

Technical Documentation

# CT-1000

The potentiometric level sensor



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## Table of contents

<b>1</b>	<b>Field of application .....</b>	<b>4</b>
<b>2</b>	<b>Safety instructions.....</b>	<b>5</b>
<b>3</b>	<b>Design and function description .....</b>	<b>6</b>
<b>4</b>	<b>Installation .....</b>	<b>8</b>
4.1	CT-1000 Mono (single rod).....	9
4.2	CT-1000 DU (two rods) .....	9
<b>5</b>	<b>Electrical connection.....</b>	<b>10</b>
<b>6</b>	<b>Configuration.....</b>	<b>12</b>
6.1	Measuring span at the level sensor .....	12
6.2	Current draw in failure mode .....	13
<b>7</b>	<b>Technical data .....</b>	<b>15</b>

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## 1 Field of application

The purpose of the CT-1000 level sensor is to provide continuous level gauging of electrically conductive liquids ( $> 1 \mu\text{S}/\text{cm}$ ). During the measurement no insulating layer must be formed on the probe tube.

The level sensor is available in lengths of 8" to 19.7' .

With the "single-rod probe" model (CT-1000 Mono), the inside of the container must have a conductive surface (metal containers/downpipes). The "two-rod probe" model (CT-1000 DU) is compatible with non-conductive containers.

The standard sensors work by outputting the measured fill level as an analog value in the range 4 to 20 mA.

With the HART option, the configuration and retrieval of measured values by the digital HART protocol are supported, see

- Technical Documentation for CT-1000 with HART protocol– art. no. 350044

In conjunction with the standard level sensors, wetted parts are in stainless steel 1.4571, insulators are in PTFE. On request, the probe tubes are also available in Hastelloy, tantalum, titanium or stainless steel 1.4404.

## 2 Safety instructions

The purpose of the CT-1000 level sensor is to provide continuous level gauging of liquids. The level sensor must be used exclusively for this purpose. The manufacturer accepts no liability for any loss or damage arising from improper use.

The level sensor has been developed, manufactured and tested in accordance with the latest good engineering practices and generally accepted safety standards. Nevertheless, hazards may arise from its use. For this reason, the following safety information must be observed:

Do not change or modify the level sensor or add any equipment without the prior consent of the manufacturer. The installation, operation and maintenance of the level sensor must be carried out only by expert personnel. Equipment operators, set-up technicians and service technicians must comply with all applicable safety regulations. This also applies to any local safety regulations and accident prevention regulations which are not stated in these operating instructions.

The safety instructions in this manual are labelled as follows:



**Failure to observe these safety instructions could result in a risk of accident or damage to the CT-1000 level sensor.**



*Useful information designed to ensure continued and correct operation of the CT-1000 level sensor and to make your work easier.*

### 3 Design and function description

The design of the CT-1000 level sensor is illustrated in Figure 1 with the screw-in unit version as an example. Inside the sensor head (1) and concealed by the cap (2) are the protected terminals and configuration buttons. The electrical connection is established by means of an M16x1.5 screwed cable gland (3) and screw terminals or by an M12 plug-in connection. Ground connection (4) is required only in conjunction with the CT-1000 Mono version (see section 5 Electrical connection). On the probe neck, there is either a screw-in unit (5) or a flange (not shown) for installing the probe in the container. The probe neck (6) is a long, thin tube.

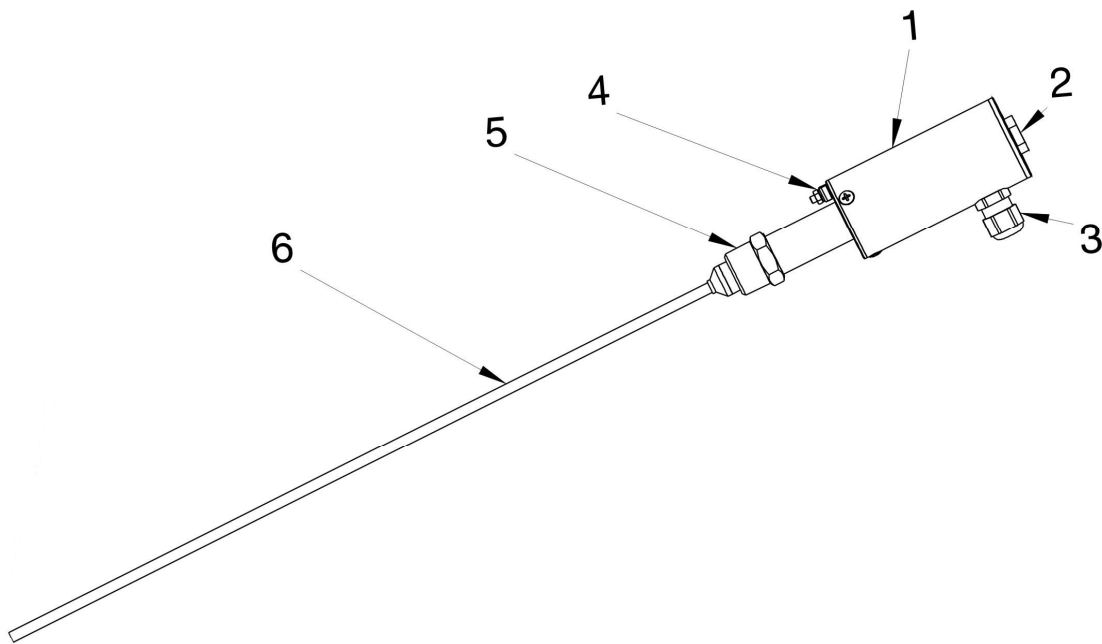


Figure 1: The CT-1000 level sensor

A current pulse generates a linear voltage drop ( $< 100$  mV) on the probe tube (6) electrically insulated from tank potential. The voltages at the bottom end and top end of the tube are measured.

As long as the probe tube is not immersed, it has no path to the tank potential. This state is detected by the signal processor, which outputs an "empty" signal. As soon as the probe tube is immersed, the voltage measured at the immersed tube end corresponds to tank potential and the voltage measured at the top end is added to the voltage drop along the non-immersed part of the probe tube.

With the probe tube fully immersed, the voltages measured at the top and bottom ends of the tube are equal in respect of the potential reference point. The region in between is mostly linear, depending on the tank geometry and the distance between the tube end and tank bottom, which makes it possible to calculate the fill level from the ratio of the measured voltages.

The fill level is calculated from the ratio of the measured voltages by a microcontroller. The ratio of the two voltages also enables the orientation of the CT-1000 sensor to be detected, i.e. whether the sensor has been installed from top down or bottom up.

The level sensor is fed from a 2-wire 4 to 20 mA interface and requires a voltage between 8 and 30 V. The positions of the 4 mA and 20 mA points on the probe tube are freely adjustable (see chapter 6 Configuration). To prevent galvanic processes from occurring in the liquid, both the discharging and charging currents flow through a galvanically isolating transformer. The alternating voltage produced across the very low-resistance probe tube is in the 100 mV range.

The table below shows the signal characteristics of the sensor depending on sensor orientation and measured value output setting (normal/inverted).

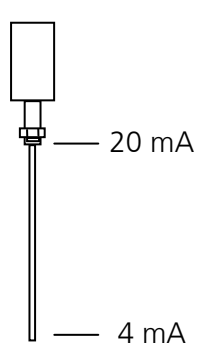
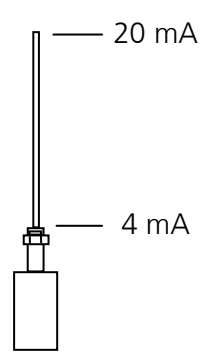
	Measured value output normal		Measured value output inverted	
	Fill level	"Empty" signal	Fill level	"Empty" signal
<b>Installation top down</b> 	3.8 mA	20.5 mA		
<b>Installation bottom up</b> 	20.5 mA	3.8 mA		

Figure 2: Measured value output

**Bottom up orientation:**

**Top down orientation:**

**Normal measured value output:**

**Inverted measured value output:**

The 0 point is at the probe base

The 0 point is at the sensor head

The 20 mA point is higher than the 4 mA point

The 20 mA point is lower than the 4 mA point

## 4 Installation



All local safety and accident prevention regulations not expressly referred to herein must be observed.

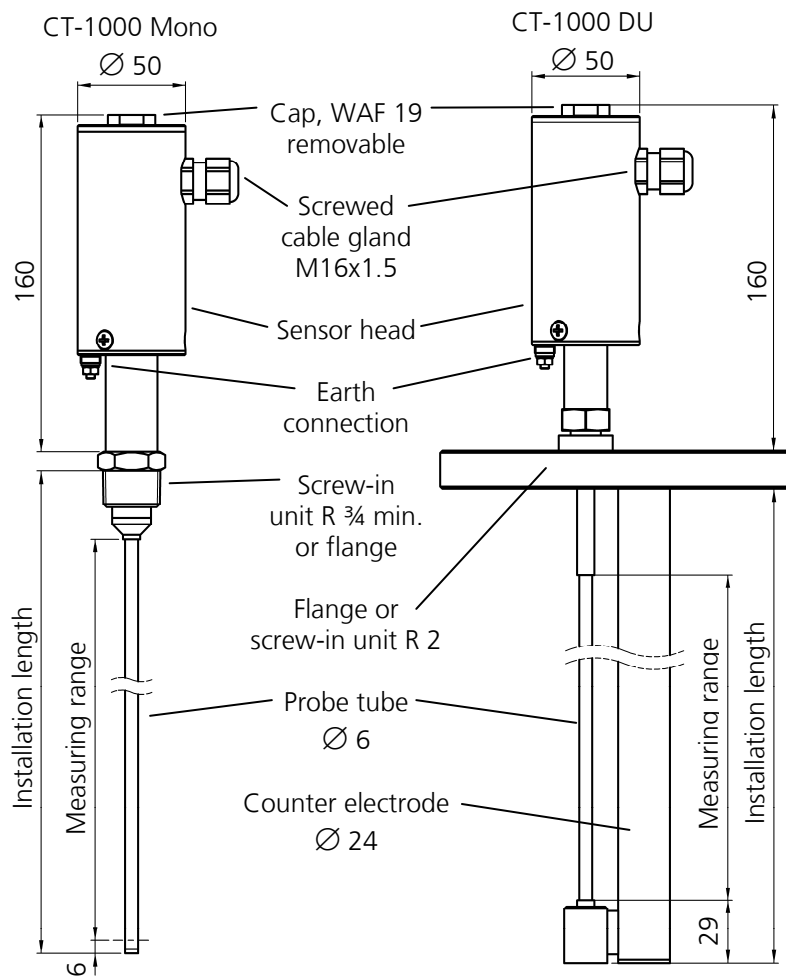


Figure 3: CT-1000 variants



Level gauging with CT-1000 is possible only in electrically conductive liquids.



The level sensor can also be fitted into the tank from underneath. The orientation is detected automatically.



CT-1000 Mono: If the probe tube is immersed in the liquid only a short way, the linearity of the measurement is affected by the short distance between the probe tube and reference potential.



## **4.1 CT-1000 Mono (single rod)**

With the single-rod probe, the tank acts as the counter electrode. For this reason, the material on the inside of the tank must be conductive and there must be good electrical contact between the tank and sensor head. For this purpose, the ground connection must be connected to the tank.

## **4.2 CT-1000 DU (two rods)**

With the two-rod probe, the second rod acts as the counter electrode. As the distance from reference potential is constant, the measurement result is unaffected by the geometry of the tank. While the second rod also adds to the stability of the mechanical design, this does require a larger process connection for installation.

## 5 Electrical connection

For the wiring of the level sensor, you need a two-core unshielded cable, which is terminated inside the sensor head of the level sensor.

It is essential that the correct minimum wire gauge be selected: the supply voltage at the level sensor must not fall below 8 V in the event of maximum current draw (21.5 mA).

To connect the level sensor (see Figure 4):

- Unscrew cap (1) using an open-ended spanner (WAF 19)
- Loosen union nut (2) of screwed cable gland (3)

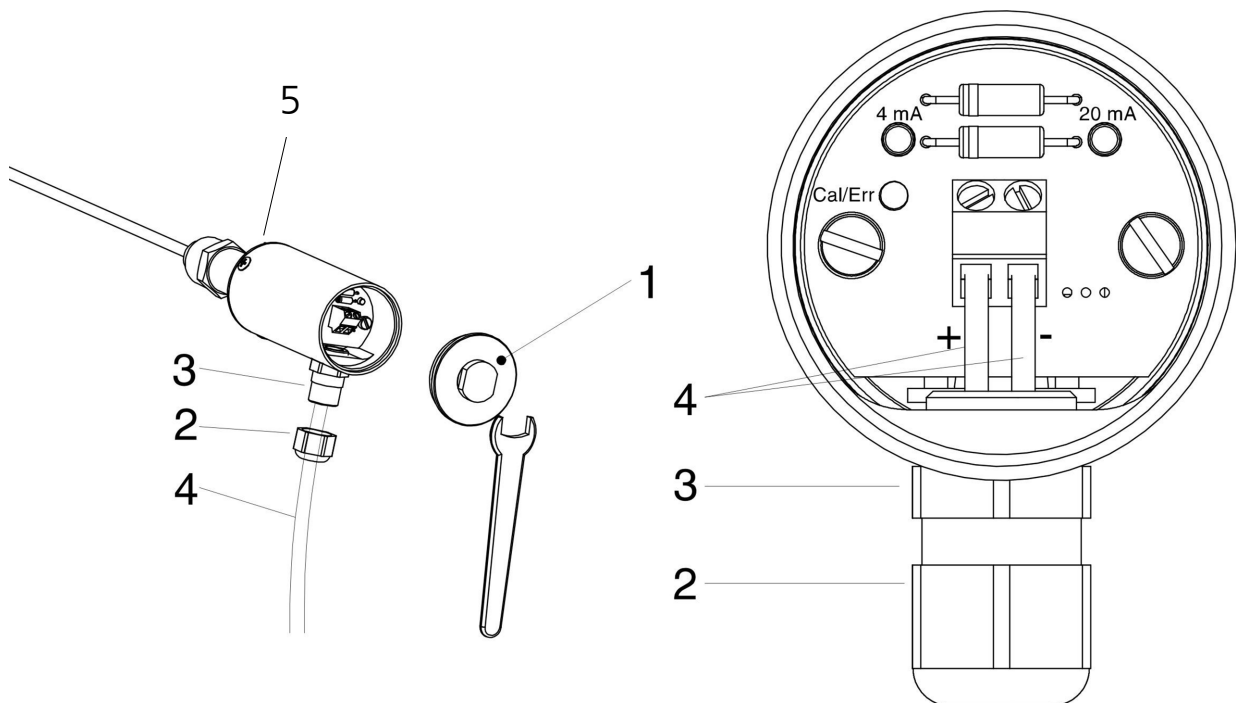


Figure 4: Connecting the CT-1000 level sensor

- Feed two-core cable (4) through union nut (2) and fit screwed cable gland (3) and then retighten the union nut.
- Connect two-core cable (4) to the screw terminals on the sensor head marked (+) and (-). Observe proper polarity.
- Screw on cap (1)

The earth connection on the underside of the sensor head can be used for earthing or equipotential bonding.



**With the CT-1000 Mono, ground connection (5) must be connected to the electrically conductive tank.**



**Protect the sensor head against the ingress of water. An external cable diameter of 5 to 10 mm ensures reliable sealing of the cable entry. Make sure that the cable gland is screwed tight, and close the cap firmly.**



*During all installation operations, it must be ensured that the negative terminal of CT-1000 is internally connected to the housing.*

## 6 Configuration

### 6.1 Measuring span at the level sensor

To enable configuration of the 4 mA and 20 mA points at the CT-1000 level sensor, two buttons and an LED (light emitting diode) are provided near the terminals inside the sensor head.

By default, the level sensor is set to maximum span with 4 mA at the probe base and 20 mA at the sensor head. The measuring span is configurable for adaptation to the tank concerned. However, the minimum distance between both points must be at least 10 mm. If this minimum distance is not observed, the display direction of the level sensor will be reversed automatically. The measured value would then be inverted.

Measuring span configuration (see Figure 5):

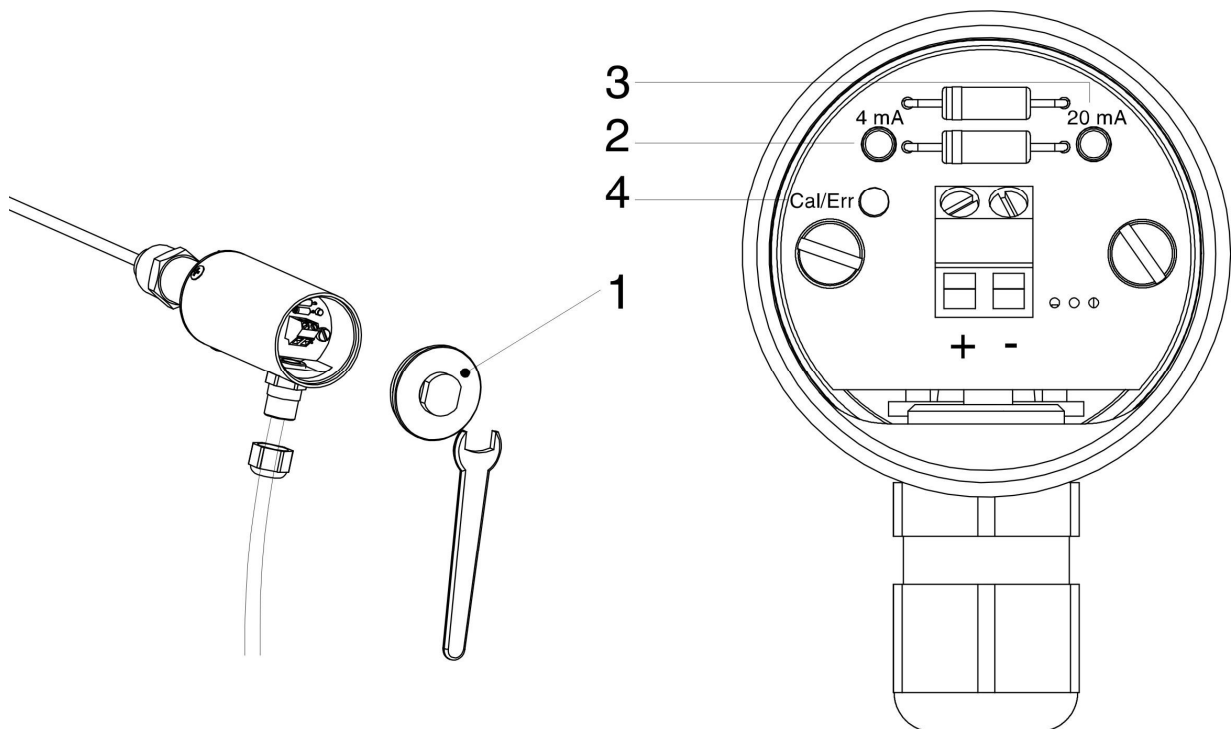


Figure 5: Measuring span configuration

- Unscrew cap (1) using an open-ended spanner (WAF 19).
- Press and hold 4 mA button (2) or 20 mA button (3) for at least 3 seconds.

The level sensor is now in configuration mode. Green LED (4) "Cal/Err" flashes. The current draw of the level sensor is 12 mA. If no button is pressed again, the level sensor remains in configuration mode for 20 seconds before reverting to measuring mode and discarding any changes.

In configuration mode, the 4 mA or 20 mA point, or both reference points, can be modified in any order.

To define a reference point while the sensor is in configuration mode

- briefly press the 4 mA button (2) (1-2 seconds) to define a current draw of 4 mA for the present immersed position of the sensor.
- briefly press the 20 mA button (3) (1-2 seconds) to define a current draw of 20 mA for the present immersed position of the sensor.

When the 4 mA button is pressed, the LED goes out for 5 seconds. When the 20 mA button is pressed, the LED lights up permanently for 5 seconds. The sensor then remains in configuration mode for a further 15 seconds before storing the change and reverting to measuring mode.



*The new configuration will not be adopted by the level sensor until it has switched from configuration mode to measuring mode automatically (LED goes out). The level sensor must, therefore, not be disconnected from the power supply until this time.*

## 6.2 Current draw in failure mode

If a malfunction is preventing the level sensor from detecting levels correctly, the sensor will enter failure mode after a short time. Failure mode signalling conforms to the NAMUR NE43 recommendation. The failure current is set by default to 21.5 mA but this value can also be set to 3.6 mA.

Configuration of current draw in failure mode (see Figure 5):

- Unscrew cap (1) using an open-ended spanner.
- Press and hold both the 4 mA button (2) and the 20 mA button (3) simultaneously for at least 3 seconds.

Green LED (4) "Cal/Err" flashes rapidly. The current draw of the level sensor is 16 mA. After 5 seconds, the LED stops flashing and then indicates the selected failure current draw for 2.5 seconds. If the LED lights up permanently, the failure current is 21.5 mA; if the LED goes out, the failure current is 3.6 mA. If no button is pressed again, the level sensor remains in failure mode for a further 2.5 seconds before reverting to measuring mode and discarding the change.

To set a current draw of 3.6 mA during the 10-second dwell period in failure mode

- briefly press the 4 mA button (2) (1–2 seconds).

To set a current draw of 21.5 mA during the 10-second dwell period in failure mode

- briefly press the 20 mA button (3) (1–2 seconds).



*The new configuration will not be adopted by the level sensor until it has switched from configuration mode to measuring mode automatically (LED goes out). The level sensor must, therefore, not be disconnected from the power supply until this time.*

- Screw on cap (1).



*If, during operation, the level sensor detects that the level cannot be output correctly due to an insufficient supply voltage, it enters failure mode and sets current draw to 3.6 mA (regardless of any failure current settings).*

## 7 Technical data

Electrical connection	Two-line terminal
Power supply	8 to 30 V DC
Output signal	4 to 20 mA
"Empty" signal	3.8 mA or 20.5 mA
Failure signal	21.5 mA or 3.6 mA
Process connection	Screw-in unit (standard 2" NPT) Flange on request For material, see probe tube
Sensor head	Height above screw-in unit/flange 6.3" Diameter 1.97" Index of protection IP 68 Material: stainless steel Cable diameter 0.2" to 0.4" Temperature -40 to +185 °F
Probe tube	Length 8" to 19.7' Diameter of single rod 0.236" Standard material: 1.4571 Optional material: tantalum, titanium, Hastelloy, or 1.4404 Measuring range freely configurable (> 10 mm)
Seal	PTFE
Accuracy	Linearity better than $\pm 0.02\%$ or $\pm 1\%$
Digital component	Resolution better than 0.1 %
Analog component	Temperature drift better than $\pm 0.01\%/K$ Resolution better than 0.5 $\mu A$
Process temperature	NT: -40 to +302 °F
Process pressure	150 bar at 68°F, 25 bar at 302 °F
Process conductivity	> 1 $\mu S/cm$