TI00461C/07/EN/20.25-00
71744157
2025-10-20

Technical Information
Turbimax CUS51D

Sensor for turbidity and solids content



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 4-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 selectable applications (e.g. activated sludge) are pre-calibrated, thereby enabling quick 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.

Endress+Hauser
People for Process Automation

Table of contents

Function and system design 3
Measuring principle 3
Measuring system 7

Input 9
Measured variable 9
Measuring range 10

Power supply 10
Electrical connection 10

Performance characteristics 11
Reference operating conditions 11
Maximum measurement error 11
Repeatability 11
Factory calibration 11
Drift 11
Detection limits 11
Applications 11

Installation 13
Installation instructions 13
Pipes 14

Environment 15
Ambient temperature range 15
Storage temperature 15
Degree of protection 15

Process 15
Process temperature range 15
Process pressure range 15
Minimum flow 15

Mechanical construction 16
Dimensions 16
Weight 17
Materials 17
Process connections 17

Certificates and approvals 17
NAMUR 17
Device safety 17

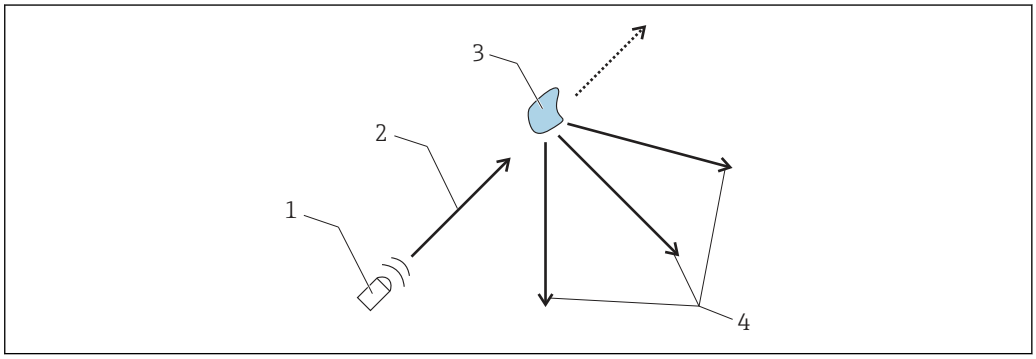
Ordering information 18
Scope of delivery 18
Product page 18
Product Configurator 18

Accessories 18
Assemblies 18
Holder 19
Compressed air cleaning 19
Mechanical cleaning 19
Cables 19

Function and system design

Measuring principle

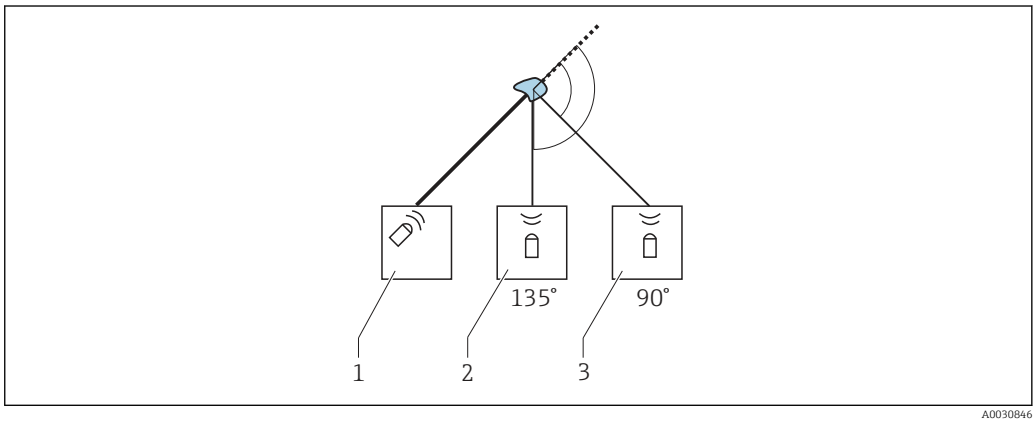
For turbidity measurement a light beam is directed through the medium and is deflected from its original direction by optically denser particles, e.g. particles of solid matter. This process is also called scattering.



1 Deflection of light

1 Light source
2 Light beam
3 Particle
4 Scattered light

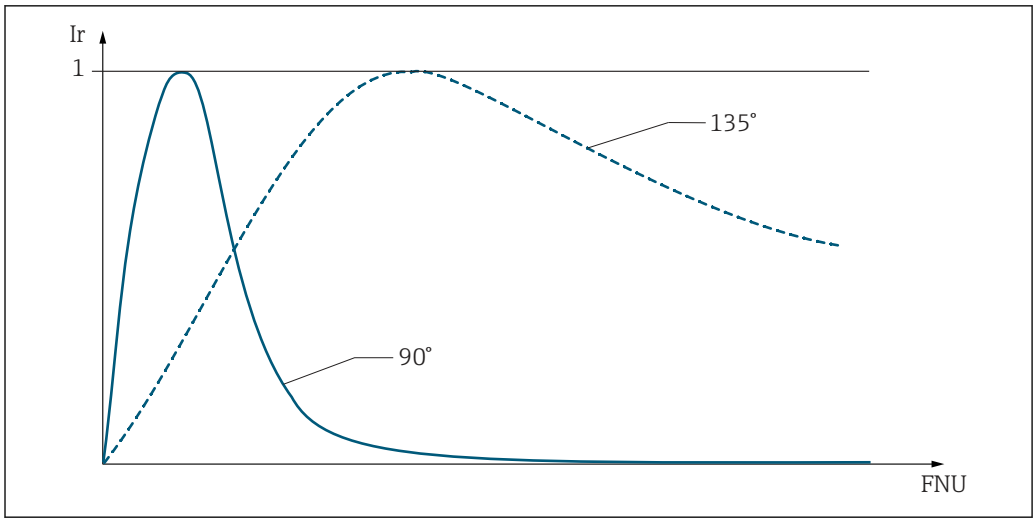
The incident light is scattered in many directions, i.e. at different angles to the direction of propagation. 2 angle ranges are of particular interest here:
- Light scattered at a 90° angle is used primarily for turbidity measurement in drinking water.
- Light scattered at a 135° angle extends the dynamic range for high particle densities.



2 Principle mode of operation of turbidity sensor

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

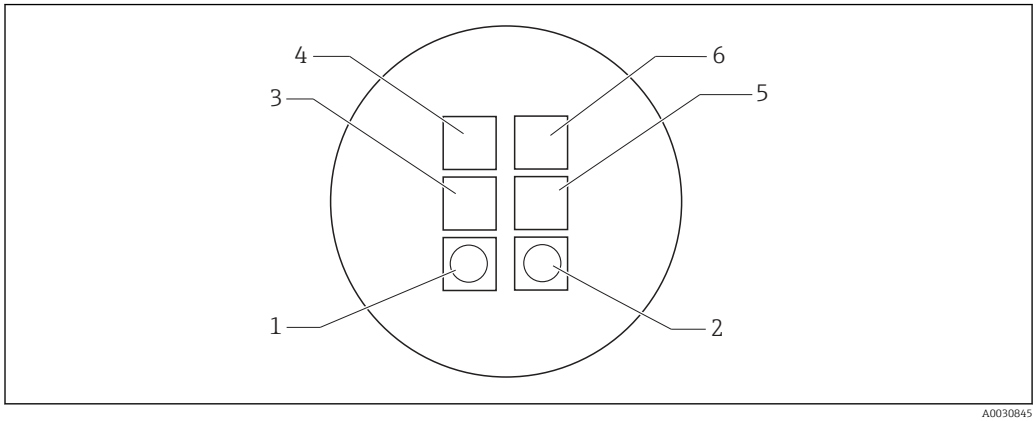
If the particle density in the medium is low, most of the light is scattered in the 90°channel and a small amount of light is scattered in the 135° channel. As the particle density increases, this ratio shifts (more light in the 135° channel, less light in the 90° channel).



3 Signal distribution as a function of the particle density

Ir Relative intensity
FNU Turbidity unit

The CUS51D 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

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 measurement errors caused by fouling (4-beam pulsed light method → 4).

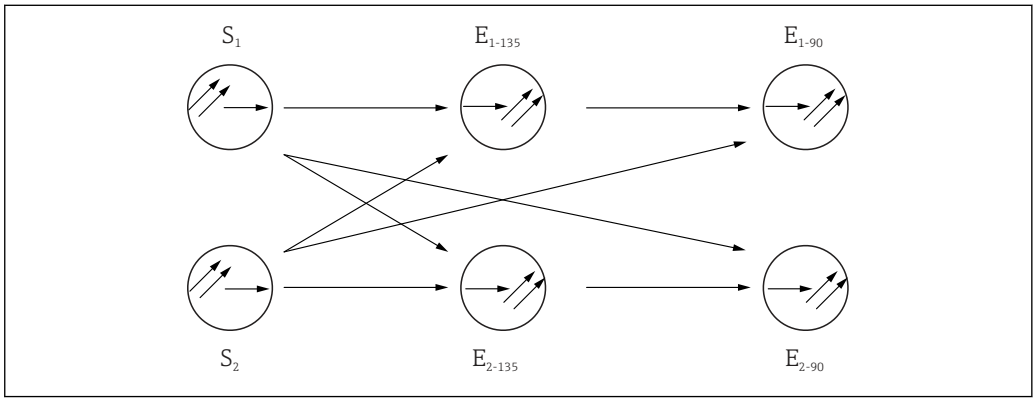
The sensor types available vary in terms of their measuring ranges and therefore the range of available applications.

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.



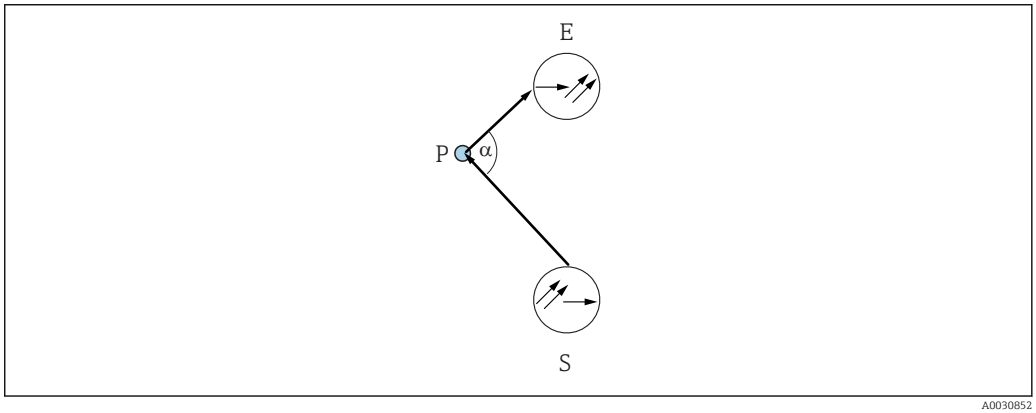
5 4-beam pulsed light method

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, 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.

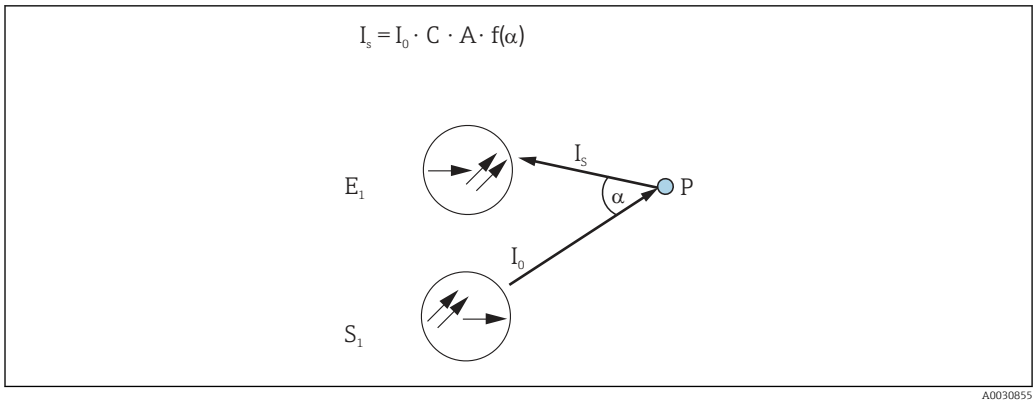


6 90° scattered light method

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.



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(a) 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. The function is disabled by default.

In addition, the following fault states are detected in conjunction with the sensor check system of the Liquiline M:
- Implausibly high or low measured values
- Disturbed regulation due to incorrect measured values

Applications

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; %	
SiO2	SiO_2, mineral-based solids (sand)	g/l; ppm; %	X
TiO2	TiO_2, (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
Excess sludge	Universal use for sludge in wastewater sector between 5 and 50 g/l (activated sludge, return activated sludge, ...)	g/l; ppm; %	X
Sludge, general	Universal use ranging from clear water to sludge with a high concentration of solids, e.g. sludge extraction in thickeners. 0 g/l to 50 g/l	g/l; ppm; %	X
Digested sludge	Digested sludge, black - homogeneous	g/l; ppm; %	

1) Contamination compensation with 4-beam pulsed light

NOTICE

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

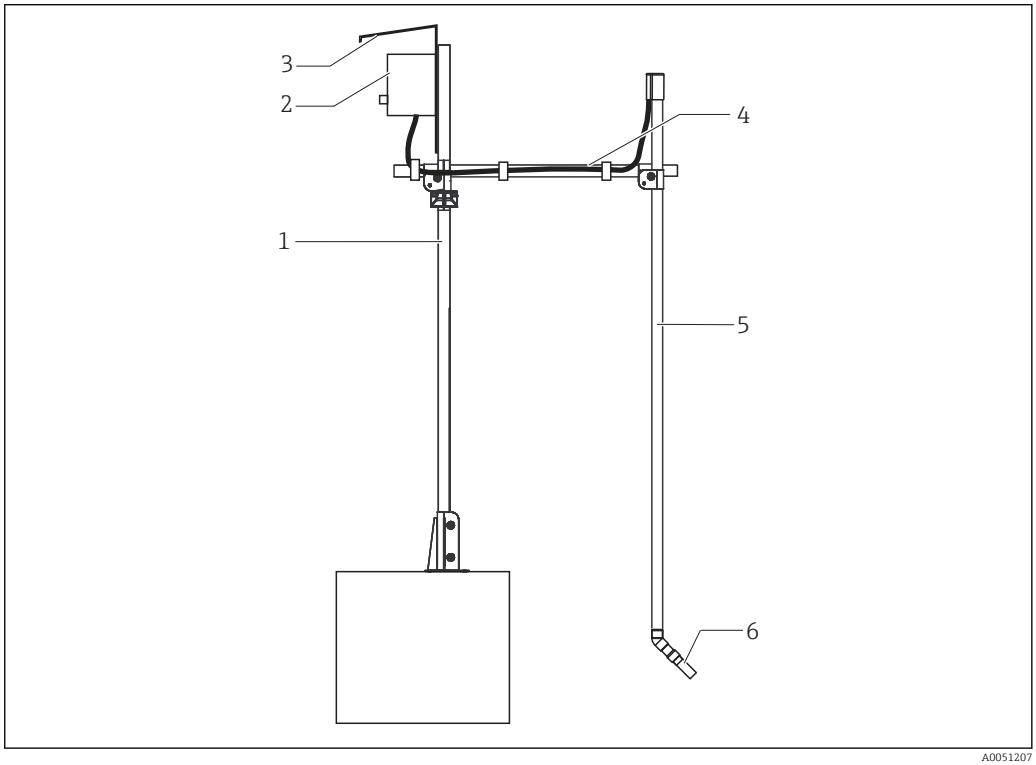
If the specific operational range is exceeded, the measured value displayed by the sensor can decrease despite increasing turbidity or increasing TS content. The indicated operational range is reduced in the case of highly absorbing (e.g. dark) media.

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

Measuring system

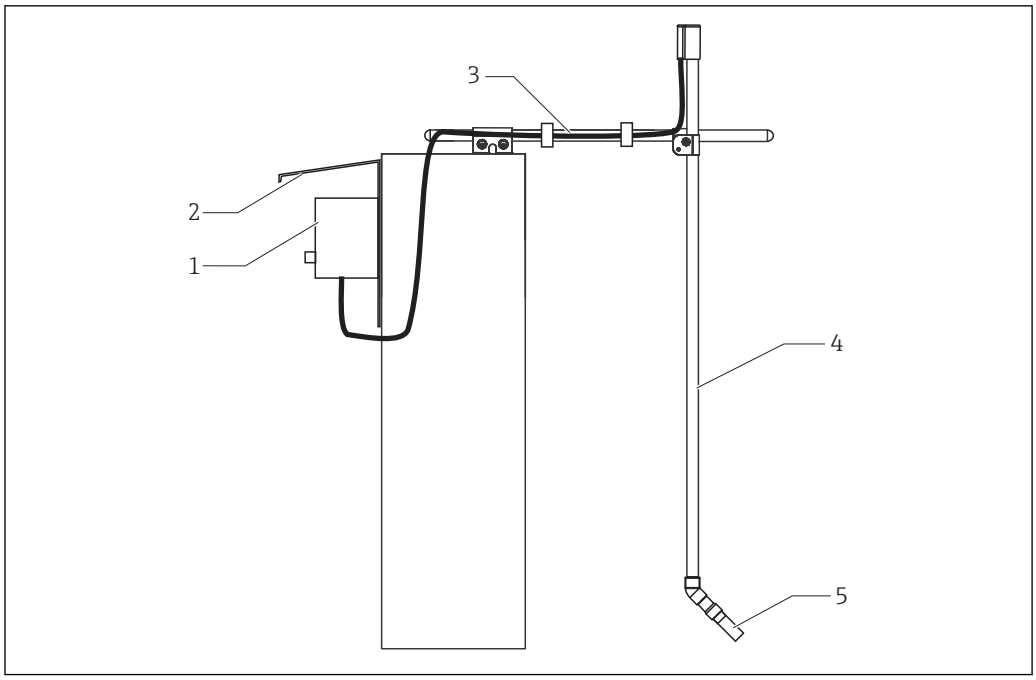
A complete measuring system comprises:

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



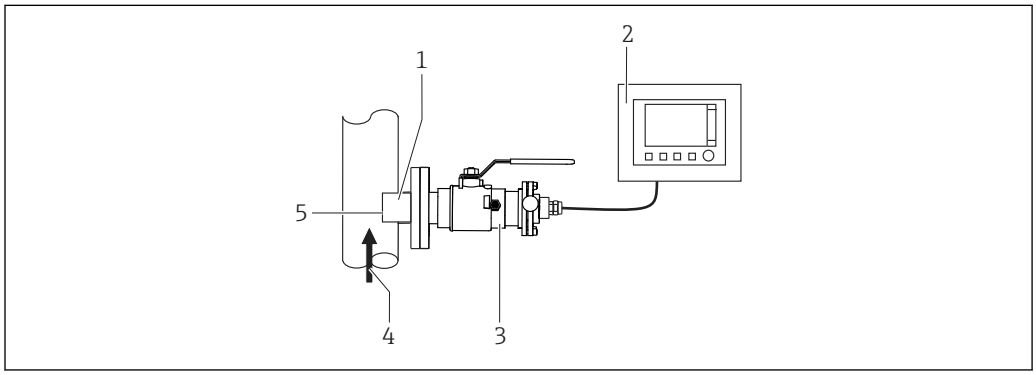
8 *Measuring system with immersion assembly (example)*

1 *Main pipe, Flexdip CYH112 holder*
2 *Liquiline CM44x multi-channel transmitter*
3 *Weather protection cover*
4 *Transverse pipe, Flexdip CYH112 holder*
5 *Wastewater assembly Flexdip CYA112*
6 *Turbimax CUS51D turbidity sensor*



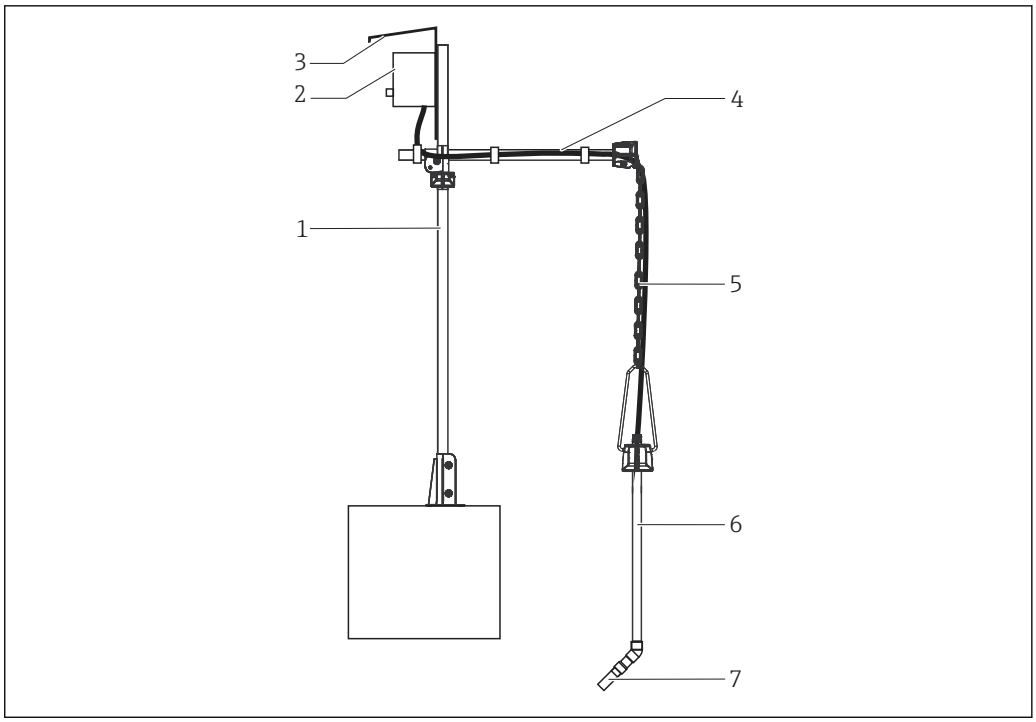
9 Measuring system with immersion assembly (example)

1 Liquiline CM44x multi-channel transmitter
2 Weather protection cover
3 Transverse pipe, Flexdip CYH112 holder
4 Wastewater assembly Flexdip CYA112
5 Turbimax CUS51D turbidity sensor



10 Measuring system with retractable assembly (example)

1 Turbimax CUS51D turbidity sensor
2 Liquiline CM44x multi-channel transmitter
3 Cleanfit CUA451 retractable assembly
4 Flow direction
5 Optical windows

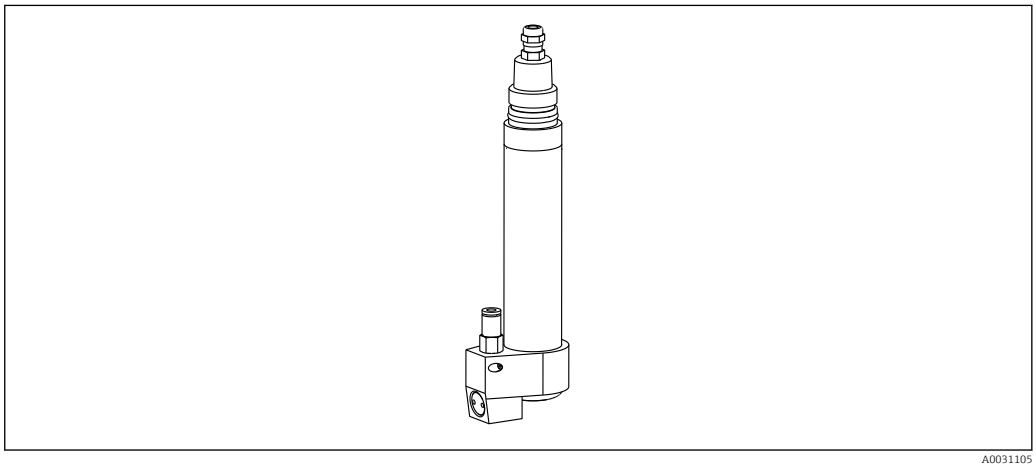


A0051208

11 *Measuring system with immersion assembly on chain holder system*

1 *Main pipe, Flexdip CYH112 holder*
2 *Liquiline CM44x multi-channel transmitter*
3 *Weather protection cover*
4 *Transverse pipe, Flexdip CYH112 holder*
5 *Chain of Flexdip CYH112 holder*
6 *Wastewater assembly Flexdip CYA112*
7 *Turbimax CUS51D turbidity sensor*

Sensor with compressed air cleaning



A0031105

12 *Turbimax CUS51D sensor with cleaning unit*

Input

Measured variable

- 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 2.5 lb/gal) 0 to 30 %	Solids content depending on the selected application (see list)
Temperature	–20 to 80 °C (–4 to 176 °F)	

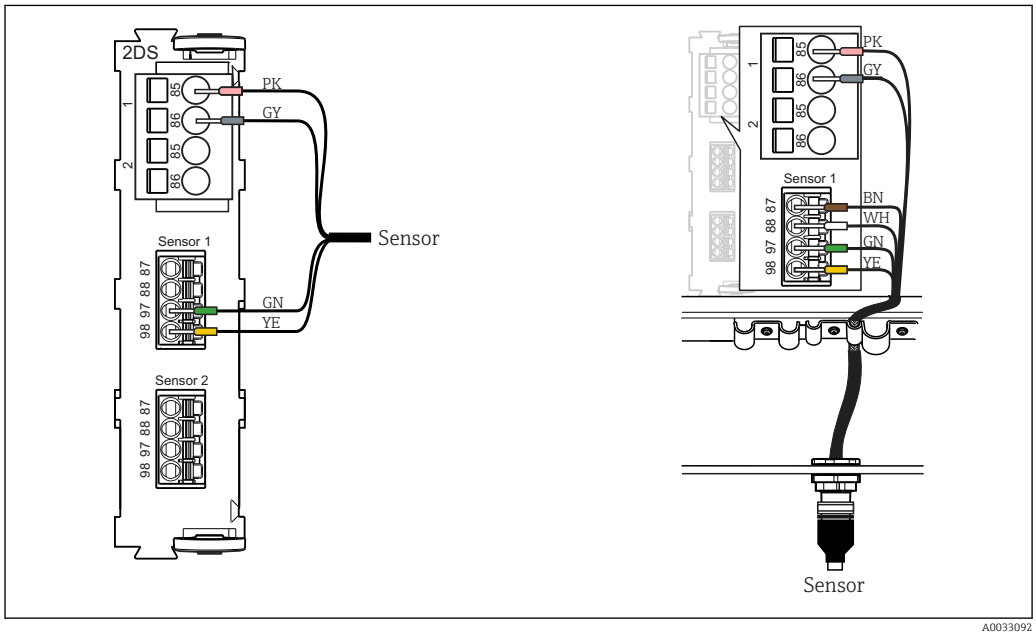
Measuring range with solids content:

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.

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)



13 *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)

Maximum measurement 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 measurement 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.

For solids, the achievable measurement errors depend very much on the media that are actually present and may differ from the specified values. Extremely inhomogeneous media cause the measured value to fluctuate and increase the measurement error.

Repeatability

< 0.2 % of reading

Factory calibration

FNU and NTU in accordance with application table

Standard: 3 points

Drift

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

Detection limits

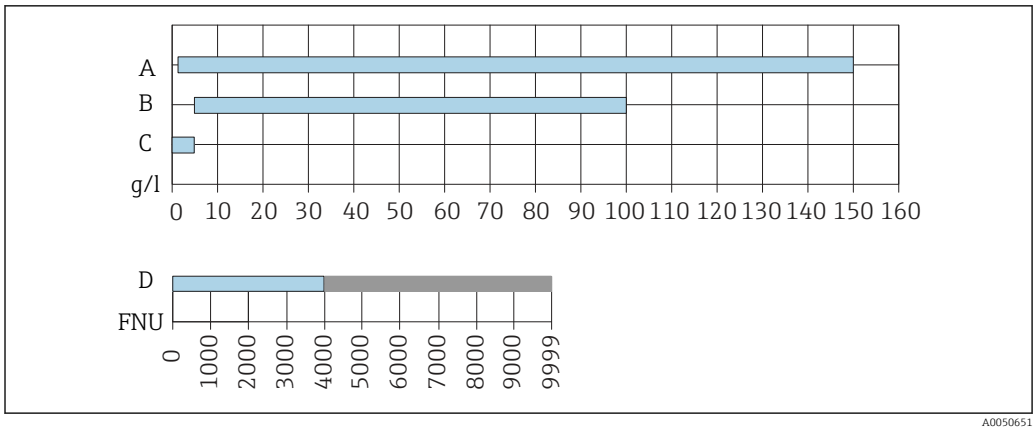
Application	Measuring range	Limit of detection
Formazine	0 to 50 FNU	0.006 FNU
	0 to 4000 FNU	0.4 FNU
Kaolin	0 to 5000 mg/l	0.85 mg/l

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.

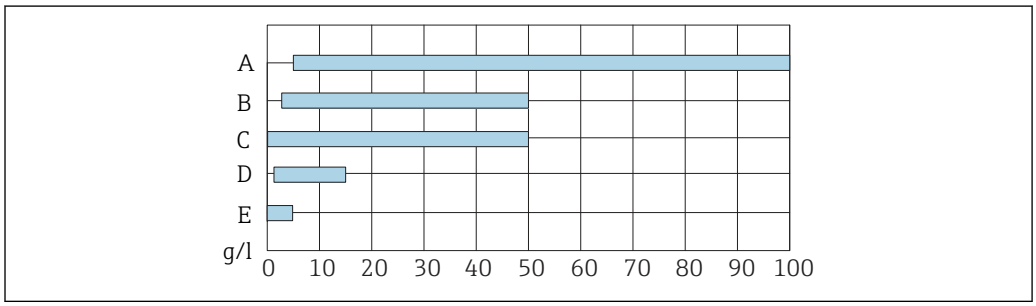
Clear water application type	Recommended operating ranges	CUS51D	
		C1	D1
Formazine	0 to 4000 FNU	X	X
Kaolin	0 to 5 g/l	X	X
SiO2	5 to 100 g/l		X
TiO2	0.2 to 150 g/l		X



14 **Clear water** *application type*

A TiO2
B SiO2
C Kaolin
D Formazine

Solids application type	Recommended operating ranges	CUS51D	
		C1	D1
Thin sludge	0 to 5 g/l		X
Activated sludge	2 to 15 g/l		X
Excess sludge	3 to 50 g/l		X
Sludge, general	0 to 50 g/l		X
Digested sludge	5 to 100 g/l / 300 g/l		X



15 *Solids application type*

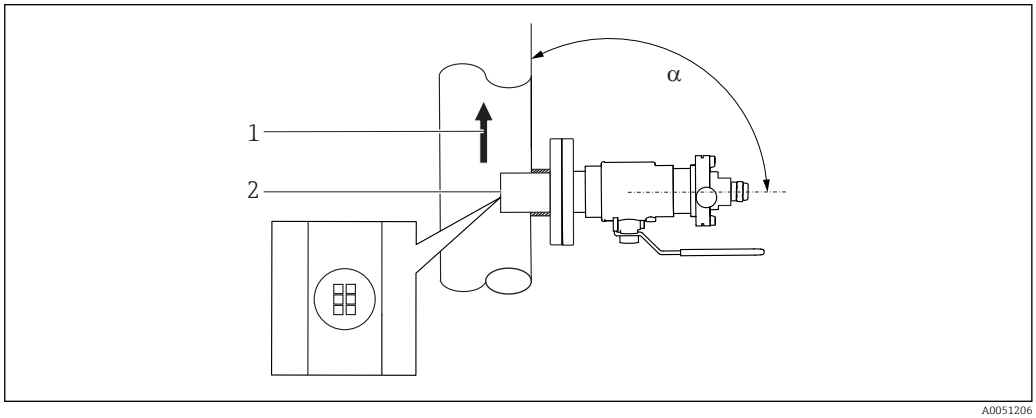
A Digested sludge
B Excess sludge
C **Sludge, general** *(mainly for SBR applications)*
D **Activated sludge** *(only for TS ranges > 2 g/l)*
E Thin sludge

For solids, the achievable measured errors depend very much on the media that are actually present and may differ from the specified values. Extremely inhomogeneous media cause the measured value to fluctuate and increase the measurement error.

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
- With Dipfit CLA140 immersion assembly

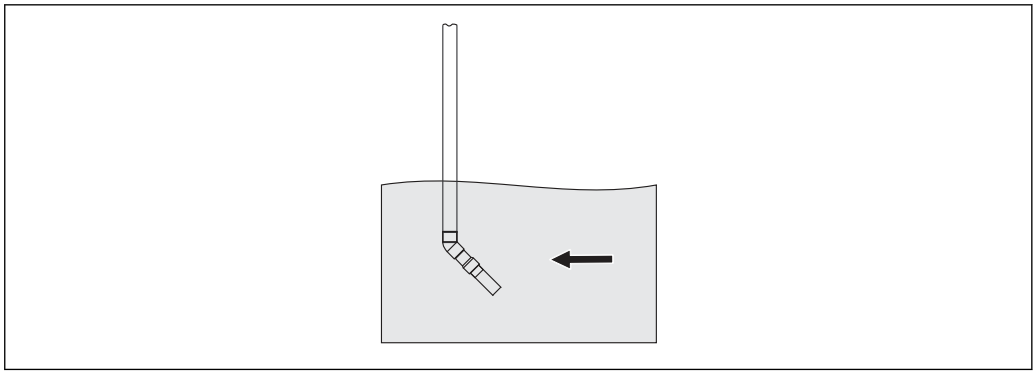


16 *Installing with retractable assembly*

1 Flow direction
2 Optical windows

The installation angle α must not exceed 90° → 16, 13. The recommended installation angle is 75°. The optical windows of the sensor must be aligned along the flow direction.

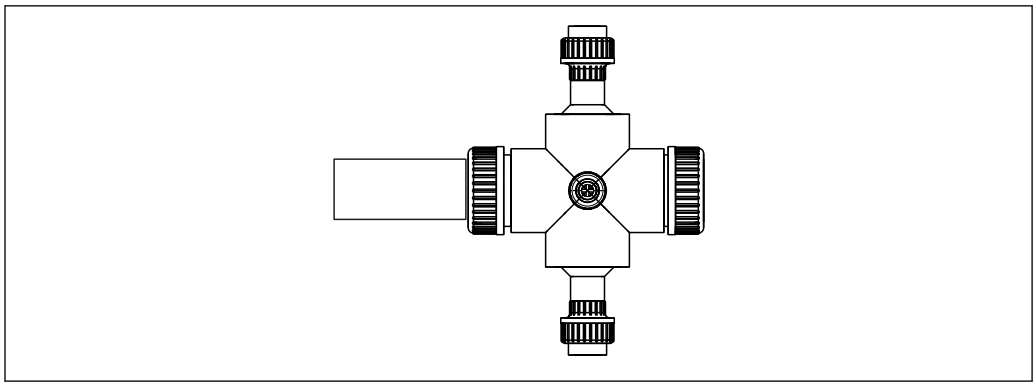
The medium pressure may not exceed 2 bar (29 psi) for manual assembly retraction.



17 *Installing with wastewater assembly*

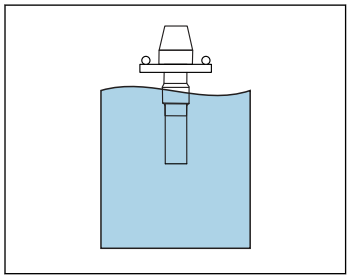
The arrow points in the direction of flow. The installation angle is 45° (preferably) or 90°.

- If you are using the sensor in open basins, install the sensor in such a way that air bubbles cannot accumulate on it.
- If you are using the sensor in highly aerated basins, install the sensor at an angle of 90° to reduce the effects of air bubbles.



18 *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.

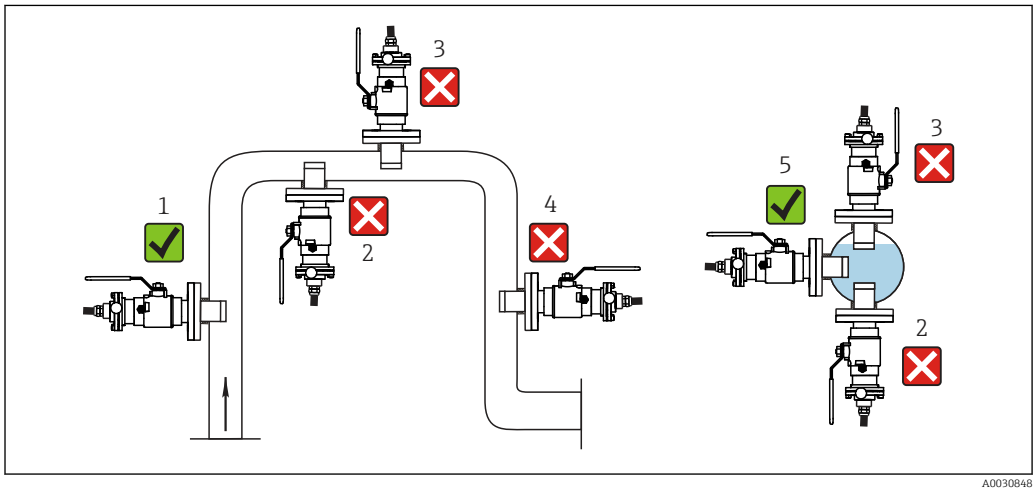


19 *CLA140 immersion assembly*

No special installation angle required.
No flow.
If the sensor is used in open basins, install the sensor in such a way that air bubbles cannot accumulate on it.

Pipes

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



20 *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, measured value adjustment with an offset is recommended here.
- Avoid fittings downstream from pressure reduction stages which can lead to outgassing.

Environment

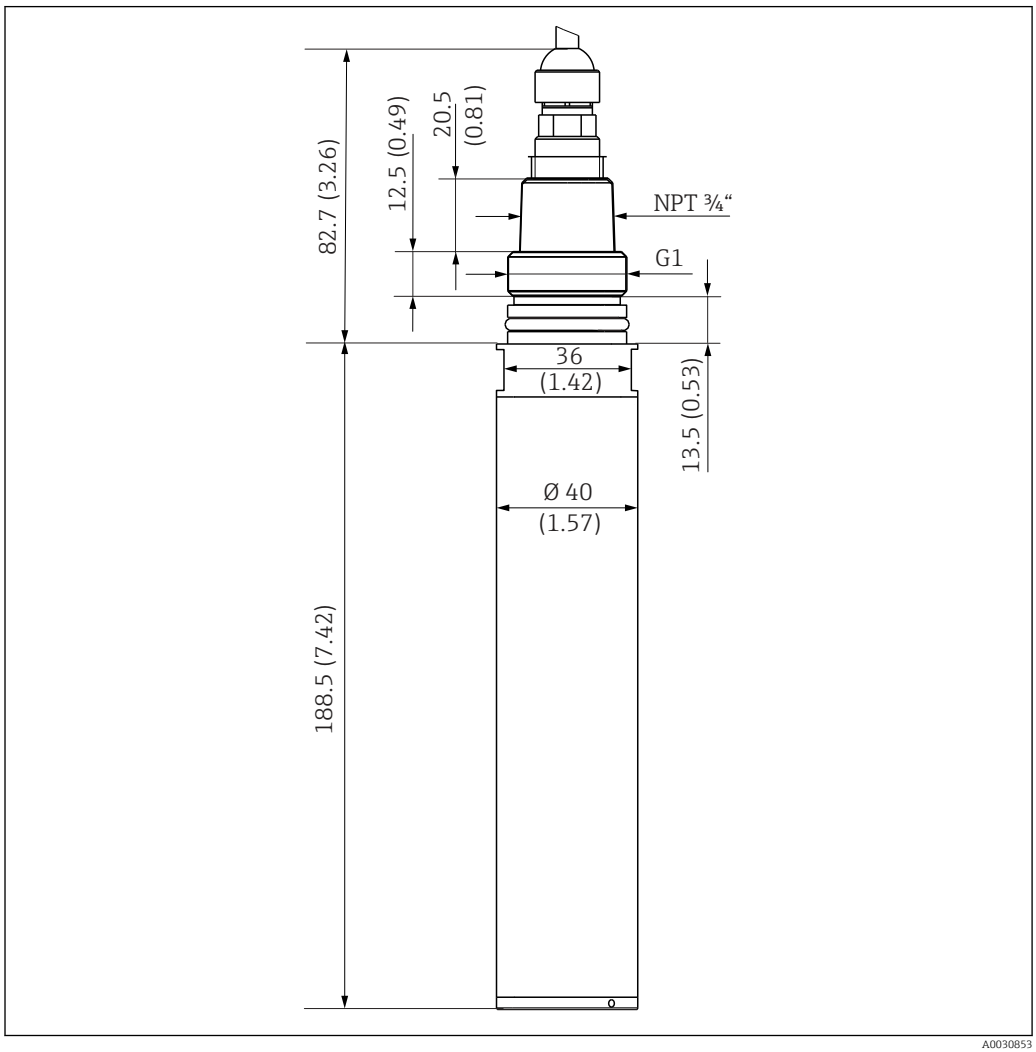
Ambient temperature range	–20 to 60 °C (–4 to 140 °F)
Storage temperature	–20 to 70 °C (–4 to 158 °F)
Degree of protection	▪ IP 68 (1.83 m (6 ft) water column over 24 hours) ▪ IP 66 ▪ Type 6P

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) absolute **Compressed air cleaning** Primary pressure: 1.5 to 2 bar (21.8 to 29 psi) absolute
Minimum flow	No minimum flow required. For solids which have a tendency to form deposits, ensure that sufficient mixing is performed.

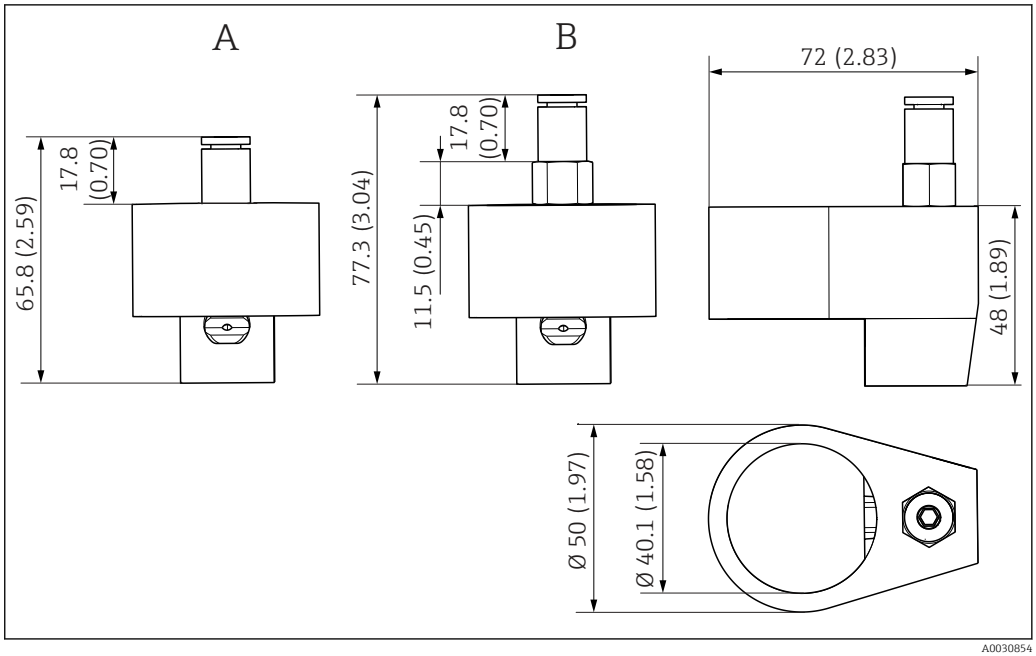
Mechanical construction

Dimensions



21 Dimensions. Engineering unit: mm (in)

Compressed air cleaning



22 Compressed air cleaning. Engineering unit: mm (in)

A Version 6 mm (0.24 in)
B Version 6.35 mm (0.25 in)

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 ¾'

Compressed air cleaning

6 mm (0.24 in) or 8 mm (0.31 in) or 6.35 mm (0.25 in) (¼")

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**.

NAMUR

NE 21

Device safety

- EN IEC 61010-1
- CAN/US General Purpose

Ordering information

Scope of delivery

The scope of delivery comprises:
- 1 sensor, version as ordered
- 1 x Operating Instructions

Product page

www.endress.com/cus51d

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.

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.

Assemblies

FlowFit CUA120
- Flange adapter for mounting turbidity sensors
- 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

Dipfit CLA140
- Immersion assembly with flange connection for very demanding processes
- Product Configurator on the product page: www.endress.com/cla140

Technical Information TI00196C

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

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
- Consumption: 50 l/min (13.2 gal/min)
- 6 mm (0.24 in) or 8 mm (0.31 in) order number: 71110782
- 6.35 mm (0.25 in) Order number: 71110783

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

Mechanical cleaning

CYR51 mechanical cleaning
- Sensors immersed in liquid can be cleaned directly in the basin or vessel.
- The mechanical cleaning unit is clipped onto the sensor and secured.
- Product Configurator on the product page: www.endress.com/cyr51

Technical Information TI01821C

Cables

Memosens data cable CYK11
- Extension cable for digital sensors with Memosens protocol
- Product Configurator on the product page: www.endress.com/cyk11

Technical Information TI00118C



www.addresses.endress.com

Endress+Hauser

People for Process Automation