

Operating Instructions

Turbimax CUS51D

Sensor for turbidity and solids content






Table of contents








1	About this document	4	12	Accessories	38
1.1	Warnings	4	12.1	Assemblies	38
1.2	Symbols used	4	12.2	Holder	38
1.3	Symbols on the device	4	12.3	Compressed air cleaning	38
2	Basic safety instructions	5	13	Technical data	40
2.1	Requirements for the personnel	5	13.1	Input	40
2.2	Designated use	5	13.2	Performance characteristics	40
2.3	Occupational safety	5	13.3	Environment	42
2.4	Operational safety	6	13.4	Process	42
2.5	Product safety	6	13.5	Mechanical construction	42
3	Product description	7	Index		43
3.1	Product design	7			
4	Incoming acceptance and product identification	12			
4.1	Incoming acceptance	12			
4.2	Product identification	12			
4.3	Scope of delivery	13			
4.4	Certificates and approvals	13			
5	Installation	14			
5.1	Mounting conditions	14			
5.2	Mounting the sensor	14			
5.3	Post-installation check	20			
6	Electrical connection	21			
6.1	Connecting the sensor	21			
6.2	Ensuring the degree of protection	22			
6.3	Post-connection check	22			
7	Commissioning	23			
7.1	Function check	23			
8	Operation	24			
8.1	Adapting the measuring device to the process conditions	24			
9	Diagnostics and troubleshooting ...	35			
9.1	General troubleshooting	35			
10	Maintenance	36			
10.1	Maintenance tasks	36			
11	Repair	37			
11.1	Return	37			
11.2	Disposal	37			

1 About this document


1.1 Warnings

Structure of information	Meaning
 DANGER Causes (/consequences) If necessary, Consequences of non-compliance (if applicable) <ul style="list-style-type: none"> ▶ 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) <ul style="list-style-type: none"> ▶ 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) <ul style="list-style-type: none"> ▶ 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) <ul style="list-style-type: none"> ▶ 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

CUS51D is a sensor for measuring turbidity and solids content in water and wastewater.

The sensor is particularly suited for use in the following applications:

- Turbidity measurement in the outlet
- Solids content in sludge activation and recirculation
- Solids content in sludge treatment
- Filterable matter in outlet of WWTPs

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 Occupational safety

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 European 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

2.5.1 State of the art

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 European standards have been observed.

3 Product description

3.1 Product design

The sensor is designed for continuous in-situ determination of interfaces and solids content.

The sensor is designed as a 40 mm sensor that can be operated directly and completely in the process without the need for further sampling (in-situ).

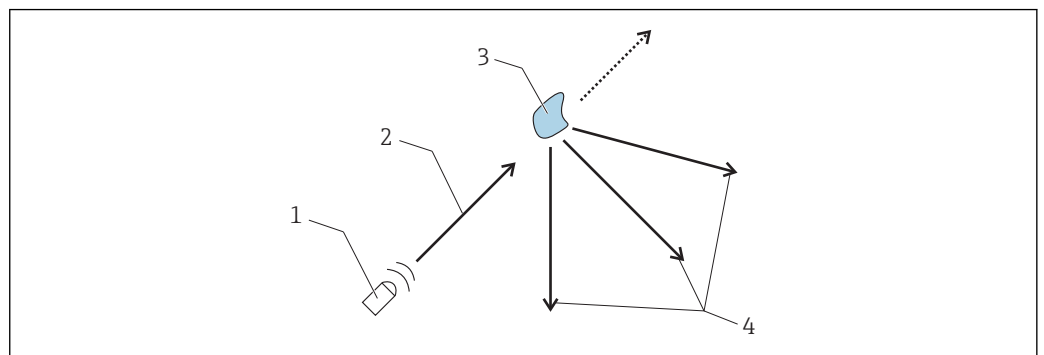
The sensor includes all necessary modules:

- Power supply
- Light sources
- Detectors,
 - Detectors record the measuring signals, digitize them and process them into a measured value.
- Sensor microcontroller
 - This is responsible for controlling internal processes and transmitting data.

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

3.1.1 Measuring principle

For turbidity measurement a light beam is directed through the medium and is deflected from its original direction by optically denser particles, e.g. particles of solid matter. This process is also called scattering.

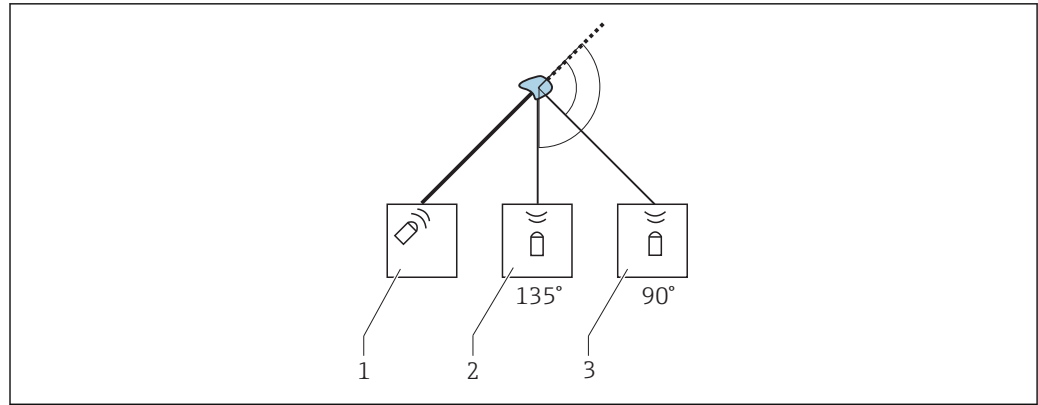


1 Deflection of light

- 1 Light source
- 2 Light beam
- 3 Particle
- 4 Scattered light

The incident light is scattered in many directions, i.e. at different angles to the direction of propagation. 2 angle ranges are of particular interest here:

- Light scattered at a 90° angle is used primarily for turbidity measurement in drinking water.
- Light scattered at a 135° angle extends the dynamic range for high particle densities.

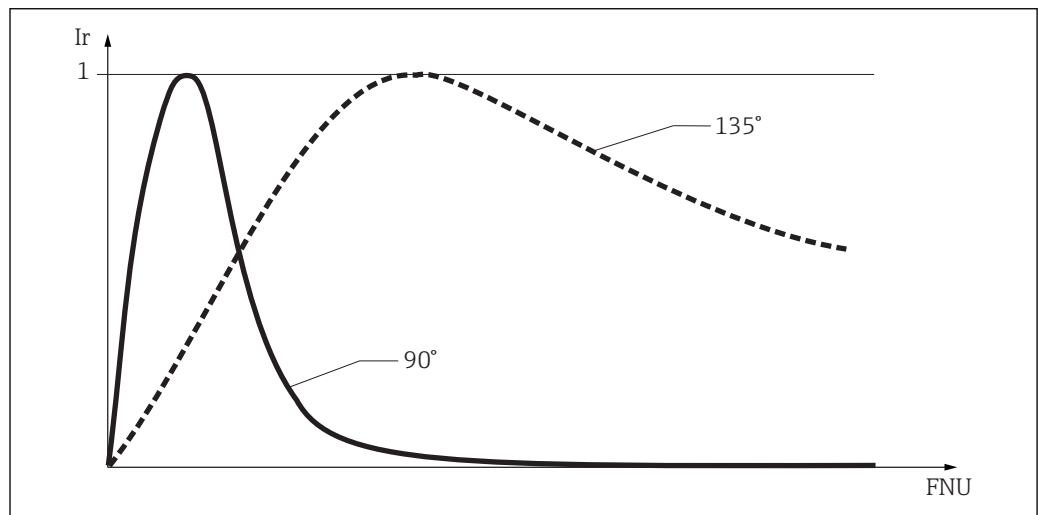


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2 Principle mode of operation of turbidity sensor

- 1 Light source
- 2 135° light receiver
- 3 90° light receiver

If the particle density in the medium is low, a large amount of light is scattered in the 90° channel and a small amount of light is scattered in the 135° channel. As the particle density increases, this ratio shifts (more light in the 135° channel, less light in the 90° channel).

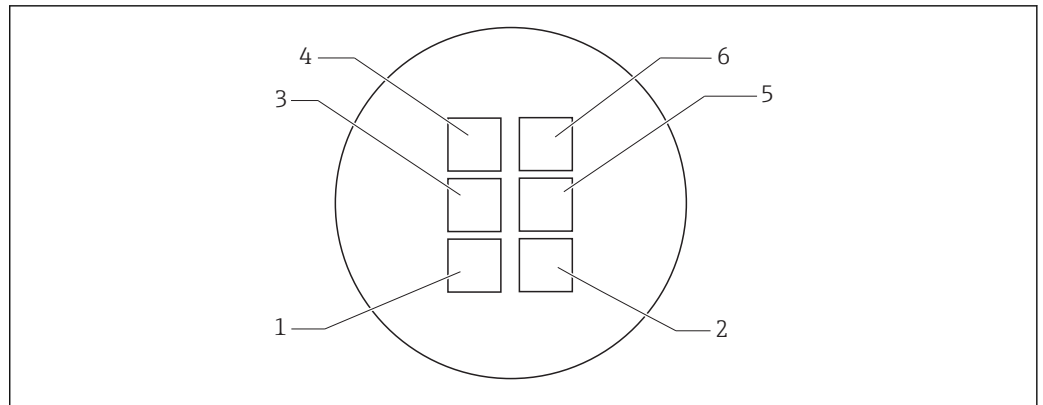


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3 Signal distribution as a function of the particle density

- I_r Relative intensity
- FNU Turbidity unit

The CUS5 1D turbidity sensor has 2 sensor units, which are independent of each other and arranged in parallel. The application-dependent evaluation of both signals leads to stable measured values.





 4 Arrangement of light sources and light receivers

- 1, 2 Light sources 1 and 2
 3, 5 135° light receiver
 4, 6 90° light receiver

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The sensor covers a broad range of turbidity and solids measurements thanks to the optical arrangement with 2 light sources, each with 2 light receivers placed at different angles (90° and 135°).

- As soon as the customer selects an application, e.g. activated sludge, the optical method best suited for the particular measuring task is automatically activated in the sensor (e.g. 90° measurements with both light sources).
- The double sensing system (2 light sources with 2 receivers per source) largely compensates for measured errors caused by fouling (4-beam pulsed light method →  9).

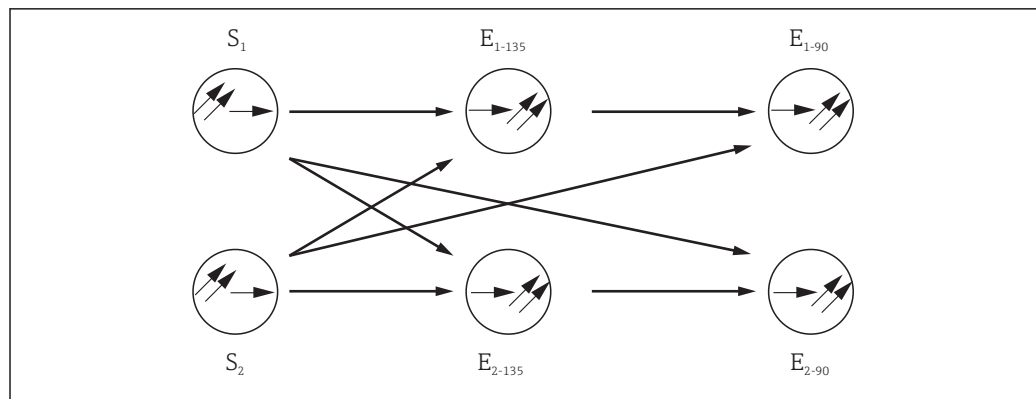
 The sensor types available vary in terms of their measuring ranges and therefore the range of available applications.

3.1.2 Measuring methods


4-beam pulsed light method

The method is based on 2 light sources and 4 light receivers. Long-life LEDs are used as monochromatic light sources. These LEDs are pulsed alternately and generate 4 scattered light signals per LED pulse at the receivers.

This offsets interference influences such as extraneous light, LED aging, fouling of windows and absorption in the medium. Depending on the chosen application, different scattered light signals are processed. The signal type, number and calculation are stored in the sensor.



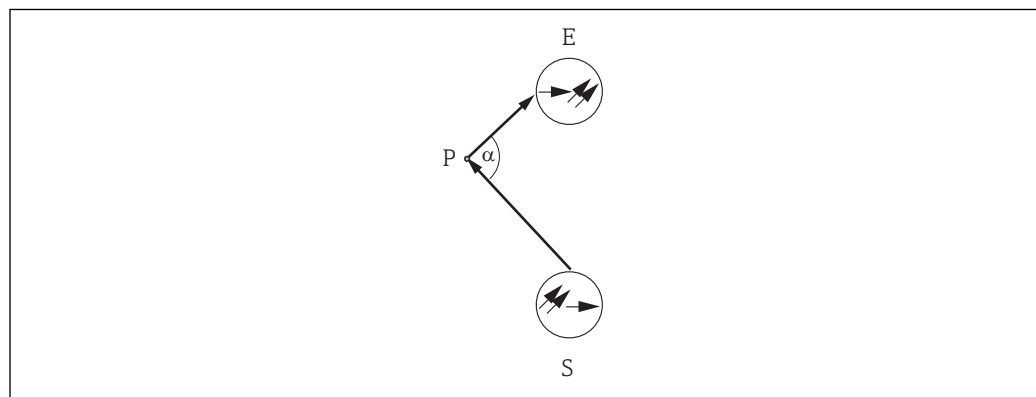
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-  5 4-beam pulsed light method
 $S_1 S_2$ Light source
 E_{90} Light receiver for 90° scattered light
 E_{135} Light receiver for 135° scattered light


90° scattered light method

Measurement is performed with a wavelength of 860 Nm (634.3 lbf ft), as described in ISO 7027 / EN 27027.

The emitted light beam is scattered by the solid particles in the medium. The scattered radiation generated in this way is measured by scattered light receivers, which are arranged at an angle of 90° to the light sources. The turbidity of the medium is determined by the amount of scattered light.

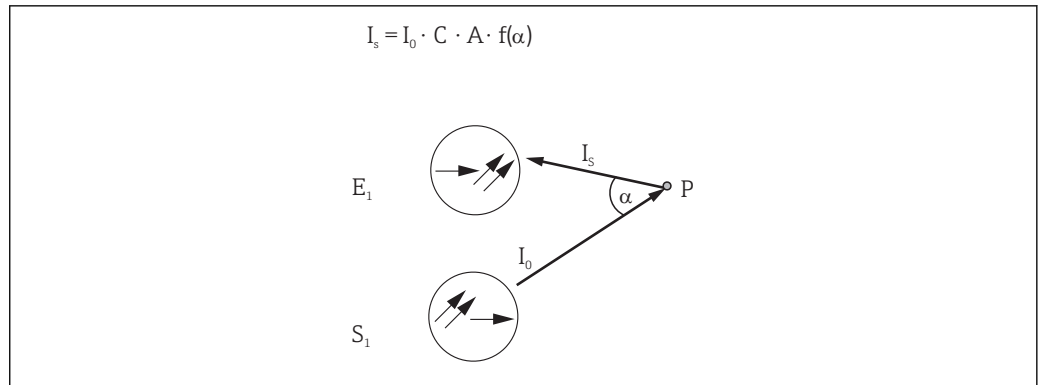


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-  6 90° scattered light method
 S Light source
 E Receiver
 P Particle

135° backscattered light method

The emitted light beam is scattered by the solid particles in the medium. The backscattering generated is measured by scattered light receivers, which are arranged next to the light sources. The turbidity of the medium is determined based on the quantity of back-scattered light. It is possible to measure very high turbidity values with this type of scattered light measurement.



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7 Principle of backscattered light method

I_0 Intensity of transmitted light

I_s Intensity of scattered light

A Geometric factor

C Concentration

P Particle

$f(\alpha)$ Angle correlation

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
 - Order code
 - 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/cus51d

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.

4.2.3 Manufacturer's address

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

4.3 Scope of delivery

The delivery comprises:

- 1 Turbimax CUS51D sensor, version as ordered
- 1 Operating Instructions BA00461C

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 Electromagnetic compatibility

Interference emission and interference immunity as per

- EN 61326-1:2013
- EN 61326-2-3:2013
- NAMUR NE21: 2012

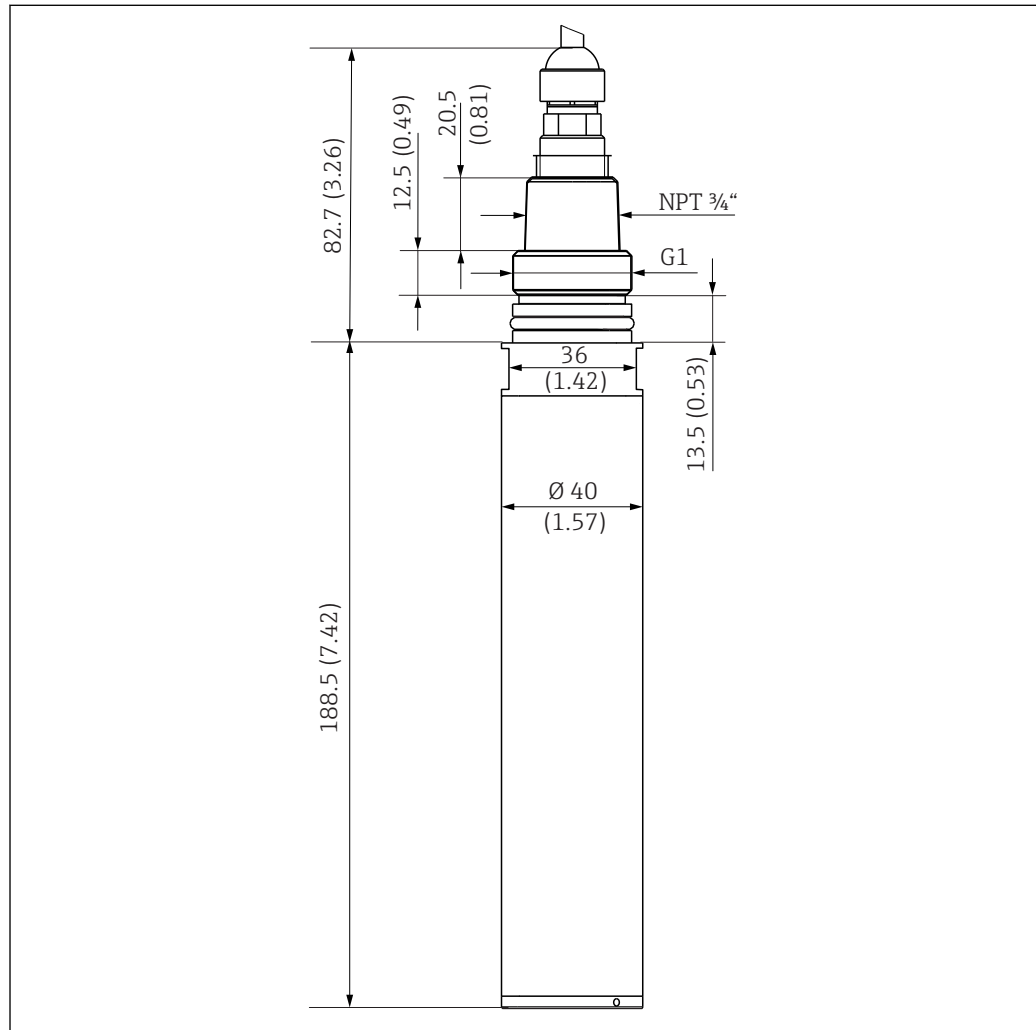
4.4.3 EAC

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 Installation

5.1 Mounting conditions

5.1.1 Dimensions



8 Dimensions. Dimensions: mm (in)

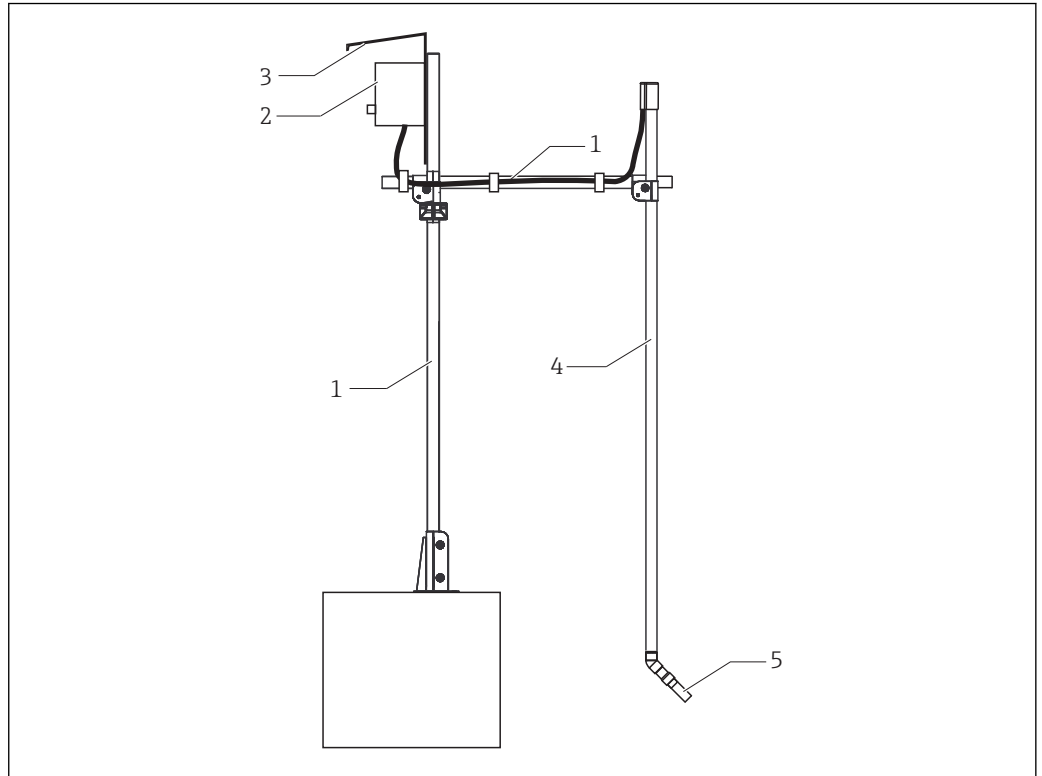
i Dimensions for compressed air cleaning → 38

5.2 Mounting the sensor

5.2.1 Measuring system

A complete measuring system comprises:

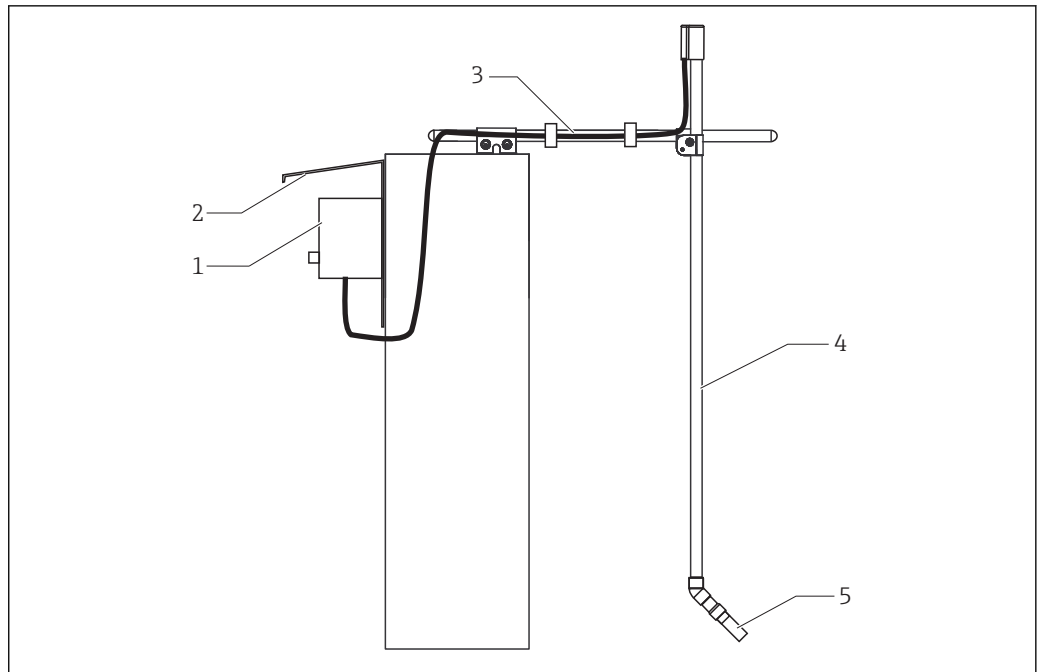
- Turbimax CUS51D turbidity sensor
- Liquiline CM44x multi-channel transmitter
- Assembly:
 - Flexdip CYA112 assembly and Flexdip CYH112 holder or
 - Retractable assembly, e.g. Cleanfit CUA451



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9 Measuring system with immersion assembly (example)

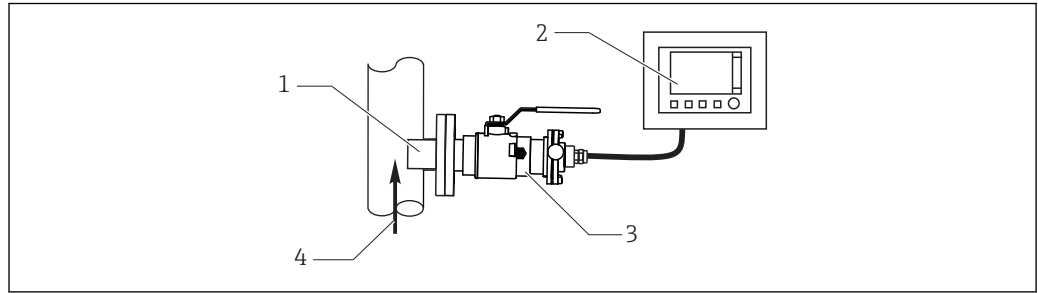
- 1 Flexdip CYH112 holder
- 2 Liquiline CM44x multi-channel transmitter
- 3 Protective cover
- 4 Flexdip CYA112 assembly
- 5 Turbimax CUS51D turbidity sensor



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10 Measuring system with immersion assembly (example)

- 1 Liquiline CM44x multi-channel transmitter
- 2 Protective cover
- 3 Flexdip CYH112 holder
- 4 Flexdip CYA112 assembly
- 5 Turbimax CUS51D turbidity sensor



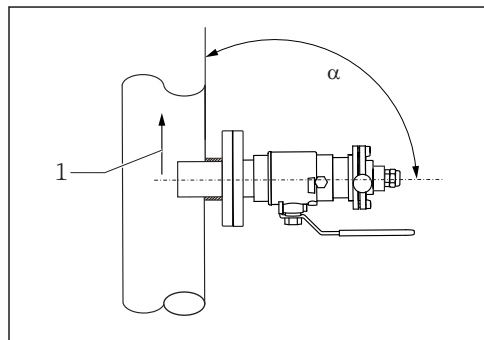
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11 Measuring system with retractable assembly (example)

- 1 Turbimax CUS51D turbidity sensor
- 2 Liquiline CM44x multi-channel transmitter
- 3 Cleanfit CUA451 retractable assembly
- 4 Direction of flow

5.2.2 Installation examples

Pipe installation

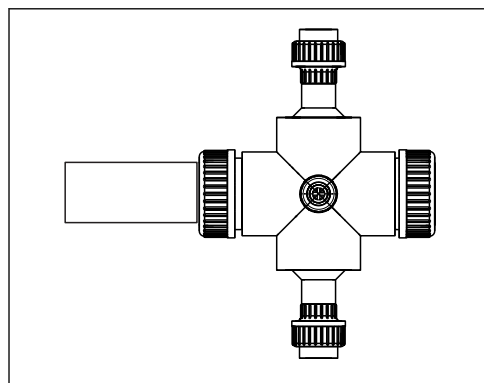


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12 Installing with retractable assembly

- 1 Direction of flow

Arrow 1 points in the direction of flow. The installation angle α must not exceed 90° . The recommended installation angle is 75° . The optical windows in the sensor must be aligned either parallel to the direction of flow ($\alpha = 90^\circ$) or against the direction of flow ($\alpha < 90^\circ$). The medium pressure may not exceed 2 bar (29 psi) for manual assembly retraction.

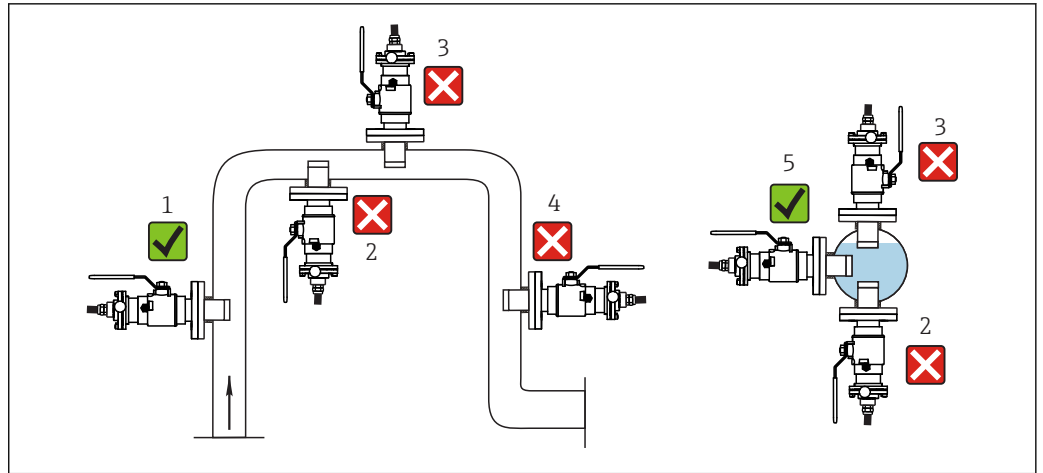


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13 Installing with CYA251 flow assembly

The installation angle is 90° . For turbidity measurements < 200 FNU, the backscattering of the internal surfaces of the assembly causes distortions in the measured values.

The following diagram shows different installation scenarios in pipes, indicating whether or not they are permitted.

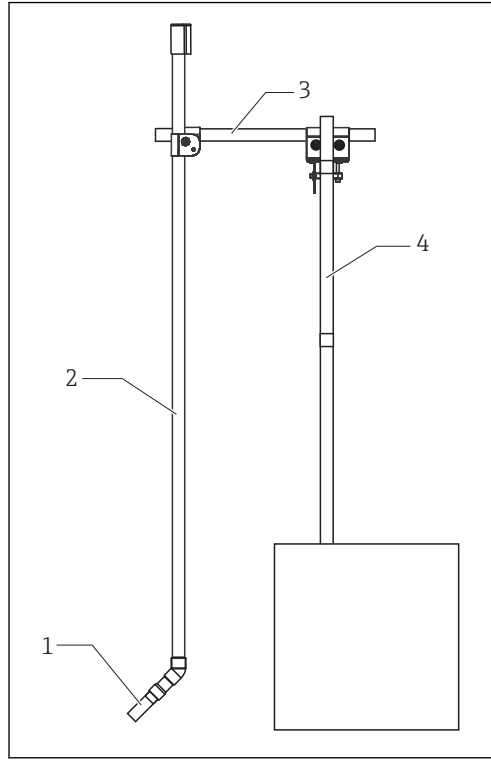


14 Orientations and positions (with CUA451 retractable assembly)

- When using reflective materials (e.g. stainless steel), the pipe diameter must be at least 100 mm (3.9 in). An onsite calibration is recommended.
- Install the sensor in places with consistent flow conditions.
- The best installation location is in the ascending pipe (item 1). Installation is also possible in the horizontal pipe (item 5).
- Do not install in places where air spaces or bubbles occur (item 3) or where sedimentation may occur (item 2).
- Avoid installation in the down pipe (item 4).
- When measuring turbidity < 200 FNU, the backscattering of the pipe wall causes distortions in the measured values. For this reason, a multipoint calibration is recommended here.
- Avoid fittings downstream from pressure reduction stages which can lead to outgassing.

Immersion operation

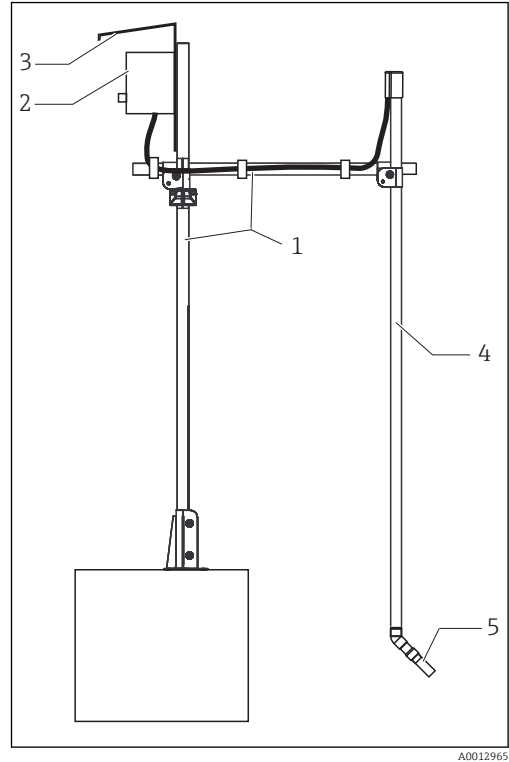
Fixed installation with wastewater assembly



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15 Installation secured on railing

- 1 Turbimax CUS51D turbidity sensor
- 2 Wastewater assembly Flexdip CYA112
- 3 Flexdip CYH112 holder
- 4 Rail



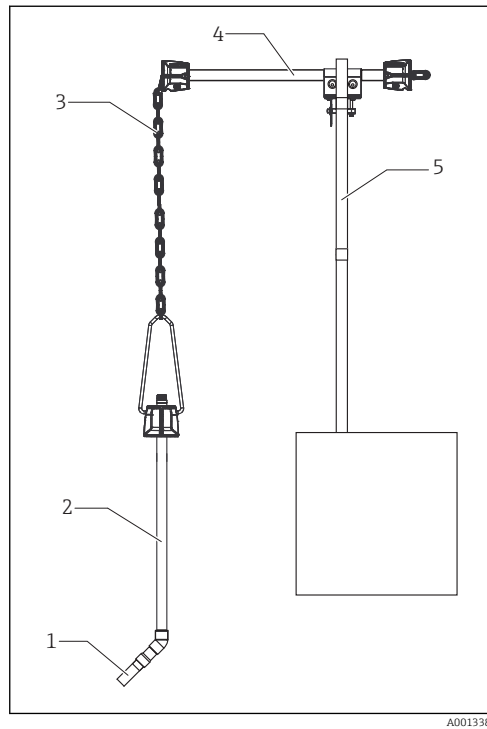
A0012965

16 Installation with upright post

- 1 Flexdip CYH112 holder
- 2 Liquiline CM44x multi-channel transmitter
- 3 Protective cover
- 4 Wastewater assembly Flexdip CYA112
- 5 Turbimax CUS51D turbidity sensor

This type of installation is particularly suitable for strong or turbulent flow (> 0.5 m/s (1.6 ft/s)) in basins or channels.

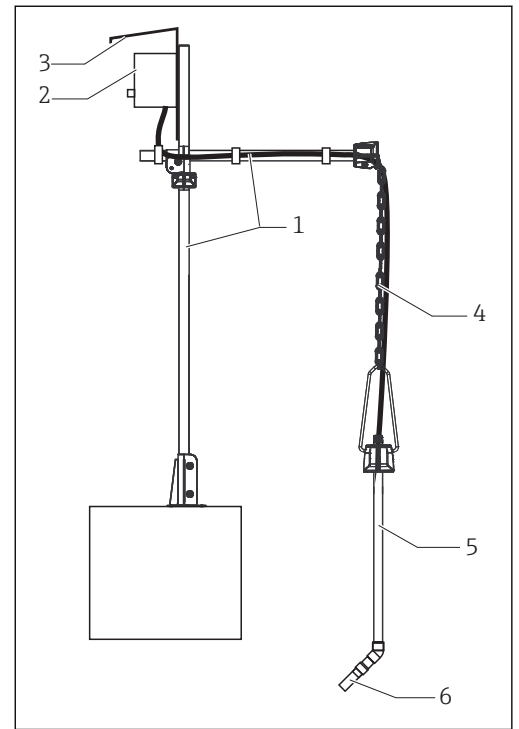
Installation with chain retainer



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17 Chain retainer on railing

- 1 Turbimax CUS51D turbidity sensor
- 2 Wastewater assembly Flexdip CYA112
- 3 Chain of Flexdip CYH112 holder
- 4 Flexdip CYH112 holder
- 4 Rail



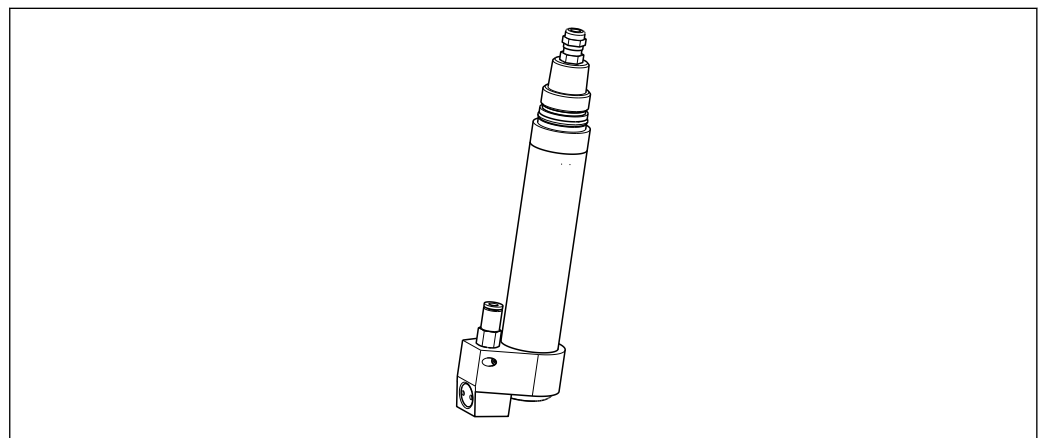
A0037077

18 Chain retainer on upright post

- 1 Rail
- 2 Liquiline CM44x multi-channel transmitter
- 3 Protective cover
- 4 Chain of Flexdip CYH112 holder
- 5 Wastewater assembly Flexdip CYA112
- 6 Turbimax CUS51D turbidity sensor

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.

Mounting the cleaning unit




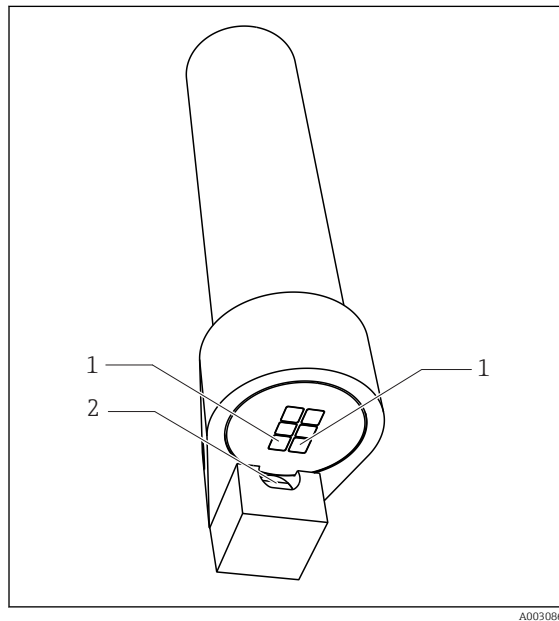
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19 Turbimax CUS51D sensor with cleaning unit

The cleaning unit is particularly suitable for clear water and media with a high fat content that tend to cause heavy buildup.

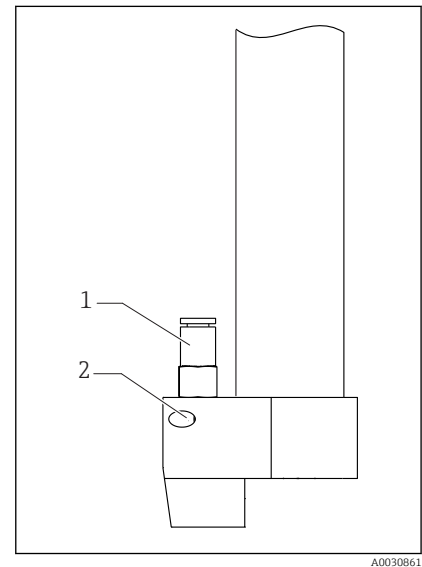
Mount the cleaning unit as follows:


1. Fit the cleaning unit onto the sensor as far as it will go.
2. Locate the two LEDs (they are installed at an angle and have a bright enclosure).
3. Position the cleaning unit in such a way that the nozzle is located at the side of the two LEDs (→  20).
4. Fix the cleaning unit in place with the securing screw (max. torque: 0.5 Nm (0.37 lbf ft)).
5. Insert the compressed air hose of the compressor into the hose connection.



 20 *Aligning the cleaning unit*

- 1 LEDs
- 2 Nozzle



 21 *Fixing the cleaning unit*

- 1 Hose connection
- 2 Fixing screw

5.3 Post-installation check

Put the sensor into operation only if the following questions can be answered with "yes":

- Are the sensor and cable undamaged?
- Is the orientation correct?
- Has the sensor been installed in the process connection, and does not suspend freely from the cable?

6 Electrical connection

⚠ WARNING

Device is live!

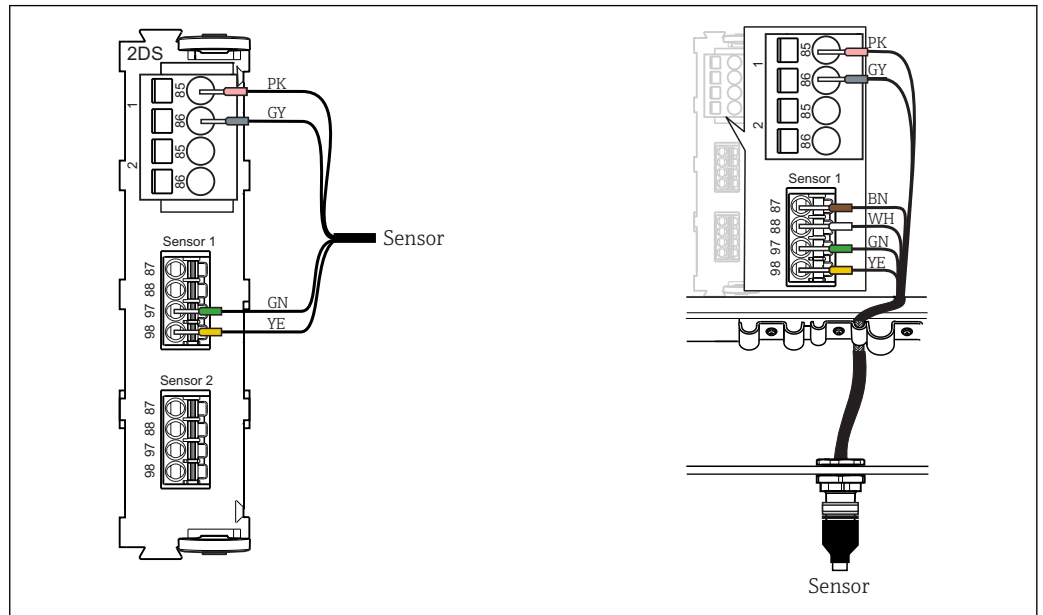
Incorrect connection may result in injury or death!

- ▶ 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 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)

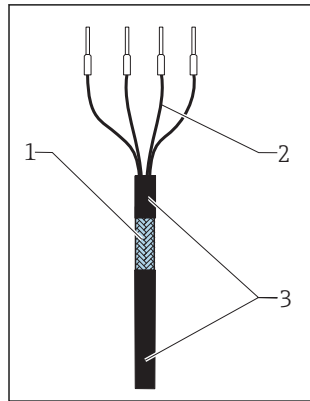


22 Sensor connection to sensor input (left) or via M12 connector (right)

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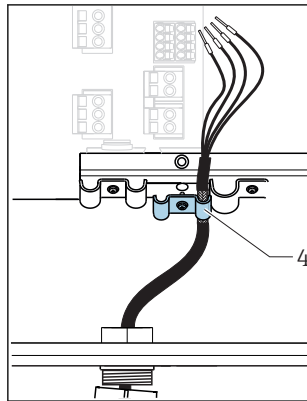
Connecting the cable shield

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



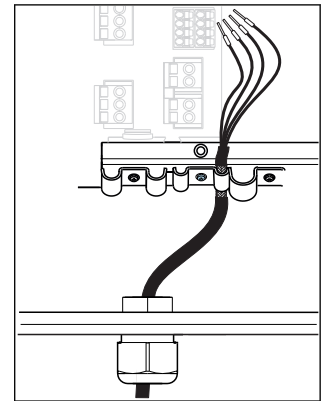
23 Terminated cable

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



24 Inserting the cable

- 4 Grounding clip



25 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).

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.

Individual types of protection permitted for this product (impermeability (IP), electrical safety, EMC interference immunity) can no longer be guaranteed if, for example :

- Covers are left off
- Different power units to the ones supplied are used
- Cable glands are not sufficiently tightened (must be tightened with 2 Nm (1.5 lbf ft) for the permitted level of IP protection)
- Unsuitable cable diameters are used for the cable glands
- Modules are not fully secured
- The display is not fully secured (risk of moisture entering due to inadequate sealing)
- Loose or insufficiently tightened cables/cable ends
- Conductive cable strands are left in the device

6.3 Post-connection check

Device condition and specifications	Notes
Are the sensor, assembly, or cables free from damage on the outside?	Visual inspection
Electrical connection	Notes
Are the mounted cables strain-relieved and not twisted?	
Is a sufficient length of the cable cores stripped, and are the cores positioned in the terminal correctly?	Check the fit (by pulling gently)
Are all the screw terminals properly tightened?	Tighten
Are all cable entries mounted, tightened and leak-tight?	For lateral cable entries, make sure the cables loop downwards to allow water to drip off
Are all cable entries installed downwards or mounted laterally?	

7 Commissioning

7.1 Function check



Prior to initial commissioning, ensure that:

- The sensor is correctly installed
- The electrical connection is correct.

8 Operation

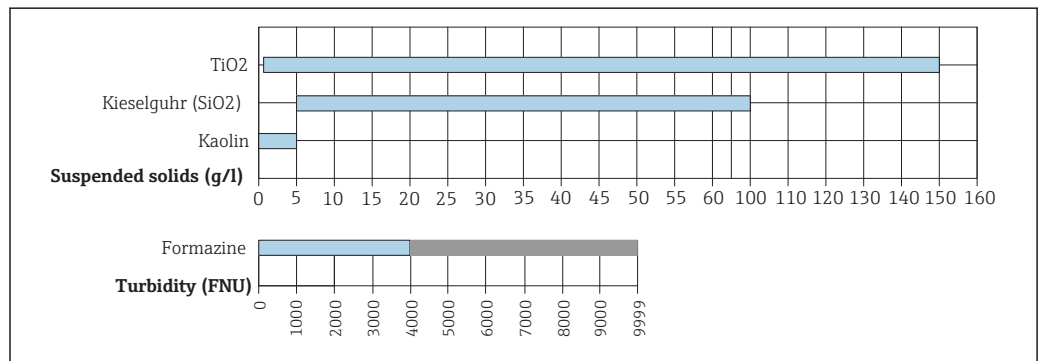
8.1 Adapting the measuring device to the process conditions

8.1.1 Applications

The sensor permits measurements in a wide variety of applications. The measuring method is set automatically by selecting the relevant application.

"Clear water" application type

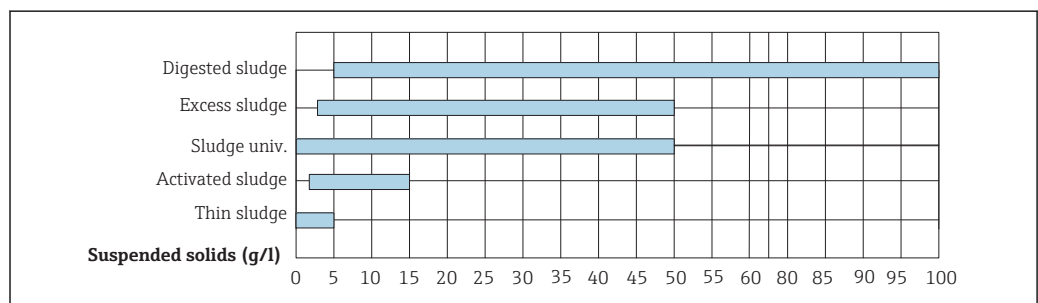
Application	Method	Measuring range
Formazine	135° - single-channel measurement	0 to 4000 FNU Display range up to 9999 FNU
Kaolin	135° - single-channel measurement	0 to 5 g/l
TiO ₂ (titanium dioxide)	135°, 4-beam pulsed light	0.2 to 150 g/l
SiO ₂ (silicon dioxide)	135°, 4-beam pulsed light	5 to 100 g/l



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"Solids" application type

Application	Method	Measuring range
Thin sludge	135° turbidity, single-channel	0 to 5 g/l
Sludge activation	90°, 4-beam pulsed light	2 to 15 g/l
Waste activated sludge	135°, 4-beam pulsed light	3 to 50 g/l
Sludge, univ.	135°, single-channel (for low TS content)	0 to 50 g/l
	135°, 4-beam pulsed light (for high TS content)	
Digested sludge	135° turbidity, single-channel	5 to 100 g/l / 300 g/l



A0038988-EN

Fields of application

Application (models)	Fields of application/use	Unit	Compensation* 1)
Formazine	Industrial water, WWTP outlet	FNU / NTU	
Kaolin	Filterable matter, industrial water, WWTP outlet, low concentrations of activated sludge	mg/l; g/l; ppm; %	
SiO ₂	SiO ₂ , mineral-based solids (sand)	g/l; ppm; %	X
TiO ₂	TiO ₂ , (white media)	g/l; ppm; %	X
Thin sludge	Thin sludge from activated sludge to clear water	g/l; ppm; %	
Activated sludge	Activated sludge basin and similar media	g/l; ppm; %	X
Waste activated sludge	Universal usage for sludge in wastewater sector between 5 and 50 g/l (activated sludge, return activated sludge, ...)	g/l; ppm; %	X
Sludge, univ.	Universal usage for clear water to sludge with high concentrations of solids, e.g. sludge extraction in thickeners. 0 g/l to 50 g/l	g/l; ppm; %	X
Digested sludge	Contaminated sludge, black homogeneous	g/l; ppm; %	

1) Contamination compensation with 4-beam pulsed light

 Fields of use and associated applications →  25

NOTICE**Multiple scattering in the following applications: formazine, kaolin and thin sludge**

If the specific operational range is exceeded, the measured value displayed by the sensor can decrease despite increasing turbidity or increasing TS content. The indicated operational range is reduced in the case of highly absorbing (e.g. dark) media.

- In the case of highly absorbing (e.g. dark) media, determine the operational range experimentally beforehand.

8.1.2 Calibration

The sensor is precalibrated on leaving the factory. It can therefore be used in a wide variety of applications (e.g. clear water measurements) without the need for additional calibration. The factory calibrations are based on a 3-point calibration in each case. The formazine application is already fully calibrated and can be used without any further calibration.

All other applications are precalibrated with reference samples and require calibration to the corresponding application.

In addition to the factory calibration data, which cannot be modified, the sensor has five other data records to be used for storing process calibrations.

Application selection

- During initial commissioning or calibration at the CM44x, select the appropriate application for your field of application.

Application: Wastewater

Field of application	Application
Inlet	Waste activated sludge (g/l, %TS), Turbidity (formazine (FNU, NTU), thin sludge (mg/l, g/l))
Primary sludge extraction, primary clarification	Waste activated sludge (g/l, %TS), Digested sludge (g/l, %TS)

Field of application	Application
Activated sludge basin, 0 to 5 g/l range, e.g. SBR	Thin sludge (mg/l, g/l)
Activated sludge basin, 2 to 15 g/l range	Activation (mg/l, g/l), Waste activated sludge (g/l, %TS),
Sequencing batch reactors Range from 0 to approx. 50 g/l	Universal model (mg/l, g/l, %TS) For applications with wide dynamic range, from clear water to high solids content
Recirculation pipe	Waste activated sludge (g/l, %TS)
Waste activated sludge extraction	Waste activated sludge (g/l, %TS), digested sludge (g/l, %TS)
Sludge thickener (primary sludge)	Waste activated sludge (g/l, %TS), Digested sludge (g/l, %TS)
Digester inlet	Waste activated sludge (g/l, %TS), Digested sludge (g/l, %TS)
Digester outlet (sludge)	Digested sludge (g/l, %TS), Waste activated sludge (g/l, %TS),
WWTP outlet	Turbidity (formazine (FNU, NTU), kaolin (mg/l, g/l)), thin sludge (mg/l, g/l)
Sand filter monitoring	Turbidity (formazine (FNU, NTU), thin sludge (mg/l, g/l))

Preferred applications are highlighted in bold.

Application: process water

Field of application	Application
Inlet	Turbidity (formazine (FNU, NTU), kaolin (mg/l, g/l))
Process control	SiO₂ (ppm, g/l), TiO₂ (ppm, g/l)
Filter flushing	Turbidity (formazine (FNU, NTU), kaolin (mg/l, g/l)), thin sludge (mg/l, g/l)
Sedimentation tank	Thin sludge (mg/l, g/l), waste activated sludge (g/l, %TS), digested sludge (g/l, %TS)
Process water	Turbidity (formazine (FNU, NTU), kaolin (mg/l, g/l), SiO₂ (ppm, g/l), TiO₂ (ppm, g/l))
Process sludges	Turbidity (formazine (FNU, NTU), kaolin (mg/l, g/l), SiO₂ (ppm, g/l), TiO₂ (ppm, g/l))

Preferred applications are highlighted in bold.


Selecting the calibration type

1 to 5 points can be calibrated for all applications.


The following recommendation describes the usual calibration types.

Model	1-point calibration (in medium)	At least 2-point calibration (outside medium)
Formazine	X	
Kaolin	X	
SiO ₂		X
TiO ₂		X
Thin sludge	X	
Activated sludge		X
Univ. sludge	X	

Model	1-point calibration (in medium)	At least 2-point calibration (outside medium)
Waste activated sludge		X
Digested sludge		X

 The "thin sludge" model enables measurements in any sludge applications from 0 to 5 g/l. The "univ. sludge" model enables measurements in any sludge applications from 0 to 50 g/l. These models can be calibrated at a single point in the process during operation.

1-point and 2-point calibrations are based on the data record stored internally in the device. Calibration at 3 or more points always causes the measuring curve to be recalculated.

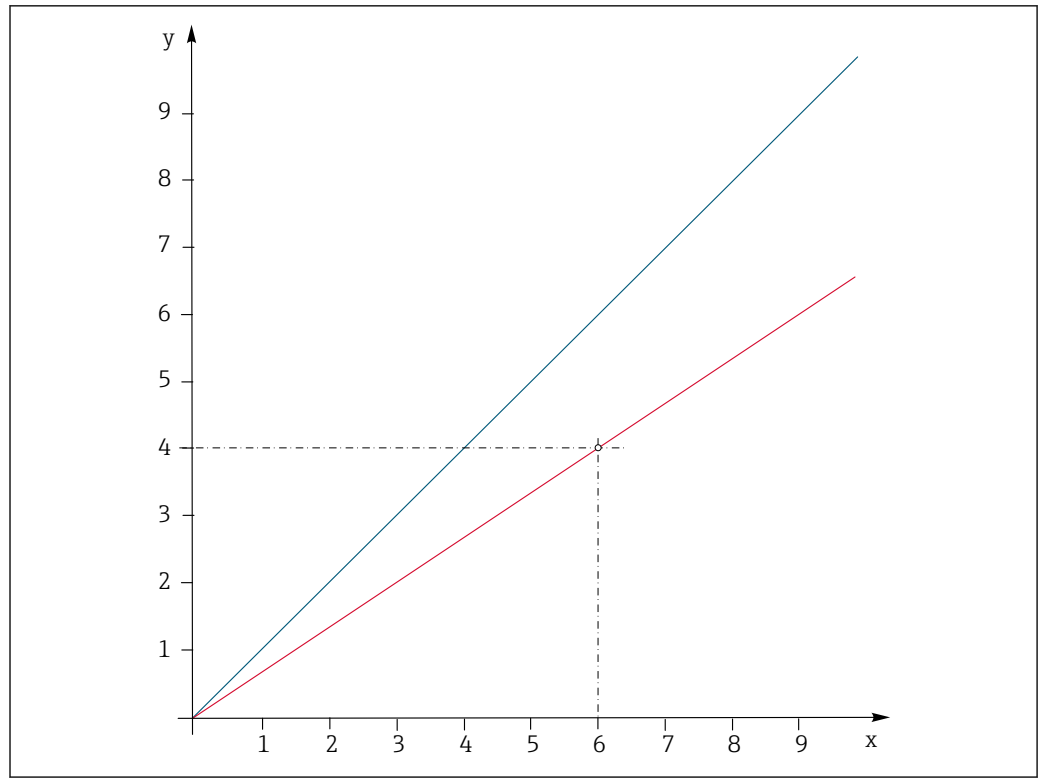
 For multipoint calibrations, the calibration points should always cover the complete measuring range of the application. Points outside the specified measuring range of the application (model) may not be selected.

A calibration with zero water (0 g/l) will result in unusable calibrations for the following applications:

- Activated sludge
- Waste activated sludge
- Digested sludge
- SiO₂
- TiO₂

1-point calibration

The measured error between the measured value of the sensor 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
 Blue Factory calibration
 Red Application calibration

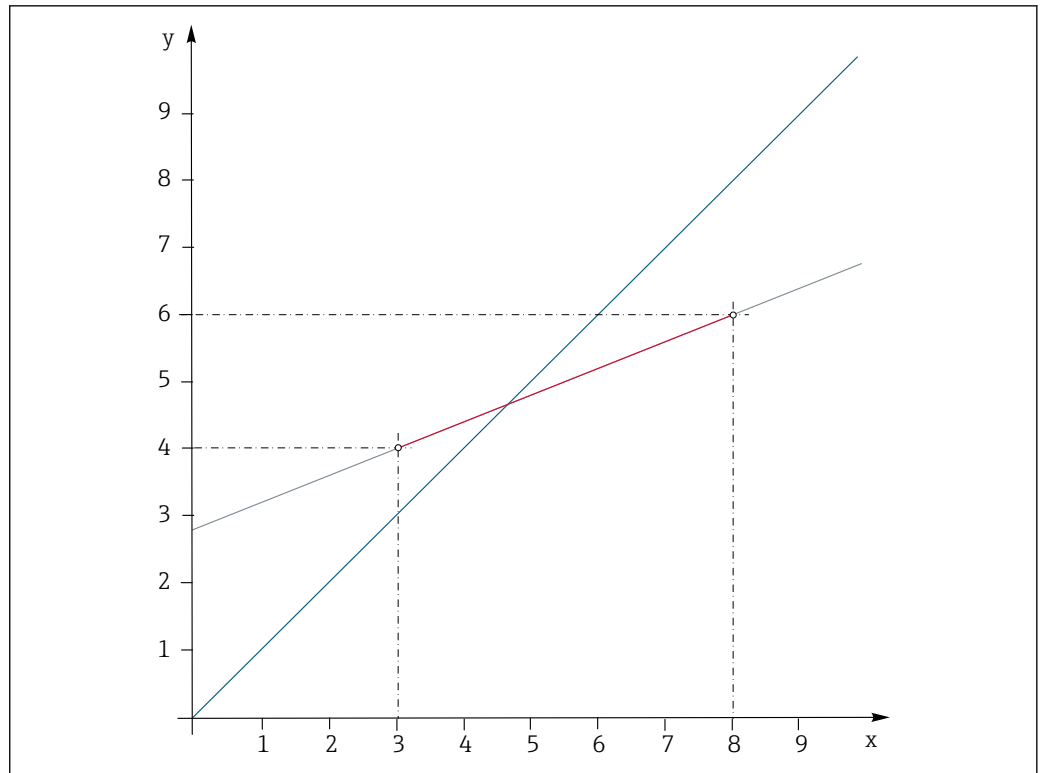
1. Select data record.
2. Set the calibration point in the medium and enter the target sample value (laboratory value).

With 1-point calibration, the sensor can remain immersed in the process medium.

1. For the laboratory measurement, take a sample of the medium in the direct vicinity of the sensor.
2. Give the sample to the laboratory so that the turbidity or solids content can be determined.
3. Select a data record on the CM44x transmitter.
4. If possible, start the calibration at the same time as the sampling procedure and enter the laboratory value of the sample as the set point.
5. Enter an approximate value as the set point if no laboratory value is available during calibration.
 - ↳ As soon as the laboratory value is available, amend the set point on the transmitter.

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.



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27 Principle of a 2-point calibration

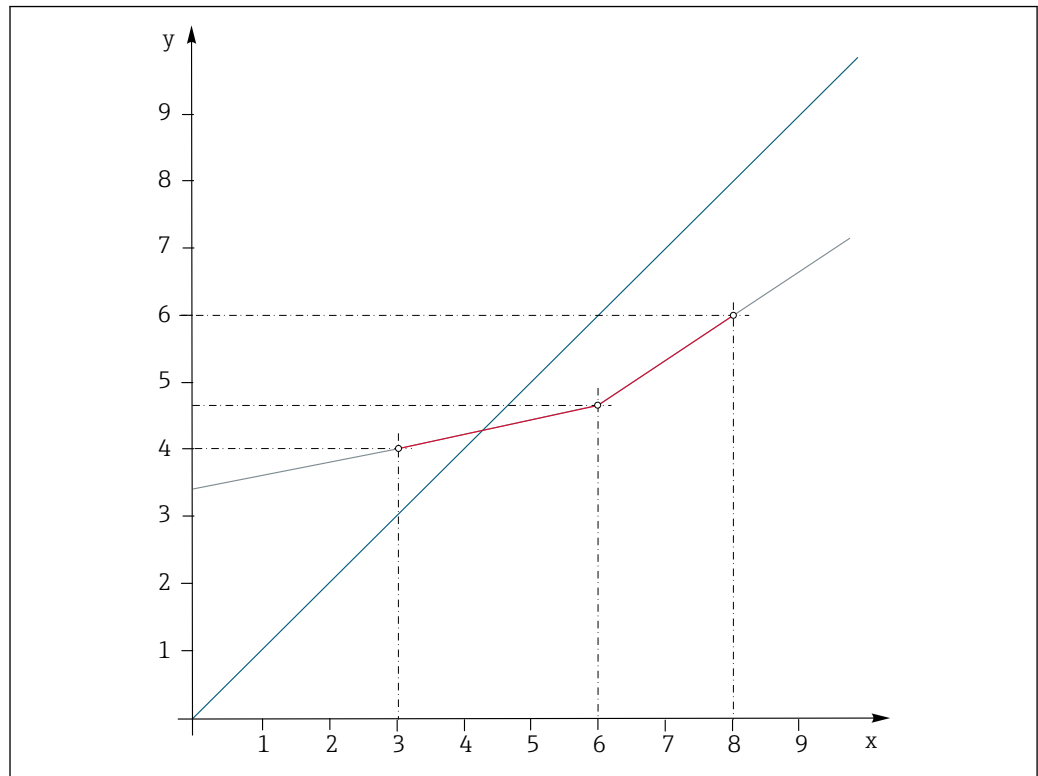
x Measured value
 y Target sample value
 Blue Factory calibration
 Red Application calibration

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

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

The calibration curve must be monotonically increasing.

Multipoint calibration



A0039322

28 Principle of multipoint calibration (3 points)

x Measured value
 y Target sample value
 Blue Factory calibration
 Red Application calibration

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

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

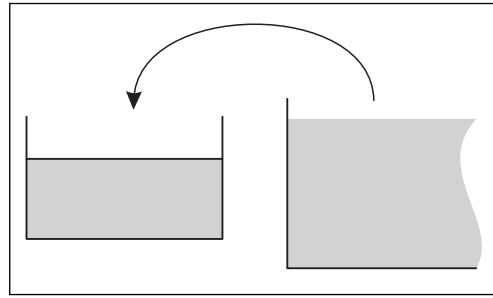
The calibration curve must be monotonically increasing.

CAUTION

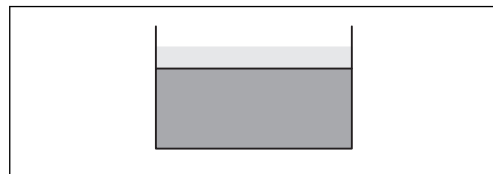
Acid or medium

Risk of injury, damage to clothing and the system!

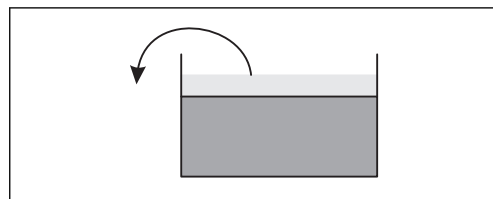
- ▶ Switch off the cleaning unit before removing the sensor from the medium.
- ▶ Wear protective goggles and safety gloves.
- ▶ Clean away splashes on clothes and other objects.



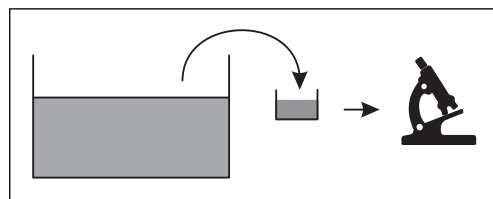
1. Take a sample from the process (e.g. 10 l (2.6 gal) bucket).



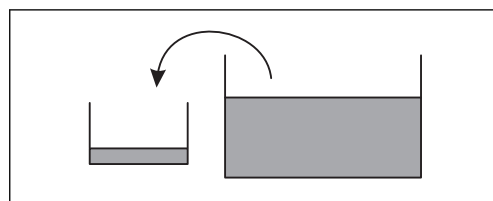
2. Wait until the sludge components have settled.



3. Siphon off the excess water (if possible) in order to increase the concentration of the sample. Stir the sample to make it more homogeneous.



4. Remove a portion of the sample for laboratory analysis.




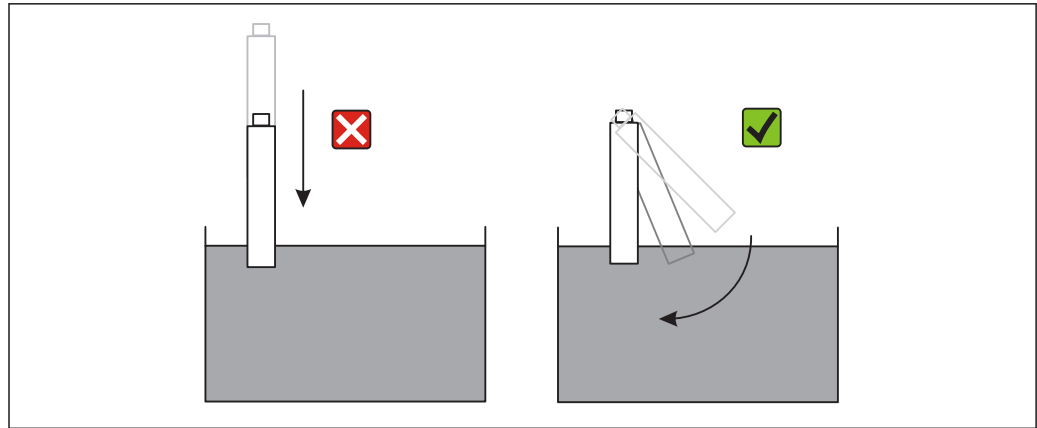
5. Transfer a defined amount of the sample (e.g. 2 l (0.5 gal)) to the calibration vessel (bucket). Continue stirring the sample to maintain homogeneity.

Calibration of the CUS51D sensor

Preparing the CUS51D sensor for calibration

1. Clean the optical components (windows) of the sensor with water and a brush.
2. Place the sensor into the calibration vessel.

 The sensor must be placed in the sample at an angle, not vertically. This prevents air bubbles from adhering to the windows.

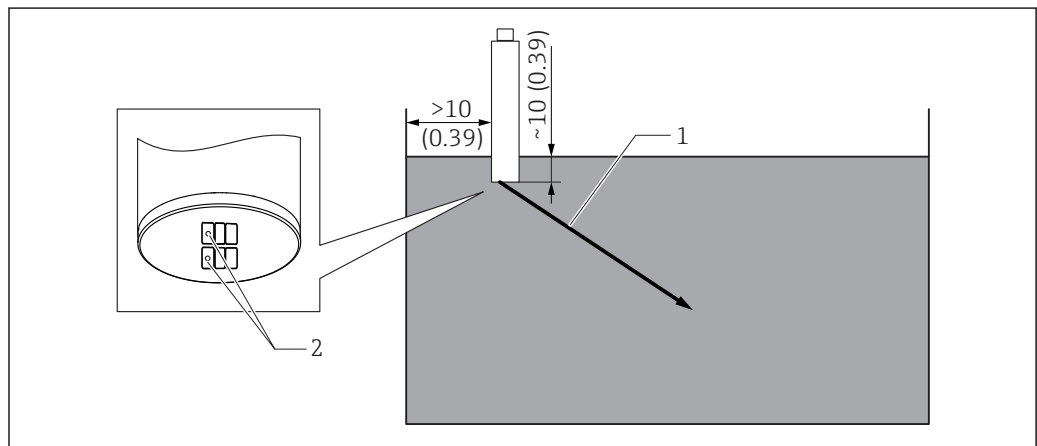


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29 Immersing the sensor

Observe the following:

- Sensor LEDs should be directed at the center of the calibration vessel.
 - The minimum distance of the sensor to the vessel wall is 10 mm (0.4 in).
 - The sensor should be distanced as far as possible from the bottom of the vessel, but at least 10 mm (0.4 in) of the sensor must be immersed.
- Secure the sensor in this position (ideally using a laboratory stand).



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30 Positioning the sensor. Dimensions: mm (in)

- 1 Beam direction of LEDs
2 LEDs

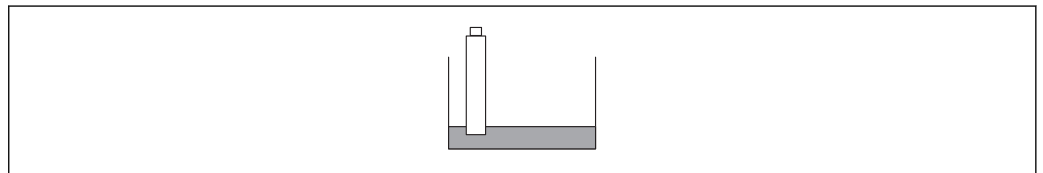
Note the following during calibration:

- The calibration points should cover the complete measuring range.
- During calibration, ensure that the medium is well homogenized (use a magnetic stirrer).
- Determine the laboratory measured values with utmost care (the quality of the laboratory measurement has a direct influence on the accuracy of the sensor).
- Apply maximum precision when dosing volumes for the sample and the dilution water (use a graduated cylinder).
- Air bubbles on optical components significantly interfere with the calibration result. For this reason, remove air bubbles before every calibration action.
- Make sure the medium is always well mixed (homogeneity).

- Avoid temperature changes during the calibration.
Ensure that the temperatures of the dilution water and the medium are as identical as possible.
- Do not alter the position of the sensor during calibration.
- It is also possible to edit the calibration set points in the CM44x at a later stage (e.g. if the reference value of the laboratory measurement is not yet known at the time of calibration).

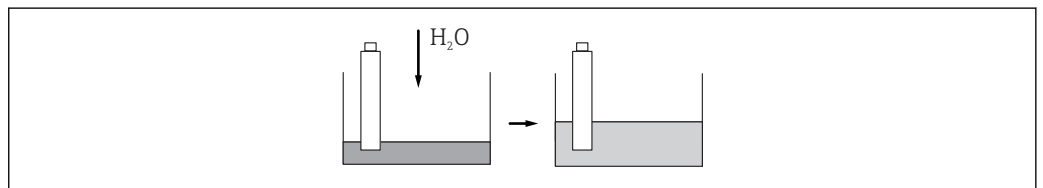
Perform the calibration (example of a 3-point calibration)

1. Select a data record on the CM44x transmitter.
2. Wait at least 1 minute (to stabilize).
3. Start the calibration for measuring point 1 (e.g. 2 l (0.5 gal) sample with a concentration of 6 g/l).
4. Enter the value of the sample determined in the laboratory as the set point (e.g. 6 g/l) or edit the value later.



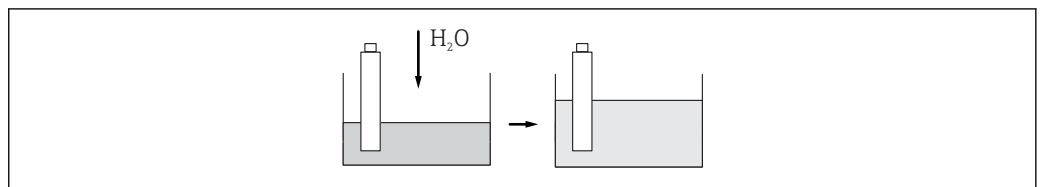
A0020489

5. Perform a 1:2 dilution of the sample. Add water (2 l (0.5 gal)), results in 3 g/l in the example.




A0030901

6. Avoid air bubbles beneath the sensor.
7. Calibrate measuring point 2. For the set point, enter half of the laboratory value.
8. Perform a 1:3 dilution of the sample. Add water (2 l (0.5 gal)), results in 2 g/l in the example.



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9. Avoid air bubbles beneath the sensor.
10. Calibrate measuring point 3. For the set point, enter one third of the laboratory value, or edit the value at a later stage.

 The calibration can also be performed in increasing concentrations (less advisable).

Stability criterion


During calibration, the measured values provided by the sensor are checked to ensure they are constant. The maximum deviations that may occur in measured values during a calibration are defined in the stability criterion.

The specifications comprise the following:

- 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

The calibration resumes as soon as the stability criteria for signal values and temperature have been reached. If these criteria are not met in the maximum time frame of 5 minutes, no calibration is performed - 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 highest possible calibration quality in the shortest possible time frame while taking external conditions into account.

 For calibrations in the field in adverse weather and environmental conditions, the measured value windows selected can be suitably large and the time frame selected can be suitably short.

8.1.3 Cyclic cleaning

For cyclic cleaning, compressed air is the most suitable option. The cleaning unit is either supplied or can be retrofitted, and is attached to the sensor head. The following settings are recommended for the cleaning unit:

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

9 Diagnostics and troubleshooting


9.1 General 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	<ul style="list-style-type: none"> ■ Power supplied to transmitter? ■ Sensor connected correctly? ■ Buildup on optical windows? 	<ul style="list-style-type: none"> ■ Connect mains voltage ■ Connect sensor correctly ■ Clean sensor
Display value too high or too low	<ul style="list-style-type: none"> ■ Buildup on optical windows? ■ Sensor calibrated? 	<ul style="list-style-type: none"> ■ Cleaning ■ Calibration
Display value fluctuating greatly	Is the mounting location correct?	<ul style="list-style-type: none"> ■ Select a different mounting location ■ Adjust the measured value filter

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

10 Maintenance

- ▶ 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

CAUTION

Acid or medium

Risk of injury, damage to clothing and the system!

- ▶ Switch off the cleaning unit before removing the sensor from the medium.
- ▶ Wear protective goggles and safety gloves.
- ▶ Clean away splashes on clothes and other objects.

10.1 Maintenance tasks

10.1.1 Clean 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.
After cleaning:	
▶ Rinse the sensor thoroughly with water.	

11 Repair

11.1 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.

11.2 Disposal

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

- ▶ Observe the local regulations.

12 Accessories

12.1 Assemblies

FlowFit CUA120

- Flange adapter for mounting turbidity sensors CUS
- Product Configurator on the product page: www.endress.com/cua120



Technical Information TI096C

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

Cleanfit CUA451

- Manual retractable assembly made of stainless steel with ball valve shut-off for turbidity sensors
- Product Configurator on the product page: www.endress.com/cua451



Technical Information TI00369C

Flowfit CYA251

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



Technical Information TI00495C

12.2 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 capstone, on the wall or directly onto railings.
- Plastic or stainless steel version
- Product Configurator on the product page: www.endress.com/cyh112

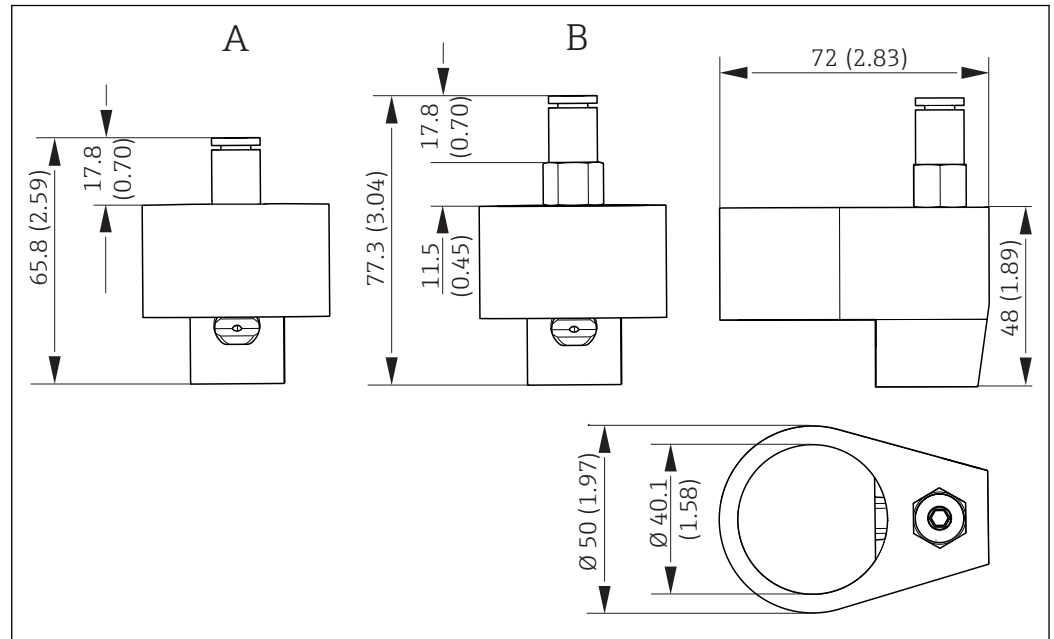


Technical Information TI00430C

12.3 Compressed air cleaning

Compressed air cleaning for CUS51D

- Connection: 6 mm (0.24 in) or 8 mm (0.31 in) (metric) or 6.35 mm (0.25 in)
- Materials: POM/V4A
- 6 or 8 mm order no.: 71110782
- 6.35 mm order no.: 71110783



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31 Compressed air cleaning. Dimensions: mm (in)

A Version 6 mm (0.24 in)

B Version 6.35 mm (0.25 in)

Compressor

- For compressed air cleaning
- 230 V AC order no. 71072583
- 115 V AC order no. 71194623

13 Technical data

13.1 Input

Measured values

- Turbidity
- Solids content
- Temperature

Measuring range

CUS51D-**C1		Application
Turbidity	0,000 to 4000 FNU Display range up to 9999 FNU	Formazine
Solids content	0 to 5 g/l	Kaolin, filterable matter
Temperature	-20 to 80 °C (-4 to 176 °F)	

CUS51D-**D1		Application
Turbidity	0,000 to 4000 FNU Display range up to 9999 FNU	Formazine
Solids content	0 to 300 g/l 0 to 30 %	Solids content depending on the selected application (see list)
Temperature	-20 to 80 °C (-4 to 176 °F)	

 Measuring range with solids content:

For solids, the achievable ranges depend very much on the media that are actually present and may differ from the recommended operating ranges. Extremely inhomogeneous media may cause fluctuations in measured values, thus narrowing the measuring range.


13.2 Performance characteristics

Reference operating conditions

20 °C (68 °F), 1013 hPa (15 psi)

Maximum measured error

Turbidity < 2% of measured value or 0.1 FNU (the greater value applies in each case).
Solids < 5% of the measured value or 1% of the upper range value (the greater value applies in each case); applies to sensors that are calibrated for the observed measuring range.

 The measured error encompasses all inaccuracies of the measuring chain (sensor and transmitter). However, it does not include the inaccuracy of the reference material used for calibration.

Factory calibration

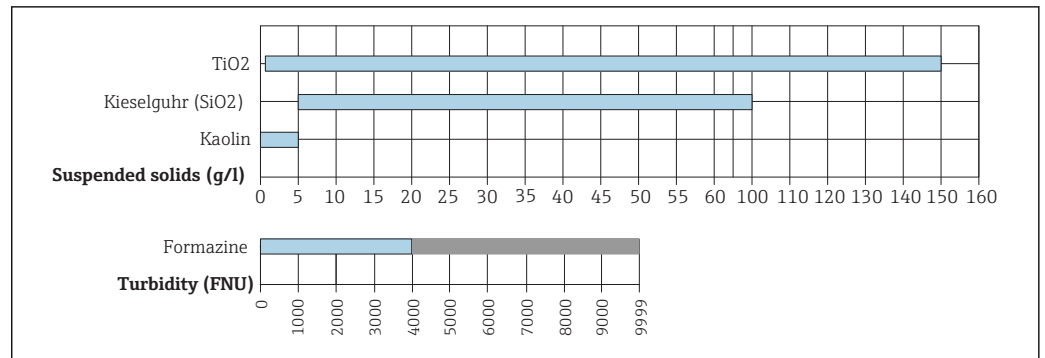
FNU and NTU in accordance with application table
Standard: 3 points

Applications

The sensor has been calibrated in the factory for "formazine" applications. All other applications are precalibrated with reference samples and require calibration to the corresponding application.

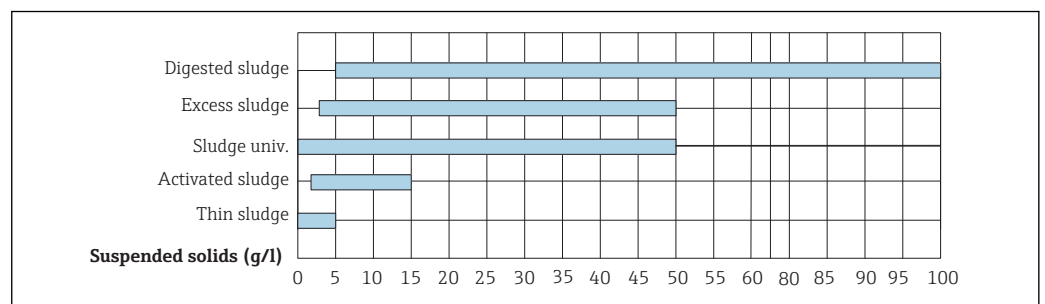
Calibration can be performed with up to 5 points.

Clear water application type	Recommended operating ranges	CUS51D	
		C1	D1
Application: Formazine	0 to 4000 FNU	X	X
Application: Kaolin	0 to 5 g/l	X	X
Application: SiO ₂	5 to 100 g/l		X
Application: titanium dioxide	0.2 to 150 g/l		X



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Solids application type	Recommended operating ranges	CUS51D	
		C1	D1
Application: thin sludge	0 to 5 g/l		X
Application: activated sludge	2 to 15 g/l		X
Application: waste activated sludge	3 to 50 g/l		X
Application: univ. sludge	0 to 50 g/l		X
Digested sludge application	5 to 100 g/l / 300 g/l		X



A0038988-EN

i For solids, the achievable ranges depend very much on the media that are actually present and may differ from the recommended operating ranges.

Drift

Working on the basis of electronic controls, the sensor is largely free of drifts.

Detection limits	Application	Measuring range	Detection limit
	Formazine		0 to 50 FNU
		0 to 4000 FNU	0.4 FNU
Kaolin		0 to 5000 mg/l	0.85 mg/l

13.3 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)

13.4 Process

Process temperature range -5 to 50 °C (23 to 122 °F)
Up to 80 °C (176 °F) for a short period of time (1 h)

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.

13.5 Mechanical construction

Dimensions → Section "Installation"

Weight Approx. 0.7 kg (1.5 lb) without cable

Materials	Sensor	Stainless steel 1.4404 (AISI 316 L) Stainless steel 1.4571 (AISI 316 Ti)
	Optical windows	Sapphire
	O-rings	EPDM

Process connections G1 and NPT 3/4"

Index

0 ... 9

4-beam pulsed light method	9
90° scattered light method	10
135° backscattered light method	10

A

Accessories	38
Applications	25
Approvals	13

C

Calibration	25
Certificates	13
Cleaning	34, 36
Cyclic cleaning	34

D

Designated use	5
Diagnostics	35
Dimensions	14
Disposal	37

E

Electrical connection	21
Environment	42

F

Function check	23
--------------------------	----

I

Immersion operation	18
Incoming acceptance	12
Input	40
Installation	14
Installation examples	16

M

Maintenance	36
Measuring methods	9
Measuring principle	7
Measuring system	14
Mechanical construction	42

N

Nameplate	12
---------------------	----

P

Performance characteristics	40
Pipe installation	16
Post-connection check	22
Post-installation check	20
Process	42
Product description	7
Product design	7
Product identification	12

R

Repair	37
Return	37

S

Safety instructions	5
Scope of delivery	13
Sensor structure	7
Stability criterion	34
Symbols	4

T

Technical data	40
Troubleshooting	35

U

Use	5
---------------	---

W

Warnings	4
Wiring	21



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