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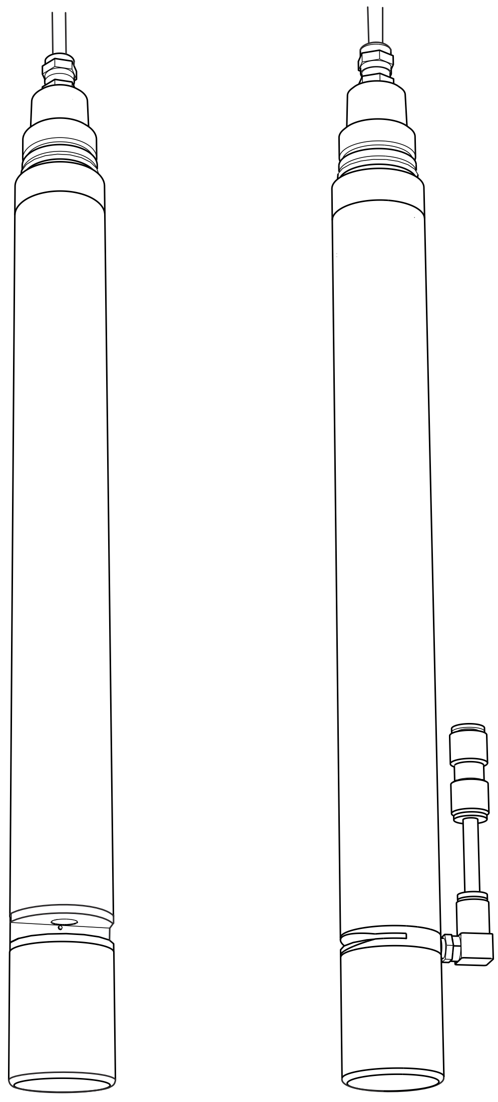
2020-11-30

Operating Instructions
Viomax CAS51D

Photometric sensor for SAC or nitrate measurement



Endress+Hauser
People for Process Automation

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1 About this document

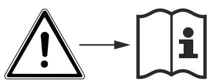
1.1 Warnings

Structure of information	Meaning
⚠ DANGER **Causes (/consequences)** If necessary, Consequences of non-compliance (if applicable) ▶ Corrective action	This symbol alerts you to a dangerous situation. Failure to avoid the dangerous situation **will** result in a fatal or serious injury.
⚠ WARNING **Causes (/consequences)** If necessary, Consequences of non-compliance (if applicable) ▶ Corrective action	This symbol alerts you to a dangerous situation. Failure to avoid the dangerous situation **can** result in a fatal or serious injury.
⚠ CAUTION **Causes (/consequences)** If necessary, Consequences of non-compliance (if applicable) ▶ Corrective action	This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or more serious injuries.
NOTICE **Cause/situation** If necessary, Consequences of non-compliance (if applicable) ▶ Action/note	This symbol alerts you to situations which may result in damage to property.

1.2 Symbols used

Symbol	Meaning
	Additional information, tips
	Permitted or recommended
	Not permitted or not recommended
	Reference to device documentation
	Reference to page
	Reference to graphic
↳	Result of a step

1.3 Symbols on the device

Symbol	Meaning
	Reference to device documentation

2 Basic safety instructions

2.1 Requirements for the personnel

- Installation, commissioning, operation and maintenance of the measuring system may be carried out only by specially trained technical personnel.
- The technical personnel must be authorized by the plant operator to carry out the specified activities.
- The electrical connection may be performed only by an electrical technician.
- The technical personnel must have read and understood these Operating Instructions and must follow the instructions contained therein.
- Faults at the measuring point may only be rectified by authorized and specially trained personnel.

Repairs not described in the Operating Instructions provided must be carried out only directly at the manufacturer's site or by the service organization.

2.2 Designated use

CAS51D is a photometric sensor for SAC or nitrate measurement in liquid media.

The sensor is particularly suited for use in the following applications:
- Monitoring and regulating water treatment plants
- Monitoring surface waters

SAC measurement
- Organic load in WWTP inlet
- Organic load WWTP outlet
- Discharger monitoring
- Organic load in drinking water

Nitrate measurement
- Nitrate measurement in natural bodies of water
- Monitoring nitrate content in WWTP outlet
- Monitoring nitrate content in aeration basins
- Monitoring and optimizing denitrification phases

Use of the device for any purpose other than that described, poses a threat to the safety of people and of the entire measuring system and is therefore not permitted.

The manufacturer is not liable for damage caused by improper or non-designated use.

2.3 Workplace safety

CAUTION

UV light

UV light can damage the eyes and skin!
- ▶ Never look into the measuring gap while the device is in operation.

As the user, you are responsible for complying with the following safety conditions:
- Installation guidelines
- Local standards and regulations

Electromagnetic compatibility
- The product has been tested for electromagnetic compatibility in accordance with the applicable international standards for industrial applications.
- The electromagnetic compatibility indicated applies only to a product that has been connected in accordance with these Operating Instructions.

2.4 Operational safety

Before commissioning the entire measuring point:

1. Verify that all connections are correct.
2. Ensure that electrical cables and hose connections are undamaged.
3. Do not operate damaged products, and protect them against unintentional operation.
4. Label damaged products as defective.

During operation:

- If faults cannot be rectified:
  products must be taken out of service and protected against unintentional operation.

2.5 Product safety

The product is designed to meet state-of-the-art safety requirements, has been tested, and left the factory in a condition in which it is safe to operate. The relevant regulations and international standards have been observed.

3 Product description

3.1 Product design

The sensor has a diameter of 40 mm and can be operated directly and completely in the process without the need for further sampling (in situ). One version of the sensor measures the amount of nitrate in the medium while another version measures the SAC value of the medium.

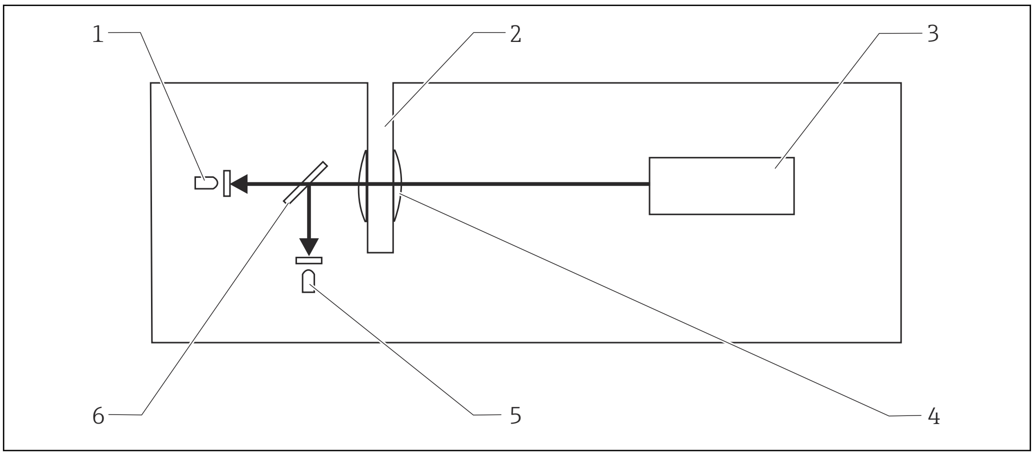
The sensor comprises the following assemblies:
- Power supply
- High-voltage generation for the strobe lamp,
- Cuvette
  Central component in which the measuring light interacts with the medium.
- Receiver assembly
  Detect the measuring signals, digitize them and process them to form a measured value.
- Controller
  Responsible for controlling internal sensor processes and transmitting data.

All data - including the calibration data - are stored in the sensor. The sensor can be precalibrated and used at a measuring point, calibrated externally, or used for several measuring points with different calibrations.

3.2 Operating principle

3.2.1 Measuring principle

The light from a pulsed, high-stability strobe lamp (item 3) passes through the measuring path [1] (item 2). A beam splitter (item 6) directs the light beam to the two receivers (items 1 and 5). A filter upstream from the receivers only lets through light in the measuring wavelength or reference wavelength.



1 Measuring principle of nitrate sensor

1 *Measuring receiver with filter*
2 *Cuvette gap*
3 *Strobe lamp*
4 *Lens*
5 *Reference receiver with filter*
6 *Beam splitter*

Within the measuring path, the medium in the cuvette (water, dissolved substances and particles) absorbs light across the entire spectrum. In the measuring wavelength range, the measured component [2] takes an additional amount of energy from the light.

For the calculation of the measured value, the ratio of the light signal of the measuring wavelength to the light signal of the reference wavelength is calculated in order to minimize the effect of turbidity and lamp aging.

This change in the ratio can be converted to determine the nitrate concentration or the SAC value. This dependency is non-linear.

Conclusion:
- Long measuring paths are required for low concentrations of the measured component. For clear water measurements, this is achieved with the 8 mm cuvette for nitrate measurement and the 40 mm cuvette for SAC measurement.
- For high turbidity values, longer measuring paths result in the total absorption of light - the measured values are no longer valid.
  The nitrate sensor with the 2 mm cuvette is recommended for media with high turbidity values (activated sludge application).
  The SAC sensor with the 2 mm cuvette is ideal for measuring the organic load in the inlet of municipal wastewater treatment plants.

1) Measuring path = open path through cuvette
2) Nitrate or substances that contribute to the spectral absorption coefficient (SAC)

3.2.2 Nitrate measurement

The sensor is designed for measuring nitrate. As nitrite is also measured, it could also be regarded as an NO_x sensor.

Nitrate ions absorb UV light in the range of approx. 190 to 230 nm. Nitrite ions have a similar absorption rate in the same range.

The sensor measures the light intensity of the 214 nm wavelength (measuring channel). At this wavelength, nitrate and nitrite ions absorb light in proportion to their concentration, while the light intensity in the reference channel remains virtually unchanged at 254 nm.

Interference factors, such as turbidity, fouling or organic hydrocarbons, are minimized.

The signal ratio between the reference wavelength and measurement wavelength constitutes the measurement result. This ratio is converted to the concentration of nitrate using the calibration curve programmed into the sensor.

3.2.3 Cross-interference when measuring with the nitrate version

The following have a direct impact on the measuring range:
- Total solids (TS) and turbidity
- Sludge properties
- Nitrite

Trends:
- A higher proportion of TS or greater turbidity reduces the upper end of the measuring range, resulting in a smaller measuring range.
- High COD [3)] levels reduce the upper end of the measuring range, resulting in a smaller measuring range.
- Nitrite is measured as nitrate, thus resulting in a higher measured value.

The following can be deduced from the interdependencies cited above:
- Sludge floc causes scattering in the medium, resulting in the attenuation of both the measuring and reference signal to varying degrees. This in turn can bring about a change in the nitrate value due to turbidity.
- High concentrations of oxidizable substances [4)] in the medium may result in an increase in the measured value.
- Nitrite absorbs light in a similar wavelength range to nitrate and is measured along with nitrate. The dependency is constant: 1.0 mg/l nitrite is displayed as 0.8 mg/l nitrate.
- An adjustment to the customer process is always worthwhile.

3.2.4 SAC measurement

Many organic substances absorb light in the range of 254 nm. In the SAC sensor, absorption on the measuring wavelength (254 nm) is compared with the largely unaffected reference measurement at 550 nm.

KHP (potassium hydrogen phthalate $C_8H_5KO_4$) is the established organic reference in SAC measurement operations. That is why the sensor is calibrated in the factory using KHP.

The SAC value can be regarded as a trend indicator of the organic load in a medium. For this purpose, it is converted to COD, TOC, BOD and DOC [5)] using predefined, adjustable factors:
c (TOC) = 0.4705 * c (KHP)
c (COD) = 1.176 * c (KHP)
c (BOD) = 1.176 * c (KHP)
c (DOC) = 0.4705 * c (KHP)

3) COD = Chemical Oxygen Demand
4) Specified as COD. Corresponds to the quantity of oxygen that would be required to oxidize the substances if oxygen were the oxidizing agent.
5) Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), Biochemical Oxygen Demand (BOD), Dissolved Organic Carbon (DOC)

The ratio to SAC (based on KHP) is calculated as follows:
1/m = 1.487 mg/l COD = 1.487 mg/l BOD = 0.595 mg/l TOC = 0.595 mg/l DOC

Many components that absorb light at 254 nm deviate significantly from KHP in terms of their absorption behavior. For this reason, an adjustment to the customer process is worthwhile.

3.2.5 Cross-interference when measuring with the SAC version

The following have a direct impact on the measuring range:
- Turbidity
- Color

Trends:
- Oxidizable substances, absorbing at 550 nm, corrupt the measurement result. In instances of this nature, a comparison or calibration is necessary.
- Coloration that absorbs in the green spectral range increases the measured value.
- Oxidizable substances with spectral properties that differ to those of KHP (potassium hydrogen phthalate) provide measurement results that can deviate from the factory calibration. In instances of this nature, a comparison or adjustment is necessary.
- A higher proportion of TS or greater turbidity reduces the upper end of the measuring range, resulting in a smaller measuring range.
- Sludge floc causes scattering in the medium, resulting in the attenuation of both the measuring and reference signal to varying degrees. This in turn can bring about a change in the measured value due to turbidity.

4 Incoming acceptance and product identification

4.1 Incoming acceptance

1. Verify that the packaging is undamaged.
   ↳ Notify the supplier of any damage to the packaging.
   Keep the damaged packaging until the issue has been resolved.
2. Verify that the contents are undamaged.
   ↳ Notify the supplier of any damage to the delivery contents.
   Keep the damaged goods until the issue has been resolved.
3. Check that the delivery is complete and nothing is missing.
   ↳ Compare the shipping documents with your order.
4. Pack the product for storage and transportation in such a way that it is protected against impact and moisture.
   ↳ The original packaging offers the best protection.
   Make sure to comply with the permitted ambient conditions.

If you have any questions, please contact your supplier or your local Sales Center.

4.2 Product identification

4.2.1 Nameplate

The nameplate provides you with the following information on your device:
- Manufacturer identification
- Extended order code
- Serial number
- Safety information and warnings

▶ Compare the information on the nameplate with the order.

4.2.2 Product identification

Product page

www.endress.com/cas51d

Interpreting the order code

The order code and serial number of your product can be found in the following locations:
- On the nameplate
- In the delivery papers

Obtaining information on the product

1. Go to www.endress.com.
2. Call up the site search (magnifying glass).
3. Enter a valid serial number.
4. Search.
   ↳ The product structure is displayed in a popup window.

5. Click on the product image in the popup window.
   ↳ A new window (**Device Viewer**) opens. All of the information relating to your device is displayed in this window as well as the product documentation.

Manufacturer's address

Endress+Hauser Conducta GmbH+Co. KG
Dieselstraße 24
D-70839 Gerlingen

4.3 Scope of delivery

The delivery comprises:
- Sensor in the version ordered
- Operating Instructions

4.4 Certificates and approvals

4.4.1 CE mark

The product meets the requirements of the harmonized European standards. As such, it complies with the legal specifications of the EU directives. The manufacturer confirms successful testing of the product by affixing to it the CE mark.

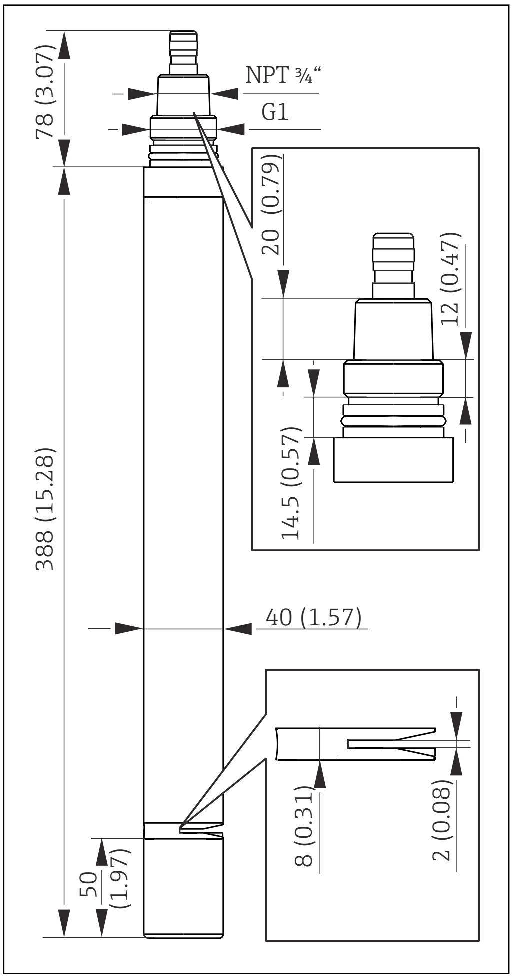
4.4.2 EAC

The product has been certified according to guidelines TP TC 004/2011 and TP TC 020/2011 which apply in the European Economic Area (EEA). The EAC conformity mark is affixed to the product.

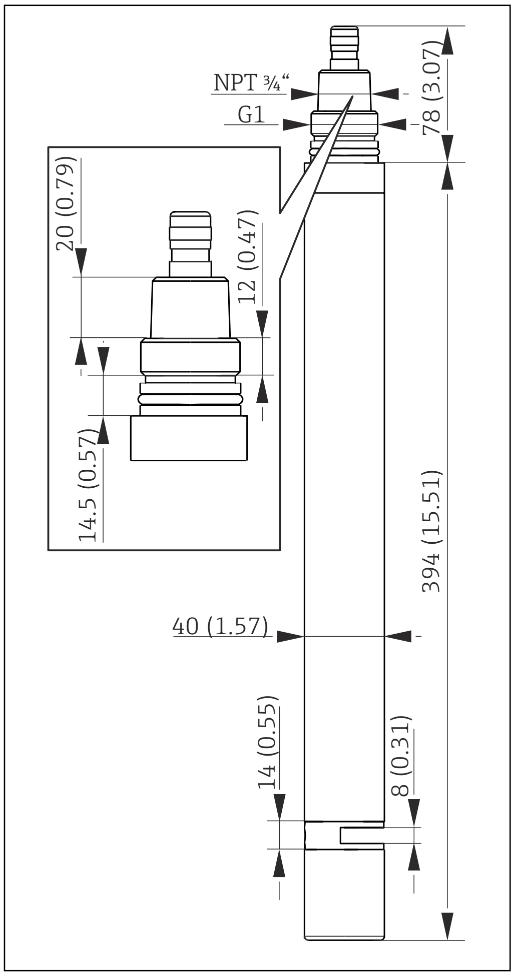
5 Mounting

5.1 Installation conditions

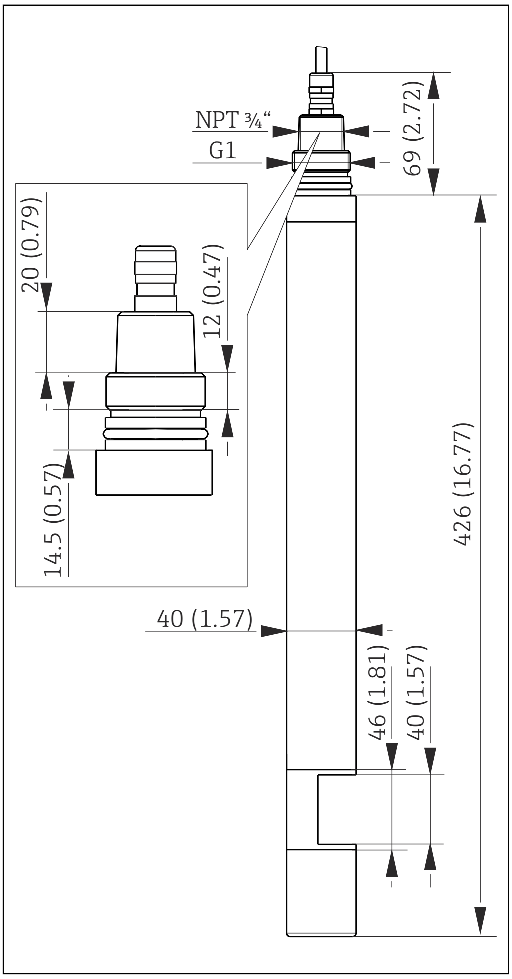
5.1.1 Dimensions



2 *Sensor with 2 mm gap width, dimensions in mm (inch)*



3 *Sensor with 8 mm gap width, dimensions in mm (inch)*

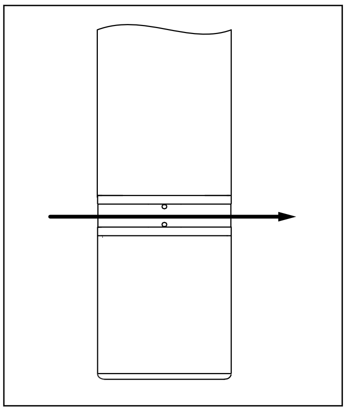


4 *Sensor with 40 mm gap width, dimensions in mm (inch)*

5.1.2 Mounting location

- Choose a mounting location that can be easily accessed at a later stage.
- Ensure that upright posts and assemblies are fully secured and vibration-free.
- Select an installation location that produces a typical nitrate concentration / a typical SAC value for the application in question.
- Do not install the sensor above aeration discs. Oxygen bubbles may accumulate at the cuvette gap and distort the measured value.

5.1.3 Orientation



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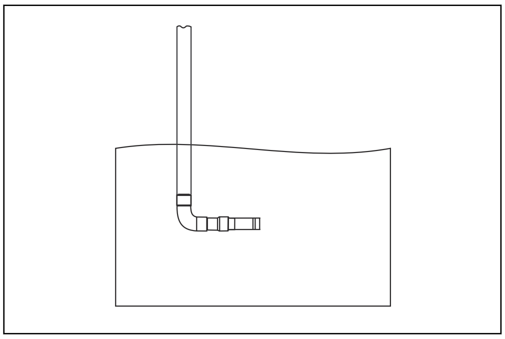
5 *Sensor orientation, arrow = direction of flow*

- Align the sensor in such a way that the cuvette gap is rinsed with the flow of medium and air bubbles are removed.

Flexdip CYA112 wastewater assembly and Flexdip CYH112 holder



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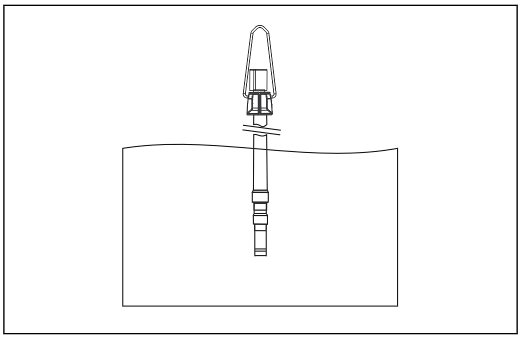
6 *Horizontal, fixed installation*

The installation angle is 90°.

- Align the sensor in such a way that the cuvette gap is rinsed with the flow of medium and air bubbles are removed.



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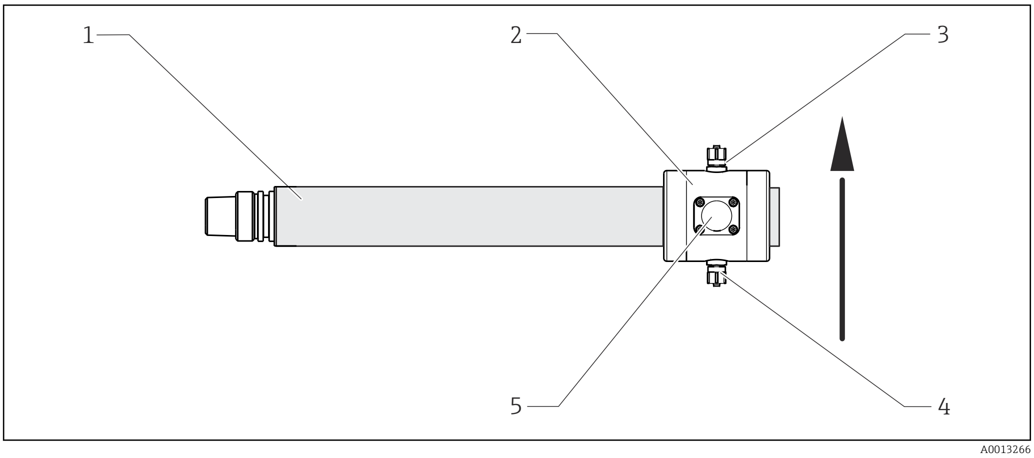
7 *Suspended vertically from a chain*

The installation angle is 0°. Tried and tested arrangement for operation in aerated zones.

- Ensure that the sensor is adequately cleaned. There must be no buildup on the optical windows.

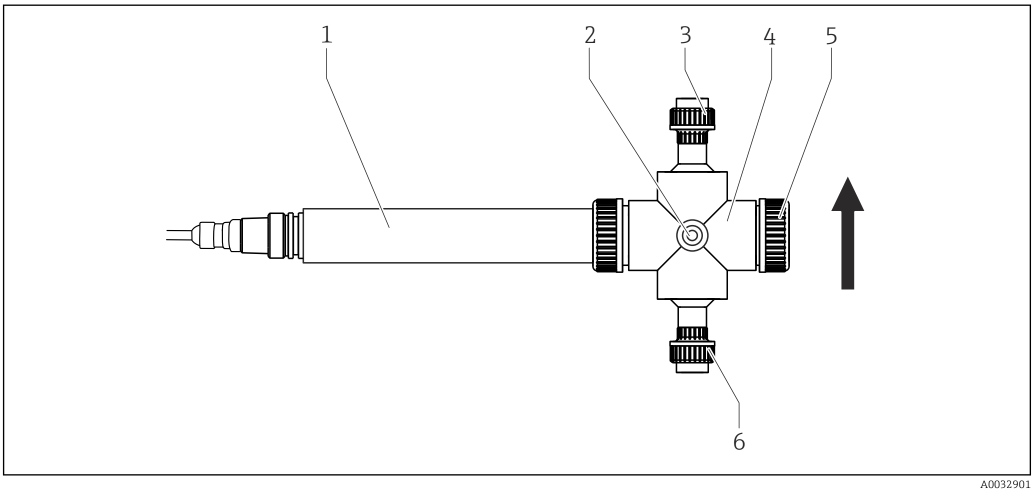
Flow assembly CAS51D 2-40 mm for small sample volumes



8 Horizontally, in flow assembly, arrow points in the direction of flow

1 *Sensor*
2 *Flow assembly*
3 *Medium outlet*
4 *Medium inflow*
5 *Window, required for aligning the sensor*

Flowfit CYA251 flow assembly



9 Horizontally, in flow assembly CYA251, arrow points in the direction of flow

1 *Sensor*
2 *Medium outlet*
3 *Cap*
4 *Flow assembly*
5 *Medium inflow*
6 *Rinse connection*

5.2 Mounting the sensor

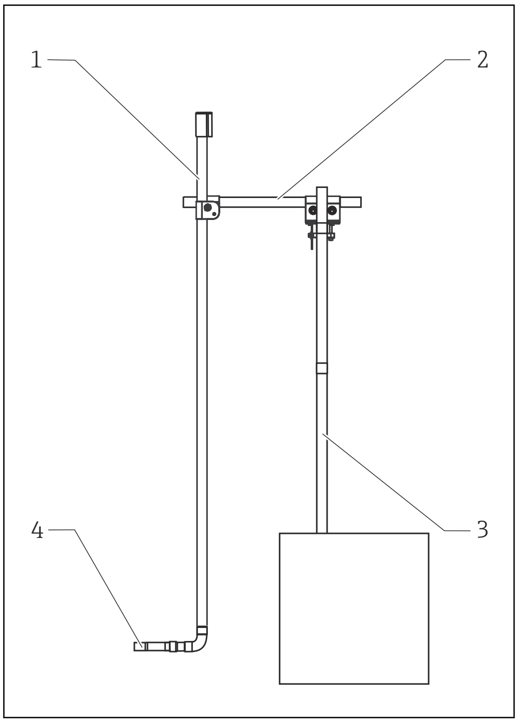
5.2.1 Installation instructions

To ensure correct measurement, the windows in the cuvette must be free from any sedimentation. The best way to ensure this is through the use of a cleaning unit (accessory) operated by compressed air.

▶ For horizontal orientations:
Mount the sensor in such a way that air bubbles can escape from the cuvette slot (do not point it downwards).

5.2.2 Immersion operation

Fixed installation with wastewater assembly



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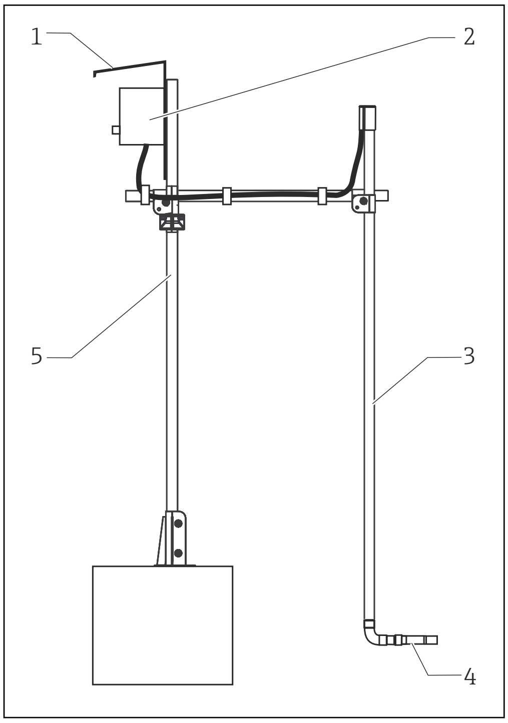
10 Installation secured on railing

1 *Wastewater assembly Flexdip CYA112*
2 *Flexdip CYH112 holder*
3 *Rail*
4 *Viomax CAS51D*



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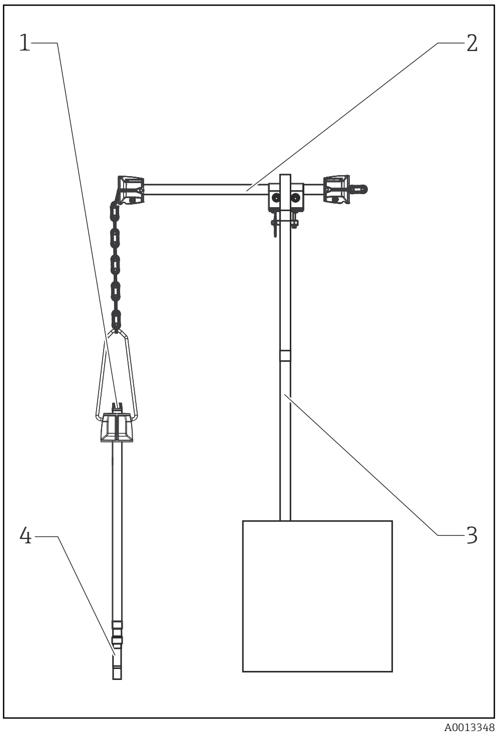
11 Installation with upright post

1 *Protective cover*
2 *Liquiline CM44x multi-channel transmitter*
3 *Wastewater assembly Flexdip CYA112*
4 *Viomax CAS51D*
5 *Flexdip CYH112 holder*

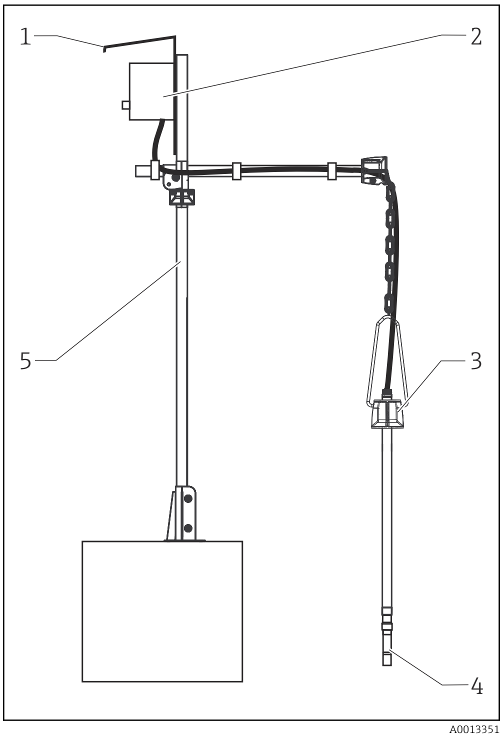
This type of installation is particularly suitable for strong or turbulent medium flow (>0.5 m/s (1.6 ft/s)) in basins or channels. A cleaning unit (accessory) operated by compressed air significantly extends the maintenance intervals for the sensor.

Installation with chain retainer



12 *Chain retainer on railing*

1 Wastewater assembly Flexdip CYA112
2 Flexdip CYH112 holder
3 Rail
4 Viomax CAS51D



13 *Chain retainer on upright post*

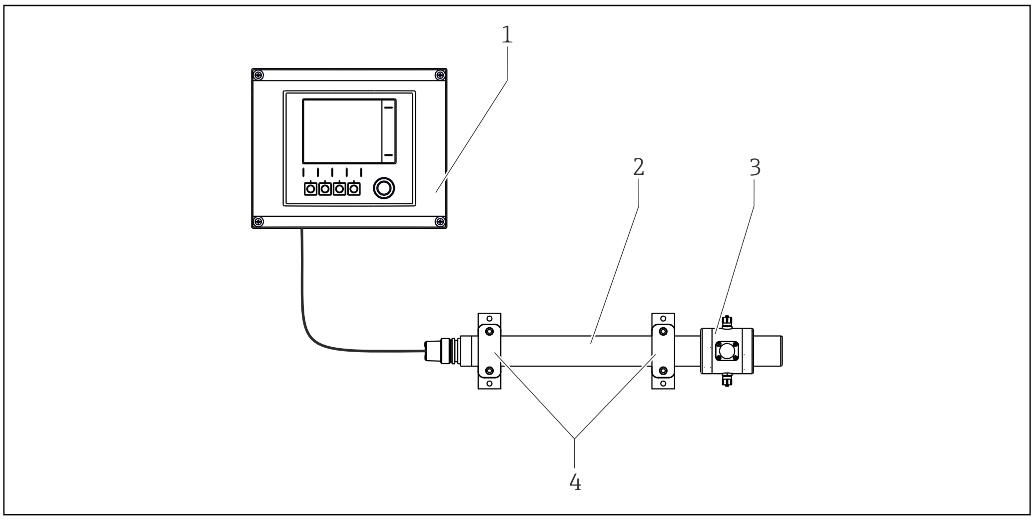
1 Protective cover
2 Liquiline CM44x multi-channel transmitter
3 Wastewater assembly Flexdip CYA112
4 Viomax CAS51D
5 Flexdip CYH112 holder

The chain retainer is particularly suitable for applications that require a sufficient distance between the mounting location and the edge of the aeration basin. As the assembly is freely suspended, any vibration of the upright post is practically ruled out.

The swinging movement of the chain retainer enhances the self-cleaning effect of the optics. A cleaning unit (accessory) operated by compressed air significantly extends the maintenance intervals for the sensor.

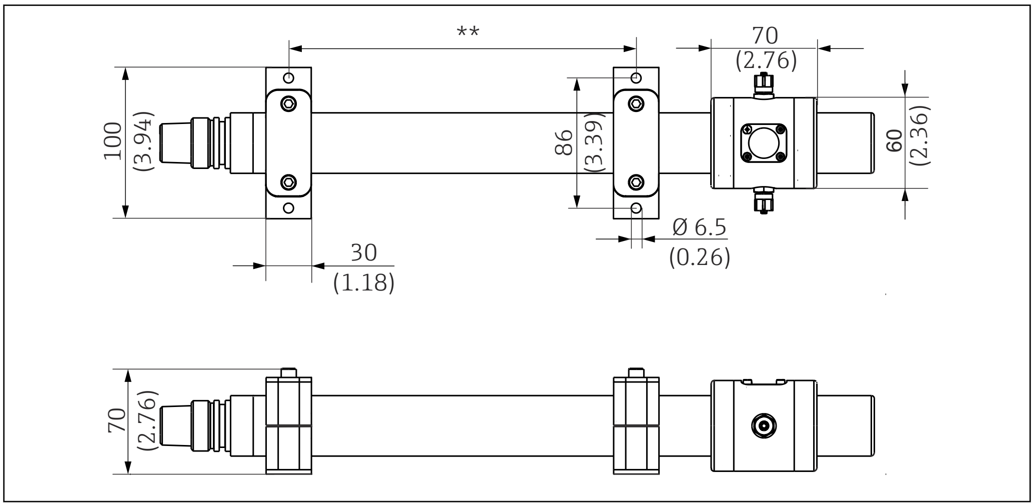
5.2.3 Flow operation

Flow assembly for clear water and small sample volumes



14 *Sensor with flow assembly*

1 *Transmitter*
2 *Sensor*
3 *Flow assembly*
4 *Sensor holder*



15 *Dimensions. Engineering unit: mm (in)*

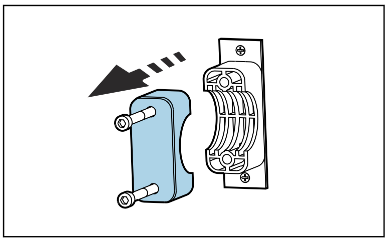
** *Variable length*

Securing the sensor holder

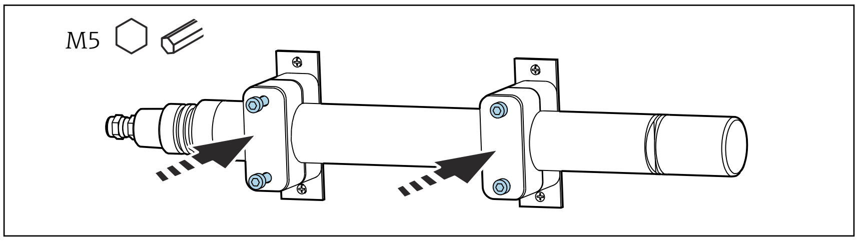
Mount the sensor in a horizontal position as follows:

1. Drill holes for the mounting clamps into a wall or panel. In doing so, comply with the dimensions indicated on → 15, 18 .
2. Secure the mounting clamps.

The required fastening fixtures (e.g. screws and wall plugs) are not included in the scope of delivery of the kit and must be provided by the customer.

3. 

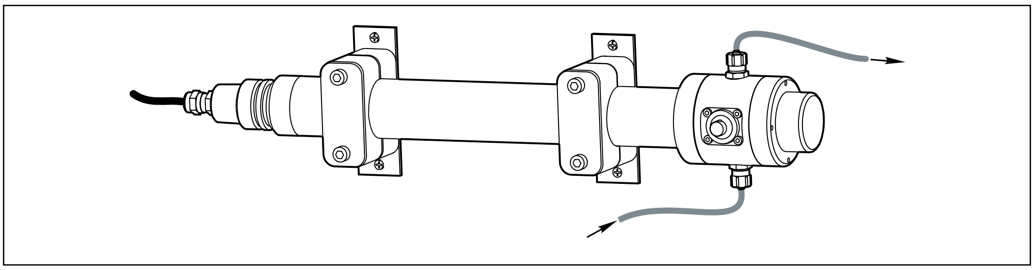
Loosen the hexagonal nuts of the pipe clamps.

4. Remove the top part.
5. 

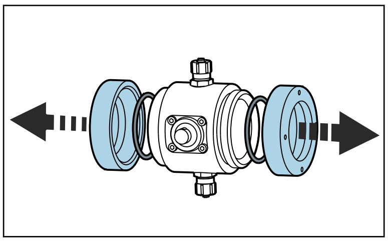
Place the sensor in the pipe clamps.

6. Screw on the top parts and tighten by hand (it should still be possible to move the sensor).

Mounting the flow assembly



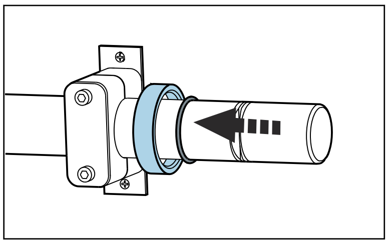
16 *Flow assembly mounted on the sensor*

1. 

Loosen the threaded rings of the flow assembly.

2. Remove 2 O-rings.
3. Check if the silicone grease provided with the kit is permitted for use in your application. If it is not permitted for this application, use a grease that suits the application instead.
Grease the O-rings.

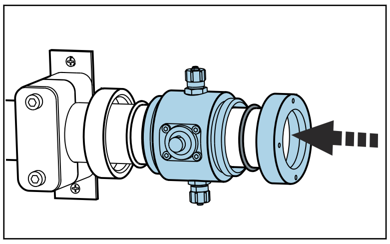
4.



Fit a threaded ring (thread in the direction of the assembly) onto the sensor.

5. Fit an O-ring onto the sensor.

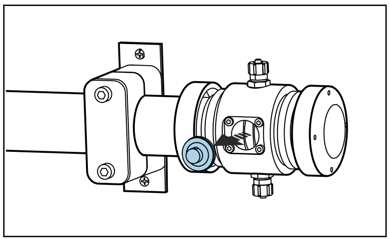
6.



Fit the assembly onto the sensor.

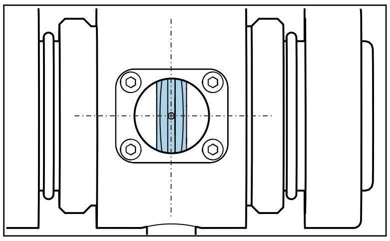
7. Fit the second O-ring and the second threaded ring onto the sensor.

8.



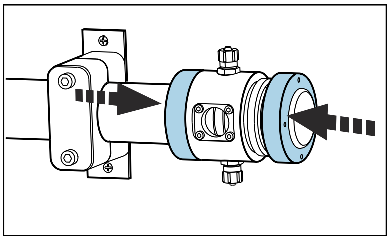
Open the cap on the viewing window.

9.

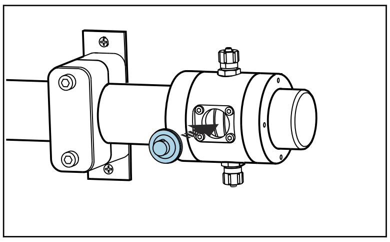


Position the assembly on the sensor in such a way that the measurement gap is visible in the center of the window.

10.

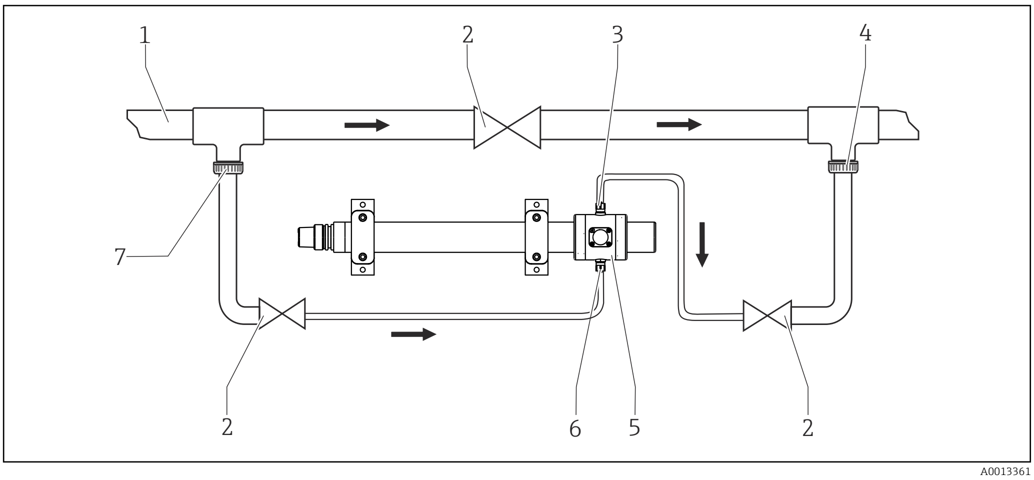


Tighten the two threaded rings. Ensure that the assembly does not change position.

11. 

Close the viewing window with the cap.
↳ To guard against loss:

12. To secure the viewing window, fasten the viewing window to one of the hose connections (no diagram) using the transparent cord.



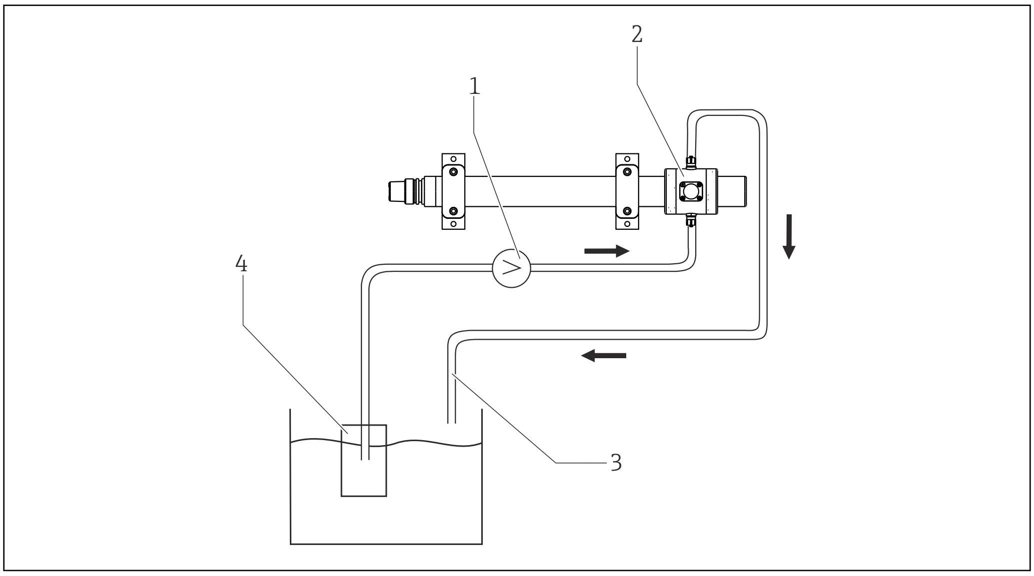
17 Connection diagram with bypass

1 *Main pipe*
2 *Manually actuated or solenoid valves*
3 *Medium outlet*
4 *Medium return*
5 *Flow assembly*
6 *Medium inflow*
7 *Medium sampling*

Mounting the assembly in the bypass

▶ Connect the medium inflow and outlet to the hose connections of the assembly → 17, 21.
↳ This fills the assembly from below and ensures that the assembly is self-venting.

- The flow rate must be at least 100 ml/h (0.026 gal/h).
- Take the extended response times into consideration.



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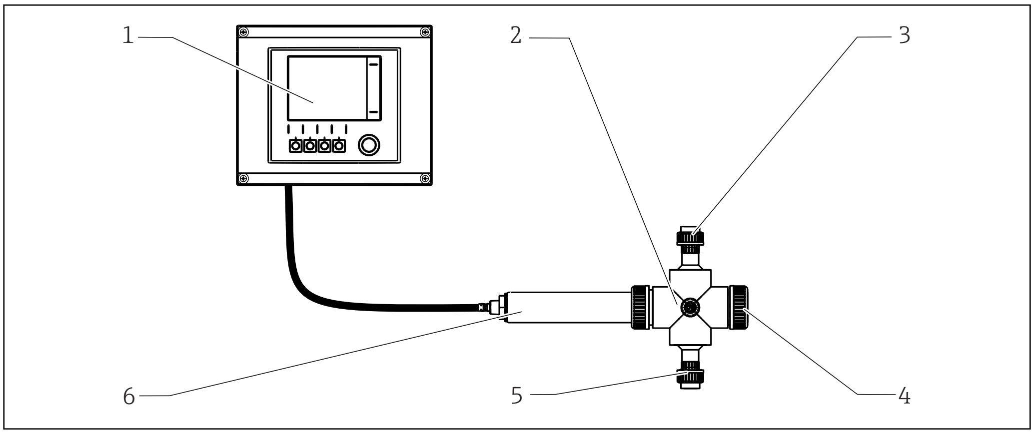
18 *Connection diagram with open outlet, arrow points in the flow direction*

1 *Pump*
2 *Flow assembly*
3 *Open outlet*
4 *Filter unit*

As an alternative to operation in the bypass, it is also possible to direct the sample flow from a filter unit with an open outlet through the assembly → 18, 22.

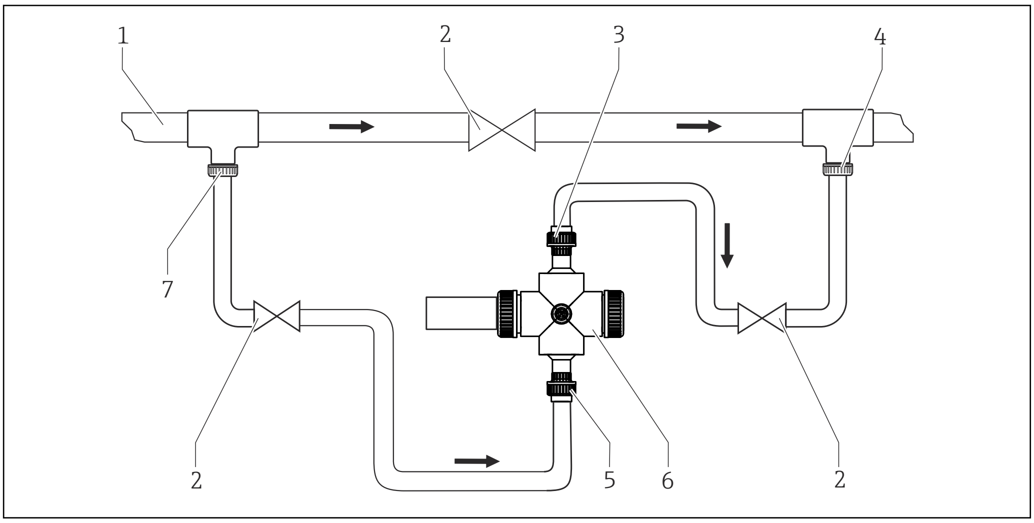
Flow assembly Flowfit CYA251



A0032917

19 *Measuring system with CYA251*

1 *Transmitter*
2 *Flow assembly*
3 *Medium outlet*
4 *Cap*
5 *Medium inflow*
6 *Viomax CAS51D*



A0032920

20 *Connection diagram*

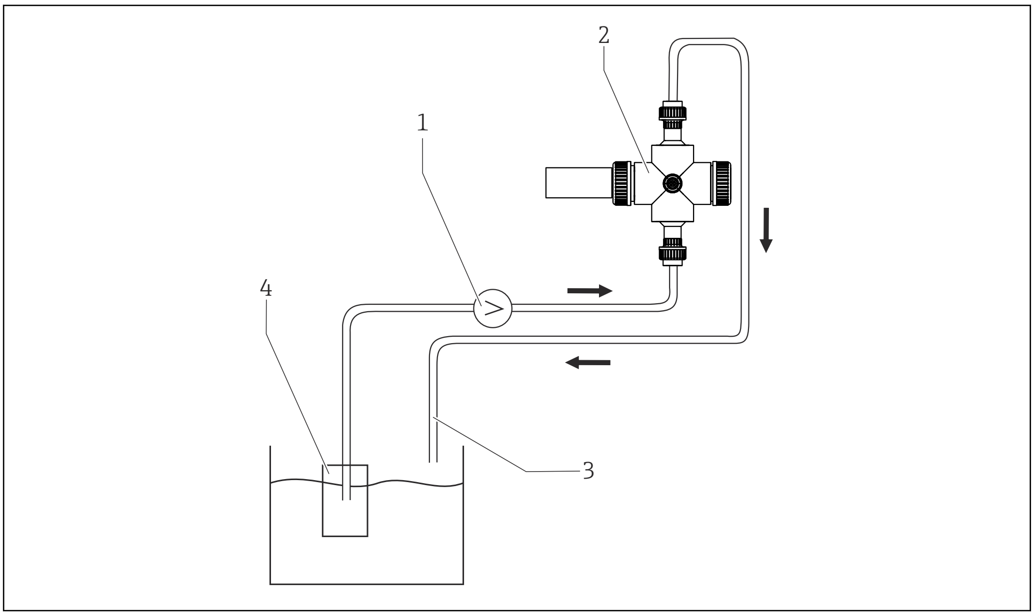
1	*Main pipe*	*5*	*Medium inflow*
2	*Manually actuated or solenoid valves*	*6*	*Flow assembly*
3	*Medium outlet*	*7*	*Medium sampling*
4	*Medium return*		

Mount the sensor in the assembly in accordance with the Operating Instructions (BA00495C).

There must be a minimum flow rate of 100 ml/h (0.026 gal/h).

▶ Take increased response times into account.

As an alternative to bypass operation, direct the sample flow from a filter unit with an open outlet through the assembly:



A0032921

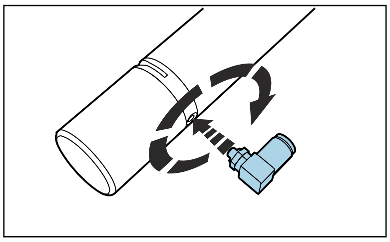
21 *Flow assembly with open outlet*

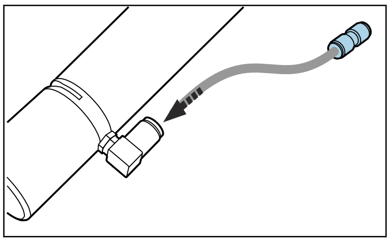
1 Pump
2 Assembly
3 Open outlet
3 Filter unit

5.3 Mounting the cleaning unit

Sensors with gap width of 2 mm or 8 mm

Mount the compressed air cleaning unit before the sensor is installed in the measuring point. Alternatively, remove the sensor from the medium.

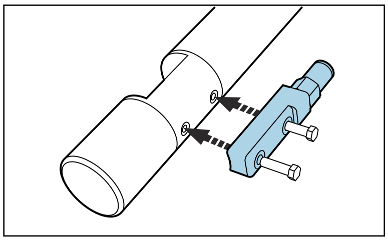
1. Clean the sensor if necessary.
2. 

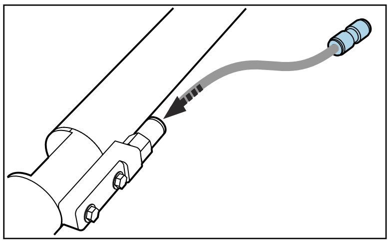
   Screw the elbow plug from the accessory kit into the mounting hole behind the sensor gap, and tighten by hand as far as it will go.
3. 

   Connect the compressed air supply at the installation location. Use the hose piece with hose coupling provided with the sensor if desired.

SAC sensors with a gap width of 40 mm

Mount the compressed air cleaning unit before the sensor is installed in the measuring point. Alternatively, remove the sensor from the medium.

1. Clean the sensor if necessary.
2. 

   Screw the air diffuser from the accessory kit into the mounting holes behind the sensor gap, and tighten by hand as far as it will go.
3. 

   Connect the compressed air supply at the installation location. Use the hose piece with hose coupling provided with the sensor if desired.

5.4 Post-installation check

Put the sensor into operation only if you can answer "yes" to the following questions:

- Are the sensor and cable undamaged?
- Is the orientation correct?
- Is the sensor installed in an assembly and not freely suspended from the cable?
- Is the cable routed so that it is completely dry (routed inside an assembly if necessary)?

6 Electrical connection

⚠ WARNING

Device is live!

Incorrect connection may result in injury or death!

- The electrical connection may be performed only by an electrical technician.
- The electrical technician must have read and understood these Operating Instructions and must follow the instructions contained therein.
- **Prior** to commencing connection work, ensure that no voltage is present on any cable.

6.1 Connecting to the transmitter

6.1.1 Connecting the cable shield to the grounding rail of the transmitter

⚠ WARNING

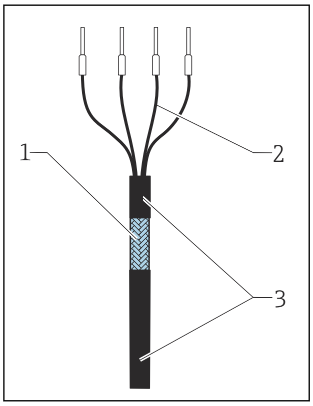
Sensor not grounded

If maintenance work (lamp replacement) is not performed correctly, moisture or dirt may penetrate the housing and cause an electric shock to anyone who touches it.

- To guarantee safety in the workplace, always connect the sensor's cable shield to the grounding rail of the transmitter or control cabinet.

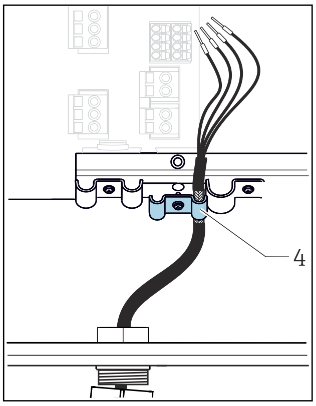
Only use terminated original cables where possible. The sensor cables must be shielded cables.

Sample cable (does not necessarily correspond to the original cable supplied)



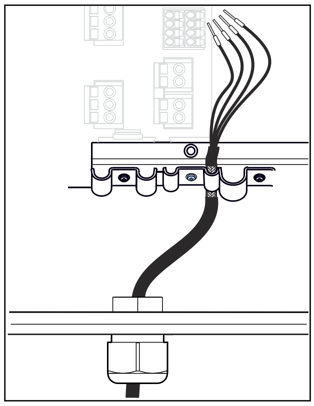
22 Terminated cable

1 Outer shield (exposed)
2 Cable cores with ferrules
3 Cable sheath (insulation)



23 Inserting the cable

4 Grounding clamp



24 Tightening the screw (2 Nm)

The cable shield is grounded using the grounding clamp [1)]

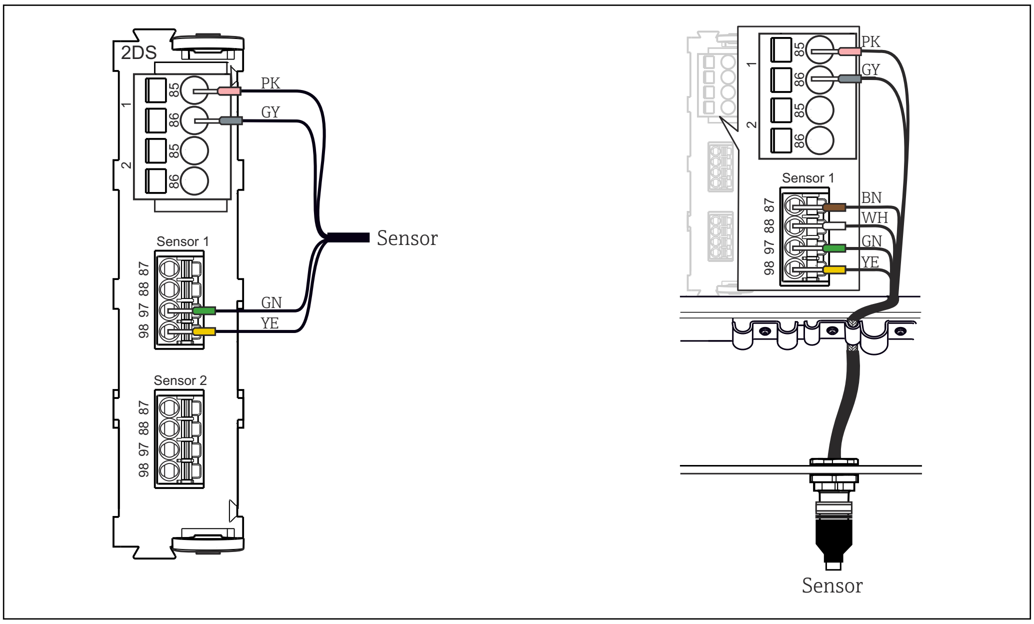
1) Please note the instructions in the "Ensuring the degree of protection" section

1. Loosen a suitable cable gland on the bottom of the housing.
2. Remove the dummy plug.
3. Attach the gland to the cable end, making sure the gland is facing the right direction.
4. Pull the cable through the gland and into the housing.
5. Route the cable in the housing in such a way that the **exposed** cable shield fits into one of the cable clamps and the cable cores can be easily routed as far as the connection plug on the electronics module.
6. Unscrew the cable clamp.
7. Clamp the cable.

8. Tighten the screw of the cable clamp again.
9. Connect cable cores as per the wiring diagram.
10. Tighten the cable gland from outside.

6.1.2 Connecting the sensor

The following connection options are available:
- via M12 connector (version: fixed cable, M12 connector)
- via sensor cable to the plug-in terminals of a sensor input on the transmitter (version: fixed cable, end sleeves)



A0033092

25 *Sensor connection to sensor input (left) or via M12 connector (right)*

The maximum cable length is 100 m (328.1 ft).

6.2 Ensuring the degree of protection

Only the mechanical and electrical connections which are described in these instructions and which are necessary for the required, designated use, may be carried out on the device delivered.

▶ Exercise care when carrying out the work.

Otherwise, the individual types of protection (Ingress Protection (IP), electrical safety, EMC interference immunity) agreed for this product can no longer be guaranteed due, for example to covers being left off or cable (ends) that are loose or insufficiently secured.

6.3 Post-connection check

▶ Put the sensor into operation only if you can answer yes to all of the following questions.

Device condition and specifications	Notes
Is the outside of the sensor, assembly and cable undamaged?	Visual inspection
Electrical connection	**Notes**
Has cable shield been applied to grounding rail of transmitter?	Cable shield is absolutely essential
Are the installed cables strain-relieved and not twisted?	
Is a sufficient length of the cable cores stripped, and is it positioned in the terminal correctly?	Check the fit (by pulling gently)
Are all the screws terminals properly tightened?	Tighten

7 Operation

- ▶ Verify that a representative measured value is displayed on the transmitter.
- ▶ For solids that have a tendency to form deposits, ensure that the medium is mixed sufficiently.

7.1 Calibration

Calibration is performed in the process by comparing the values to an external standard method, by calibrating with standard solutions or by using a combination of both (addition of standard).

7.1.1 Factory calibration

Nitrate sensor
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.

SAC sensor
The sensor is precalibrated on leaving the factory (calibrated with KHP).
Calibration to the customer process is nevertheless advantageous in the majority of cases. Reason: Organic compounds other than KHP react differently in the spectrum.

The factory calibration is based on 20 calibration points and is adjusted at three points during production. The factory calibration cannot be deleted and can be retrieved at any time. Single-point and two-point calibrations - performed as customer calibrations - are referenced to this factory calibration.

7.1.2 Types of calibration

In addition to the factory calibrations, which cannot be changed, the sensor contains six additional data records for storing process calibrations or for adaptation to the relevant measuring point (application). Each calibration data record can have up to five calibration points.

The sensor offers a wide range of options for adapting the measurement to the application in question:
- Calibration or adjustment (1 to 5 points)
- Entry of a factor (multiplication of measured values by a constant factor)
- Entry of an offset (addition/subtraction of a constant factor to/from the measured values)
- Duplication of factory calibration data records

One-point or multiple point calibration

Do not remove the sensor from the medium for calibration purposes; it can be calibrated directly in the application.

1. For the calibration, ensure that the measuring gap is not soiled with deposit buildup: Clean the measuring gap of the sensor (remove soiling and deposits).
2. To perform the calibration, immerse the sensor in the medium in such a way that the measuring gap is completely filled with the medium.
   ↳ All air bubbles and air pockets must be cleaned out of the measuring gap during immersion.

- In the calibration table, the actual values can be edited as well as the set points (right and left columns).
- Additional pairs of calibration values (actual values and set points) can be added, if required, even without measurement in a medium.

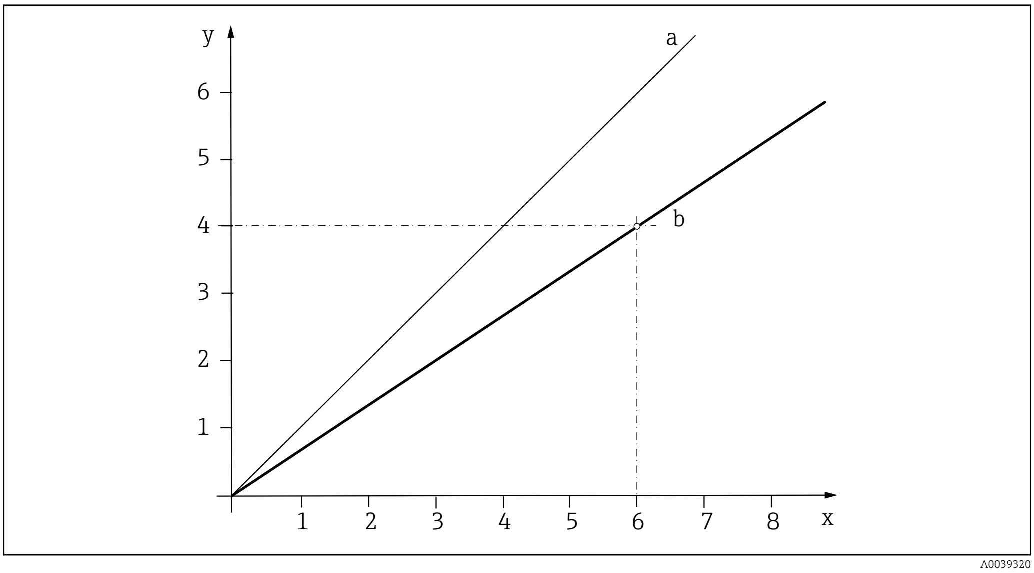
Lines interpolate between the calibration points.

▸ Give your calibration data records meaningful and useful names.

For example, the name can contain the name of the application on which the data record was originally based. This makes it easier to distinguish between different data records.

Principle of a 1-point calibration

The measured error between the measured value of the device and the laboratory measured value is too large. This is corrected by a 1-point calibration.



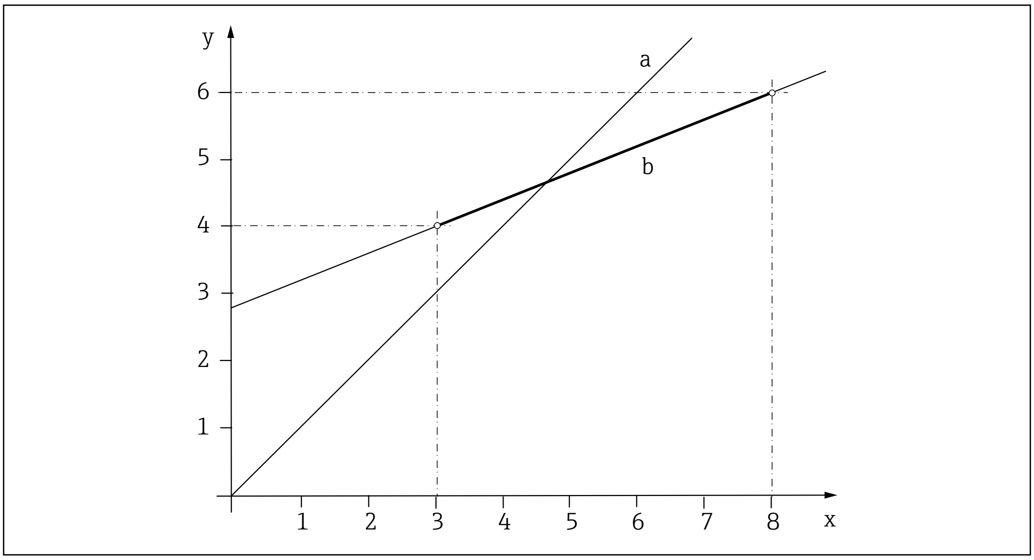
26 Principle of a 1-point calibration

x *Measured value*
y *Target sample value*
a *Factory calibration*
b *Application calibration*

1. Select data record.
2. Set the calibration point in the medium and enter the target sample value (laboratory value).

Principle of a 2-point calibration

Measured value deviations are to be compensated for at 2 different points in an application (e.g. the maximum and minimum value of the application). This aims to ensure a maximum level of accuracy between these two extreme values.



27 Principle of a 2-point calibration

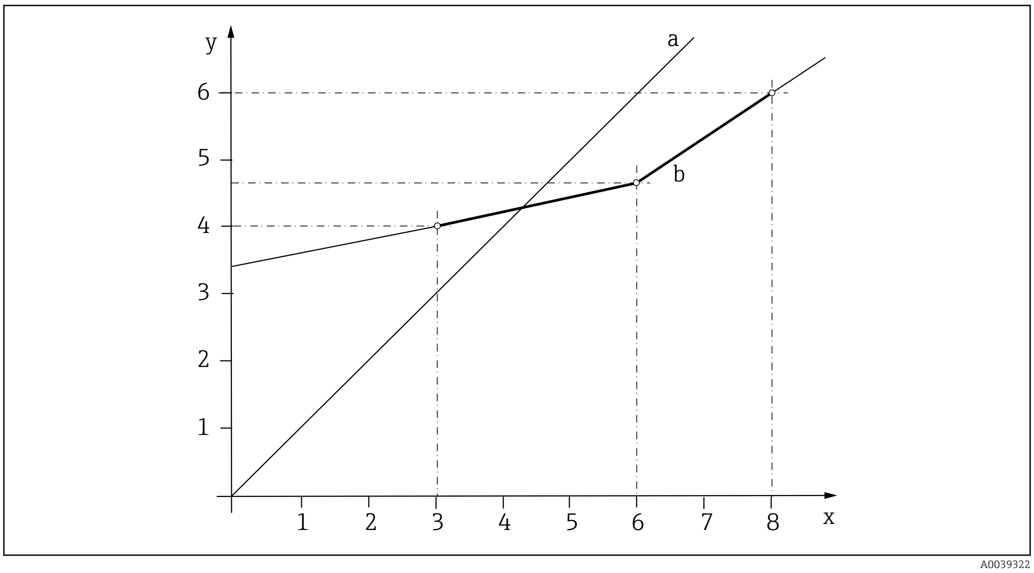
x Measured value
y Target sample value
a Factory calibration
b Application calibration

1. Select a data record.
2. Set 2 different calibration points in the medium and enter the corresponding set points.

A linear extrapolation is performed outside the calibrated operational range (gray line).

The calibration curve must be monotonically increasing.

Principle of multiple point calibration



28 *Principle of multipoint calibration (3 points)*

x *Measured value*
y *Target sample value*
a *Factory calibration*
b *Application calibration*

1. Select data record.
2. Set 3 different calibration points in the medium and specify the corresponding set points.

A linear extrapolation is performed outside the calibrated operational range (gray line).

The calibration curve must be monotonically increasing.

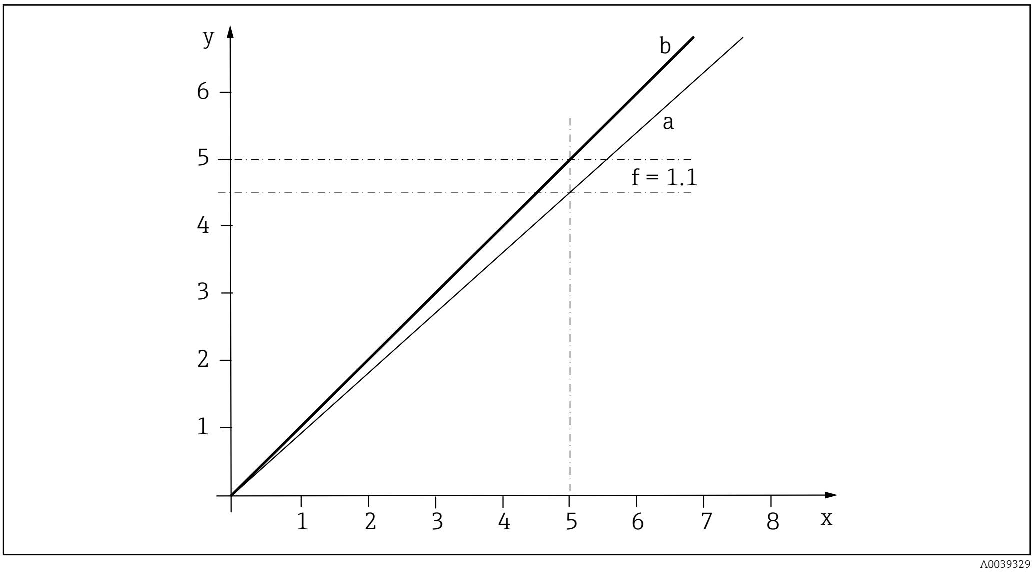
Principle of entering a factor

With the "Factor" function, the measured values are multiplied by a constant factor. The functionality corresponds to that of a 1-point calibration.

Example:

This type of adjustment can be selected if the measured values are compared to the laboratory values over a longer period of time and all values are too low by a constant factor, e.g. 10%, in relation to the laboratory value (target sample value).

In the example, the adjustment is made by entering the factor 1.1.

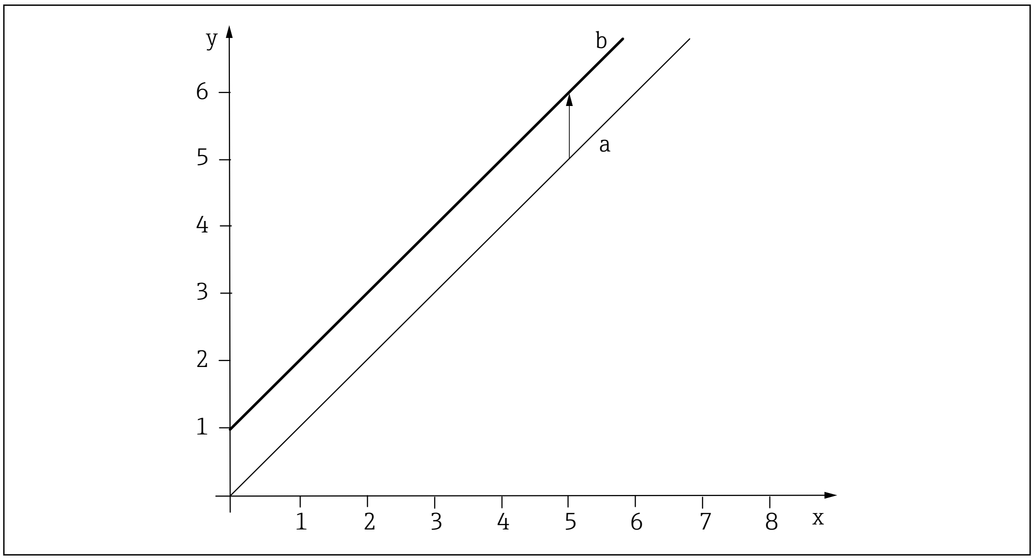


29 Principle of factor calibration

x Measured value
y Target sample value
a Factory calibration
b Factor calibration

Principle of entering an offset

With the "Offset" function, the measured values are offset by a constant amount (added or subtracted).



30 *Principle of an offset*

x *Measured value*
y *Target sample value*
a *Factory calibration*
b *Offset calibration*

7.1.3 Stability criterion

During the calibration process, the measured values are checked to ensure that they remain constant.

You use the stability criterion to define maximum deviations during a calibration. Only a measured value within the specified deviation is accepted.

The stability criterion includes:
- The maximum permitted deviation in temperature measurement
- The maximum permitted deviation in measured value as a %
- the minimum time frame in which these values must be maintained

If the measured value or temperature deviate more than is permitted in the specified time frame, this calibration point becomes invalid and a warning is issued.

The stability criteria are used to monitor the quality of the individual calibration points in the course of the calibration process. The aim is to achieve the best possible calibration quality in the shortest possible time frame while taking external conditions into account.
- For high-precision calibrations in the laboratory, the maximum deviation permitted in the measured value can be kept as small as possible and the time frame selected can be as long as possible..
- For calibrations in the field in adverse weather and environmental conditions, the maximum deviation permitted in the measured value can be kept suitably large and the time frame selected can be kept suitably short.

Operating Instructions Memosens inputs BA01245C

7.1.4 Determining the reference values in the laboratory

Nitrate sensor

1. Take a representative sample of the medium.

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 using the laboratory method (for example, by colorimetric means using a cuvette test - the standard method as per DIN 38405 Part 9).

SAC sensor

1. Take a representative sample of the medium.
2. Take suitable measures to ensure that the process of biological and chemical reduction in the sample does not progress any further.
3. Determine the measured values of your sample array using the laboratory method (for example, by colorimetric means using a cuvette test).

7.1.5 Nitrate sensor

Processes with nitrate values > 0.1 mg/l

1. Take sample and determine nitrate concentration in the laboratory.
2. Calibrate and adjust the sensor using the laboratory value.

Processes with very different nitrate values

1. At time A, take a sample with a high concentration, and measure and calibrate the sample.
2. At time B - which can be a few days later - 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.

1. Take a larger sample (bucket) and analyze some of it by colorimetric means.
2. Calibrate the value of the calorimetric measurement in the sensor.
3. Add standard to the sample and determine the laboratory value.
4. Calibrate the laboratory value of the sample with added standard in the sensor.

Avoid incorrect measurements:
- Drinking water may contain higher concentrations of nitrate and is not suitable as a blank value. Use fully deionized water as a blank value.
- During calibration, make sure the sample is homogeneous.
- When calibrating, start with a low concentration and increase the concentrations gradually to prevent nitrate carryover.
- Clean and dry the sensor after a calibration. Ensure that there is no medium residue in the cuvette gap. In this way, you avoid mixing the different samples and changing the nitrate concentrations.

7.1.6 SAC sensor

The required data record is activated by selecting the application in question and can be adapted to that application using the following options:
- Calibration (1 to 10 points)
- Entry of a factor (multiplication of measured values by a constant factor)
- Entry of an offset (addition/subtraction of a constant factor to/from the measured values)
- Duplication of factory calibration data records
- Adjustment of the conversion factors

Further data records can be created in the sensor and adapted to the application by means of calibration or by entering a factor or offset. Two free, unused data records are available for this. The number of free data records can be increased if necessary by deleting (sample) data records that are not required. The sample data records are restored to factory status when the sensor is reset.

General calibration steps

1. Take a sample.
2. Determine the SAC value of the sample in the laboratory.
3. Calibrate and adjust the sensor using the laboratory value.

In the SAC sensor version, the calculated variables COD, TOC, BOD and DOC can also be output if desired, in addition to the actual measured variable. These variables are based on the following ratios:
1 mg/l KHP = ~1.176 mg/l COD
1 mg/l KHP = ~0.4705 mg/l TOC
1 mg/l KHP = ~1.176 mg/l BOD
1 mg/l KHP = ~0.4705 mg/l DOC

Using other conversion factors

Sometimes the conversion factors for COD, TOC, BOD or DOC are predetermined by control bodies. In such instances, these factors can be adjusted as follows:

1. Copy the factory data record to a free data record of your choice in the SAC basic setting.

A copy is necessary because the factory data record cannot be modified. If you already have another data record, you can change its factors directly.

2. Activate the new data record (in the **Setup** menu).
3. Set the desired factor (in the **CAL** menu).
4. Set the device to the desired measured variable (in the **Setup** menu).

Operating Instructions Memosens inputs BA01245C.

The SAC sensor can be calibrated for the measured variables SAC, COD, TOC, BOD and DOC.

If the sensor has been calibrated for the measured variable SAC, the conversion factors for COD, TOC, BOD or DOC can be adjusted at a later stage. If calibrated for TOC, COD, BOD or DOC, only the factor for the measured variable in use can be changed subsequently.

Avoid incorrect measurements:
- Drinking water contains many organic elements. The use of fully deionized water as a blank is also recommended here.
- During calibration, make sure the medium is homogeneous.
- Avoid any carryover of organic elements during calibration.

Processes with widely varying SAC values

Record the calibration points in different operational states. Example of a WWTP inlet:
- After a rainy spell
- In "normal conditions"
- After a dry spell

1. Save the points in any data record.
2. Add the lab results pertaining to the points.
3. Activate the calibration once a sufficient number of points have been set.

While this type of calibration can be more time-consuming, it allows the precise adjustment of the measurement technology to the operating conditions of the plant.

7.1.7 Calibrating and adjusting the sensor

To calibrate the sensor, use the same medium sample or sample array that was used to determine the laboratory measured values. The sample array can also be pure standard solutions.

The general sequence of a calibration is as follows:

1. Select data record.
2. Place sensor in medium.
3. During calibration, ensure that the medium is well homogenized.
4. Start the calibration for the measuring point.
5. If only one point should be calibrated:
   End the calibration by accepting the calibration data.
   ↳ Otherwise continue with the next step.
6. Add parent solution to the sample for the 2nd measuring point.
7. Determine the measured value.
8. Calculate the reference value from the laboratory measured value plus the added concentration.
9. Repeat the previous step as often as needed until you have reached the desired number of calibration points (maximum 5).

To avoid incorrect calibration from 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 and in the connection opening for the compressed air (e.g. by rinsing with the next calibration solution).

7.2 Cyclic cleaning

Compressed air is most suitable for automatic cyclic cleaning. There is a connection for compressed air on every sensor. The cleaning unit, which is supplied with the device or can be retrofitted, operates effectively at a rate of 20 l/min (5.4 US gal/min).

Type of soiling	Cleaning interval	Cleaning duration
Severe fouling with rapid buildup	5 min	10 s
Low risk of soiling	10 min	10 s

8 Diagnostics and troubleshooting

When troubleshooting, the entire measuring point must be taken into account:
- Transmitter
- Electrical connections and cables
- Assembly
- Sensor

The possible causes of error in the following table relate primarily to the sensor.

Problem	Testing	Solution
No display, no sensor reaction	▪ Power supplied to transmitter? ▪ Sensor connected correctly? ▪ Medium flow present? ▪ Buildup on optical windows?	1. Connect mains voltage 2. Connect sensor correctly 3. Ensure medium is flowing 4. Clean sensor
Display value too high or too low	▪ Buildup on optical windows? ▪ Gas bubbles present? ▪ Sensor calibrated?	1. Cleaning 2. Eliminate gas bubbles 3. Calibration 4. Check data record and modify if necessary 5. Examine in workshop with test unit
Display value fluctuating greatly	Gas bubbles present?	1. Eliminate gas bubbles 2. Check mounting location and select a different mounting location if necessary

Pay attention to the troubleshooting information in the Operating Instructions for the transmitter. Check the transmitter if necessary.

9 Maintenance

⚠ CAUTION

Acid or medium

Risk of injury, damage to clothing and the system!

- ▶ Wear protective goggles and safety gloves.
- ▶ Clean away splashes on clothes and other objects.

- ▶ You must perform maintenance tasks at regular intervals.

We recommend setting the maintenance times in advance in an operations journal or log.

The maintenance cycle primarily depends on the following:
- The system
- The installation conditions
- The medium in which measurement takes place

9.1 Maintenance intervals

The sensor requires very little maintenance, particularly if a cleaning unit is connected. Nevertheless, maintenance must be performed at regular intervals. Schedule maintenance times in advance in an operations journal or log.

Monthly:	Visual check, clean sensor if necessary. Cleaning intervals depend on the medium.
Every 125 million flashes (= two years at 2 Hz) or at least every four years:	Replace optical filters (manufacturer service team)
Every 250 million flashes (= four years at 2 Hz) or at least every eight years:	Replace strobe lamp (manufacturer service team)

9.2 Cleaning the sensor

Sensor fouling can affect the measurement results and even cause a malfunction.

The sensor must be cleaned regularly to ensure reliable measurement results. The frequency and intensity of the cleaning process depend on the medium.

Clean the sensor:
- As specified in the maintenance schedule
- Before every calibration
- Before returning it for repairs

Type of fouling	Cleaning measure
Lime deposits	▶ Immerse the sensor in 1 to 5% hydrochloric acid (for several minutes).
Dirt particles on the optics	▶ Clean the optics with a cleaning cloth.
Deposit buildup on the optics	There may be deposit buildup in the non-visible range (UV). Therefore, always clean the optics. ▶ Wet a cotton bud with 5-10% phosphoric acid or 5-10% hydrochloric acid and use it to clean the optics.
After cleaning: ▶ Rinse the sensor thoroughly with water.	

9.3 Maintenance of optical filters and strobe lamp

This work must be performed only by the manufacturer service team. Contact your Sales Center. → 📄 40

ℹ The replacement of the optical filter and strobe lamp also entails a new factory calibration and adjustment of the sensor.

10 Repairs

10.1 Return

The product must be returned if repairs or a factory calibration are required, or if the wrong product was ordered or delivered. As an ISO-certified company and also due to legal regulations, Endress+Hauser is obliged to follow certain procedures when handling any returned products that have been in contact with medium.

To ensure the swift, safe and professional return of the device:

▸ Refer to the website www.endress.com/support/return-material for information on the procedure and conditions for returning devices.

10.2 Disposal

The device contains electronic components. The product must be disposed of as electronic waste.

▸ Observe the local regulations.

11 Accessories

11.1 Assemblies

Flexdip CYA112
- Immersion assembly for water and wastewater
- Modular assembly system for sensors in open basins, channels and tanks
- Material: PVC or stainless steel
- Product Configurator on the product page: www.endress.com/cya112

Technical Information TI00432C

Flowfit CYA251
- Connection: See product structure
- Material: PVC-U
- Product Configurator on the product page: www.endress.com/cya251

Technical Information TI00495C

Flow assembly for CAS51D
- For small flow volumes
- Connection: hose, OD 6 mm
- Material: PVC-U
- Two brackets for CAS51D
- Order number: 71110000

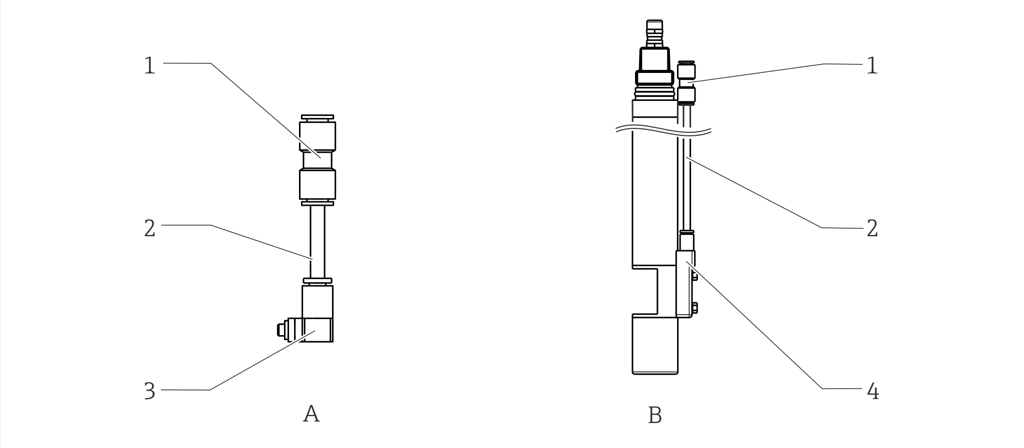
11.2 Holder

Flexdip CYH112
- Modular holder system for sensors and assemblies in open basins, channels and tanks
- For Flexdip CYA112 water and wastewater assemblies
- Can be affixed anywhere: on the ground, on the coping stone, on the wall or directly onto railings.
- Stainless steel version
- Product Configurator on the product page: www.endress.com/cyh112

Technical Information TI00430C

11.3 Compressed air cleaning

Compressed air cleaning for CAS51D
- Connection: 6 or 8 mm (metric) or 6.35 mm (¼")
- Order numbers for sensor with 2 mm gap or 8 mm gap:
  - 6 mm (with 300 mm hose and 8 mm adapter)
    Order No.: 71110787
  - 6.35 mm (¼")
    Order No.: 71110788
- Order numbers for sensor with 40 mm gap:
  - 6 mm (with 300 mm hose and 8 mm adapter)
    Order No.: 71126757
  - 6.35 mm (¼")
    Order No.: 71126758



31 *Compressed air cleaning for CAS51D*

A Cleaning for sensors with 2 mm and 8 mm gap
B Cleaning for sensors with 40 mm gap
1 Adapter, 8 mm
2 300 mm hose (Ø = 6 mm)
3 Coupling, 6 mm or 6.35 mm (¼") for 2 mm and 8 mm gap
4 Coupling, 6 mm or 6.35 mm (¼") for 40 mm gap

Compressor
- For compressed air cleaning
- 230 V AC, order number: 71072583
- 115 V AC, order number: 71194623

11.4 Standard solutions

Nitrate standard solutions, 1 liter
- 5 mg/l NO_3-N, order number: CAY342-V10C05AAE
- 10 mg/l NO_3-N, order number: CAY342-V10C10AAE
- 15 mg/l NO_3-N, order number: CAY342-V10C15AAE
- 20 mg/l NO_3-N, order number: CAY342-V20C10AAE
- 30 mg/l NO_3-N, order number: CAY342-V20C30AAE
- 40 mg/l NO_3-N, order number: CAY342-V20C40AAE
- 50 mg/l NO_3-N, order number: CAY342-V20C50AAE

KHP standard solution
CAY451-V10C01AAE, 1000 ml parent solution 5 000 mg/l TOC

12 Technical data

12.1 Input

Measured variables

Nitrate
NO_3-N [mg/l], NO_3 [mg/l]

SAC
SAC [1/m], COD [mg/l], TOC [mg/l], BOD [mg/l], DOC [mg/l], transmission [%]

Measuring range

CAS51D-**A2 (2 mm gap)	0.1 to 50 mg/l NO_3-N 0.4 to 200 mg/l NO_3 Clear water and sludge activation
CAS51D-**A1 (8 mm gap)	0.01 to 20 mg/l NO_3-N 0.04 to 80 mg/l NO_3 Clear water (with a COD (KHP) content of up to 125 mg/l and up to 50 FNU turbidity based on mineral kaolin)
CAS51D-**C1 (40 mm gap)	SAC 0 to 50 1/m CSB/BSB 0 to 75 mg/l [1)] TOC/DOC 0 to 30 mg/l [1)] Clear water, low measuring range, drinking water
CAS51D-**C2 (8 mm gap)	SAC 0 to 250 1/m COD/BOD 0 to 375 mg/l [1)] TOC/DOC 0 to 150 mg/l [1)] Clear water, medium measuring range, drinking water, wastewater treatment plant outlet, monitoring of bodies of water
CAS51D-**C3 (2 mm gap)	SAC 0 to 1000 1/m COD/BOD 0 to 1500 mg/l [1)] TOC/DOC 0 to 600 mg/l [1)] Organic load in the inlet, influent control, industrial processes

1) equivalent KHP

The possible measuring range depends greatly on the properties of the medium.

Empirical values for typical COD measuring ranges

Inlet of municipal wastewater treatment plant	0 to 4000 mg/l COD
Influent from milk-processing industry	0 to 10 000 mg/l COD
Influent from chemical industry	0 to 10 000 mg/l COD

12.2 Performance characteristics

Reference operating conditions	20 ℃ (68 ℉), 1013 hPa (15 psi)

Measured error [6]

Nitrate	With 0.1 to 50 mg/l NO_3-N (2 mm cuvette gap): 2 % of full scale value above 10 mg/l 0.4 % of full scale value below 10 mg/l With 0.01 to 20 mg/l NO_3-N (8 mm cuvette gap): 2 % of full scale value above 2 mg/l 0.2 % below 2 mg/l
SAC	2 % of full scale value for standard measurement with potassium hydrogen phthalate (KHP)

Repeatability [6]

Nitrate
At least ±0.2 mg/l NO_3-N

SAC
0.5 % of end of measuring range (for homogeneous media)

Detection limits

Nitrate
- CAS51D-AAA1
  0.003 mg/l NO_3-N
- CAS51D-AAA2
  0.013 mg/l NO_3-N

SAC
In relation to the standard potassium hydrogen phthalate (KHP):
- CAS51D-AAC1
  0.045 mg/l COD
- CAS51D-AAC2
  0.3 mg/l COD
- CAS51D-AAC3
  1.5 mg/l COD

Determination limits

Nitrate
- CAS51D-AAA1
  0.01 mg/l NO_3-N
- CAS51D-AAA2
  0.043 mg/l NO_3-N

SAC
In relation to the standard potassium hydrogen phthalate (KHP):
- CAS51D-AAC1
  0.15 mg/l COD
- CAS51D-AAC2
  1.0 mg/l COD
- CAS51D-AAC3
  5.0 mg/l COD

Long-term drift

Nitrate
Better than 0.1 mg/l NO_3-N over one week

6) The measured error contains all the uncertainties of the sensor and transmitter (electrode system). It does not contain all the uncertainties caused by the reference material and adjustments that may have been performed.

SAC
Better than 0.2 % of end of measuring range over one week

12.3 Environment

Ambient temperature range	−20 to 60 °C (−4 to 140 °F)
Storage temperature	−20 to 70 °C (−4 to 158 °F)
Degree of protection	IP 68 (1 m (3.3 ft) water column, 60 days, 1 mol/l KCl)

12.4 Process

Process temperature range	5 to 50 °C (41 to 122 °F)
Process pressure range	0.5 to 10 bar (7.3 to 145 psi) (abs.)
Minimum flow	No minimum flow required. For solids which have a tendency to form deposits, ensure that sufficient mixing is performed.

12.5 Mechanical construction

Dimensions	→ 12	
Weight	Approx. 1.6 kg (3.53 lbs) (without cable)	
Materials	Sensor	Stainless steel 1.4404 (AISI 316 L)
	Optical windows	Quartz glass
	O-rings	EPDM
Process connections	▪ G1 and NPT ¾' ▪ Clamp 2" (depending on sensor version)/DIN 32676	

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