

# Technical Information

## Turbimax CUS51D

Sensor for turbidity and solids content  
Installation and immersion sensor for low, middle  
and high turbidity and solids concentrations



### Application

Turbimax CUS51D is a sensor for all applications of wastewater treatment.

- Turbidity measurement in the outlet
- Suspended solids in the activated sludge basin and in the recirculation
- Suspended solids in the sludge treatment
- Filterable solids in the outlet

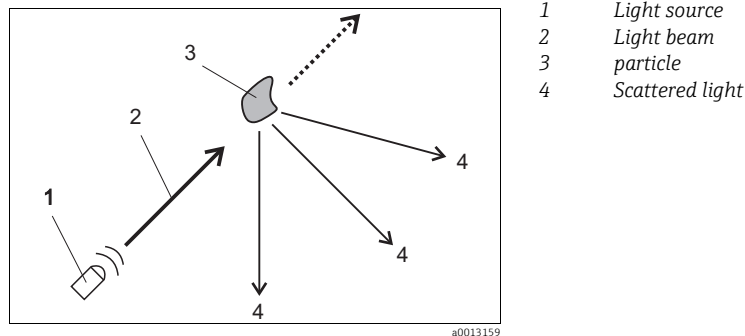
### Your benefits

- All sensor principles (90°, 135° and four-beam pulsed light) are included in the sensor head and allow optimal adaption to the measurement task.
- The sensor is factory-calibrated (basis formazine). All selectable applications (e.g. activated sludge) are precalibrated and allow quick and easy commissioning.
- Standardized communication (Memosens technology) allows "plug and play".
- Intelligent sensor - all characteristics and calibration values are stored in the sensor.
- Calibrations provided by the customer with up to 5 points - realizable in lab or on site.

## Function and system design

### Measuring principle

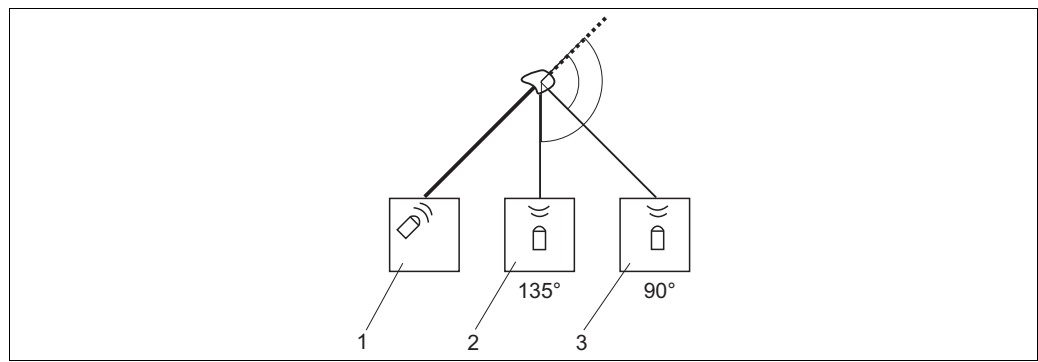
For turbidity measurement a light beam is sent through the medium and is diverted from its original direction by optically denser particles, e.g. solid matter particles. This process is also called scattering.



Deflection of the light

The impinging light will be scattered in different angles. Two angles are of interest in this matter:

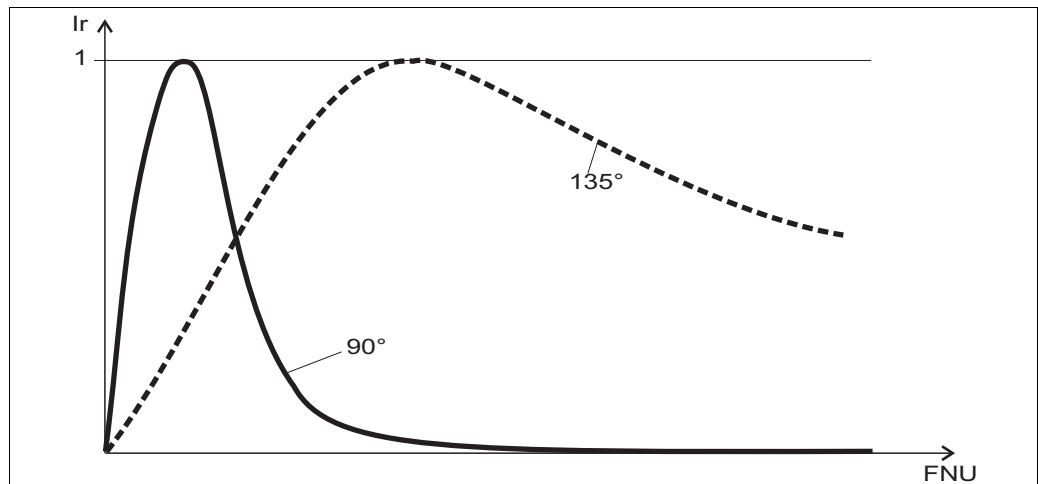
- The scattered light in the 90° direction is less influenced by the size of the particles.
- The scattered light in the 135° direction gives enough information also at a high number of particles.



Principle operating mode of the turbidity sensor

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

If only a small number of particles is in the medium, most of the light will be scattered to the 90° channel and less light will be scattered to the 135° channel. When the number of particles increases the relationship will change (more light scattered to the 135° channel, less light scattered to the 90° channel).

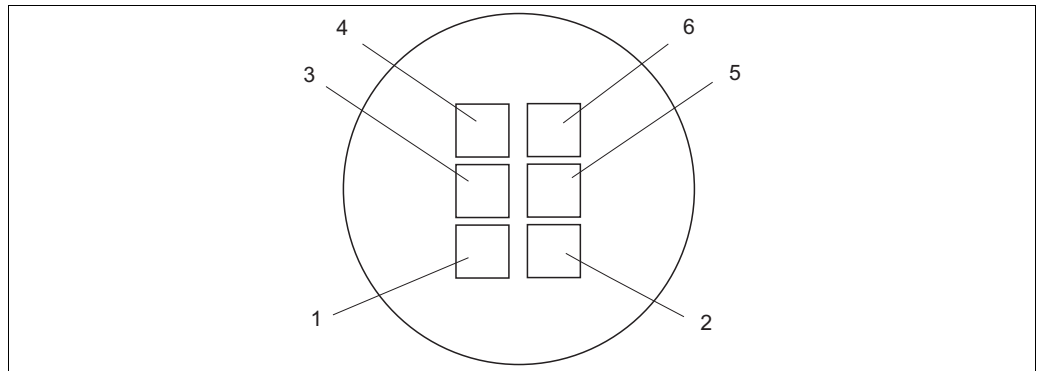


Signal distribution depending on the number of particles

Ir Relative intensity

**Sensor design**

The turbidity sensor CUS51D is equipped with two independent sensor units that are arranged in parallel. The application-specific analysis of both signals results in stable measured values.



Arrangement of the light sources and the light receivers

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

This allows the optimal turbidity and suspended solids measurement:

- For low turbidity values often the 90° channel is used, but CUS51D uses preferably the 135° channel.
- For average and high turbidity values and for suspended solids measurement the 135° channel is used.
- The dual sensor technology allows operation with a large range of soiling compensation, e.g. suspended solids measurement in the activated sludge basin (basis: four-beam pulsed light).

Based on the chosen application the appropriate model is used automatically inside the sensor.

**i** The available sensor types differ in their measuring ranges and therefore in the selection of the available applications.

**Measurement methods**

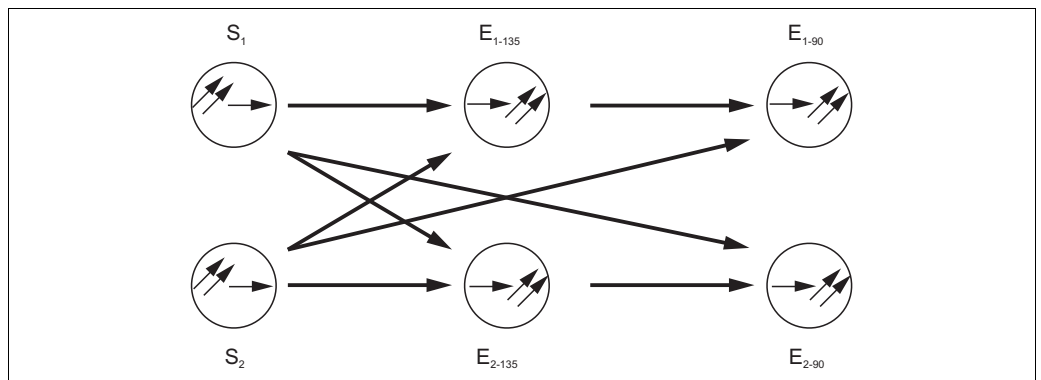
**Four-beam pulsed light method**

The method is based on two light sources and four light receivers. Long-life LEDs are used as monochromatic light sources. To eliminate interference from extraneous light sources, these LEDs are pulsed.

Two measuring signals are detected at the four light receivers. The eight measuring signals are processed in the sensor and are converted into turbidity units and solids concentrations.

The four-beam pulsed light method compensates the sensor soiling as well as the wearing of the optical components.

The number of the used signals depends on the application.

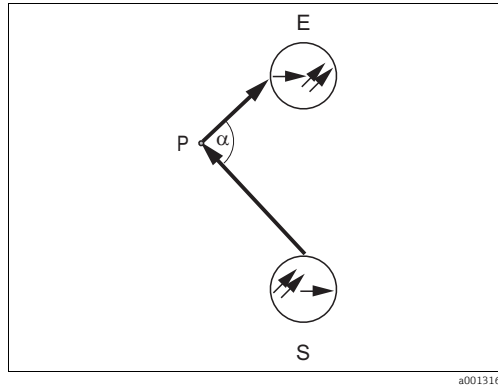


Four-beam pulsed light method

- $S_1 S_2$  Light sources
- $E_{90}$  90° channel light-receiver
- $E_{135}$  135° channel light-receiver

**90° scattered light method**

The measurement uses a wavelength of 860 nm like described in ISO 7027 / EN 27027. The transmitted light beam is scattered by the solid matter particles in the medium. The scattered beams are detected 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 the scattered light.

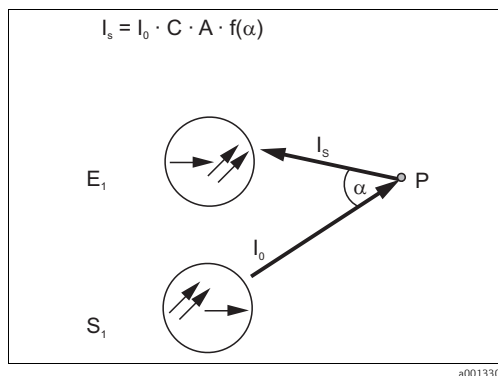


*S = Light source  
E = Light receiver  
P = Particle*

Principle of the 90° scattered light method

**135° backscattered light method**

The transmitted light beam is scattered by the solid matter particles in the medium. The backscattered beams are detected by scattered light receivers, which are arranged next to the light sources. The turbidity of the medium is determined by the amount of backscattered light. This method is used to measure high turbidity values.



$$I_s = I_0 \cdot C \cdot A \cdot f(\alpha)$$

*I<sub>0</sub> = Intensity of transmitted light  
I<sub>s</sub> = Intensity of backscattered light  
A = Geometric factor  
C = Concentration  
P = Particle  
f(α) = Angle dependence*

Principle of backscattered light method

**Sensor monitoring**

The optical signals are continuously monitored und checked for plausibility  
Discrepancies are reported via error messages by the transmitter.

The sensor check system of the Liquiline M reports the following failure conditions:

- Implausible high or low measuring values
- Disturbed controlling due to erroneous measuring values

**Applications**

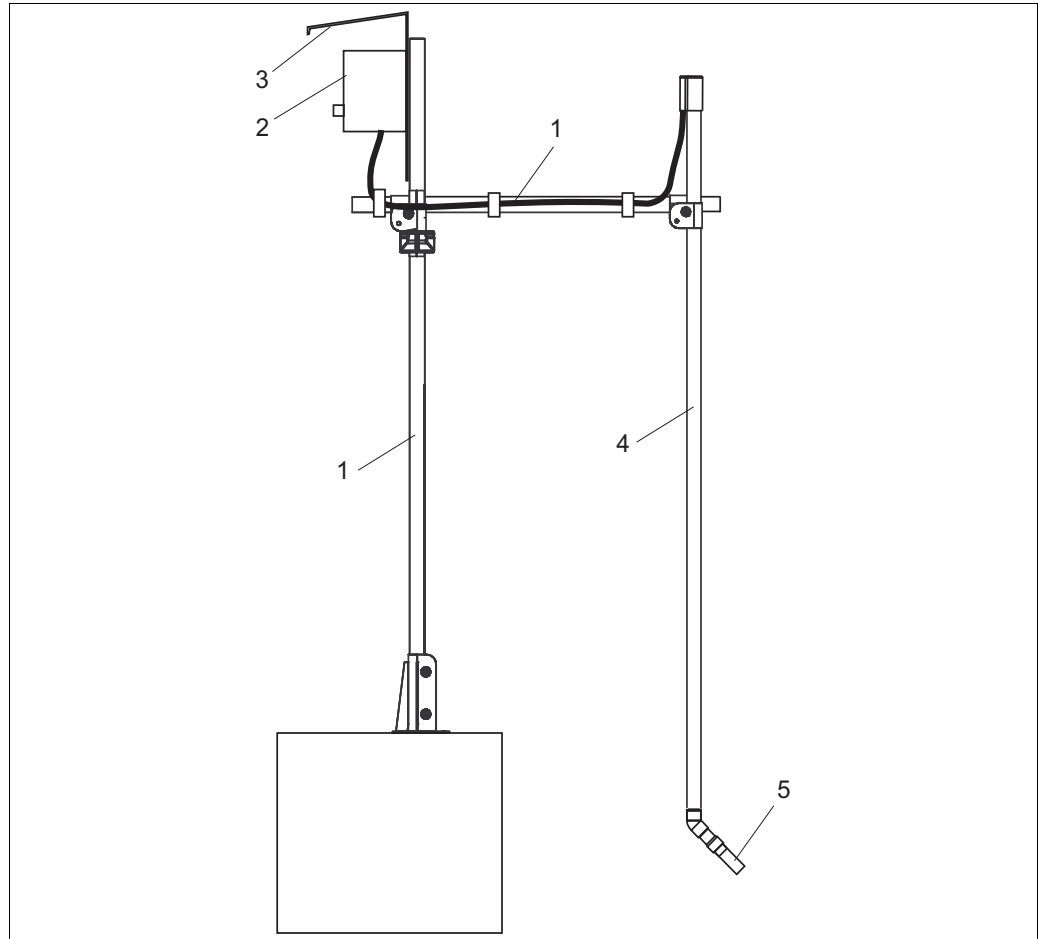
Model name	Application	Unit	Compensation *
Formazine	Process water, sewage treatment plant outlet	FTU / FNU	
Kaolin	Filterable solids, process water, sewage treatment plant outlet, activated sludge in low concentration	mg/l ; g/l; ppm; %	
SiO <sub>2</sub>	SiO <sub>2</sub> , mineralic solids (sands)	g/l; ppm; %	X
TiO <sub>2</sub>	TiO <sub>2</sub> , (white medium)	g/l; ppm; %	X
Thin sludge	From activated sludge down to clear water	g/l; ppm; %	
Activated sludge	Activated sludge basin and comparable medium	g/l; ppm; %	X
Excess sludge	Excess sludge, primary sludge, thickened sludge	g/l; ppm; %	X
Digested sludge	Digested sludge, black - homogeneous	g/l; ppm; %	

\* compensation of contamination with four-beam pulsed light

**Measuring system**

A complete measuring system comprises:

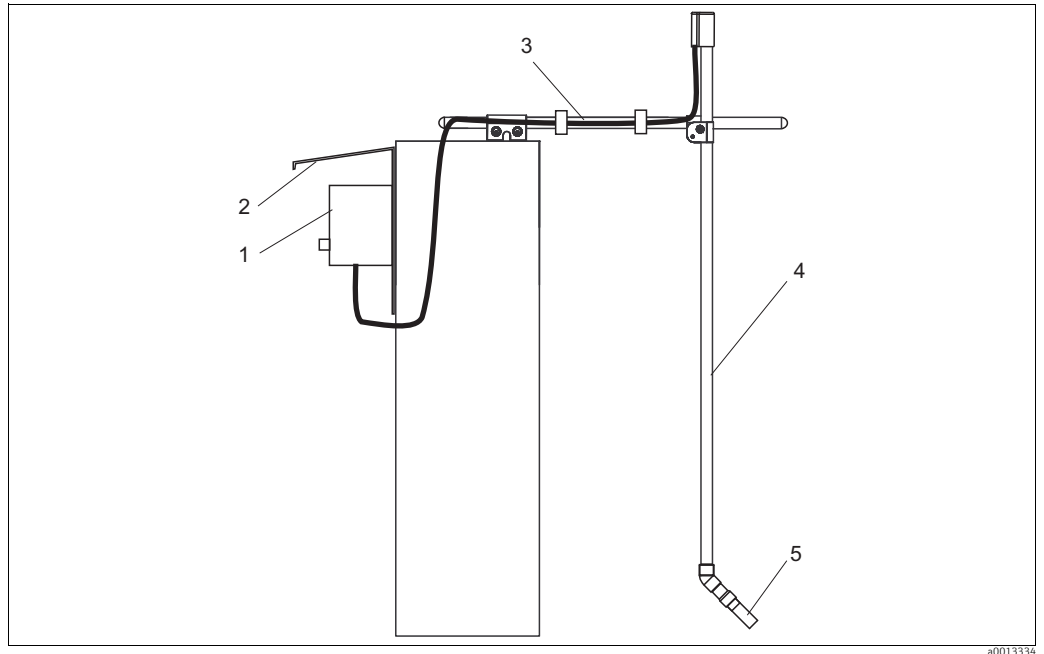
- Turbidity sensor Turbimax CUS51D
- Transmitter Liquiline
- Assembly:
  - Assembly Flexdip CYA112 and holder system Flexdip CYH112 or
  - Retractable assembly , e.g. Cleanfit CUA451



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*Measuring system with immersion assembly (example)*

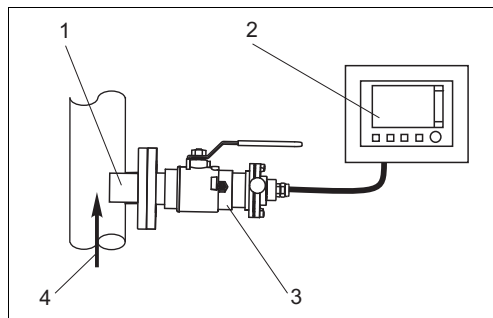
- |   |                              |   |                                  |
|---|------------------------------|---|----------------------------------|
| 1 | Holder system Flexdip CYH112 | 4 | Assembly Flexdip CYA112          |
| 2 | Transmitter Liquiline        | 5 | Turbidity sensor Turbimax CUS51D |
| 3 | Weather protection roof      |   |                                  |



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Measuring system with immersion assembly (example)

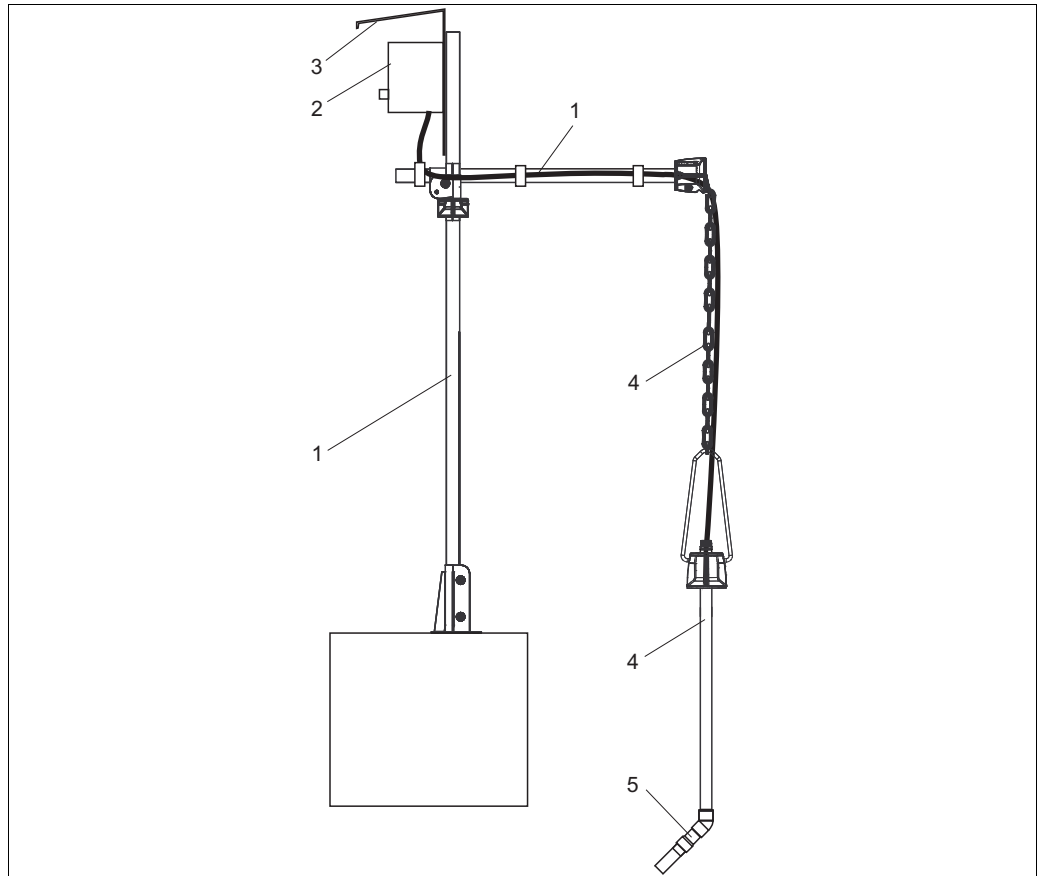
- |   |                              |   |                                  |
|---|------------------------------|---|----------------------------------|
| 1 | Transmitter Liquiline        | 4 | Assembly Flexdip CYA112          |
| 2 | Weather protection roof      | 5 | Turbidity sensor Turbimax CUS51D |
| 3 | Holder system Flexdip CYH112 |   |                                  |



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Measuring system with retractable assembly (example)

- |   |                                      |
|---|--------------------------------------|
| 1 | Turbidity sensor Turbimax CUS51D     |
| 2 | Transmitter Liquiline                |
| 3 | Retractable assembly Cleanfit CUA451 |
| 4 | Flow direction                       |



Measuring system with immersion assembly and chain holder system

- |   |                              |   |                                  |
|---|------------------------------|---|----------------------------------|
| 1 | Holder system Flexdip CYH112 | 4 | Assembly Flexdip CYA112          |
| 2 | Transmitter Liquiline CM44x  | 5 | Turbidity sensor Turbimax CUS51D |
| 3 | Weather protection roof      |   |                                  |





## Performance characteristics

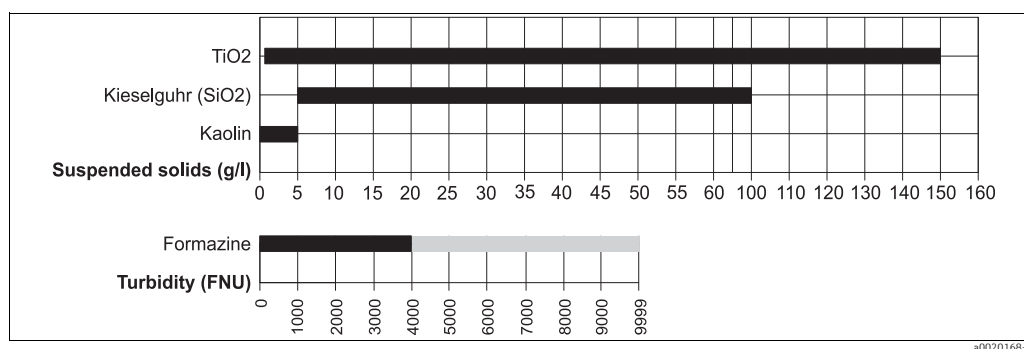
<b>Maximum measured error</b>	Turbidity	< 2% of the measured value or 0.1 FNU (the respectively larger value is valid)
	Solids	< 5 % of the measured value or 1 % of full scale ( the respectively larger value is valid); valid for sensors in the calibrated measuring range

**Wavelength** 860 ± 30 nm

**Factory calibration** FNU, FTU and solids concentration according to the application table  
Standard: 3 points

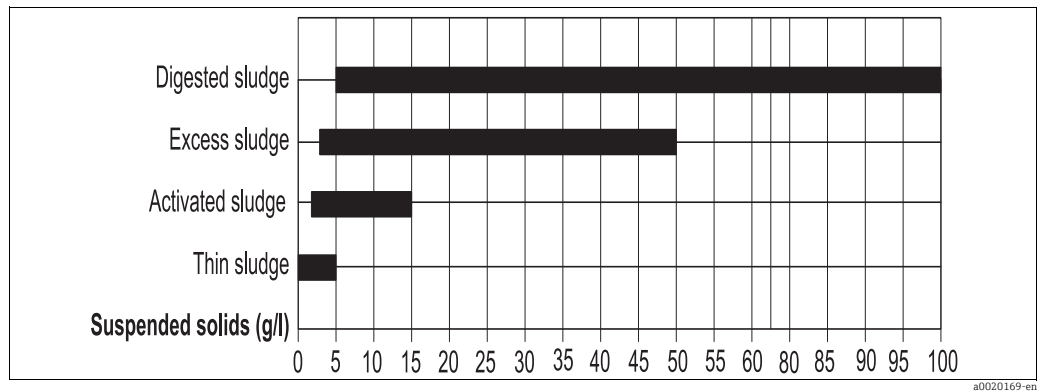
**Applications** The sensor is factory calibrated in the application "formazine" and hereof derived for "kaolin filterable solids)". Further precalibrated applications are optimized for the corresponding medium. The calibration can be performed up to 5 points.

Application water	Recommended working ranges	CUS51D-	
		C1	D1
Factory calibration formazine	0 to 4000 FNU	X	X
Factory calibration kaolin	0 to 4 g/l	X	X
Application SiO <sub>2</sub>	5 to 100 g/l		X
Application titanium dioxide	0.2 to 150 g/l		X



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Application wasterwater	Recommended working ranges	CUS51D-	
		C1	D1
Application thin sludge	0 to 5 g/l		X
Application activated sludge	0.5 to 15 g/l		X
Application excess sludge	3 to 50 g/l		X
Application digested sludge / ooze	5 to 100 g/l / 300 g/l		X



**i** For solids the achievable measuring ranges are depending of the actual medium and can deviate from the recommended operating ranges.

**Drift** Thanks to electronic control the sensor works drift compensated in a wide range.

**Limit of detection**

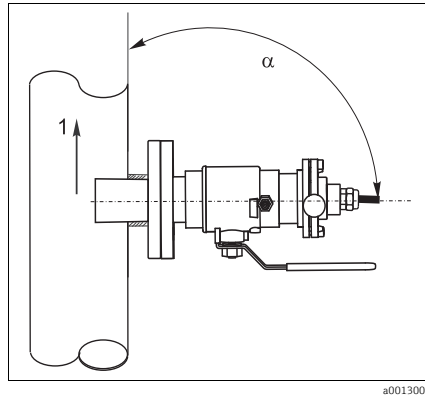
Application	Measuring range	Limit of detection
Formazine	0 to 50 FNU	0.006 FNU
	0 to 9999 FNU	0.4 FNU
Kaolin	0 to 4000 mg/l	0.85 mg/l

## Installation conditions

### Installation instructions

Mounting applications:

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



Installation with retractable assembly

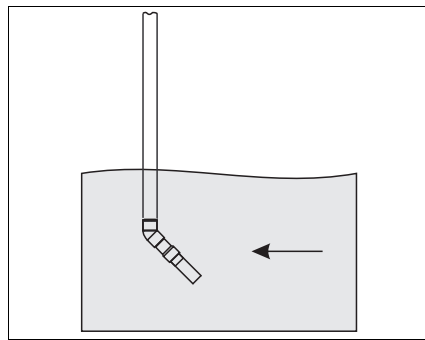
Arrow 1 shows the flow direction.

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

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

The optical windows of the sensor have to be aligned parallel to the flow direction ( $\alpha = 90^\circ$ ) or face the flow direction ( $\alpha < 90^\circ$ ).

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



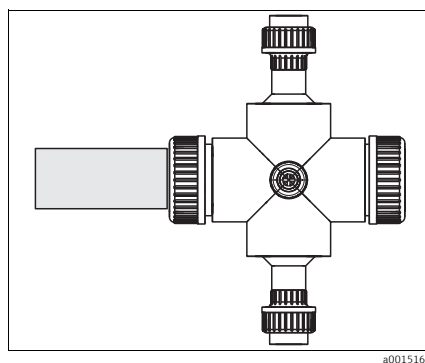
Installation with wastewater assembly

The arrow shows the flow direction.

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

If you use the sensor in open basins, install the sensor in a way no bubbles can build up around the optical windows.

If you use the sensor in strong aerated basins install the sensor in an installation angle of  $90^\circ$  to minimize the influence of bubbles.



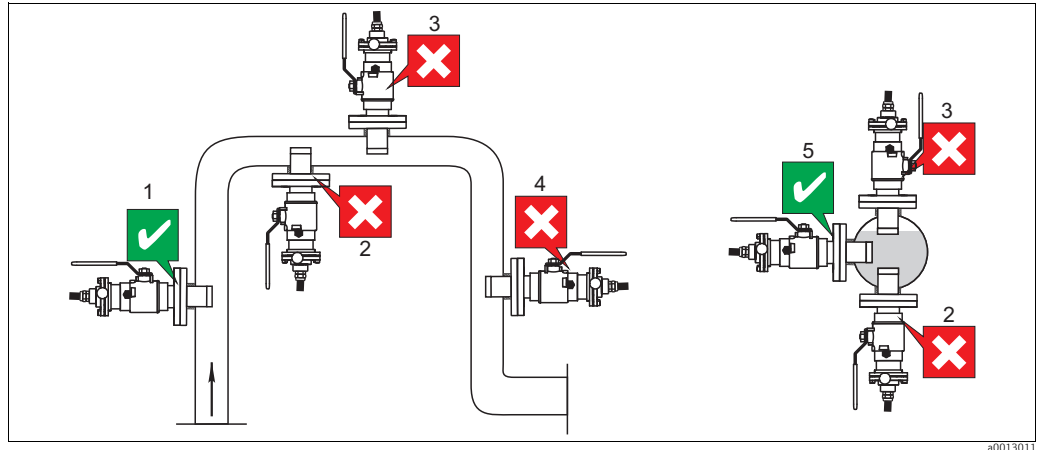
Installation with flow assembly CYA251

The installation angle is  $90^\circ$ .

Turbidity measurement  $< 200$  FNU will result in erroneous measuring results due to backscattering of pipe wall.

**Pipe installation**

The following figure illustrates various installation positions in pipes and indicates whether they are permitted or not.



Orientation and installation positions (with retractable assembly CUA451)

- The pipeline diameter must be at least 100 mm (4") if reflective materials (e.g. stainless steel) are used. An onsite calibration is recommended.
- Install the sensor in places with uniform flow conditions.
- The best installation location is in the ascending pipe (it. 1). Installation is also possible in the horizontal pipe (it. 5).
- Do not install the sensor in places where air may collect or foam bubbles form (it. 3) or where suspended particles may settle (it. 2).
- Avoid installation in the down pipe (it. 4).
- Turbidity measurement < 200 FNU will result in erroneous measuring results due to backscattering of pipe wall. Therefore a multipoint calibration is recommended.
- Avoid installations behind pressure reduction steps which can outgas.

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## Environment

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<b>Ambient temperature</b>	-20 to 60 °C (-4 to 140 °F)
<b>Storage temperature</b>	-20 to 70 °C (-4 to 158 °F)
<b>Ingress protection</b>	IP 68 (test conditions: 1 m (3.3 ft) water column during 60 days, 1 mol/l KCl)

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## Process

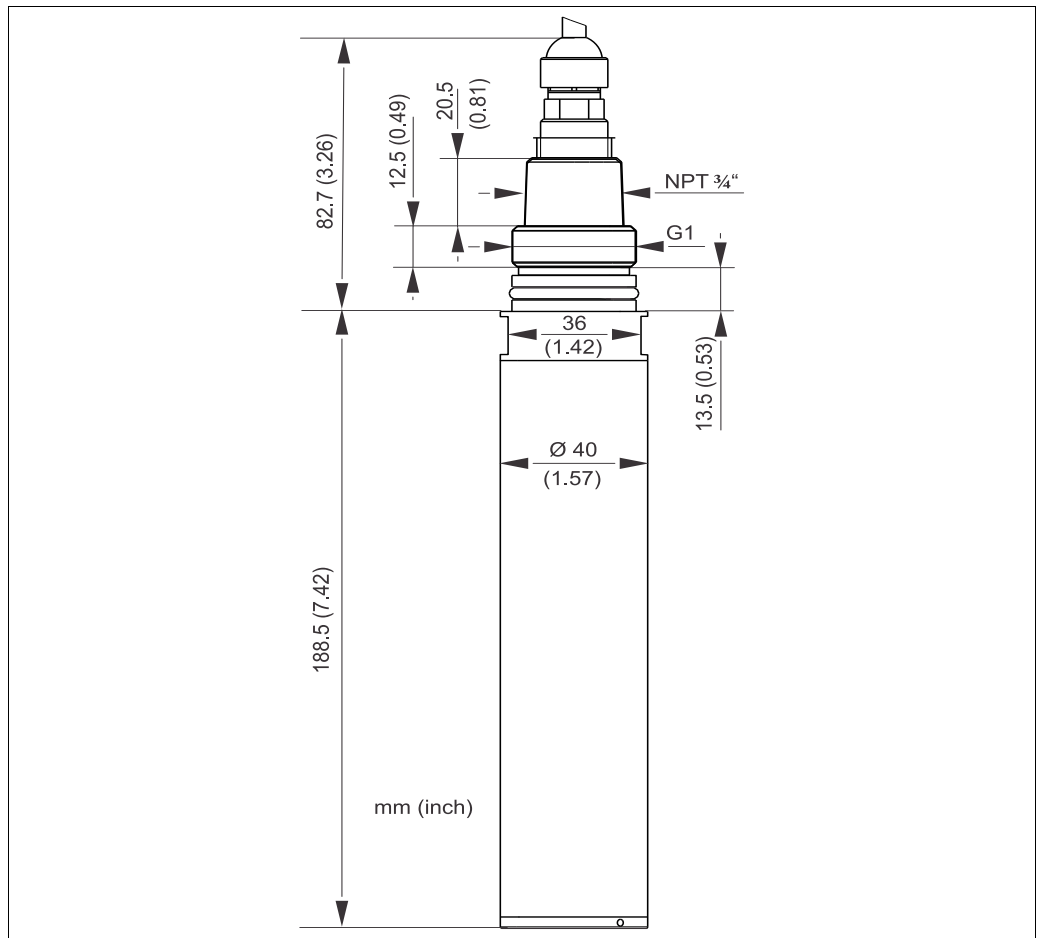
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<b>Process temperature</b>	-5 to 50 °C (23 to 120 °F) max. 80 °C (175 °F) short term(1 h)
<b>Process pressure</b>	0.5 to 10 bar (7 to 145 psi) absolute
<b>Minimum flow</b>	No minimum flow required. Make sure that there is a sufficient turbulence for solids with a tendency to sedimentation.

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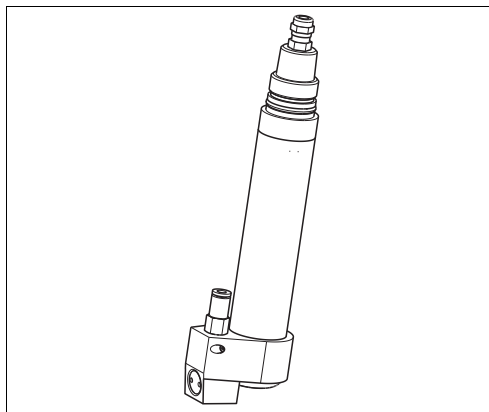
## Mechanical construction

### Dimensions



Dimensions

### Cleaning system



CUS51D with cleaning system

Cleaning system with pressurized air  
 Consumption: 50 l/min (13.2 gal/min)  
 Primary pressure: 1.5 to 2 bar (22 to 30 psi)  
 Connection: 6/8 mm or 6.35 mm (1/4")

### Weight

approx. 0.7 kg (1.5 lbs) without cable

### Materials

Sensor	Stainless steel 1.4404 (AISI 316 L)
Optical windows	Stainless steel 1.4571 (AISI 316 L) for pipe cover
O-rings	Sapphire
	EPDM

### Process connections

G1 and NPT 3/4"

## Certificates and approvals

### EMC compatibility

Interference emission and interference immunity complies with EN 61326: 2005, Namur NE 21:2007

## Ordering information

### Order code

To get to the product page enter the following address into your browser:


[www.products.endress.com/cus51d](http://www.products.endress.com/cus51d)

1. You can choose from the following options on the product page located on the right:

Product page function
:: Add to product list
:: Price & order information
:: Compare this product
:: Configure this product

2. Click "Configure this product".
3. The configurator opens in a separate window. You can now configure your device and receive the complete order code that applies for the device.
4. Afterwards, export the order code as a PDF or Excel file. To do so, click the appropriate button at the top of the page.

### Product structure

 The following product structure represents the status of printing. You can create a complete and valid order code on the Internet using the configurator tool.

Approval	
AA	Non-hazardous area
Application, measuring range	
C1	Process water
D1	Process water; solids
Adaption cable	
A	Fixed cable, crimp sleeves
B	Fixed cable, M12-plug
Cable length	
2	3 m (9.9 ft)
3	7 m (23 ft)
4	15 m (49.2 ft)
CUS51D-	order code

Accessories code	Accessories mounted
IA	Air cleaning, 6/8 mm
IB	Air cleaning, 6.35 mm (1/4")

Note! To complete your order code, simply add the accessories code to the end of order code. If you have any questions, please contact your local sales office.

### Scope of delivery

The scope of delivery comprises:

- 1 sensor Turbimax CUS51D in the ordered version
- 1 Operating Instructions BA461C/07/en



## Accessories

### Assemblies

Retractable assembly Cleanfit CUA451

- Retractable assembly with ball valve; for turbidity sensors; material: stainless steel
- Ordering per product structure (--> Online configurator, [www.products.endress.com/cua451](http://www.products.endress.com/cua451))
- Technical Information TI00369C/07/EN

Wastewater assembly Flexdip CYA112

- Modular assembly system for sensors in open basins, channels and tanks
- Versions in stainless steel or PVC
- Ordering per product structure (--> Online configurator: [www.products.endress.com/cya112](http://www.products.endress.com/cya112))
- Technical Information TI00432C/07/EN

Flow assembly Flowfit CYA251

- Connection: see product structure
- Material: PVC-U
- Order as per product structure

### Holder system

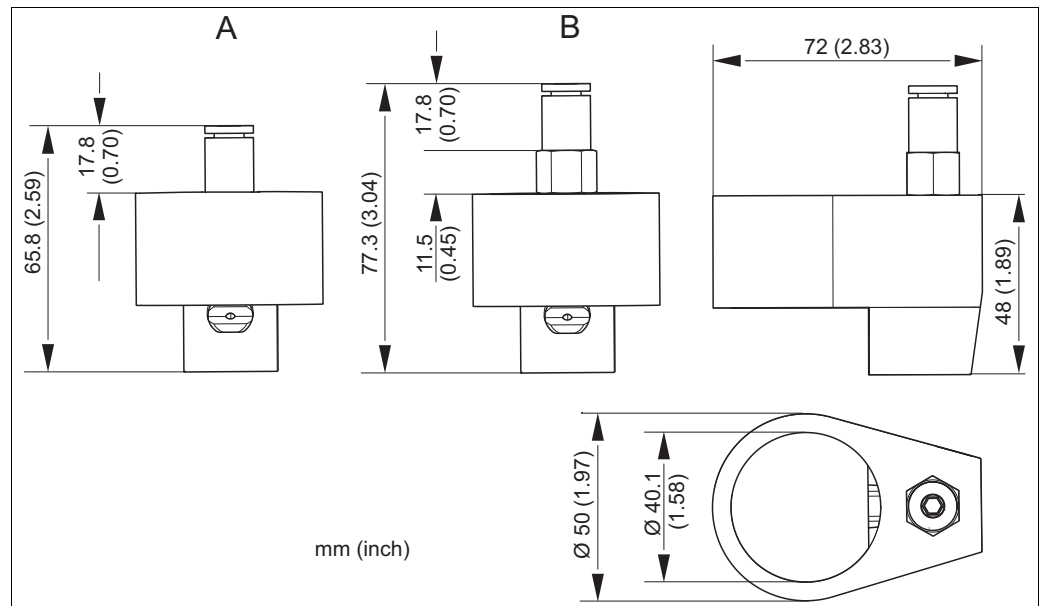
Holder system Flexdip CYH112 for water

- Modular holder system for sensors and assemblies in open basins, channels and tanks
- The holder system CYH112 works for nearly any type of fixing - fixing on the floor, wall or directly on a rail.
- Material: stainless steel
- Ordering acc. to product structure (--> Online configurator: [www.products.endress.com/cyh112](http://www.products.endress.com/cyh112))
- Technical Information TI00430C/07/EN

### Cleaning system

Cleaning system with pressurized air

- Connection: 6 or 8 mm (metric) or 6.35 mm (1/4")
- Materials: POM/V4A
- 6/8 mm order number: 71110782
- 6.35 mm (1/4") order number: 71110783



Cleaning system

- A Version 6 mm  
B Version 6.35 mm (1/4")

Compressor

- For cleaning system
- 230 V AC order number: 71072583
- 115 V AC order number: 71194623

**Transmitter**

## Liquiline CM44x

- Multiple-channel transmitter for the connection of digital sensors with Memosens technology
- Power supply: 85 to 265 V AC, 18 to 36 V DC or 20 to 28 V AC (not CM448)
- Universally upgradeable
- SD card slot
- Alarm relay
- IP 66
- Ordering acc. to product structure (Technical Information TI444C/07/en)



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

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