TI00459C/07/EN/17.24-00
71669891
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Technical Information
Viomax CAS51D

Photometric sensor for measuring the spectral absorption coefficient or nitrate content

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

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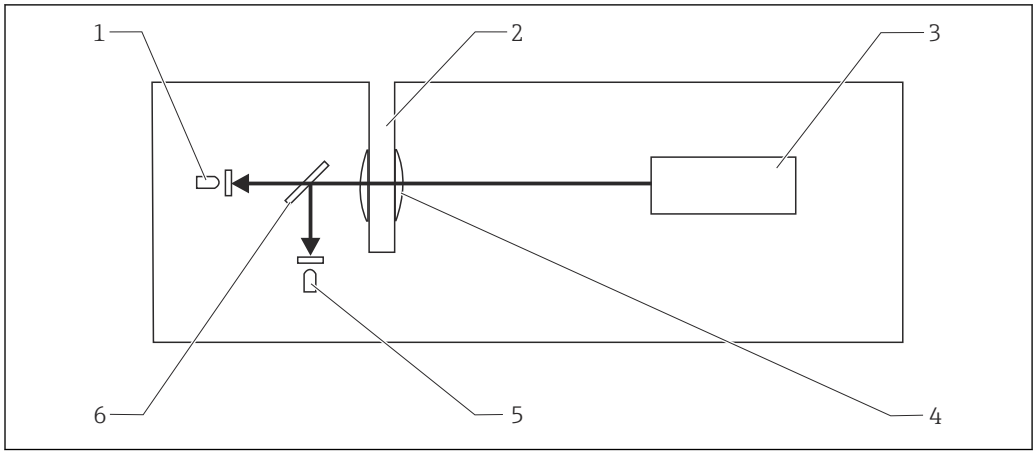
Function and system design

Measuring principle

The light from a pulsed, highly stable strobe lamp (item 3) passes through the measurement gap (item 2). A beam splitter (item 6) directs the light beam to the two receivers (items 1 and 5). A filter in front of 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 Measurement gap
3 Strobe lamp
4 Optical window
5 Reference receiver with filter
6 Beam splitter

Within the measuring gap, the medium (water, dissolved ingredients, and particles) absorbs light across the entire spectrum. In the measuring wavelength range, the measured component [1] 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 measurement paths [2] measurement gap are required for detecting low concentrations of the measured component.
  This is achieved in nitrate measurement with the measurement gap 8 mm (0.31 in) and in SAC measurement with the 40 mm (1.57 in) measurement gap for clear water samples.
- For high turbidity values, longer measuring paths result in the total absorption of light - the measured values are no longer valid.
  For media with high turbidity (such as in activated sludge applications), the nitrate sensor with the 2 mm (0.08 in) measurement gap is recommended. Alternatively, a nitrate sensor with the 8 mm (0.31 in) measurement gap can be used with an appropriate sample preparation.
  The SAC sensor with the 2 mm (0.08 in) measurement gap 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_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.

1) Nitrate or substances that contribute to the spectral absorption coefficient (SAC)
2) Measurement path = Open path length through the

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 [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 worthwhile in this case.

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 (DOC) = 0.4705 × c (KHP)
- c (COD) = 1.176 × c (KHP)
- c (BOD) = 1.176 × c (KHP)

The calculated relationships between COD, TOC, BOD, and DOC with SAC are as follows:
- TOC = 0.595 (mg/l × m)× SAC (1/m)
- DOC = 0.595 (mg/l × m)× SAC (1/m)
- COD =1.487 (mg/l × m)× SAC (1/m)
- BOD =1.487 (mg/l × m)× SAC (1/m)

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

The factors (F) stored in Liquiline can be adapted to the customer process (in the **CAL** menu). You can determine the factor F(Liquiline) to be entered as follows:

F(Liquiline) = laboratory value/SAC(CAS51D) × 0.7909

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 was the oxidizing agent.
5) Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), Biochemical Oxygen Demand (BOD), Dissolved Organic Carbon (DOC)

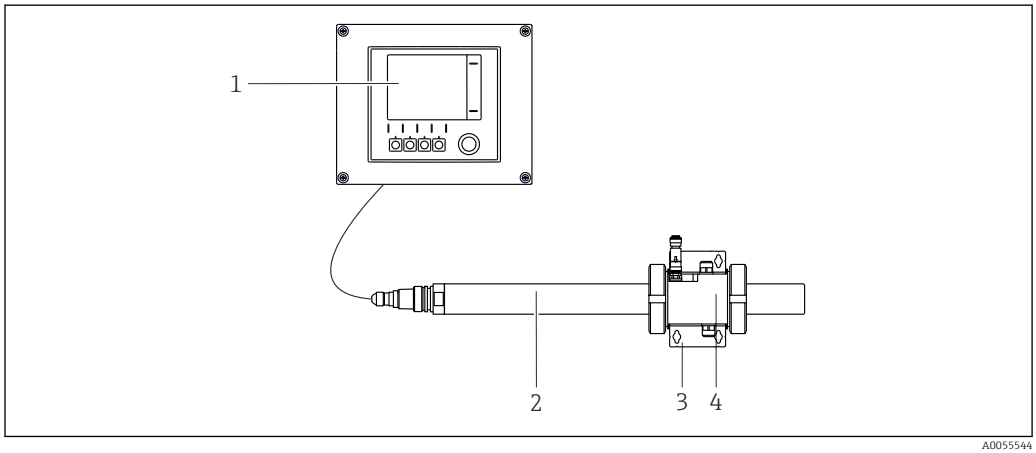
Cross-interference when measuring SAC

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.

Measuring system

A complete measuring system comprises:
- Viomax CAS51D sensor
- Liquiline CM44x multi-channel transmitter
- Universal installation or flow assembly:
  - Flexdip CYA112 and Flexdip CYH112 holder or
  - Flowfit CYA251 or
  - CAV01 (for clear water)



2 Measuring system with flow assembly CAV01

1 Transmitter
2 Sensor Viomax CAS51D
3 Holder
4 Flow assembly

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 (0.08 in) measurement 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 (0.31 in) measurement 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 (1.57 in) measurement gap)	SAC 0 to 50 1/m COD/BOD 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 (0.31 in) measurement 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 (0.08 in) measurement 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, discharger control, industrial processes

1) equivalent KHP

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

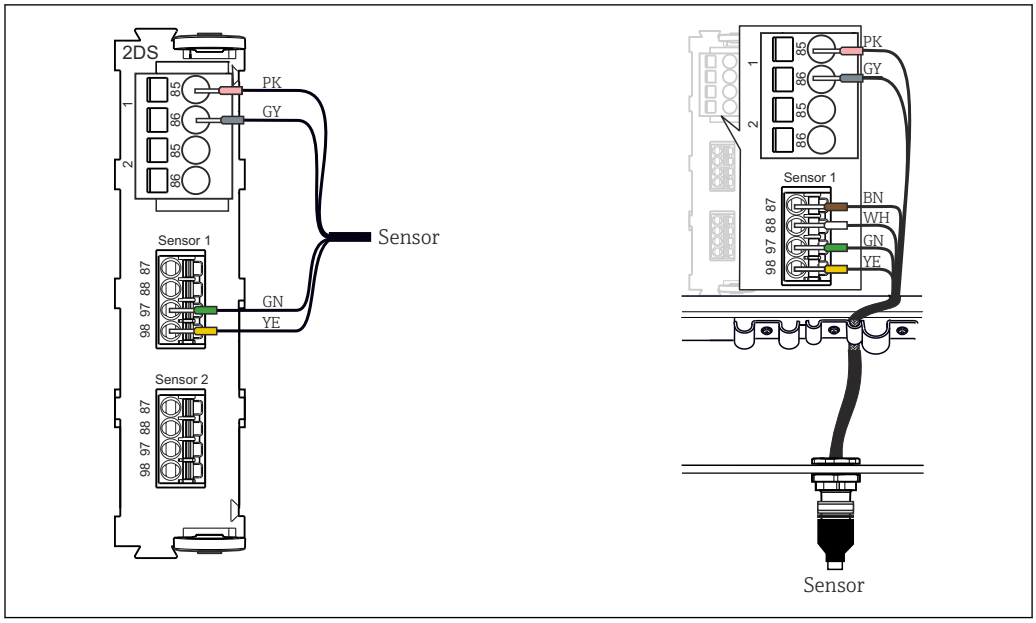
Empirical values for typical COD measuring ranges

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 plug (version: fixed cable, M12 plug)
- Via sensor cable to the plug-in terminals of a sensor input on the transmitter (version: fixed cable, end sleeves)



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

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

Performance characteristics

Reference operating conditions

20 °C (68 °F), 1013 hPa (15 psi)

Measurement error [6]

Nitrate	For 0.1 to 50 mg/l NO_3-N (measurement gap 2 mm (0.08 in)): 2 % of full scale value above 10 mg/l 0.4 % of full scale value below 10 mg/l For 0.01 to 20 mg/l NO_3-N (measurement gap 8 mm (0.31 in)): 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)

6) The measurement 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.

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

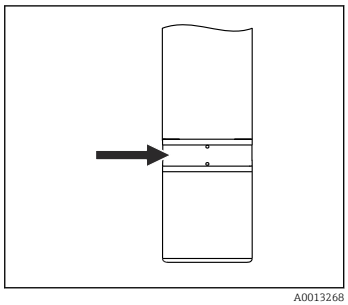
SAC
Better than 0.2 % of end of measuring range over one week

Installation

Mounting location

1. Do not install the device in places where air pockets and foam bubbles form.
2. Choose a mounting location that can be easily accessed at a later stage.
3. Ensure that upright posts and assemblies are fully secured and vibration-free.
4. Align the device so that the measurement gap is rinsed by the flow of medium.
5. Do not install the sensor above aeration discs. Oxygen bubbles may accumulate on the optical windows of the sensor, leading to inaccurate measurements.
6. Select an installation location that produces a typical nitrate concentration/a typical SAC value for the application in question.

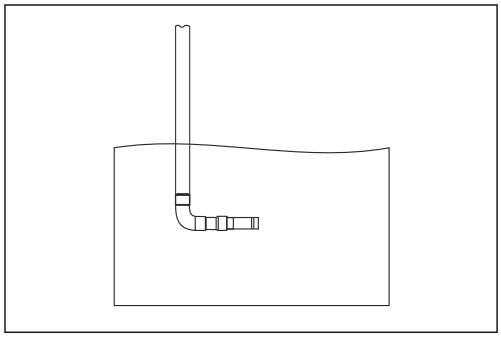
Orientation



4 Sensor orientation, arrow = direction of flow

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

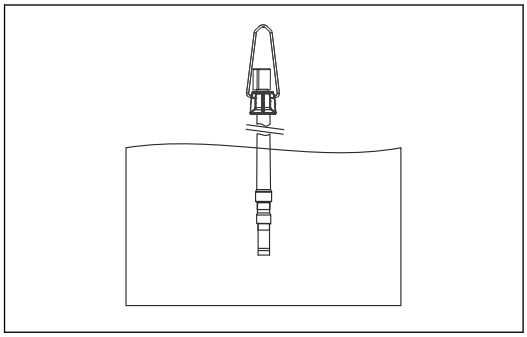
Flexdip CYA112 wastewater assembly and Flexdip CYH112 holder



5 Horizontal, fixed installation

The installation angle is 90°.

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

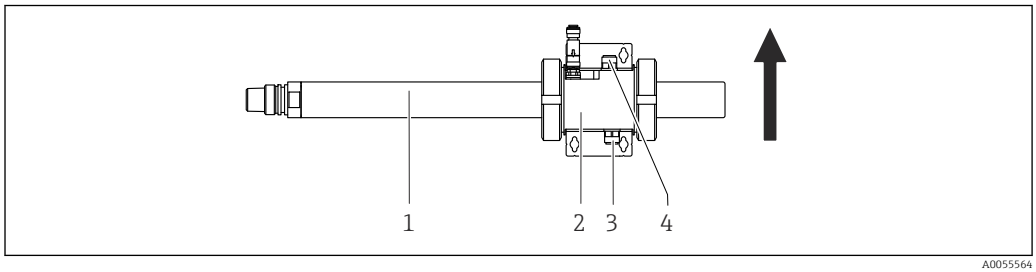


6 Suspended vertically from a chain

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 of the sensor.

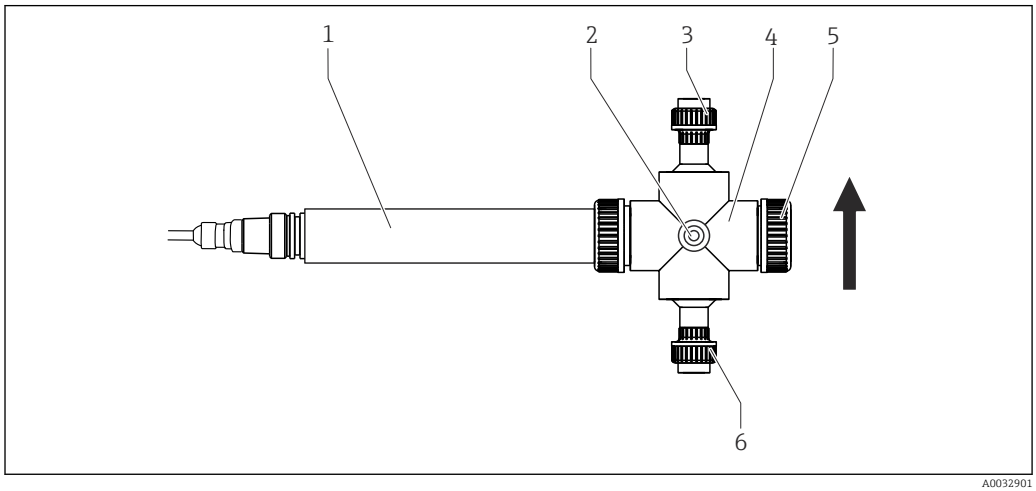
Flow assembly CAV01



7 Horizontal, in flow assembly CAV01, arrow indicates the flow direction

1 Sensor Viomax CAS51D
2 Flow assembly
3 Medium inlet
4 Medium outlet

Flowfit CYA251 flow assembly



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

1 Sensor Viomax CAS51D
2 Rinse connection
3 Medium outlet
4 Flow assembly
5 Cap
6 Medium inlet

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, 24 hours, 1 mol/l KCl)

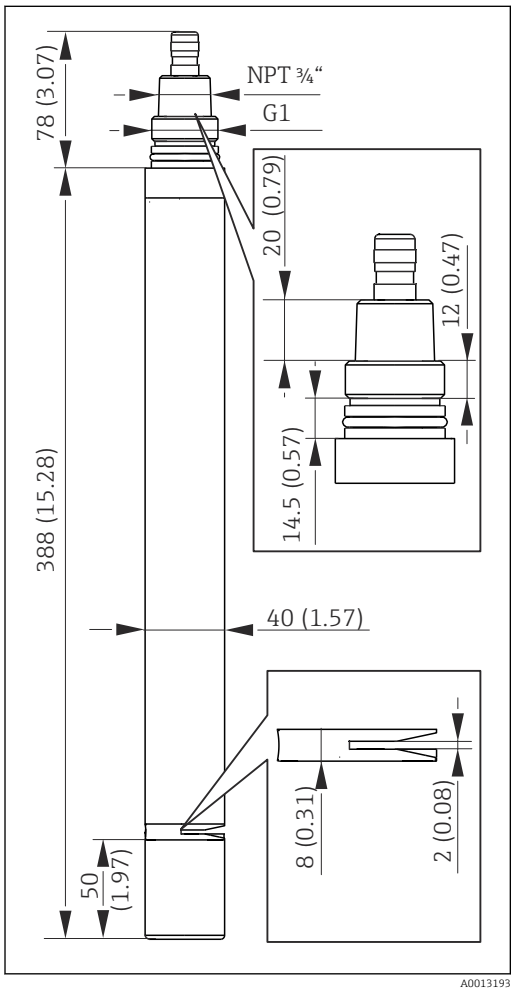
Process

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

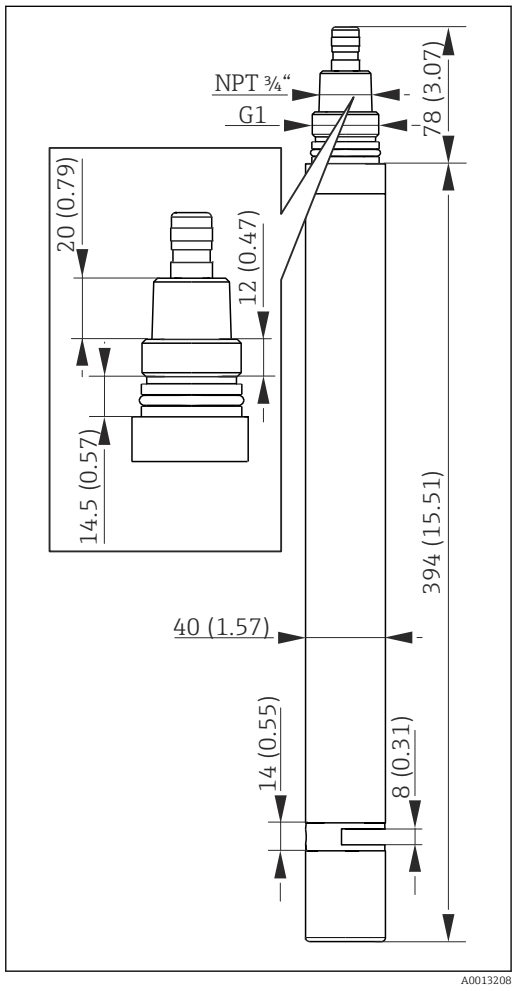
Mechanical construction

Dimensions

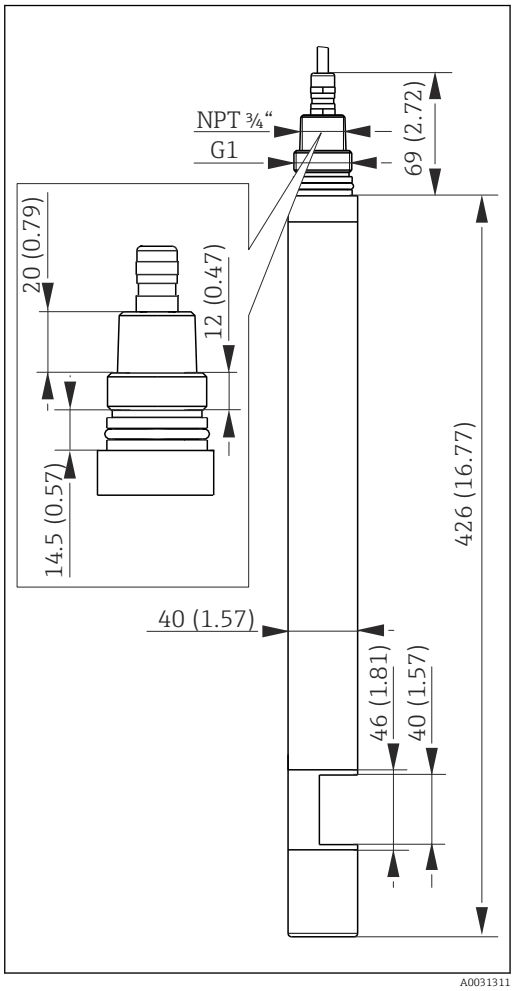
Sensor



9 *Dimensions of sensor with measurement gap 2 mm (0.08 in). Unit: mm (in)*

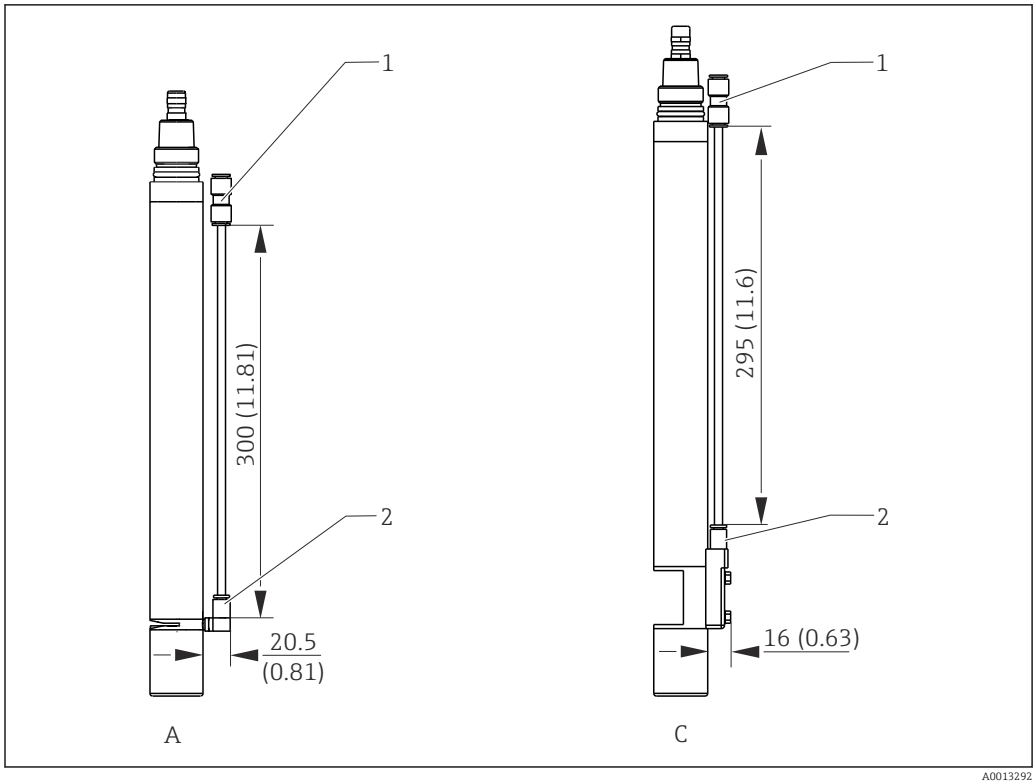


10 *Dimensions of sensor with measurement gap 8 mm (0.31 in). Unit: mm (in)*



11 Dimensions of sensor with measurement gap 40 mm (1.57 in). Unit: mm (in)

Cleaning unit



12 Dimensions in mm (inch)

1 Adapter 8 mm (0.31 in) with 300 mm (11.81 in) hose (only for connection 8 mm (0.31 in))
2 Connection 6 mm (0.24 in) or 6.35 mm (0.25 in))
A Sensor (measurement gap 2 mm (0.08 in) or 8 mm (0.31 in))
C SAC sensor (measurement gap 40 mm (1.57 in))

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

Certificates and approvals

Current certificates and approvals for the product are available at www.endress.com on the relevant product page:

1. Select the product using the filters and search field.
2. Open the product page.
3. Select **Downloads**.

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

www.endress.com/cas51d

Product Configurator

1. **Configure**: Click this button on the product page.
2. Select **Extended selection**.
   ↳ The Configurator opens in a separate window.
3. Configure the device according to your requirements by selecting the desired option for each feature.
   ↳ In this way, you receive a valid and complete order code for the device.
4. **Accept**: Add the configured product to the shopping cart.

For many products, you also have the option of downloading CAD or 2D drawings of the selected product version.

5. **CAD**: Open this tab.
   ↳ The drawing window is displayed. You have a choice between different views. You can download these in selectable formats.

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.

Listed accessories are technically compatible with the product in the instructions.

1. Application-specific restrictions of the product combination are possible.
   Ensure conformity of the measuring point to the application. This is the responsibility of the operator of the measuring point.
2. Pay attention to the information in the instructions for all products, particularly the technical data.
3. 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

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

CAV01
- Flow assembly
- Material: POM-C
- Product Configurator on the product page: www.endress.com/cav01

Technical Information TI01797C

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

Cleaning

Cleaning brushes
- Cleaning brushes to clean the measurement gap (for all gap sizes)
- Order number: 71485097

Compressed air cleaning for CAS51D
- Pressure: 1.5 to 2 bar (21.8 to 29 psi)
- Measurement gap 2 mm (0.08 in) or 8 mm (0.31 in):
  - 6 mm (0.24 in) (with 300 mm (11.81 in) hose and 8 mm (0.31 in) adapter)
    Order number: 71485094
  - 6.35 mm (0.25 in)
    Order number: 71485096
- Measurement gap 40 mm (1.57 in):
  6 mm (0.24 in) (with 300 mm (11.81 in) hose and 8 mm (0.31 in) adapter)
  Order No. 71126757

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_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

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