

# Technical Information

## Viomax CAS51D

Photometric sensor for SAC or nitrate measurement



### Application

#### 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

### Your benefits

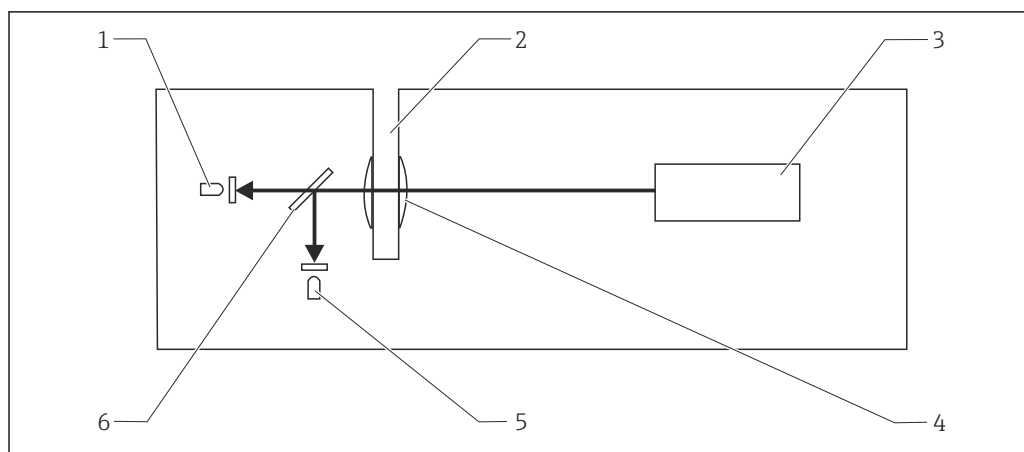
- Affordable, environmentally friendly product
  - No complicated sampling and treatment
  - Chemical-free measurement

- Low-maintenance
- Data conditioning in the sensor
  - Minimum sensitivity to interference during signal transmission
  - Short response time
- Early, continuous detection of load peaks without delay
- Ready for use thanks to factory calibration
- Standardized communication (Memosens technology) enables "plug and play"
- Very long maintenance intervals thanks to compressed air cleaning
- Customer calibrations with 1 - 5 points (max.) - in the lab or at place of installation

# Function and system design

## Measuring principle

The light from a pulsed, high-stability strobe lamp (item 3) passes through the measuring path <sup>1)</sup> (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.



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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 <sup>2)</sup> 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.

## Nitrate measurement

The sensor is designed for measuring nitrate. As nitrite is also measured, it could also be regarded as an NO<sub>x</sub> 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.

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

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.

#### **Cross-interference when measuring nitrate**

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 <sup>3)</sup> 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 <sup>4)</sup> 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.

#### **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 <sup>5)</sup> using predefined, adjustable factors:

$$c(\text{TOC}) = 0.4705 \cdot c(\text{KHP})$$

$$c(\text{COD}) = 1.176 \cdot c(\text{KHP})$$

$$c(\text{BOD}) = 1.176 \cdot c(\text{KHP})$$

$$c(\text{DOC}) = 0.4705 \cdot c(\text{KHP})$$

The ratio to SAC (based on KHP) is calculated as follows:

$$1/m = 1.487 \text{ mg/l COD} = 1.487 \text{ mg/l BOD} = 0.595 \text{ mg/l TOC} = 0.595 \text{ mg/l DOC}$$

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.

#### **Cross-interference when measuring SAC**

The following have a direct impact on the measuring range:

- Turbidity
- Color

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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)

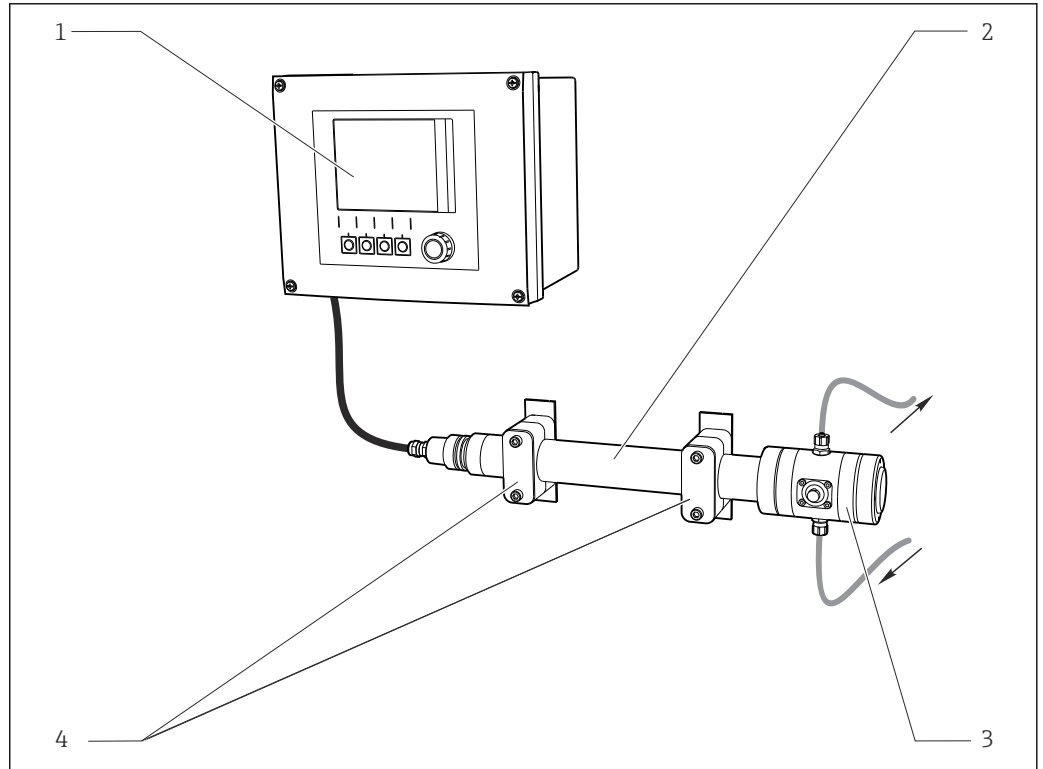
## Trends:

- 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.

## Measuring system

A complete measuring system comprises:

- Viomax CAS51D
- Liquiline CM44x multi-channel transmitter
- Universal installation or flow assembly
  - Flexdip CYA112 and Flexdip CYH112 holder or
  - Flowfit CYA251 or 71110000 (for clear water)



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2 Example of a measuring system with flow assembly for clear water

- 1 Transmitter CM44x
- 2 Sensor Viomax CAS51D
- 3 Flow assembly
- 4 Holders (included in the flow assembly delivery)

## Input

### Measured variables

#### Nitrate

NO<sub>3</sub>-N [mg/l], NO<sub>3</sub> [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 <sub>3</sub> -N 0.4 to 200 mg/l NO <sub>3</sub> Clear water and sludge activation
CAS51D-**A1 (8 mm gap)	0.01 to 20 mg/l NO <sub>3</sub> -N 0.04 to 80 mg/l NO <sub>3</sub> 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 <sup>1)</sup> TOC/DOC 0 to 30 mg/l <sup>1)</sup> 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 <sup>1)</sup> TOC/DOC 0 to 150 mg/l <sup>1)</sup> 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 <sup>1)</sup> TOC/DOC 0 to 600 mg/l <sup>1)</sup> 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

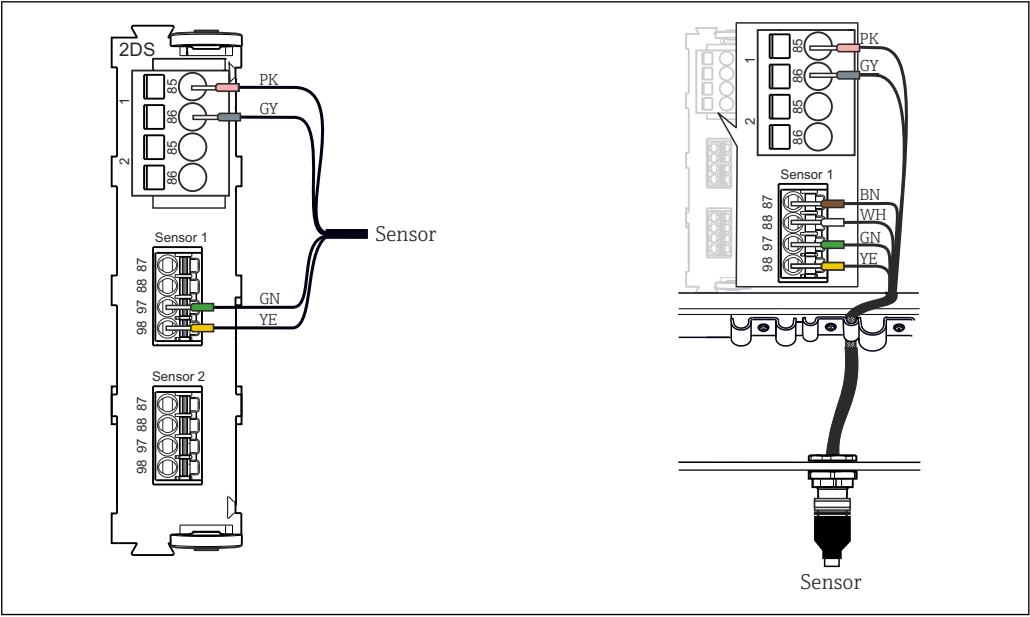
Inlet of municipal wastewater treatment plant	0 to 4000 mg/l COD
Influent from milk-processing industry	0 to 10 000 mg/l COD
Influent from chemical industry	0 to 10 000 mg/l COD

## Power supply

### Electrical connection

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)

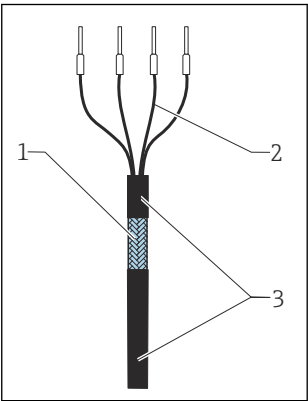


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3 Sensor connection to sensor input (left) or via M12 connector (right)

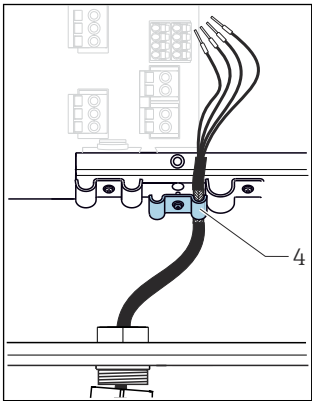
### Connecting the cable shield

Cable sample (does not necessarily correspond to the original cable supplied)



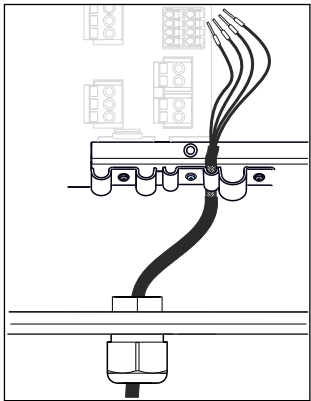
4 Terminated cable

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



5 Inserting the cable

- 4 Grounding clip



6 Tightening the screw  
(2 Nm (1.5 lbf ft))

The cable shield is grounded by the grounding clip

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

## Performance characteristics

Reference operating conditions

20 °C (68 °F), 1013 hPa (15 psi)

<b>Measured error</b> <sup>6)</sup>	Nitrate	With 0.1 to 50 mg/l NO <sub>3</sub> -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 <sub>3</sub> -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)
<b>Repeatability</b> <sup>6)</sup>	<b>Nitrate</b> At least ±0.2 mg/l NO <sub>3</sub> -N  <b>SAC</b> 0.5 % of end of measuring range (for homogeneous media)	
<b>Detection limits</b>	<b>Nitrate</b> <ul style="list-style-type: none"> <li>■ CAS51D-AAA1 0.003 mg/l NO<sub>3</sub>-N</li> <li>■ CAS51D-AAA2 0.013 mg/l NO<sub>3</sub>-N</li> </ul> <b>SAC</b> In relation to the standard potassium hydrogen phthalate (KHP): <ul style="list-style-type: none"> <li>■ CAS51D-AAC1 0.045 mg/l COD</li> <li>■ CAS51D-AAC2 0.3 mg/l COD</li> <li>■ CAS51D-AAC3 1.5 mg/l COD</li> </ul>	
<b>Determination limits</b>	<b>Nitrate</b> <ul style="list-style-type: none"> <li>■ CAS51D-AAA1 0.01 mg/l NO<sub>3</sub>-N</li> <li>■ CAS51D-AAA2 0.043 mg/l NO<sub>3</sub>-N</li> </ul> <b>SAC</b> In relation to the standard potassium hydrogen phthalate (KHP): <ul style="list-style-type: none"> <li>■ CAS51D-AAC1 0.15 mg/l COD</li> <li>■ CAS51D-AAC2 1.0 mg/l COD</li> <li>■ CAS51D-AAC3 5.0 mg/l COD</li> </ul>	
<b>Long-term drift</b>	<b>Nitrate</b> Better than 0.1 mg/l NO <sub>3</sub> -N over one week  <b>SAC</b> Better than 0.2 % of end of measuring range over one week	

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

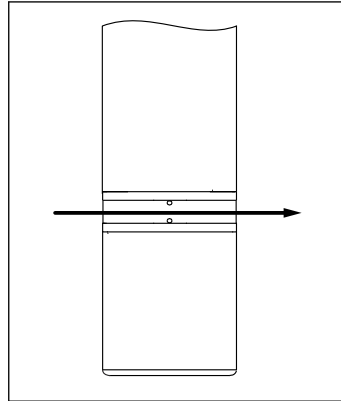


## Mounting

### 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.

### Orientation

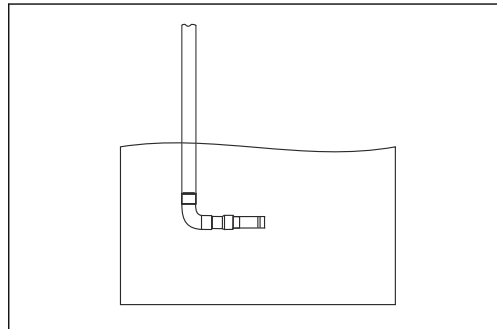


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7 Sensor orientation, arrow = direction of flow

- 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

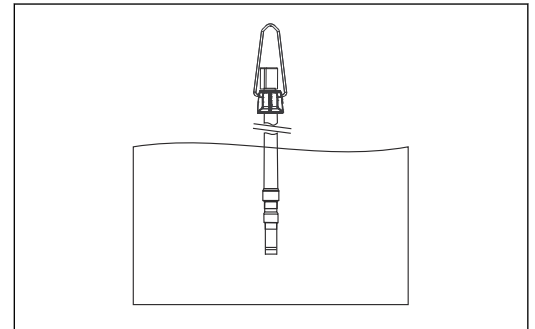


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8 Horizontal, fixed installation

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.



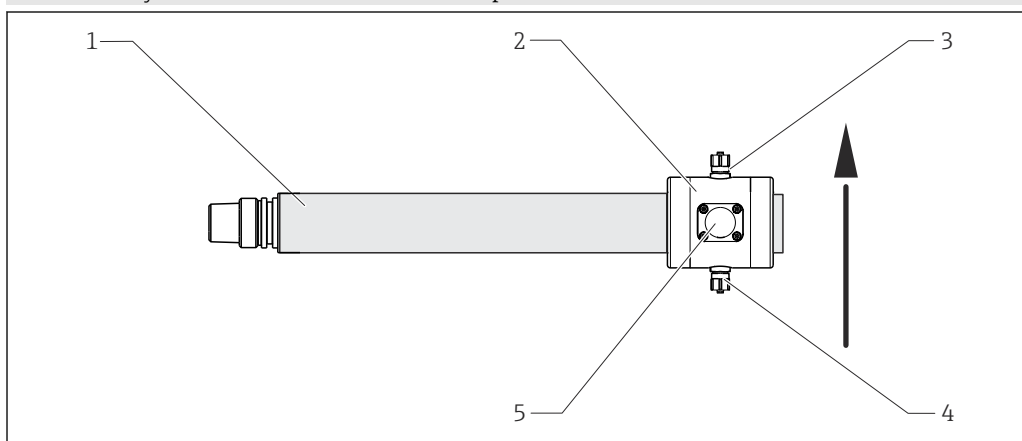
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9 Suspended vertically from a chain

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

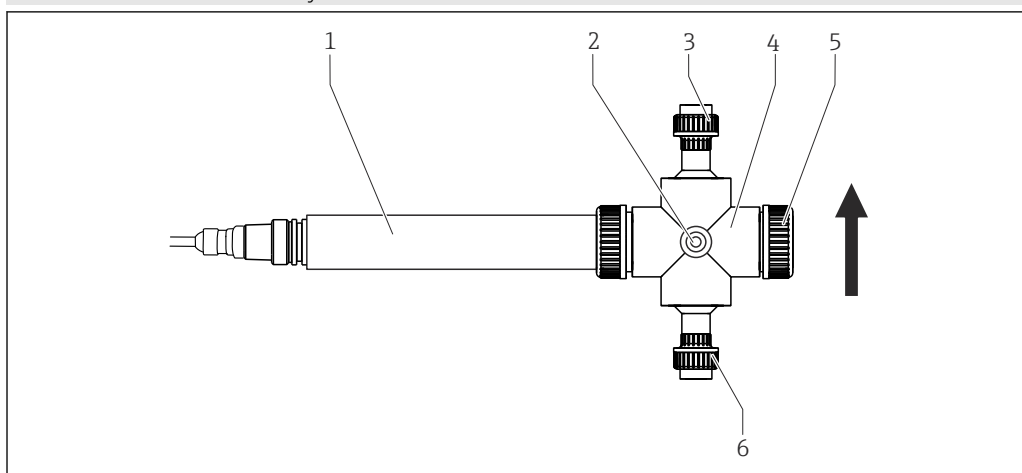


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10 Horizontally, in flow assembly, arrow points in the direction of flow

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

Flowfit CYA251 flow assembly



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11 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

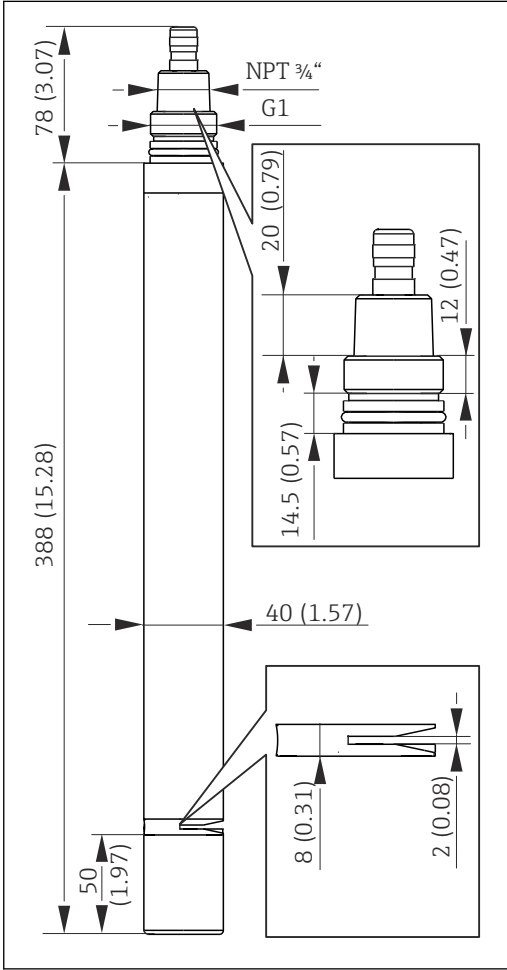
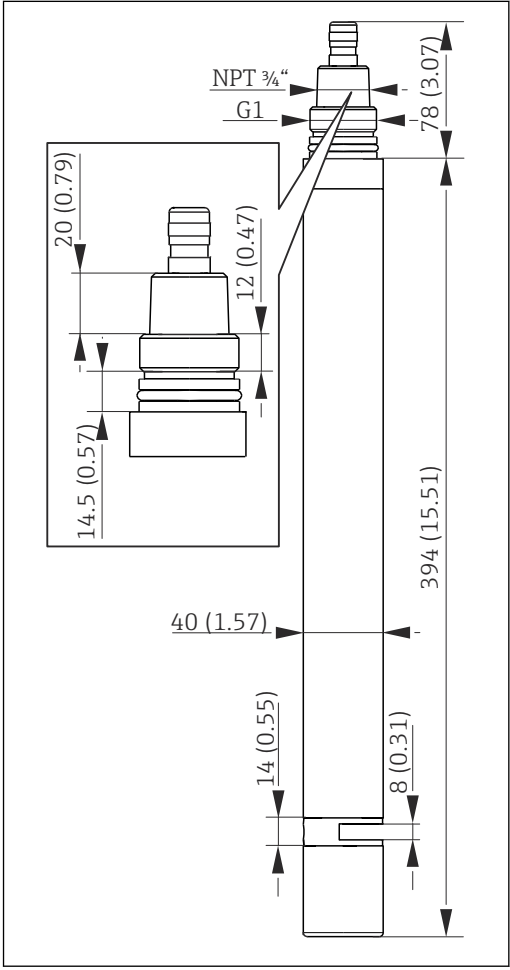


## Environment

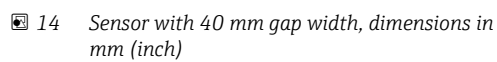
Ambient temperature range	-20 to 60 °C (-4 to 140 °F)
Storage temperature	-20 to 70 °C (-4 to 158 °F)
Degree of protection	IP 68 (1 m (3.3 ft) water column, 60 days, 1 mol/l KCl)

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.	

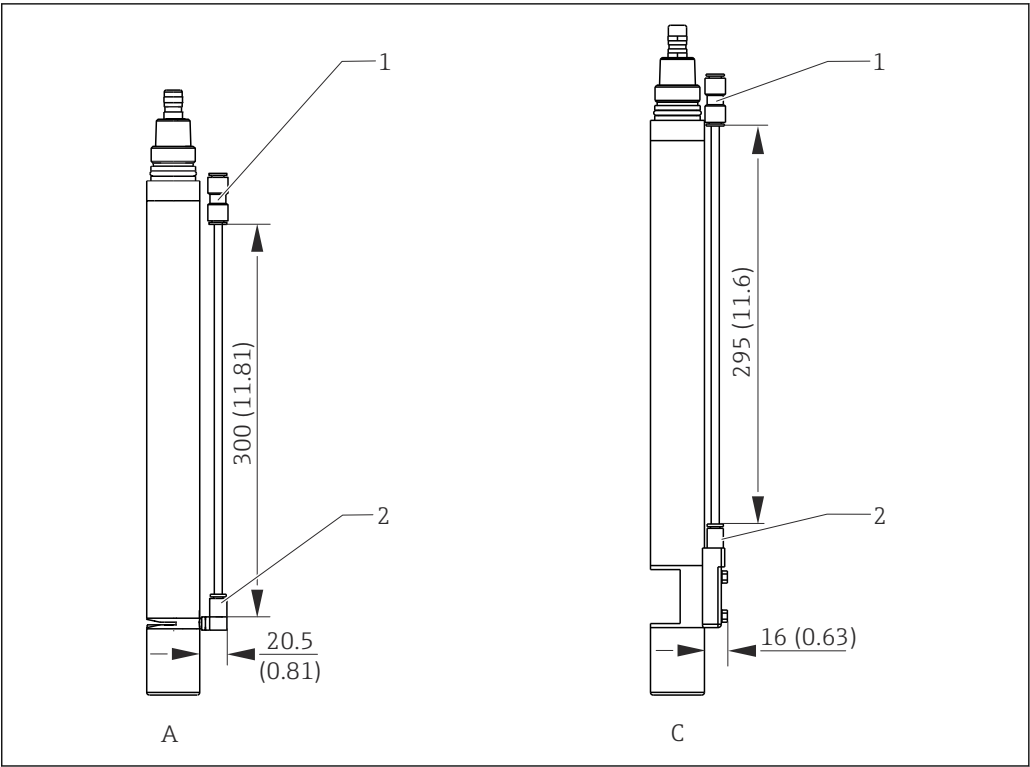
Mechanical construction

Dimensions	Sensor
<div></div> <div>A0013193</div> <div></div> <div>A0013208</div>	
 12	Sensor with 2 mm gap width, dimensions in mm (inch)
 13	Sensor with 8 mm gap width, dimensions in mm (inch)



**\*\* Variable length**

Cleaning unit



A0013292

16 Dimensions in mm (inch)

- 1 Adapter 8 mm with 300 mm hose (only for 8 mm connection)
- 2 Connection 6 mm or 6.35 mm (1/4")
- A Sensor (2 mm oder 8 mm gap)
- C SAC sensor (40 mm gap)

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	<ul style="list-style-type: none"><li>■ G1 and NPT 3/4"</li><li>■ Clamp 2" (depending on sensor version)/DIN 32676</li></ul>	

Certificates and approvals

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.
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.

Ordering information

Product page	<a href="http://www.endress.com/cas51d">www.endress.com/cas51d</a>
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## Product Configurator

On the product page there is a **Configure** button to the right of the product image.

1. Click this button.
  - ↳ The Configurator opens in a separate window.
2. Select all the options to configure the device in line with your requirements.
  - ↳ In this way, you receive a valid and complete order code for the device.
3. Export the order code as a PDF or Excel file. To do so, click the appropriate button on the right above the selection window.



For many products you also have the option of downloading CAD or 2D drawings of the selected product version. Click the **CAD** tab for this and select the desired file type using picklists.

## Scope of delivery

The delivery comprises:

- Sensor in the version ordered
- Operating Instructions

## Accessories

The following are the most important accessories available at the time this documentation was issued.

- For accessories not listed here, please contact your Service or Sales Center.

## Device-specific accessories

### 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](http://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](http://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

### 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](http://www.endress.com/cyh112)

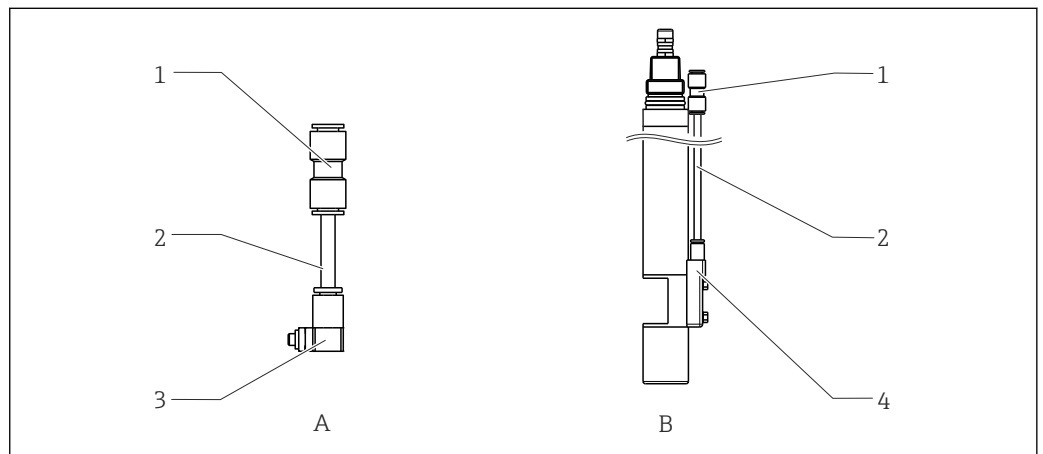


Technical Information TI00430C

### Compressed air cleaning

#### Compressed air cleaning for CAS51D

- Connection: 6 or 8 mm (metric) or 6.35 mm (1/4")
- 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 (1/4")  
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 (1/4")  
Order No.: 71126758



17 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 (1/4") for 2 mm and 8 mm gap  
 4 Coupling, 6 mm or 6.35 mm (1/4") for 40 mm gap

#### Compressor

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

### Standard solutions

#### Nitrate standard solutions, 1 liter

- 5 mg/l NO<sub>3</sub>-N, order number: CAY342-V10C05AAE
- 10 mg/l NO<sub>3</sub>-N, order number: CAY342-V10C10AAE
- 15 mg/l NO<sub>3</sub>-N, order number: CAY342-V10C15AAE
- 20 mg/l NO<sub>3</sub>-N, order number: CAY342-V20C10AAE
- 30 mg/l NO<sub>3</sub>-N, order number: CAY342-V20C30AAE
- 40 mg/l NO<sub>3</sub>-N, order number: CAY342-V20C40AAE
- 50 mg/l NO<sub>3</sub>-N, order number: CAY342-V20C50AAE

#### KHP standard solution

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



[www.addresses.endress.com](http://www.addresses.endress.com)

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