OPTIWAVE 5200 C/F

Handbook

Non-contact Radar (FMCW) Level Meter

for distance, level and volume measurement of liquids, pastes and slurries

KROHNE

IMPRINT

CONTENTS

1.1 Software history

Introduction	Signal converter	
Mth./year	Hardware	Firmware
Test version for field tests		
03/2012	OPTIWAVE 5200	x.xx
Series version		
03/2012	OPTIWAVE 5200	x.xx

1.2 Intended use

CAUTION!
Responsibility for the use of the measuring devices with regard to suitability, intended use and corrosion resistance of the used materials against the measured fluid lies solely with the operator.

INFORMATION!
The manufacturer is not liable for any damage resulting from improper use or use for other than the intended purpose.

This radar level transmitter measures distance, level, mass, volume, flow rate (in open channels) and reflectivity of liquids, pastes and slurries. It does not touch the measured product.

1.3 Certification

DANGER!
For devices used in hazardous areas, additional safety notes apply; please refer to the Ex documentation.

CE

In accordance with the commitment to customer service and safety, the device described in this document meets the following safety requirements:

- Electromagnetic Compatibility (EMC) Directive 2004/108/EC in conjunction with EN 61326-1 (2006).
- Radio Equipment and Telecommunications Terminal Equipment (R & TTE) Directive 1999/05/EC in conjunction with ETSI EN 302 372 (2006). For more data, refer to European Union (EU) on page 7.
- Low-Voltage Directive 2006/95/EC in conjunction with EN 61010-1 (2001).

All devices are based on the CE marking and meet the requirements of NAMUR Guideline NE 21, NE 43, NE 53 and NE 107

1.4 Radio approvals

1.4.1 European Union (EU)

§

LEGAL NOTICE!
This level transmitter is intended for installation in closed tanks. It meets the requirements of the R & TTE (Radio Equipment and Telecommunications Terminal Equipment) Directive 1999/05/EC for use in the member countries of the EU.
An industry agreement includes approval for use of the frequency band (8.6...10.4 GHz) in industrial environments.
According to article 6.4 of the R&TTE Directive, the product is marked by the CE sign + notified body number (0682) + Class II identifier (= alert sign).
Refer to EN 302372 for installation conditions.

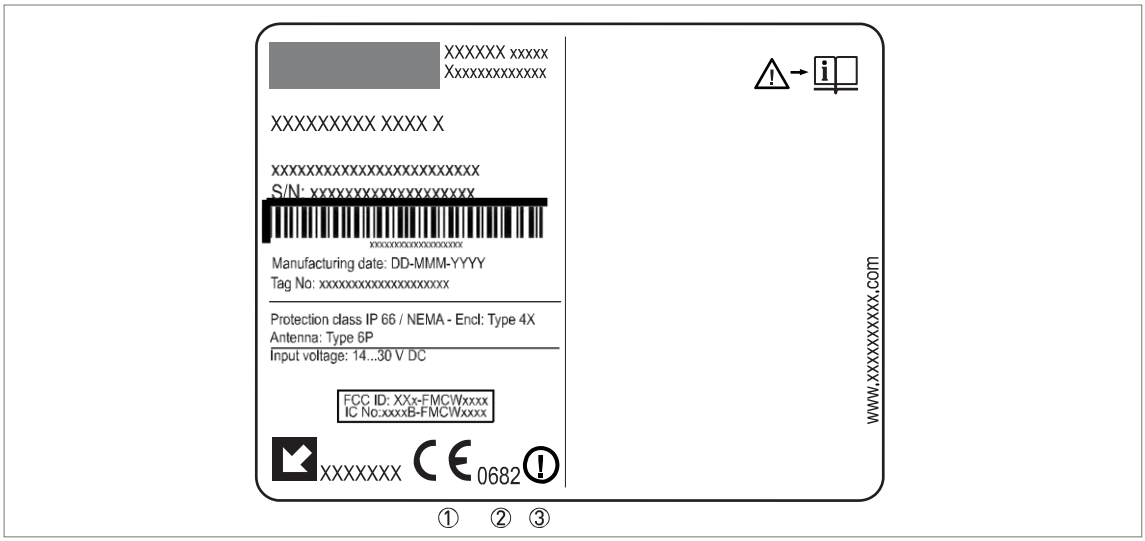

Figure 1-1: Radio approval information on the nameplate

1 CE sign
2 Notified body number (0682 = CETECOM)
3 Class II identifier

According to ETSI EN 302 372 (2006-04), the radiated power outside a metallic tank is less than -30 dBm.

Refer also to the radio approval certificate on the internet site. The radio approval report is given on the CD-ROM supplied with the device.

1.4.2 U.S.A. and Canada

LEGAL NOTICE!
This device complies with Part 15 of the FCC Rules and with RSS-210 of Industry Canada.
Operation is subject to the following two conditions:
1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference which may cause un- desired operation.

Changes or modifications made to this equipment not expressly approved by the manufacturer may void the FCC and IC authorizations to operate this equipment.

This legal information is shown on a label on the rear side of the device.

The radio approval report is given on the CD-ROM supplied with the device. You can also download it from the internet site.

1.5 Safety instructions from the manufacturer

1.5.1 Copyright and data protection

The contents of this document have been created with great care. Nevertheless, we provide no guarantee that the contents are correct, complete or up-to-date.

The contents and works in this document are subject to copyright. Contributions from third parties are identified as such. Reproduction, processing, dissemination and any type of use beyond what is permitted under copyright requires written authorisation from the respective author and/or the manufacturer.

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The collection of personal data (such as names, street addresses or e-mail addresses) in the manufacturer's documents is always on a voluntary basis whenever possible. Whenever feasible, it is always possible to make use of the offerings and services without providing any personal data.

We draw your attention to the fact that data transmission over the Internet (e.g. when communicating by e-mail) may involve gaps in security. It is not possible to protect such data completely against access by third parties.

We hereby expressly prohibit the use of the contact data published as part of our duty to publish an imprint for the purpose of sending us any advertising or informational materials that we have not expressly requested.

1.5.2 Disclaimer

The manufacturer will not be liable for any damage of any kind by using its product, including, but not limited to direct, indirect or incidental and consequential damages.

This disclaimer does not apply in case the manufacturer has acted on purpose or with gross negligence. In the event any applicable law does not allow such limitations on implied warranties or the exclusion of limitation of certain damages, you may, if such law applies to you, not be subject to some or all of the above disclaimer, exclusions or limitations.

Any product purchased from the manufacturer is warranted in accordance with the relevant product documentation and our Terms and Conditions of Sale.

The manufacturer reserves the right to alter the content of its documents, including this disclaimer in any way, at any time, for any reason, without prior notification, and will not be liable in any way for possible consequences of such changes.

1.5.5 Warnings and symbols used

Safety warnings are indicated by the following symbols.

DANGER!
This information refers to the immediate danger when working with electricity.

DANGER!
This warning refers to the immediate danger of burns caused by heat or hot surfaces.

DANGER!
This warning refers to the immediate danger when using this device in a hazardous atmosphere.

DANGER!
These warnings must be observed without fail. Even partial disregard of this warning can lead to serious health problems and even death. There is also the risk of seriously damaging the device or parts of the operator's plant.

WARNING!
Disregarding this safety warning, even if only in part, poses the risk of serious health problems. There is also the risk of damaging the device or parts of the operator's plant.

CAUTION!
Disregarding these instructions can result in damage to the device or to parts of the operator's plant.

INFORMATION!
These instructions contain important information for the handling of the device.

LEGAL NOTICE!
This note contains information on statutory directives and standards.

- HANDLING
  This symbol designates all instructions for actions to be carried out by the operator in the specified sequence.

i RESULT
This symbol refers to all important consequences of the previous actions.

1.6 Safety instructions for the operator

WARNING!
In general, devices from the manufacturer may only be installed, commissioned, operated and maintained by properly trained and authorized personnel.
This document is provided to help you establish operating conditions, which will permit safe and efficient use of this device.

2.2 Device description

The FMCW radar level transmitter is designed to measure the distance, level, mass, volume and reflectivity of liquids, pastes and slurries. Radar level transmitters use an antenna to guide a signal to the surface of the measured product. Radar is a non-contact technology. It is particularly suitable for the level measurement of corrosive products.

The signal converter of the device has 2 versions: Compact version
The signal converter is attached directly to the process connection and antenna.

Figure 2-2: Compact version

Remote version
The signal converter is installed away from the process connection and antenna (for example: at the bottom of a tank). The communication cable between the signal converter and the antenna has a maximum length of 100 m / 328 ft.

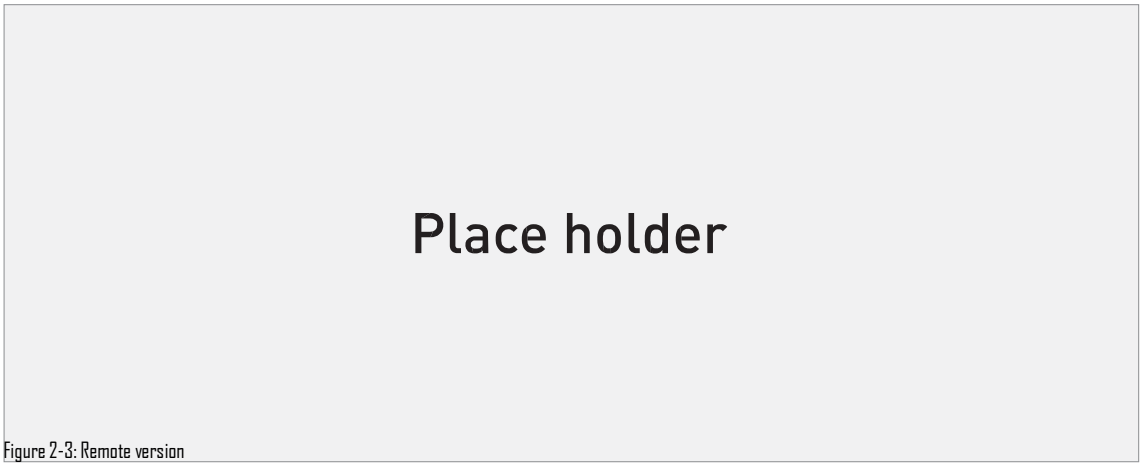


Figure 2-3: Remote version

The converter can be ordered with horizontal or vertical housing options for easy access to the device terminals and the optional display.

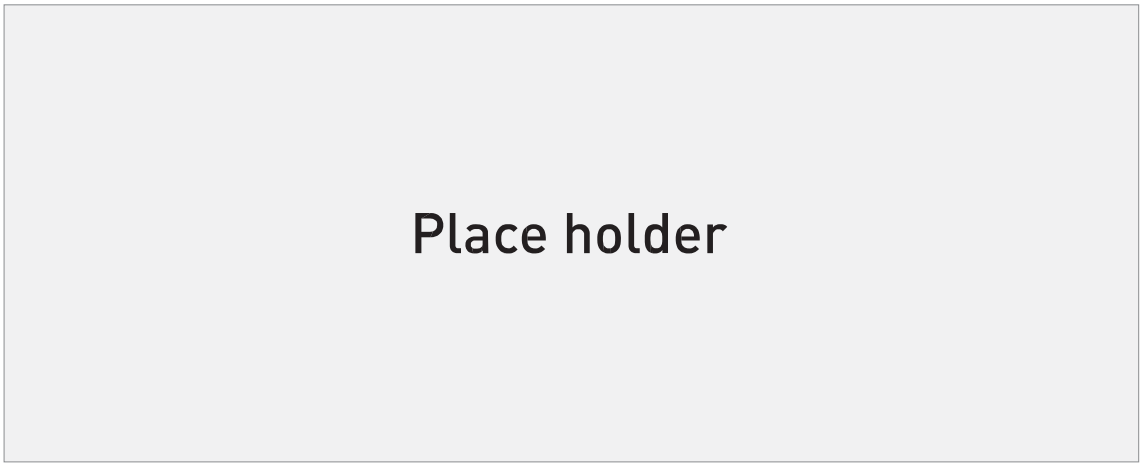


Figure 2-4: Antenna options

1 PP Wave Horn antenna
2 PTFE Wave Horn antenna
3 Metallic Horn antenna (available sizes: DN80, DN100, DN150 and DN200)
4 Wave Guide antenna (Length options: 1...6 m / 3.28...19.68 ft, in increments of 0.5 m / 1.64 ft)

Antenna extensions are available for PTFE Wave Horn and Metallic Horn antenna options for difficult installation conditions.

A distance piece option is available for high-temperature applications (if the process connection temperature is more than +150°C / +302°F).

Figure 2-5: Distance piece option

For more data, refer to Technical data on page 79. The device has a set-up wizard. You usually will not need this document to install, set up and operate the device.

3.5 Installation

3.5.1 Pressure and temperature ranges

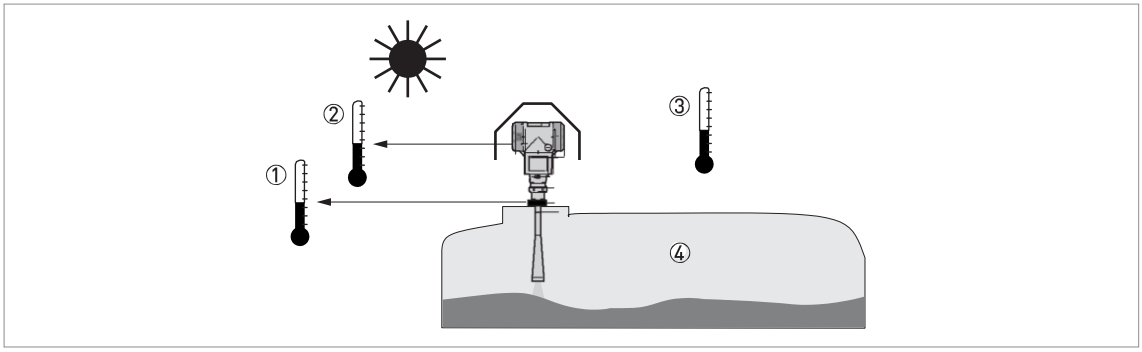


Figure 3-2: Pressure and temperature ranges

1 Flange temperature
Non-Ex devices: Depends on the type of antenna, process connection and the seal material. Refer to the table that fol- lows.
Ex devices: see supplementary operating instructions

2 Ambient temperature for operation of the display
-20...+60°C / -4...+140°F
If the ambient temperature is not between these limits, the display screen switches off automatically. The device con- tinues to operate.

3 Ambient temperature
Non-Ex devices: -40...+80°C / -40...+176°F
Ex devices: see supplementary operating instructions

4 Process pressure
Depends on the type of antenna and process connection. Refer to the table that follows.

Antenna type	Process connection	Seal	Process connection temperature		Process pressure	
			[°C]	[°F]	[barg]	[psig]
PP Wave Horn	G 1½; 1½ NPT	-	-20...+100	-4...+212	-1...16 1	-14.5...232 1
PTFE Wave Horn	Flange with PTFE plate	-	-50...+150	-58...+302	-1...34 1	-14.5...493 1
Metallic Horn Wave Guide	Flange	Metaglas® with FKM/FPM	-40...+200	-40...+392	-1...40 1	-14.5...580 1
		Metaglas® with Kalrez® 6375	-20...+250	-4...+482	-1...40 1	-14.5...580 1
		Metaglas® with PFA	-60...+150	-76...+302	-1...40 1	-14.5...580 1
		Metaglas® with EPDM	-50...+130	-58...+266	-1...40 1	-14.5...580 1

1 Higher pressures on request

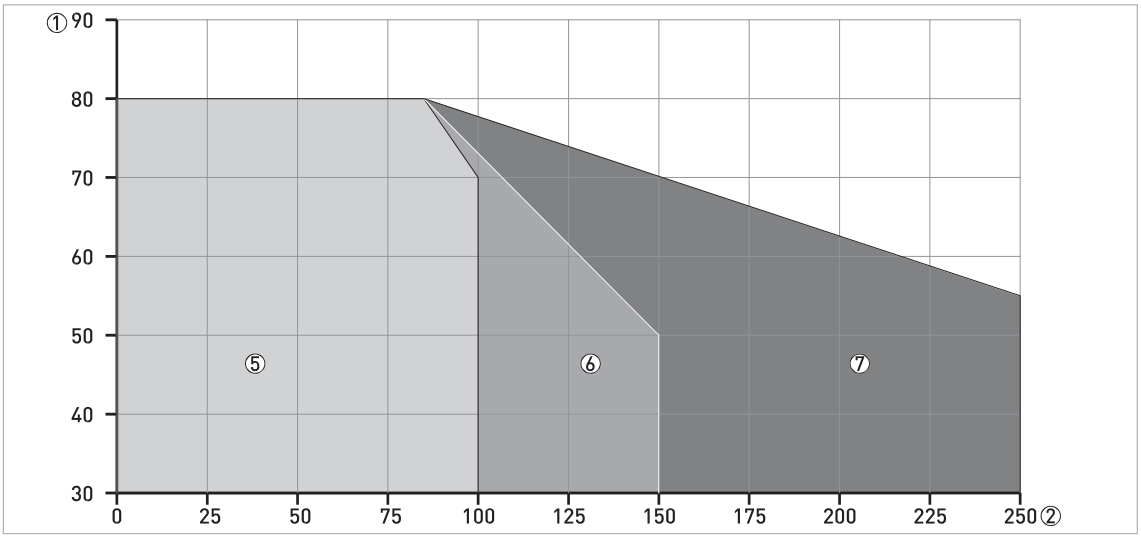


Figure 3-3: Ambient temperature / flange temperature, flange and threaded connection, in °C

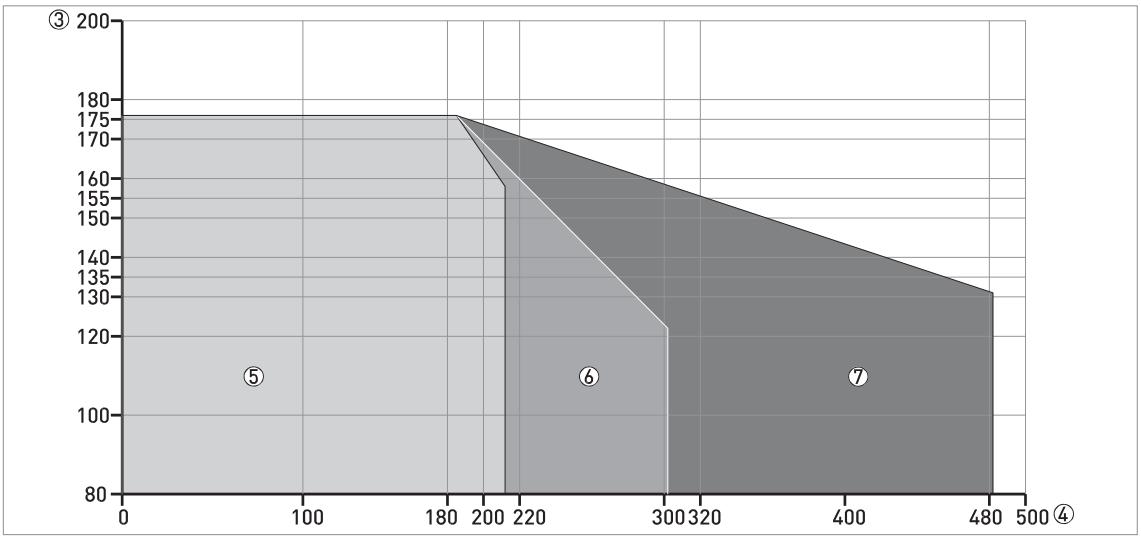


Figure 3-4: Ambient temperature / flange temperature, flange and threaded connection, in °F

1 Maximum ambient temperature, °C
2 Maximum flange temperature, °C
3 Maximum ambient temperature, °F
4 Maximum flange temperature, °C
5 PP Wave Horn antenna
6 PTFE Wave Horn and Wave Guide antennas. Metallic Horn antenna (standard temperature version).
7 Metallic Horn antenna (high-temperature version)

For pressure rating data, refer to Pressure ratings on page 87.

3.5.2 Mounting position (theoretical data for nozzle position)

CAUTION!
Follow these recommendations to make sure that the device measures correctly.

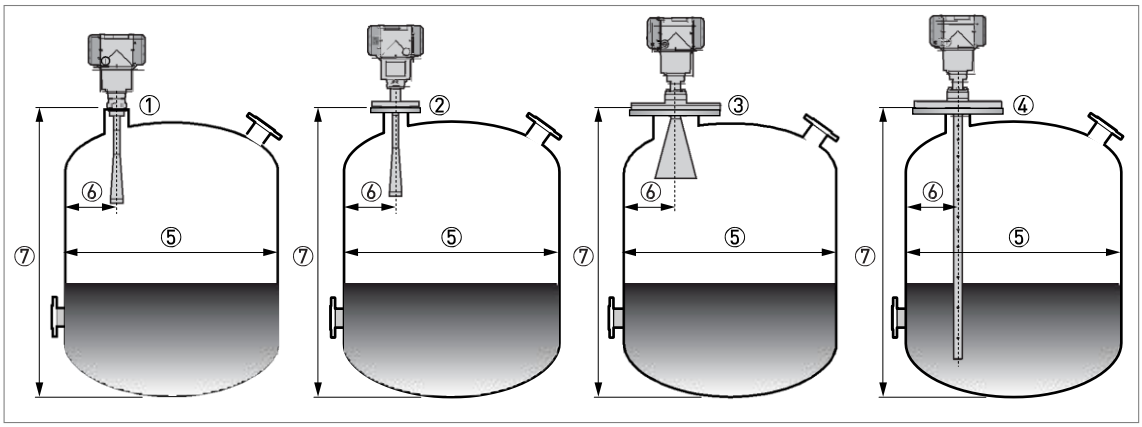


Figure 3-5: Recommended mounting position for liquids, pastes and slurries

1 Sockets for the PP Wave Horn antenna
2 Nozzles for the PTFE Wave Horn antenna
3 Nozzles or sockets for DN150 or DN200 Metallic Horn antennas
4 Nozzles or sockets for Wave Guide antennas
5 Tank diameter
6 Minimum distance of the nozzle or socket from the tank wall (depends on the antenna type and size - refer to items 1, 2 and 3 in this list):
   1 1/7 × tank height
   2 1/10 × tank height
   3 There is no minimum distance from the Wave Guide antenna to metallic walls and other metal objects.
   Maximum distance of nozzle from the tank wall (depends on the antenna type and size - refer to items 1, 2 and 3 in this list):
   1 1/3 × tank diameter
   2 1/3 × tank height
   3 There is no maximum distance from the Wave Guide antenna to metallic walls and other metal objects.
7 Tank height

CAUTION!
Do not put the device near to the product inlet. If the product that enters the tank touches the antenna, the device will measure incorrectly. If the product fills the tank directly below the antenna, the device will also measure incorrectly.

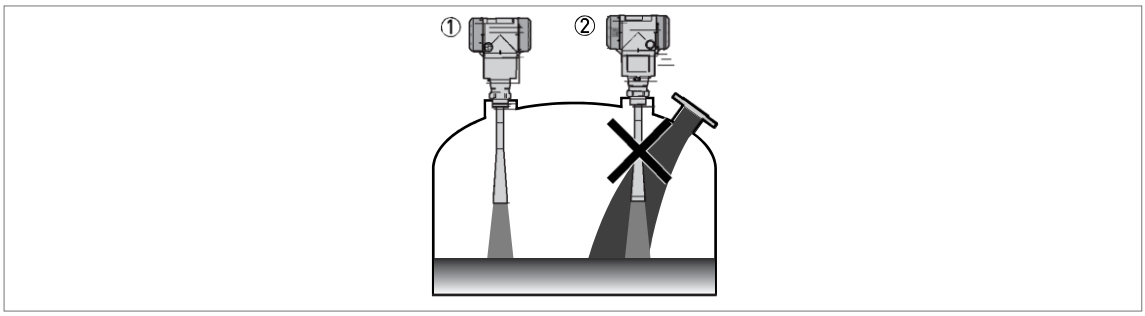


Figure 3-6: Product inlets

1 The device is in the correct position.
2 The device is too near to the product inlet.

Point the device in the correct direction

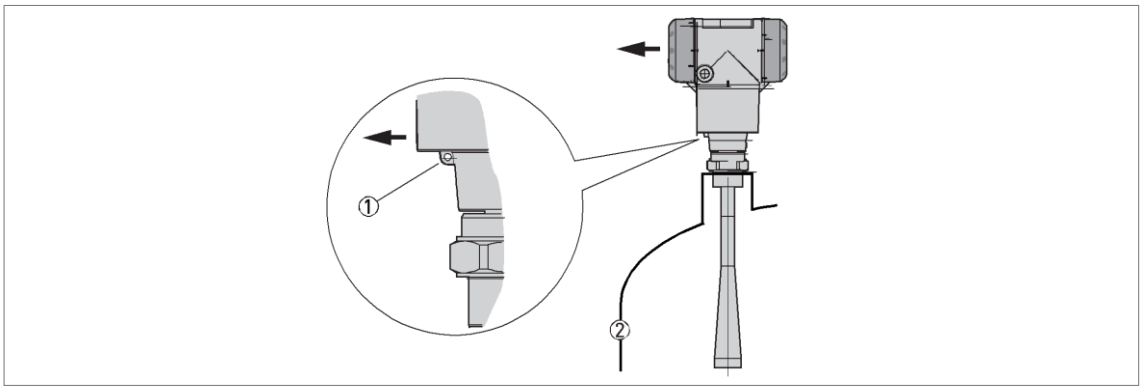


Figure 3-7: Point the device in the correct direction to get the best performance

Point the tag hole on the housing in the direction of the nearest tank wall.

1 Tag hole
2 Nearest tank wall

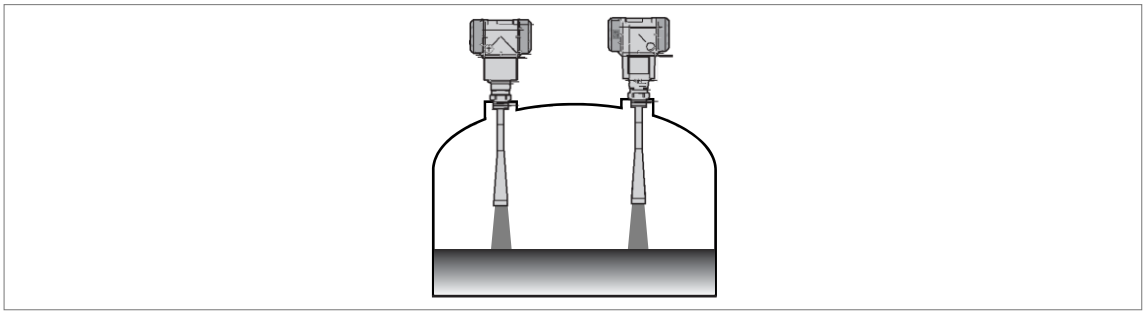


Figure 3-8: A maximum of 4 FMCW radar level meters can be operated in a tank

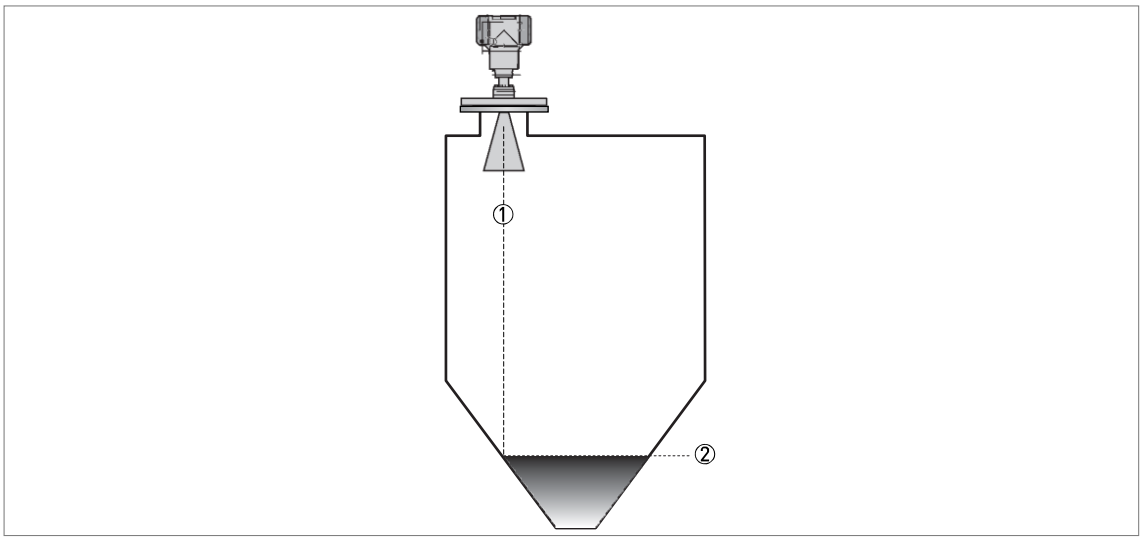


Figure 3-9: Tanks with tapered (conical etc.) bottoms

Tapered (conical etc.) bottoms have an effect on the measuring range. The device cannot measure to the bottom of the tank.

1 Radar beam
2 Minimum level reading

3.5.3 Mounting restrictions

CAUTION!
Follow these recommendations to make sure that the device measures correctly.

We recommend that you prepare the installation when the tank is empty.

Mounting restrictions: General data

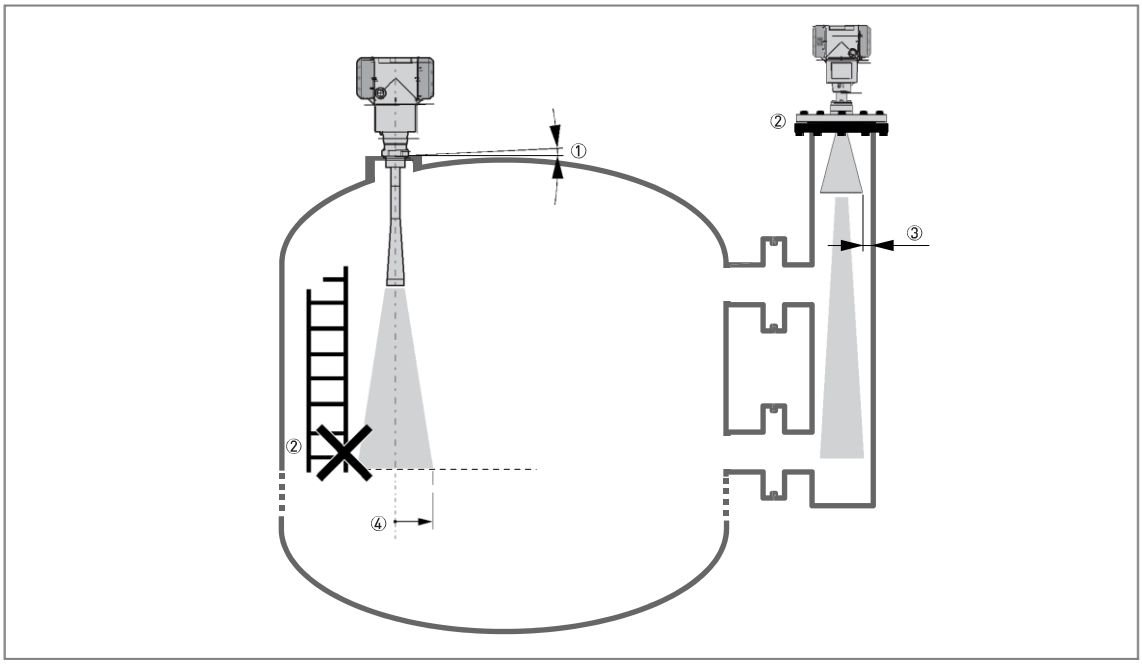


Figure 3-10: Mounting restrictions: General data

1 Do not tilt the device more than 2°
2 If there are too many obstacles in the radar beam, do an empty spectrum scan (refer to Operation) to remove parasitic signals with a filter. If necessary, install a bypass chamber or stilling well or use an S-shaped extension or a 90° bend extension (the device must be installed on the side of the tank) to move the device away from obstacles.
3 5 mm / 0.2" max. for high-dielectric constant liquids
4 Radius of radar footprint (Wave Guide antenna or DN80 and DN100 Metallic Horn antenna): no beam angle. The device transmits the radar signal along a tube of constant diameter.
Radius of radar footprint (DN150 Metallic Horn antenna): increments of 140 mm/m or 1.7"/ft (8°) Radius of radar footprint (DN200 Metallic Horn antenna): increments of 100 mm/m or 1.3"/ft (6°)
Radius of radar footprint (PP Wave Horn and PTFE Wave Horn antenna): increments of 176 mm/m or 2.1"/ft (10°)

Obstacles in the tank

Place holder

Figure 3-11: Obstacles in the tank

Do not put the device directly above obstacles (agitator, support beams, heating tubes etc.). Parasitic signals from obsta- cles will cause the device to measure incorrectly.

1 Solution 1: Put the device on another process connection away from obstacles
2 Solution 2: Use the same process connection, but also use an S-shaped extension
3 Solution 3: Attach the device to the side of the tank and use a 90° bend extension

Devices with Metallic Horn antenna

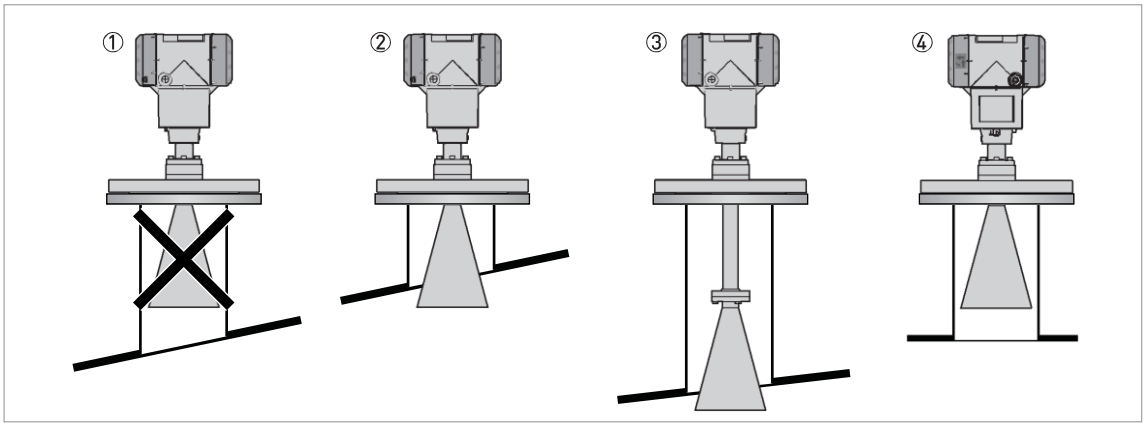


Figure 3-12: Devices with Metallic Horn antenna

1 If the roof is not flat, the antenna must project out of the nozzle
2 Short tank nozzle
3 Long tank nozzle (device with an antenna extension)
4 If the roof is flat (symmetrical tank fitting), it is not necessary for the antenna to project out of the nozzle

The antenna must project out of the nozzle. If necessary, use an antenna extension. If the tank fitting is symmetrical, it is not necessary for the antenna to project out of the nozzle.

Devices with plastic Wave Horn antenna (PTFE, PP)

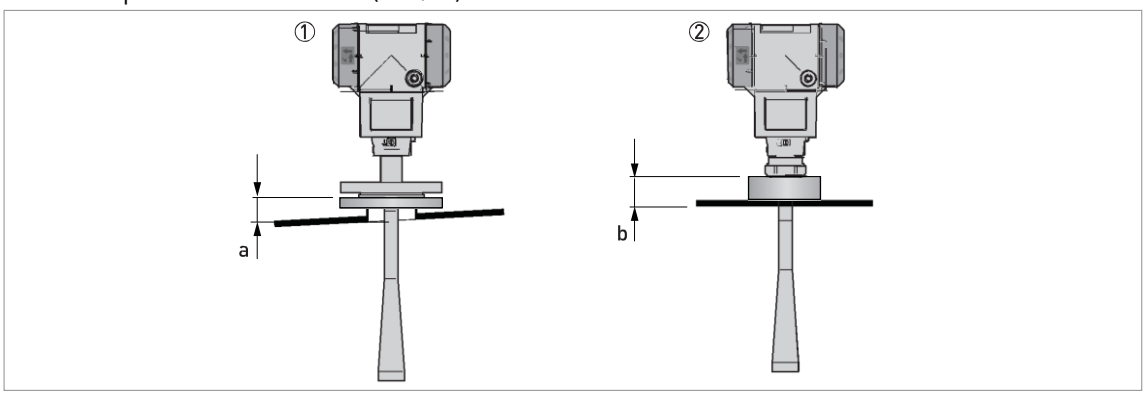


Figure 3-13: Devices with plastic Wave Horn antenna

a ≤ 44 mm / 1.7"; b ≤ 40 mm / 1.6"

1 Device with a PTFE Wave Horn antenna and a flange connection
2 Device with a PP Wave Horn antenna and a thread connection

Risk of mutliple reflections

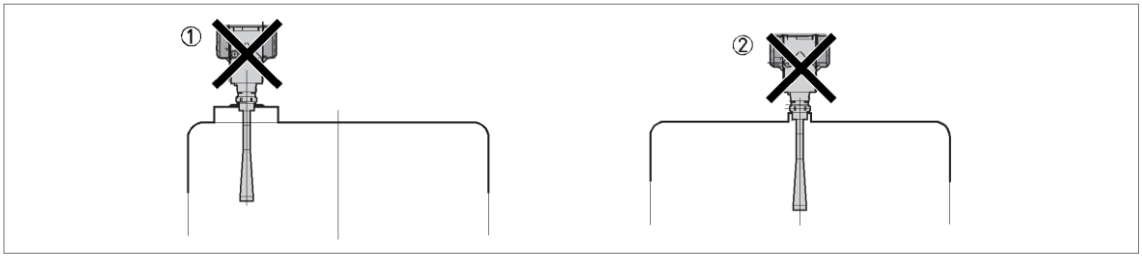


Figure 3-14: Risk of mutliple reflections

1 Do not install on the centerline of a manhole cover
2 If possible, do not install a nozzle on the tank centerline

CAUTION!
If there are parasitic signals, the device will not measure correctly.
Parasitic signals are caused by:

- Objects in the tank.
- Sharp corners that are perpendicular to the path of the beam.
- Sudden changes in tank diameter in the path of the beam.

Requirements for flange connections

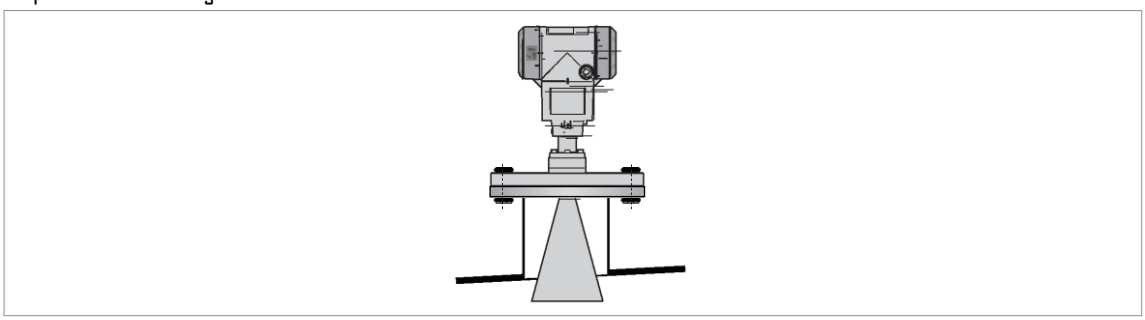


Figure 3-15: Flange connection

Equipment needed:

- Device
- Flange gasket (not supplied)
- Wrench (not supplied)

- Make sure the flange on the nozzle is level.
- Make sure that you use the applicable gasket for the flange dimensions and the process.
- Align the gasket correctly on the flange facing of the nozzle.
- Lower the antenna carefully into the tank.
- Make sure that you point the device in the correct direction. Refer to "Point the device in the correct direction" in this section.
- Tighten the flange bolts.

i Refer to local rules and regulations for the correct torque to apply to the bolts.

Requirements for threaded connections

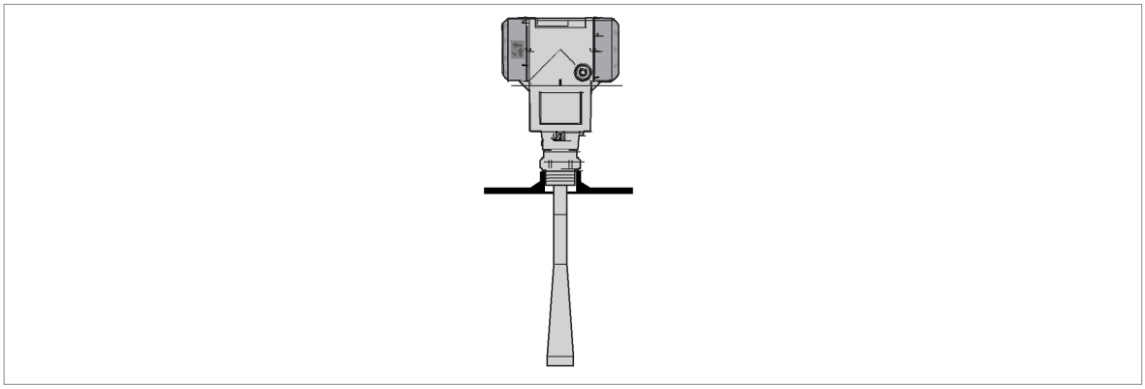


Figure 3-16: Threaded connection

Equipment needed:

- Device
- Gasket for G 1½ connection (not supplied)
- 50 mm / 2¨ wrench (not supplied)

- Make sure the tank connection is level.
- Make sure that you use the applicable gasket for the connection dimensions and the process.
- Align the gasket correctly.
- Lower the antenna carefully into the tank.
- Turn the threaded connection on the housing to attach the device to the process connection.

- Make sure that you point the device in the correct direction. Refer to "Point the device in the correct direction" in this section.
- Tighten the connection.

ℹ Refer to local rules and regulations for the correct torque to apply to the connection.

3.5.4 Standpipes (stilling wells and bypass chambers)

Use a standpipe if:

- There is highly conductive foam in the tank.
- The liquid is very turbulent or agitated.
- There are too many other objects in the tank.
- The device is measuring a liquid (petro-chemicals) in a tank with a floating roof.
- The device is installed in a horizontal cylindrical tank (refer to the end of this section)

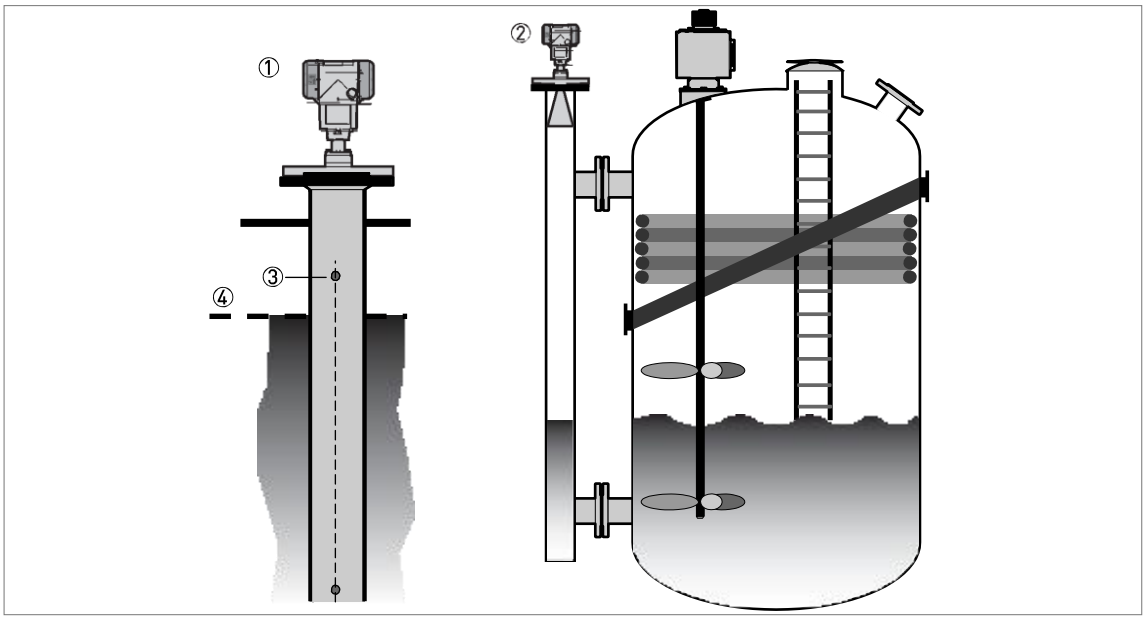


Figure 3-17: Installation recommendations for standpipes (stilling wells and bypass chambers)

1 A stilling well solution
2 A bypass chamber solution
3 Air circulation hole
4 Level of the liquid

CAUTION!

Installation requirements

- The standpipe must be electrically conductive.
- The inside diameter of the standpipe must not be more than 5 mm / 0.2" over the diameter of the antenna (for a high-dielectric constant liquid).
- The standpipe must be straight. There must be no sudden changes in internal diameter greater than 1 mm / 0.04".
- The standpipe must be vertical.
- Recommended surface roughness: <±0.1 mm / 0.004".
- Stilling well only: The bottom of the stilling well must be open.
- Make sure that there are no deposits at the bottom of the standpipe.
- Make sure that there is liquid in the standpipe.

Stilling wells - general notes

Installation in tanks containing one liquid and foam

- Drill an air circulation hole (max. Ø10 mm / 0.4") in the stilling well above the maximum level.
- Remove the burr from the hole.

Installation in tanks containing one liquid or more without foam

- Drill an air circulation hole (max. Ø10 mm / 0.4") in the stilling well above the maximum level.
- Drill 1 or more liquid circulation holes in the stilling well (if there is more than 1 liquid in the tank).

i These holes help the liquid to move freely between the stilling well and the tank.

- Remove the burr from the hole.

Stilling wells: floating roofs

If the device must be installed on a tank with a floating roof, install it in a stilling well.

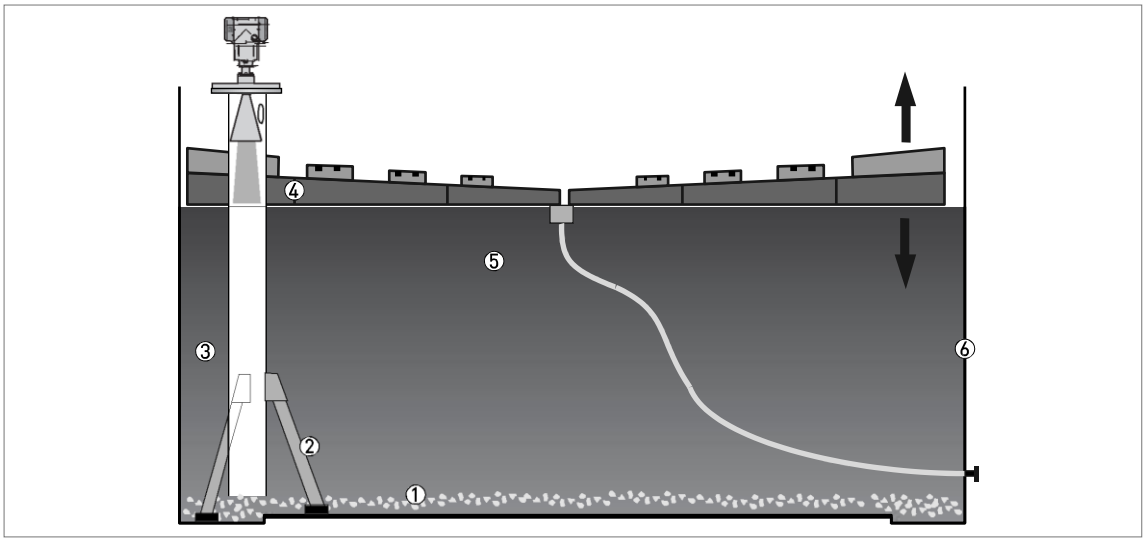


Figure 3-18: Floating roofs

1 Sediment
2 Support fixtures
3 Stilling well
4 Floating roof
5 Product
6 Tank

Stilling wells: horizontal cylindrical tanks

We recommend that you install the device in a stilling well if the device:

- is for a horizontal cylindrical tank,
- is in a metallic tank,
- measures a product with a high dielectric constant and
- is on the centerline of the tank.

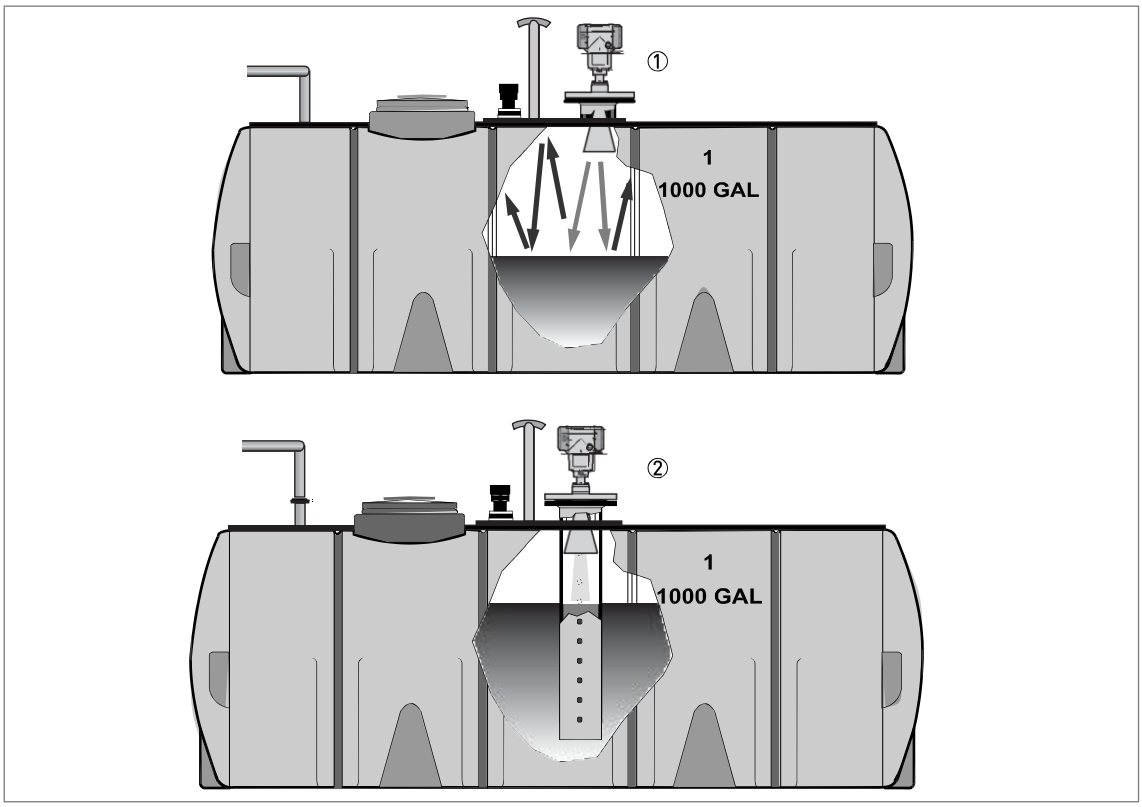


Figure 3-19: Horizontal cylindrical tanks

1 The device is installed without a stilling well. There are multiple reflections. Refer to the CAUTION! that follows.
2 The device is installed in a stilling well and measures correctly.

CAUTION!
If the device is installed in horizontal cylindrical tank that contains a high dielectric constant liquid without a stilling well, do not put it on the tank centerline. This will cause multiple reflections and the device will not measure accurately. Use the 2.3.12 Multiple Reflections function in Supervisor > Basic Parameters to keep the effects of multiple reflections to a minimum. For more data, refer to Function description on page 58 (2. Supervisor).

Bypass chambers

Installation next to tanks containing one liquid and foam

- The top process connection of the bypass chamber must be above the maximum level of liquid.
- The bottom process connection of the bypass chamber must be below the lowest measured level of liquid.

Installation next to tanks containing more than one liquid

- The top process connection of the bypass chamber must be above the maximum level of liquid.
- The bottom process connection of the bypass chamber must be below the lowest measured level of liquid.

- Additional process connections are necessary for the liquids to circulate freely along the length of the bypass chamber.

3.5.5 How to turn or remove the signal converter

INFORMATION!
The converter turns 360°.

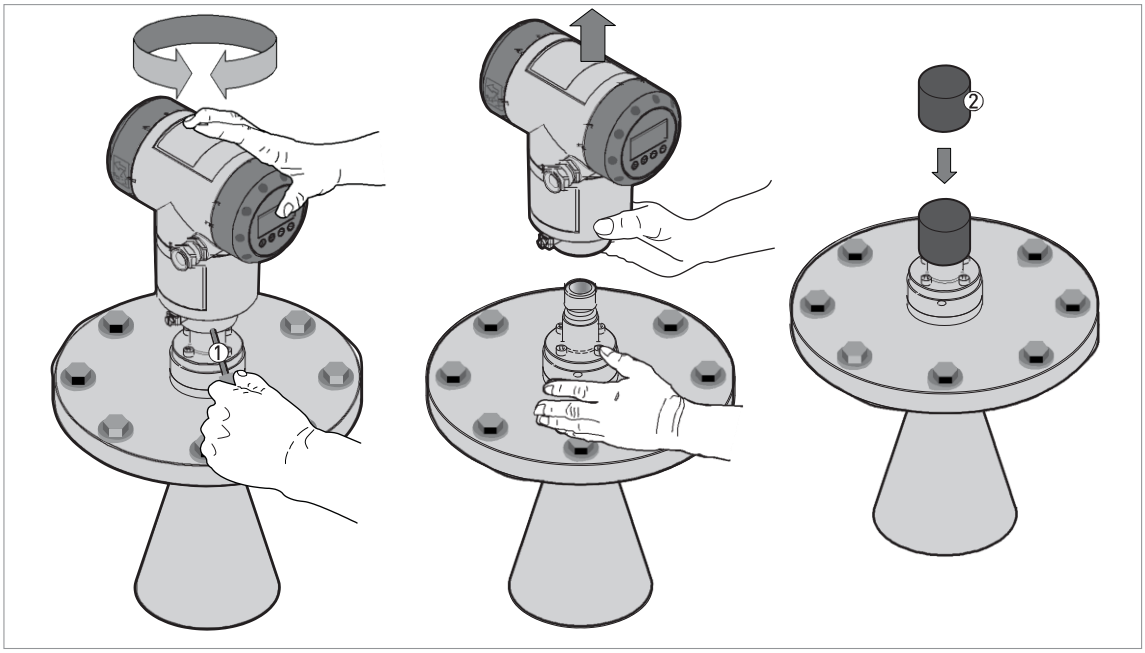


Figure 3-20: How to turn or remove the signal converter

1 Tool: 5 mm Allen wrench (not supplied)
2 Cover for the coaxial hole on top of the process connection assembly (not supplied)

CAUTION!
If you remove the housing, put a cover on the coaxial hole on top of the process connection assembly.
When the housing is attached to the process connection assembly, tighten the lock screw.

3.5.6 How to open the weather protection

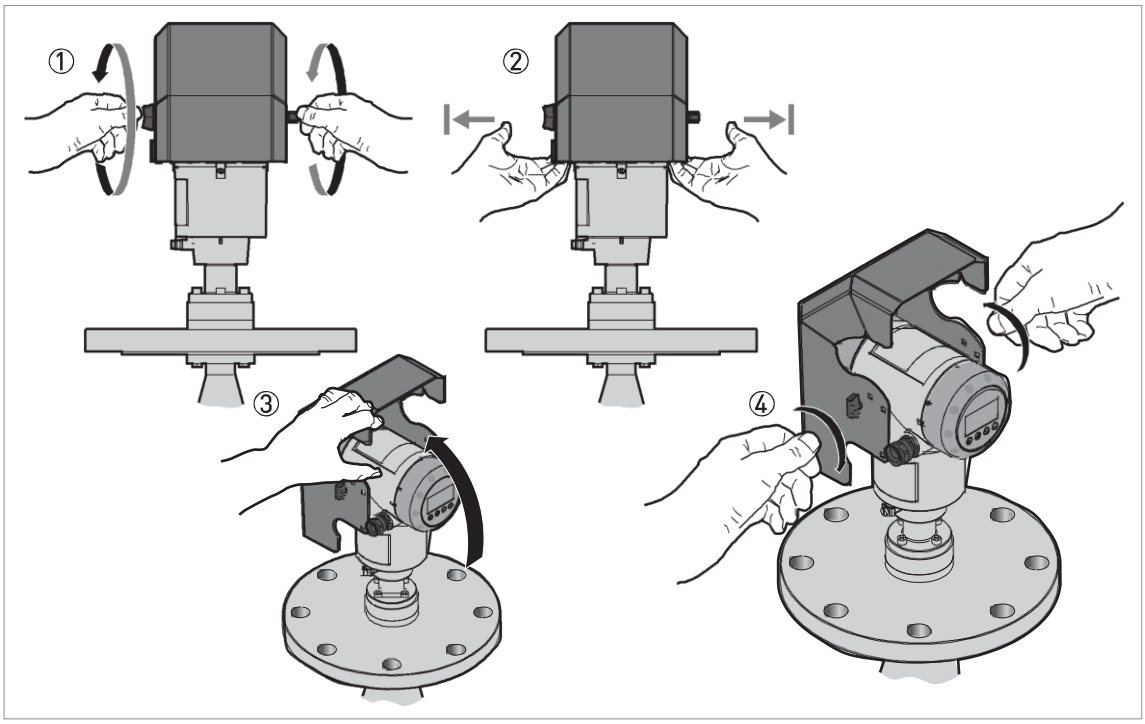


Figure 3-21: How to open the weather protection

1 Loosen the bolt on each side of the weather protection.
2 Pull the sides of the weather protection out of the notch for the closed position.
3 Pull the weather protection up and back.
i This will open the weather protection.
4 Tighten the bolts to lock the weather protection in its open position.

4.1 Safety instructions

DANGER!
All work on the electrical connections may only be carried out with the power disconnected. Take note of the voltage data on the nameplate!

DANGER!
Observe the national regulations for electrical installations!

DANGER!
For devices used in hazardous areas, additional safety notes apply; please refer to the Ex documentation.

WARNING!
Observe without fail the local occupational health and safety regulations. Any work done on the electrical components of the measuring device may only be carried out by properly trained specialists.

INFORMATION!
Look at the device nameplate to ensure that the device is delivered according to your order. Check for the correct supply voltage printed on the nameplate.

4.2 Electrical installation: compact version

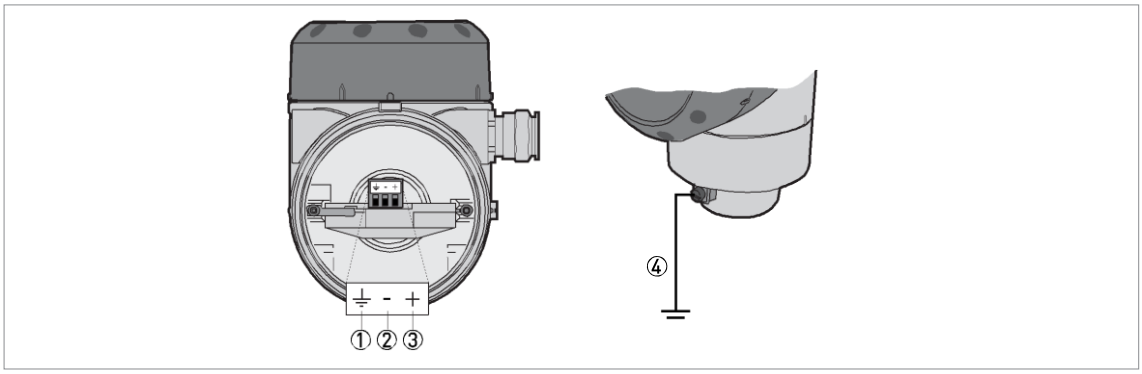


Figure 4-1: Terminals for electrical installation

1 Grounding terminal in the housing (if the device is grounded)
2 Current output -
3 Current output +
4 Location of the external grounding terminal (at the bottom of the converter)

INFORMATION!
The output energizes the device and is used for HART® communication.

CAUTION!
Make sure that the polarity of the power supply is correct.

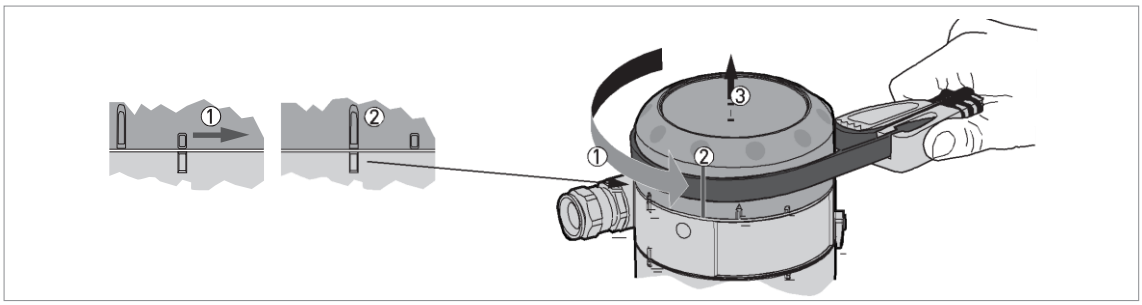


Figure 4-2: How to open the terminal compartment cover

- Turn the cover counterclockwise with a strap wrench.
- Remove the cover.

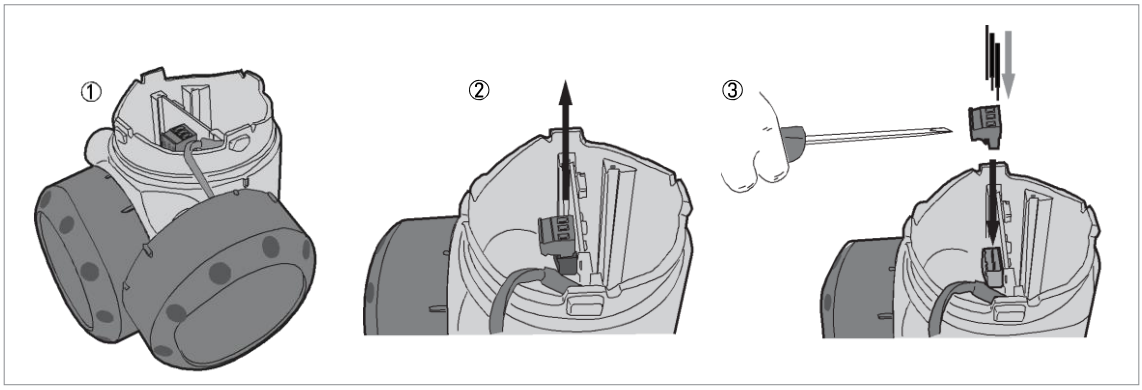


Figure 4-3: Procedure for electrical installation

Equipment needed:

- Small slotted tip screwdriver (not supplied)

CAUTION!
Make sure that the polarity of the wires is correct.

Procedure:

1 Do not disconnect the safety cord from the terminal compartment cover. Put the terminal compartment cover adjacent to the housing.
2 Remove the connector from the circuit board.
3 Connect the electrical wires to the connector. Attach the connector to the circuit board. Tight- en the cable entry glands.

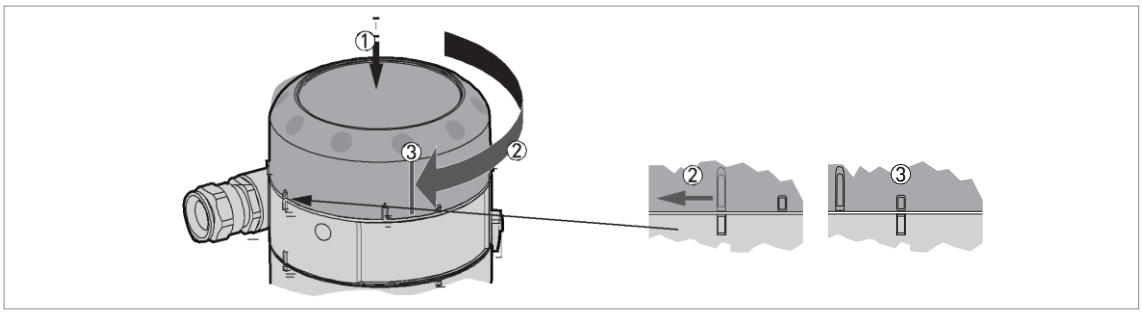


Figure 4-4: How to close the terminal compartment cover

- Attach the cover.
- Turn the cover clockwise.

4.2.1 Non-Ex devices

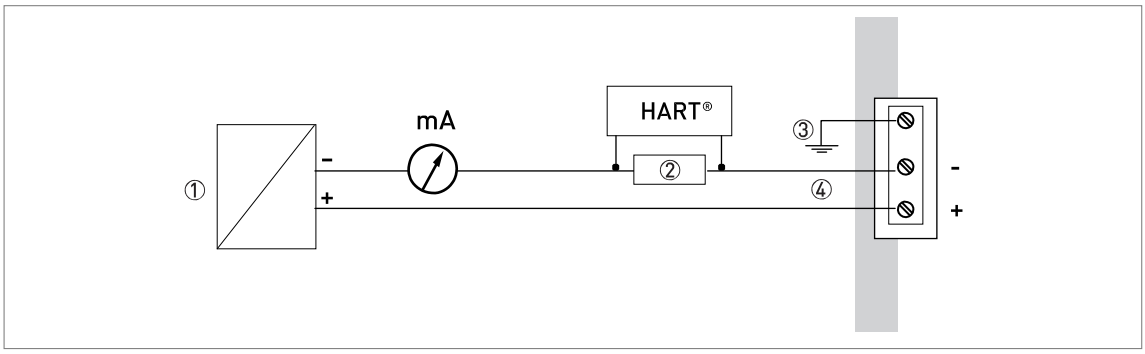


Figure 4-5: Electrical connections for non-Ex devices

1 Power supply
2 Resistor for HART® communication
3 Optional connectional to the grounding terminal
4 Output: 12...30 VDC for an output of 22 mA at the terminal

4.2.2 Devices for hazardous locations

DANGER!
For electrical data for device operation in hazardous locations, refer to the related certificates of compliance and supplementary instructions (ATEX, IECEx, cFMus, ...). You can find this documentation on the CD-ROM delivered with the device or it can be downloaded free of charge from the website (Download Center).

4.2.3 PROFIBUS PA

For electrical data for PROFIBUS PA networks, refer to the PROFIBUS PA supplement. You can find this documentation on the CD-ROM delivered with the device or it can be downloaded free of charge from the website (Downloadcenter).

4.2.4 FOUNDATION Fieldbus

For electrical data for FOUNDATION Fieldbus networks, refer to the FOUNDATION Fieldbus supplement. You can find this documentation on the CD-ROM delivered with the device or it can be downloaded free of charge from the website (Downloadcenter).

4.3 Remote device version

4.3.1 General notes

To be defined.

4.3.2 Electrical installation: remote version

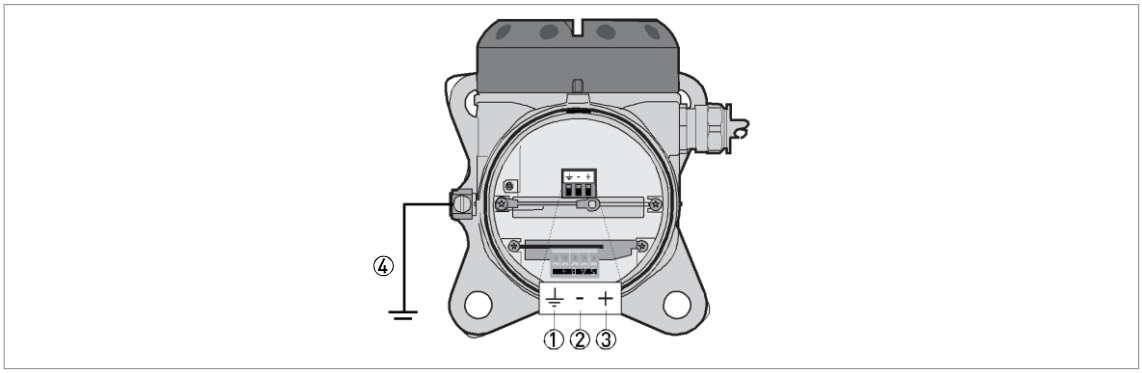


Figure 4-6: Terminals for electrical installation

1 Grounding terminal in the housing (if the device is grounded)
2 Current output -
3 Current output +
4 Location of the external grounding terminal (on the wall support)

INFORMATION!
The output energizes the device and is used for HART® communication.

CAUTION!
Make sure that the polarity of the power supply is correct.

4.3.3 Requirements for communication cables supplied by the customer

INFORMATION!
The communication cable is an option for non-Ex devices. Ex-approved cable is supplied with devices for hazardous locations.

Non-Ex devices only: If the communication cable is not supplied by the device manufacturer, the cable must have properties that follow:

Basic properties

- Twisted cable 2 by 2 or quad-twisted, PVC insulated core, shielded or screened with 65...100% coverage. The PVC jacket must agree with DIN EN 50290-2-22 and the RoHS Directive 2002/95/EC. The communication cable must not contain any halogens, must be unplasticized, and must stay flexible at low temperatures.

Maximum length of the communication cable

- Non-Ex applications: 100 m / 328 ft
- Ex applications: refer to the supplementary operating instructions or approval certificates.
  Use the Ex-approved cable supplied with the device!

Temperature

- Use electrical cable with the applicable temperature rating for the operating conditions.
- Ambient temperature range: -40...+80°C / -40...+175°F

Dimensions of the insulated conductors

- Min.-max. cross-sectional area of the conductors: 4×0.326...4×2.5 mm² (22....14 AWG), shielded cable
- Use the applicable cable glands for the cable entry openings in the housing.
- Use the applicable cable for the cable glands.

Electrical characteristics

- Test voltage: Insulated conductor / shield (screen) ≥ 500 VAC
- Line resistance: >55 Ω/km
- The cable must agree with EN 60811 (Low Voltage Directive) or equivalent national regulations.

Twist rate of the insulated conductors

- The minimum twist rate is 10 twists per metre, to prevent interference from external electromagnetic fields.

4.3.4 How to prepare a communication cable supplied by the customer

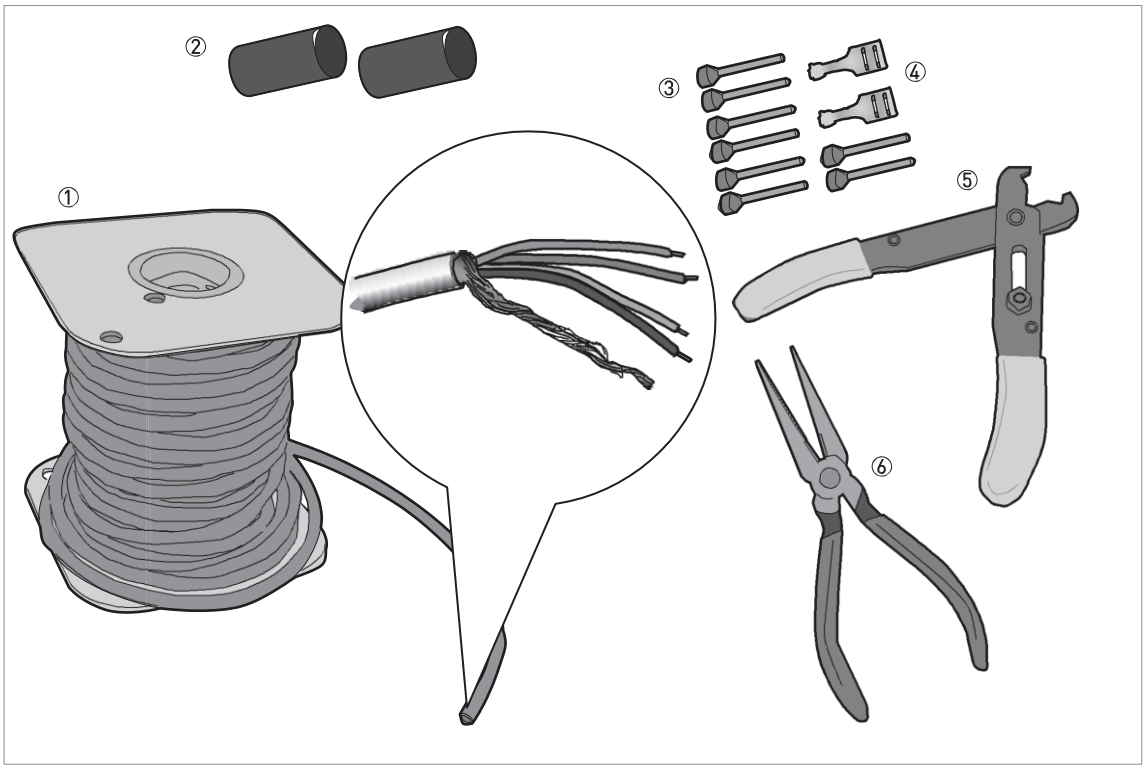


Figure 4-7: Equipment needed to prepare the communication cable

1 Communication cable (supplied on request)
2 2 heat-shrinkable sleeves for the PVC jacket (not supplied)
3 8 ferrules for the end of the conductors (not supplied)
4 2 Faston connectors for the drain wires
5 Wire stripper (not supplied)
6 Crimping pliers (not supplied)

INFORMATION!

- The Faston connector for the stranded drain wire must agree with DIN 46 228: E 1.5-8
- The wire end ferrules for the twisted pair of conductors must agree with DIN 46 228: E 0.5-8

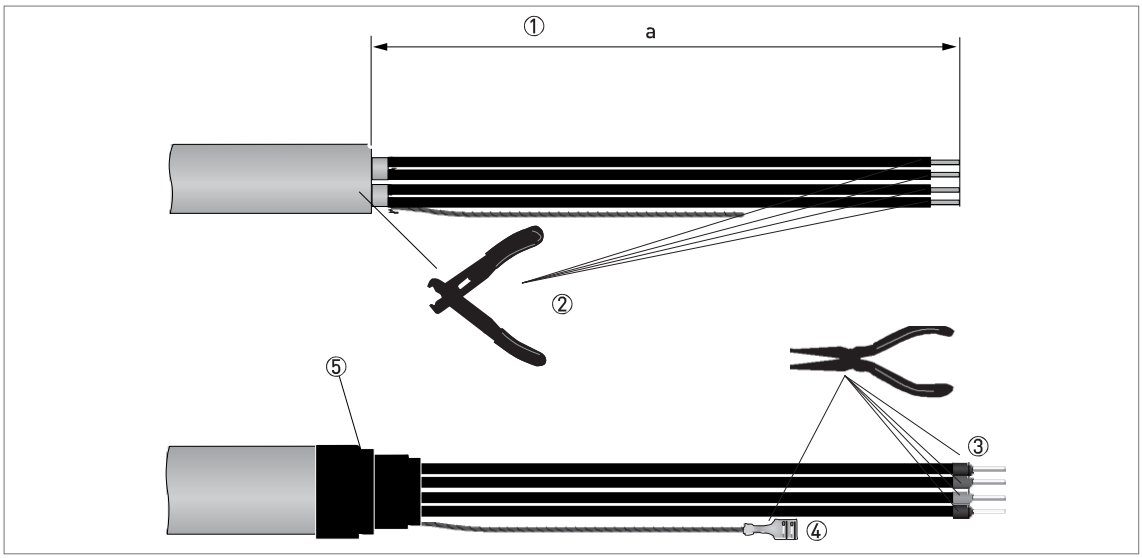


Figure 4-8: How to prepare the communication cable
a = 50 mm / 2"

1 Remove the PVC jacket from the wire to dimension "a".
2 Remove the insulation from the wire. Obey national regulations for electrical wiring.
3 Crimp the wire end ferrules on the conductors.
4 Crimp the Faston connectors on the drain wires.
5 Install a heat-shrinkable sleeve on the PVC jacket.

4.3.5 How to connect the communication cable to the device

DANGER!
Cables may only be connected when the power is switched off.

DANGER!
The device must be grounded in accordance with regulations in order to protect personnel against electric shocks.

DANGER!
For devices used in hazardous areas, additional safety notes apply; please refer to the Ex documentation.

WARNING!
Observe without fail the local occupational health and safety regulations. Any work done on the electrical components of the measuring device may only be carried out by properly trained specialists.

Equipment needed

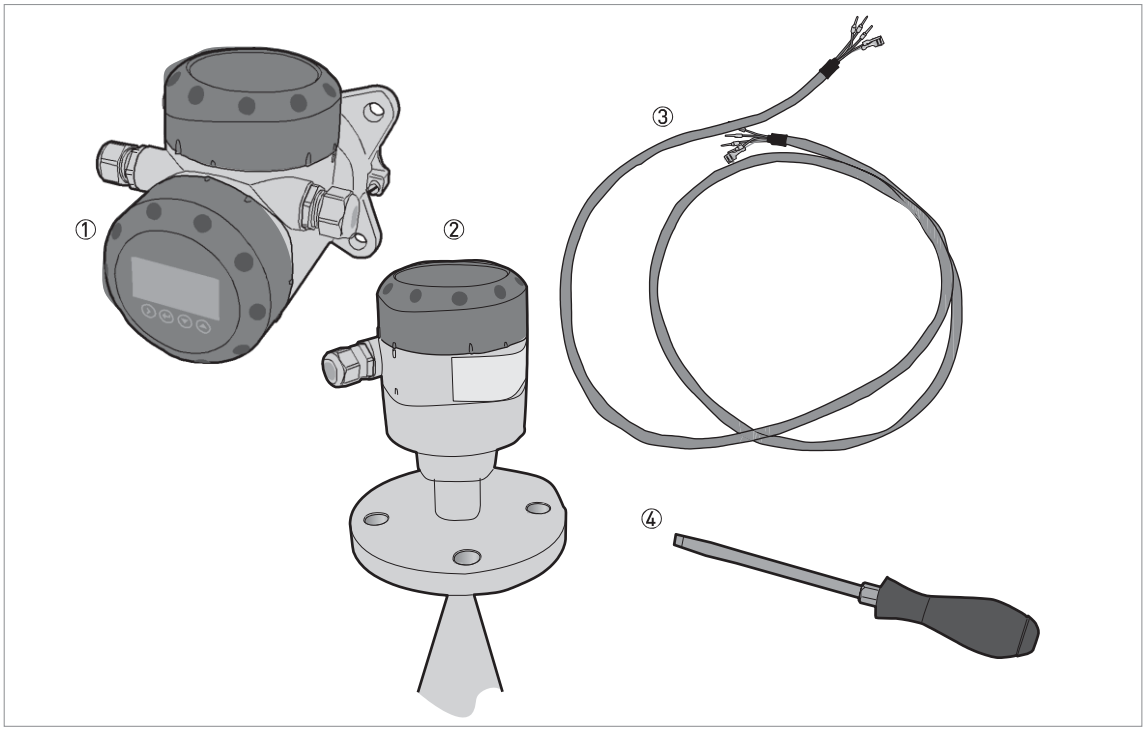


Figure 4-9: Equipment needed to prepare the communication cable

1 Remote coverter
2 Antenna housing
3 Communication cable (supplied on request for non-Ex devices) - for more data, refer to How to prepare a communi- cation cable supplied by the customer on page 38
4 Small slotted-tip screwdriver (not supplied)

Connection diagram

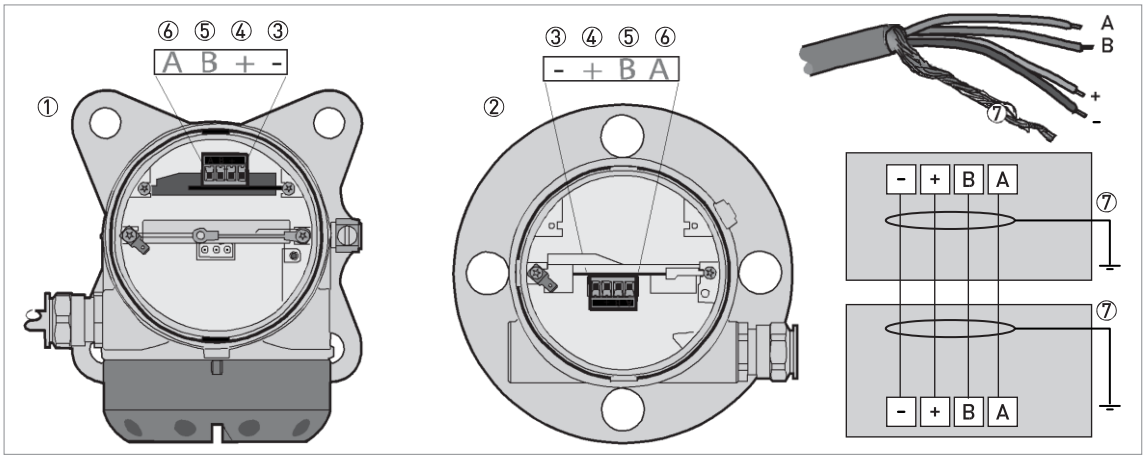


Figure 4-10: Connections between the remote converter and the antenna housing

1 Remote coverter
2 Antenna housing
3 Power supply: voltage in -
4 Power supply: voltage in +
5 Signal cable B
6 Signal cable A
7 Drain wire

How to connect the communication cable to the remote converter

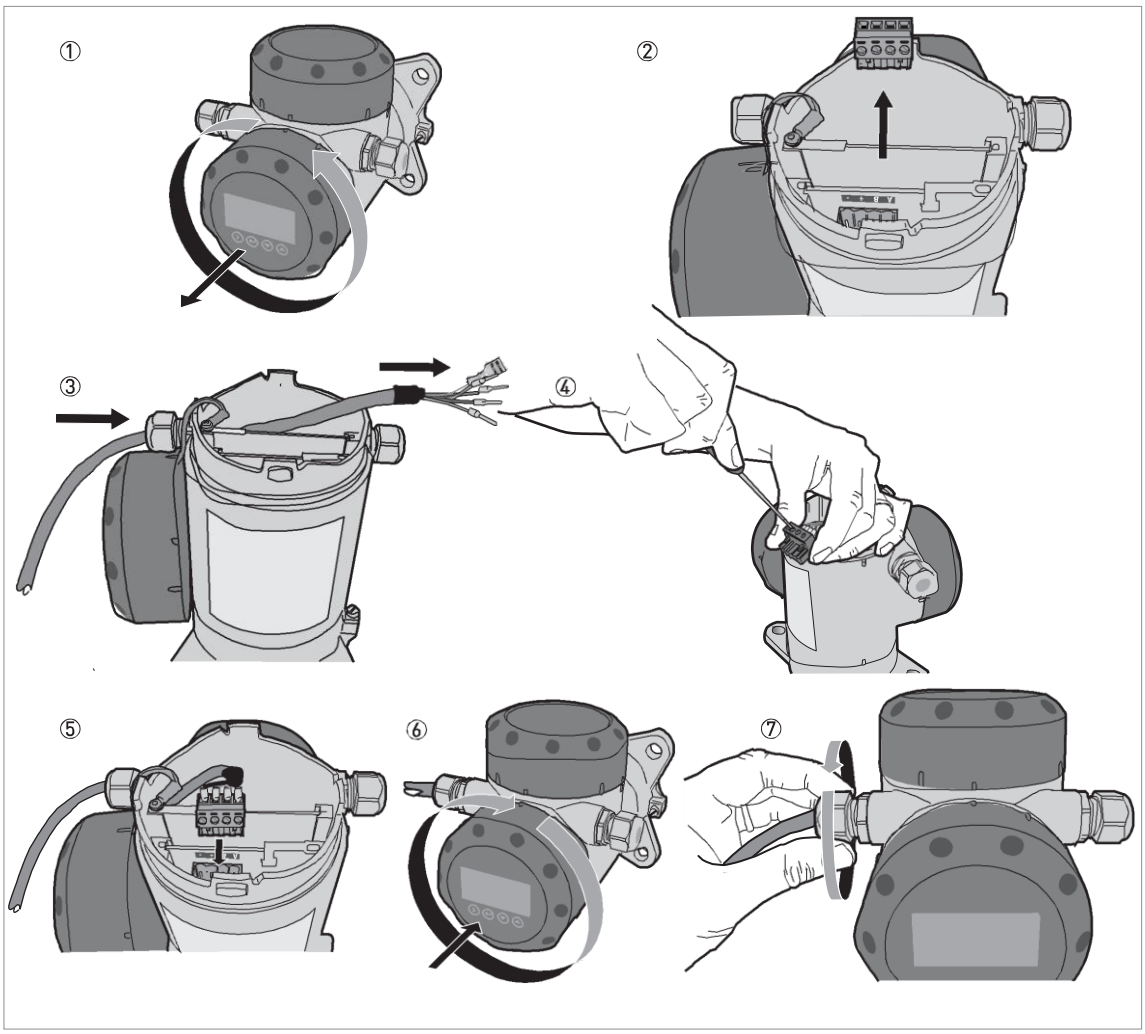


Figure 4-11: How to connect the communication cable to the remote converter

CAUTION!
Bending radius of the communication cable: ≥ 50 mm / 2¨

1 Remove the terminal compartment cover.
2 Remove the 4-pin connector.
3 Put the communication cable into the opening of the cable gland.
4 Put the electrical wires in the connector terminals. Tighten the terminal screws with a small slotted-tip screwdriver. Make sure that the electrical wires agree with the terminals. For more data, refer to the electrical schema in this section.
5 Put the connector into the 4-pin socket. Attach the Faston connector (drain wire).
6 Attach the terminal compartment cover.
7 Tighten the cable gland. Make sure that the remote converter is correctly sealed.

How to connect the communication cable to the antenna housing

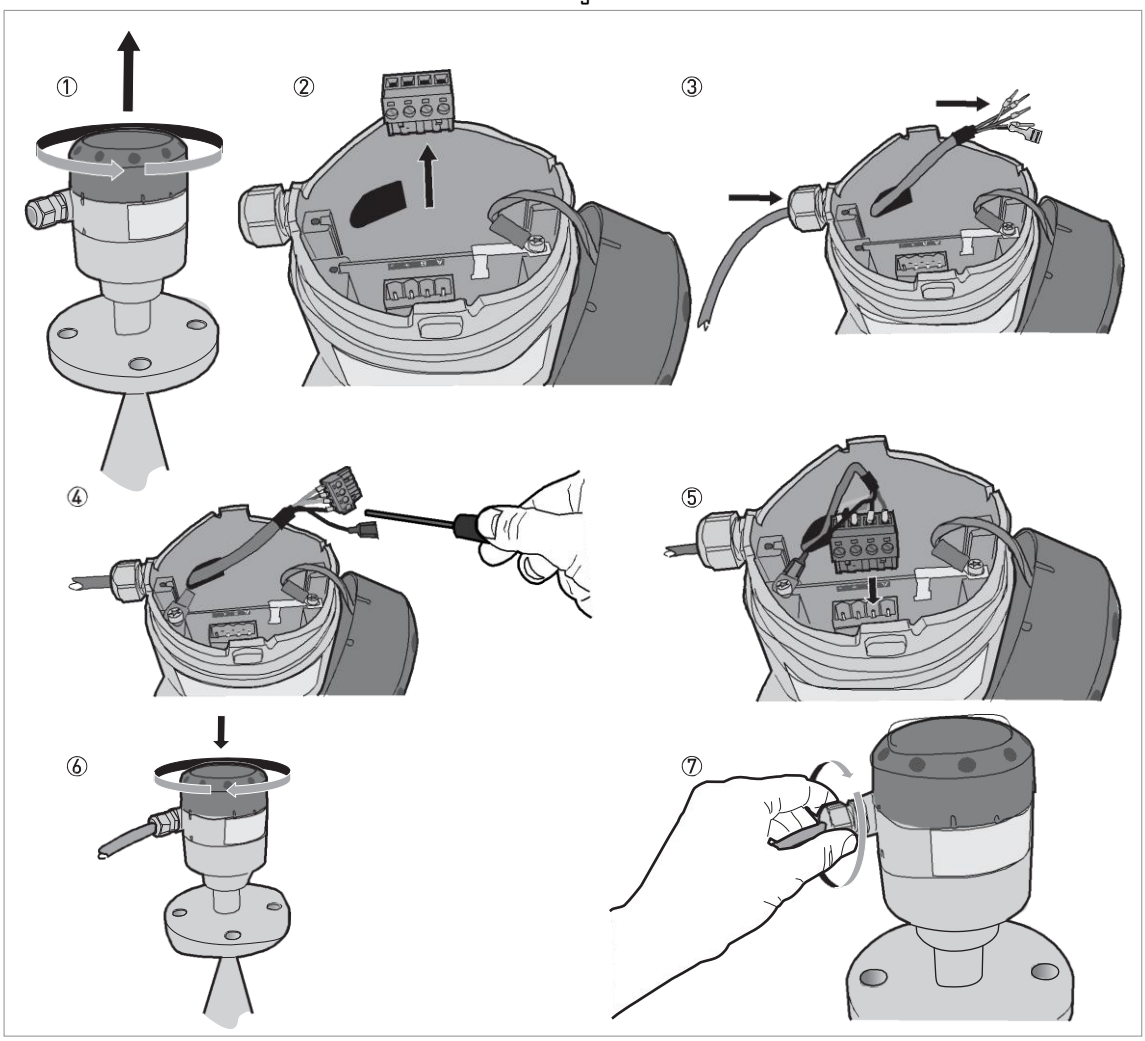


Figure 4-12: How to connect the communication cable to the antenna housing

CAUTION!
Bending radius of the communication cable: ≥ 50 mm / 2¨

1 Remove the terminal compartment cover.
2 Remove the 4-pin connector.
3 Put the communication cable into the opening of the cable gland.
4 Put the electrical wires in the connector terminals. Tighten the terminal screws with a small slotted-tip screwdriver. Make sure that the electrical wires agree with the terminals. For more data, refer to the electrical schema in this section.
5 Put the connector into the 4-pin socket. Attach the Faston connector (drain wire).
6 Attach the terminal compartment cover.
7 Tighten the cable gland. Make sure that the probe housing is correctly sealed.

4.4 Protection category

INFORMATION!
The device fulfills all requirements per protection category IP 66/67 (equivalent to NEMA type 4X (housing) and type 6P (antenna)).

DANGER!
Make sure that the cable gland is watertight.

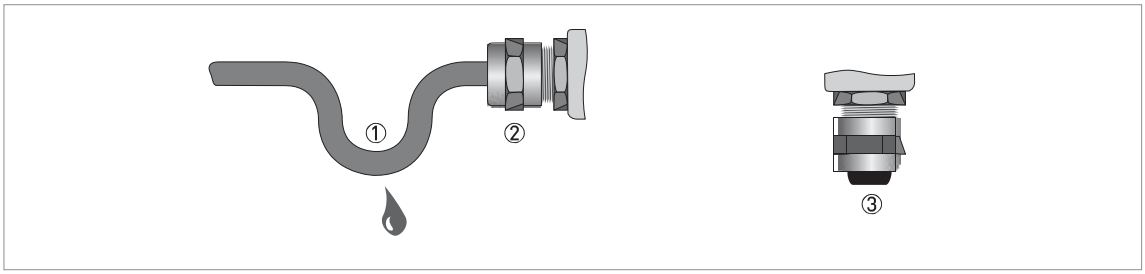


Figure 4-13: How to make the installation agree with protection category IP 67

- Make sure that the gaskets are not damaged.
- Make sure that the electrical cables are not damaged.
- Make sure that the electrical cables agree with the national electrical code.
- The cables are in a loop in front of the device 1 so water does not go into the housing.
- Tighten the cable feedthroughs 2.
- Close unused cable feedthroughs with dummy plugs 3.

4.5 Networks

4.5.1 General information

The device uses the HART® communication protocol. This protocol agrees with the HART® Communication Foundation standard. The device can be connected point-to-point. It can also operate in a multi-drop network of up to 15 devices.

The device output is factory-set to communicate point-to-point. To change the communication mode from point-to-point to multi-drop, refer to Network configuration on page 66.

4.5.2 Point-to-point connection

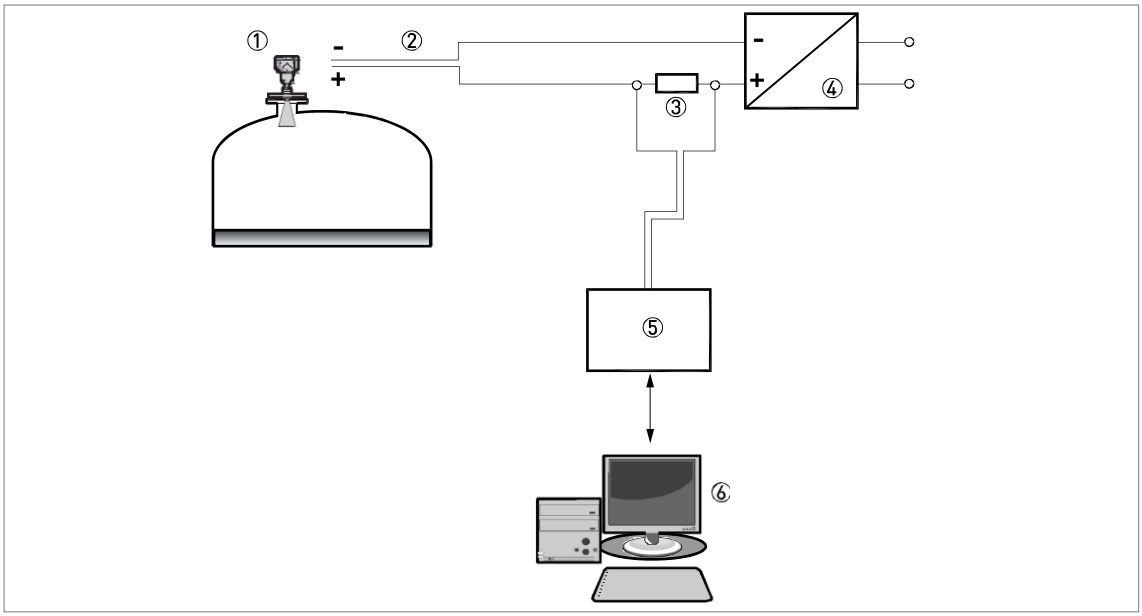


Figure 4-14: Point-to-point connection (non-Ex)

1 Address of the device (0 for point-to-point connection)
2 4...20 mA + HART®
3 Resistor for HART® communication
4 Power supply
5 HART® converter
6 HART® communication software

4.5.3 Multi-drop networks

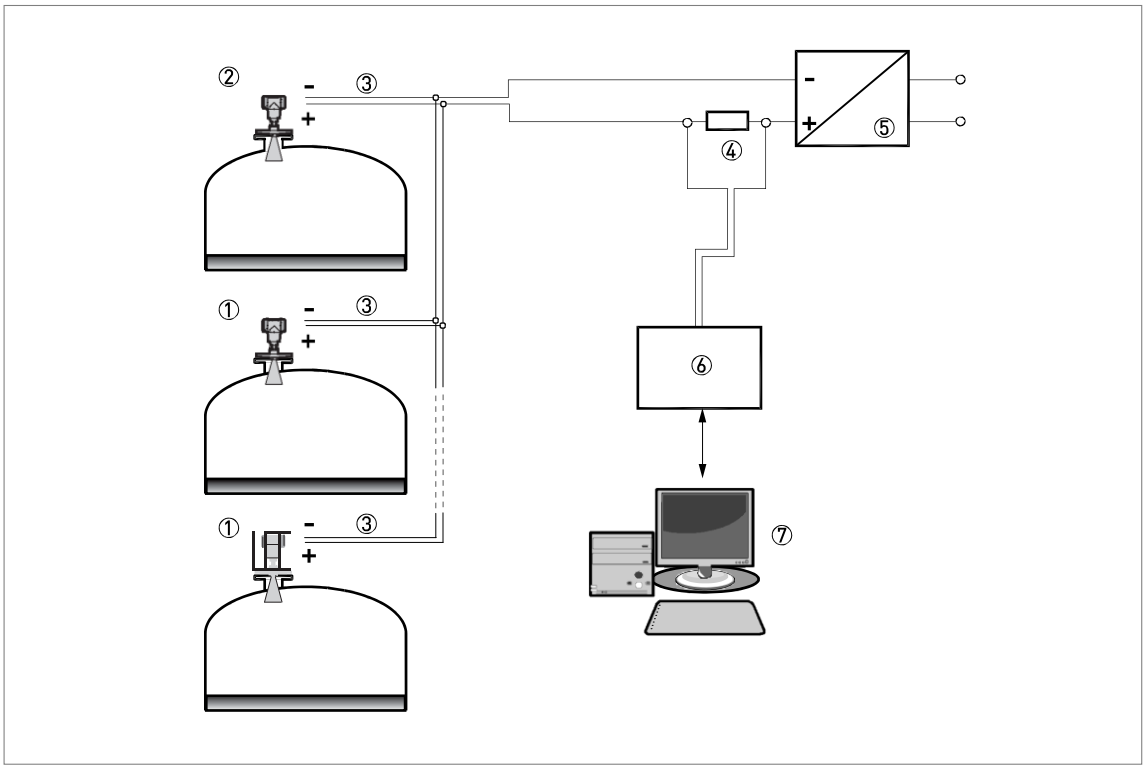


Figure 4-15: Multi-drop network (non-Ex)

1 Address of the device (n+1 for multidrop networks)
2 Address of the device (1 for multidrop networks)
3 4 mA + HART®
4 Resistor for HART® communication
5 Power supply
6 HART® converter
7 HART® communication software

4.5.4 Fieldbus networks

FOUNDATION Fieldbus ™ network (non-Ex)

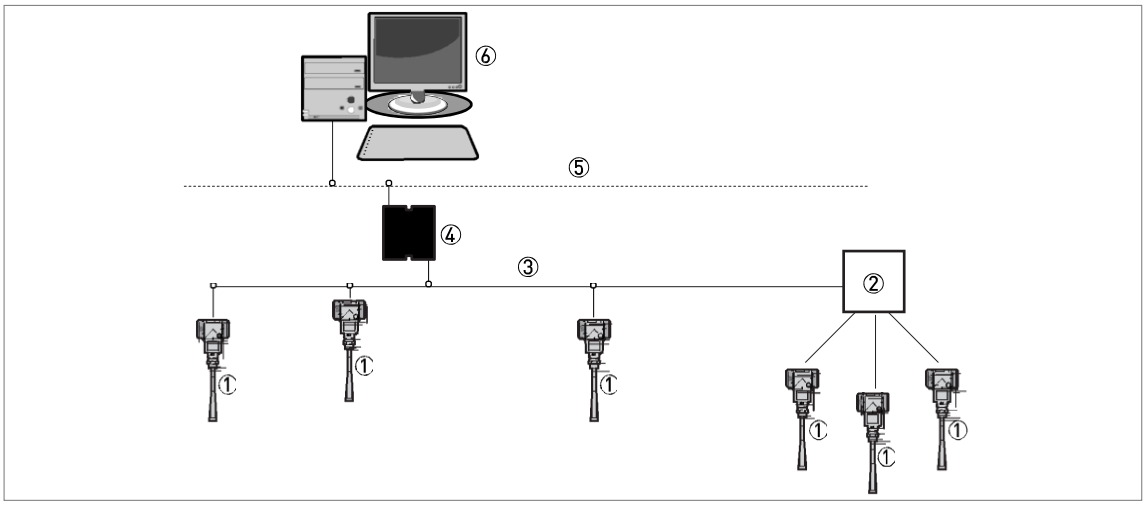


Figure 4-16: FOUNDATION Fieldbus ™ network (non-Ex)

1 Field device
2 Junction box
3 HI network
4 HI/HSE converter
5 High Speed Ethernet (HSE)
6 Workstation

INFORMATION!

It is necessary to have a separate power supply to energize devices with the FOUNDATION ™ Fieldbus output option (4-wire device with local HART® connection). The FF terminal is connected to a Fieldbus Power Hub. The 24 VDC terminal energizes the device. The power supply is not shown in the illustration.

PROFIBUS PA/DP network (non-Ex)

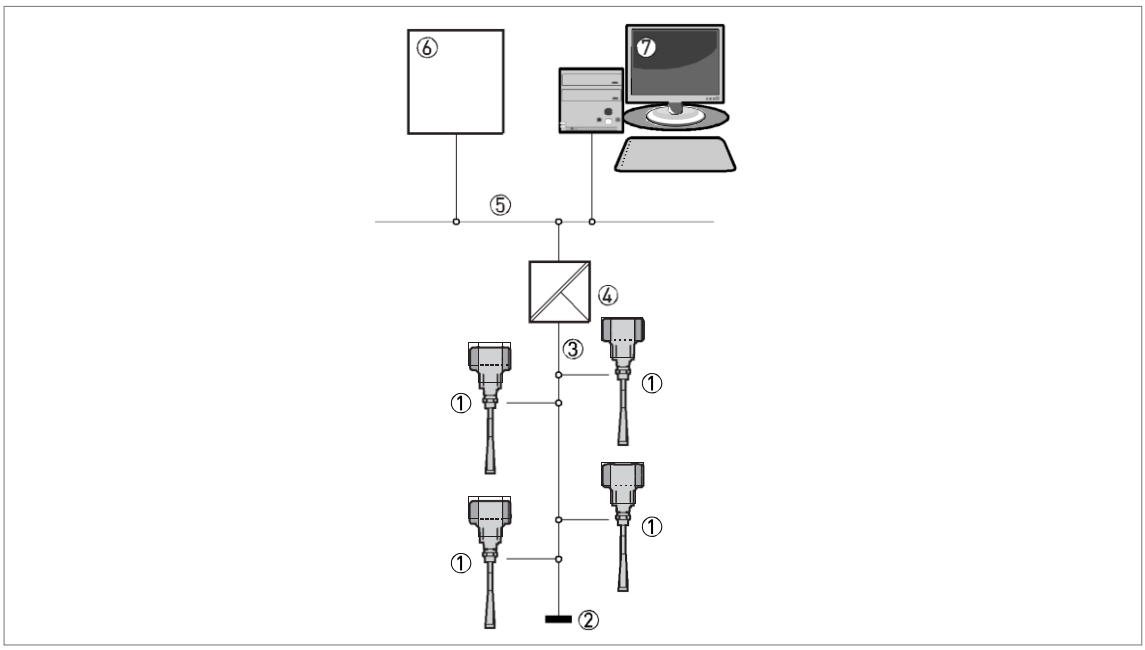


Figure 4-17: PROFIBUS PA/DP network (non-Ex)

1 Field device
2 Bus termination
3 PROFIBUS PA bus segment
4 Segment coupler (PA/DP link)
5 PROFIBUS DP bus line
6 Control system (PLC / Class 1 master device)
7 Engineering or operator workstation (Control tool / Class 2 master device)

INFORMATION!

It is necessary to have a separate power supply to energize devices with the PROFIBUS PA output option (4-wire device with local HART® connection). The PROFIBUS PA terminal is connected to a segment coupler. The 24 VDC terminal energizes the device. The power supply is not shown in the illustration.

5.1 How to start the device

5.1.1 Start-up checklist

Check these points before you energize the device:

- Are all the wetted components (antenna, flange and gaskets) resistant to the product in the tank?
- Does the information on the signal converter nameplate agree with the operating data?
- Did you correctly install the device on the tank?
- Do the electrical connections agree with the national electrical codes?

DANGER!
Before you energize the device, make sure that the supply voltage and polarity are correct.

DANGER!
Make sure that the device and the installation agrees with the requirements of the Ex certificate of compliance.

5.1.2 How to start the device

- Connect the converter to the power supply.
- Energize the converter.

  Devices with the LCD display option only: After 10 seconds the screen will display "Starting up". After 20 seconds the screen will display the software version numbers. After 30 seconds the default screen will appear.
- The device will display readings.

5.2 Operating concept

You can read measurements and configure the device with:

- A digital display screen (optional).
- A connection to a system or PC with PACTware™. You can download the Device Type Manager (DTM) file from the internet site. It is also supplied on the CD-ROM delivered with the device.
- A connection to a system or PC with AMS™. You can download the Device Description (DD) file from the internet site. It is also supplied on the CD-ROM delivered with the device.
- A connection to a HART® Handheld Communicator.

5.3 Digital display screen

5.3.1 Local display screen layout

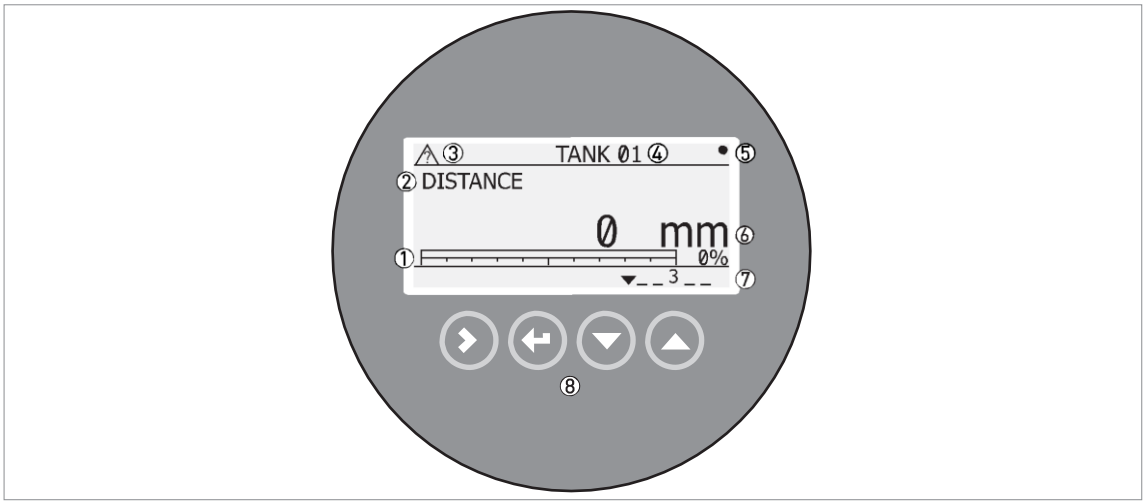


Figure 5-1: Local display screen layout in Normal mode

1 Current output percentage (bar graph and text - only shown if the current output function is the same as the measure- ment on the screen in normal mode)
2 Measurement type (in this example, distance)
3 Device status (NE 107 symbols)
4 Device tag name
5 Updated measurement data symbol
6 Measurement value and units
7 Device status (markers)
8 Keypad buttons (refer to the table in the section that follows)

INFORMATION!
The current output percentage is only shown for the output function (set in menu item 2.4.1 OUTPUT FUNC.). For example, if the output function is set to "Level" and normal mode displays "Distance" measurements, the bar graph and text is not shown.

Figure 5-2: Local display screen layout in configuration mode

1 Function name
2 Configuration mode symbol
3 Menu number

5.3.2 Keypad buttons

Keypad button	Function
[Right]	Readings: Enter Commissioning menu (Enter Configuration mode)
[Return / Escape]	Readings: Change units (m, cm, mm, in, ft) Configuration mode: Exit
[Down]	Readings: Change measurement type (distance, level , output (%), output (mA)) Configuration mode: Decrease value or change parameter
[Up]	Readings: Change measurement type (distance, level , output (%), output (mA)) Configuration mode: Increase value or change parameter

For data on keypad functions, refer to Normal mode on page 52.

6.1 User modes

Normal mode	This mode displays measurement data. For more data, refer to Normal mode on page 52.
Configuration mode	Use this mode to view parameters, commission the device, create tables for volume or mass measurement, change critical values to measure in difficult process conditions. To get access to supervisor menu, refer to Protection of the device settings on page 65. For more data on menu items, refer to Function description on page 58.

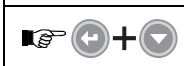
6.2 Normal mode

This mode shows measurement data. Use the table that follows:

- for the selection of the measurement type (level, distance, percentage, conversion),
- for the selection of the measurement units and

Some measurement types will only be available if the device has the correct parameters entered in the configuration mode.

Keypad functions

Button	Description	Function	"Hot key" function
	Right	Enter configuration mode.	-
	Return / Escape	Change the measurement units.	-
	Down	Change the measurement type.	-
	Up	Change the measurement type.	Display language will change to English [1]
	Return and Down	-	-

1 The display language will change when you press this button for 2 seconds. Press the button again and it will go back to the original language.

Measurement type definitions

Measurement type	Description	Available units
LEVEL	This is a display and an output function option. It is the height from the bottom of the tank to the surface of the liquid (Tank height - Distance).	m, cm, mm, in (inches), ft (feet)
DISTANCE	This is a display and an output function option. It is the distance from the face of the flange to the surface of the liquid.	m, cm, mm, in (inches), ft (feet)
CONVERSION	This is a display and an output function option. It gives the volume, mass or flow rate of the tank contents. This data is available if you prepare a volume, mass or flow rate table in configuration mode. For data on how to prepare the conversion table, refer to How to configure the device to measure volume or mass on page 68.	m3, L, gal (US gallons), ImpG (Imperial gallons), ft3, bbl (oil barrel), kg, t, Ston, Lton, m, cm, mm, in, ft, m3/h, ft3/h
ULLAGE CONV.	This is a display and an output function option. It gives the empty volume or remaining mass that can be put in the tank. This data is available if you prepare a volume or mass table in configuration mode. For data on how to prepare the conversion table, refer to How to configure the device to measure volume or mass on page 68.	m3, L, gal (US gallons), ImpG (Imperial gallons), ft3, bbl (oil barrel), kg, t, Ston, Lton, m, cm, mm, in, ft, m3/h, ft3/h
OUTPUT I (mA)	The current output of the device.	mA
OUTPUT I (%)	The percentage of the current output. 0% = 4 mA. 100% = 20 mA.	%

6.3 Configuration mode

6.3.1 General notes

Change the settings of your device in Configuration mode. Data about the menus is given on page 58. You can:

- Use the 1.0.0 INFORMATION menu to read settings, device software versions and error records. For more data about the Information menu, refer to Table A. Info.
- Use the 2.0.0 SUPERVISOR menu run diagnostic tests, set up a conversion table for volume, mass or flow rate measurement, change critical parameters for difficult process conditions, reset the device and change basic parameters (tank height etc.), output settings, HART Address etc. For more data about the Supervisor menu, refer to Table 2. Supervisor.

INFORMATION!
It is not possible to enter the 3.0.0 SERVICE and 4.0.0 MASTER menus. These menus are for factory calibration and qualified service personnel only.

6.3.2 How to get access to the commissioning menu

Do the steps that follow:

- Press the [>] button.

ℹ This shows the Information menu. The Information menu is read only and does not have password security.

- Press the [ ] button one time to scroll up to the Supervisor menu.

ℹ The screen shows the text "2.0.0 SUPERVISOR".

- Press the [>] button one time.

ℹ The screen shows a line. You must enter the password. Press the buttons under the display screen 6 times (in total and in a given order) to to get access to Configuration mode.

- Type in the password. The factory-set password is [>], [^], [ ], [ ], [>] and [^].

ℹ The device shows the text "2.1.0 COMMISSION.". Make a selection from the items in the supervisor menu.

CAUTION!
SIL-approved devices:
For data about critical device parameters for SIL approval, refer to the Safety Manual (SIL approval).

INFORMATION!
How to set the supervisor password to "on" or "off"
The supervisor password is set to "on" by default. If it is necessary to set this function to "off", refer to Function description on page 58, Table 2: Supervisor menu, menu item PSWD YES/NO (2.7.4).

INFORMATION!
How to change the supervisor password
You can change the password for the supervisor menu. For more data, refer to Function description on page 58, Table 2: Supervisor menu, menu item PASSWORD (2.7.5).

6.3.3 Keypad functions

Figure 6-1: Local display screen layout in configuration mode

1 Function name
2 Configuration mode symbol
3 Menu number

This is what you see when you are in Configuration mode. The functions of the buttons are given in the table that follows:

Functions of buttons for menu navigation

Button	Description	Function
☞	Right	• Go down to the sub-menu level (for example, from menu 1.0.0 to sub- menu 1.1.0). • Enter the menu item
☞	Enter / Esc (Escape)	• Go up to the menu level (for example, from sub-menu 1.1.0 to menu 1.0.0). • Go to Normal mode. If you changed settings in Configuration mode, you must save or cancel your new settings. For more data, refer to the end of this section.
☞	Down	• Scroll down the menu list (for example, from menu 2.0.0 to menu 1.0.0). • Scroll down the sub-menu list (for example, from sub-menu 2.2.0 to sub-menu 2.1.0).
☞	Up	• Scroll up the menu list (for example, from menu 1.0.0 to menu 2.0.0). • Scroll up the sub-menu list (for example, from sub-menu 2.1.0 to sub-menu 2.2.0).

Lists of parameters in menu items

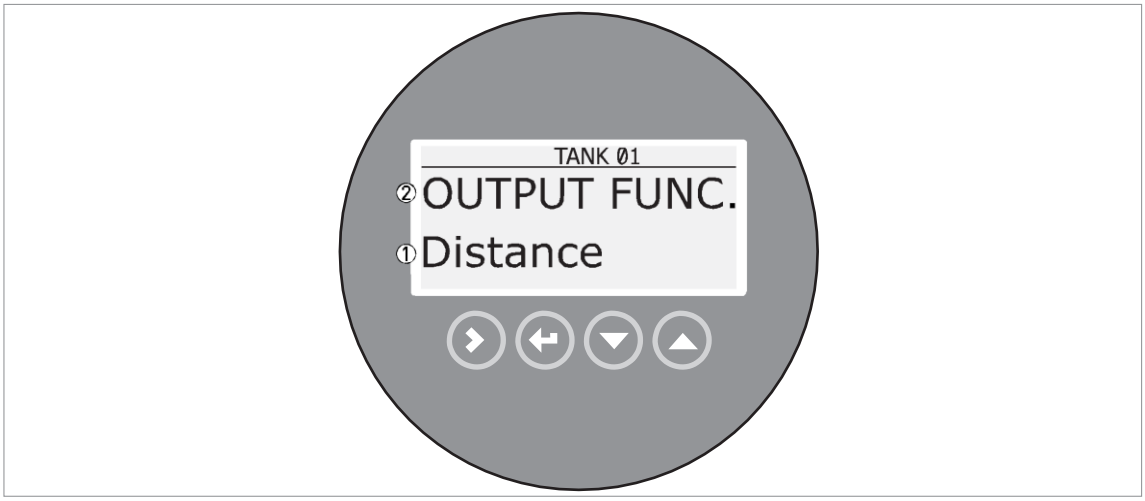


Figure 6-2: Lists of parameters in menu items

1 Parameter
2 Menu name

This is what you see when you select a menu item that has a list of parameters. The functions of the buttons are given in the table that follows:

Function of buttons in menu items that have a list of parameters

Button	Description	Function
☞	Right	n/a
☞	Enter / Esc (Escape)	Select the parameter and go back to the menu
☞	Down	Move down the list
☞	Up	Move up the list

Values in menu items

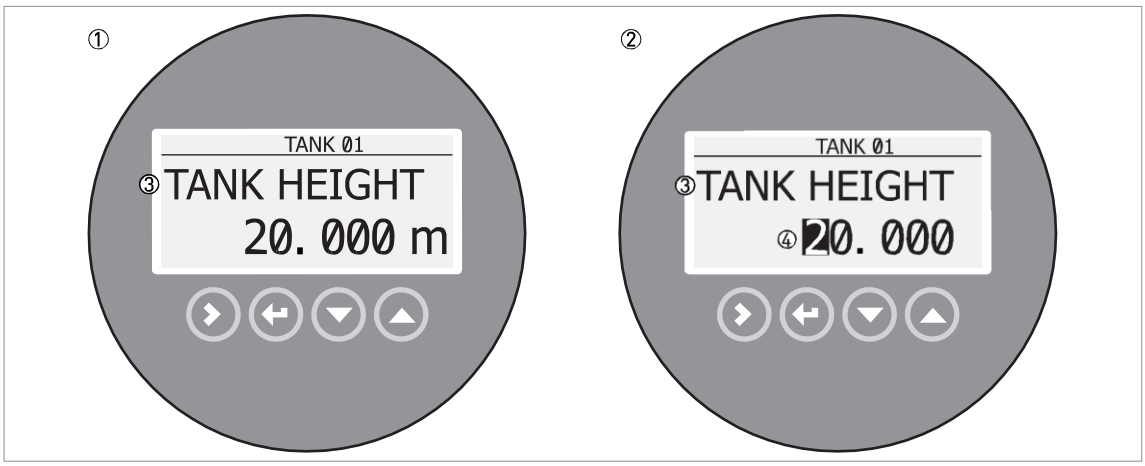


Figure 6-3: Values in menu items

1 Menu item with values stored at this time (first screen)
2 Press [>] again to change the values. A cursor shows on the first digit.
3 Menu item name
4 Cursor on the selected digit

This is what you see when you select a menu item that has a value. The functions of the buttons are given in the table that follows:

Function of buttons in menu items that have values

Button	Description	Function
☞ (right)	Right	• Enter the menu item and see the value stored at this time. • Enter the menu item configuration level to change the value. • Move the cursor to the next digit on the right. If the cursor is on the last digit, press [>] again to go back to the first digit.
☞ (enter)	Enter / Esc (Escape)	Accept the value and go back to the sub-menu.
☞ (down)	Down	Decrease the digit value.
☞ (up)	Up	Increase the digit value.

How to save settings changed in the supervisor menu (menu 2.0.0)

- When you have changed parameters in all the necessary menu items, press [↗] to accept the new parameter.
- Press [↗] to go back to the "STORE" screen.
- The device will ask you to save or cancel your settings. Press [ ] or [ ] to select STORE YES or STORE NO. Press [↗] to accept or reject the new settings.

ℹ The display goes back to Normal mode.

6.3.4 Menu overview

1.0.0 Info. (Information)

1.1.0	Ident. (Identification)
1.2.0	Output
1.3.0	History

2.0.0 Supervisor

2.1.0	Commissioning
2.2.0	Tests
2.3.0	Basic Parameters
2.4.0	Output I
2.5.0	Application
2.6.0	Communication
2.7.0	Display
2.8.0	Conversion
2.9.0	Config/Reset

3.0.0 Service

n/a	Password locked. Menus for factory calibration and qualified service personnel only.

4.0.0 Master

n/a	Password locked. Menus for factory calibration and qualified service personnel only.

6.3.5 Function description

1. Information (Info.) menu

Menu No.	Function	Function description	Selection list	Default
1.0.0	INFORMATION	A summary of information relating to the device.		
1.1.0	IDENT.			
1.1.1	SERIAL NUM.	The device serial number.	Read only.	
1.1.2	CONV.FIRM.VER	The converter firmware version.	Read only.	
1.1.3	SEN.FIRM.VER	The sensor firmware version.	Read only.	
1.1.4	HMI.FIRM.VER	The HMI (device display screen) firmware version.	Read only.	
1.2.0	OUTPUT I			
1.2.1	SUMMARY I	This shows the settings at this time for the output function (OUTPUT FUNC.), output range (RANGE I), 4 mA setting (SCALE 4mA), 20 mA setting (SCALE 20mA), and error delay (ERROR DELAY).	Read only.	

Menu No.	Function	Function description	Selection list	Default
1.3.0	HISTORY			
1.3.1	ERROR RECORD	A log of device errors. Press [>] to read the errors. Press [ ] or [ ] to scroll up or down the list. Each error is identified by a code. Press > again to show the number of incidents and the time since the last incident in days, hours, minutes and seconds. For more data on errors,.	Read only.	

2. Supervisor menu

Menu No.	Function	Function description	Selection list	Default
2.0.0	SUPERVISOR	The supervisor can use this menu to change parameters.		
2.1.0	COMMISSION.			
2.1.1	PARAMETERS	This starts a quick set-up procedure applicable to most applications. The supervisor can give the tank height (TANK HEIGHT), type of tank (TANK TYPE), output function (OUTPU FUNC.), current output range (RANGE I), 4 mA setting (SCALE 4mA), 20 mA setting (SCALE 20mA), error delay (ERROR DELAY) and tag name (TAG NAME).		
2.1.2	EMP.SPEC.REC.	Fixed and moving objects in the tank cause interference signals. Put them through this filter to correctly measure the tank contents. A quick set-up procedure will go through the steps that follow:		
	1	Do you have a completely filled tank? If the tank is full, it is not possible to complete this procedure. The tank must be partially filled or empty.	Yes [>], No [ ]	
	2	Please, activate moving parts! We recommend that you switch on moving equipment to filter all interference signals.	OK [>]	
	3	Ils your tank partially filled or empty? If the tank is partially filled, the device must include the tank contents when it filters the signal.	Partially [>], Empty [ ]	
	4	MEAS.DISTANCE If the tank is partially filled, type in a distance shorter than that between the flange and the tank contents.	min-max: 0…tank height (2.3.1)	?

Menu No.	Function	Function description	Selection list	Default
	5	Emp.Spec.Type Use the average value for tanks which contain fixed objects only. Use the maximum value for tanks which contain many objects or moving objects.	Maximum, Average	?
	6	Recording in progress Reading in progress		
	7	Empty spectrum graph Push [>] to make a selection from the available spectra to get the correct level signal, if the tank is partially filled.		
	8	Do you want to save the spectrum?	Yes [>], No [ ]	
2.2.0	TESTS	The device serial number.		
2.2.1	SET OUTPUT	This sets the current output to a test value [mA]. The output will change to the given value, independent of the measured value. The current output will go back to the measured value when the display goes back to the menu level.	3.5, 4, 6, 8, 10, 12, 14, 16, 18, 20 or 22 mA	3.5 mA
2.2.2	DIAGNOSTIC	This starts the hardware test. Press [>] many times to show: the time of operation (01), temperature of the electronic converter board (T1), loop current (I1), load current (I2), voltage 5.6 V (V1), voltage on capacitors (V2), voltage 3.3 V (V3), reset counter (C1). If you press [>] again, the display goes back to the menu level.		
2.3.0	BASIC PARAM.	The basic parameters for configuration of the device.		
2.3.1	TANK HEIGHT	The distance from the flange face / thread stop of the tank connection down to the tank bottom.	min-max: 0…30 m / 0…98.4 ft	10.0 m / 32.8 ft
2.3.2	BLOCK. DIST.	Blocking distance. The distance from the flange to the top limit of the measuring range (a zone given by the user where it is not possible to measure). We recommend a blocking distance of 500 mm / 19.7" below the antenna. If the distance is less than the blocking distance, the device continues to display the blocking distance.	min: 100 mm / 13.9" or 2.3.6 ANTENNA.EXT max: 2.3.1 TANK HEIGHT	500 mm / 19.7"
2.3.3	TIME CONST.	Using this function, the device processes several measurement readings to filter out disturbances. Increasing the time constant will smoothen the integrated readings, decreasing will roughen the readings. s=seconds.	min-max: 1.00...100.00 s	10.00 s

Menu No.	Function	Function description	Selection list	Default
2.3.4	STILLWELL EN.	If the device is installed in a stilling well or has a Wave- Guide antenna, set this menu item to "Yes".	YES, NO	NO
2.3.5	STILLWELL D.	The inner diameter of the stilling well. If the device is installed in a stilling well or has a Wave-Guide antenna, enter the diameter. The device will use this data if you set 2.3.4 STILLWELL EN. to "Yes". This menu item is not shown if you set 2.3.4 STILLWELL EN. to "No".	min-max: 22...999 mm / 0.9...39.3"	100 mm / 3.9"
2.3.6	STILLWELL H.	The height of the stilling well. If the device is installed in a stilling well or has a Wave-Guide antenna, enter the height. The device will use this data if you set 2.3.4 STILLWELL EN. to "Yes". This menu item is not shown if you set 2.3.4 STILLWELL EN. to "No".	min: 500 mm / 19.7" max: 2.3.1 TANK HEIGHT	10000 mm / 393.7"
2.3.7	ANTENNA.EXT	Optional antenna extensions. These are attached between the flange and the antenna.	min: 0 mm / 0" or 2.3.6 ANTENNA.EXT max: 2000 mm / 78.7" or 2.3.1 TANK HEIGHT	0 mm / 0"
2.3.8	ANTENNA.TYP	Type of antenna. For more data, refer to Technical data on page 79.	PP Horn, PTFE Horn, Metal. Horn, Wave Stick, Wave Guide	PP Horn
2.3.9	DIST.PIECE	Optional distance piece between the converter and the process connection. This is for high-temperature applications more than +150°C / +302°F. The distance piece is 120 mm / 4.7" long. For more data, refer to Technical data on page 79.	min: 0 mm / 0" max: TANK HEIGHT	0 mm / 0"
2.3.10	TAG NAME	The device has a code (tag name) to identify it. The supervisor can enter a maxmimum of 8 numbers or letters.	?	TANK 01
2.4.0	OUTPUT 1	Use this sub-menu to give measurement values to the current output.		
2.4.1	OUTPUT FUNC.	The output function. Select an output function to scale the current values in relation to a given point (usually the device process connection or the tank bottom). The output current value is shown on a bar graph in normal mode if the measurement name is the same as the output function. Conversion parameters are shown if there is volume, mass or flow rate data in 2.8.1 INPUT TABLE.	Distance, Level, Conversion, Ullage conversion	Distance

Menu No.	Function	Function description	Selection list	Default
2.4.2	RANGE I	This parameter sets the range of the output current with (3.8...20.5 mA) or without (4...20 mA) over-run values. It also tells the device what to do if an error occurs. For example, the device will change to an error value of 22 mA if you set RANGE I to 4-20/22E. If you set RANGE I to 4-20 and the device senses a measurement error, the value will stop at the last correct measurement.	4-20, 4-20/22E, 4-20/3.6E, 3.8-20.5/22E, 3.8-20.5/3.6E	4-20/3.6E 1
2.4.3	SCALE 4mA	This gives a measurement value to 4 mA.	min.-max: 2	1 m / 3.28 ft
2.4.4	SCALE 20mA	This gives a measurement value to 20 mA.	min.-max: 3	45 m / 147.63 ft
2.4.5	ERROR DELAY	The time after which the current output changes to an error value. The error value shows that there is a measurement error. mn=minutes and s=seconds.	0 s, 10 s, 20 s, 30 s, 1 mn, 2 mn, 5 mn,15 mn	1 mn
2.5.0	APPLICATION	Use this sub-menu to configure the device when there are difficult process conditions. Only approved personnel can change these parameters.		
2.5.1	TANK TYPE	The conditions in which the device is used. If the surface of the product is flat, select "Storage". If the surface of the product is disturbed, select "Process". If the surface of the product is agitated with vortexes and foam, select "Agitator".	Storage, Process, Agitator	Process
2.5.2	TRACKING VEL.	Maximum tracking velocity. This value must agree with the maximum rate of change of the level of the liquid or solid contents in the tank.	min-max: 0.1...10.0 m/min	1.0 m/min 4
2.5.3	Er PRODUCT	The device automatically calculates the level based on the product ε_r. If you select "TBF Partial" or "TBF Full" in menu item 2.3.9 MEASUR.MODE, you can change the ε_r value manually to adjust readings.	min-max: 1.100 to 10.000	2.000

Menu No.	Function	Function description	Selection list	Default
2.5.4	MEASUR.MODE	The device uses the dielectric constant (ε_r) of the tank contents to monitor level. In direct mode (if the dielectric constant is high), the level signal is a reflection on the surface of the tank contents. If the dielectric constant is low, the device uses TBF mode. The device in TBF mode uses the radar reflection on the bottom of the tank (the signal goes through the tank contents). This menu item is set by default to "Direct" for tank contents with an ε_r >1.8. If ε_r is very low (<1.6), use "TBF Full". If ε_r is low (ε_r = 1.5...1.7), use "TBF Partial" mode. "TBF Partial" is an automatic mode that lets the device make a selection between "Direct mode and "TBF" mode. If you use "TBF Full" or "TBF Partial", enter the dielectric constant in menu item 2.5.3 Er PRODUCT. Refer also to "Measuring principle" on page 79.	Direct, TBF Partial, TBF Full	Direct
2.5.5	OVERF. ENAB.	If this function is switched on, the device will monitor the level even if it is in the blocking distance. The displayed output stays fixed at the blocking distance. An error is recorded by default.	YES, NO	NO
2.5.6	MULT.REF.EN.	Multiple reflections will cause the device to display smaller readings. Objects in the tank, sharp corners, installation of the device on a large nozzle or at the centre of a dome roof can cause multiple reflections. A very calm surface or a tank with a small convex or flat roof can also cause multiple reflections.	YES, NO	NO
2.5.7	EMP.SPEC.EN.	The supervisor can start or stop the empty spectrum filter.	YES, NO	NO
2.6.0	SERIAL I/O	Menu items for communication in field networks.		
2.6.1	ADDRESS	Any HART® address greater than 0 will activate HART® multidrop mode. The current output stays constant at 4 mA.	min.-max: 0…63	0
2.7.0	DISPLAY	This sub-menu includes all the display parameters and password security parameters for the supervisor menu.		
2.7.1	LANGUAGE	Data can be shown in any of the languages stored in the device. The standar language is given in the customer order.	English, German, French, Italian, Spanish, Portuguese, Japanese, Chinese (Mandarin) and Russian	English

Menu No.	Function	Function description	Selection list	Default
2.7.2	LENGTH UNIT	The length unit shown in normal mode.	m, cm, mm, in (inches), ft (feet)	m
2.7.3	CONV UNIT	Conversion unit. The length, volume, mass or flow rate conversion unit for the conversion table and shown in normal mode.	m3, L, gal (US gallons), ImpG (Imperial gallons), ft3, bbl (oil barrel), kg, t, Ston, Lton, m, cm, mm, in, ft, m3/h, ft3/h	L
2.7.4	PSWD YES/NO	If it is necessary to protect your settings in the supervisor menu with a password, set this menu item to "YES".	YES, NO	YES
2.7.5	PASSWORD	This changes the password for the supervisor menu. Press the buttons up to 6 times in any order. This will be the new password. To confirm the change, enter the new password a second time.		[>], [^], [ ], [ ], [>] and [^]
2.7.6	CONTRAST	The contrast control for the display screen. You can select a shade of grey between light grey (level 20) and black (level 54).	min.-max: 20…54	36
2.8.0	CONV. TABLE	Conversion table. Use these menu items to set up or erase conversion tables to show length, volume or mass measurement values in normal mode.		
2.8.1	INPUT TABLE	The device uses the conversion table to convert measurements to volume, mass and flow rate readings. The readings are shown in normal mode. Give the number of entries on the table. Enter the height and the related volume / mass / flow rate values.	max. 30 entries (distance / volume, mass or flow rate)	0 entries 5
2.8.2	DELETE TABLE	This menu item erases the data in the conversion table.	YES, NO	NO
2.9.0	CONFIG/RESET	Use this sub-menu to start the device again.		
2.9.1	SAVE	This menu item is not available.	YES, NO	NO
2.9.2	RECALL	This menu item is not available.	YES, NO	NO
2.9.3	RESTART	This menu item starts the device again.	YES, NO	NO

1 "4-20/3.6E" is necessary for SIL 2 approval. If you make a different selection, the device does not have SIL 2 approval.

2 Units and range depend on the output function, length unit and volume unit selected. See also the table of data depen- dencies for the 4 mA settings in this section.

3 Units and range depend on the output function, length unit and volume unit selected. See also the table of data depen- dencies for the 20 mA settings in this section.

4 1.0 m/min is necessary for SIL 2 approval. If you make a different selection, the device does not have SIL 2 approval.

5 0 entries is necessary for SIL 2 approval. If you make a different selection, the device does not have SIL 2 approval.

3. Service menu

Menu No.	Function	Function description	Selection list	Default
3.0.0	SERVICE	Advanced settings. The settings in this menu are protected with a password. Only approved personnel can change the parameters in this menu. For more data, contact your local sales office.		

4. Master menu

Menu No.	Function	Function description	Selection list	Default
4.0.0	MASTER	Factory settings. The settings in this menu are protected with a password. Only approved personnel can change the parameters in this menu. For more data, contact your local sales office.		

8.1 Measuring principle

A radar signal is emitted via an antenna, reflected from the product surface and received after a time t. The radar principle used is FMCW (Frequency Modulated Continuous Wave).

The FMCW-radar transmits a high frequency signal whose frequency increases linearly during the measurement phase (called the frequency sweep). The signal is emitted, reflected on the measuring surface and received with a time delay, t. Delay time, t=2d/c, where d is the distance to the product surface and c is the speed of light in the gas above the product.

For further signal processing the difference Δf is calculated from the actual transmit frequency and the receive frequency. The difference is directly proportional to the distance. A large frequency difference corresponds to a large distance and vice versa. The frequency difference Δf is transformed via a Fourier transformation (FFT) into a frequency spectrum and then the distance is calculated from the spectrum. The level results from the difference between tank height and measuring distance.

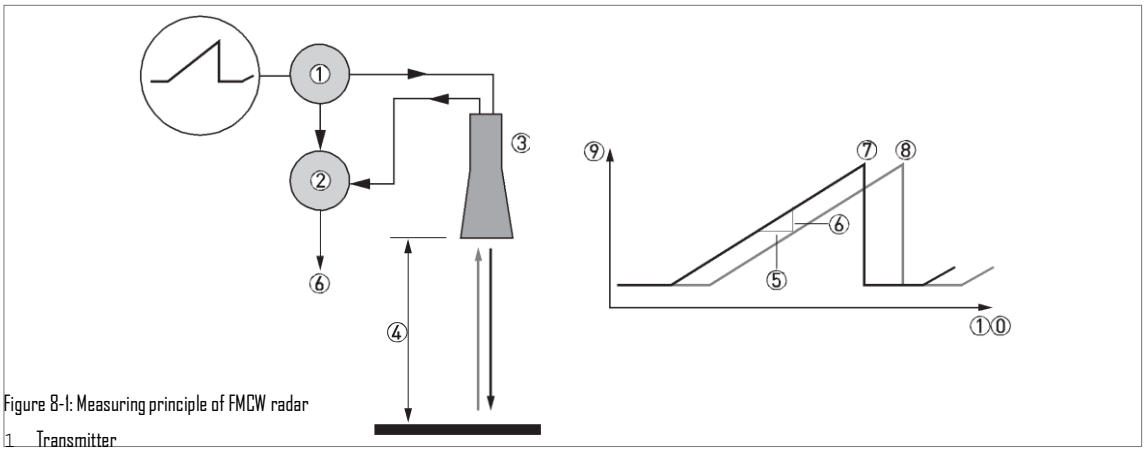


Figure 8-1: Measuring principle of FMCW radar

1 Transmitter
2 Mixer
3 Antenna
4 Distance to product surface, where change in frequency is proportional to distance

5 Differential time delay, Δt
6 Differential frequency, Δf
7 Frequency transmitted
8 Frequency received
9 Frequency
10 Time

Measurement modes

"Direct" mode
If the dielectric constant of the tank contents is high (ε_r >1.8), the level signal is a reflection on the surface of the tank contents.

"Full TBF" mode
TBF = Tank Bottom Following. If the dielectric constant of the tank contents is very low (ε_r <1.6), you must use "Full TBF" mode to measure level correctly. The device uses the radar reflection on the bottom of the tank (the signal goes through the tank contents).

"TBF Partial" mode
If the dielectric constant of the tank contents is low (ε_r =1.5...1.7), you must use "TBF Partial" mode to measure level correctly. TBF Partial" is an automatic mode that lets the device make a selection between "Direct mode and "TBF" mode. If the device finds a large radar reflection above the "tank bottom area" (the bottom 20% of the tank height), the device will use "Direct" mode. If the device finds a large radar reflection in the "tank bottom area", the device uses TBF mode.

CAUTION!
"Full TBF" and "TBF Partial" modes
It is important to enter the correct dielectric constant value in menu item 2.5.3 Er Product. If not, the device will not measure level accurately.

8.2 Technical data

INFORMATION!

- The following data is provided for general applications. If you require data that is more relevant to your specific application, please contact us or your local representative.
- Additional information (certificates, special tools, software,...) and complete product documentation can be downloaded free of charge from the website (Download Center).

Measuring system

Measuring principle	2-wire loop-powered level transmitter; X-band (8.6...10.4 GHz) FMCW radar
Application range	Level measurement of liquids, pastes and slurries
Primary measured value	Distance
Secondary measured value	Level, volume, mass, flow rate and reflectivity

Design

Construction	The measurement system consists of a measuring sensor (antenna) and a signal converter
Options	Integrated LCD display (-20..+60°C / -4...+140°F); if the ambient temperature is not in these limits, the display switches off automatically
	Distance piece (for process temperatures more than +150°C / +302°F)
	Straight antenna extensions Max. extension length, PTFE Wave Horn antenna: 300 mm / 11.8"; Max. extension length, Metallic Horn antenna: 1000 mm / 39.4"
	S-bend antenna extension - only for DN150 and DN200 Metallic Horn antenna options
	90° bend antenna extension - only for DN150 and DN200 Metallic Horn antenna options
	Communication cable for remote housing version (refer to cable properties in "Electrical connection: Remote device version")
	Weather protection
Max. measuring range	PTFE and PP Wave Horn antennas and DN150 / DN200 Metallic Horn antennas: 30 m / 98.4 ft
	DN80 / DN100 Metallic Horn antennas (installation only in stilling wells): 10 m / 32.8 ft
	Wave Guide antenna: 6 m / 32.8 ft
	Also depends on the dielectric constant of the product and the installation type. Refer also to "Antenna selection".
Min. tank height	1 m / 3.3 ft
Dead zone	Antenna extension length + antenna length + 0.5 m / 19.7"
Beam angle of antenna	PP Wave Horn: 10°
	PTFE Wave Horn: 10°
	Metallic Horn DN80 / 3": n/a - used only in stilling wells
	Metallic Horn DN100 / 4": n/a - used only in stilling wells
	Metallic Horn DN150 / 6": 8°
	Metallic Horn DN200 / 8": 6°
	Wave-Guide / stilling well: n/a - the radar signal is inside the tube.

Display and user interface	
Display	LCD display
	128 × 64 pixels in 8-step greyscale with 4-button keypad
Interface languages	3 language pack options (the language is given the customer order): 1 English, French German and Italian 2 English, French,Spanish and Portuguese 3 English, Chinese (Mandarin), Japanese and Russian

Measuring accuracy

Resolution	1 mm / 0.04"
Repeatability	±1 mm / ±0.04"
Accuracy	Standard: ±10 mm / ±0.4", when distance < 10 m / 33 ft; ±0.1% of measured distance, when distance > 10 m / 33 ft Option: ±5 mm / ±0.2", when distance < 10 m / 33 ft; ±0.05% of measured distance, when distance > 10 m / 33 ft
Function of temperature	
Reference conditions acc. to EN 61298-1	
Temperature	+18...+30°C / 64.4...86°F
Pressure	1013 mbara ±50 mbar / 14.69 psia ±0.73 psi
Relative air humidity	60% ±15%
Target	Metal plate or trihedron in an anechoic chamber

Operating conditions

Temperature	
Ambient temperature	-40…+80°C / -40…+176°F Ex: see supplementary operating instructions or approval certificates
Storage temperature	-40…+80°C / -40…+176°F
Process connection temperature	PP Wave Horn antenna: -20...+100°C / -4...+212°F
	PTFE Wave Horn antenna: -50...+150°C / -58...+302°F
	Metallic Horn antenna / Wave Guide antenna: Standard: -50…+130°C / -58…+266°F (-60°C / -76°F and +250°C / +482°F is possible with the appropriate options. The process connection temperature must agree with the temperature limits of the gasket material. Refer to "Materials" in this table.) Ex: see supplementary operating instructions or approval certificates
Pressure	
Process pressure	PP Wave Horn antenna: -1…16 barg / -14.5…232 psig at 100°C / 212°F
	PTFE Wave Horn antenna: -1…34 barg / -14.5…493 psig at 150°C / 302°F
	Metallic Horn antenna / Wave Guide antenna: Standard: -1…40 barg / -14.5…580 psig: subject to the process connection used and the flange temperature
Other conditions	
Dielectric constant (ε_r)	Direct mode: ≥1.8 TBF mode: ≥1.1 Refer also to "Technical data: Antenna selection".
Ingress protection	IP 66/67 equivalent to NEMA type 4X (housing) and type 6P (antenna)

Installation conditions

Process connection size	The nominal diameter (DN) should be equal to or larger than the antenna diameter.
Process connection position	Make sure that there are not any obstructions directly below the process connection for the device. For more data, refer to Installation on page 16.
Dimensions and weights	Refer to "Technical data: Dimensions and weights".

Materials

Housing	Standard: Aluminium with a polyester topcoat
	Option: Stainless steel (1.4404 / 316L)
Wetted parts, including antenna	Plastic Wave Horn antenna: PTFE or PP only
	Mettalic Wave Horn and Wave Guide antennas: Stainless steel (1.4404 / 316L) - refer also to "Gaskets"
Process connection	PP Wave Horn antenna: PP
	PTFE Wave Horn antenna: Stainless steel (1.4404 / 316L) with a PTFE plate / lining
	Metallic Horn and Wave Guide antennas: Stainless steel (1.4404 / 316L)
Gaskets	PP and PTFE Wave Horn antennas: n/a (gaskets are not supplied)
	Metallic Horn and Wave Guide antennas: FKM/FPM (-40…+200°C / -40…+392°F); Kalrez® 6375 (-20…+250°C / -4…+482°F); PFA (-60°C…+150°C / -58…+302°F); EPDM (-50...+130°C / -58...+266°F) 1
Feedthrough	PP and PTFE Wave Horn antennas: n/a
	Metallic Horn and Wave Guide antennas: Metaglas® 2
Cable gland	Plastic (Non-Ex: black, Ex i-approved: blue); nickel-plated brass (Ex d devices only); stainless steel (Ex d devices only)
Weather protection (Option)	Stainless steel (1.4404 / 316L) - for the compact version only

Process connections

Thread	PP Wave Horn antenna: G 1½; 1½ NPT
Flange version	
EN	PTFE Wave Horn antenna: DN50…150 in PN16, PN40
	Metallic Horn and Wave Guide antennas: DN50…150 in PN16, PN40; DN200 in PN16; others on request
ASME	PTFE Wave Horn antenna: 2"…6" in 150 lb / 300 lb
	Metallic Horn and Wave Guide antennas: 3"…6" in 150 lb / 300 lb; 8" in 300 lb; others on request
JIS	PTFE Wave Horn antenna: 50A in 10K
	Metallic Horn and Wave Guide antennas: 80…200A in 10K; others on request
Other	Others on request

Electrical connections

Power supply	Terminals output - Non-Ex / Ex i: 12…30 VDC; min./max. value for an output of 22 mA at the terminal
	Terminals output - Ex d: 16…36 VDC; min./max. value for an output of 22 mA at the terminal
Current output load	Non-Ex / Ex i: R_L [Ω] ≤ ((U_{ext} -13 V)/22 mA). For more data, refer to Minimum power supply voltage on page 86.
	Ex d: R_L [Ω] ≤ ((U_{ext} -16 V)/22 mA). For more data, refer to Minimum power supply voltage on page 86.
Cable entry	Standard: M20×1.5; Option: ½ NPT

Cable gland	Standard: none
	Options: M20×1.5 (cable diameter: 6...10 mm / 0.23...0.39"); others are available on request
Cable entry capacity (terminal)	0.5…1.5 mm²

Input and output

Output signal	4…20 mA HART® or 3.8…20.5 mA acc. to NAMUR NE 43 3
Resolution	±3 µA
Temperature drift	Typically 50 ppm/K
Error signal	High: 22 mA; Low: 3.6 mA acc. to NAMUR NE 43

Approvals and certification

CE	This device fulfils the statutory requirements of the EC directives. The manufacturer certifies successful testing of the product by applying the CE mark.
Vibration resistance	EN 60068-2-64 Metallic Horn: (DN200): 5 Hz to 100 Hz: 4g PTFE or PP Wave Horn: 3.5 mm up to 8 Hz and 10 m/s²: 1g, 8.5 to 2000 Hz
Explosion protection	
ATEX (pending) KEMA 10ATEX0036 X	II 1/2 G, 2 G Ex ia IIC T6...T2 Ga/Gb or Ex ia IIC T6...T2) Gb;
	II 1/2 D, 2 D Ex ia IIIC T90°C Da/Db or Ex ia IIIC T90°C Db IP6X;
	II 1/2 G, 2 G Ex d ia IIC T6...T3 (or T2) Ga/Gb or Ex d ia IIC T6...T3 (or T2) Gb;
	II 1/2 D, 2 D Ex ia tb IIIC T90°C Da/Db or Ex ia tb IIC T90°C Db IP6X
IECEx (pending) IECEx KEM 10.0006 X	Ex ia IIC T6…T3 (or T2) Ga/Gb or Ex ia IIC T6…T3 (or T2) Gb;
	Ex ia IIIC T90°C Da/Db or Ex ia IIIC T90°C Db IP6X;
	Ex d ia IIC T6...T3 (or T2) or Ex d ia IIC T6...T3 (or T2) Gb;
	Ex ia tb IIIC T90°C Da/Db or Ex ia tb IIIC T90°C IP6X
cFMus - Dual Seal-approved (pending)	NEC 500
	XP-IS / Cl. I / Div. 1 / Gr. ABCD / T6;
	DIP / Cl. II/III / Div. 1 / Gr. EFG / T6;
	IS / Cl. I/II/III / Div. 1 / Gr. ABCDEFG / T6;
	NI / Cl. I / Div. 2 / Gr. ABCD / T6
	NEC 505
	Cl. I / Zone 0 / AEx d [ia] / IIC / T6;
	Cl. I / Zone 0 / AEx ia / IIC / T6;
	Cl. I / Zone 2 / AEx nA [ia] / IIC / T6;
	Hazardous (Classified) Locations, indoor/outdoor Type 4X and 6P, IP66, Dual Seal
	CEC Section 18 (Zone ratings)
	Cl. I, Zone 1, Ex d, IIC (Antenna: Zone 0), T6;
	Cl. I, Zone 0, Ex ia, IIC, T6;
	Cl. I, Zone 2, Ex nA, IIC, T6 DIP A21 IP66 TB 95°C
	CEC Section 18 and Annex J (Division ratings)
	Cl. I, Div. 1/2, Gr. ABCD; Cl. II, Gr. EFG; Cl. III, T6;
NEPSI (pending)	Ex ia IIC T2~T6 DIP A21 T_A IP66;
	Ex dia IIC T2~T6 DIP A21 T_A IP66

Other standards and approvals	
SIL	SIL 2 (the requirements for functional safety agree with IEC 61508 (2010))
EMC	Electromagnetic Compatibility Directive 2004/108/EC in conjunction with EN 61326-1 (2006) SIL 2-approved devices agree with EN 61326-3-1 (2006) and EN 61326-3-2 (2006)
R & TTE	Radio Equipment and Telecommunications Terminal Equipment Directive 1999/5/EC in conjunction with ESTI EN 302 372 (2006)
FCC Rules	Part 15
Industry Canada	RSS-210
LVD	Low-Voltage Directive 2006/95/EC in conjunction with EN 61010-1 (2001)
NAMUR	NAMUR NE 21 Electromagnetic Compatibility (EMC) of Industrial Process and Laboratory Control Equipment
	NAMUR NE 43 Standardization of the Signal Level for the Failure Information of Digital Transmitters
	NAMUR NE 107 Self-Monitoring and Diagnosis of Field Devices
CRN (pending)	This certification is for all Canadian provinces and territories. For more data, refer to the website.
Construction code	On request: NACE MR0175 / ISO 15156; NACE MR0103

1 Kalrez® is a registered trademark of DuPont Performance Elastomers L.L.C.

2 Metaglas® is a registered trademark of Herberts Industrieglas, GMBH & Co., KG

3 HART® is a registered trademark of the HART Communication Foundatio