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.

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.

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).
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](image)

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.

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](image)

$S_1$, $S_2$: 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.

**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.

\[
I_s = I_0 \cdot C \cdot A \cdot f(\alpha)
\]

- \(I_0\): Intensity of transmitted light
- \(I_s\): Intensity of backscattered light
- \(A\): Geometric factor
- \(C\): Concentration
- \(P\): Particle
- \(f(\alpha)\): Angle dependence

![Principle of the 90° scattered light method](image1)

![Principle of backscattered light method](image2)
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

<table>
<thead>
<tr>
<th>Application</th>
<th>Model name</th>
<th>Unit</th>
<th>Compensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process water, sewage treatment plant outlet</td>
<td>Formazine</td>
<td>FTU / FNU</td>
<td></td>
</tr>
<tr>
<td>Filterable solids, process water, sewage treatment plant outlet, activated sludge in low concentration</td>
<td>Kaolin</td>
<td>mg/l : g/l; ppm; %</td>
<td></td>
</tr>
<tr>
<td>SiO₂, mineralic solids (sands)</td>
<td>SiO₂</td>
<td>g/l; ppm; %</td>
<td>X</td>
</tr>
<tr>
<td>TiO₂, (white medium)</td>
<td>TiO₂</td>
<td>g/l; ppm; %</td>
<td>X</td>
</tr>
<tr>
<td>From activated sludge down to clear water</td>
<td>Thin sludge</td>
<td>g/l; ppm; %</td>
<td></td>
</tr>
<tr>
<td>Activated sludge basin and comparable medium</td>
<td>Activated sludge</td>
<td>g/l; ppm; %</td>
<td>X</td>
</tr>
<tr>
<td>Excess sludge, primary sludge, thickened sludge</td>
<td>Excess sludge</td>
<td>g/l; ppm; %</td>
<td>X</td>
</tr>
<tr>
<td>Digested sludge, black - homogeneous</td>
<td>Digested sludge</td>
<td>g/l; ppm; %</td>
<td></td>
</tr>
</tbody>
</table>

* 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

![Diagram of Measuring System with Immersion Assembly](image-url)

Measuring system with immersion assembly (example)

1. **Holder system Flexdip CYH112**
2. **Transmitter Liquiline**
3. **Weather protection roof**
4. **Assembly Flexdip CYA112**
5. **Turbidity sensor Turbimax CUS51D**
Measuring system with immersion assembly (example)

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

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
2. Transmitter Liquiline CM44x
3. Weather protection roof
4. Assembly Flexdip CYA112
5. Turbidity sensor Turbimax CUS51D
Input

Measuring variables
- Turbidity
- Solids content
- Temperature

Measuring range

<table>
<thead>
<tr>
<th>Turbidity</th>
<th>Solids content</th>
<th>Temperature</th>
<th>Application</th>
<th>Formazine</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUS51D-**C1</td>
<td>0 to 4000 FNU</td>
<td>0 to 4 g/l</td>
<td>0 to +80 °C (4 to +176 °F)</td>
<td>Formazine</td>
</tr>
<tr>
<td>display range up to 9999 FNU</td>
<td>Kaolin, filterable solids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CUS51D-**D1</td>
<td>0 to 4000 FNU</td>
<td>0 to 300 g/l</td>
<td>0 to 30 %</td>
<td>Solids content according to chosen application (see list)</td>
</tr>
<tr>
<td>display range up to 9999 FNU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Measuring range of solids content:
For solids the achievable measuring ranges are depending on the actual medium and can deviate from the recommended operating ranges. Nonhomogeneous media produce fluctuations in measured values and restrict the measuring range.

Power supply

The sensor will be connected to the transmitter as follows:
- With the M12 plug (version CUS51D-xxxxBxxx) or
- the fixed cable has to be connected to the terminal as follows (version CUS51D-xxxxAxxx):

![Sensor connection diagram]

Sensor connection

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

### Maximum measured error
- **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.

<table>
<thead>
<tr>
<th>Application water</th>
<th>Recommended working ranges</th>
<th>CUS51D-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory calibration formazine</td>
<td>0 to 4000 FNU</td>
<td>X</td>
</tr>
<tr>
<td>Factory calibration kaolin</td>
<td>0 to 4 g/l</td>
<td>X</td>
</tr>
<tr>
<td>Application SiO₂</td>
<td>5 to 100 g/l</td>
<td>X</td>
</tr>
<tr>
<td>Application titanium dioxide</td>
<td>0.2 to 150 g/l</td>
<td>X</td>
</tr>
</tbody>
</table>

### Application wastewater

<table>
<thead>
<tr>
<th>Application wastewater</th>
<th>Recommended working ranges</th>
<th>CUS51D-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application thin sludge</td>
<td>0 to 5 g/l</td>
<td>X</td>
</tr>
<tr>
<td>Application activated sludge</td>
<td>0.5 to 15 g/l</td>
<td>X</td>
</tr>
<tr>
<td>Application excess sludge</td>
<td>3 to 50 g/l</td>
<td>X</td>
</tr>
<tr>
<td>Application digested sludge / ooze</td>
<td>5 to 100 g/l / 300 g/l</td>
<td>X</td>
</tr>
</tbody>
</table>
For solids the achievable measuring ranges are depending on 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

<table>
<thead>
<tr>
<th>Application</th>
<th>Measuring range</th>
<th>Limit of detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formazine</td>
<td>0 to 50 FNU</td>
<td>0.006 FNU</td>
</tr>
<tr>
<td></td>
<td>0 to 9999 FNU</td>
<td>0.4 FNU</td>
</tr>
<tr>
<td>Kaolin</td>
<td>0 to 4000 mg/l</td>
<td>0.85 mg/l</td>
</tr>
</tbody>
</table>
Installation conditions

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

Arrow 1 shows the flow direction. The installation angle $\alpha$ must not exceed 90°. The recommended installation angle is 75°. The optical windows of the sensor have to be aligned parallel to the flow direction ($\alpha = 90°$) or face the flow direction ($\alpha < 90°$). For manual insertion/retraction of the assembly the medium pressure may not exceed 2 bar (29 psi).

The arrow shows the flow direction. The installation angle is 45° (recommended) or 90°. 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° to minimize the influence of bubbles.

The installation angle is 90°. 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.

- 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.
Environment

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

Process

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

Dimensions

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 (¼"

CUS51D with cleaning system

Weight
approx. 0.7 kg (1.5 lbs) without cable

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

Process connections
G1 and NPT ¼"
Certificates and approvals

EMC compatibility

Ordering information

Order code
To get to the product page enter the following address into your browser:
www.products.endress.com/cus51d
1. You can choose from the following options on the product page located on the right:

- 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.

<table>
<thead>
<tr>
<th>Approval</th>
<th>AA</th>
<th>Non-hazardous area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application, measuring range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>Process water</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>Process water; solids</td>
<td></td>
</tr>
<tr>
<td>Adaption cable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Fixed cable, crimp sleeves</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Fixed cable, M12-plug</td>
<td></td>
</tr>
<tr>
<td>Cable length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3 m (9.9 ft)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>7 m (23 ft)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>15 m (49.2 ft)</td>
<td></td>
</tr>
</tbody>
</table>

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)
- 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)
- 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)
- Technical Information TI00430C/07/EN

Cleaning system
Cleaning system with pressurized air
- Connection: 6 or 8 mm (metric) or 6.35 mm (¼"
- Materials: POM/V4A
- 6/8 mm order number: 71110782
- 6.35 mm (¼") order number: 71110783

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

Cleaning system

Compressor
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)