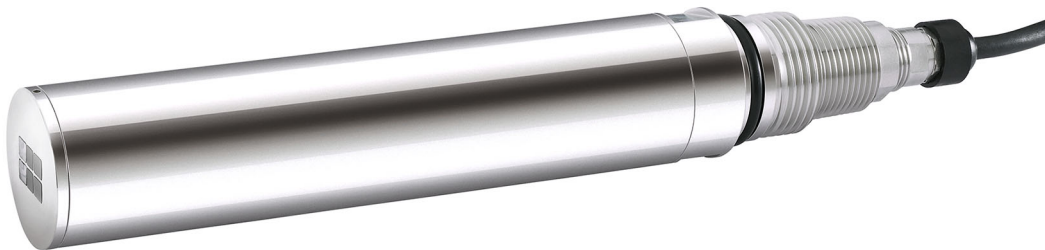


# Technical Information

## Turbimax CUS51D

Turbidity and solids content sensor, inline and immersion sensor for low, medium and high turbidity and solids concentrations



### Application

Turbimax CUS51D is a sensor for all wastewater treatment applications.

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

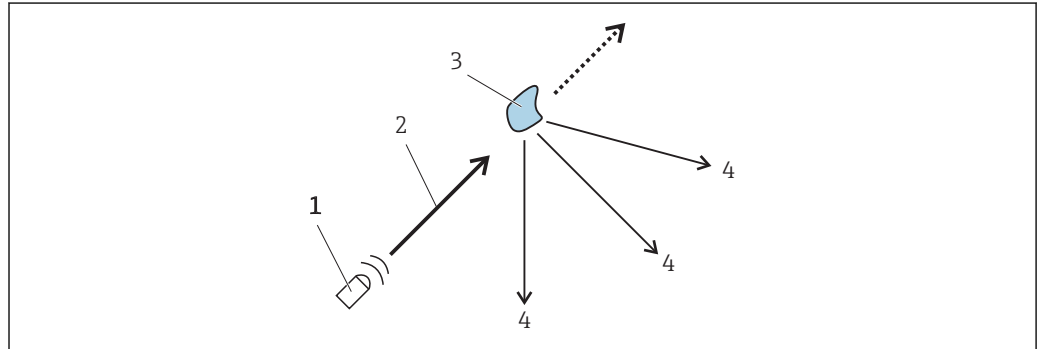
### Your benefits

- All sensor principles (90°, 135° and four-beam pulsed light) are contained in the sensor head and enable optimum adaptation to the measuring task.
- The sensor is calibrated in the factory (on the basis of formazine). All applications available for selection (e.g. activated sludge) are precalibrated, therefore enabling fast and easy commissioning.
- Standardized communication (Memosens technology) enables "plug and play".
- Intelligent sensor - all characteristics and calibration values are stored in the sensor.
- Customer calibrations with 1 to 5 points (max.) - can be performed in the lab or at place of installation.

## Function and system design

### 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.



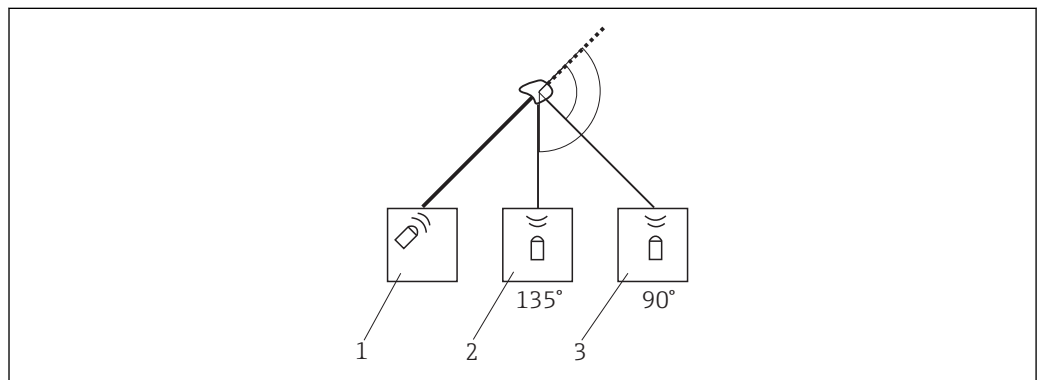
A0030850

#### 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. Two angle ranges are of particular interest here:

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

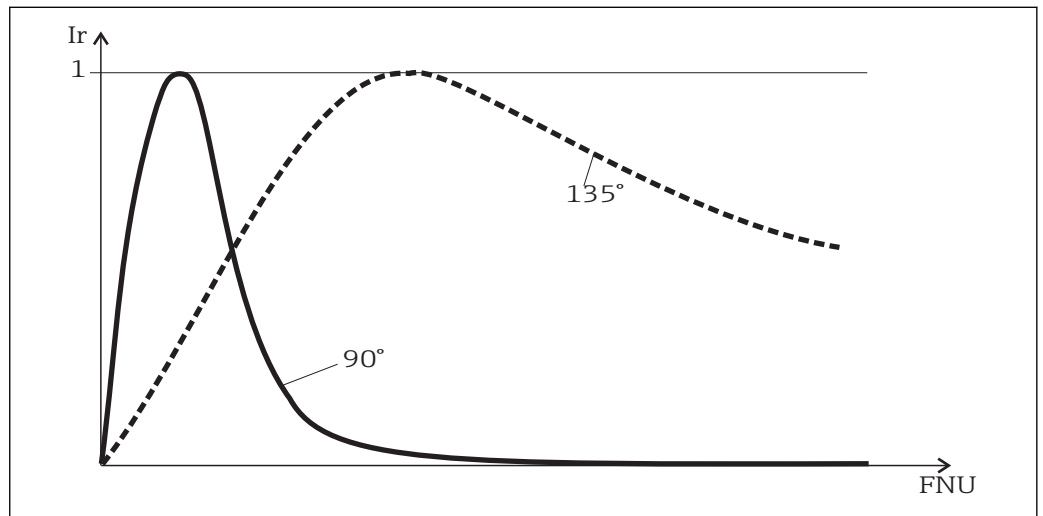


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#### 2 Principle mode of operation of turbidity sensor

- 1 Light source
- 2  $135^\circ$  light receiver
- 3  $90^\circ$  light receiver

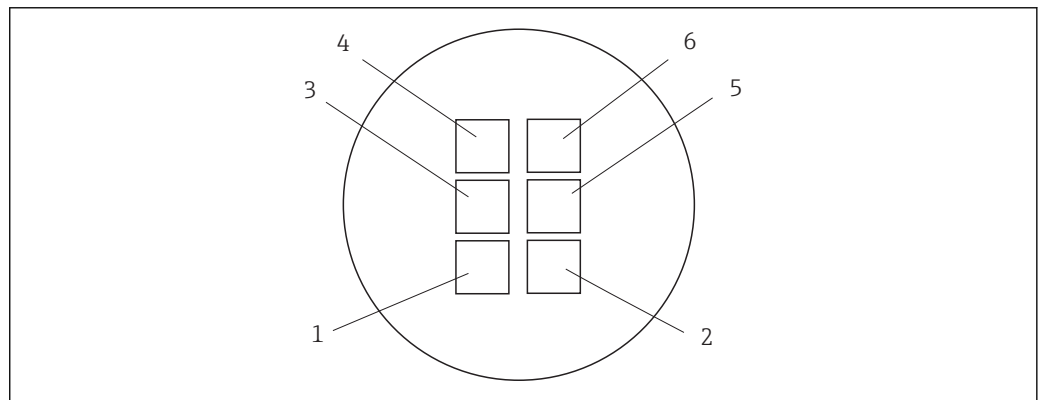
If the particle density in the medium is low, a large amount of light is scattered in the 90° channel and a small amount of light is scattered in the 135° channel. As the particle density increases, this ratio shifts (more light in the 135° channel, less light in the 90° channel).



3 Signal distribution as a function of the particle density

*Ir* Relative intensity

The CUS51D turbidity sensor has two 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

This enables optimum measurement of turbidity and solid matter:

- The 90° channel is often used for low turbidity values.
- The 135° channel is used for moderate and high turbidity values and also for solids measurement.
- To a large extent, the dual sensors enable operation regardless of fouling, e.g. solids measurement in sludge activation basin (using four-beam pulsed light).

The selection of the measuring principle is linked to the customer's application selection and is performed automatically in the sensor.



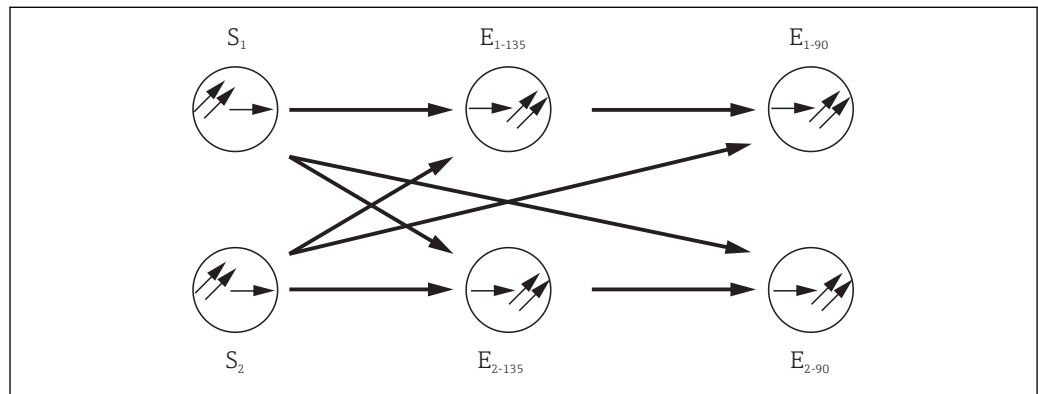
The sensor types available vary in terms of their measuring ranges and therefore the range of available applications.

## Measuring methods

### Four-beam pulsed light method

This method is based on two light sources and four light receivers. Long-life LEDs are used as monochromatic light sources. These LEDs are pulsed alternately and generate four 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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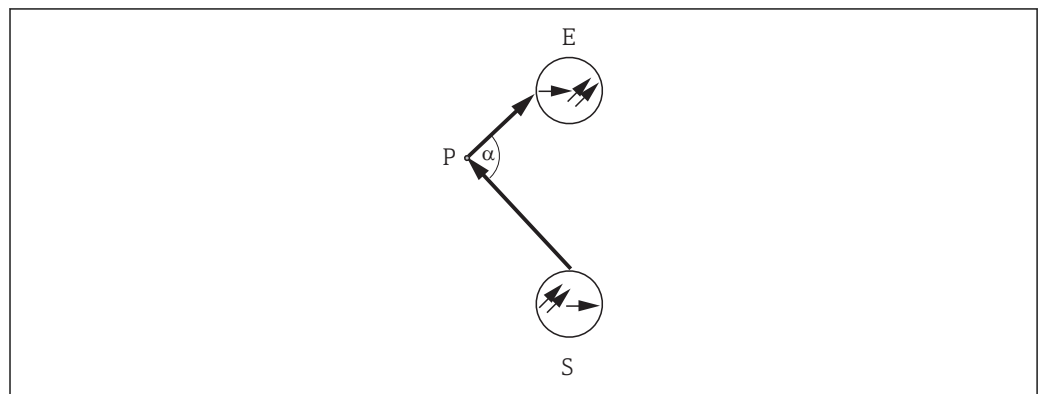
5 Four-beam pulsed light method

- $S_1 S_2$  Light source
- $E_{90}$  Light receiver for  $90^\circ$  scattered light
- $E_{135}$  Light receiver for  $135^\circ$  scattered light

90° scattered light method

Measurement is performed with a wavelength of 860 nm, 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  $90^\circ$  to the light sources. The turbidity of the medium is determined by the amount of scattered light.



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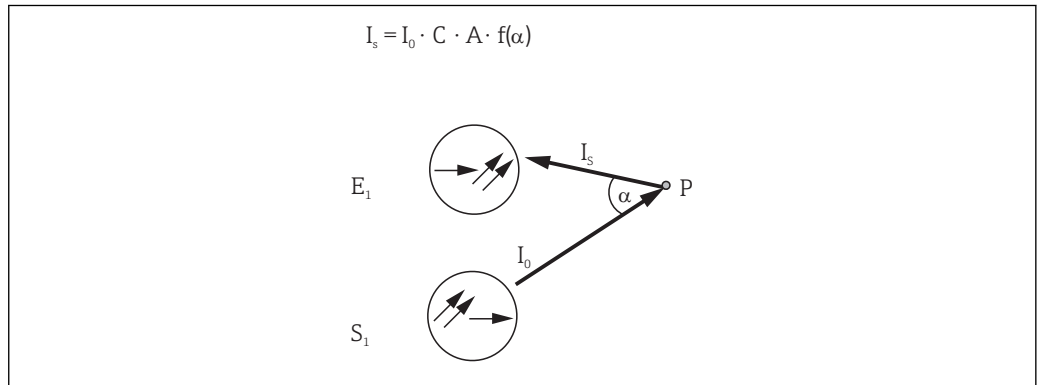
6 90° scattered light method

- $S$  Light source
- $E$  Receiver
- $P$  Particle

135° scattered 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.



A0030855

7 Principle of backscattered light method

$I_o$  Intensity of transmitted light

$I_s$  Intensity of scattered light

$A$  Geometric factor

$C$  Concentration

$P$  Particle

$f(\alpha)$  Angle correlation

**Sensor monitoring**

The optical signals are continuously monitored and analyzed for plausibility. If inconsistencies occur, an error message is output via the transmitter.

In addition, the following fault states are detected in conjunction with the Liquiline M's sensor check system:

- Implausibly high or low measured values
- Disturbed regulation due to incorrect measured values

**Applications***Areas of application*

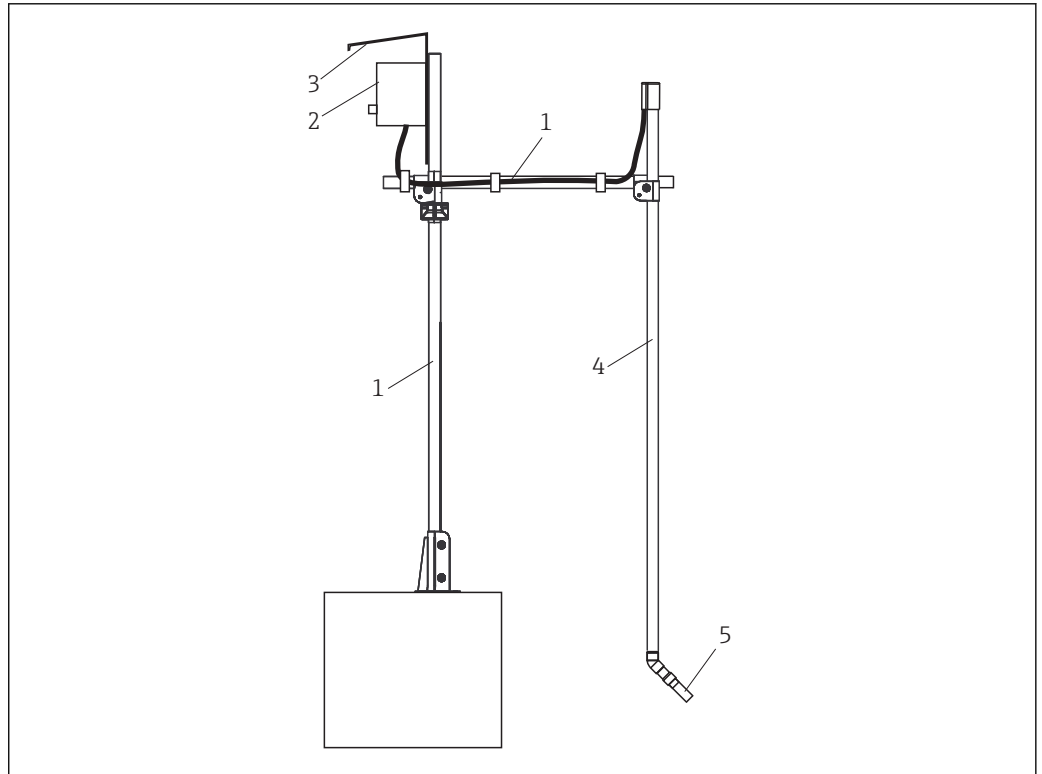
<b>Application (Models)</b>	<b>Areas of application / Use</b>	<b>Unit</b>	<b>Compensation*</b>
Formazine	Industrial water, WWTP outlet	FTU / FNU	
Kaolin	Filterable matter, industrial water, WWTP outlet, low concentrations of activated sludge	mg/l ; g/l; ppm; %	
SiO <sub>2</sub>	SiO <sub>2</sub> , mineral-based solids (sand)	g/l; ppm; %	X
TiO <sub>2</sub>	TiO <sub>2</sub> , (white media)	g/l; ppm; %	X
Thin sludge	Thin sludge, ranging 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 use for sludge in wastewater sector between 5 and 50 g/l (activated sludge, return activated sludge, ...)	g/l; ppm; %	X
Univ. sludge	Universal use ranging from clear water to sludge with a high concentration of solids, e.g. sludge extraction in thickeners. 0 g/l bis 50 g/l	g/l; ppm; %	X
Digested sludge	Contaminated sludge, black - homogeneous	g/l; ppm; %	

\* Compensation for fouling using four-beam pulsed light

**Measuring system**

A complete measuring system comprises:

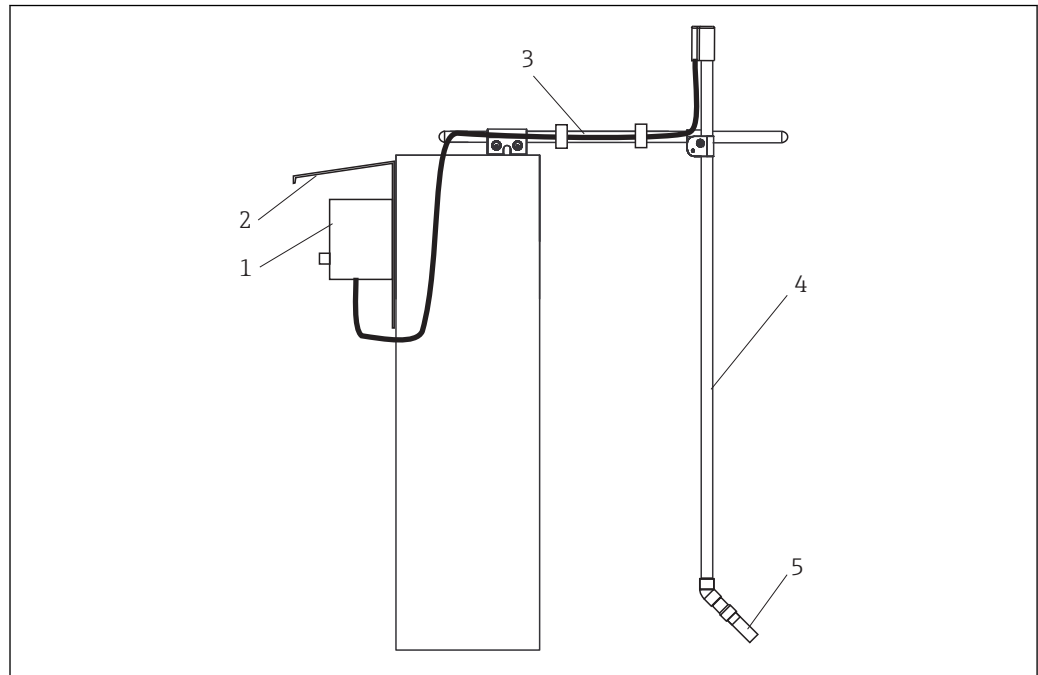
- Turbimax CUS51D turbidity sensor
- Liquiline CM44x multi-channel transmitter
- Assembly:
  - Flexdip CYA112 assembly and Flexdip CYH112 holder or
  - Retractable assembly, e.g. Cleanfit CUA451



A0030944

8 Measuring system with immersion assembly (example)

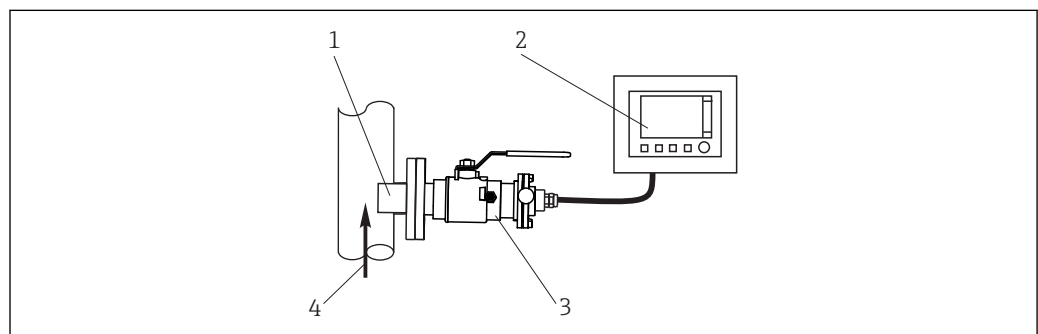
- 1 Flexdip CYH112 holder
- 2 Liquiline CM44x multi-channel transmitter
- 3 Protective cover
- 4 Flexdip CYA112 assembly
- 5 Turbimax CUS51D turbidity sensor



A0030856

9 Measuring system with immersion assembly (example)

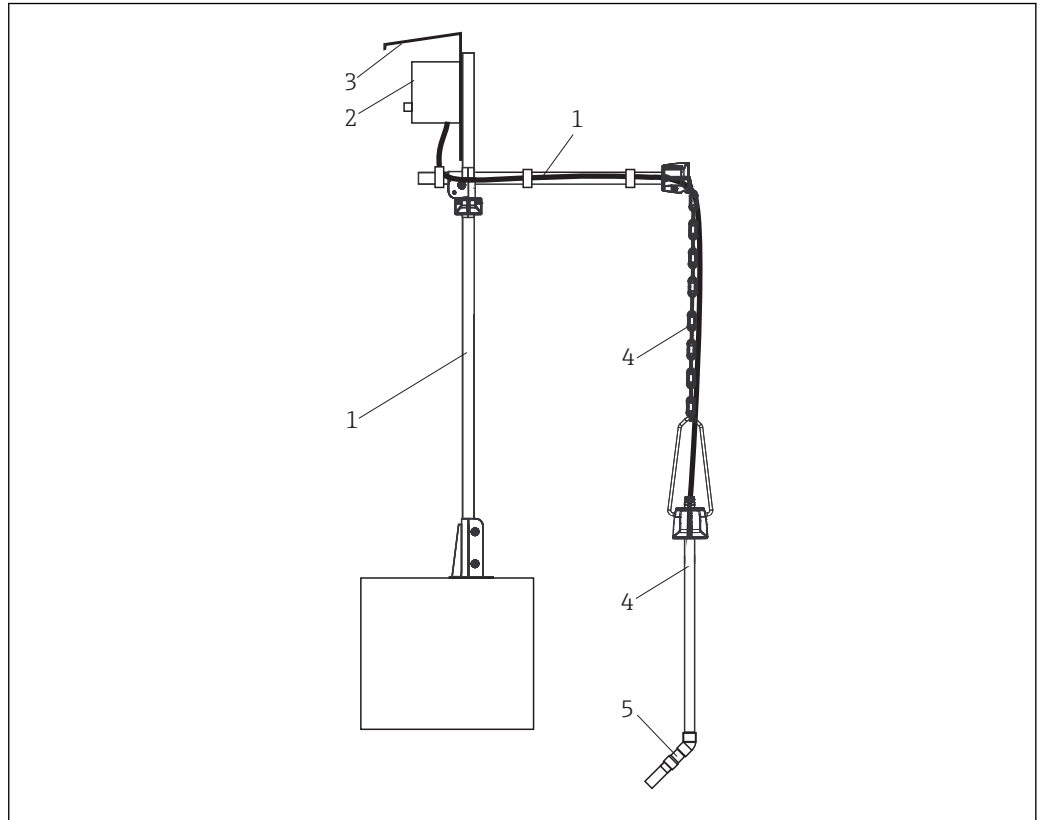
- 1 Liquiline CM44x multi-channel transmitter
- 2 Protective cover
- 3 Flexdip CYH112 holder
- 4 Flexdip CYA112 assembly
- 5 Turbimax CUS51D turbidity sensor



A0030843

10 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



A0030859

11 Measuring system with immersion assembly on chain holder system

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

## Input

<b>Measured values</b>	Turbidity
	Solids content
	Temperature

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

<b>Measuring ranges</b>	<b>CUS51D-**D1</b>	<b>Application</b>	
	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)	

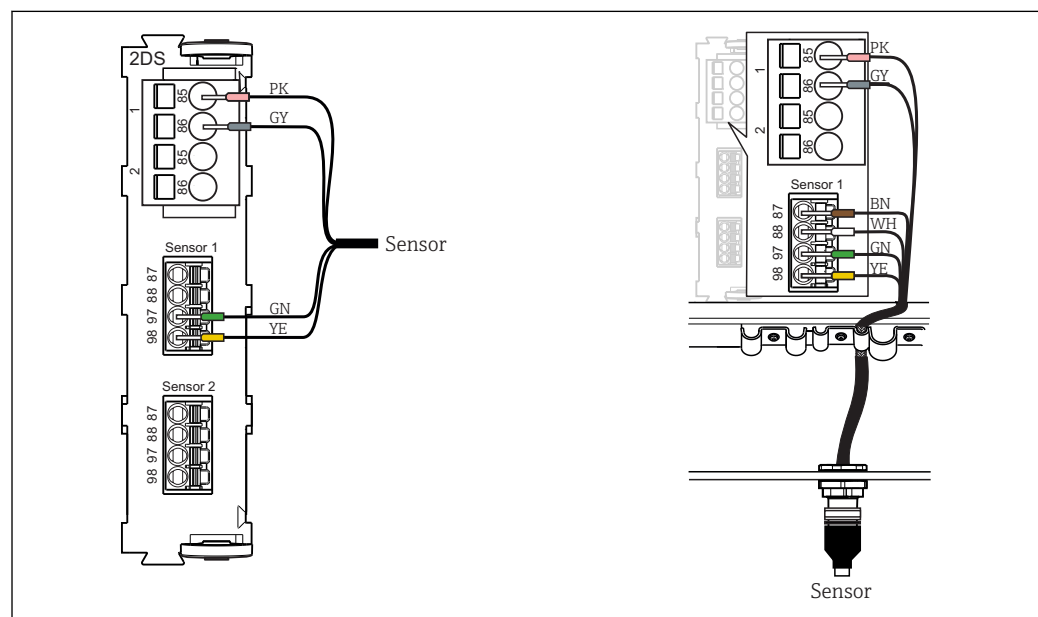
**i** Measuring range with solids content:

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.

## Power supply

You have the following connection options:

- 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)



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

A0033092

The maximum cable length is 100 m (328 ft).

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

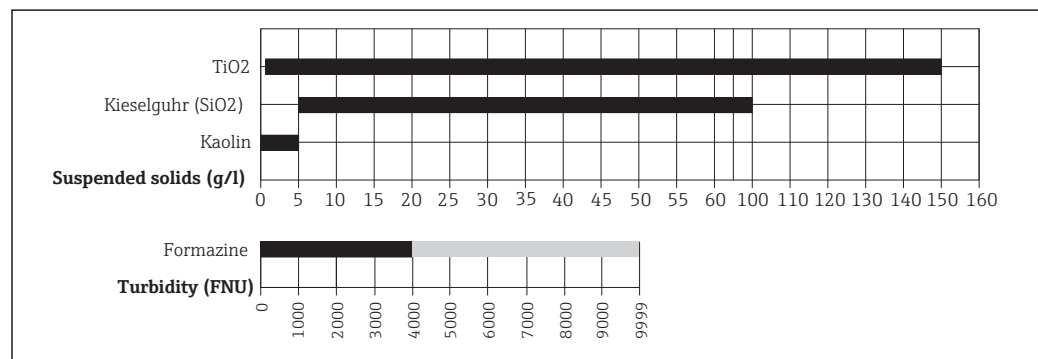
**Wavelength** 860 nm ± 30 nm

**Factory calibration** FNU, NTU and FTU in accordance with application table  
Standard: 3 points

**Applications** The sensor has been calibrated in the factory for "formazine" applications and, by deduction, for "kaolin (filterable matter)". All other applications are precalibrated with reference samples and require calibration to the corresponding application.

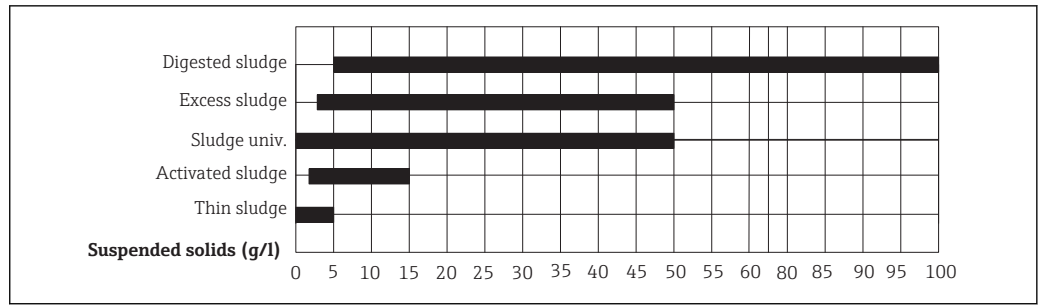
Calibration can be performed with up to 5 points.

Application: water	Recommended operating ranges	CUS51D	
		C1	D1
Factory calibration for formazine	0 to 4000 FNU	X	X
Factory calibration for kaolin	0 to 5g/l	X	X
Application: SiO <sub>2</sub>	5 to 100 g/l		X
Application: titanium dioxide	0.2 to 150 g/l		X



A0030862-EN

Application: wastewater	Recommended operating ranges	CUS51D	
		C1	D1
Application: thin sludge	0 to 5 g/l		X
Application: activated sludge	0.5 to 15 g/l		X
Application: waste activated sludge	3 to 50 g/l		X
Application: univ. sludge	0 to 50 g/l		X
Application: digested sludge / silt	5 to 100 g/l / 300 g/l		X



A0030863-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**

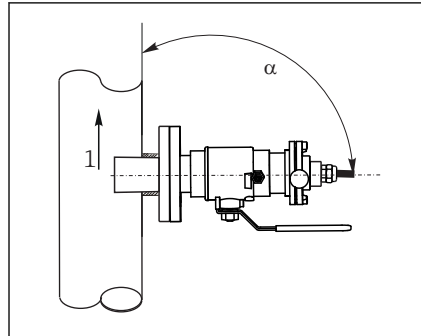
Application	Measuring range	Detection limit
Formazine	0 to 50 FNU	0.006 FNU
	0 to 9999 FNU	0.4 FNU
Kaolin	0 to 4000 mg/l	0.85 mg/l

## Installation

### Installation instructions

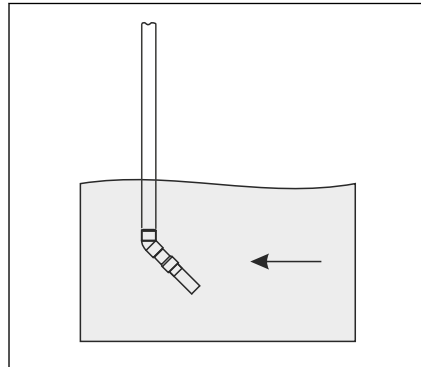
Installation options:

- with Cleanfit W CUA451 retractable assembly
- with Flexdip CYA112 wastewater assembly and Flexdip CYH112 holder
- with Flowfit CYA251 flow assembly



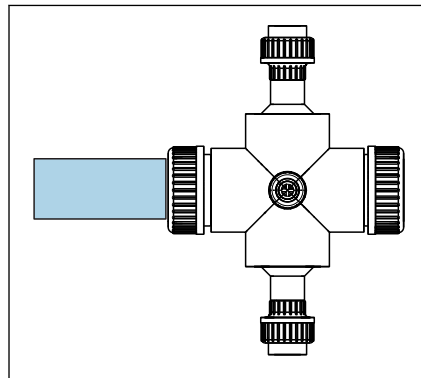
A0031134

13 Installing with retractable assembly



A0013010

14 Installing with wastewater assembly



A0035858

15 Installing with CYA251 flow assembly

Arrow 1 points in the direction of flow.

The installation angle  $\alpha$  must not exceed  $90^\circ$ .

The recommended installation angle is  $75^\circ$ .

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 ( $\alpha < 90^\circ$ ).

For manual insertion/retraction of the assembly, the medium pressure must not exceed 2 bar (29 psi).

The arrow points in the direction of flow.

The installation angle is  $45^\circ$  (preferably) or  $90^\circ$ .

If you are using the sensor in open basins, install the sensor in such a way that bubbles cannot accumulate on it.

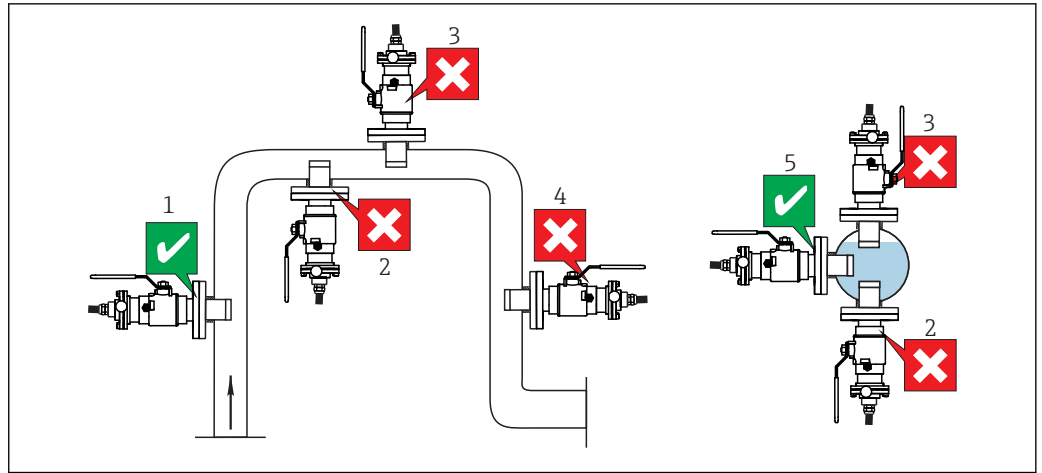
If you are using the sensor in highly aerated basins, install the sensor at an angle of  $90^\circ$  to reduce the effects of air bubbles.

The installation angle is  $90^\circ$ .

For turbidity measurements  $< 200$  FNU, the backscattering of the internal surfaces of the assembly causes distortions in the measured values.

### Pipes

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



16 Orientations and positions (with CUA451 retractable assembly)

- When using reflective materials (e.g. stainless steel), the pipe diameter must be at least 100 mm (4"). 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, as this may lead to outgassing.

## Environment

Ambient temperature	-20 to +60 °C (-4 to 140 °F)
Storage temperature	-20 to +70 °C (0 to 160 °F)
Degree of protection	IP 68 (1 m (3.3 ft) water column over 60 days, 1 mol/l KCl)

## Process

**Process temperature** -5 to 50 °C (23 to 120 °F)  
up to 80 °C (175 °F) for a brief period (1 h)

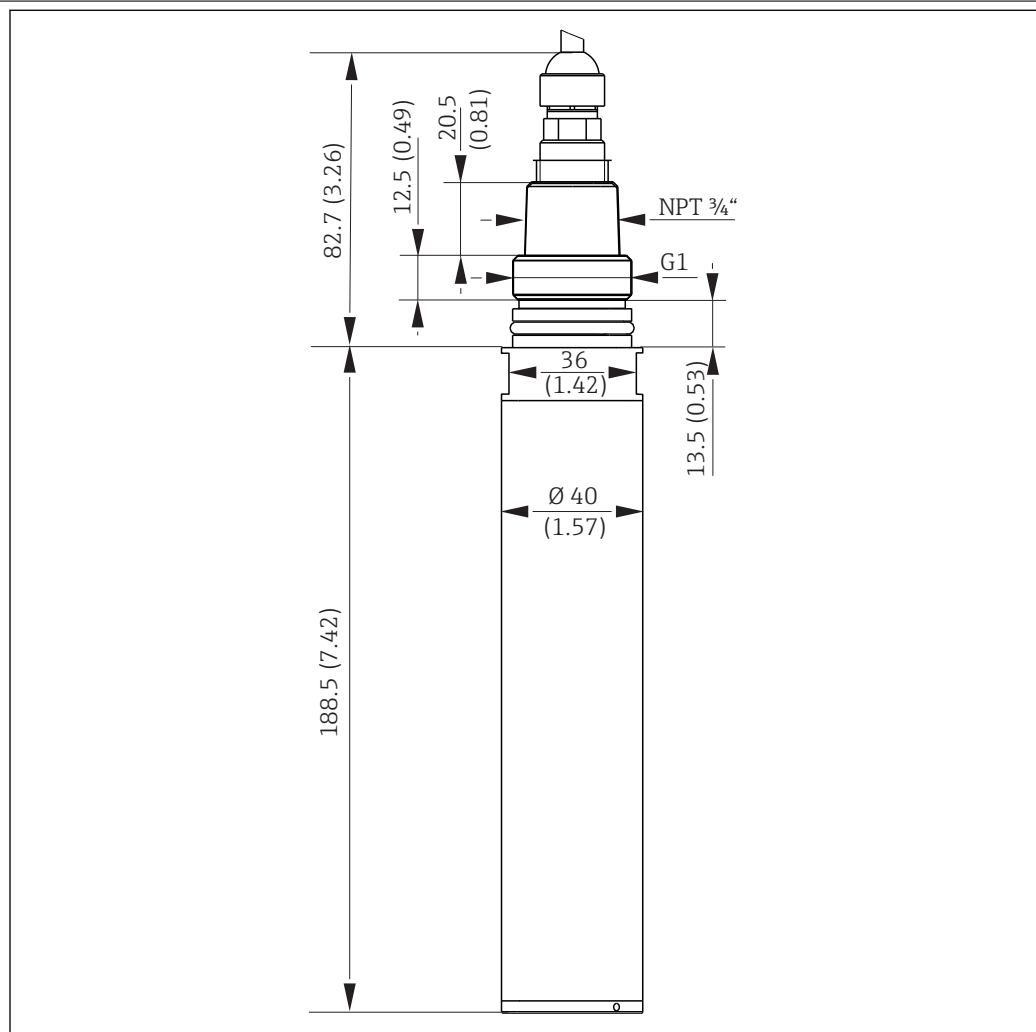
**Process pressure (absolute)** 0.5 to 10 bar (7 to 145 psi) absolute

**Minimum flow** No minimum flow required.

**i** For solids which have a tendency to form deposits, ensure that sufficient mixing is performed.

## Mechanical construction

### Design, dimensions



A0030853

**17** Dimensions


For the dimensions of the cleaning unit, see the "Accessories" section.



## Certificates and approvals

<b>Electromagnetic compatibility</b>	Interference emission and interference immunity as per <ul style="list-style-type: none"> <li>▪ EN 61326-1:2013</li> <li>▪ EN 61326-2-3:2013</li> <li>▪ NAMUR NE21: 2012</li> </ul>
<b>ISO 7027</b>	The measuring method used with the sensor complies with the ISO 7027-1:2016 standard.
<b>CE mark</b>	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 <b>CE</b> mark.
<b>EAC</b>	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

<b>Product page</b>	<a href="http://www.endress.com/cus51d">www.endress.com/cus51d</a>
<b>Product Configurator</b>	<p>On the product page there is a <b>Configure</b> button to the right of the product image.</p> <ol style="list-style-type: none"> <li>1. Click this button. <ul style="list-style-type: none"> <li>↳ The Configurator opens in a separate window.</li> </ul> </li> <li>2. Select all the options to configure the device in line with your requirements. <ul style="list-style-type: none"> <li>↳ In this way, you receive a valid and complete order code for the device.</li> </ul> </li> <li>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.</li> </ol> <p> For many products you also have the option of downloading CAD or 2D drawings of the selected product version. Click the <b>CAD</b> tab for this and select the desired file type using picklists.</p>
<b>Scope of delivery</b>	<p>The delivery comprises:</p> <ul style="list-style-type: none"> <li>▪ 1 Turbimax CUS51D sensor, version as ordered</li> <li>▪ 1 set of Operating Instructions BA00461C/07/EN</li> </ul>

## 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.

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### Assemblies

#### 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](http://www.endress.com/cua451)



Technical Information TI00369C

#### FlexdipCYA112

- 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

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### 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.
- Stainless steel version
- Product Configurator on the product page: [www.endress.com/cyh112](http://www.endress.com/cyh112)

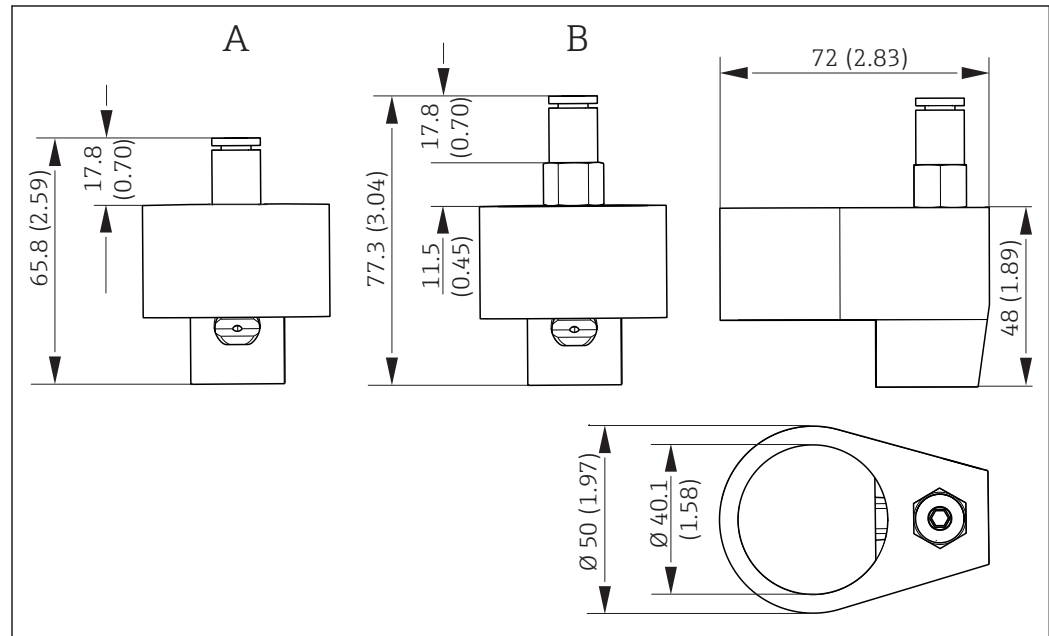


Technical Information TI00430C

## Compressed air cleaning

## Compressed air cleaning for CUS51D

- Connection: 6 or 8 mm (metric) or 6.35 mm (1/4")
- Materials: POM/V4A
- 6/8 mm order no.: 71110782
- 6.35 mm (1/4") order no.: 71110783



A0030854

19 Compressed air cleaning, dimensions in mm (inch)

A 6 mm version

B 6.35 mm (1/4") version

## Compressor

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