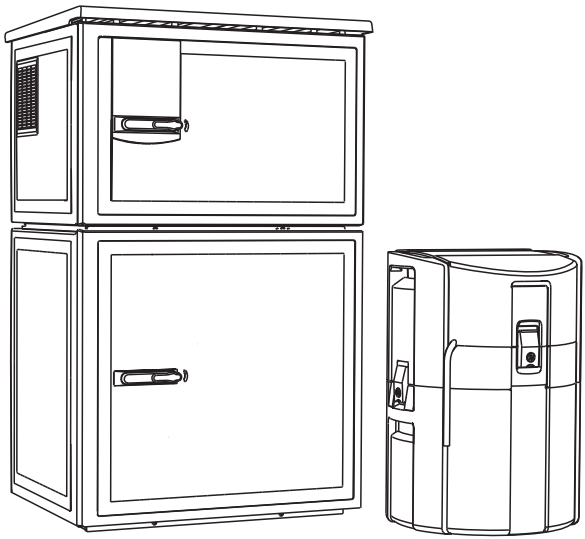
Level Pressure Flow Temperature Liquid Analysis Registration Systems Components Services Solutions

Operating Instructions

CSF48/CSP44

Automatic sampler for liquid media

Calibration



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Endress+Hauser

People for Process Automation

About this manual

This manual describes how to calibrate the distribution arm and the sample volume. In addition, it also explains all the possible ways of calibrating and adjusting digital sensors with the Memosens protocol.

This manual does not include the following:

- Setup/General settings
  —> Operating Instructions BA443C "Commissioning"
- Display/Operation
  —> Operating Instructions BA443C "Commissioning"
- Inputs
  —> Operating Instructions BA464C "Operation & settings"
- Outputs
  —> Operating Instructions BA464C "Operation & settings"
- Sampling programs
  —> Operating Instructions BA464C "Operation & settings"
- Additional functions
  —> Operating Instructions BA464C "Operation & settings"
- Data management
  —> Operating Instructions BA464C "Operation & settings"
- Expert
  —> Internal Service Manual
- Diagnostics
  —> Operating Instructions BA463C "Maintenance & diagnostics"

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1 Calibrating the distribution arm

It is only possible to calibrate the distribution arm in the version with the distributor plate.

The distribution arm must be calibrated if:
- The distribution arm motor has been replaced
- Error message "F236 Distribution arm" appears on the display

Proceed as follows to calibrate the distribution arm:

Path: Menu/Calibration

Function	Options	Info
▶ Distribution arm		
▷ Go to ref. point	Action	The reference run is started. The reference point is in the middle at the front. In the case of the distributor plate, the reference point is at the arrow on the plate.

With ▷ Adjust you can correct the distribution arm if the unit does not move to the reference point correctly. Use the two arrow keys to correct the position.

2 Calibrating the sample volume

2.1 Vacuum pump

The desired sample volume is set by manually adjusting the dosing tube.

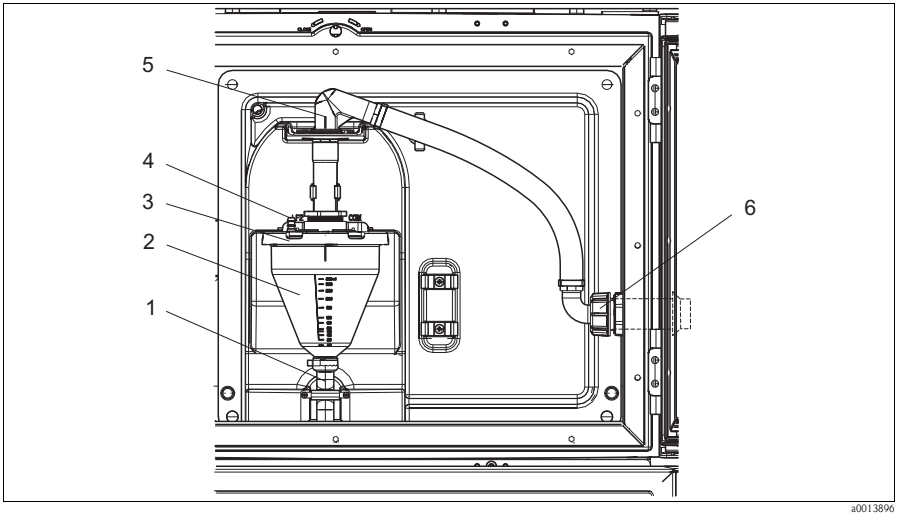
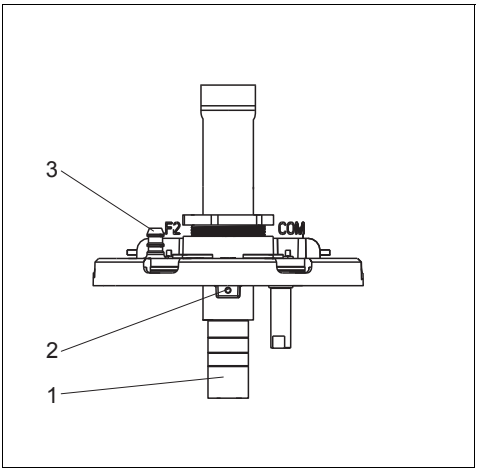


Fig. 1: Vacuum pump

1 Outlet hose
2 Dosing chamber
3 Dosing chamber cover
4 Air hose connection
5 Lock for intake hose
6 Thread adapter nut for intake hose

Proceed as follows to calibrate the sample volume:

1. Check the sample volume set under Menu/Setup/General settings/Sampling/Dosing volume.
2. Release the thread adapter nut on the intake hose (item 6).
3. Turn the intake hose to the "open" position at the hose lock (item 5) and remove the hose from above.
4. Release the air hose (item 4) and remove the dosing chamber (item 2) from the front along with the outlet hose (item 1).
5. Open the bayonet lock (item 3) and open the dosing chamber.



1 Dosing tube
2 Allen screw
3 Air hose connection

Fig. 2: Vacuum pump

1. Release the 2mm Allen screw with the key provided.
2. Set the sample volume by adjusting the dosing tube. Secure the dosing tube with the screw.
   Use the white scale (A) to dose without pressure.
   Use the blue scale (B) to dose with pressure.
3. Reinstall the parts in reverse order. Make sure that the contacts of the conductivity sensors are in the correct position.
4. Check that the dosing tube is set correctly by triggering a manual sampling routine.

2.2 Peristaltic pump

In order to calibrate the sample volume, a measurement beaker with a volume of at least 200 ml is required.
CSP44: remove the pump hose from the hose feeder and feed it into the measurement beaker.

Proceed as follows to calibrate:

Path: Menu/Calibration

Function	Options	Info
▶ Sample volume		
▶ 1-point calibration		

Path: Menu/Calibration

Function	Options	Info
Distributor position	Options - Front - Bottle x - Back	Select the distributor position.
Sample volume	50 to 2000 ml **Factory setting** 100 ml	Set the sample volume.
▷ Start sampling	Action	The progress of the sampling operation is displayed.
Check whether the sample volume is correct. Use ▶ No to enter the sample volume actually taken, e.g. 110 ml. Use ▷ Yes to repeat the sampling.		
▶ 2-point calibration Use 2-point calibration for levels that fluctuate greatly. The second sampling point must be either higher or lower (height difference of at least 1 m).		
Distributor position	Options - Front - Bottle x - Back	Select the distributor position.
Sample volume	50 to 2000 ml **Factory setting** 100 ml	Set the sample volume.
▷ Start 1. sampling	Action	The progress of the sampling operation is displayed.
Check whether the sample volume is correct. Use ▶ No to enter the sample volume actually taken, e.g. 110 ml. Use ▷ Yes to repeat the sampling.		
▷ Start 2. sampling	Action	The progress of the sampling operation is displayed.
Check whether the sample volume is correct. Use ▶ No to enter the sample volume actually taken, e.g. 110 ml. Use ▷ Yes to repeat the sampling.		

3 Calibration and adjustment

3.1 Definitions

Calibration (as per DIN 1319):
A calibration is defined as a set of operations that establish the relationship between the measured value or expected value of the output variable and the related true or correct value of the measured variable (input variable) for a measuring system under specified conditions.
A calibration does not alter the performance of the measuring device.

Adjustment
An adjustment corrects the value displayed by a measuring device, in other words the measured/displayed value (the actual value) is corrected so that the reading agrees with the correct, set value.
The value determined during calibration is used to calculate the correct measured value and saved in the sensor.

3.2 Terminology

3.2.1 Zero point and slope

Using a mathematical function, the controller converts the input signal of the sensor y (raw measured value) to the measured value x. In many cases, this function is a simple linear of the form $y = a + b \cdot x$.
The linear element "a" is usually equivalent to the zero point and the factor "b" is the slope of the line.

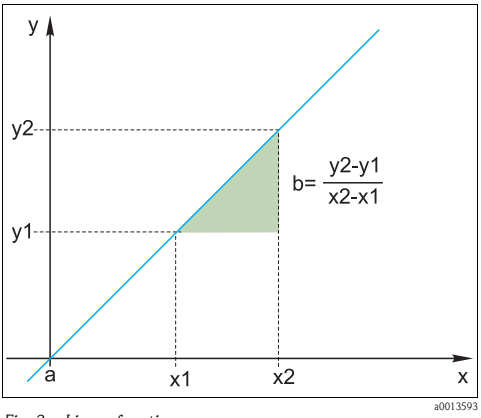


Fig. 3: Linear function

a Zero point
b Slope

The **Nernst equation**, which is used to calculate the pH value, is a typical linear relationship:

$$U_i = U_0 - \frac{2.303\ RT}{F}\ pH$$

$pH = -lg(a_{H+})$, a_{H+} ... activity of the hydrogen ions
U_i ... raw measured value in mV
U_0 ... zero point (=voltage at pH 7)
R ... relative gas constant (8.3143 J/molK)
T ... temperature [K]
F ... Faraday constant (26.803 Ah)

The slope of the Nernst equation (-2.303RT/F) is known as the **Nernst factor** and has the value -59.16 mV/pH at 25 °C.

3.2.2 Delta slope

The controller determines the difference in the slope between the last and second-last calibration. Depending on the sensor type, this difference is an indicator of the condition of the sensor. The smaller the slope, the less sensitive the measurement, and the accuracy deteriorates particularly in the low measuring range.
Depending on the operating conditions, users can define limit values that represent the still tolerable absolute values of the slope and/or slope differentials. If the limit values are exceeded, maintenance must be performed on the sensor at the very least. The sensor must be replaced if the insensitivity problems persist after maintenance has been carried out.

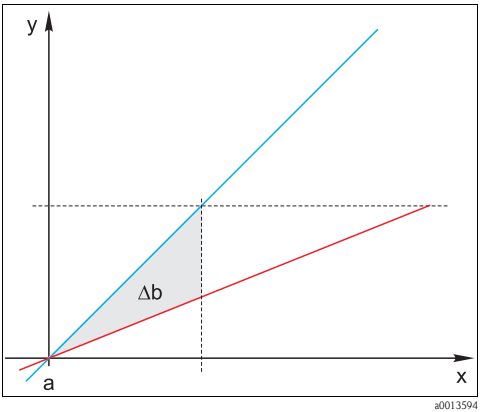


Fig. 4: Delta slope

Blue Second-last calibration
Red Last calibration
?b Delta slope

3.2.3 Delta zero point

The controller calculates the difference in the zero point between the last and second-last calibration. A shift in the zero point (offset) does not alter the sensitivity of the measurement. However, if the offset is not corrected this can falsify the measured value.
As with the slope, you can also define and monitor limit values for the offset. If the limit values are exceeded, this means that maintenance must be performed on the sensor. For example, you may have to eliminate a blockage in the reference for the pH sensor.

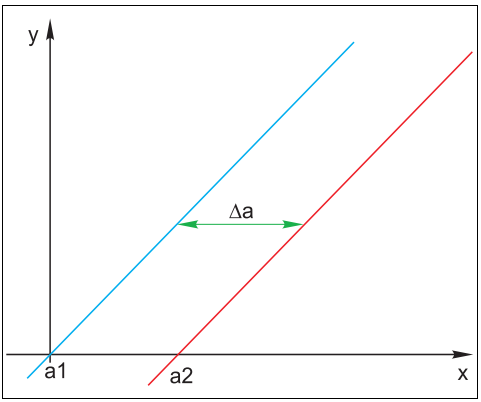


Fig. 5: Delta zero point

a1 *Zero point of the second-last calibration*
a2 *Zero point of the last calibration*
?a *Delta zero point*

3.3 Notes on performing a calibration

The following rules apply for all parameters:
- Calibrate in a way that reflects conditions in the process.
  - If the process medium is constantly moving, also move the calibration buffer accordingly (e.g. use a magnetic stirrer if calibrating in the laboratory).
  - If your medium is relatively stationary, calibrate in buffers that are also stationary.
- Make sure that the samples are homogeneous for reference measurements, sample calibration etc.
- Avoid changes in the medium samples resulting from ongoing biological activity.
  Example: Use outlet water instead of a sample from the aeration basin for nitrate calibration.
- Use the same menu settings as those in the process to perform the calibration.
  Example: If you automatically compensate for the temperature effect during pH measurement, switch on automatic temperature compensation for the calibration also.

4 pH sensors

The calibration provides important information on the condition of your sensor and the quality of the pH measurement.

pH glass electrodes
In addition to the slope that has an ideal value of approx. -59 mV/pH at 25 °C, the change in the zero point also provides important information to the user. It is an indicator of the condition of the gel-like layer of the pH glass and could point to a blockage in the reference system. Suitable maintenance would involve cleaning or regenerating the sensor.
To perform a quick test, simply immerse the sensor in a buffer solution with the same pH value as the internal buffer (e.g. pH 7, see Menu/Setup/Inputs/pH/Internal buffer). 0 mV would be an ideal value. The greater the deviation from the ideal value, the poorer the condition of the sensor (±20 mV is still acceptable in most situations).

pH-ISFET sensors
ISFET sensors use a control loop. The ISFET chip and reference must be immersed in the medium and the sensor must be connected. When commissioning, a certain settling time has to be taken into account until the control loop is established. The settling time depends on the type and duration of the interruption and generally takes 5-8 minutes.
The operating point of the sensor is between -200 mV and +200 mV and is primarily determined by the thickness of the sensitive layer on the chip. The operating point changes over the lifetime of the sensor as a result of wear and abrasion.
The slope of the sensor, which - like glass electrodes - has an ideal value of approx. -59 mV/pH (at 25 °C), changes primarily as a result of buildup forming on the chip.

4.1 Calibration intervals

4.1.1 Specifying the intervals

The service life of a pH glass electrode is limited. This is due, in part, to the deterioration and aging of the pH-sensitive membrane glass. This aging causes the gel-like layer to change and become thicker over time.

Symptoms of aging include:
- Higher membrane resistance
- Slow response
- Decrease in the slope

A change in the reference system (e.g. due to contamination, i.e. unwanted redox reactions at the reference electrode) or electrolyte solution dissolving away in the reference half cell can change the reference potential, which, in turn, causes a zero point shift in the measuring electrode.
To ensure a high level of accuracy, it is important to readjust the pH sensors at set intervals. The calibration interval depends heavily on the area of application of the sensor, as well as the required level of accuracy and reproducibility. The calibration interval can vary between daily and once every few months.

Defining the calibration interval for the process

1. Check the sensor with a buffer solution, e.g. pH 7.
   Proceed as specified in Step 2 only if the value deviates from the set point. No calibration/adjustment is necessary if the value is within the defined deviation tolerance range (see the Technical Information for the sensor).
2. Calibrate and adjust the sensor.
3. After 24 hours, check again with the buffer solution.
   a. If the deviation is within the permitted tolerance range, increase the checking interval by doubling it for example.
   b. If the deviation is larger, you must shorten the interval.
4. Continue to proceed as defined in Steps 2 and 3 until you have identified the suitable interval.

Monitoring the calibration

1. Define the limit values for monitoring the slope and zero point differentials (Menu/Setup/Inputs/pH/Diag. settings/Delta slope or Delta zeropoint).
   These limit values depend on the process and must be determined by empirical means.
2. During calibration a diagnostics message is displayed if the defined warning limits have been exceeded. You then have to service the sensor by cleaning the sensor or reference, or by regenerating the glass membrane.
3. You have to replace the sensor if warning messages continue to be displayed despite the maintenance measure.

4.1.2 Monitoring the calibration interval

If you have established calibration intervals for your process, you can also have the controller monitor them.

Two functions are available for this purpose:

1. Calibration timer (Menu/Setup/Inputs/<Sensortype>/Calib. settings/Calibration timer)
   You specify the calibration interval and the controller generates a diagnostics message once the set time has elapsed. You then recalibrate the sensor or replace it with a precalibrated sensor. The timer is reset with the new calibration.
2. Calibration expiration date (Menu/Setup/Inputs/<Sensortype>/Calib. settings/Calib. expiration date)
   You set time limits to specify how long a calibration should be regarded as valid. Memosens sensors save all the calibration data. In this way it is easy to see whether the last calibration took place in the specified timeframe and is therefore still valid. This is particularly advantageous when working with precalibrated sensors.

4.2 Types of calibration

The following types of calibration are possible:
- Two-point calibration
  - With calibration buffers
  - Entry of data for the slope, zero point and temperature
- Single-point calibration
  - Entry of an offset or a reference value
  - Sample calibration with laboratory comparative value
- Temperature adjustment by entering a reference value

4.3 Two-point calibration

4.3.1 Applications and requirements

Two-point calibration is the preferred method for pH sensors, particularly in the following applications:
- Municipal and industrial wastewater
- Natural waters and drinking water
- Boiler feedwater and condensates
- Beverages

Calibrating with buffers with pH 7.0 and 4.0 is recommended for most applications.
Alkaline buffer solutions have the disadvantage that carbon dioxide from the air can alter the pH value of the buffer on the long term. If calibrating with alkaline buffers it is best to do so in closed systems, such as flow assemblies or retractable assemblies with a rinse chamber, to minimize the effect of air.

4.3.2 With calibration buffers

You use calibration buffers to perform two-point calibration. The quality buffers supplied by Endress+Hauser are certified and measured in an accredited laboratory. The accreditation (DAR registration number "DKD-K-52701") confirms that the actual values and the maximum deviations are correct and traceable.

To calibrate the sensor, remove it from the medium and calibrate it in the laboratory. Since Memosens sensors save the data, you can always work with "precalibrated" sensors and do not have to stop monitoring the process to perform a calibration.

1. Go to the "CAL/2-pnt. calibration" menu. The following message is displayed:
   ⓘ Do you want to start the calibration? (Hold turns to active)
2. Select "OK" by way of confirmation.
   The next items displayed depend on your settings in "Menu/Setup/Inputs/Calib. settings".
   a. Buffer recognition="fixed"
      Depending on the "Buffer manufacturer", in "Calib. settings" you specified two buffers that are displayed in succession during the calibration.
   b. Buffer recognition="Manual"

In "Calib. settings" you specified any two buffers that are displayed in succession during the calibration.

c. Buffer recognition="Automatic" (only pH glass)
Liquiline displays the name of the buffer manufacturer you chose in "Calib. settings".

3. Follow the instructions on the display:
ⓘ Please clean sensor before immersing in buffer 1.
4. Press "OK" **after** you have immersed the sensor into the first buffer.
The system starts calculating the measured value for the first buffer. Once the stability criterion is met, the measured value is displayed in mV.
5. Follow the instructions on the display again:
ⓘ Please clean sensor before immersing in buffer 2.
6. Press "OK" **after** you have immersed the sensor into the second buffer.
The system starts calculating the measured value for the buffer. Once the stability criterion is met, the measured values of the two buffers and the calculated values for the slope and zero point are displayed.
7. Select "OK" when you are asked to accept the calibration data for adjustment.
8. Put the sensor back into the medium and press "OK" again.
This deactivates the hold and the system starts measuring again.

You can cancel the calibration any time by pressing the "ESC" key. No data are then used to adjust the sensor.

4.3.3 Entering data for the zero point, slope and temperature

You enter the slope, zero point and temperature manually. The function for determining the pH value is calculated from these values. Thus, the data entry returns the same result as two-point calibration.
You must determine the slope, zero point and temperature alternatively.

1. Go to the "CAL/Data input" menu.
The slope, zero point and temperature are shown on the display.
2. Select each value one after another and then enter your desired numerical value.
Since you are entering all the variables for the Nernst equation directly, no additional information is displayed by the controller.
3. Select "OK" when you are asked to accept the calibration data for adjustment.

You can cancel the calibration any time by pressing the "ESC" key. No new data are then used to adjust the sensor.

4.4 Single-point calibration

4.4.1 Applications and requirements

Single-point calibration is particularly useful if the deviation of the pH value from a reference value, and not the absolute pH value itself, is of interest to the user. Applications for single-point calibration include:

- Process control
- Quality assurance

Fluctuations in the process value should not exceed ±0.5 pH and the process temperature must remain relatively constant. As the measuring range is limited as a result, it is possible to set the slope to -59 mV/pH (at 25 °C). To adjust the sensor, you enter an offset or a reference value. Alternatively, you can also use the "sample calibration". Here, you take a sample from the process and determine the pH value in the laboratory. In the case of the laboratory sample, you must make sure that the pH value is determined at the process temperature.

4.4.2 Sample calibration

With this type of calibration, you take a sample of the medium and determine its pH value (at process temperature) in the laboratory. You then use this laboratory value to adjust the sensor. This does not change the slope of the calibration function.

1. Go to the "CAL/Sample calibration" menu. The following message is displayed:
   ⓘ Do you want to start the calibration? (Hold turns to active)
2. Select "OK" by way of confirmation.
   The current measured value and temperature are displayed.
3. Follow the instructions on the display:
   ⓘ Please pick medium for grab sample.
4. Press "OK" **after** you have taken the sample.
   The following message appears on the display:
   ▶Sample calibration.
5. Press the navigation button **after** you have determined the laboratory value.
   A line appears where you can enter the laboratory value.
6. Enter your laboratory measured value here and then go to ▷ Continue.
   The measured value, laboratory value and the resulting offset are displayed.
7. ⓘTake over the calibration data?
   Select "OK" by way of confirmation.
   The following message is then displayed:
   ⓘ The calibration is finished. Please clean sensor before immersing in process medium.
   (Hold will be reset)
8. Follow the instructions and then press "OK".

You can cancel the calibration any time by pressing the "ESC" key. No data are then used to adjust the sensor.

4.4.3 Entering the offset or reference value

You either enter an offset or a (reference) measured value calculated beforehand. This then shifts the calibration function along the X-axis (pH). The slope is not affected.

1. Go to the "CAL/1-pnt. calibration" menu.
2. Decide which value you want to enter:
   a. Offset
      Select the displayed value and press the navigator button.
      Now enter the desired offset. Once accepted, the value you entered immediately affects the "Measured value".
   b. Measured value
      Select the displayed value and press the navigator button.
      Now enter the desired measured value. Once accepted, the value you entered immediately affects the "Offset".
3. ▷ Take over the calibration data?
   Select "OK" by way of confirmation.

You can cancel the calibration any time by pressing the "ESC" key. No data are then used to adjust the sensor.

4.5 Temperature adjustment

1. Determine the temperature of your process medium with an alternative measurement, e.g. a precision thermometer.
2. Go to the "CAL/<Sensor type>/Temperature adjustment" menu.
3. **Leave the sensor in the process medium** and keep clicking "OK" until temperature measurement is started via the sensor:
   Waiting for a stable meas. value..
4. Afterwards, you have the possibility of entering the reference temperature from the alternative measurement. You can either enter the absolute value or an offset for this purpose.
5. Once you have entered your data, click "OK" until the new data have been accepted. This completes temperature sensor adjustment.

4.6 Error messages when performing the calibration

Display message	Causes and possible remedial measures
The calibration is invalid. Do you want to start a new calibration?	The calibration buffer is contaminated or the pH value is no longer within the permitted limits. As a result, the permitted measured value deviation is exceeded. ■ Check the expiry date ■ Use a fresh buffer Incorrect buffers used. As a result, the buffer recognition function – for example – does not work correctly. ■ pH values of the buffers are too close together, e.g. pH 9 and 9.2 ■ Use buffers with a larger pH difference Sensor aging or contaminated. As a result, the permitted limit values for the slope and/or zero point are exceeded ■ Clean the sensor ■ Adjust the limit values ■ Regenerate or replace the sensor
The stability criterion is not fulfilled. Do you want to repeat the last step?	The measured value or temperature is not stable. As a result, the stability criterion is not met. ■ Keep the temperature constant during calibration ■ Replace the buffer ■ Sensor old or contaminated. Clean or regenerate. ■ Adjust stability criteria (Menu/Setup/Inputs/pH/Calib. settings/Stability criteria)
The calibration aborted. Please clean sensor before immersing in process medium. (Hold will be deactivated)	The user has aborted the calibration.

5 ORP sensors

5.1 Types of calibration

The following types of calibration are possible:
- Two-point calibration with medium samples (only Main value = "%")
- Single-point calibration with calibration buffer
- Entry of data for an offset
- Temperature adjustment via reference value

5.2 Two-point calibration (only ORP %)

You must adapt the sensor to your process to obtain useful ORP % values. This is achieved through two-point calibration. The two calibration points are characteristic of the most important states your medium can assume in the process.
You require two different compositions of your medium that represent the characteristic limits of your process (e.g. 20% and 80% value).
The absolute value in mV is not relevant for the ORP % measurement.

1. Go to the "CAL/ORP/2-pnt. calibration" menu.
2. Select "OK" when asked the following question:
   ⓘ Do you want to start the calibration? (Hold turns to active)
3. Immerse the sensor into the first medium sample and select "OK" to answer the prompt shown on the display.
4. The measured value is displayed and the following message appears:
   Please enter reference value.
5. Under "Medium 1" enter the related % value.
6. ▷ Continue
7. Follow the instructions to clean and subsequently immerse the sensor in the second medium sample.
8. Then enter the reference value for buffer 2.
9. ▷ Continue
   Select "OK" when you are asked to accept the calibration data for adjustment.
   The following message is then displayed:
   ⓘ The calibration is finished. Please clean sensor before immersing in process medium. (Hold will be reset)
10. Follow the instructions and then press "OK".

You can cancel the calibration any time by pressing the "ESC" key. No data are then used to adjust the sensor.

5.3 Single-point calibration

5.3.1 General information

The buffers contain ORP pairs with a high exchange current density. Such buffers have the advantage of higher accuracy levels, better reproducibility and faster measurement response times.
Temperature compensation does not take place when measuring the ORP since the thermal behavior of the medium is not known. However, the temperature is indicated with the measurement result and for this reason it makes sense to adjust the temperature sensor at process-dependent intervals.

5.3.2 Single-point calibration with calibration buffers

With this type of calibration, you work with calibration buffers, e.g. ORP buffers from Endress+Hauser. For this purpose, you remove the sensor from the medium and calibrate it in the laboratory. Since Memosens sensors save the data, you can always work with "precalibrated" sensors and do not have to stop monitoring the process for extended periods to perform a calibration.

1. Go to the "CAL/1-pnt. calibration" menu. The following message is displayed:
   Please enter buffer.
2. Under "Buffer:" enter the ORP value of your calibration buffer.
3. ▷ Continue
4. Select "OK" when asked the following question:
   ⓘ Do you want to start the calibration? (Hold turns to active)
   The value of the expected calibration buffer is displayed and you are instructed to clean the sensor before immersing it into the buffer.
5. Follow the instructions and then immerse the sensor into the buffer.
6. Press "OK".
   The system starts calculating the measured value for the buffer. If the stability criterion is met, the expected value, the current measured value of the buffer and the calculated offset are displayed.
7. Select "OK" when you are asked to accept the calibration data for adjustment.
   The following message is then displayed:
   ⓘ The calibration is finished. Please clean sensor before immersing in process medium. (Hold will be reset)
8. Follow the instructions and then press "OK".

You can cancel the calibration any time by pressing the "ESC" key. No data are then used to adjust the sensor.

5.3.3 Entering data for an offset

You enter the offset directly with this type of calibration. Use the measured value of a reference measurement, for example, to determine the offset.

1. Go to the "CAL/Data input" menu.

2. The current offset is displayed.
   Decide whether you want to keep this value or enter a new value.
3. Enter the new offset.
4. Answer the question shown on the display:
   ▷ Take over the calibration data?
5. Select "OK" by way of confirmation.
   The new offset is accepted (no other information is displayed).

You can cancel the calibration any time by pressing the "ESC" key. No data are then used to adjust the sensor.

5.4 Temperature adjustment

1. Determine the temperature of your process medium with an alternative measurement, e.g. a precision thermometer.
2. Go to the "CAL/<Sensor type>/Temperature adjustment" menu.
3. **Leave the sensor in the process medium** and keep clicking "OK" until temperature measurement is started via the sensor:
   Waiting for a stable meas. value..
4. Afterwards, you have the possibility of entering the reference temperature from the alternative measurement. You can either enter the absolute value or an offset for this purpose.
5. Once you have entered your data, click "OK" until the new data have been accepted. This completes temperature sensor adjustment.

5.5 Error messages when performing the calibration

Display message	Causes and possible remedial measures
The calibration is invalid. Do you want to start a new calibration?	The calibration buffer is contaminated or the ORP potential is no longer within the permitted limits. As a result, the permitted measured value deviation is exceeded. ■ Check the expiry date ■ Use a fresh buffer
The stability criterion is not fulfilled. Do you want to repeat the last step?	The measured value is not stable. As a result, the stability criterion is not met. ■ Replace the buffer ■ Sensor old or contaminated. Clean or regenerate. ■ Adjust stability criteria (Menu/Setup/Inputs/pH/Calib. settings/Stability criteria)
The calibration aborted. Please clean sensor before immersing in process medium. (Hold will be deactivated)	The user has aborted the calibration.

6 Conductivity sensors

6.1 Types of calibration

The following types of calibration are possible:
- Cell constant with calibration solution
- Installation factor (only inductive sensors)
- Air set (residual coupling, only inductive sensors)
- Temperature adjustment via reference value

6.2 Cell constant

6.2.1 General information

A conductivity measuring system is generally calibrated in such a way that the exact cell constant is determined or checked using suitable calibration solutions. This process is described in the standards EN 7888 and ASTM D 1125, for example, and the method for producing a number of calibration solutions is explained. Another alternative is to purchase international calibration standards from national measurement institutes. This is particularly important in the pharmaceutical industry, which requires a calibration to be traced to internationally recognized standards. To calibrate its testing units, Endress+Hauser uses special reference material (SRM) from the US National Institute of Standards and Technology (NIST).

6.2.2 Calibrating the cell constant

You enter a reference value for the conductivity with this type of calibration. In addition, you specify how the system should compensate for the influence of temperature. In the result, the controller calculates a new cell constant for the sensor.

1. Go to the "CAL/Cell constant" menu.
2. Work your way through the menu functions that follow.
3. Start the calibration.

Path: CAL/Conductivity/Cell constant

Function	Options	Info
Current cell const.	Read only	Value currently saved in the sensor
Temp. compensation	Options ■ No ■ Yes **Factory setting** Yes	As an alternative to the compensated conductivity (Yes), you can also determine the cell constant by calibrating the uncompensated conductivity (No).

Path: CAL/Conductivity/Cell constant

Function	Options	Info
Coeff. Alpha	0.00 to 20.00 %/K **Factory setting** Depends on the sensor	*Temp. compensation = "Yes"* The alpha coefficients and alpha reference temperatures of Endress+Hauser can be found in the documentation supplied with the calibration solutions. Enter the appropriate values.
Alpha ref. temp.	-5.0 to 100.0 °C (23.0 to 212.0 °F) **Factory setting** 25.0 °C (77.0 °F)	
Temp. source	Options ■ Sensor ■ Manual **Factory setting** Sensor	Decide how you want to compensate the medium temperature: ■ Automatically using the temperature sensor of your sensor ■ Manually by entering the medium temperature
Medium temperature	-50.0 to 250.0 °C (-58.0 to 482.0 °F) **Factory setting** 25.0 °C (77 °F)	*Temp. source = "Manual"* Enter the temperature of your medium.
Conductivity ref.	0.000 to 2000000 µS/cm **Factory setting** 0.000 µS/cm	**Temp. compensation ="Yes"** Enter the **compensated** conductivity of your calibration solution here. **Temp. compensation ="No"** Enter the **uncompensated** conductivity of your calibration solution here.
▷ Start calibration	Start the calibration. Follow the instructions on the display.	

You can cancel the calibration any time by pressing the "ESC" key. No new data are then used to adjust the sensor.

6.3 Air set (residual coupling, only inductive sensors)

While the calibration line goes through zero for physical reasons in the case of conductive sensors (a current flow of 0 corresponds to a conductivity of 0), when working with inductive sensors, the residual coupling between the primary coil (transmitter coil) and secondary coil (receiver coil) must be taken into account or compensated for. The residual coupling is not only caused by the direct magnetic coupling of the coils but also by crosstalk in the supply cables. For this reason, the process of commissioning an inductive sensor always starts with an "air set". Here, the sensor is connected to the transmitter with the cables provided, held in air in a dry state (zero conductivity) and an air set calibration is performed at the transmitter.
The cell constant is then determined using a precise calibration solution, as is the case with conductive sensors.

Sensors with a Memosens protocol are already calibrated at the factory and their residual coupling generally does not have to be adjusted on site.

6.4 Installation factor (only inductive sensors)

In confined installation conditions, the wall affects conductivity measurement in the liquid. The installation factor compensates for this effect. The transmitter corrects the cell constant by multiplying by the installation factor.
The size of the installation factor depends on the diameter and the conductivity of the pipe nozzle, as well as the distance between the sensor and the wall.
If there is a sufficient distance between the wall and the sensor (a > 15 mm (0.59"), from DN 80), the installation factor f does not have to be taken into consideration (f = 1.00).
If distances from the wall are smaller, the installation factor is bigger for electrically insulating pipes (f >1), and smaller for electrically conductive pipes (f < 1).
It can be measured using calibration solutions, or a close approximation determined from the following diagram.

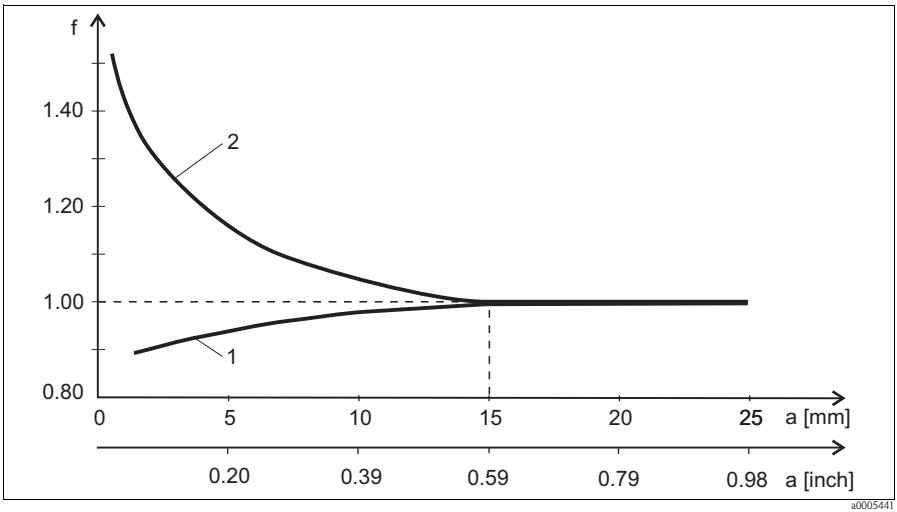


Fig. 6: Relation between the installation factor f and the wall distance

1 Electrically conductive pipe wall
2 Electrically insulating pipe wall

6.4.1 Calibrating the installation factor

1. Go to the "CAL/Cond i/Inst. factor/Calibration" menu.
2. Work your way through the menu functions that follow.
3. Start the calibration.

Path: CAL/Cond i/Inst. factor/Calibration

Function	Options	Info
Cur. inst. factor	Read only	Value currently saved in the sensor
Temp. compensation	Options ■ No ■ Yes **Factory setting** Yes	As an alternative to the compensated conductivity (Yes), you can also determine the cell constant by calibrating the uncompensated conductivity (No).
Coeff. Alpha	0.00 to 20.00 %/K **Factory setting** Depends on the sensor	*Temp. compensation = "Yes"* The alpha coefficients and alpha reference temperatures of Endress+Hauser can be found in the documentation supplied with the calibration solutions. Enter the appropriate values.
Alpha ref. temp.	-5.0 to 100.0 °C (23.0 to 212.0 °F) **Factory setting** 25.0 °C (77.0 °F)	
Temp. source	Options ■ Sensor ■ Manual **Factory setting** Sensor	Decide how you want to compensate the medium temperature: ■ Automatically using the temperature sensor of your sensor ■ Manually by entering the medium temperature
Medium temperature	-50.0 to 250.0 °C (-58.0 to 482.0 °F) **Factory setting** 25.0 °C (77 °F)	*Temp. source = "Manual"* Enter the temperature of your medium.
Conductivity ref.	0.000 to 2000000 µS/cm **Factory setting** 0.000 µS/cm	**Temp. compensation ="Yes"** Enter the **compensated** conductivity of your calibration solution here. **Temp. compensation ="No"** Enter the **uncompensated** conductivity of your calibration solution here.
▷ Start calibration	Start the calibration. Follow the instructions on the display.	

You can cancel the calibration any time by pressing the "ESC" key. No new data are then used to adjust the sensor.

6.4.2 Entering the installation factor

1. Go to the "CAL/Cond i/Inst. factor/Entry" menu.
   The installation factor currently used is displayed.
2. New inst. factor
   Enter the installation factor, which you took from the diagram previously displayed for example.
3. Start the calibration.

You can cancel the calibration any time by pressing the "ESC" key. No new data are then used to adjust the sensor.

6.5 Temperature adjustment

The temperature sensor has to be calibrated at regular intervals to ensure the measured value is not falsified by incorrect temperature measurement.

1. Go to the "CAL/Conductivity/Temperature adjustment" menu.
   The offset (of the last calibration) and the actual temperature value are shown on the display.
2. Mode
   Decide which mode to use for temperature adjustment
   a. 1-point calibration
      You measure the medium temperature with a reference measurement and use this value to adjust the temperature sensor.
   b. 2-point calibration
      You use two samples of different temperatures.
   c. Table
      Adjustment based on data entries. You enter value pairs comprising the measured temperature of the temperature sensor and the related reference temperature. The temperature function is calculated from these value pairs. Press "SAVE" once you have entered all the points and select "OK" to confirm you want to accept the calibration data.
3. ▷ Start calibration (only "1-point calibration" and "2-point calibration")
   Press the navigator button.
4. ⓘ Do you want to start the calibration? (Hold turns to active)
   Select "OK" by way of confirmation. The following message is then displayed:
   ⓘ Please immerse the sensor in calibration medium.
5. Follow the instructions and then press the navigator button.
   The (current) temperature, reference temperature and offset are displayed.
6. Decide whether you want to enter a reference temperature or an offset.
   Navigate to the desired value and edit it. The other value changes immediately with your entry.
7. ▷ Continue
   Repeat Steps 5 and 6 for the 2nd measuring point (only "2-point calibration").
8. Select "OK" when you are asked to accept the calibration data for adjustment.
9. Then follow the instruction displayed:
   ⓘ The calibration is finished. Please clean sensor before immersing in process medium.
   (Hold will be reset)

You can cancel the calibration any time by pressing the "ESC" key. No new data are then used to adjust the sensor.

6.6 Error messages when performing the calibration

Display message	Causes and possible remedial measures
The calibration is invalid. Do you want to start a new calibration?	Calibration solution exhausted. As a result, the permitted measured value deviation is exceeded ■ Check the expiry date ■ Use a fresh calibration solution
Currently no calibration possible due to sensor failure.	Sensor communication problem ■ Replace sensor ■ Contact the Service Department
The calibration aborted. Please clean sensor before immersing in process medium. (Hold will be deactivated)	The user has aborted the calibration.

7 Oxygen sensors

7.1 Calibration intervals

7.1.1 Specifying the intervals

The calibration intervals depend heavily on:
- The application
- The sensor installation position

If you want to calibrate the sensor intermittently for a special application and/or on account of a special type of installation, you can calculate the intervals using the following method:

1. Inspect the sensor one month after commissioning for example:
   – Remove the sensor from the medium.
   – Clean the outside of the sensor with a damp cloth.
   – Then dry the sensor diaphragm carefully with a paper towel for example. (only amperometric sensors)
   – After 20 minutes, measure the oxygen saturation index in air.
   – Protect the sensor against external influences such as sunlight and wind.
2. Decide whether to calibrate depending on the result:
   a. Amperometric sensor:
      If the measured value is not 102 ±2 %SAT, you must calibrate the sensor.
   b. Optical sensor:
      If the measured value is not 100 ±2 %SAT, you must calibrate the sensor.
   c. Otherwise extend the period until the next inspection.
3. Proceed as explained in Point 1 after two, four or eight months to determine the optimum calibration interval for your sensor.

7.1.2 Monitoring the calibration interval

Once you have established the calibration intervals for your process, you can also have the controller monitor them.

Two functions are available for this purpose:
1. Calibration timer (Menu/Setup/Inputs/<Sensortype>/Calib. settings/Calibration timer)
   You specify the calibration interval and the controller generates a diagnostics message once the set time has elapsed. You then recalibrate the sensor or replace it with a precalibrated sensor. The timer is reset with the new calibration.
2. Calibration expiration date (Menu/Setup/Inputs/<Sensortype>/Calib. settings/Calib. expiration date)
   You set time limits to specify how long a calibration should be regarded as valid. Memosens sensors save all the calibration data. In this way it is easy to see whether the last calibration took place in the specified timeframe and is therefore still valid. This is particularly advantageous when working with precalibrated sensors.

7.2 Types of calibration

The following types of calibration are possible:
- Slope
  - Air, water vapor-saturated
  - Air-saturated water
  - Air, variable
  - Data entry
- Zero point
  - Single-point calibration in nitrogen or oxygen-free water
  - Data entry
- Sample calibration
  - Slope
  - Zero point
- Temperature adjustment

Furthermore, the calibration menu for amperometric sensors contains two additional functions to reset the sensor's internal counters:
- Change electrolyte
- Change sensorcap

7.3 Slope calibration

You can calibrate the slope in the following ways:
- Sensor in water vapor-saturated air
- Sensor in air-saturated water
- Sensor in variable air
- By data entry

7.3.1 In different media

The calibration procedure is identical regardless of whether you are calibrating in water vapor-saturated air, air-saturated water or variable air:
1. Go to the "Oxygen/Oxygen/Slope" menu.
2. Choose between "Air 100% rh", "H2O air-saturated" and "Air variable".
   The following message is displayed:
   ⓘ Do you want to start the calibration? (Hold turns to active)
3. Select "OK" by way of confirmation.
4. Follow the instructions on the display:
   ⓘ Please clean sensor before immersing in medium/air.
5. The current slope and the new slope are displayed once a stable measured value is available.
   The following message appears on the display:
   ⓘTake over the calibration data?
6. Select "OK" by way of confirmation.
   The following message is then displayed:

ⓘ The calibration is finished. Please clean sensor before immersing in process medium. (Hold will be reset)

7. Follow the instructions and then press "OK".

You can cancel the calibration any time by pressing the "ESC" key. No data are then used to adjust the sensor.

7.3.2 Data entry

1. Go to the "CAL/Oxygen/Slope/Data input" menu.
2. Select "New slope" and enter the new value.
3. Then select "OK" when you are asked to accept the calibration data for adjustment.

7.4 Zero point calibration

Zero point calibration is particularly important if measurements are to be compared to one another.
A zero point shift in amperometric sensors is primarily caused by fouling on the cathode. The special mechanical construction of the sensor with the membrane cap and electrolyte almost completely eliminates such fouling.

7.4.1 Zero point calibration with "zero solution"

Use oxygen-free water for this calibration. What is known as a "zero solution" is available from Endress+Hauser for oxygen calibration.
As an alternative to the aqueous version, you can also work in an atmosphere that is free from oxygen, such as high-purity nitrogen.

1. Go to the "CAL/Oxygen/Zero point" menu.
   The following question is displayed:
   ⓘ Do you want to start the calibration? (Hold turns to active)
2. Select "OK" by way of confirmation.
3. Immerse the sensor in oxygen-free water or hold it in nitrogen **(not in air!)**.
4. The following question appears once the stability criterion is met:
   ⓘ Take over the calibration data?
5. Select "OK" by way of confirmation.
   The following message is then displayed:
   ⓘ The calibration is finished. Please clean sensor before immersing in process medium. (Hold will be reset)
6. Follow the instructions and then press "OK".

You can cancel the calibration any time by pressing the "ESC" key. No data are then used to adjust the sensor.

7.4.2 Zero point calibration via data entry

1. Go to the "CAL/Oxygen/Zero point/Data input" menu.
2. Select "New zeropoint" and enter the new value.
3. Then select "OK" when you are asked to accept the calibration data for adjustment.

7.5 Sample calibration

Calibration is possible both in the medium and in air. For this purpose, you measure the raw oxygen value using a reference measurement. You use this reference value to adjust the sensor. You can either calibrate the slope or the zero point with the reference value.

1. Go to the "CAL/Oxygen/Sample calibration" menu.
2. Choose between:
   "Slope" and "Zero point".
   Use the calibration of the zero point if you want to align the measurement with another measurement. You can correct the sensitivity of your measurement with the slope calibration.
3. Select "OK" by way of response to the following question:
   ⓘDo you want to start the calibration? (Hold turns to active)
4. Follow the instruction displayed:
   ⓘ Please clean sensor before immersing in medium/air.
5. Press the navigator button.
   A line appears where you can enter the reference value ("New value").
6. Enter your reference measured value here and then go to ▷ Continue.
   The old and the new value are displayed depending on whether you chose slope or zero point.
7. ▷ Take over the calibration data?
   Select "OK" by way of confirmation.
   The following message is then displayed:
   ⓘ The calibration is finished. Please clean sensor before immersing in process medium. (Hold will be reset)
8. Follow the instructions and then press "OK".

You can cancel the calibration any time by pressing the "ESC" key. No data are then used to adjust the sensor.

7.6 Resetting the counter

These functions do not adjust the sensor but manually reset the sensor's internal counters to "0". The counter for sensor cap calibrations is used to set warning limits and alarm limits. This ensures that exhausted membrane caps are replaced in time.

CAL/Oxygen

Select the desired function:

1. Change electrolyte
   – The internal sensor counter for calibrations with the electrolyte used is reset (not visible in the sensor information).
   – Use this function after changing the electrolyte without replacing the membrane cap.
2. Change sensorcap
   – The internal sensor counter for calibrations with the membrane cap used is reset. The number of calibrations performed with the current membrane cap is indicated in the sensor information.
   – Select this function after replacing the membrane cap.

7.7 Temperature adjustment

1. Determine the temperature of your process medium with an alternative measurement, e.g. a precision thermometer.
2. Go to the "CAL/<Sensor type>/Temperature adjustment" menu.
3. **Leave the sensor in the process medium** and keep clicking "OK" until temperature measurement is started via the sensor:
   Waiting for a stable meas. value..
4. Afterwards, you have the possibility of entering the reference temperature from the alternative measurement. You can either enter the absolute value or an offset for this purpose.
5. Once you have entered your data, click "OK" until the new data have been accepted. This completes temperature sensor adjustment.

7.8 Error messages when performing the calibration

Display message	Causes and possible remedial measures
The calibration is invalid. The range was overrun. Do you want repeat the last step?	Sensor contaminated or exhausted zero solution. As a result, the permitted limit values for the zero point are exceeded. ■ Clean the sensor ■ Renew the zero solution ■ Repeat the calibration
The stability criterion is not fulfilled. Do you want to repeat the last step?	The measured value is not stable. As a result, the stability criterion is not met. ■ Electrolyte and/or membrane cap exhausted, replace ■ Adjust stability criteria (Menu/Setup/Inputs/Oxygen/Calib. settings/Stability criteria)
Storage of the data failed. Do you want to retry?	*Optical sensor only!* The calibration data could not be stored in the sensor ■ Check the sensor connection ■ Repeat the calibration.
The calibration aborted. Please clean sensor before immersing in process medium. (Hold will be deactivated)	The user has aborted the calibration.

8 Turbidity and solids sensor

The sensor facilitates measurements with different methods adapted to suit the measuring tasks. The method is specified by selecting the appropriate application and the reference model.

General models	Method	Measuring range
Formazin	90° - turbidity, single-channel	0 to 4000 FNU Display range up to 9999 FNU
Kaolin	135°, single-channel	0 to 5 g/l
TiO_2 (titanium oxide)[1)]	4 beam pulsed light, 135°	0 to 150 g/l

1) also suitable for measuring sludges, especially in the 10 g/l to 100 g/l range

Wastewater models	Method	Measuring range
Sludge activation	4 beam pulsed light, 90°	Up to 15 g/l
Primary sludge	135° - turbidity, single-channel	0 to 20 g/l
Digested sludge	135° - turbidity, single-channel	5 to 100 g/l

8.1 Types of calibration

In addition to the uneditable factory calibration, the sensor stores six other data records. Each calibration data record can have up to five calibration points.

- Single-point calibration
  This causes a change in the slope. This type of calibration is used if the measured value only changes to a limited extent.
- Two-point calibration
  This causes a change in the slope and zero point. This type of calibration is used if the measured value changes to a large extent.
- Multipoint calibration
  Calibration at three or more points always causes the measuring curve to be recalculated (zero point and slope).
- Temperature adjustment via reference value

Single-point and two-point calibration are based on the data record stored internally in the device.

The **three-point calibration** of the sensor is the standard calibration.
It is absolutely essential:
- When commissioning the sensor in sludge applications
- When measuring in another type of sludge

Three-point sensor calibration is **not necessary** when recalibrating with the same type of sludge. Single point calibration suffices here if the levels of turbidity do not differ too much.

8.2 Turbidity and solids

8.2.1 Factory calibration

The sensor is precalibrated on leaving the factory. As such, it can be used in a wide range of clear water measurements without the need for additional calibration. The factory calibration is based on a three-point calibration of a reference sample.
The factory calibration cannot be deleted and can be retrieved at any time. All other calibrations – performed as customized calibrations – are referenced to this factory calibration.

8.2.2 Calibration and adjustment principle

The calibration is always based on a factory calibration saved.
If you use one or two medium concentration values for calibration, the factory data record is recalculated using these measuring points (non-linear function) and saved as the **new data record**. The original factory calibration is not lost.
If you use three or more concentration values for calibration, a completely new calibration function is calculated that no longer takes the original data record into account.

Give your calibration data records meaningful and useful names. For example, the name could contain the name of the application on which your data record was originally based. This makes it easier for you to distinguish between different data records.

8.2.3 Determining the reference value in the laboratory

1. Take a representative sample of the medium.
2. Make sure the sample is as homogeneous as possible.
3. Determine the solids content or the turbidity of the sample with the laboratory method.
4. Use the laboratory measured value as the reference value for calibrating the sensor.

You can also calibrate with samples with added concentrations, or where solid particles have settled to the base of the tank. In this way, you use a serial dilution to obtain calibration points that are above and below the expected turbidity or the expected solids content.

8.2.4 Calibration and adjustment of the sensor

Use the same medium sample that you used to determine the laboratory measured value.
1. Make sure the sample is as homogeneous as possible.
2. Create the necessary number of calibration samples by diluting the medium sample into suitable concentrations.
   For example, you generally obtain very good calibration results with a three-point calibration with concentrations levels of 100 : 33 : 10.

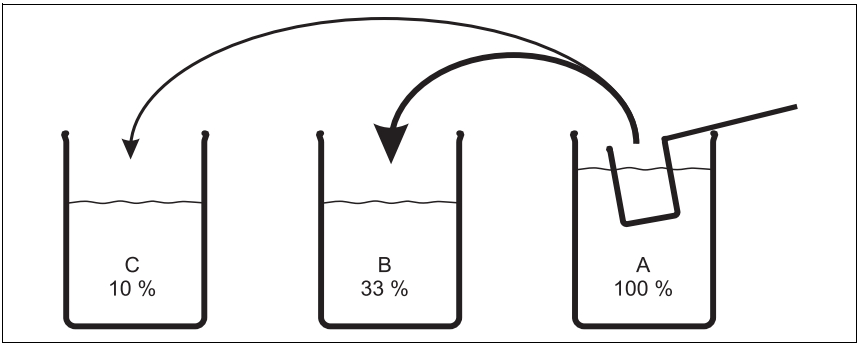


Fig. 7: Creating samples for a three-point calibration

A Original sample
B 1 part sample A + 2 parts water
C 1 part sample A + 9 parts water

3. Determine the solids content or the turbidity of the calibration samples in a series of decreasing concentrations.
4. Calculate the reference values of your serial dilution from the laboratory measured value and enter these for every calibration point.

1. **Sequence of menus during the calibration**
   a. Menu/Setup/Inputs/Turbidity/Application
      Select the application whose saved calibration function is to be changed by additional measuring points.
   b. CAL/Turbidity/Assay
      Select a data record for your serial dilution.
   c. Dataset name
      Assign a name to the data record.
   d. Basic application
      Select the same application as selected in a.
   e. Unit
      Decide which unit you want to use. Use the unit in which you also obtained the laboratory values.

2. First measuring point (lowest concentration)
   a. ⓘ Do you want to start the calibration? (Hold turns to active)
   b. Select "OK" by way of confirmation.
   c. Follow the instructions on the display:
      ⓘ Please clean sensor before immersing in calibration medium.
   d. Once a stable measured value has been determined, you will be asked for the set point (=laboratory value) of the sample. Enter this set point.

3. Decide:
   a. Whether you want to add another value (next highest concentration) to your data record ("Calibrate next assay") or

b. Whether you want to end the calibration and accept the data for adjustment ("Accept calibration data").

4. Determine all the desired measuring points as explained in Steps 2 and 3.
5. Completing the calibration and adjustment
   a. Once you have determined the last measuring point, accept the data. A message is displayed informing you whether the data record is valid.
   b. Select "OK" when you are asked to accept the calibration data for adjustment. The following message is then displayed:
      ⓘ The calibration is finished. Please clean sensor before immersing in process medium. (Hold will be reset)
   c. Follow the instructions and then press "OK".
   d. You are then asked whether you want to activate the data record just recorded. If you select "OK", the measured values are calculated on the basis of the new calibration function.
   e. You still have the possibility of editing the data record. Once you have activated the data record you can only change the set points. It is then no longer possible to delete measuring points.

You can cancel the calibration any time by pressing the "ESC" key. No data are then used to adjust the sensor.

8.3 Temperature adjustment

1. Determine the temperature of your process medium with an alternative measurement, e.g. a precision thermometer.
2. Go to the "CAL/<Sensor type>/Temperature adjustment" menu.
3. **Leave the sensor in the process medium** and keep clicking "OK" until temperature measurement is started via the sensor:
   Waiting for a stable meas. value..
4. Afterwards, you have the possibility of entering the reference temperature from the alternative measurement. You can either enter the absolute value or an offset for this purpose.
5. Once you have entered your data, click "OK" until the new data have been accepted. This completes temperature sensor adjustment.

8.4 Error messages when performing the calibration

Display message	Causes and possible remedial measures
The stability criterion is not fulfilled. Do you want to repeat the last step?	The measured value or temperature is not stable. As a result, the stability criterion is not met. ■ Keep the temperature constant during calibration ■ Sensor old or contaminated. Clean or regenerate. ■ Adjust stability criteria (Menu/Setup/Inputs<Sensor type>Calib. settings/Stability criteria)
The calibrated dataset is invalid. Do you want to restart the calibration?	Calibration point not plausible ■ Repeat the calibration ■ Exchange the calibration medium ■ Sensor fouled —> Clean
The calibration aborted. Please clean sensor before immersing in process medium. (Hold will be deactivated)	The user has aborted the calibration.

9 Nitrate sensors

Calibration is performed in the process by comparing the values to an external standard method. A sample of the process medium is taken and analyzed in the laboratory for nitrate.

- Processes with high nitrate values (> 0.1 mg/l)
  Take a sample and determine the nitrate concentration in the laboratory. Then calibrate and adjust the sensor with the laboratory value.
- Processes with very different nitrate values
  At time A, take a sample with a high concentration, and measure and calibrate the sample. At time B – which can be a few days after time A – take a sample with a low concentration, and measure and calibrate the second value.
- Calibration with the addition of standard
  If the sludge parameters tend to be constant, you can perform the calibration with a sample with a low concentration of nitrate and then add standard to the sample.
  Take a larger sample (bucket) and analyze some of it by colorimetric means. Calibrate this value in the sensor. Then add standard to the sample, determine the laboratory value and calibrate the value in the sensor.

Additional calibration points, recalibration
Points can be added to an existing calibration (max. 5 points per data record).
In this way, different media or concentrations can be included in the calibration at different times.

9.1 Types of calibration

In addition to the uneditable factory calibration, the sensor stores six other data records. Each calibration data record can have up to five calibration points.

- Single-point calibration
  This causes a change in the slope. This type of calibration is used if the measured value only changes to a limited extent.
- Two-point calibration
  This causes a change in the slope and zero point. This type of calibration is used if the measured value changes to a large extent.
- Multipoint calibration
  Calibration at three or more points always causes the measuring curve to be recalculated (zero point and slope).
- Temperature adjustment via reference value

Single-point and two-point calibration are based on the data record stored internally in the device.

9.2 Nitrate

9.2.1 Factory calibration

The sensor is precalibrated on leaving the factory. As such, it can be used in a wide range of clear water measurements without the need for additional calibration. The factory calibration is based on a three-point calibration of a reference sample.
The factory calibration cannot be deleted and can be retrieved at any time. All other calibrations – performed as customized calibrations – are referenced to this factory calibration.

9.2.2 Principle of calibration

The calibration is always based on a factory calibration saved.
If you use one or two medium concentration values for calibration, the factory data record is recalculated using these measuring points (non-linear function) and saved as the **new data record**. The original factory calibration is not lost.
If you use three or more concentration values for calibration, a completely new calibration function is calculated that no longer takes the original data record into account.

Give your calibration data records meaningful and useful names. For example, the name could contain the name of the application on which your data record was originally based. This makes it easier for you to distinguish between different data records.

9.2.3 Determining the reference values in the laboratory

1. Take a representative sample of the medium
   Outlet water is very suitable for obtaining a representative sample. In this case, you do not have to carry out the subsequent step concerning value stabilization.
2. Take suitable measures to ensure that the process of nitrate reduction in the sample does not progress any further, such as immediate filtration (0.45 µm) of the sample as per DIN 38402.
3. Determine the concentration of nitrate in the sample with the laboratory method (e.g. determining the concentration by colorimetric means using a cuvette test – standard method in accordance with DIN 38405 Part 9).

9.2.4 Calibration and adjustment of the sensor

1. To calibrate the sensor, use the same medium sample that you used to determine the laboratory measured value.
2. Depending on what type of calibration you wish to perform
   a. Calibrate the sensor with a measuring point and enter the laboratory measured value as the reference value.
   b. Add nitrate parent solution to the sample for the 2nd measuring point and determine the measured value. The reference value is calculated from the laboratory measured value plus the added concentration.
   c. Repeat Step b as often as needed until you have the desired number of calibration points (max. 5).

To avoid incorrect calibration from nitrate carryover:
- Always go from a low concentration to a high concentration.
- Clean and dry the sensor after each measurement.
- Make sure to remove medium residue in the sensor gap (e.g. by rinsing with the next calibration solution).

1. **Menu settings for the calibration**
   a. CAL/Nitrate/Assay
      Select a data record for your serial dilution.
   b. Dataset name
      Assign a name to the data record.
   c. Unit
      Decide which unit you want to use. Use the unit in which you also obtained the laboratory values.

2. First measuring point (lowest concentration)
   a. ⓘ Do you want to start the calibration? (Hold turns to active)
   b. Select "OK" by way of confirmation.
   c. Follow the instructions on the display:
      ⓘ Please clean sensor before immersing in calibration medium.
   d. Once a stable measured value has been determined, you will be asked for the set point (=laboratory value) of the sample. Enter this set point.

3. Decide:
   a. Whether you want to add another value (next highest concentration) to your data record ("Calibrate next assay") or
   b. Whether you want to end the calibration and accept the data for adjustment ("Accept calibration data").

4. Determine all the desired measuring points as explained in Steps 2 and 3.
5. Completing the calibration and adjustment
   a. Once you have determined the last measuring point, accept the data. A message is displayed informing you whether the data record is valid.
   b. Select "OK" when you are asked to accept the calibration data for adjustment. The following message is then displayed:
      ⓘ The calibration is finished. Please clean sensor before immersing in process medium. (Hold will be reset)
   c. Follow the instructions and then press "OK".
   d. You are then asked whether you want to activate the data record just recorded. If you select "OK", the measured values are calculated on the basis of the new calibration function.
   e. You still have the possibility of editing the data record. Once you have activated the data record you can only change the set points. It is then no longer possible to delete measuring points.

You can cancel the calibration any time by pressing the "ESC" key. No data are then used to adjust the sensor.

9.3 Temperature adjustment

1. Determine the temperature of your process medium with an alternative measurement, e.g. a precision thermometer.
2. Go to the "CAL/<Sensor type>/Temperature adjustment" menu.
3. **Leave the sensor in the process medium** and keep clicking "OK" until temperature measurement is started via the sensor:
   Waiting for a stable meas. value..
4. Afterwards, you have the possibility of entering the reference temperature from the alternative measurement. You can either enter the absolute value or an offset for this purpose.
5. Once you have entered your data, click "OK" until the new data have been accepted. This completes temperature sensor adjustment.

9.4 Error messages when performing the calibration

Display message	Causes and possible remedial measures
The stability criterion is not fulfilled. Do you want to repeat the last step?	The measured value or temperature is not stable. As a result, the stability criterion is not met. ■ Keep the temperature constant during calibration ■ Sensor old or contaminated. Clean or regenerate. ■ Adjust stability criteria (Menu/Setup/Inputs<Sensor type>Calib. settings/Stability criteria)
The calibrated dataset is invalid. Do you want to restart the calibration?	Calibration point not plausible ■ Repeat the calibration ■ Exchange the calibration medium ■ Sensor fouled —> Clean
The calibration aborted. Please clean sensor before immersing in process medium. (Hold will be deactivated)	The user has aborted the calibration.

10 Calibration accessories

10.1 pH calibration buffer

Quality buffers from Endress+Hauser
Solutions which are traced by a DKD-accredited laboratory (DKD = German Calibration Service) to a primary reference material of the PTB and to standard reference material of the National Institute of Standards and Technology (NIST) in accordance with DIN 19266 are used as secondary reference buffer solutions.

	pH value				
	A	pH 2.00 (accuracy ± 0.02 pH)			
	C	pH 4.00 (accuracy ± 0.02 pH)			
	E	pH 7.00 (accuracy ± 0.02 pH)			
	G	pH 9.00 (accuracy ± 0.02 pH)			
	I	pH 9.20 (accuracy ± 0.02 pH)			
	K	pH 10.00 (accuracy ± 0.05 pH)			
	M	pH 12.00 (accuracy ± 0.05 pH)			
		Quantity			
		01	20 x 18 ml (0.68 fl.oz) only buffer pH 4.00 and 7.00		
		02	250 ml (8.45 fl.oz)		
		10	1000 ml (0.26 US gal)		
		50	5000 ml (1.32 US gal) canister for Topcal S		
			Certificate		
			A	Buffer analysis certificate	
				Version	
				1	Standard
CPY20-					Complete order code

10.2 ORP buffer

Technical ORP buffer solutions
- +220 mV, pH 7, 100 ml (3.4 fl.oz.); Order No. CPY3-0
- +468 mV, pH 0.1, 100 ml (3.4 fl.oz.); Order No. CPY3-1

10.3 Conductivity

Calibration solutions
Precision solutions referenced to the NIST standard reference material (SRM) for the qualified calibration of conductivity measuring systems as per ISO, accuracy ± 0.5 %, with temperature table,

- CLY 11-A
  74.0 µS/cm (reference temperature 25 °C), 500 ml
  Order No. 50081902
- CLY 11-B
  149.6 µS/cm (reference temperature 25 °C), 500 ml
  Order No. 50081903
- CLY 11-C
  1.406 mS/cm (reference temperature 25 °C), 500 ml
  Order No. 50081904
- CLY 11-D
  12.64 mS/cm (reference temperature 25 °C), 500 ml
  Order No. 50081905
- CLY 11-E
  107.00 mS/cm (reference temperature 25 °C), 500 ml
  Order No. 50081906

10.4 Oxygen

10.4.1 Zero solution

- 3 screw-cap bottles for producing 3 x 1 liter oxygen-free solution
- Order No. 50001041

10.4.2 Calibration vessel

Calibration vessel
- for COS61/61D
- Order No.: 51518599

10.5 Nitrate

Nitrate standard solutions, 1 liter
- Standard 5 mg/l NO_3 - N; Order No. CAY342-V10C05AAE
- Standard 10 mg/l NO_3 - N; Order No. CAY342-V10C10AAE
- Standard 15 mg/l NO_3 - N; Order No. CAY342-V10C15AAE
- Standard 20 mg/l NO_3 - N; Order No. CAY342-V10C20AAE
- Standard 30 mg/l NO_3 - N; Order No. CAY342-V10C30AAE
- Standard 40 mg/l NO_3 - N; Order No. CAY342-V10C40AAE
- Standard 50 mg/l NO_3 - N; Order No. CAY342-V10C50AAE

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