation

An accurate conductivity measurement should be performed without the temperature compensation. The measured solution should be adjusted to the reference temperature entered earlier. When controlling, it is possible to use the temperature probe. In case of work without the temperature probe it is necessary to enter the temperature value according to the point 29.5.

Follow the instructions:
- connect the conductivity cell and the temperature probe to the **Cond** and **t** connectors respectively (Pic. 2);
- turn the meter on with 
;
- choose the conductivity measurement mode (section 15.3);
- if the conductivity cell is not calibrated, calibrate it (chapter 17);
- immerse the conductivity cell and the temperature probe in the solution, hold the conductivity cell at least 1 cm away from the bottom and walls of the vessel. Make sure, that the measuring cell is filled up with the sample solution and does not include any air bubbles, and the electrode's surface is evenly moistened*;
- Adjust the solution temperature to the reference temperature;
- check the reading when it stabilises (Pic. 16).



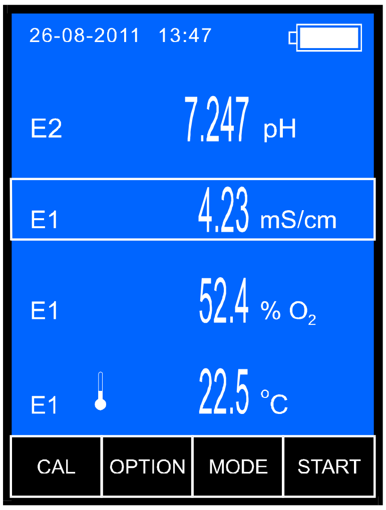
Pic. 16.

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

18.2. Measurement with automatic temperature compensation

Follow the instructions:

- connect the conductivity cell and the temperature probe to the **Cond** and **t** connectors respectively (Pic. 2);
- turn the meter on with ;
- choose the conductivity measurement mode (section 15.3);
- if the conductivity cell is not calibrated, calibrate it (chapter 17);
- check or change the α coefficient and the reference temperature;
- immerse the conductivity cell and the temperature probe in the solution, hold the conductivity cell at least 1 cm away from the bottom and walls of the vessel. Make sure, that the measuring cell is filled up with the sample solution and does not include any air bubbles, and the electrode's surface is evenly moistened*;
- check the reading when it stabilises (Pic. 17).



Pic. 17.

Notice: in case of exceeding the range of temperature compensation the readout changes its colour to yellow. The symbol next to the readout instead of informs that the temperature probe is broken or disconnected.

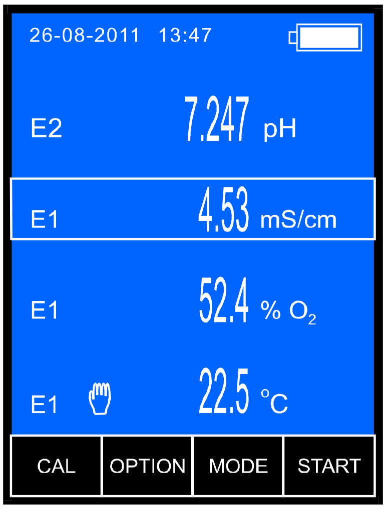
* - air bubbles may be removed by moving the immersed cell. In order to make moistening of the electrodes easier, it is recommended to immerse the cell in distilled water with washing-up liquid, and than wash it in distilled water.

18.3. Measurement with manual temperature compensation

Measurement with manual temperature compensation may be performed in stable working conditions, i.e., measurements in laboratory, especially with use of thermostat, or in case of the temperature probe breakdown. Disconnecting the temperature probe switches the meter to manual temperature compensation.

To make measurement with manual temperature compensation:

- connect the conductivity cell to the **Cond** connector (Pic. 2);
- disconnect the temperature probe;
- turn the meter on with 
;
- choose the conductivity measurement mode (section 15.3);
- if the conductivity cell is not calibrated, calibrate it (chapter 17);
- check or change the α coefficient and the reference temperature;
- immerse the conductivity cell and the temperature probe in the solution, hold the conductivity cell at least 1 cm away from the bottom and walls of the vessel. Make sure, that the measuring cell is filled up with the sample solution and does not include any air bubbles, and the electrode's surface is evenly moistened*;
- measure the temperature of the solution and enter its value according to the point 29.5;
- check the reading when it stabilises (Pic. 18.).



Pic. 18.

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

19. 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 isn't linear and the conversion coefficient is changing 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 results in significant error.

Table 3.

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

The microcontroller in CX-461 calculates 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 this 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 of 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 $103 \div 105^0$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 which 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.

19.1. Salinity measurement with conversion to NaCl or KCl

To make the salinity measurement with conversion to NaCl or KCl content, follow the instructions:

- choose the salinity measurement with conversion to NaCl or KCl content according to section 15.3;
- choose the unit (g/l or %);
- act as during the conductivity measurement (chapter 18);
- check the reading when it stabilises.

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

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

19.3. The salinity measurement with conversion to TDS

To perform the salinity measurement with conversion to TDS, follow the instructions:
- enter the W_{TDS} coefficient according to the point 15.8;
- choose the measurement of salinity with conversion to TDS and the unit (g/l or %);
- act as during conductivity measurement.

Check the reading when it stabilises.

20. SIMPLIFIED WAY OF DETERMINING THE α COEFFICIENT

The knowledge of α coefficient is significant during measurements in temperatures different than the reference temperature.
This coefficient is changing 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.

substancja	stężenie wagowe	współczynnik α
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 approximated values of α coefficient for KCl and NaCl depending on the temperature and concentration of the measured liquid.

Table 5.

temp. `^{0}C	współczynnik temperaturowy α			
	roztwór KCl			Nasycony 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.
An assumption may be made that the α coefficient is constant in the range of ±5 ^{O}C difference 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 solution to the reference temperature (**T_R**) and measure its conductivity (**G_{TR}**).
2. Adjust 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 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 measured in ref. Temperature **T_R**
G_{TX} - conductivity measured in temperature **T_x**

Now, the α coefficient is determined for the reference temperature T_R and the measurement temperature T_x.
During measurements in 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℃ the formula is different:

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

where: **T_X** - changed temperature in ^{0}C
G_{25} - conductivity at 25 ^{0}C
G_{TX} - conductivity measured at **T_x** temperature

IV. OXYGEN CONCENTRATION MEASUREMENT

21. BASIC INFORMATION ABOUT THE 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; the cell's 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 salinity and atmospheric pressure parameters should be additionally entered. The measurement of saturation 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, the problems are the result of neglecting basic sensor maintenance activities by the user. It is worth remembering that during measurement the sensor absorbs oxygen from the environment of the membrane.

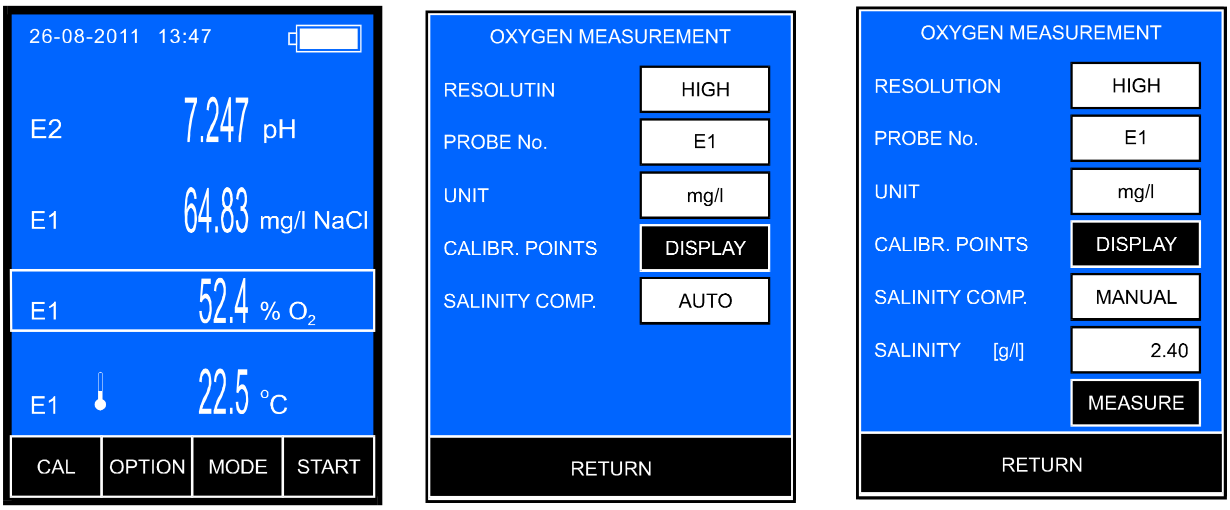
The sensor's manufacturers recommend the minimal flow-rate of the tested water, assuring a stable result. When this requirement is not complied, the result will regularly decrease. During measurements in stagnant solutions the flow can be partly simulated by keeping the sensor in slow rotary motion. 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 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 the **CX-461** multifuncion 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.

22. ENTERING DISSOLVED OXYGEN MEASUREMENT PARAMETERS

The oxygen meter parameters screen is entered by pressing the oxygen readout (the frame will display around it – Pic. 19A), and next the **MODE** button. On this screen (Pic. 19B) choose the unit, the method of salinity compensation and its value. After entering parameters, return to the measurement screen pressing the **RETURN** button.



A B C

Pic. 19

22.1. Resolution

The reading can be displayed with low or high resolution. By pressing the **RESOLUTION** window, choose:

LOW - 1% or 0.1mg/l measurement resolution;
HIGH - 0.1% or 0.01 mg/l measurement resolution.

22.2. Sensor number

If the meter stores more than one sensor characteristic, the sensor may be replaced without calibration. This option is very useful in case of field work. After pressing the **PROBE NO** window, choose one of the characteristics stored under **E1**, **E2** or **E3** number. The number‘s colour informs about the sensor‘s condition:

white - sensor calibrated;
yellow - the calibration validity date expired;
red - characteristic erase, the sensor calibration necessary.

22.3. Unit

The readout can be displayed in % of the oxygen saturation or in **mg/l**. By pressing the **UNIT** window, choose:

- [%] - measurement in % of oxygen concentration
- [mg/l] - measurement in mg/l
- [% Air] - measurement of percantage of the oxygen content in air.

22.4. Calibration points and date

After pressing the [DISPLAY] button the screen with calibration points, validity time and last calibration date. Marker next to the point value informs, that the last calibration was performed in this particular point. Validity time and last calibration date are stored separately for each of the three sensors. Calibration points are the same for all three sensors and should not be changed.

22.5. Calibration validity time

The meter stores the calibration validity time for each of the three sensors separately. Termination of this time is signalised with yellow sensor number. To set the calibration validity time, press the **VALIDITY** window, the numerical keyboard will appear to enter the number of days and confirm with the [OK] button.

22.6. The salinity influence compensation

Oxygen solubility in water is decreased by its salinity which has to be taken into consideration during measurements in mg/l. **1 g/l of salinity change causes about 0.5% of the oxygen saturation change.** The meter enables entering the salinity value in g/l and counts the change of oxygen saturation in mg/l.

Choose among three salinity compensation modes:

- [AUTO] - the salinity measured simultaneously with the oxygen concentration calculated automaticaly;
- [MANUAL] - the salinity value entered manually with the numerical keyboard or collected once from the conductivity measurement course;
- [OFF] - the salinity compensation off.

22.6.1. Manual introduction of the salinity value

After choosing the manual mode the **SALINITY** window will appear (Pic. 19C) for entering the salinity value. To enter, press the **SALINITY** window, the numerical keyboard will appear for entering the salinity value and confirm with the **OK** button. If the value is to be measured and entered once, press the **MEASURE** button during the salinity measurement. The currently measured value will be entered into the **SALINITY** window automatically.

22.7. Automatic compensation of the atmospheric pressure influence

The concentration of oxygen dissolved in water and measured in mg/l depends on the atmospheric pressure value. Change of the pressure equal 10% causes also 10% oxygen saturation change. The meter enables automatic compensation thanks to build-in atmospheric pressure sensor. This influence is automatically calculated during measurements in **mg/l**.

In case of the measurement in % the atmospheric pressure has no influence on the reading.

23. CALIBRATION OF THE DISSOLVED 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%. 2 point calibration is carried out in **0% of oxygen concentration solution** (i.e. **saturated** sodium sulphide) and calibration in 100% of oxygen saturation is made in the air. **In such case the membrane has to be immersed in distilled water for a few minutes before calibration.** It is assumed that O_2 content in the air corresponds to 100% of saturation, what enables simplified calibration to be carried out.
1 point calibration is made only for 100% of oxygen saturation.

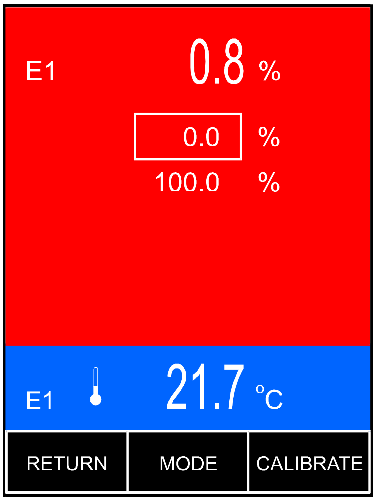
In case of measurement of oxygen content in air let the fresh air in into the room. Usually, 1-point calibration in air is sufficient, as the zero point of the meter is at its resolution level.

Entering the calibration mode under the chosen sensor number erases the characteristic stored in the memory under this number.
In case of choosing the sensor's number, entering the calibration mode and escaping it without making calibration, the characteristic stored previously will be erased and a standard characteristic will be applied. The characteristic erase is signalised with red coulour of the sensor number on the screen.

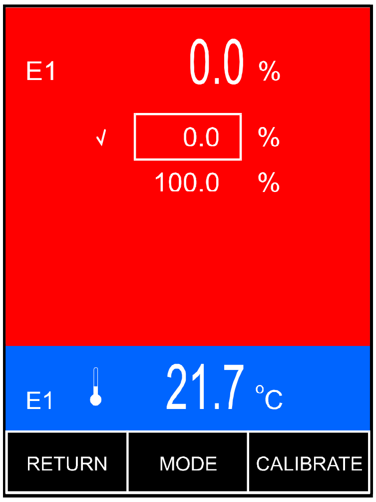
To calibrate, follow the instructions:

- choose the sensor number according to the point 22.2.
- enter the calibration mode: select the dissolved oxygen measurement on the measurement screen, press and hold the **CAL** button until the background changes its colour to red, the meter enters the calibration mode and automatically changes the unit to %. The previous sensor characteristic is erased;
- put the DO sensor into the 0% oxygen saturated solution (saturated sodium sulphide). The meter will mark the recognised calibration point value with a frame (Pic. 20.A);
- when the reading stabilises, press the **CALIBRATE** button. Next to the 0% calibration point a marker appears, what informs about recording the calibration value, at the same time the measurement value will be corrected to 0% (Pic. 20.B).;
- take the sensor out, **rinse it accurately with distilled water** and put into the 100% oxygen saturation solution providing the flow or leave it in the air;
- when the reading stabilises, press the **CALIBRATE** button. Next to the 100% calibration point a marker appears, what informs about recording the calibration value, at the same time the measurement value will be corrected to 100% (Pic. 20.C). If the reading is still different, wait until it stabilises and press the **CALIBRATE** button again.
- return the measurement mode by pressing the **RETURN** button.

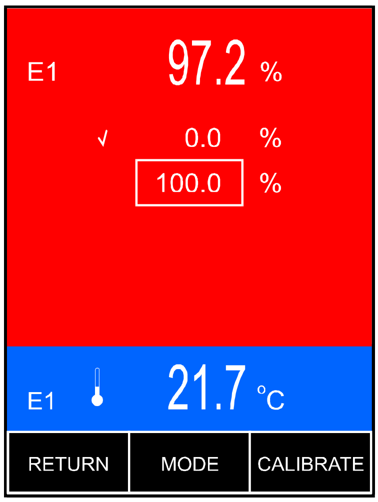
If the meter cannot recognise the 0% or 100% value (the frame does not appear), it will signalise the error after pressing the **CALIBRATE** button with a tripple warning sound. In such case check the membrane condition and the applied standards.



A



B



C

Pic. 20.

24. MEASUREMENT OF OXYGEN CONCENTRATION IN WATER

Before starting the oxygen concentration measurement the meter should be prepared for work (chapter 7) and the oxygen sensor calibrated (chapter 23). The measurement in **%** of saturation does not require additional measurements of the temperature, salinity or atmospheric pressure. **However, frequent measurements in mg/l depend on these factors.** This influence is corrected automatically by the device, which takes into consideration the temperature value measured by the sensor or - in case of manual compensation - the value entered by the user. The oxygen sensor is equipped with an additional system compensating the temperature influence on the membrane. Because of limited accuracy of this compensation the highest accuracy can be achieved by calibrating the sensor at the same temperature at which the measurement will be carried out. **The measurement error increases together with the difference between the calibration and measurement temperatures and results from characteristic features of the sensor, not the device.** For the applied sensor this error is about < 3% at a $\pm 5^0$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 salinity of the tested solution is low, the compensation may be turned off before the measurement (point 22.6). **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 and choose automatic or manual salinity compensation according to the section 22.6.

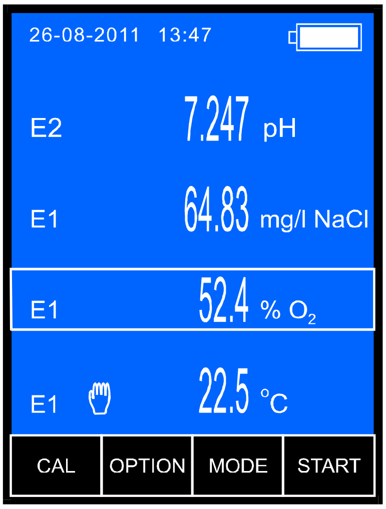
24.1. Measurement with automatic temperature compensation

Follow the instructions:
- connect the DO sensor and temperature probe to the meter;
- put the probe and the sensor to the measured solution;
- turn the meter on with the  button;
- choose displaying the oxygen concentration value according to the point 31.1;
- choose the unit according to the section 22.3;
- for accurate measurement of oxygen concentration in **mg/l** enter the salinity value (section 22.6);
- check or simulate the solution flow;
- wait about 1 ÷ 1.5 min until the reading stabilises (depending on sensor) and read the value.

24.2. Measurement with manual temperature compensation

Follow the instructions:

- disconnect the temperature probe;
- turn the meter on with the  button;
- choose displaying the oxygen concentration value according to the point 31.1;
- choose the unit according to the section 22.3;
- for accurate measurement of oxygen concentration in **mg/l** enter the salinity value (section 22.6);
- put the DO sensor to the measured solution;
- measure the solution temperature with a thermometer and enter the value according to the point 29.5;
- check or simulate the solution flow;
- check the readout when it stabilises (Pic. 21).



Pic. 21

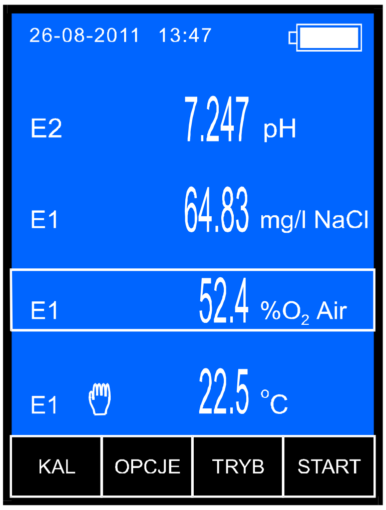
Notice: in case of solutions with low salinity check according to the section 22.6 if the salinity compensation is off.

25. MEASUREMENT OF OXYGEN CONTENT IN AIR

Before starting the oxygen content measurement, the meter should be prepared for work (chapter 7) and the oxygen sensor calibrated (chapter 23). The oxygen content measurement does not require additional measurements of temperature, salinity and atmospheric pressure.

In order to make measurement:

- connect the oxygen sensor to the **O2** connector (pic. 2);
- leave the oxygen sensor in the air;
- switch the meter on with the  button;
- choose the oxygen concentration measurement according to the point 31.1;
- choose the unit according to the chapter 22.3;
- wait until the reading stabilises and check it (Pic. 22).



Pic. 22

Note: during the measurement of the oxygen content in air next to the reading (on the left) the **%O_2 Air** symbol is displayed to differenciate it from the reading of percentage of the dissolved oxygen concentration in water.

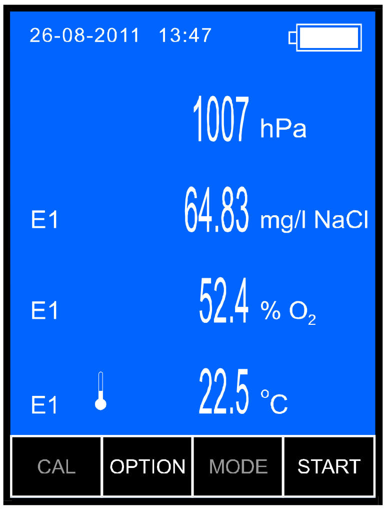
V. ATMOSPHERIC PRESSURE MEASUREMENT

26. ATMOSPHERIC PRESSURE MEASUREMENT

The meter enables atmospheric pressure measurement. To read its value:

- turn the meter on by pressing the 

 button;
- choose the atmospheric pressure measurement function on the measurement screen according to the point 31.1
- return to the measurement screen by pressing the **RETURN** button and read the pressure value (Pic. 23);

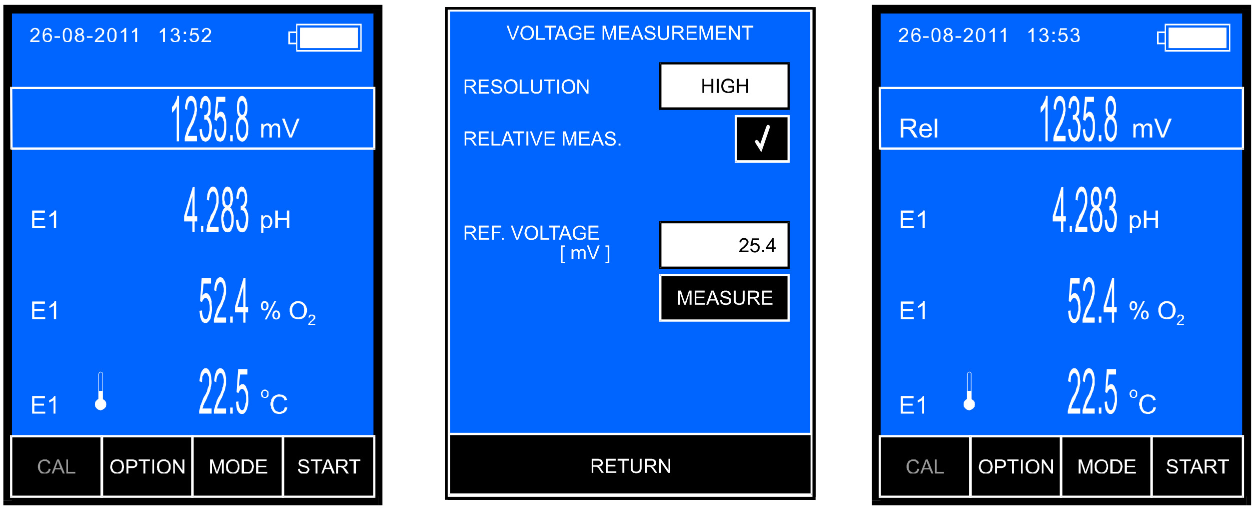


Pic. 23.

VI. REDOX POTENTIAL (MV) AND TEMPERATURE MEASUREMENT

27. SETTING THE REDOX POTENTIAL PARAMETERS

The redox potential parameters window is entered by selecting the redox potetial readout (a frame will be displayed around it – Pic. 24A) and the **MODE** button. The screen (Pic. 24B) enables choosing the resolution, the reference temperature and setting the zero offset for the relative measurement.



A B C

Pic. 24

After setting the parameters return to the measurement screen by pressing the **RETURN** button.

If the relative measurement has been chosen, next to the redox value the Rel symbol will appear (Pic. 24C). The difference between the redox potential value and the reference value is displayed.

27.1. Resolution

The reading can be displayed with low or high resolution. By pressing the **RESOLUTION** window, choose:

LOW - 0.1 mV measurement resolution;
HIGH - 1 mV measurement resolution.

27.2. Relative measurement

The meter enables relative measurement of the redox potential. To make measurement, on the redox potential parameters screen (Pic. 24B) select the **RELATIVE MEAS** window. Pressing the window again turns the relative measurement off.

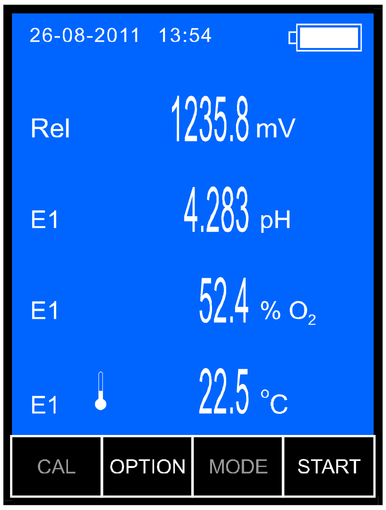
27.3. Reference voltage

After choosing the relative measurement the **REF. VOLTAGE** window appears to enter the reference voltage value. To enter, press the **REF. VOLTAGE** window, the numerical keyboard will appear to enter the reference voltage value and confirm with the **OK** button. To enter the current reference voltage value, press the **MEASURE** button during the measurement process, the currently measured reference voltage value will be entered into the **REF. VOLTAGE** window automatically.

28. REDOX POTENTIAL MEASUREMENT

CX-461 is an accurate voltmeter. The measurement may be made with redox electrode or during titration. To make measurement:

- turn the meter on by pressing the  button;
- choose the redox potential measurement to be displayed on the measuring screen according to the point 31.1;
- enter the measurement parameters according to the point 27;
- return to the measurement screen by pressing the **RETURN** button and check the reading (Pic. 25).

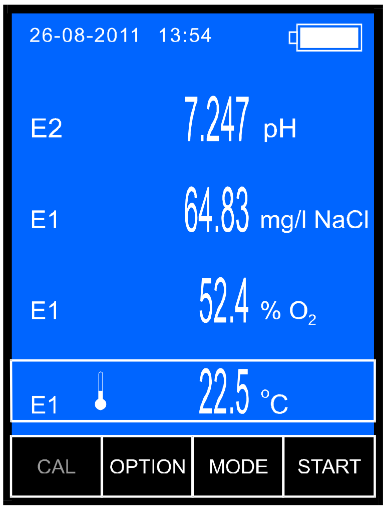


Pic. 25.

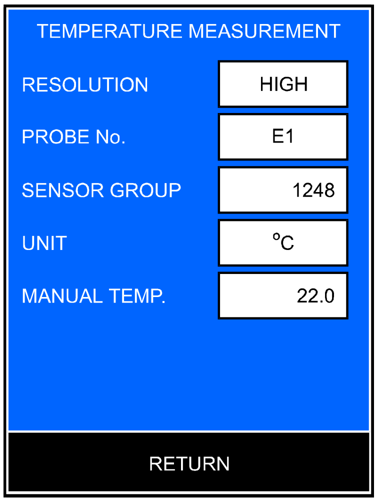
29. SETTING THE TEMPERATURE MEASUREMENT PARAMETERS

The temperature measurement parameters window is entered by selecting the temperature readout (Pic. 26A) and next the **MODE** button (Pic. 26B). The screen enables choosing resolution, probe group, unit and entering the manual temperature compensation value.

A



B



Pic. 26

After setting the parameters return to the measurement screen by pressing the **RETURN** button.

29.1. Resolution

The reading can be displayed with low or high resolution. By pressing the **RESOLUTION** window, choose:

- LOW - 1 ^{0}C measurement resolution;
- HIGH - 0.1 ^{0}C measurement resolution.

29.2. Probe number

The meter may store parameters of three probes, which may be replaced without the need of entering the group again, only the number which symbolises the sensor group has to be selected. By pressing the **PROBE NO.** window choose one of the three groups recorded under **E1**, **E2** or **E3** number.

29.3. Sensor group

The meter may cooperate with Pt-1000B standard temperature sensor or with Pt-1000S selective sensor of higher accuracy. Before starting measurement, the probe data have to be entered.
To enter, press the **SENSOR GROUP** window, the numerical keyboard will appear to insert the value given on the probe's plug (the number following the G letter) and confirm with the **OK** button.
The meter is calibrated and ready for the measurement.

To adjust the meter for cooperation with Pt-1000B standard sensor, into the **SENSOR GROUP** window insert the **nn00** number, where nn – cable lenght in meters in range 1 - 19m. For the Pt-1000B sensor on 1 meter cable the number will be 100 (the zero at the frontal position is not displayed) and for the same sensor on 15 meter cable the number will be 1500.

29.4. Unit

The readout may be displayed in ^{0}C, K or ^{0}F.
By pressing the **UNIT** window choose the measurement unit.

29.5. Temperature of the manual compensation

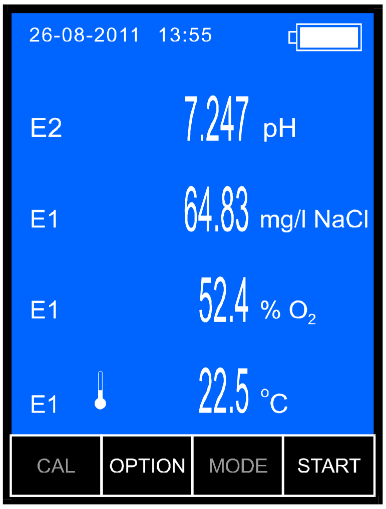
After disconnecting the temperature probe the meter switches to manual compensation automatically and calculates in the entered temperature value. To enter this value, press the **MANUAL TEMP.** window, the numerical keyboard will appear to enter the value and confirm with the **OK** button.

30. TEMPERATURE MEASUREMENT

Follow the instructiions:

- turn the meter on by pressing the button
- connect the temperature probe to the Chinch connector, the symbol will appear on the screen;
- immerse the temperature probe into the solution;
- wait till the value stabilises and read the result.

The meter cooperates with Pt-1000 platinum resistor sensor and the final accuracy of the temperature measurement is dependent on the sensor‘s class.



Pic. 27

NOTICE: break in the temperature probe’s circuit switches the meter to the manual temperature compensation mode. It is signalised by change of the symbol to the symbol. Instead of the measured temperature value, the value inserted by the user is displayed.

Displaying of -50℃ value in red while making measu rement at positive temperature informs about short circuit in the temperature probe.

VII. OPTIONS

31. OPTIONS SCREEN

Enter the options screen by pressing the **OPTION** button in the measurement screen. The OPTIONS screen contains the following tabs:

FUNCTIONS - choose the measurement functions to be displayed on the measurement screen;

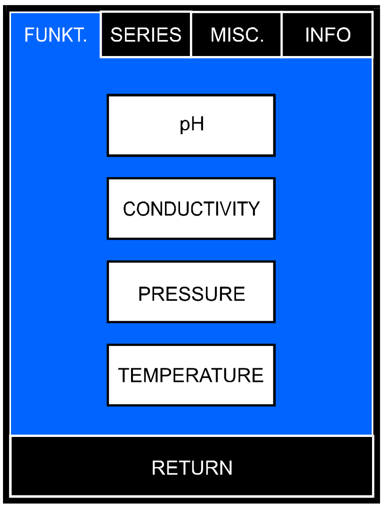
SERIES - parameters for collecting measurement series;

MISC. - choose the language, set the economical mode, time and date;

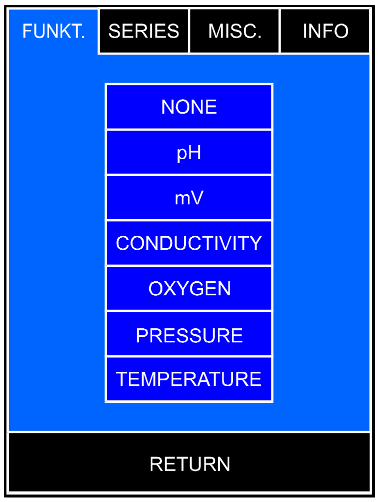
INFO - information about the sotware version and the manufacturer's address.

31.1. Functions

This tab enables choosing the measurement functions to be displayed on the measurement screen. After entering this screen the recently chosen configuration is displayed.



A



B

Pic. 28

After pressing the window with function which is to be changed, the table will display with all measurement functions. After pressing the chosen function the meter returns to the functions screen with the new configuration. In case of choosing a function which already has been chosen in another window, a **NONE** symbol will be displayed.

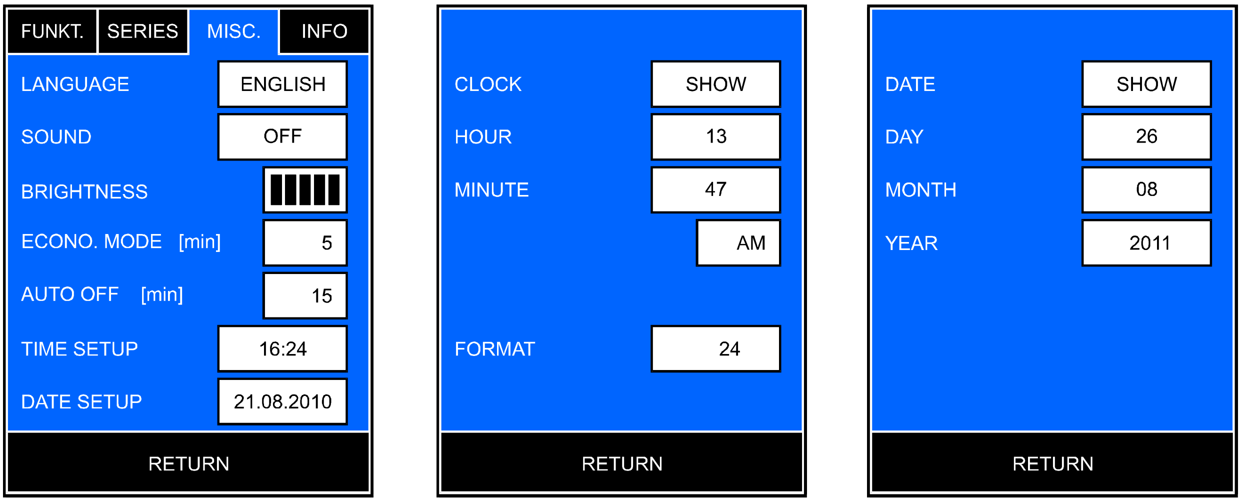
Return to the measurement screen by pressing the **RETURN** button.

31.2. Series

For the description of the **SERIES** tab, see the chapter 32.

31.3. Miscellaneous

This screen (Pic. 29A) the following parameters may be entered:



A B C

Pic. 29

LANGUAGE	-	choosing the language (Polish, English, German);
SOUND	-	turning the buttons sound on / off;
BRIGHTNESS	-	setting the display's brightness;
ECONO. MODE	-	the time of non-use (the last press of any button), until the meter switches to the economical mode, reducing the brightness to the minimum;
AUTO OFF	-	the time of non-use until the meter turns off;
TIME SETUP	-	after pressing the **TIME SETUP** window the screen will appear (Pic. 29B) to turn the time displaying on / off, chosse the 12 / 24 clock mode and set the current time;
DATE SETUP	-	after pressing the **DATE SETUP** pokaże się ekran (Pic. 29C), na którym można włączyć lub wyłączyć wyświetlanie daty i wprowadzić aktualną datę;

To enter a logical value (lanuage, sound, brightness), press the chosen window, a table will appear to choose the value.

To enter a numerical value, press the chosen window, a numerical keyboard will appear to enter the value and confirm with the **OK** button.

31.3.1. Automatic switch-off

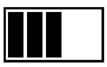
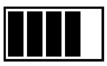
Automatic switch-off mode prolongs an operating time with rechargeable batteries and prevents from discharging in case when the meter has been unintentionally left in operation.

The automatic switch-off mode is active only while working with the rechargeable batteries.
The function is deactivated for calibration, collecting measurement series and work with the power adapter.

Entering zero for the **AUTO OFF** parameter deactivates this mode entirely.

31.3.2. Setting the brightness and lighting time

The brightness settings are very important while working in the field. Choose one of five brightness modes. The table below shows the influence of the brightness settings to the meter's operating time.

backlight	**operating time**
econimical mode (backlight off)	30 h
brightness 	18 h
brightness 	16 h
brightness 	14 h
brightness 	13 h
brightness 	11 h

31.4. Info

The INFO tab contains the company address and the software version number. (Pic. 30).

Pic. 30.

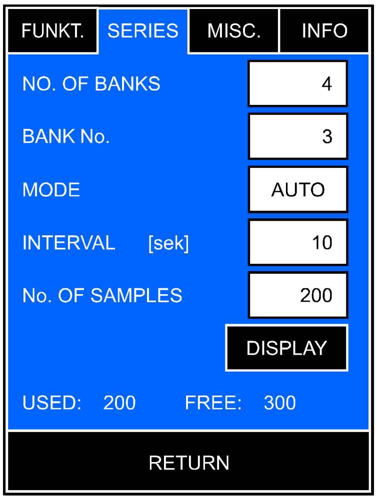
Return to the measurement mode by pressing the **RETURN** button.

32. RECORDING THE READINGS, MEMORY READOUT

The meter enables recording 2000 readings of the displayed measurement functions. The readouts are stored in memory even in case of power shortage. Before the measurement set the recording parameters for the readings.

32.1. Storage parameters

Parameters may be changed in the **SERIES** tab - the **OPTIONS** screen. Enter the screen from the measurement screen, by pressing the OPTION screen.



Pic. 31.

The screen enables setting the following parameters:

NUMBER OF BANKS	- number of banks (parts) into which the readouts are to be divided;
BANK	- the number of bank into which the sampleas shall be collected or to be displayed after pressing the DISPLAY button;
MODE	- choosing the collecting series mode between manual and automatic. Each press of the window changes the mode;
INTERVAL	- the interval between recorded readings in the automatic mode;
NUMBER OF SAMPLES	- number of measurements to be recorded in the automatic mode.

At the screen‘s bottom an information is given about the recorded samples number (**USED**) and how many samples are yet to be recorded (**FREE**).

To enter the number of banks or the bank number, press the chosen window, a table will appear to choose the value.

To enter the interval or number of samples, press the chosen window, a numerical keyboard will appear to enter the value and confirm with the OK button.

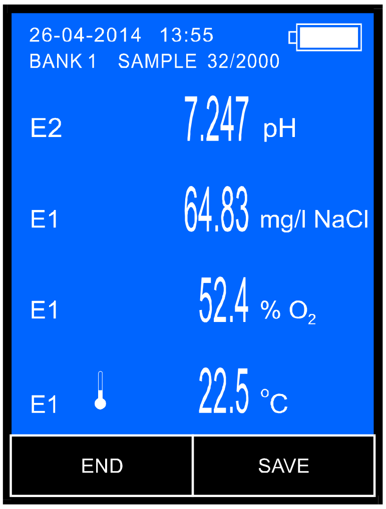
32.1.1. Number of banks

All the content of the meter‘s memory may be divided into parts (banks) to facilitate viewing or groupping the readings. Changing the number of banks results in erasing all the memory content, what is signalised by the meter. The table below shows the dependency between the number of banks and the maximal number of samples in one bank.

number of banks	max. number of samples in one bank
1	2000
2	1000
4	500
8	250
10	200

32.2. Entering single readouts into the memory

If, according to the previous section, collecting single readouts has been chosen, than pressing the START button starts up manual readouts collecting (the SAVE and END button will show at the bottom of the measurement screen). If the chosen bank already contains any readouts, the meter asks whether they should be deleted or the new readouts placed after the earlier recorded ones. Every press of the SAVE button records the readout. Pressing the END button escapes from the readouts collecting mode. If pressing the SAVE button results in filling the last free cell in the bank, the meter escapes the readouts collecting mode automatically.



Pic. 32

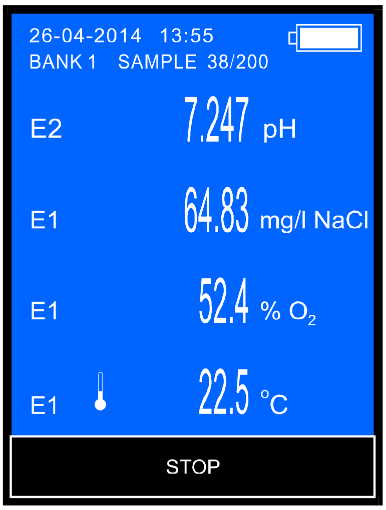
32.3. Collecting measurement series

There is a possibility to store series of measurements in the meter's memory. Follow the instructions:

- choose the bank and automatic collection of readouts (point 32.1);
- enter the time interval and number of samples (point 32.1);
- return to the measurement screen with the RETURN button;
- start collecting series with the START button. If the chosen bank already contains any readouts, the meter asks whether they should be deleted or the new readouts placed after the earlier recorded ones.

The buttons at the screen bottom will be replaced with the STOP button and the meter will start collecting measurement series. At the top of the screen, below the clock and date displays the number of bank to which the series is collected, the recorded sample number and the declared number of samples.

Collecting series is finished when the declared number of samples has been collected, the STOP button pressed or the bank filled up. If the series does not fill the entire capacity of the bank, the next series may be collected until the bank is full.



Pic. 33

Notice: pressing the ON OFF button during manual or automatic series collection results in signalising an error with a tripple warning sound. Collecting series will be continued until the STOP button is pressed.

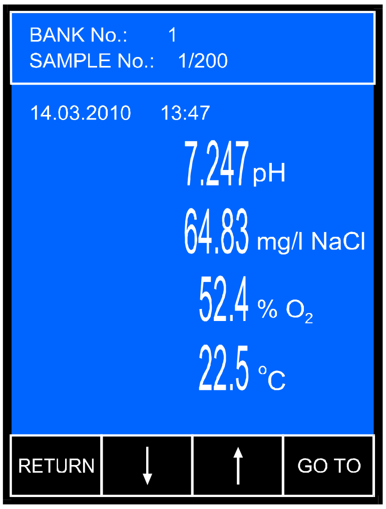
32.4. Reviewing the readouts

The stored readouts may be viewed on the meter's screen. Follow the instructions:

- on the measurement screen press the **OPTION** button and choose the **SERIES** tab on the options screen;
- Choose the number of bank that is to be viewed and press the **DISPLAY** button. A screen with the readouts collected in the chosen bank will display (Pic. 34);
- change the displayed sample number with the ↓ , ↑ buttons;

or

- press the **GO TO** button, a numerical keyboard will display to enter the number of the chosen sample and confirm with the **OK** button.



Pic. 34

Return from the bank review mode by pressing the **RETURN** button.

33. POWER, REPLACING THE RECHARGEABLE BATTERIES

The meter is powered with 2 x R6 rechargeable batteries (AA) or stabilised power adapter (6V). The adapter should be connected with the **P** connector (pic.2). The batteries are necessary in order to keep the clock working. The degree of filling the symbol in the top right corner of the LCD informs about the condition of the batteries. Red symbol informs that charging is necessary. When the voltage drops below the minimal value, the meter turns off automatically. After connecting the power adapter the charging process begins, what is signalised by the symbol filling up. When the symbol displays continuously, the charging process is finished. The meter may work while being charged. 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 according to their polarity. 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 to it - the ring should be put inside the housing in the whole perimeter. Next, do the screws till the moment of resistance (not too hard). Leaving the wall improperly screwed may cause the meter's inundation. This kind of failure is not repaired under the warranty conditions.

Caution: aplication of batteries instead of rechargeable batteries when using the power adapter may result in fire and damage the meter!

34. COOPERATION WITH PC

Connecting the meter with PC enables collecting the data directly on the computer, what makes a possible number of results to store unlimited. The PC should be equipped with a serial RS-232 connector. Connection to USB port may be obtained with use of a RS-232/USB converter (additional equipment).
In the back wall of the meter the **PC** connector is placed, what enables connection with PC or RS-232/USB converter by 4xx-PC cable.

If the converter is used, its software should be installed first according to the manual attached to it. After the instalation, an additional emulated COM serial port will become available on the computer.
Next, check the number of phisical (in case of connecting the meter to the RS-232 connector) or emulated (in case of connecting the meter by the converter) port (COMx). It may be checked in the Device Menager / Ports: COM, LPT).

For data transmission, use the special software prepared by our company. The software is delivered on CD. After inserting the CD to a drive the installation program will start automatically. It is necessary to follow the instructions appearing during the installation progress.

After connecting, turn on the meter and the PC and launch the transmission program. From the DEVICES / CONFIGURATION menu choose COMx, (x is the number of the serial port checked earlier).

Next, choose the mode of working with the meter. There are two 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”

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

35. 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 ^{0}C
pH ELECTRODE CALIBRATION: automatic,
1 ÷ 5 point

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

mV MEASUREMENT:

range	resolution	accuracy (±1 digit)
-2000.0 ÷ 2000.0 mV	0.1 mV	±0.1 mV

INPUT IMPEDANCE: $>10^{12}$ Ω

CONDUCTIVITY MEASUREMENT:

ranges	resolution	accuracy* (±1 digit)	frequency
0.000 ÷ 19.999 µS/cm	0.001 / 0.01 µS/cm	±0.1 %	100 Hz
20.00 ÷ 199.99 µS/cm	0.01 / 0.1 µS/cm	±0.1 %	1 kHz
200.0 ÷ 1999.9 µS/cm	0.1 / 1 µS/cm	±0.1 %	2 kHz
2.000 ÷ 19.999 mS/cm	0.001 / 0.01 mS/cm	±0.1 %	5 kHz
20.00 ÷ 199.99 mS/cm	0.01 / 0.1 mS/cm	±0.25 %	10 kHz
200.0 ÷ 2000.0 mS/cm	0.1 / 1 mS/cm	±0.25 %	10 kHz

* Accuracy for the end value of the range.

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

Temperature compensation: manual/automatic
Compenstion range: -5.0 ÷ 70.0 ^{0}C
K constant range: 0.010 ÷ 20.000 cm^{-1}
α coefficient range: 0.00 ÷ 10.00 %/ ^{0}C
TDS coefficient range: 0.20 ÷ 1.00
Measurement with conversion to KCl: 0 ÷ 200 g/l
Measurement with conversion to NaCl 0 ÷ 250 g/l
Cell calibration: jednopunktowa

1. by introducing the K constant of the cell
2. with use of calibration solution

DISSOLVED OXYGEN MEASUREMENT:

range	resolution	accuracy
0 ÷ 600.0 %	0.1 %	of the cell* ±1 digit
0 ÷ 60.00 mg/l	0.01 mg/l	of the cell* ±1 digit

* The cell‘s accuracy given in the chapter "The dissolved oxygen sensor".

Temperature compensation range: 0.0 ÷ 40.0 ^{0}C
Salinity compensation range: 0.0 ÷ 50.0 g/l
Atmospheric pressure measurement: 800 ÷ 1100 hPa
Sensor calibration:
2 point in 0% and 100% O_2
or 1 point in 100%O_2
Dissolved 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 ÷ 200.0 ^{0}C	0.1 ^{0}C	±0.1 ^{0}C

* Accuracy given for the meter. The final accuracy depends on the type of Pt-1000 probe.

Temperature probe: Pt-1000 platinum resistor

The probe‘s accuracy in range 0 ÷ 100 ^{0}C:
for Pt1000B resistor ±0.8 ^{0}C
for Pt1000$^{1}/_{3}$B resistor ±0.27 ^{0}C

OTHER:

MEMORY CAPACITY: 2000 results, divided into 1 ÷ 10 banks
OPERATING TEMPERATURE: -5 ÷ 45 ^{0}C
POWER SUPPLY: AA NiMH rechargeable battery x 2
6V/500mA stab. power adapter
POWER CONSUMPTION:
0% brightness 70 mW
100% brightness 180 mW
recharging batteries max. 2.4 W
DISPLAY: LCD 55 x 45 mm
DIMENSIONS: 149 x 82 x 22 mm
WEIGHT: 260 g (with rechargeable battery)

36. EQUIPMENT

The standard equipment includes:

1. Pt-1000B temperature probe (standard).
2. Plastic container for the meter, electrode and temperature probe.
3. 6V/500mA stabilised power adapter.
4. User‘s manual on CD.

Additionally may be ordered:

1. Combination pH electrde (glass membrane).
2. Conductivity cell.
3. Dissolved oxygen sensor.
4. 4XX-PC cable.
5. RS-232/USB converter.
6. Program for data collection and transmission on CD.
7. Adapter for connecting measuring and reference electrode instead of the combination electrode.
8. Pt-1000 S selective temperature probe of higher accuracy.
9. Conductivity cells for measurements in other conductivity ranges.
10. Redox electrodes.

W A R R A N T Y

The ELMETRON company ensures a 24-month warranty for the multifunction meter **CX-461** number:

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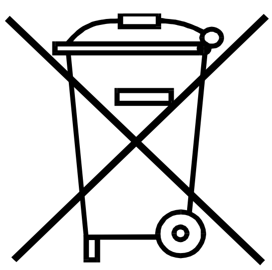
In case of damage the manufacturer will repair the meter within 14 days from the day of delivery.
The warranty doesn’t cover the damages caused by usage not in conformity with the user’s manual, using wrong power adapter, mechanical damages and damages caused by repairs made by unauthorised persons.

The pH electrode, conductivity cell, oxygen sensor have the separate warranty of the manufacturer.

NOTICE: Before sending the meter to us please contact the firm by phone or email.
Before sending the meter, please ensure, that the applied electrode, conductivity cell, oxygen sensor, temperature probe and power adapter have been also included.

We also provide after warranty repair service.

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



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