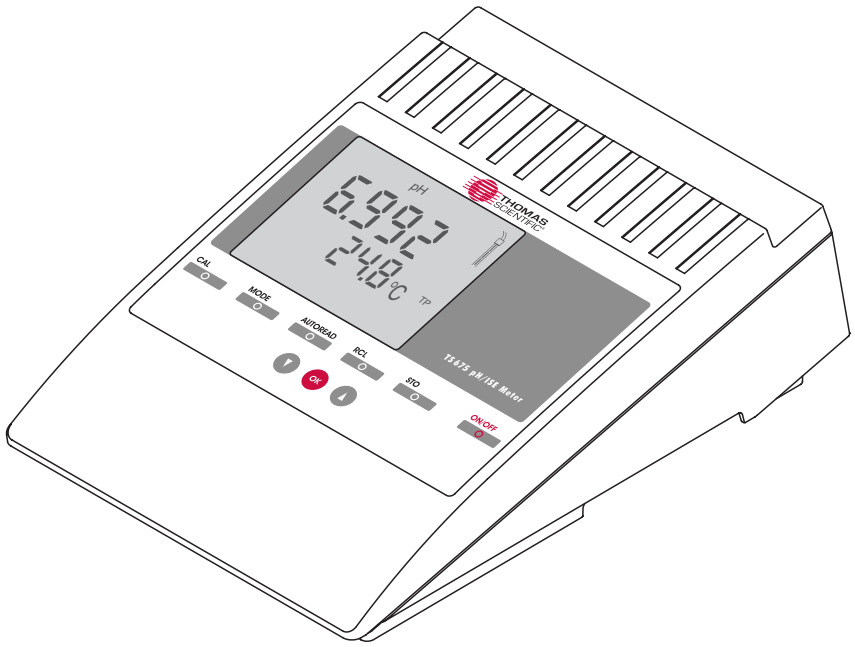
THOMAS SCIENTIFIC®

Operating Manual

TS 675 pH/ISE



pH/ION meter

ba75569e01 12/2005

Accuracy when going to press

The use of advanced technology and the high quality standard of our instruments are the result of continuous development. This may result in differences between this operating manual and your instrument. We cannot guarantee that there are absolutely no errors in this manual. We are sure you will understand that we cannot accept any legal claims resulting from the data, figures or descriptions.

Warranty declaration

The designated instrument is covered by a warranty of 2 years from the date of purchase.
The instrument warranty extends to manufacturing faults that are determined within the period of warranty.
The warranty excludes components that are replaced during maintenance such as batteries, etc.

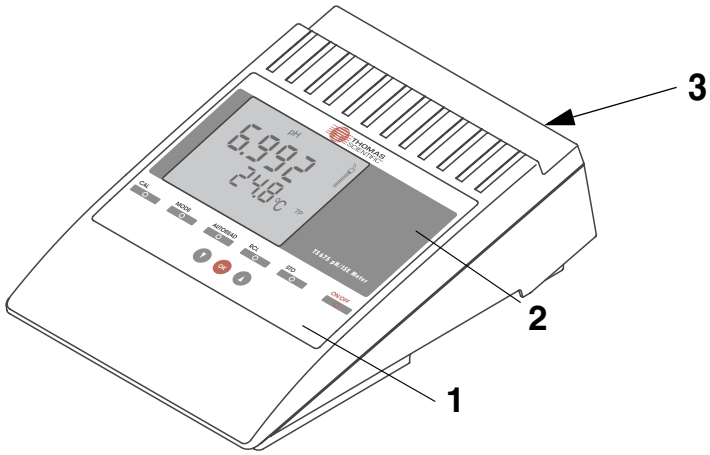
The warranty claim extends to restoring the instrument to readiness for use but not, however, to any further claim for damages. Improper handling or unauthorized opening of the instrument invalidates any warranty claim.

To ascertain the warranty liability, return the instrument and proof of purchase together with the date of purchase freight paid or prepaid.

1 Overview

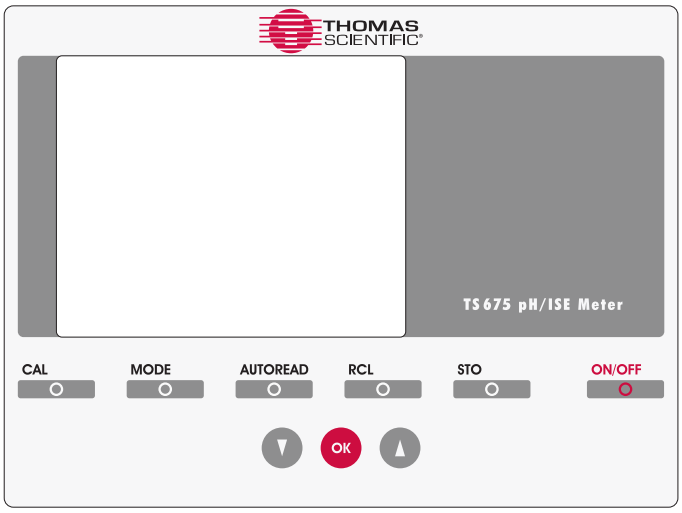
The compact TS 675 pH/ISE precision measuring instrument lets you perform pH, Redox, and concentration measurements using ion selective electrodes rapidly and reliably.
The TS 675 pH/ISE provides the highest degree of operating comfort, reliability and measuring safety for all applications.

The proven MultiCal® calibration procedures and special *AutoRead* function support your work with the meter.



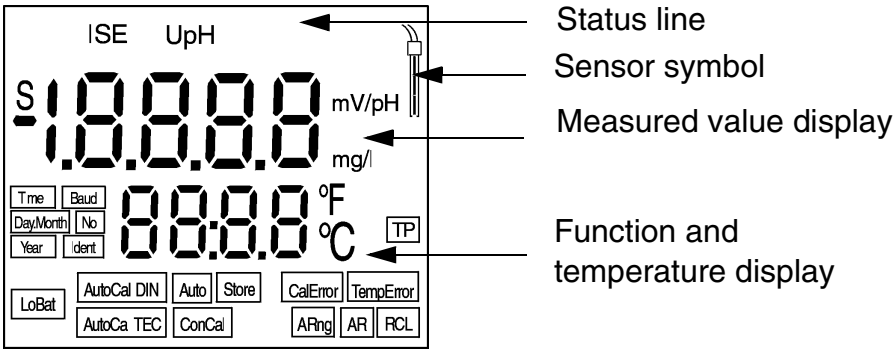
1	Keypad
2	Display
3	Sockets

1.1 Keyboard

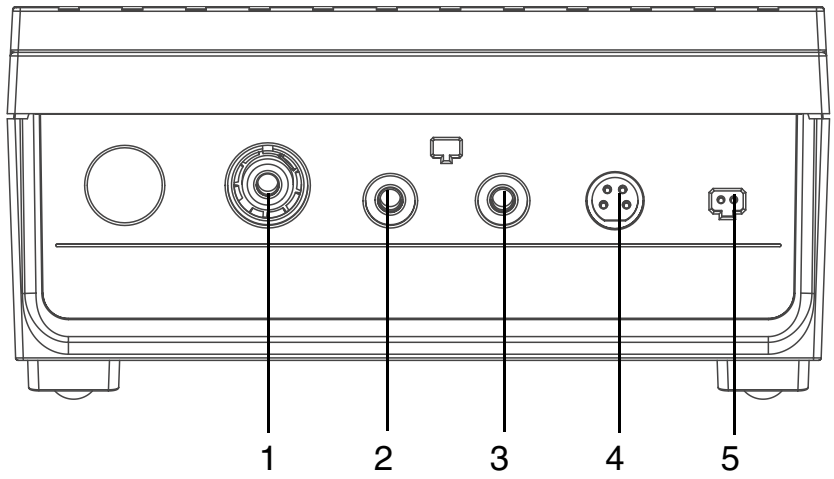


<CAL>	Call up calibration procedure
<MODE>	Select measuring mode
<AUTOREAD>	Activate/deactivate AutoRead function
<RCL>	Display or transmit measured values
<STO>	Store measured value
<ON/OFF>	Measuring instrument ON/OFF
<▼>	Reduce values, scroll
<▲>	Increase values, scroll
<OK>	Confirm inputs, start AutoRead

1.2 Display



1.3 Sockets



Connectors:

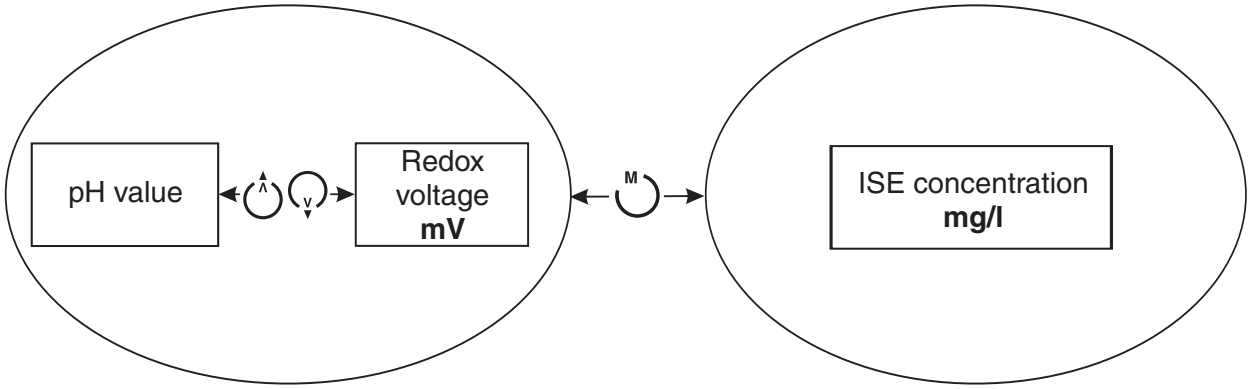
1	pH/ion electrode
2	Temperature probe
3	Reference electrode
4	RS232 interface
5	Plug-in power supply

Caution

Only connect electrodes to the instrument that cannot feed excessive voltages or currents (> SELV and > circuit with current limiter). Almost all commercial electrodes meet these requirements.

1.4 Operating structure

The following overview diagram shows which keys you have to press to select between the different measuring modes:



Note

For measuring, the electrode suiting the selected measuring mode must be connected to the instrument.

2 Safety

This operating manual contains basic instructions that you must follow during the commissioning, operation and maintenance of the instrument. Consequently, all responsible personnel must read this operating manual before working with the instrument.
The operating manual must always be available within the vicinity of the instrument.

Target group

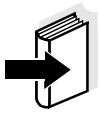
This measuring instrument was developed for use in the laboratory. Thus, we assume that, as a result of their professional training and experience, the operators will know the necessary safety precautions to take when handling chemicals.

Symbols used

Caution
indicates instructions that have to be followed to prevent damage to your instrument.

Warning
indicates instructions that have to be followed to protect yourself and the instrument from dangerous electrical voltage.

Note
indicates notes that draw your attention to special features.



Note
indicates cross-references to other documents, e.g. application reports, operating manuals of electrodes, etc.

2.1 Authorized use

This instrument is authorized exclusively for pH, Redox, and ISE concentration measurements in the laboratory.
The technical specifications as given in chapter 7 TECHNICAL DATA must be observed. Only the operation and running of the measuring instrument according to the instructions given in this operating manual is authorized.
Any other use is considered **unauthorized**.

2.2 General safety instructions

This instrument is constructed and tested in compliance with the EN 61010-1 safety regulations for electronic measuring instruments. It left the factory in a safe and secure technical condition.

Function and operational safety

The smooth functioning and operational safety of the instrument can only be guaranteed if the generally applicable safety measures and the specific safety instructions in this operating manual are followed.

The smooth functioning and operational safety of the instrument can only be guaranteed under the climatic conditions specified in chapter 7 TECHNICAL DATA.

If the instrument was transported from a cold environment to a warm environment, the formation of condensate can lead to the faulty functioning of the instrument. In this event, wait until the temperature of the instrument reaches room temperature before putting the instrument back into operation.

Caution
The instrument is only allowed to be opened by personnel authorized by Thomas Scientific.

Safe operation

If safe operation is no longer possible, the instrument must be taken out of service and secured against inadvertent operation.
Safe operation is no longer possible if:

- the instrument has been damaged in transport
- the instrument has been stored under adverse conditions for a lengthy period of time
- the instrument is visibly damaged
- the instrument no longer operates as described in this manual.

If you are in doubt contact the supplier of the instrument.

Obligations of the operator

The operator of this measuring instrument must ensure that the following laws and guidelines are observed when using dangerous substances:

- EEC directives for protective labor legislation
- National protective labor legislation
- Safety regulations
- Safety datasheets of the chemical manufacturer.

3 Commissioning

3.1 Scope of delivery

- Laboratory measuring instrument, TS 675 pH/ISE
- Operating manual
- 4 x type AA Mignon 1.5 V batteries
- Plug-in power supply

3.2 Initial commissioning

Perform the following activities:

- Set the date and time
- Connect the plug-in power supply.

Setting the date and time

1	Press and hold down the **<MODE>** key.
2	Press the **<ON/OFF>** key. The *display test* appears briefly on the display. The measuring instrument then switches automatically to the setting of the baud rate.
3	Press the **<OK>** key repeatedly until the date flashes on the display.
4	Set today's date by pressing **<▲><▼>**.
5	Confirm with **<OK>**. The date (month) flashes on the display.
6	Set the current month by pressing **<▲><▼>**.
7	Confirm with **<OK>**. The year appears on the display.
8	Set the current year by pressing **<▲><▼>**.
9	Confirm with **<OK>**. The hour field flashes on the display.
10	Set the current time by pressing **<▲><▼>**.
11	Confirm with **<OK>**. The minutes field flashes on the display.

12	Set the current time by pressing <▲><▼>.
13	Confirm with **<OK>**. The measuring instrument then switches to the measuring mode.
14	Switch off the instrument by pressing **<ON/OFF>**.

Connecting the plug-in power supply

The plug-in power supply supplies the pH meter with low voltage (7.5 V ... 12 V DC).

Warning
The line voltage on site must lie within the input voltage range of the original plug-in power supply unit (see chapter 7 TECHNICAL DATA).

Caution
Use original plug-in power supplies only
(see chapter 7 TECHNICAL DATA).

1	Insert the plug into the socket of the meter.
2	Connect the original plug-in power supply to an easily accessible mains socket.

Note
You can also perform measurements without a plug-in power supply.

4 Operation

4.1 Switch on the instrument

1	Place the instrument on a flat surface and protect it against intense light and heat.
2	Press the **<ON/OFF>** key. The display test appears briefly on the display. The instrument then switches automatically to the previously selected measuring mode.

Note
The instrument has an energy saving feature to avoid unnecessary battery depletion.
The energy saving feature switches the instrument off if no key has been pressed for an hour.
The energy saving feature is not active:

- if the power is supplied by the plug-in power supply
- if the *AutoStore* function is active
- if the communication cable is connected
- if the printer cable is connected
  (for external printers).

4.2 Measuring the pH value/Redox voltage

Preparatory activities

Perform the following activities when you want to measure:

1	Connect the electrode to the instrument.
2	Adjust the temperature of the buffer or test solutions or measure the current temperature if the measurement is made without a temperature probe.
3	Select the measuring mode by pressing **<MODE>**.
4	Calibrate or check the instrument with the electrode.

Note
Incorrect calibration of the pH electrode will result in incorrect measured values. Therefore, regularly perform calibration before measuring.

Temperature probe

Measurements can be performed with and without a temperature probe. A connected temperature probe is indicated by *TP* on the display.

Note
The meter automatically recognizes the type of the temperature probe used. As a result, you can connect electrodes with the NTC30 or Pt1000.

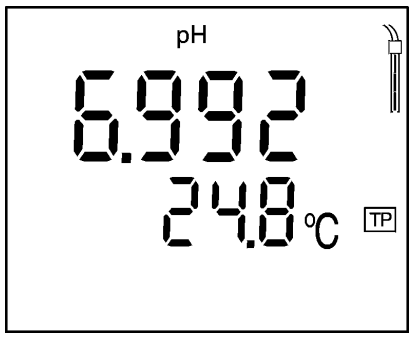
The temperature measurement is absolutely essential for a reproducible pH measurement. If the measurement is made without a temperature probe, proceed as follows:

1	Determine the current temperature using a thermometer.
2	Set up the temperature by pressing **<▲><▼>**, while keeping the **<OK>** key depressed.

Note
When calibrating without a temperature probe, set up the current temperature of the respective buffer solution manually using **<▲><▼>** while keeping the **<OK>** key depressed.

4.2.1 Measuring the pH value

1	Perform the preparatory activities according to section 4.2.
2	Immerse the pH electrode into the test sample.
3	Press the **<MODE>** key repeatedly until the pH/ Redox measurement appears on the display.
4	Select the pH measuring mode by pressing **<▲>** or **<▼>**. *pH* appears in the status line. The pH value appears on the display.



AutoRead AR (Drift control)

The *AutoRead* function (drift control) checks the stability of the measurement signal. The stability has a considerable effect on the reproducibility of the measured values.

1	Activate the AutoRead function by pressing **<AUTO-READ>**. The current measured value is frozen (Hold function).
2	Immerse the pH electrode into the test sample.
3	Start the AutoRead function by pressing **<OK>**. *AR* flashes on the display until a stable measured value is reached. This measured value is transmitted to a interface.
4	If necessary, start the next AutoRead measurement by pressing **<OK>**.
5	To cancel the AutoRead function: Press the **<AUTO-READ>** key.

Note
The current AutoRead measurement (with acceptance of the current value) can be terminated at any time by pressing **<OK>**.

AutoRead criteria

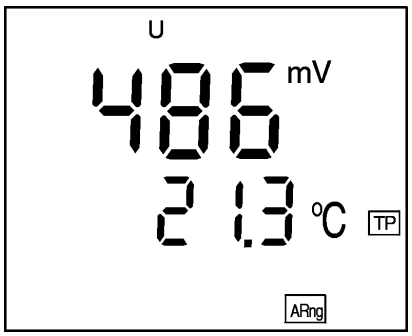
For identical measurement conditions, the following criteria apply:

Reproducibility	better than ± 0.01
Response time	> 30 seconds

4.2.2 Measuring the Redox voltage

The instrument can measure the Redox voltage (mV) of a solution when connected with a Redox electrode.

1	Perform the preparatory activities according to section 4.2.
2	Immerse the Redox electrode into the test sample.
3	Press the **<MODE>** key repeatedly until the pH/ Redox measurement appears on the display.
4	Select the Redox measuring mode by pressing **<▲>** or **<▼>**. *U* appears in the status line. The pH value appears on the display.
5	Wait for a stable measured value.



Note
Redox electrodes are not calibrated. However, you can check Redox electrodes using a test solution.

4.3 Calibrating

Why calibrate?

pH electrodes age. This changes the asymmetry (zero point) and slope of the pH electrode. As a result, an inexact measured value is displayed. Calibration determines the current values of the asymmetry and slope of the electrode and they are stored in the instrument.
Thus, you should calibrate at regular intervals.

When to calibrate?

- After connecting another electrode
- When the sensor symbol flashes:
  - after expiry of the calibration interval
  - after a voltage interruption, e.g. battery change.

You can choose between 3 calibration procedures:

AutoCal TEC

is specially adapted to the technical buffer solutions as a fully automatic two-point calibration. The buffer solutions are automatically recognized by the instrument.

AutoCal DIN / NIST

is specially adapted to permanently programmed buffer solutions according to DIN 19266 or NIST traceable buffers as a fully automatic two-point calibration. The buffer solutions are automatically recognized by the instrument.

ConCal

is the conventional two-point calibration with 2 freely selectable buffer solutions or single-point calibration as the rapid method.

AutoRead

In calibration using AutoCal TEC and AutoCal DIN, the *AutoRead* function is automatically activated. The current AutoRead measurement (with acceptance of the current value) can be terminated at any time by pressing **<OK>**.

Calibration protocol

The calibration protocol contains the calibration data of the current calibration. You can call up the calibration protocol by outputting the data storage (section 4.7.3).

Note
You can automatically print out a calibration protocol after the calibration. To do so, connect an external printer before the calibration. After a valid calibration, the protocol is printed.

Sample printout:

```
CALIBRATION PROTOCOL
 02.03.99     14:19
Device No.: 12345678
CALIBRATION pH
Cal Time: 01.03.99 / 15:20
Cal Interval:   7d
AutoCal DIN   Tauto
Buffer 1   1.679
Buffer 2   4.008 *
Buffer 3   6.865
Buffer 4   9.180 *
C1      174.1mV  25.0°C
C2     -133.3mV  25.0°C
S1     -59.4 mV/pH
ASY1   -   4 mV
Probe:     +++
```

Calibration evaluation

After the calibration, the instrument automatically evaluates the current status. The asymmetry and slope are separately evaluated. The worst evaluation appears on the display.

Display	Asymmetry [mV]	Slope [mV/ pH]
	-15 ... +15	-60.5 ... -58
	-20 ... +20	-58 ... -57
	-25 ... +25	-61 ... -60.5 or -57 ... -56
 Clean the electrode according to the electrode operating manual	-30 ... +30	-62 ... -61 or -56 ... -50
E3 Clear the fault according to chapter 6 WHAT TO DO IF...	< -30 or > 30	< -62 or > -50

Preparatory activities

1	Switch on the instrument by pressing **<ON/OFF>**.
2	Connect the pH electrode to the instrument.
3	Keep the buffer solutions ready.
4	Adjust the temperature of the solutions and measure the current temperature if the measurement is performed without a temperature probe.

4.3.1 Calibration interval (Int 3)

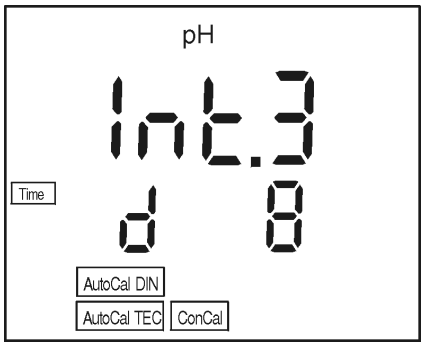
The calibration interval (Int 3) determines the time interval between 2 calibrations. After the selected calibration interval expires, the sensor symbol flashes. Measurements can continue.

Note
To ensure the high measuring precision of the measuring system, perform a calibration after the calibration interval expires.

Setting the calibration interval

The calibration interval (Int 3) is set to 7 days in the factory. The interval can be changed (1 ... 999 days):

1	Switch off the instrument.
2	Press **<MODE>** and hold down the key.
3	Press the **<ON/OFF>** key. The display test appears briefly on the display. The instrument then switches automatically to the configuration level.
4	Press the **<OK>** key until *Int 3* appears on the display.



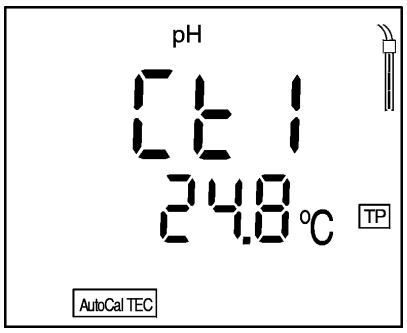
5	Press **<▲><▼>** to set the required time interval until the next calibration.
6	Confirm with **<OK>**.
7	Change to the measuring mode by pressing **<MODE>**.

4.3.2 AutoCal TEC

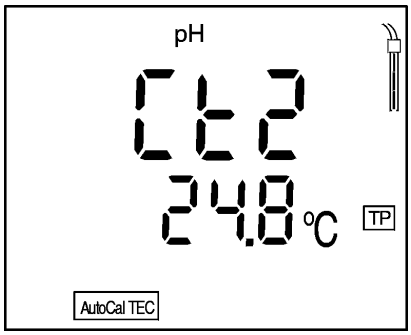
Use any two of the technical buffer solutions for this procedure in increasing or decreasing order.

Note
Steps 3 and 7 are not required if you use a temperature probe.

1	Press the **<MODE>** key repeatedly until the pH/ Redox measurement appears on the display. *pH* or *U* appears in the status line.
2	Press the **<CAL>** key repeatedly until the *AutoCal TEC* function display appears.



3	If necessary, set the temperature of the buffer solution using **<▲><▼>** while keeping the **<OK>** key depressed.
4	Submerse the pH electrode in the first buffer solution.
5	Press the **<OK>** key. *AR* flashes on the display. The electrode voltage (mV) appears on the display. As soon as a stable value is recognized, *Ct2* appears.



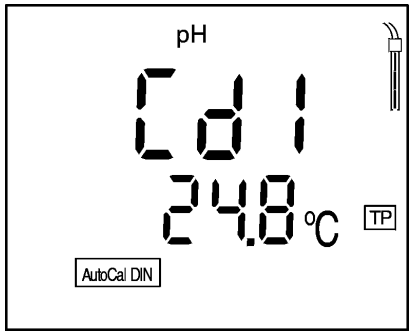
6	Thoroughly rinse the electrode with distilled water.
7	If necessary, set the temperature of the second buffer solution by pressing **<▲><▼>** while keeping the **<OK>** key depressed.
8	Submerse the electrode in the second buffer solution.
9	Press the **<OK>** key. *AR* flashes on the display. The electrode voltage (mV) appears on the display. As soon as a stable value is recognized, *AR* disappears. The sensor symbol shows the electrode evaluation after the two-point calibration. The value of the slope (mV/pH) appears on the display.
10	Press the **<OK>** key. The value of the asymmetry (mV) appears on the display.
11	To return to the measuring mode: Press the **<MODE>** key.

4.3.3 AutoCal DIN / NIST

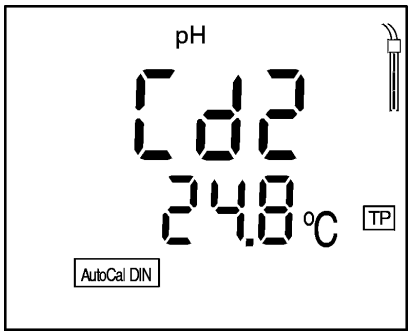
Use two different DIN buffer solutions (type A, C, D or F with the pH values 1.679, 4.006, 6.865, 9.180) or NIST traceable buffers for this procedure in increasing or decreasing order.

Note
Steps 3 and 7 are not required if you use a temperature probe.

1	Press the **<MODE>** key repeatedly until the pH/ Redox measurement appears on the display. *pH* or *U* appears in the status line.
2	Press the **<CAL>** key repeatedly until the *AutoCal DIN* function display appears.



3	If necessary, set the temperature of the buffer solution using **<▲><▼>** while keeping the **<OK>** key depressed.
4	Submerse the pH electrode in the first buffer solution.
5	Press the **<OK>** key. *AR* flashes on the display. The electrode voltage (mV) appears on the display. As soon as a stable value is recognized, *Cd2* appears.



6	Thoroughly rinse the electrode with distilled water.
7	If necessary, set the temperature of the second buffer solution using **<▲><▼>** while keeping the **<OK>** key depressed.
8	Submerse the electrode in the second buffer solution.
9	Press the **<OK>** key. *AR* flashes on the display. The electrode voltage (mV) appears on the display. As soon as a stable value is recognized, *AR* disappears. The sensor symbol shows the electrode evaluation after the two-point calibration. The value of the slope (mV/pH) appears on the display.
10	Press the **<OK>** key. The value of the asymmetry (mV) appears on the display.
11	To return to the measuring mode: Press the **<MODE>** key.

4.3.4 ConCal (pH)

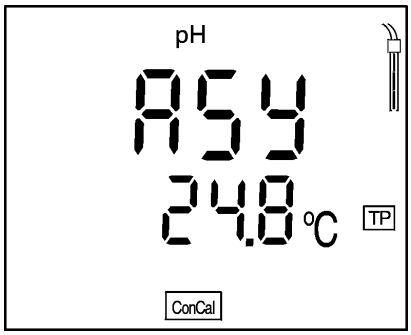
Two-point calibration

Use two buffer solutions for this procedure:

- pH 7.0 ± 0.5
- any other buffer solution

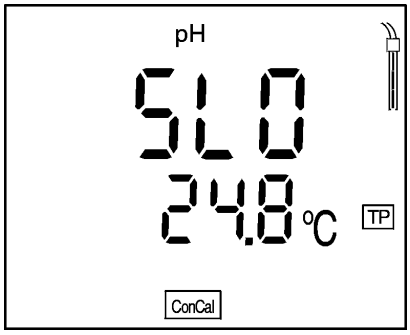
Note
Steps 3 and 10 are not required if you use a temperature probe.

1	Press the **<MODE>** key repeatedly until the pH/ Redox measurement appears on the display. *pH* or *U* appears in the status line.
2	Press the **<CAL>** key repeatedly until the *ConCal* function display appears.



3	If necessary, set the temperature of the buffer solution using **<▲><▼>** while keeping the **<OK>** key depressed.
4	Submerse the pH electrode in the first buffer solution pH 7.0 ± 0.5.
5	Press the **<OK>** key. The measured pH value appears on the display.
6	Set the nominal pH value of the buffer solution (at the current temperature) by pressing the **<▲><▼>** keys.
7	Press the **<OK>** key. The value of the asymmetry (mV) and the sensor symbol appear on the display.

8	Press the **<OK>** key. *SLO*(pe) appears on the display.



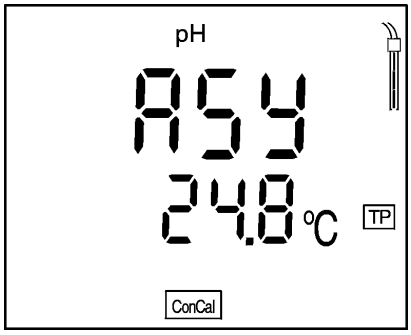
9	Thoroughly rinse the electrode with distilled water.
10	If necessary, set the temperature of the buffer solution using **<▲><▼>** while keeping the **<OK>** key depressed.
11	Submerse the electrode in the second buffer solution.
12	Press the **<OK>** key. The second measured pH value appears on the display.
13	Set the nominal pH value of the second buffer solution (at the current temperature).
14	Press the **<OK>** key. The value of the slope (mV/pH) appears on the display. The sensor symbol shows the evaluation of the electrode after the two-point calibration.
15	Press the **<OK>** key. The value of the asymmetry (mV) appears on the display again.
16	To return to the measuring mode: Press the **<MODE>** key.

Single-point calibration

Only the electrode asymmetry is determined in single-point calibration. The slope of the last two-point calibration is retained.
Use a buffer solution in the range pH = 7.0 ± 0.5 for this procedure.

Note
Step 3 is not required if you use a temperature probe. The *TP* message indicates an active temperature measurement.

1	Press the **<MODE>** key repeatedly until *pH* or *U* appears in the status line.
2	Press the **<CAL>** key repeatedly until the *ConCal* function display appears.



3	Set the temperature of the buffer solution using **<▲><▼>** while keeping the **<OK>** key depressed.
4	Submerse the pH electrode in the buffer solution.
5	Press the **<OK>** key. The measured pH value appears on the display.
6	Set the nominal pH value of the buffer solution (at the current temperature) by pressing the **<▲><▼>** keys.
7	Press the **<OK>** key. The value of the asymmetry (mV) and the sensor symbol for the evaluation of the electrode appears on the display.
8	To return to the measuring mode: Press the **<MODE>** key.

4.4 Measuring the ISE concentration

Preparatory activities

Perform the following preparatory activities when you want to measure the concentration using an ion sensitive electrode:

1	Connect the electrode to the instrument.
2	Adjust the temperature of the test solutions or measure the current temperature if the measurement is made without a temperature probe.
3	Select the ISE measuring mode by pressing **<MODE>**.
4	Calibrate or check the instrument with the electrode.

Note
Incorrect calibration of the ion sensitive electrode will result in incorrect measured values. Therefore, regularly perform calibration before measuring.

Temperature probe

Measurements can be performed with and without a temperature probe. A connected temperature probe is indicated by *TP* on the display.

Note
The meter automatically recognizes the type of the temperature probe used. As a result, you can connect electrodes with the NTC30 or Pt1000.

The temperature measurement is absolutely essential for a reproducible measurement. If the measurement is made without a temperature probe, proceed as follows:

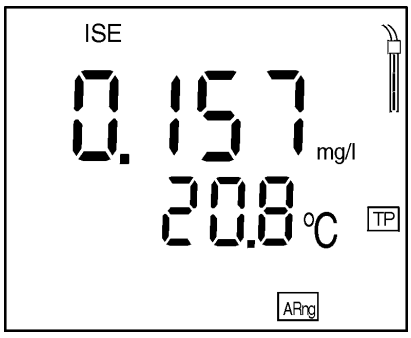
1	Measure the current temperature.
2	Temper the test sample and the calibration standards to the same temperature (in the range ± 2 °C).

Note
It is not possible to enter temperature values manually for ISE measurements and calibration.

Measuring the concentration

To measure the concentration proceed as follows:

1	Perform the preparatory activities.
2	Immerse the electrode into the test sample.
3	Press the **<MODE>** key repeatedly until *ISE* appears in the status line. The concentration value appears on the display.



AutoRead AR (Drift control)

The *AutoRead* function (drift control) checks the stability of the measurement signal. The stability has a considerable effect on the reproducibility of the measured values.

1	Call up the ISE measuring mode by pressing **<MODE>**.
2	Immerse the electrode into the test sample.
3	Activate the AutoRead function by pressing **<AUTO-READ>**. The current measured value is frozen (Hold function).
4	Start the AutoRead function by pressing **<OK>**. *AR* flashes on the display until a stable measured value is reached. This measured value is transmitted to the interface.
5	If necessary, start the next AutoRead measurement by pressing **<OK>**.
6	To cancel the AutoRead function: Press the **<AUTO-READ>** key.

Note
The current AutoRead measurement (with acceptance of the current value) can be terminated at any time by pressing **<OK>**.

AutoRead criteria

For identical measurement conditions, the following criteria apply:

Reproducibility	better than ± 0.05 mV
Response time	> 30 seconds

4.5 ISE Calibration

Why calibrate?

Ion sensitive electrodes age and are temperature dependent. This changes the slope. As a result, an inexact measured value is displayed. Calibration determines the current values of the slope of the electrode and stores it in the instrument.

Thus, you should calibrate before each measurement (if possible), and at regular intervals.

Note
For calibration, use tempered standard solutions with a temperature that differs by maximum ± 2 °C from the temperature of the test sample.

When to calibrate?

- Before each ISE measurement if possible
- After connecting another electrode
- When the sensor symbol flashes after a voltage interruption, e.g. battery change.

ConCal

is the conventional two-point calibration or three-point calibration with 2 or 3 freely selectable buffer solutions. The concentration of the calibration standards depends on the concentration that is expected to be measured.

AutoRead

In calibration, the *AutoRead* function is automatically activated.
The current AutoRead measurement (with acceptance of the current value) can be terminated at any time by pressing **<OK>**.

***TP* display**

If you use a temperature probe, a flashing *TP* display indicates that the temperature difference between the test sample and the standard solutions is too high (± 2 °C).

Calibration protocol

The calibration protocol contains the calibration data of the current calibration. You can call up the calibration protocol by outputting the data storage (section 4.7.3 OUTPUTTING THE DATA STORAGE).

Note
You can automatically print out a calibration protocol after the calibration. To do so, switch on the printer before the calibration (Print LED lights up green). After a valid calibration, the protocol is printed.

Sample printout:

```
CALIBRATION Protocol
 02.03.99 / 16:20
Device No.: 1234
CALIBRATION ISE
Cal Time: 01.03.99 / 15:10
Std 1   10,01  mg/l
Std 2   20,00  mg/l
Std 3   50,00  mg/l
C1          0,5 mV  25.0°C
C2          8,4 mV  24.9°C
C3         21,2 mV  25.0°C
S1         26.4 mV
S2         32,1 mV
Probe:     +++
```

Electrode evaluation

After the calibration, the instrument evaluates the current status of the electrode, i. e. the slope of the electrode (mV). The evaluation appears on the display.

Display	Slope [mV]
	50.0 ... 70.0 25.0 ... 35.0
E3	Clear the fault according to chapter 6 WHAT TO DO IF...

Preparatory activities

Perform the following preparatory activities:

1	Switch on the instrument by pressing **<ON/OFF>**.
2	Connect the electrode to the instrument.
3	Connect a temperature probe to the instrument in order to notice whether there are temperature differences too high while calibrating.
4	Keep the standard solutions ready.
5	Adjust the temperature of the solutions.

Note
For calibration, use tempered standard solutions with a temperature that differs by maximum ± 2 °C from the temperature of the test sample.

Calibration

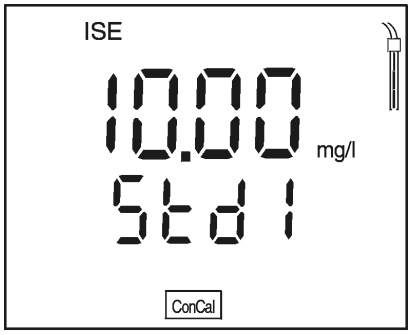
Use two or three different standard solutions out of the following range. For the three point calibration, the standards must be selected in increasing or decreasing order.

Parameter	Values [mg/l]
Std 1	0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1; 2; 5; 10; 20; 50; 100; 200; 500; 1000 If Std 2 > Std 1, Std 3 must be > Std 2 If Std 2 < Std 1, Std 3 must be < Std 2
Std 2	
Std 3	

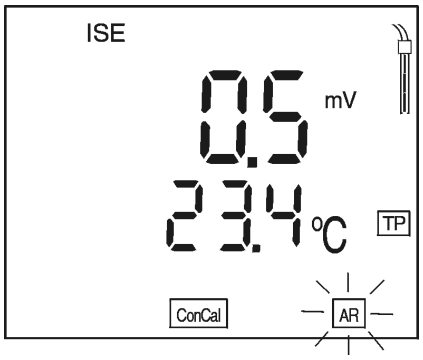
Note
The measuring accuracy depends on the standard solutions selected and on the expected concentration of the ISE measurement following.

Two point calibration

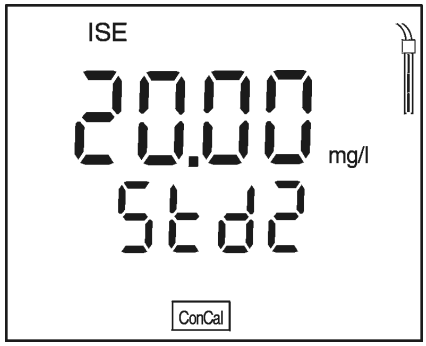
1	Select the ISE measuring mode using **<MODE>**.
2	Press the **<CAL>** key. The previously set up concentration of the first standard solution and the *ConCal* display indicator appear on the display.



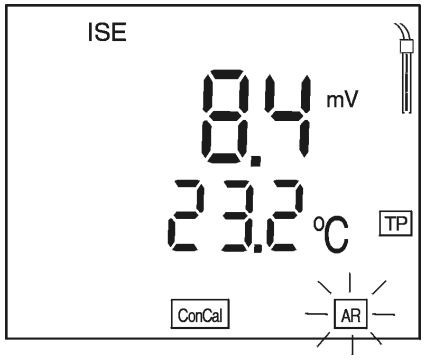
3	Enter the current concentration of the first standard solution using **<▲><▼>**.
4	Immerse the electrode into the first standard solution.
5	Press the **<OK>** key. The electrode voltage appears on the display, the *AR* display indicator flashes.



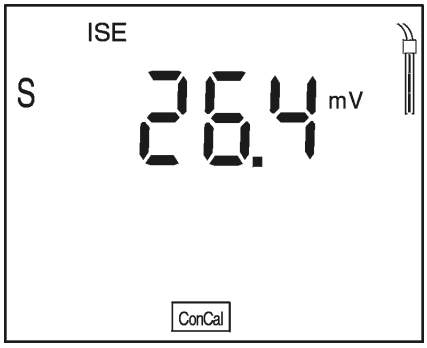
6	As soon as a stable value is achieved *AR* stops flashing. The previously set up concentration of the second standard solution appears on the display.



7	Enter the current concentration of the second standard solution using <▲><▼>.
8	Thoroughly rinse the electrode with distilled water.
9	Immerse the electrode into the second standard solution.
10	Press the **<OK>** key. The electrode voltage appears on the display, the *AR* display indicator flashes.



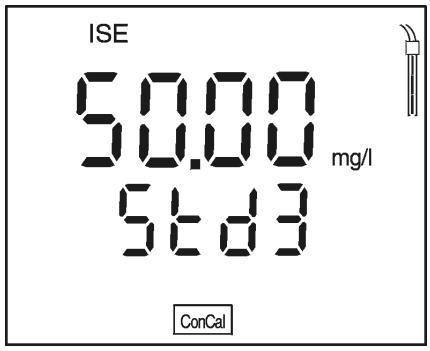
11	The *AR* display indicator stops flashing as soon as a stable value is achieved. The slope of the electrode (mV) appears on the display. The sensor symbol shows the evaluation of the electrode for the measuring range I after the two point calibration.



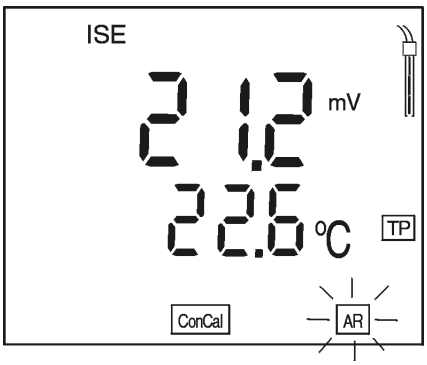
12	To return to the measuring mode: press the **<MODE>** key or continue with the three point calibration.

Three point calibration

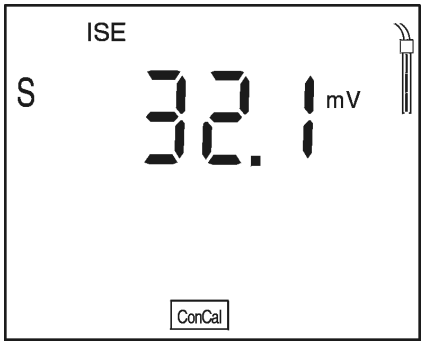
13	Press the **<OK>** key. The previously selected concentration of the third standard solution appears on the display.



14	Enter the current concentration of the third standard solution using **<▲><▼>**.
15	Thoroughly rinse the electrode with distilled water.
16	Immerse the electrode into the third standard solution.
17	Press the **<OK>** key. The electrode voltage appears on the display, the *AR* display indicator flashes.



18	The *AR* display indicator stops flashing as soon as a stable value is achieved. The slope of the electrode (mV) for the measuring range II appears on the display. The sensor symbol shows the evaluation of the electrode after the three point calibration.



19	To return to the measuring mode: press the **<MODE>** key.

Note
You can prematurely terminate the three point calibration by pressing **<MODE>**. The values of the two point calibration will then remain stored.

4.6 Printing measured values

Measured values (data records) can be transmitted to the interface.

Note
To transmit to the interface, you must connect the interface cable.

You can print measured values (data records) in 3 ways:

- Switch on the data transmission (Int 2) (see page 48).
  - After expiry of the selected interval, the current data record is sent to the interface.
- Switch on AutoStore (Int 1) (see page 43).
  - After expiry of the selected interval, the current data record is sent to the interface and in addition is stored in the data store of the instrument
  - AutoStore (Int 1) covers the *data transmission* interval (Int 2).
- Press the **<OK>** key.
  This manually triggers a printout of the current measured values at any time - independently of the selected intervals.

4.7 Storing

The meter has an internal data storage device. Up to 80 data records can be stored in it.
A complete data record consists of:

- Memory location
- Date/time
- Measured value
- Temperature
- Temperature measurement procedure
- I.D. number

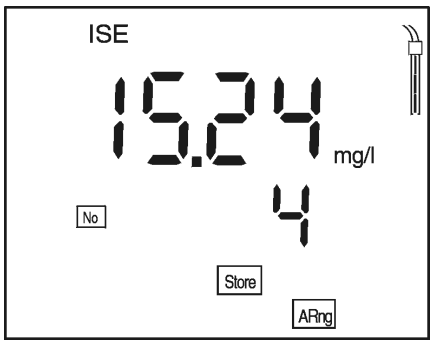
You can transmit measured values (data records) to the data storage in 2 ways:

- Manual storage
- Switching on the AutoStore function (Int 1) (see page 43).

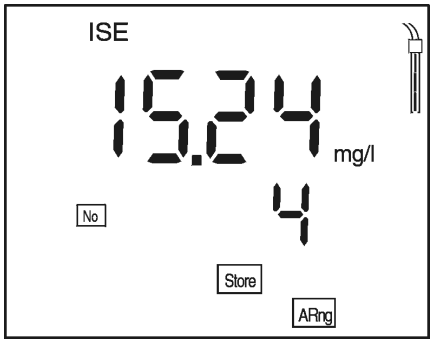
4.7.1 Manual storage

You can transmit a measured value to the data storage as follows:

1	Press the **<STO>** key. The current number of the next free memory location appears on the display.



2	Confirm with **<OK>**. The display changes to the input of the I.D. number.



3	Enter the required I.D. number (1 ... 999) by pressing **<▲><▼>**.

Note
Up to this point, you can cancel with **<MODE>** the procedure without storing.

4	Confirm with **<OK>**. The measured value is stored in the data storage. The instrument changes to the measuring mode.

StoFull message

This message appears if all 80 memory locations are full.

You have the following options:

Store the current measured value. The oldest measured value (memory location 1) is overwritten by this	Press **<OK>**
Return to the measuring mode without storing	Press any key
Output the data storage	See section 4.7.3
Delete the data storage	See section 4.7.4

4.7.2 Switching on AutoStore (Int 1)

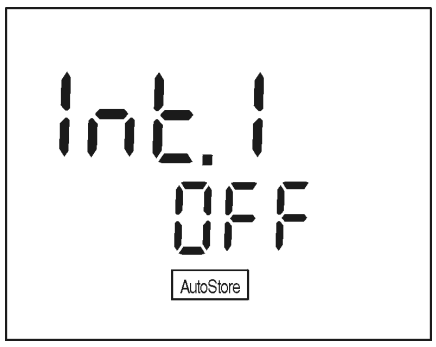
The storage interval (Int 1) determines the time interval between automatic storage processes.
After the time interval expires, the current data record is transmitted to the data storage and to the interface.

The storage interval (Int 1) is set to OFF in the factory. Thus, the *AutoStore* function is switched off.
To switch the function on, set up a time interval (5 s, 10 s, 30 s, 1 min, 5 min, 10 min, 15 min, 30 min, 60 min).

Note
If AutoStore is switched on, the setting of the data transmission interval (Int 2) is ineffective (see see page 48).

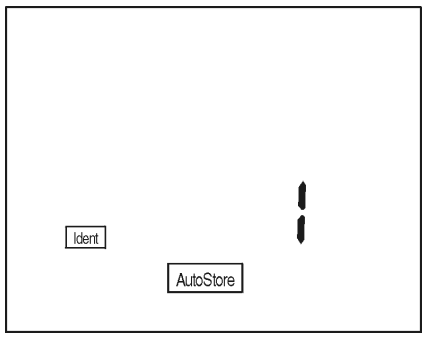
Setting the storage interval

1	Press and hold down the **<OK>** key.
2	Press the **<STO>** key. *Int 1* appears on the display.



3	Press the **<▲><▼>** keys to set up the required time interval between storage processes.
4	Confirm with **<OK>**. The number of free memory locations appears on the display.

5	As soon as all 80 memory locations are full, the AutoStore function is terminated (Int 1 = OFF). If too few storage locations are available for your measurements: – backup the data storage (see see page 45) and – clear the data storage (see see page 47).
6	Confirm with **<OK>**. The prompt for the I.D. number appears on the display.



7	Press **<▲><▼>** to set the required I.D. number.
8	Confirm with **<OK>**. The instrument changes to the measuring mode and starts the measuring and storage procedure. *AutoStore* flashes on the display.

Note
The *AutoStore* function is interrupted if you perform other functions, e.g. output data storage.
After completing the other function, the *AutoStore* function continues. However, as a result, gaps can occur in the recording of the measured values.

Switching off the AutoStore

Switch off the *AutoStore* function by:

- Setting the storage interval (Int 1) to OFF or
- Switch the meter off and on again.

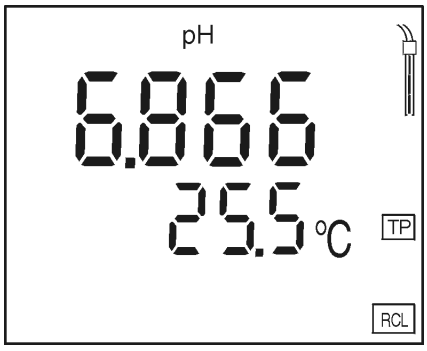
4.7.3 Outputting the data storage

The contents of the data storage can be output to the:

- display
- interface

Outputting to the display

1	Press the **<RCL>** key repeatedly until *Sto disp* appears on the display.
2	Press the **<OK>** key. A measured value appears on the display. The memory location of the data store appears for approx. 2 s. This is followed by the corresponding temperature.



You can perform the following activities:

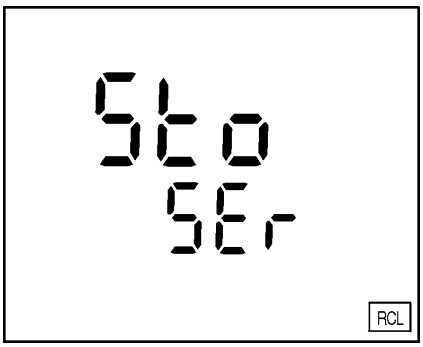
Display further parameters of the data record (I.D. no., date, time, memory location)	Press **<OK>**
Advance one data record (memory location)	Press **<▲>**
Go back one data record (memory location)	Press **<▼>**

Note
If you want to find a specific parameter (e.g. date), proceed as follows:

1	Select the parameter (e.g. date) by pressing **<OK>**.
2	Press **<▲>** or **<▼>** repeatedly until the required date appears on the display. After approx. 2 s, the temperature of the displayed measured value appears.

Outputting to interface

1	Press the **<RCL>** key repeatedly until *Sto SEr* appears on the display.



2	Press the **<OK>** key. *Sto CAL* appears on the display. The calibration protocol is transmitted to the interface. Following the calibration protocol, the complete contents of the storage is transmitted to the interface.

Note
You can the cancel the transmission by pressing **<MODE>** or **<OK>**.

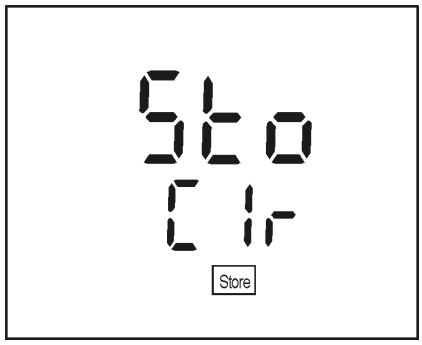
4.7.4 Clearing the storage

This function can erase the stored data records. 80 memory locations will then become available again.

Note
The *Clear store* function only appears if data records have already been stored in the storage. Otherwise, the meter automatically changes to the measuring mode.

In order to delete all the data records, proceed as follows:

1	Switch off the instrument.
2	Press and hold down the **<STO>** key.
3	Press the **<ON/OFF>** key. The display test appears briefly on the display.



4	Confirm the clearing process by pressing **<OK>**. Pressing any other key stops the clearing process and the data records remain in the storage.

Note
The calibration data remain in the storage and can be called up via the calibration protocol.

4.8 Data transmission

You can use the following options to transmit data:

- One of the following options:
  - The *AutoStore* function (see page 43) is used to periodically (*Int 1* storage interval) save measured values internally and output them on the interface.
  - The *data transmission interval (Int 2)* function is used to periodically output measured values to the interface (see below).
- The *Output data store* function (see page 45) is used to output calibration data and stored measured values to the interface.

4.8.1 Data transmission interval (Int 2)

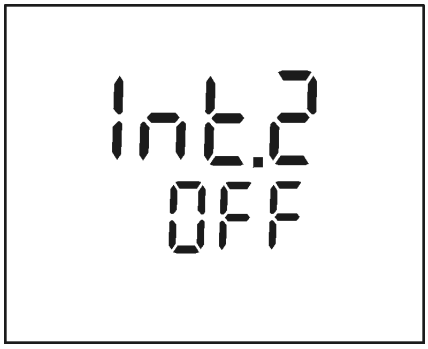
The interval for the data transmission (Int 2) determines the time interval between automatic data transmissions. After the time interval expires, the current data record is transmitted to the interface.

Note
The setting of the data transmission interval (Int 2) only has an effect when the storage interval (*AutoStore* Int 1 function) is switched off.

Setting the data transmission interval

The interval is set to OFF in the factory.
To start the data transmission, set up an interval (5 s, 10 s, 30 s, 1 min, 5 min, 10 min, 15 min, 30 min, 60 min):

1	Press and hold down the **<OK>** key.
2	Press the **<AUTOREAD>** key. *Int 2* appears on the display.



3	Press <▲><▼> to set up the required time interval between storage processes.
4	Confirm with **<OK>**. The instrument changes automatically to the measuring mode.

Note
If the *AutoStore* function is active, the data transmission is performed according to the setting of the storage interval (Int 1). Set the storage interval (Int 1) to OFF to activate the *data transmission* interval (Int 2).

Note
You can also set the *data transmission* interval (Int 2) in the *Configuration* menu (see page 51).

4.8.2 PC/external printer (RS232 interface)

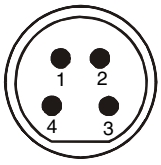
You can transmit data to a PC or an external printer via the RS232 interface.
Connect the interface to the instrument via the PC cable or the printer cable.
The data output switches automatically to RS232.

Note
The RS232 interface is not galvanically isolated.
If it is connected to an earthed PC/printer, measurements cannot be made in earthed media as this would give incorrect results!

Set up the following transmission data on the PC/printer:

Baud rate	Selectable between: 1200, 2400, 4800, 9600
Handshake	RTS/CTS + Xon/Xoff
PC only:	
Parity	None
Data bits	8
Stop bits	1

Socket assignment



RS 232
REC

1 CTS
2 RxD
3 Ground
4 TxD

4.9 Configuration

You can adapt the meter to your individual requirements. To do this, the following parameters can be changed (the status on delivery is marked in bold):

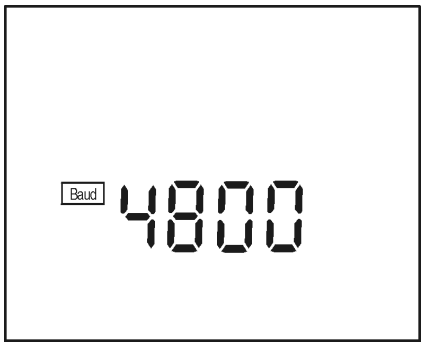
Baud rate	1200, 2400, **4800**, 9600
Data transmission interval (Int 2)	**OFF**, 5 s, 10 s, 30 s, 1 min, 5 min, 10 min, 15 min, 30 min, 60 min
Calibration interval (Int 3) - only for pH	1 ... **7** ... 999 d
Temperature unit	°**C**, °F
Date/time	As required
Resolution of pH display	0.01, **0.001**

1	Switch off the instrument.
2	Press and hold down the **<MODE>** key.
3	Press the **<ON/OFF>** key. The display test appears briefly on the display. The instrument then switches automatically to the setting of the baud rate.

Note

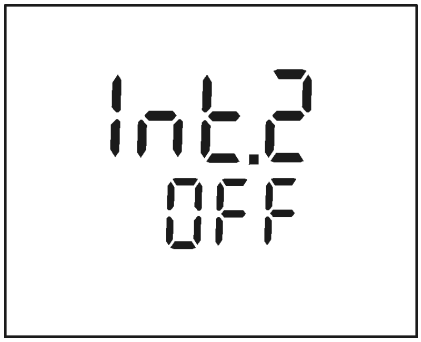
You can leave the configuration menu at any time. Parameters that have already been changed are stored.
To do this, press the **<MODE>** key.

Baud rate



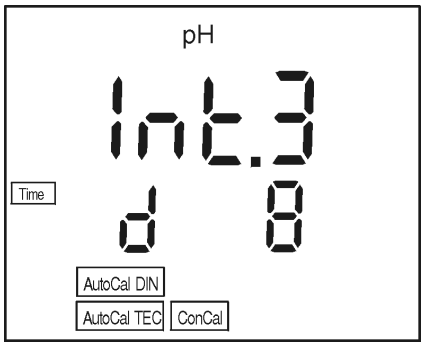
4	Set up the required baud rate by pressing <▲><▼>.
5	Confirm with **<OK>**. *Int 2* (data transmission interval) appears on the display.

Data transmission interval



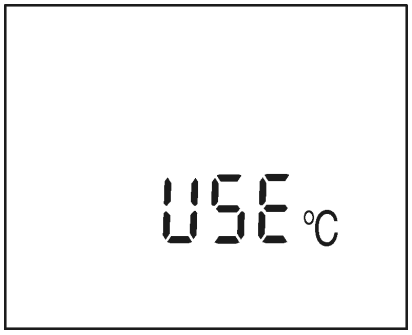
6	Set up the required time interval by pressing <▲><▼>.
7	Confirm with **<OK>**. *Int 3* (calibration interval) appears on the display.

Calibration interval



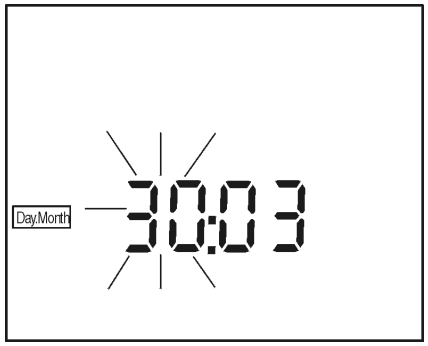
8	Set up the required time interval by pressing <▲><▼>.
9	Confirm with **<OK>**. *USE °C* appears on the display.

Temperature unit



10	Change between *°C* and *°F* by pressing <▲><▼>.
11	Confirm with **<OK>**. The date flashes on the display.

Date and time



12	Set today's date by pressing <▲><▼>.
13	Confirm with **<OK>**. The date (month) flashes on the display.
14	Set the current month by pressing <▲><▼>.
15	Confirm with **<OK>**. The year appears on the display.
16	Set the current year by pressing <▲><▼>.

17	Confirm with **<OK>**. The hours flash on the display.
18	Set the current time by pressing **<▲><▼>**.
19	Confirm with **<OK>**. The minutes flash on the screen.
20	Set the current time by pressing **<▲><▼>**.
21	Confirm with **<OK>**. The instrument changes automatically to the measuring mode.

Adjusting the resolution for the pH/ Redox measurement

1	Press and hold down the **<OK>** key.
2	Press the **<MODE>** key. The measured values appear with the higher resolution on the display, e.g. pH = 4.012.
3	Press the **<OK>** key and **<MODE>** key again. The measured values with the lower resolution appear on the display, e.g. pH = 4.01.

4.10 Reset

You can reset (initialize) measuring and configuration parameters separately from one another.

Measuring parameters

The following measuring parameters (pH InI) are reset to the values they had on delivery:

Measuring mode	pH
Asymmetry of the pH electrode	0 mV
Slope of the pH electrode	-59.16 mV/pH
pH calibration procedure	AutoCal DIN / NIST
Temperature, manual	25 °C
Resolution of pH display	0.001

Note
When the measuring parameters are reset, the calibration data are lost. After the parameters have been reset, calibrate!

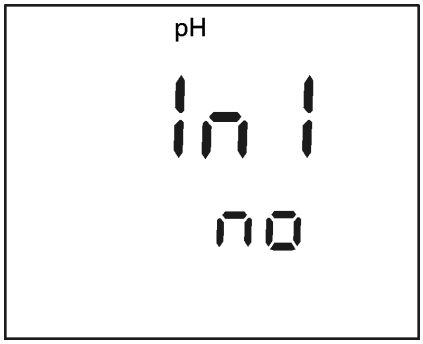
Configuration parameters

The following configuration parameters (InI) are reset to the values they had on delivery:

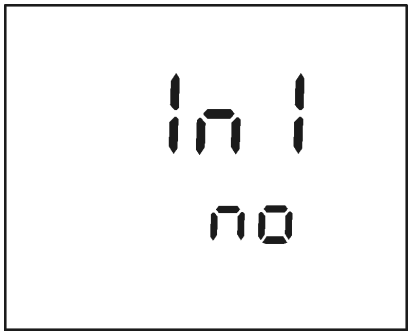
Baud rate	4800
Interval 1 (automatic storing)	OFF
Interval 2 (for data transmission)	OFF

Resetting measuring parameters

1	Press and hold down the **<OK>** key.
2	Press the **<CAL>** key.



3	Use **<▲><▼>** to toggle between *no* and *YES*. YES: reset measuring parameters. no: retain settings.
4	Confirm with **<OK>**. The instrument changes to the configuration parameters.



Resetting configuration parameters

5	Toggle between *no* and *YES* by pressing **<▲><▼>**. YES: reset configuration parameters. no: retain settings.
6	Confirm with **<OK>**. The instrument changes automatically to the measuring mode.

5 Maintenance, cleaning

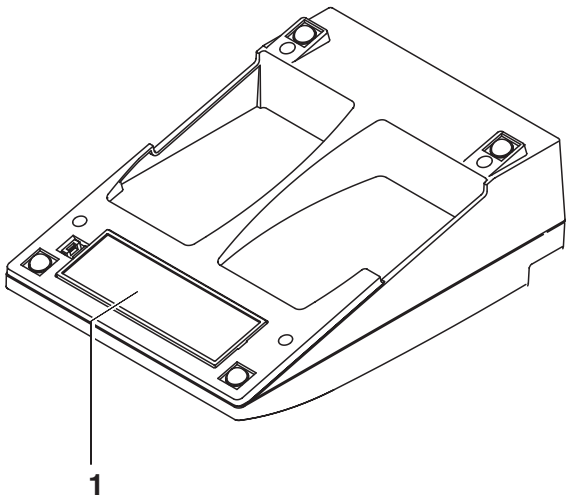
5.1 Maintenance

The maintenance tasks are restricted to replacing the batteries.

Note
See the relevant operating manual of the electrodes for instructions on electrode maintenance.

5.1.1 Changing the batteries

1	Open the battery compartment (1) on the underside of the instrument.
2	Remove the four batteries from the battery compartment.
3	Insert four new batteries (Type Mignon AA) into the battery compartment.
4	Close the battery compartment (1). The date (day) flashes on the display.
5	Set up the date and time according to section 3.2.



Caution
Make sure that the poles of the batteries are the right way round.
The ± signs in the battery compartment must correspond to the ± signs on the batteries.
Only use leakproof alkaline manganese batteries.

5.2 Cleaning

Occasionally wipe the outside of the measuring instrument with a damp, lint-free cloth. Disinfect the housing with isopropanol as required.

Caution
The housing is made of synthetic material (ABS). Thus, avoid contact with acetone or similar detergents that contain solvents. Remove any splashes immediately.

6 What to do if...

6.1 pH system messages

Error message, OFL

Cause	Remedy
pH electrode:	
– Not connected	– Connect electrode
– Air bubbles in front of the diaphragm	– Remove air bubbles
– Air in the diaphragm	– Extract air or moisten diaphragm
– Cable broken	– Replace electrode
– Gel electrolyte dried out	– Replace electrode

Error message, E3

Cause	Remedy
pH electrode:	
– Diaphragm contaminated	– Clean diaphragm
– Membrane contaminated	– Clean membrane
– Moisture in the plug	– Dry plug
– Electrolyte obsolete	– Replenish electrolyte or replace electrode
– Electrode obsolete	– Replace electrode
– Electrode broken	– Replace electrode
Measuring instrument:	
– Incorrect calibration procedure	– Select correct procedure
– Incorrect solution temperature (without temp. probe)	– Set up correct temperature
– Socket damp	– Dry socket

Buffer solutions:	
– Incorrect buffer solutions	– Change calibration procedure
– Buffer solutions too old	– Only use once. Note the shelf life
– Buffer solutions depleted	– Change solutions

No stable measured value

Cause	Remedy
pH electrode:	
– Diaphragm contaminated	– Clean diaphragm
– Membrane contaminated	– Clean membrane

Sample:	
– pH value not stable	– Measure with air excluded if necessary
– Temperature not stable	– Adjust temperature if necessary

Electrode + sample:	
– Conductivity too low	– Use suitable electrode
– Temperature too high	– Use suitable electrode
– Organic liquids	– Use suitable electrode

Sensor symbol flashes

Cause	Remedy
– Calibrating interval expired	– Newly calibrate measuring system

Obviously incorrect measured values values

Cause	Remedy
pH electrode:	
– pH electrode unsuitable	– Use suitable electrode
– Temperature difference between buffer and sample too large	– Adjust temperature of buffers or samples
– Measuring procedure not suitable	– Follow special procedure

6.2 ISE system messages

Error message OFL

Cause	Remedy
Ion sensitive electrode:	
– Not connected	– Connect electrode
– Cable broken	– Replace electrode

Error message, E3

Cause	Remedy
Ion sensitive electrode:	
– Slope not in the range 50 ... 70 mV or 23 ... 35 mV	– Replace electrode – Recalibrate
– Moisture in the plug	– Dry plug
– Electrode obsolete	– Replace electrode
– Electrode broken	– Replace electrode
Measuring instrument:	
– Calibration procedure: order of the standards wrong in three point calibration	– Select correct order
– Socket moist	– Dry socket

Concentration display flashes

Cause	Remedy
During measurement:	
– Measured value is outside the range determined by calibration	– Select calibration standards bracketing the measured value
During calibration:	
$\lvert U2 - U1 \rvert \leq 5\,mV$ $\lvert U3 - U2 \rvert \leq 5\,mV$	– Calibration standards are too close together. Select other calibration standards

TP flashes Temp Error

Cause	Remedy
During calibration:	
– Calibration standards have the wrong temperature (maximum temperature difference ± 2 °C)	– Temper the calibration standards
During measurement:	
– Test sample has the wrong temperature (maximum temperature difference ± 2 °C)	– Temper the test sample

Calibration Std 2 flashes

Cause	Remedy
– Standard 2 = Standard 1	– Use different calibration standards

Calibration Std 3 flashes

Cause	Remedy
One of the following requirements is not met: – Standard 3 > standard 2, if Std 2 > Std 1 or – Standard 3 < standard 2, if Std 2 < Std 1	– Use different standard 3

6.3 General errors

LoBat display

Cause	Remedy
– Batteries almost depleted	– Replace batteries (see section 5.1.1 CHANGING THE BATTERIES)

to display

Cause	Remedy
– Timeout of the interface	– Checkout connected instrument

Instrument does not react to keystroke

Cause	Remedy
– Operating state undefined or EMC electric stress unallowed	– Processor reset: Press the **<AUTOREAD>** key and switch on instrument

You would like to know which software version is in the instrument

Cause	Remedy
– e.g. question of the Thomas Scientific service department	– Press the **<AUTOREAD>** key and switch on instrument. The software version is displayed.

StoFull message

Cause	Remedy
– All 80 memory locations are full	– Output data store and clear data store

7 Technical Data

7.1 General data

Dimensions and weight	Length [mm]	250
	Width [mm]	300
	Height [mm]	70
	Weight [kg]	Approx. 1.3 (without plug-in power supply)
Mechanical structure	Type of protection	IP 43
Electrical safety	Protective class	III
Test certificates	cETLus, CE	
Ambient temperature	Storage temperature	- 25 °C ... + 65 °C
	Operating temperature	0 °C ... + 55 °C
	Allowable relative humidity	Annual mean: < 75 % 30 days/year: 95 % Other days: 85 %
	Climatic Class	2
Energy supply	Batteries	4 x 1.5 V AA type alkaline manganese batteries
	Runtime	Approx. 3000 operating hours

Power supply	FRIWO FW7555M/09, 15.1432.500-00 Friwo Part. No. 1883259 Input: 100 ... 240 V ~ / 50 ... 60 Hz / 400 mA Output: 9 V = / 1,5 A Connection max. overvoltage category II Primary plugs contained in the scope of delivery: Euro, US, UK and Australian.

Serial interface

Automatic switch-over when the cable is connected.

Type	RS232, data output
Baud rate	can be set to 1200, 2400, 4800, 9600 Baud
Data bits	8
Stop bit	1
Parity	none
Handshake	RTS/CTS+Xon/Xoff
Cable length	max. 15m

Guidelines and norms used

EMC	EC guideline 89/336/EEC EN 61326-1 EN 61000-3-2 EN 61000-3-3 FCC Class A
Instrument safety	EEC guideline 73/23/EEC EN 61010-1 ANSI/UL 611010-1; Issued 2004/07/12 Ed: 2, Rev.: 2005/07/22 CAN/CSA-C22.2 No. 61010-1
Climatic class	VDI/VDE 3540
Type of protection	EN 60529

FCC Class A Equipment Statement

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

7.2 Measuring ranges, resolution, accuracy

Note
The accuracy values specified here apply exclusively to the meter. The accuracy of the electrodes and buffer solutions has to be taken into account additionally.

7.2.1 pH/Redox measurement

Measuring ranges and resolution

pH	- 2.000 ... + 19.99 - 2.00 ... + 19.99
U [mV]	- 999.9 ... + 999.9 - 1999 ... + 1999
T [°C]	- 5.0 ... + 105.0
T [°F]	+ 23.0 ... + 221.0

Accuracy (± 1 digit)

pH (in the measuring range of 2 pH units around the calibration point)	± 0.005 at +15°C ... to +35°C ± 0.01
U [mV]	± 0.3 (at + 15 °C ... + 35 °C) ± 1
T [°C]	NTC 30: ± 0.1 PT 1000: ± 0.5 at 0 °C ... 15 °C ± 0.1 at 15 °C ... 35 °C ± 1 at 35 °C ... 55 °C
T [°F]	NTC 30: ± 0.2 PT 1000: ± 0.9 at 32 °F ... 59 °F ± 0.2 at 59 °F ... 95 °F ± 1.8 at 95 °F ... 131 °F

7.2.2 ISE measurement

Measuring ranges and resolution

Measuring range 1 Resolution	0.000 ... 9.999 mg/l 0.001 mg/l
Measuring range 2 Resolution	0.00 ... 99.9 mg/l 0.01 mg/l
Measuring range 3 Resolution	0.0 ... 999.9 mg/l 0.1 mg/l
Measuring range 4 Resolution	0 ... 1999 mg/l 1 mg/l

Used electrodes

Combined or double electrodes with plug according to DIN 19262

Calibration procedures

Two point or three point calibration with standards suiting the sample

Slope ranges

± 25 to 35 mV and ±50 to 70 mV

8 Lists

This chapter provides additional information and orientation aids.

Abbreviations The list of abbreviations explains abbreviations that appear on the display or when dealing with the instrument.

Specialist terms The glossary briefly explains the meaning of the specialist terms. However, terms that should already be familiar to the target group are not described here.

Index The index helps you find the topics that you are looking for.

Abbreviations

AR	AutoRead (drift control)
ARng	Automatic range switching Measuring instrument measures with highest resolution
ASY	Asymmetry
AutoCal DIN	Automatic calibration with DIN / NIST buffer solutions
AutoCal TEC	Automatic calibration with technical buffer solutions
Cal	Calibration
Cal Error	Calibration error
Cd...	Calibration with with DIN / NIST buffer solutions
ConCal	Conventional one/two point calibration; in the ISE measuring mode also three point calibration
Ct...	Calibration with technical buffer solutions
disp	Display Displays the data storage on the screen
E3	Error message (see WHAT TO DO IF ...)
InI	Initialization Resets individual basic functions to the status they had on delivery
ISE	Ion sensitive electrode
LoBat	Low Battery Batteries are almost empty
mg/l	Concentration unit in ISE measurement
mV	Voltage unit
mV/pH	Unit of the electrode slope

OFL	Overflow Display range exceeded
pH	pH value
S	Slope
SELV	Safety Extra Low Voltage
SEr	Serial interface Output of the data storage on the RS232 or on the internal printer
SLO	Slope Slope setting on calibration
Sto	Store Memory
Temp error	Temperature measurement error
TP	Temperature probe Temperature measurement active
U_{ASY}	Asymmetry potential
°C	Temperature unit, °Celsius
°F	Temperature unit, Fahrenheit

Glossary

Asymmetry Zero point of a pH electrode.

AutoRead Monitors the electrode drift and releases the measured value only after the stability criterion has been reached. In this way, this procedure ensures the highest degree of precision and reproducibility.

Baud rate Transmission rate in bits/s.

Buffer solution Stable solution with a precisely known pH value.

Calibration Action to adjust the measuring instrument to a probe.

Diaphragm Contact point between the reference electrolytic solution and the sample.

Drift control See AUTOREAD.

MultiCal® Group term for the various calibration procedures used for automatic calibration in buffer solutions.

Test sample Sample to be measured (can be liquid or solid).

Test solution Stable solution with a precisely known Redox voltage.

Redox voltage Potentiometric quantity.

Resolution Number of decimal places that appear for a measured value.

Slope Specifies the voltage change per pH unit.

Standard Solution with a defined concentration for calibration.

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