



Level



Pressure



Flow



Temperature

Liquid  
Analysis

Registration

Systems  
Components

Services



Solutions

## Technical Information

# Micropilot FMR53, FMR54

Level radar

Level measurement in liquids



### Application

Continuous, non-contact level measurement of liquids, pastes and slurries

#### Features FMR53:

- Especially suited for small process connections; PTFE sensors usable in chemically aggressive media
- Rod antenna
- Maximum measuring range: 20 m (66 ft)
- Process connection: 1½" thread or flange
- Temp. range: -40 to +150 °C (-40 to +302 °F)
- Pressure range: -1 to +40 bar (-14.5 to +580 psi)
- Accuracy: ± 6 mm

#### Features FMR54:

- Ideally suited for measurements in bypasses and stilling wells
- Horn or planar antenna
- Maximum measuring range: 20 m (66 ft)
- Process connection: flange
- Temp. range: -196 to +400 °C (-321 to +752 °F)
- Pressure range: -1 to +160 bar (-14.5 to +2320 psi)
- Accuracy: ± 6 mm

### Your benefits

- Reliable measurement even for changing product and process conditions
- Integrated data memory (HistoROM) for high availability
- Intuitive operating menu in national languages for easy commissioning
- Simple integration into control or asset management systems
- Exact diagnostic and process information to assist fast decisions
- International approvals for use in hazardous areas
- 5-point linearity protocol
- WHG and marine approvals
- SIL2 according to IEC 61508, SIL3 in case of homogeneous or heterogeneous redundancy
- System integration via HART/PROFIBUS PA (Profile 3.02)/FOUNDATION Fieldbus

## Table of contents





<b>Important document information</b> . . . . .	<b>4</b>	Degree of protection . . . . .	58
Document conventions . . . . .	4	Vibration resistance . . . . .	58
<b>Function and system design</b> . . . . .	<b>6</b>	Cleaning the antenna . . . . .	58
Measuring principle . . . . .	6	Electromagnetic compatibility (EMC) . . . . .	59
<b>Input</b> . . . . .	<b>8</b>	<b>Process</b> . . . . .	<b>60</b>
Measured variable . . . . .	8	Process temperature range . . . . .	60
Measuring range . . . . .	8	Process pressure range . . . . .	60
Operating frequency . . . . .	11	Dielectric constant . . . . .	61
Transmitting power . . . . .	11	<b>Mechanical construction</b> . . . . .	<b>62</b>
<b>Output</b> . . . . .	<b>12</b>	Dimensions . . . . .	62
Output signal . . . . .	12	Weight . . . . .	66
Signal on alarm . . . . .	13	Materials . . . . .	67
Linearization . . . . .	13	<b>Operability</b> . . . . .	<b>72</b>
Galvanic isolation . . . . .	13	Operating concept . . . . .	72
Protocol-specific data . . . . .	13	Local operation . . . . .	72
<b>Power supply</b> . . . . .	<b>17</b>	Operation with remote display and operating module FHX50 . . . . .	73
Terminal assignment . . . . .	17	Remote operation . . . . .	73
Device plug connectors . . . . .	24	Integration in tank gauging system . . . . .	77
Supply voltage . . . . .	25	System integration via Fieldgate . . . . .	78
Power consumption . . . . .	27	<b>Certificates and approvals</b> . . . . .	<b>79</b>
Current consumption . . . . .	27	CE mark . . . . .	79
Power supply failure . . . . .	28	C-Tick symbol . . . . .	79
Potential equalization . . . . .	28	Ex approval . . . . .	79
Terminals . . . . .	28	Dual seal according to ANSI/ISA 12.27.01 . . . . .	79
Cable entries . . . . .	28	Functional Safety . . . . .	79
Cable specification . . . . .	28	Sanitary compatibility . . . . .	79
Overvoltage protection . . . . .	29	AD2000 . . . . .	79
<b>Performance characteristics</b> . . . . .	<b>30</b>	Pressure Equipment Directive . . . . .	79
Reference operating conditions . . . . .	30	Marine certificate (in preparation) . . . . .	79
Maximum measured error . . . . .	30	Radio standard EN302372-1/2 . . . . .	79
Measured value resolution . . . . .	30	FCC / Industry Canada . . . . .	79
Reaction time . . . . .	30	CRN approval . . . . .	80
Influence of ambient temperature . . . . .	30	Track record . . . . .	80
Influence of gas layer . . . . .	30	Other standards and guidelines . . . . .	80
Gas phase compensation with external pressure sensor (PROFIBUS PA, in preparation) . . . . .	31	<b>Ordering information</b> . . . . .	<b>81</b>
<b>Installation</b> . . . . .	<b>32</b>	Ordering information . . . . .	81
Installation conditions . . . . .	32	5-point linearity protocol (in preparation) . . . . .	81
Measuring conditions . . . . .	36	Customized parametrization . . . . .	82
Installation in vessel (free space) . . . . .	37	<b>Accessories</b> . . . . .	<b>83</b>
Installation in stilling well . . . . .	42	Device-specific accessories . . . . .	83
Installation in bypass . . . . .	45	Communication-specific accessories . . . . .	85
Vessels with heat insulation . . . . .	48	Service-specific accessories . . . . .	86
<b>Environment</b> . . . . .	<b>49</b>	System components . . . . .	86
Ambient temperature range . . . . .	49	<b>Documentation</b> . . . . .	<b>87</b>
Ambient temperature limits . . . . .	49	Standard documentation . . . . .	87
Storage temperature . . . . .	58	Supplementary documentation . . . . .	87
Climate class . . . . .	58	Safety Instructions (XA) . . . . .	87
Geometric height according to IEC61010-1 Ed.3 . . . . .	58	<b>Registered trademarks</b> . . . . .	<b>88</b>

**Patents** ..... 89







## Important document information

### Document conventions






### Safety symbols



Symbol	Meaning
 A0011189-EN	<b>DANGER!</b> This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.
 A0011190-EN	<b>WARNING!</b> This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.
 A0011191-EN	<b>CAUTION!</b> This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.
 A0011192-EN	<b>NOTICE!</b> This symbol contains information on procedures and other facts which do not result in personal injury.

### Electrical symbols



Symbol	Meaning
 A0011197	<b>Direct current</b> A terminal to which DC voltage is applied or through which direct current flows.
 A0011198	<b>Alternating current</b> A terminal to which alternating voltage is applied or through which alternating current flows.
 A0017381	<b>Direct current and alternating current</b> <ul style="list-style-type: none"> <li>■ A terminal to which alternating voltage or DC voltage is applied.</li> <li>■ A terminal through which alternating current or direct current flows.</li> </ul>
 A0011200	<b>Ground connection</b> A grounded terminal which, as far as the operator is concerned, is grounded via a grounding system.
 A0011199	<b>Protective ground connection</b> A terminal which must be connected to ground prior to establishing any other connections.
 A0011201	<b>Equipotential connection</b> A connection that has to be connected to the plant grounding system: This may be a potential equalization line or a star grounding system depending on national or company codes of practice.

### Symbols for certain types of information



Symbol	Meaning
 A0011182	<b>Allowed</b> Indicates procedures, processes or actions that are allowed.
 A0011183	<b>Preferred</b> Indicates procedures, processes or actions that are preferred.
 A0011184	<b>Forbidden</b> Indicates procedures, processes or actions that are forbidden.
 A0011193	<b>Tip</b> Indicates additional information.
 A0011194	<b>Reference to documentation</b> Refers to the corresponding device documentation.

Symbol	Meaning
 A0011195	<b>Reference to page</b> Refers to the corresponding page number.
 A0011196	<b>Reference to graphic</b> Refers to the corresponding graphic number and page number.

### Symbols in graphics

Symbol	Meaning
1, 2, 3 ...	Item numbers
1, 2, 3 ...	Series of steps
A, B, C, ...	Views
A-A, B-B, C-C, ...	Sections
 A0011187	<b>Hazardous area</b> Indicates a hazardous area.
 A0011188	<b>Safe area (non-hazardous area)</b> Indicates a non-hazardous location.

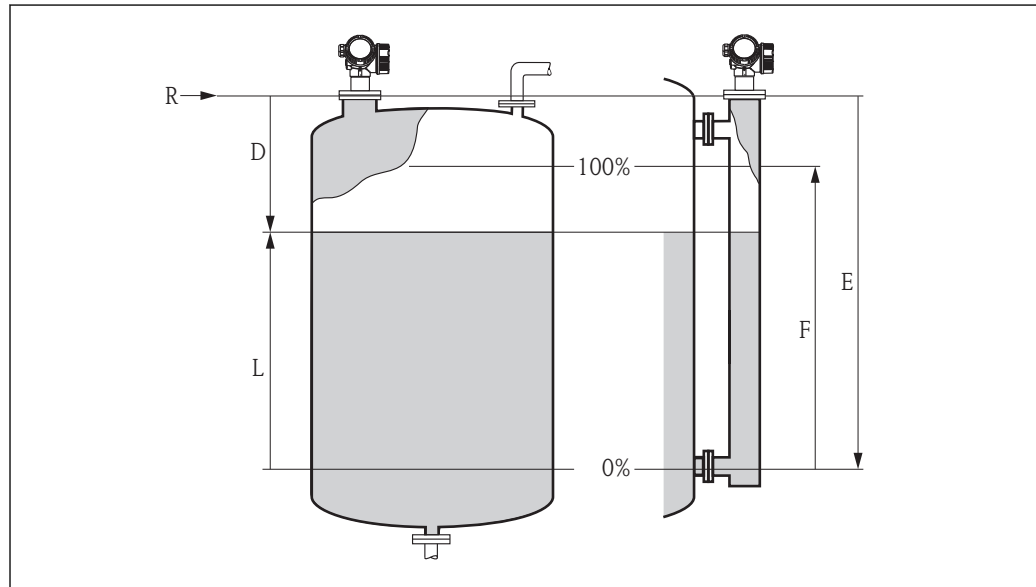
### Symbols at the device

Symbol	Meaning
	<b>Safety instructions</b> Observe the safety instructions contained in the associated Operating Instructions.
	<b>Temperature resistance of the connection cables</b> Specifies the minimum value of the temperature resistance of the connection cables.

## Function and system design

### Measuring principle

The Micropilot is a "downward-looking" measuring system, operating based on the time-of-flight method (ToF). It measures the distance from the reference point (process connection) to the product surface. Radar impulses are emitted by an antenna, reflected off the product surface and received again by the radar system.



A0017871

 1 Setup parameters of the Micropilot

- R* Reference point of the measurement (lower edge of the flange or threaded connection)
- E* Empty calibration (= zero)
- F* Full calibration (= span)
- D* Measured distance
- L* Level ( $L = E - D$ )

### Input

The reflected radar impulses are received by the antenna and transmitted into the electronics. A microprocessor evaluates the signal and identifies the level echo caused by the reflection of the radar impulse at the product surface. The unambiguous signal identification is accomplished by the PulseMaster® eXact software together with the Multi-echo tracking algorithms, based on many years of experience with time-of-flight technology.

The distance  $D$  to the product surface is proportional to the time of flight  $t$  of the impulse:



$$D = c \cdot t / 2,$$

with  $c$  being the speed of light.

Based on the known empty distance  $E$ , the level  $L$  is calculated:

$$L = E - D$$

The reference point  $R$  of the measurement is located at the process connection. For details see the dimensional drawing:

- FMR53: (→  63)
- FMR54: (→  64)

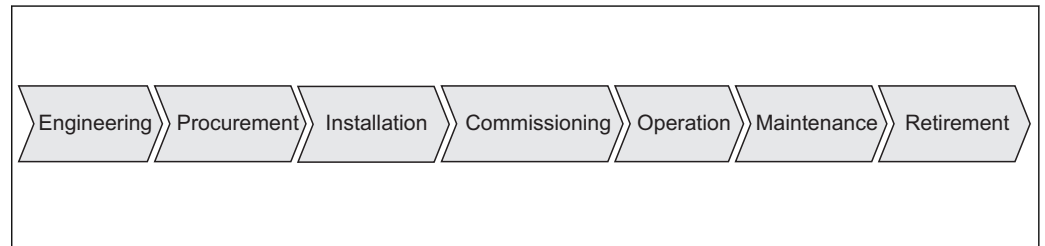
The Micropilot is equipped with functions to suppress interference echoes. The user can activate these functions. Together with the multi-echo tracking algorithms they ensure that interference echoes (i.e. from edges and weld seams) are not interpreted as level echo.

## Output

The Micropilot is commissioned by entering an empty distance "E" (=zero), a full distance "F" (=span) and application parameters. The application parameters are automatically adapt into the instrument to the process conditions. For models with a current output, the factory adjustment for zero point "E" and span "F" is 4 mA and 20 mA. For digital outputs and the display module, the factory adjustment for zero point "E" and span "F" is 0 % and 100 %.

A linearization with max. 32 points, based on a table entered either manually or semi-automatically, can be activated locally or remotely. This function provides a measurement in engineering units and a linear output signal for spheres, horizontal cylindrical tanks and vessels with conical outlet.

## Life cycle of the product



A0013773-EN

2 Life cycle

### Engineering

- Universal measuring principle
- Measurement unaffected by medium properties
- Hardware and software developed according to SIL IEC 61508

### Procurement

- Endress+Hauser being the world market leader in level measurement guarantees asset protection
- Worldwide support and service

### Installation

- Special tools are not required
- Reverse polarity protection
- Modern, detachable terminals
- Main electronics protected by a separate connection compartment

### Commissioning

- Fast, menu-guided commissioning in only a few steps on site or from the control room
- Plain text display in national languages reduces the risk of error or confusion
- Direct local access of all parameters
- Short instruction manual at the device

### Operation

- Multi-echo tracking: Reliable measurement through self-learning echo-search algorithms taking into account the short-term and long-term history in order to check the found echoes for plausibility and to suppress interference echoes.
- Diagnostics in accordance with NAMUR NE107

### Maintenance

- HistoROM: Data backup for instrument settings and measured values
- Exact instrument and process diagnosis to assist fast decisions with clear details concerning remedies
- Intuitive, menu-guided operating concept in national languages saves costs for training, maintenance and operation
- Cover of the electronics compartment can be opened in hazardous areas

### Retirement

- Order code translation for subsequent models
- RoHS-conforming (Restriction of certain Hazardous Substances), unleaded soldering of electronic components
- Environmentally sound recycling concept

## Input

### Measured variable

The measured variable is the distance between the reference point and the product surface.

Subject to the empty distance entered "E" the level is calculated.

Alternatively, the level can be converted into other variables (volume, mass) by means of linearization (32 points).

### Measuring range

#### Maximum measuring range

Device	Maximum measuring range
FMR53	20 m (66 ft)
FMR54	20 m (66 ft)

#### Usable measuring range

The usable measuring range depends on the size of the antenna, the reflectivity of the medium, the mounting location and eventual interference reflections.

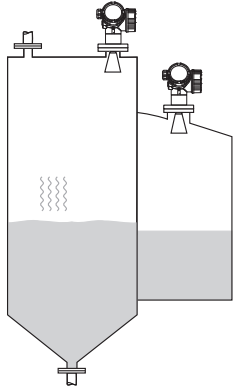
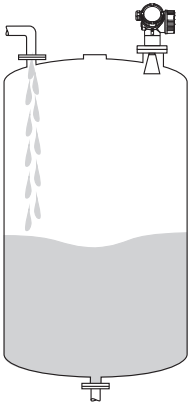
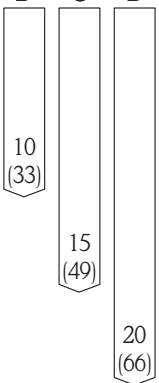
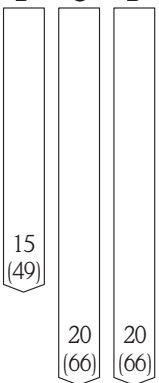
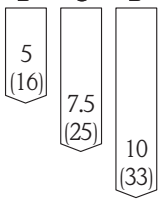
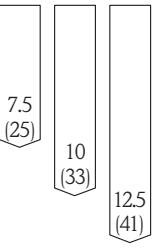
The following tables describe the groups of media as well as the achievable measuring range as a function of application and media group. If the dielectric constant of a medium is unknown, it is recommended to assume media group B to ensure a reliable measurement.

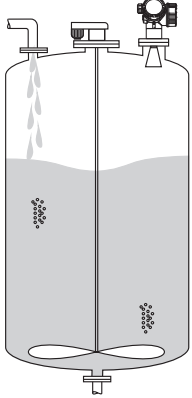
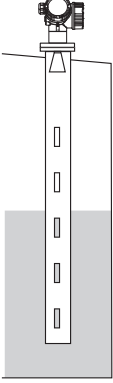








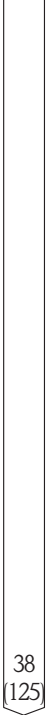

#### Media groups

Media groups	DK ( $\epsilon_r$ )	Example
<b>A</b>	1.4 to 1.9	non-conducting liquids, e.g. liquefied gas <sup>1)</sup>
<b>B</b>	1.9 to 4	non-conducting liquids, e.g. benzene, oil, toluene, ...
<b>C</b>	4 to 10	e.g. concentrated acids, organic solvents, esters, aniline, alcohol, acetone, ...
<b>D</b>	> 10	conducting liquids, e.g. aqueous solutions, dilute acids and alkalis

1) Treat Ammonia NH<sub>3</sub> as a medium of group A.



Device	Storage tank		Buffer tank	
	 <p style="text-align: right; font-size: small;">A0018833</p>		 <p style="text-align: right; font-size: small;">A0018835</p>	
	Calm product surface (e.g. intermittent filling, filling from bottom, immersion tubes)		Moving surfaces (e.g. continuous filling, from above, mixing jets)	
	Antenna type and size		Antenna type and size	
FMR53	Rod 390 mm (15 in) Rod 540 mm (21 in)	-	Rod 390 mm (15 in) Rod 540 mm (21 in)	-
FMR54	Horn 150 mm (6 in)	Horn 200 mm (8 in) Horn 250 mm (10 in)	Horn 150 mm (6 in)	Horn 200 mm (8 in) Horn 250 mm (10 in)
	<p style="text-align: center;"><b>B C D</b></p>  <p style="text-align: right; font-size: x-small;">A0018844</p>	<p style="text-align: center;"><b>B C D</b></p>  <p style="text-align: right; font-size: x-small;">A0018845</p>	<p style="text-align: center;"><b>B C D</b></p>  <p style="text-align: right; font-size: x-small;">A0018846</p>	<p style="text-align: center;"><b>B C D</b></p>  <p style="text-align: right; font-size: x-small;">A0018847</p>
	Measuring range [m (ft)]			

Device	Process tank with agitator		Stilling well		Bypass
	 <p data-bbox="587 696 639 712">A0018837</p> <p data-bbox="236 741 624 790">Turbulent surface. Single stage agitator (<math>f_{rot} &lt; 1</math> Hz)</p>		 <p data-bbox="1118 680 1171 696">A0018839</p>		 <p data-bbox="1385 647 1437 663">A0018840</p>
	A Antenna type and size		Antenna type and size		
FMR53	Rod 390 mm (15 in) Rod 540 mm (21 in)	-	-	-	-
FMR54	Horn 150 mm (6 in)	Horn 200 mm (8 in) Horn 250 mm (10 in)	Horn 80 to 250 mm (3 to 10 in)	Planar 150 to 300 mm (6 to 12 in)	Horn 80 to 250 mm (3 to 10 in)
	<p data-bbox="236 1021 272 1037"><b>B</b></p>  <p data-bbox="288 1021 325 1037"><b>C</b></p>  <p data-bbox="341 1021 378 1037"><b>D</b></p>  <p data-bbox="357 1205 410 1220">A0018848</p>	<p data-bbox="437 1021 474 1037"><b>B</b></p>  <p data-bbox="489 1021 526 1037"><b>C</b></p>  <p data-bbox="542 1021 579 1037"><b>D</b></p>  <p data-bbox="563 1238 616 1254">A0018850</p>	<p data-bbox="722 1021 834 1037"><b>A, B, C, D</b></p>  <p data-bbox="762 1361 799 1424">20 (66)</p> <p data-bbox="855 1435 908 1451">A0018851</p>	<p data-bbox="989 1021 1101 1037"><b>A, B, C, D</b></p>  <p data-bbox="1029 1697 1066 1760">38 (125)</p> <p data-bbox="1118 1771 1171 1787">A0018854</p>	<p data-bbox="1283 1021 1335 1037"><b>C, D</b></p>  <p data-bbox="1291 1361 1327 1424">20 (66)</p> <p data-bbox="1385 1435 1437 1451">A0018852</p>
Measuring range [m (ft)]					

**Operating frequency**

C-band (~ 6 GHz)

Up to 8 Micropilot transmitters can be installed in the same tank because the transmitter pulses are statistically coded.

**Transmitting power**

Distance	Average energy density in beam direction
1 m (3.3 ft)	< 12 nW/cm <sup>2</sup>
5 m (16 ft)	< 0.4 nW/cm <sup>2</sup>

## Output

### Output signal

#### HART

Signal coding	FSK $\pm 0.5$ mA over current signal
Data transmission rate	1 200 Bit/s
Galvanic isolation	Yes


#### PROFIBUS PA (in preparation)

Signal coding	Manchester Bus Powered (MBP)
Data transmission rate	31.25 kBit/s, voltage mode
Galvanic isolation	Yes

#### FOUNDATION Fieldbus (in preparation)

Signal coding	Manchester Bus Powered (MBP)
Data transmission rate	31.25 kBit/s, voltage mode
Galvanic isolation	Yes

### Switch output

 For HART devices, the switch output is available as an option. See product structure, feature 20: "Power Supply, Output", option B: "2-wire; 4-20mA HART, switch output"

Devices with PROFIBUS PA and FOUNDATION Fieldbus always have a switch output.

Switch output	
Function	Open collector switching output
Switching behavior	Binary (conductive or non-conductive), switches when the programmable switch point is reached
Failure mode	non-conductive
Electrical connection values	$U = 10.4$ to $35 V_{DC}$ , $I = 0$ to $40$ mA
Internal resistance	$R_I < 880 \Omega$ The voltage drop at this internal resistance has to be taken into account on planning the configuration. For example, the resulting voltage at a connected relay must be sufficient to switch the relay.
Insulation voltage	floating, Insulation voltage $1\ 350 V_{DC}$ to power supply and $500 V_{AC}$ to ground
Switch point	freely programmable, separately for switch-on and switch-off point
Switching delay	freely programmable from 0 to 100 sec. , separately for switch-on and switch-off point
Number of switching cycles	corresponds to the measuring cycle
Signal source device variables	<ul style="list-style-type: none"> <li>■ Level linearized</li> <li>■ Distance</li> <li>■ Terminal voltage</li> <li>■ Electronic temperature</li> <li>■ Relative echo amplitude</li> <li>■ Diagnostic values, Advanced diagnostics</li> </ul>
Number of switching cycles	unlimited

**Signal on alarm** Depending on the interface, failure information is displayed as follows:

- Current output (for HART devices)
  - Failsafe mode selectable (in accordance with NAMUR Recommendation NE 43):
    - Minimum alarm: 3.6 mA
    - Maximum alarm (= factory setting): 22 mA
  - Failsafe mode with user-selectable value: 3.59 to 22.5 mA
- Local display
  - Status signal (in accordance with NAMUR Recommendation NE 107)
  - Plain text display
- Operating tool via digital communication (HART, PROFIBUS PA, FOUNDATION Fieldbus) or service interface (CDI)
  - Status signal (in accordance with NAMUR Recommendation NE 107)
  - Plain text display

**Linearization** The linearization function of the device allows the conversion of the measured value into any unit of length or volume. Linearization tables for calculating the volume in cylindrical tanks are pre-programmed. Other tables of up to 32 value pairs can be entered manually or semi-automatically.

**Galvanic isolation** All circuits for the outputs are galvanically isolated from each other.

**Protocol-specific data**

**HART**

Manufacturer ID	17 (0x11)
Device type ID	41 (0x28)
HART specification	6.0
Device description files (DTM, DD)	Information and files under: <ul style="list-style-type: none"> <li>■ <a href="http://www.endress.com">www.endress.com</a></li> <li>■ <a href="http://www.hartcomm.org">www.hartcomm.org</a></li> </ul>
HART load	Min. 250 Ω
HART device variables	The measured values can be freely assigned to the device variables. <b>Measured values for PV (primary variable)</b> <ul style="list-style-type: none"> <li>■ Level linearized</li> <li>■ Distance</li> <li>■ Electronic temperature</li> <li>■ Relative echo amplitude</li> <li>■ Analog output adv. diagnostics</li> </ul> <b>Measured values for SV, TV, FV (second, third and fourth variable)</b> <ul style="list-style-type: none"> <li>■ Level linearized</li> <li>■ Distance</li> <li>■ Terminal voltage</li> <li>■ Electronic temperature</li> <li>■ Absolute echo amplitude</li> <li>■ Relative echo amplitude</li> <li>■ Area of incoupling</li> </ul>
Supported functions	<ul style="list-style-type: none"> <li>■ Burst mode</li> <li>■ Additional transmitter status</li> </ul>

**PROFIBUS PA (in preparation)**

Manufacturer ID	17 (0x11)
Ident number	0x1559
Profile version	3.02
GSD file	Information and files under: <ul style="list-style-type: none"> <li>■ <a href="http://www.endress.com">www.endress.com</a></li> <li>■ <a href="http://www.profibus.org">www.profibus.org</a></li> </ul>
GSD file version	

Output values	<p><b>Analog Input:</b></p> <ul style="list-style-type: none"> <li>■ Level linearized</li> <li>■ Distance</li> <li>■ Terminal voltage</li> <li>■ Electronic temperature</li> <li>■ Absolute echo amplitude</li> <li>■ Relative echo amplitude</li> </ul> <p><b>Digital Input:</b></p> <ul style="list-style-type: none"> <li>■ Extended diagnostic blocks</li> <li>■ Status output PFS Block</li> </ul>
Input values	<p><b>Analog Output:</b></p> <ul style="list-style-type: none"> <li>■ Analog value from PLC (for sensor block external pressure and temperature)</li> <li>■ Analog value from PLC to be indicated on the display</li> </ul> <p><b>Digital Output:</b></p> <ul style="list-style-type: none"> <li>■ Extended diagnostic block</li> <li>■ Level limiter</li> <li>■ Sensor block measurement on</li> <li>■ Sensor block save history on</li> <li>■ Status output</li> </ul>
Supported functions	<ul style="list-style-type: none"> <li>■ Identification &amp; Maintenance Einfachste Geräteidentifizierung seitens des Leitsystems und des Typenschildes</li> <li>■ Automatic Ident Number Adoption GSD compatibility mode with respect to the preceding product Micropilot M FMR2xx</li> <li>■ Physical Layer Diagnostics Installation check of the PRFIBUS segment and the Micropilot FMR5x via the terminal voltage and telegram surveillance.</li> <li>■ PROFIBUS Up-/Download Up to 10 times faster writing and reading of parameters via PROFIBUS up-/download</li> <li>■ Condensed Status Simple and self-explanatory diagnostic information by categorization of occurring diagnostic messages.</li> </ul>

#### FOUNDATION Fieldbus (in preparation)

Manufacturer ID	0x452B48
Device type	0x1028
Device Revision	0x01
DD Revision	Information and files can be found:
CFF Revision	<ul style="list-style-type: none"> <li>■ <a href="http://www.endress.com">www.endress.com</a></li> <li>■ <a href="http://www.fieldbus.org">www.fieldbus.org</a></li> </ul>
Device Tester Version (ITK Version)	6.0.1
ITK Test Campaign Number	IT085300
Link Master (LAS) capable	yes
Link Master / Basic Device selectable	yes; default: Basic Device
Node address	Default: 247 (0xF7)
Features supported	<p>Following methods are supported:</p> <ul style="list-style-type: none"> <li>■ Restart</li> <li>■ ENP Restart</li> <li>■ Setup</li> <li>■ Linearization</li> <li>■ Self Check</li> </ul>
<b>Virtual Communication Relationships (VCRs)</b>	
Number of VCRs	44
Number of Link Objects in VFD	50

Permanent entries	1
Client VCRs	0
Server VCRs	10
Source VCRs	43
Sink VCRs	0
Subscriber VCRs	43
Publisher VCRs	43
<b>Device Link Capabilities</b>	
Slot time	4
Min. inter PDU delay	8
Max. response delay	20

*Transducer Blocks*

Block	Content	Output values
Setup Transducer Block	Contains all parameters for a standard commissioning procedure	<ul style="list-style-type: none"> <li>■ Level or volume <sup>1)</sup> (Channel 1)</li> <li>■ Distance (Channel 2)</li> </ul>
Advanced Setup Transducer Block	Contains all parameters for a more detailed configuration of the device	no output values
Display Transducer Block	Contains all parameters for the configuration of the display module	no output values
Diagnostic Transducer Block	Contains diagnostic information	no output values
Expert Configuration Transducer Block	Contains parameters which require detailed knowledge of the functionalities of the device	no output values
Expert Information Transducer Block	Contains information about the state of the device	no output values
Service Sensor Transducer Block	Contains parameters which can only be operated by Endress+Hauser service personnel	no output values
Service Information Transducer Block	Contains information on the state of device which is relevant for service operations	no output values
Data Transfer Transducer Block	Contains parameters which allow to backup the device configuration in the display module and to restore it into the device.	no output values

1) depending on the configuration of the block

*Function Blocks*

Block	Content	Number of permanent blocks	Number of instantiable blocks	Execution time	Functionality
Resource Block	The Resource Block contains all the data that uniquely identifies the field device. It is an electronic version of a nameplate of the device.	1	0	-	enhanced
Multiple Analog Input Block	The AI block takes the manufacturer's input data, selected by channel number, and makes it available to other function blocks at its output.	2	3	25 ms	enhanced
Discrete Input Block	The DI block takes a discrete input value (e.g. indication of an level limit), and makes it available to other function blocks at its output.	1	2	20 ms	standard

Block	Content	Number of permanent blocks	Number of instantiable blocks	Execution time	Functionality
PID Block	The PID block serves as proportional-integral-derivative controller and is used almost universally to do closed-loop-control in the field including cascade and feedforward.	1	1	25 ms	standard
Arithmetic Block	This block is designed to permit simple use of popular measurement math functions. The user does not have to know how to write equations. The math algorithm is selected by name, chosen by the user for the function to be done.	1	1	25 ms	standard
Signal Characterizer Block	The signal characterizer block has two sections, each with an output that is a non-linear function of the respective input. The non-linear function is determined by a single look-up table with 21 arbitrary x-y pairs.	1	1	25 ms	standard
Input Selector Block	The input selector block provides selection of up to four inputs and generates an output based on the configured action. This block normally receives its inputs from AI blocks. The block performs maximum, minimum, middle, average and 'first good' signal selection.	1	1	25 ms	standard
Integrator Block	The Integrator Function Block integrates a variable as a function of the time or accumulates the counts from a Pulse Input block. The block may be used as a totalizer that counts up until reset or as a batch totalizer that has a setpoint, where the integrated or accumulated value is compared to pre-trip and trip settings, generating discrete signals when these settings are reached.	1	1	25 ms	standard
Analog Alarm Block		1	1	25 ms	standard

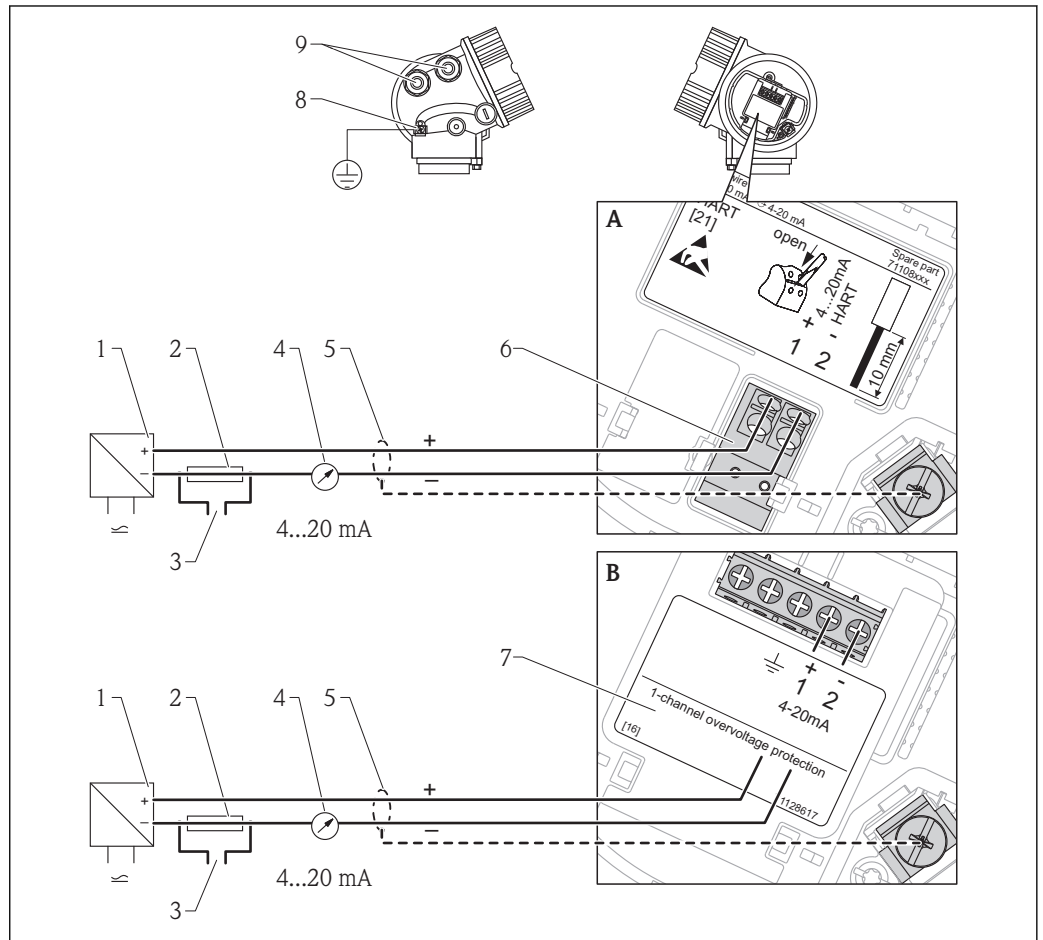
 Up to 20 blocks can be instantiated in the device altogether, including the blocks already instantiated on delivery.



## Power supply

Terminal assignment

2-wire: 4-20mA HART



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### 3 Terminal assignment 2-wire; 4-20mA HART

A Without integrated overvoltage protection

B With integrated overvoltage protection

1 Active barrier with power supply (e.g. RN221N): Observe terminal voltage (→ 25)

2 HART communication resistor ( $\geq 250 \Omega$ ): Observe maximum load (→ 25)

3 Connection for Commubox FXA195 or FieldXpert SFX100 (via VIATOR Bluetooth modem)

4 Analog display device: Observe maximum load (→ 25)

5 Cable screen; observe cable specification (→ 28)

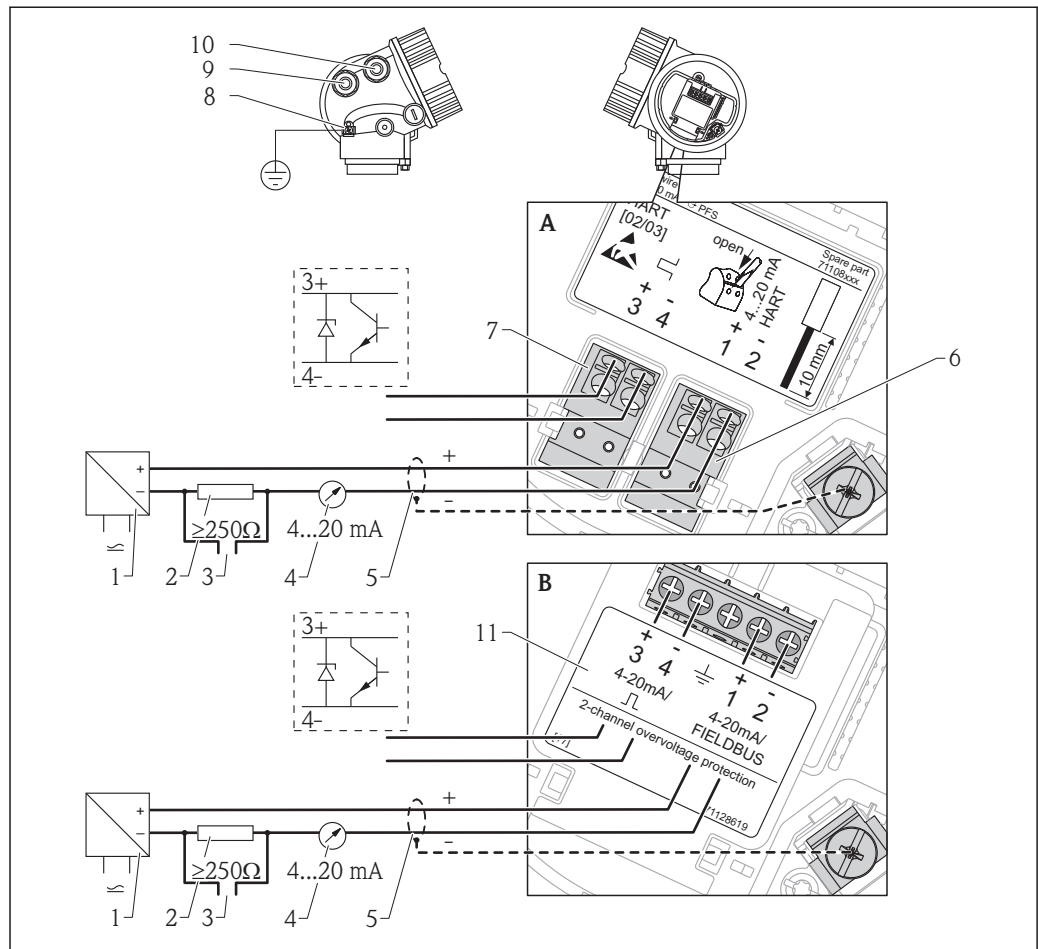
6 Terminals for 4-20mA HART (passive)

7 Overvoltage protection module

8 Terminal for potential equalization line

9 Cable entry

2-wire: 4-20mA HART, switch output

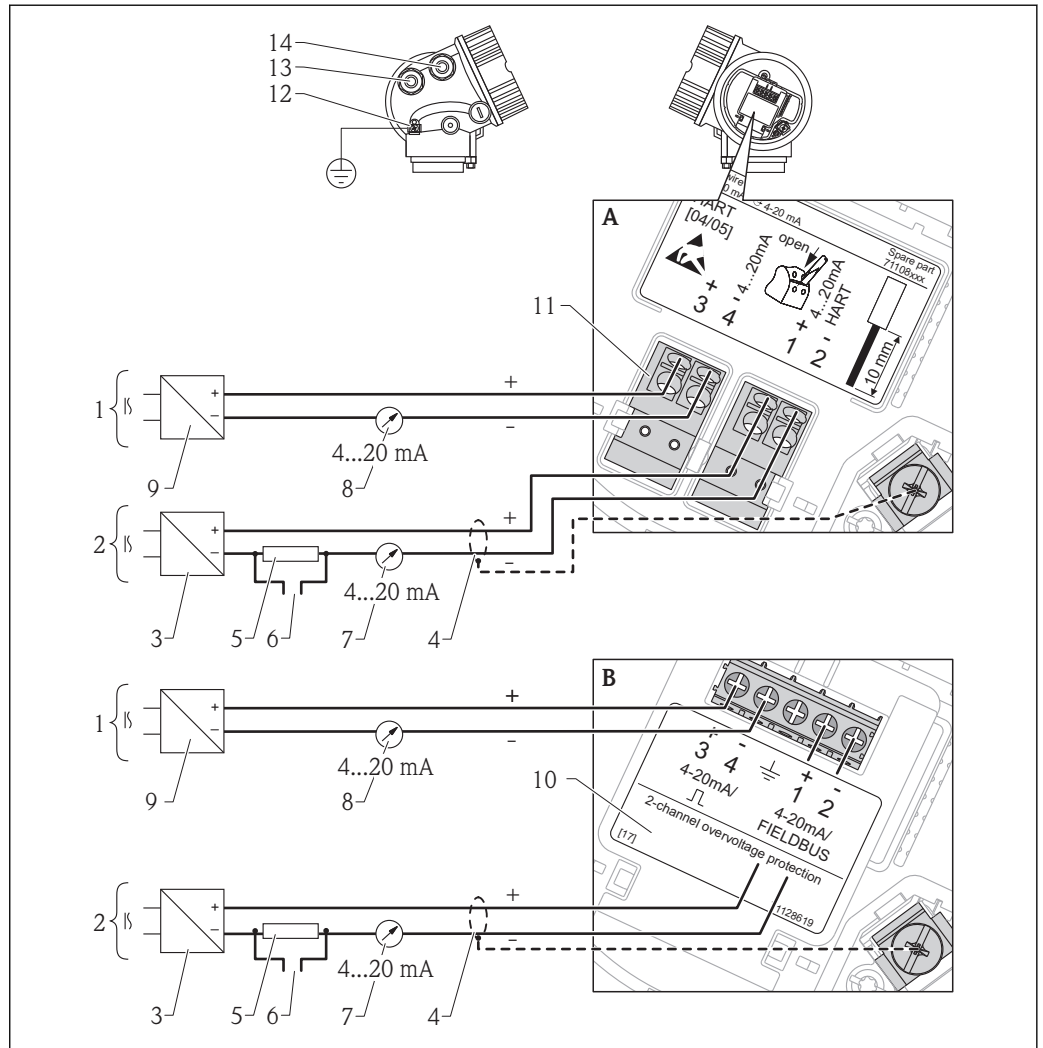


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4 Terminal assignment 2-wire; 4-20mA HART, switch output

- A Without integrated overvoltage protection
- B With integrated overvoltage protection
- 1 Active barrier with power supply (e.g. RN221N): Observe terminal voltage (→ 25)
- 2 HART communication resistor ( $\geq 250 \Omega$ ): Observe maximum load (→ 25)
- 3 Connection for Commubox FXA195 or FieldXpert SFX100 (via VIATOR Bluetooth modem)
- 4 Analog display device: Observe maximum load (→ 25)
- 5 Cable screen; observe cable specification (→ 28)
- 6 Terminals for 4-20mA HART (passive)
- 7 Terminals for switch output (open collector)
- 8 Terminal for potential equalization line
- 9 Cable entry for 4-20mA HART line
- 10 Cable entry for switch output line
- 11 Overvoltage protection module

2-wire: 4-20mA HART, 4-20mA



5 Terminal assignment 2-wire, 4-20 mA HART, 4...20mA

A Without integrated overvoltage protection

B With integrated overvoltage protection

1 Connection current output 2

2 Connection current output 1

3 Supply voltage for current output 1 (e.g. RN221N); Observe terminal voltage (→ 26)

4 Cable screen; observe cable specification (→ 28)

5 HART communication resistor ( $\geq 250 \Omega$ ); Observe maximum load (→ 26)

6 Connection for Commubox FXA195 or FieldXpert SFX100 (via VIATOR Bluetooth modem)

7 Analog display device ; observe maximum load (→ 26)

8 Analog display device ; observe maximum load (→ 26)

9 Supply voltage for current output 2 (e.g. RN221N); Observe terminal voltage (→ 26)

10 Overvoltage protection module

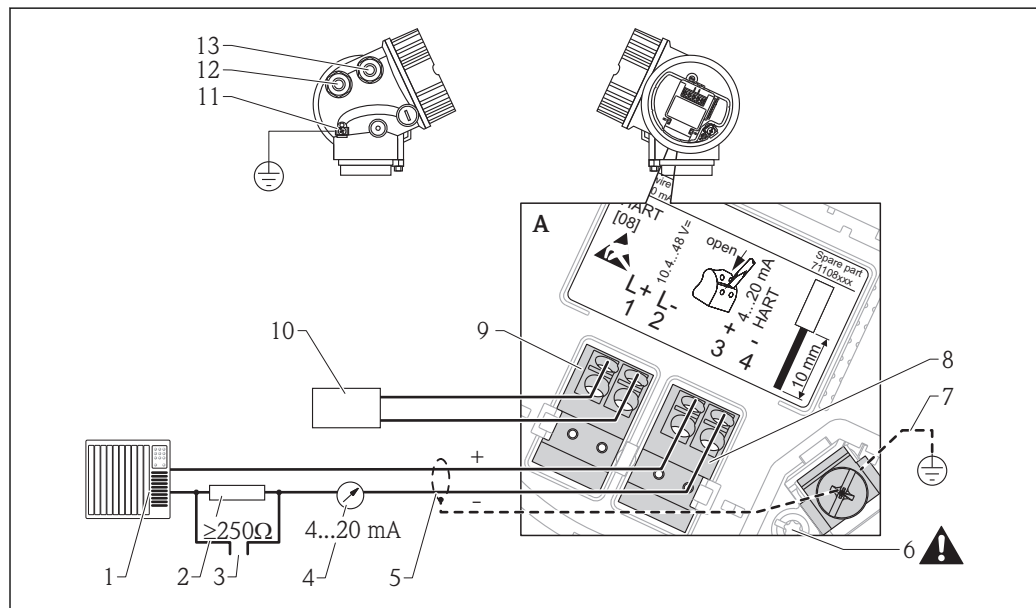
11 Terminals for current output 2

12 Terminal for the potential equalization line

13 Cable entry for current output 1

14 Cable entry for current output 2

**i** This version is also suited for single-channel operation. In this case, current output 1 (terminals 1 and 2) must be used.

4-wire: 4-20mA HART (10.4 to 48 V<sub>DC</sub>)

6 Terminal assignment 4-wire; 4-20mA HART (10.4 to 48 VDC)

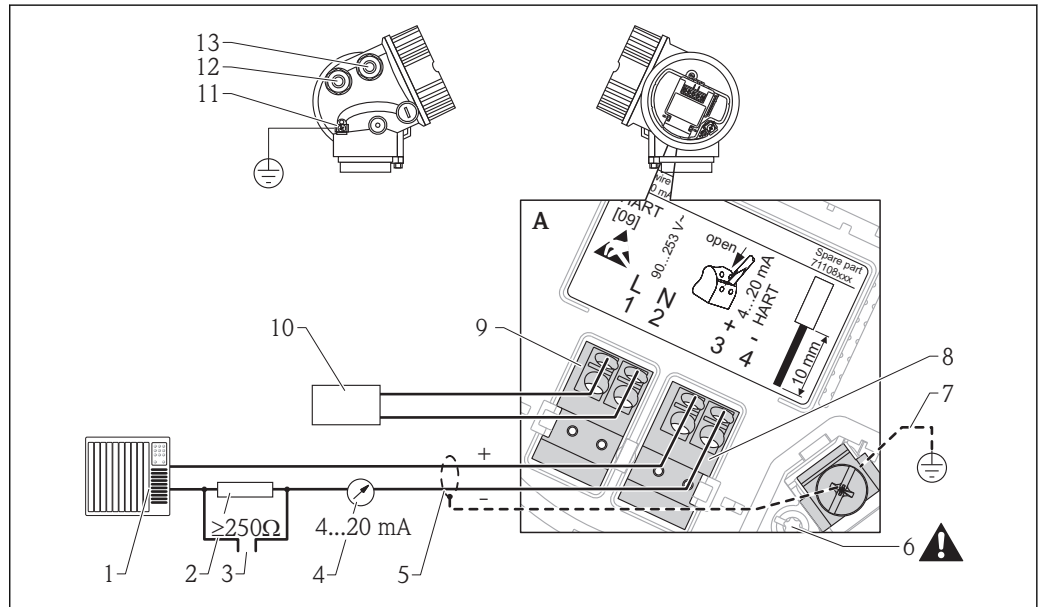
- 1 Evaluation unit, e.g. PLC
- 2 HART communication resistor ( $\geq 250 \Omega$ ): Observe maximum load (→ 27)
- 3 Connection for Commubox FXA195 or FieldXpert SFX100 (via VIATOR Bluetooth modem)
- 4 Analog display device: Observe maximum load (→ 27)
- 5 Signal cable including screening (if required), observe cable specification (→ 28)
- 6 Protective connection; do not disconnect!
- 7 Protective earth, observe cable specification (→ 28)
- 8 Terminals for 4...20mA HART (active)
- 9 Terminals for supply voltage
- 10 Supply voltage: Observe terminal voltage (→ 27), observe cable specification (→ 28)
- 11 Terminal for potential equalization
- 12 Cable entry for signal line
- 13 Cable entry for power supply

**CAUTION**

**To ensure electrical safety:**

- ▶ Do not disconnect the protective connection (7).
  - ▶ Disconnect the supply voltage before disconnecting the protective earth (8).
- i** Connect protective earth to the internal ground terminal (8) before connecting the supply voltage. If necessary, connect the potential matching line to the external ground terminal (12).
- i** In order to ensure electromagnetic compatibility (EMC): Do not only ground the device via the protective earth conductor of the supply cable. Instead, the functional grounding must also be connected to the process connection (flange or threaded connection) or to the external ground terminal.
- i** An easily accessible power switch must be installed in the proximity of the device. The power switch must be marked as a disconnecter for the device (IEC/EN61010).

**4-wire: 4-20mA HART (90 to 253 V<sub>AC</sub>)**



7 Terminal assignment 4-wire; 4-20mA HART (90 to 253 VAC)

- 1 Evaluation unit, e.g. PLC
- 2 HART communication resistor ( $\geq 250 \Omega$ ): Observe maximum load (→ 27)
- 3 Connection for Commubox FXA195 or FieldXpert SFX100 (via VIATOR Bluetooth modem)
- 4 Analog display device: Observe maximum load (→ 27)
- 5 Signal cable including screening (if required), observe cable specification (→ 28)
- 6 Protective connection; do not disconnect!
- 7 Protective earth, observe cable specification (→ 28)
- 8 Terminals for 4...20mA HART (active)
- 9 Terminals for supply voltage
- 10 Supply voltage: Observe terminal voltage (→ 27), observe cable specification (→ 28)
- 11 Terminal for potential equalization
- 12 Cable entry for signal line
- 13 Cable entry for power supply

**CAUTION**

**To ensure electrical safety:**

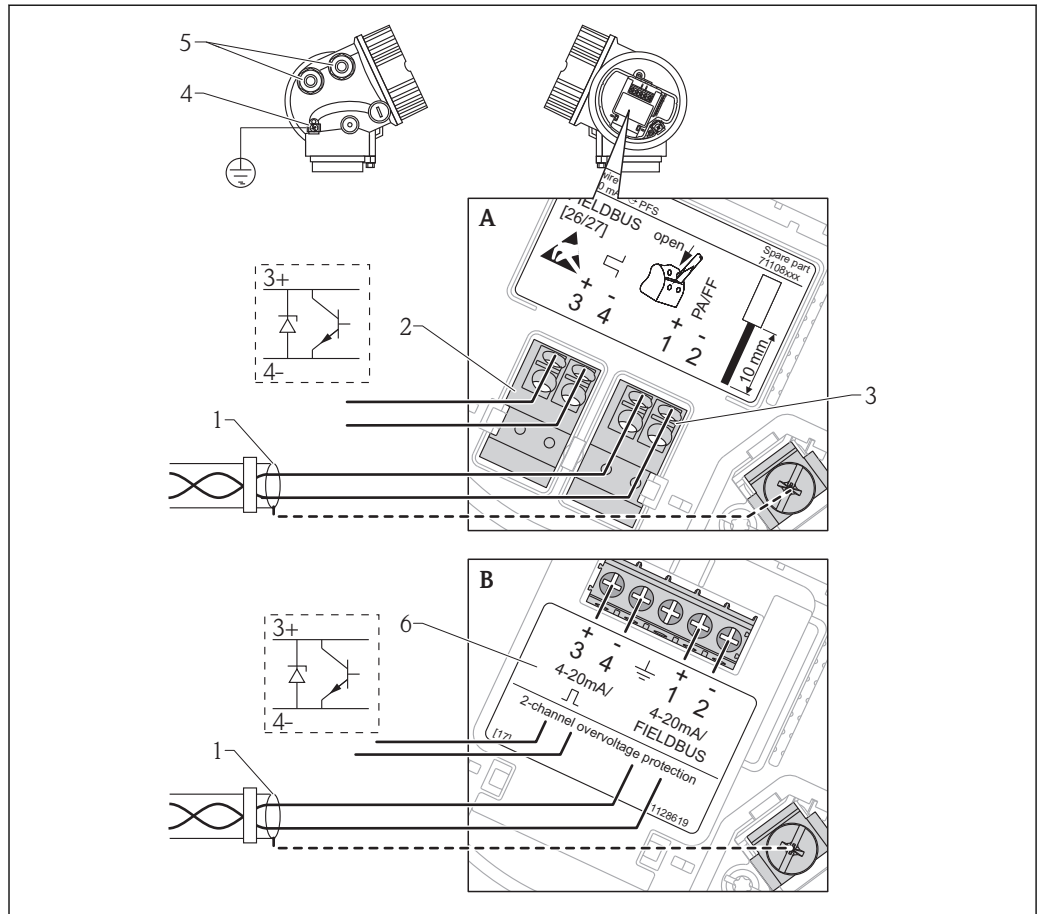
- ▶ Do not disconnect the protective connection (7).
- ▶ Disconnect the supply voltage before disconnecting the protective earth (8).

**i** Connect protective earth to the internal ground terminal (8) before connecting the supply voltage. If necessary, connect the potential matching line to the external ground terminal (12).

**i** In order to ensure electromagnetic compatibility (EMC): Do not only ground the device via the protective earth conductor of the supply cable. Instead, the functional grounding must also be connected to the process connection (flange or threaded connection) or to the external ground terminal.

**i** An easily accessible power switch must be installed in the proximity of the device. The power switch must be marked as a disconnector for the device (IEC/EN61010).

PROFIBUS PA / FOUNDATION Fieldbus (in preparation)



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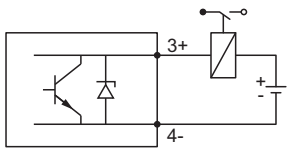
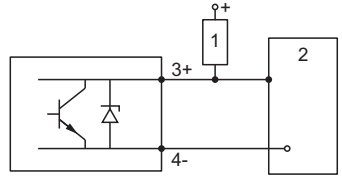
8 Terminal assignment PROFIBUS PA / FOUNDATION Fieldbus

- A Without integrated overvoltage protection
- B With integrated overvoltage protection
- 1 Cable screen: Observe cable specifications (→ 28)
- 2 Terminals for switch output (open collector)
- 3 Terminals PROFIBUS PA / FOUNDATION Fieldbus
- 4 Terminal for potential equalization line
- 5 Cable entries
- 6 Overvoltage protection module

**Connection examples for the switch output**

**i** For HART devices, the switch output is available as an option. See product structure, feature 20: "Power Supply, Output", option B: "2-wire; 4-20mA HART, switch output"

Devices with PROFIBUS PA and FOUNDATION Fieldbus always have a switch output.

 <p style="text-align: right; font-size: small;">A0015909</p> <p><b>9</b> <i>Connection of a relay</i></p> <p>Suitable relays (examples):</p> <ul style="list-style-type: none"> <li>■ Solid-state relay: Phoenix Contact OV-24DC/480AC/5 with mounting rail connector UMK-1 OM-R/AMS</li> <li>■ Electromechanical relay: Phoenix Contact PLC-RSC-12DC/21</li> </ul>	 <p style="text-align: right; font-size: small;">A0015910</p> <p><b>10</b> <i>Connection of a digital input</i></p> <p>1 <i>Pull-up resistor</i> 2 <i>Digital input</i></p>
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**Device plug connectors**



For the versions with fieldbus plug connector (M12 or 7/8"), the signal line can be connected without opening the housing.

*Pin assignment of the M12 plug connector*

	Pin	Meaning
	1	Signal +
	2	not connected
	3	Signal -
	4	Ground



*Pin assignment of the 7/8" plug connector*

	Pin	Meaning
	1	Signal -
	2	Signal +
	3	Screen
	4	Not connected

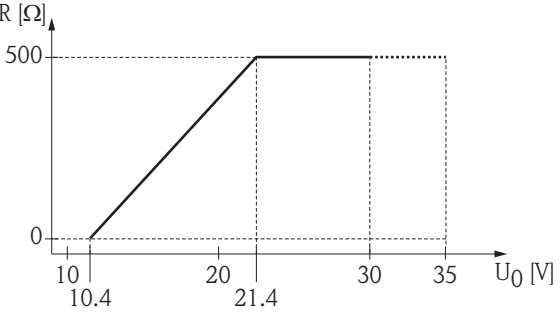
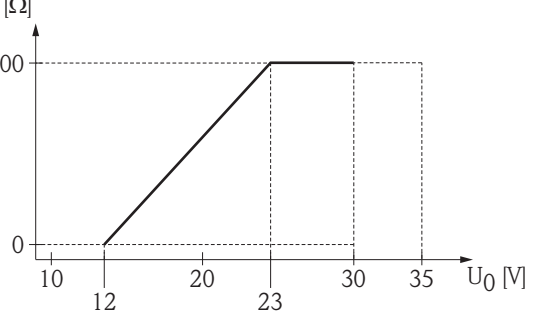


**Supply voltage**

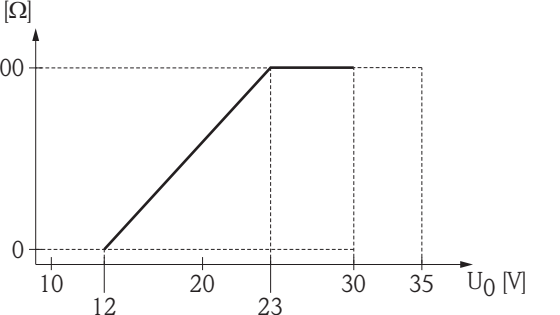
An external power supply is required.

 Various supply units can be ordered from Endress+Hauser: see "Accessories" section (→  86)

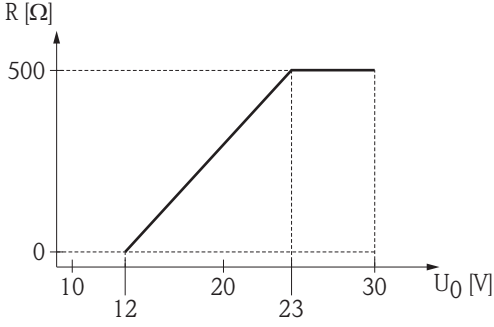
**2-wire, 4-20mA HART, passive**

"Power Supply, Output" <sup>1)</sup>	"Approval" <sup>2)</sup>	Terminal voltage U at the device	Maximum load R, depending on the supply voltage U <sub>0</sub> at the supply unit
A: 2-wire; 4-20mA HART	<ul style="list-style-type: none"> <li>■ Non-Ex</li> <li>■ Ex nA</li> <li>■ Ex ic</li> <li>■ CSA GP</li> </ul>	10.4 to 35 V <sup>3)</sup>	
	Ex ia / IS	10.4 to 30 V <sup>3)</sup>	
	<ul style="list-style-type: none"> <li>■ Ex d(ia) / XP</li> <li>■ Ex ic(ia)</li> <li>■ Ex nA(ia)</li> <li>■ Ex ta / DIP</li> </ul>	12 to 35 V <sup>4)</sup>	
Ex ia + Ex d(ia) / IS + XP	12 to 30 V <sup>4)</sup>		

- 1) Feature 020 of the product structure
- 2) Feature 010 of the product structure
- 3) For ambient temperatures T<sub>a</sub> ≤ -20 °C (-4 °F) a minimum voltage of 15 V is required for the sartup of the device at the MIN error current (3,6 mA). The startup current can be parametrized. If the device is operated with a fixed current I ≥ 5,5 mA (HART multidrop mode), a voltage of U ≥ 10,4 V is sufficient throughout the entire range of ambient temperatures.
- 4) For ambient temperatures T<sub>a</sub> ≤ -20 °C (-4 °F) a minimum voltage of 16 V is required for the sarttup of the device at the MIN error current (3.6 mA).

"Power Supply, Output" <sup>1)</sup>	"Approval" <sup>2)</sup>	Terminal voltage U at the device	Maximum load R, depending on the supply voltage U <sub>0</sub> at the supply unit
B: 2-wire; 4-20 mA HART, switch output	<ul style="list-style-type: none"> <li>■ Non-Ex</li> <li>■ Ex nA</li> <li>■ Ex nA(ia)</li> <li>■ Ex ic</li> <li>■ Ex ic(ia)</li> <li>■ Ex d(ia) / XP</li> <li>■ Ex ta / DIP</li> <li>■ CSA GP</li> </ul>	12 to 35 V <sup>3)</sup>	
	<ul style="list-style-type: none"> <li>■ Ex ia / IS</li> <li>■ Ex ia + Ex d(ia) / IS + XP</li> </ul>	12 to 30 V <sup>3)</sup>	

- 1) Feature 020 of the product structure
- 2) Feature 010 of the product structure
- 3) For ambient temperatures T<sub>a</sub> ≤ -30 °C (-22 °F) a minimum voltage of 16 V is required for the sarttup of the device at the MIN error current (3.6 mA).

"Power Supply, Output" <sup>1)</sup>	"Approval" <sup>2)</sup>	Terminal voltage U at the device	Maximum load R, depending on the supply voltage U <sub>0</sub> at the supply unit
C: 2-wire; 4-20mA HART, 4-20mA	any	12 to 30 V <sup>3)</sup>	 <p>The graph plots Maximum load R [Ω] on the y-axis (0 to 500) against supply voltage U<sub>0</sub> [V] on the x-axis (10 to 30). The load is 0 Ω for U<sub>0</sub> &lt; 12 V. It increases linearly from 0 Ω at 12 V to 500 Ω at 23 V. It remains constant at 500 Ω for U<sub>0</sub> between 23 V and 30 V.</p>

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- 1) Feature 020 of the product structure
- 2) Feature 010 of the product structure
- 3) For ambient temperatures  $T_a \leq -30\text{ °C}$  (-22 °F) a minimum voltage of 16 V is required for the startup of the device at the MIN error current (3.6 mA).

<b>Polarity reversal protection</b>	Yes
<b>Admissible residual ripple at f = 0 to 100 Hz</b>	$U_{SS} < 1\text{ V}$
<b>Admissible residual ripple at f = 100 to 10000 Hz</b>	$U_{SS} < 10\text{ mV}$

**4-wire, 4-20mA HART, active**

"Power supply; Output" <sup>1)</sup>	Terminal voltage	Maximum load R <sub>max</sub>
<b>K:</b> 4-wire 90-253VAC; 4-20mA HART	90 to 253 V <sub>AC</sub> (50 to 60 Hz), overvoltage category II	500 Ω
<b>L:</b> 4-wire 10,4-48VDC; 4-20mA HART	10.4 to 48 V <sub>DC</sub>	

1) Feature 020 of the product structure

**PROFIBUS PA, FOUNDATION Fieldbus (in preparation)**

"Power supply; Output" <sup>1)</sup>	"Approval" <sup>2)</sup>	Terminal voltage
<b>E:</b> 2-wire; FOUNDATION Fieldbus, switch output <b>G:</b> 2-wire; PROFIBUS PA, switch output	<ul style="list-style-type: none"> <li>■ Non-Ex</li> <li>■ Ex nA</li> <li>■ Ex nA(ia)</li> <li>■ Ex ic</li> <li>■ Ex ic(ia)</li> <li>■ Ex d(ia) / XP</li> <li>■ Ex ta / DIP</li> <li>■ CSA GP</li> </ul>	9 to 32 V <sup>3)</sup>
	<ul style="list-style-type: none"> <li>■ Ex ia / IS</li> <li>■ Ex ia + Ex d(ia) / IS + XP</li> </ul>	9 to 30 V <sup>3)</sup>

- 1) Feature 020 of the product structure
- 2) Feature 010 of the product structure
- 3) Input voltages up to 35 V will not spoil the device.

<b>Polarity sensitive</b>	No
<b>FISCO/FNICO compliant according to IEC 60079-27</b>	Yes

**Power consumption**

"Power supply; Output" <sup>1)</sup>	Power consumption
<b>A:</b> 2-wire; 4-20mA HART	< 0.9 W
<b>B:</b> 2-wire; 4-20mA HART, switch output	< 0.9 W
<b>C:</b> 2-wire; 4-20mA HART, 4-20mA	< 2 x 0.7 W
<b>K:</b> 4-wire 90-253VAC; 4-20mA HART	6 VA
<b>L:</b> 4-wire 10,4-48VDC; 4-20mA HART	1.3 W

1) Feature 020 of the product structure

**Current consumption**

**HART**

<b>Nominal current</b>	3.6 to 22 mA, the start-up current for multidrop mode can be parametrized (is set to 3.6 mA on delivery)
<b>Breakdown signal (NAMUR NE43)</b>	adjustable: 3.59 to 22.5 mA

**PROFIBUS PA (in preparation)**

<b>Nominal current</b>	14 mA
<b>Error current FDE (Fault Disconnection Electronic)</b>	0 mA

**FOUNDATION Fieldbus (in preparation)**

Device basic current	14 mA
Error current FDE (Fault Disconnection Electronic)	0 mA

**FISCO (in preparation)**

$U_i$	17.5 V
$I_i$	550 mA
$P_i$	5.5 W
$C_i$	5 nF
$L_i$	10 $\mu$ H

**Power supply failure**

- Configuration is retained in the HistoROM (EEPROM).
- Error messages (incl. value of operated hours counter) are stored.

**Potential equalization**

No special measures for potential equalization are required.



If the device is designed for hazardous areas, observe the information in the documentation "Safety Instructions" (XA, ZD).

**Terminals**

- **Without integrated overvoltage protection**  
Plug-in spring terminals for wire cross-sections 0.5 to 2.5 mm<sup>2</sup> (20 to 14 AWG)
- **With integrated overvoltage protection**  
Screw terminals for wire cross-sections 0.2 to 2.5 mm<sup>2</sup> (24 to 14 AWG)

**Cable entries**

- Cable gland (not for Ex d):
  - Plastics M20x1.5 for cable  $\varnothing$  5 to 10 mm (0.2 to 0.39 in): non-Ex, ATEX/IECEx/NEPSI Ex ia/ic
  - Metal M20x1.5 for cable  $\varnothing$  7 to 10 mm (0.28 to 0.39 in): dust-Ex, FM IS, CSA IS, CSA GP, Ex nA
- Thread for cable entry:
  - 1/2" NPT
  - G 1/2"
  - M20  $\times$  1.5
- Connector (only for non-Ex, Ex ic, Ex ia): M12 or 7/8"

**Cable specification**

- Standard device cable is sufficient for the power supply of the device.
- Minimum cross-section: ( $\rightarrow$  28)
- For ambient temperature  $T_U \geq 60$  °C (140 °F): use cable for temperature  $T_U + 20$  K.

**HART**

- A normal device cable suffices if only the analog signal is used.
- A shielded cable is recommended if using the HART protocol. Observe grounding concept of the plant.

**PROFIBUS (in preparation)**

Use a twisted, screened two-wire cable, preferably cable type A.



For further information on the cable specifications, see Operating Instructions BA00034S "Guidelines for planning and commissioning PROFIBUS DP/PA", PNO Guideline 2.092 "PROFIBUS PA User and Installation Guideline" and IEC61158-2 (MBP).

**FOUNDATION Fieldbus (in preparation)**

Endress+Hauser recommends using twisted, shielded two-wire cables.



For further information on the cable specifications, see Operating Instructions BA00013S "FOUNDATION Fieldbus Overview", FOUNDATION Fieldbus Guideline and IEC 61158-2 (MBP).

**Overvoltage protection**

If the measuring device is used for level measurement in flammable liquids which requires the use of overvoltage protection according to DIN EN 60079-14, standard for test procedures 60060-1 (10 kA, pulse 8/20  $\mu$ s), overvoltage protection has to be ensured by an integrated or external overvoltage protection module.

**Integrated overvoltage protection**

An integrated overvoltage protection module is available for 2-wire HART as well as PROFIBUS PA and FOUNDATION Fieldbus devices.

Product structure: Feature 610 "Accessory mounted", option NA "Overvoltage protection".

Technical data	
Resistance per channel	2 * 0.5 $\Omega$ max
Threshold DC voltage	400 to 700 V
Threshold impulse voltage	< 800 V
Capacitance at 1 MHz	< 1.5 pF
Nominal arrest impulse voltage (8/20 $\mu$ s)	10 kA

**External overvoltage protection**

HAW562 or HAW569 from Endress+Hauser are suited as external overvoltage protection.



For detailed information please refer to the following documents:

- HAW562: TI01012K
- HAW569: TI01013K

## Performance characteristics

### Reference operating conditions

- Temperature = +24 °C (+75 °F) ±5 °C (±9 °F)
- Pressure = 960 mbar abs. (14 psia) ±100 mbar (±1.45 psi)
- Humidity = 60 % ±15 %
- Reflector: metal plate with a minimum diameter of 1 m (40 in)
- No major interference reflections inside the signal beam

### Maximum measured error

Typical data under reference operating conditions: DIN EN 61298-2, percentage values in relation to the span.

Device	Value	Output	
		digital	analog <sup>1)</sup>
FMR53/FMR54	Sum of non-linearity, nonrepeatability and hysteresis	± 6 mm (0.24 in) throughout the complete measuring range	± 0.02 %
	Offset/Zero	± 4 mm (0.2 in)	± 0.03 %

1) Add error of the analogous value to the digital value.

### Measured value resolution

Dead band according to EN61298-2:

- digital: 1 mm
- analog: 1 µA

### Reaction time

The reaction time can be parametrized. The following step response times (as per DIN EN 61298-2)<sup>1)</sup> are valid if the damping is switched off:

Tank height	Sampling rate	Step response time
< 10 m (33 ft)	≥ 3.6 s <sup>-1</sup>	< 0.8 s
< 20 m (66 ft)	≥ 2.7 s <sup>-1</sup>	< 1 s

### Influence of ambient temperature

#### The measurements are carried out in accordance with EN 61298-3

- Digital (HART, PROFIBUS PA): average  $T_K = 3 \text{ mm}/10 \text{ K}$ ; maximum 10 mm
- Analog (current output):
  - zero point (4 mA): average  $T_K = 0.02 \text{ %}/10 \text{ K}$
  - span (20 mA): average  $T_K = 0.05 \text{ %}/10 \text{ K}$

### Influence of gas layer

High pressures reduce the propagation velocity of the measuring signals in the gas/vapor above the fluid. This effect depends on the kind of gas/vapor and of its temperature. This results in a systematic measuring error that gets bigger as the distance increases between the reference point of the measurement (flange) and the product surface. The following table illustrates this measured error for a few typical gases/vapors (with regard to distance; a positive value means that too large a distance is being measured):

Gas layer	Temperature		Pressure				
	°C	°F	1 bar (14,5 psi)	10 bar (145 psi)	50 bar (725 psi)	100 bar (1450 psi)	160 bar (2320 psi)
Air/ Nitrogen	20	68	0.00 %	0.22 %	1.2 %	2.4 %	3.89 %
	200	392	-0.01 %	0.13 %	0.74 %	1.5 %	2.42 %
	400	752	-0.02 %	0.08 %	0.52 %	1.1 %	1.70 %
Hydrogen	20	68	-0.01 %	0.10 %	0.61 %	1.2 %	2.00 %
	200	392	-0.02 %	0.05 %	0.37 %	0.76 %	1.23 %
	400	752	-0.02 %	0.03 %	0.25 %	0.53 %	0.86 %

1) According to DIN EN 61298-2 the response time is the time which passes after a sudden change of the input signal until the output signal for the first time assumes 90% of the steady-state value.

Gas layer	Temperature		Pressure				
	°C	°F	1 bar (14,5 psi)	10 bar (145 psi)	50 bar (725 psi)	100 bar (1450 psi)	160 bar (2320 psi)
Water (saturated steam)	100	212	0.02 %	-	-	-	-
	180	356	-	2.1 %	-	-	-
	263	505,4	-	-	8.6 %	-	-
	310	590	-	-	-	22 %	-
	364	687	-	-	-	-	41.8 %



When the pressure is known and constant, this measured error can, for example, be compensated by means of a linearization.

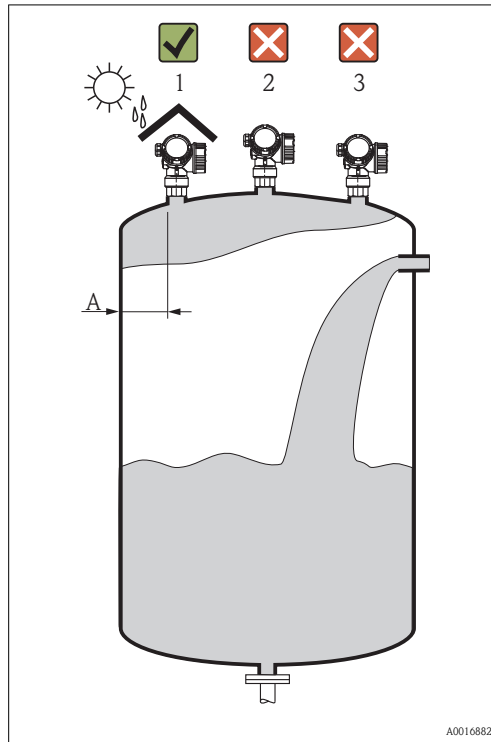
**Gas phase compensation with external pressure sensor (PROFIBUS PA, in preparation)**

PROFIBUS devices can receive the signal of an external pressure sensor through the bus and use it to perform a pressure dependent time-of-flight correction. In the case of saturated steam in the temperature range from 100 to 350 °C (212 to 662 °f), for example, the measuring error of the distance measurement can be reduced by this method from up to 29 % (without compensation) to less than 3 % (with compensation).

## Installation

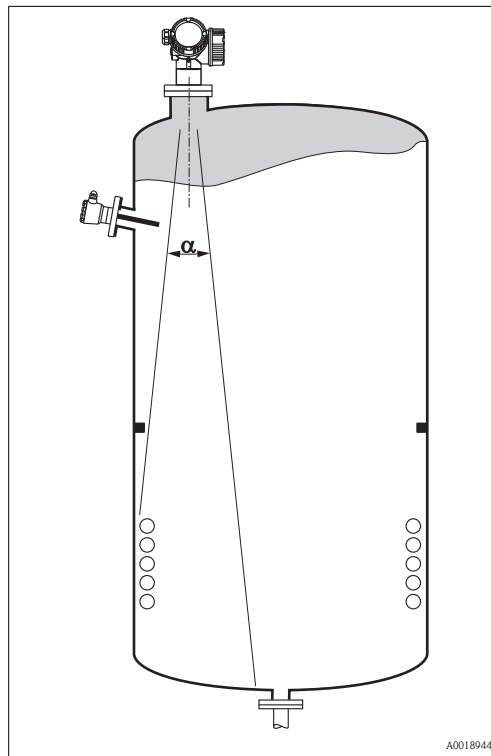
### Installation conditions

### Mounting position



- Recommended distance **A** from wall to outer edge of nozzle:  $\sim 1/6$  of tank diameter. Nevertheless the device should not be installed closer than 30 cm (11.8 in) to the tank wall.
- Not in the center (2), as interference can cause signal loss.
- Not above the fill stream (3).
- It is recommended to use a weather protection cover (1) in order to protect the device from direct sun or rain.

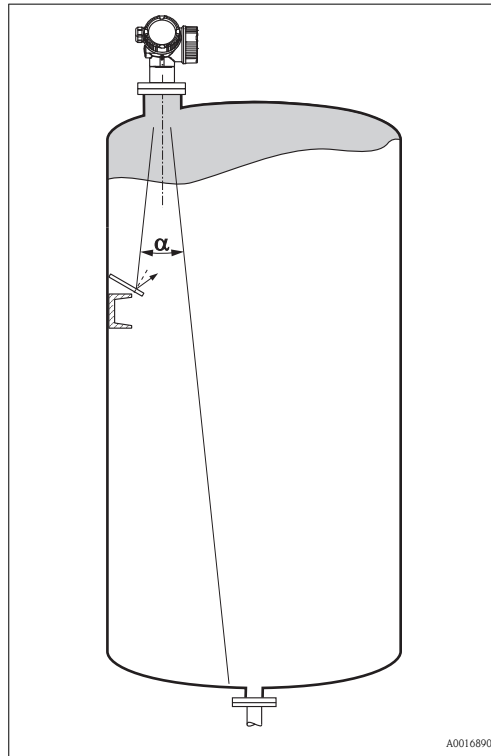
### Vessel installations



Avoid any installations (limit switches, temperature sensors, braces, vacuum rings, heating coils, baffles etc.) inside the signal beam. Take into account the beam angle ( $\rightarrow$  35):



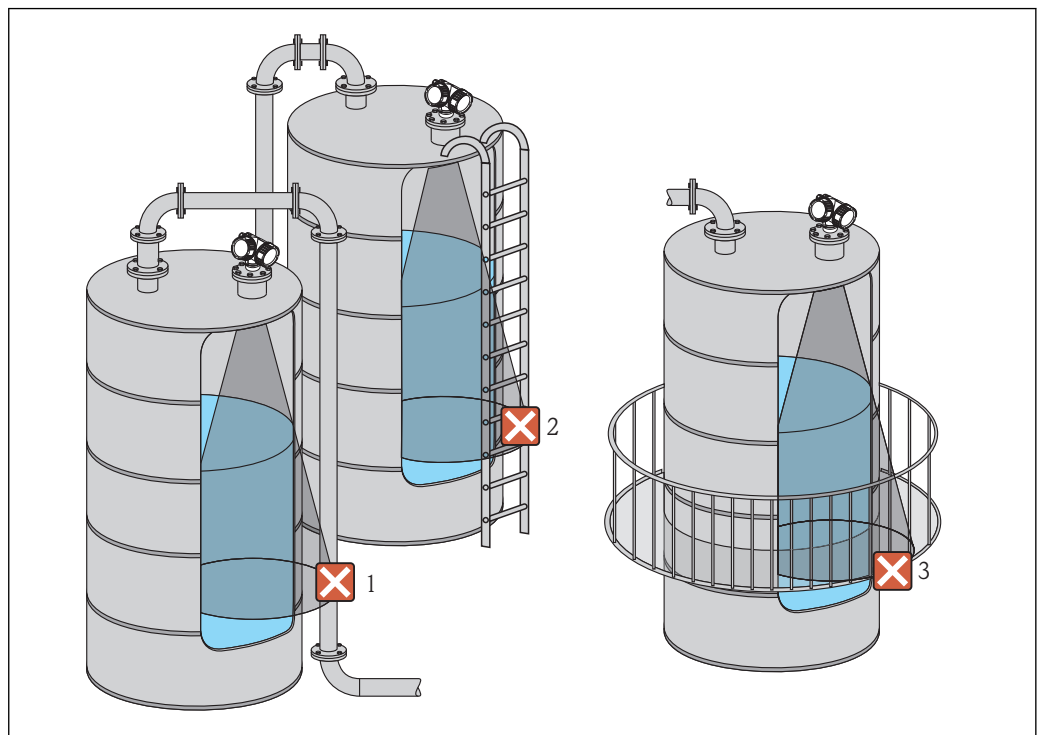
### Reduction of interference echoes



Metallic screens mounted at a slope spread the radar signal and can, therefore, reduce interference echoes.

### Measurement in a plastic vessel

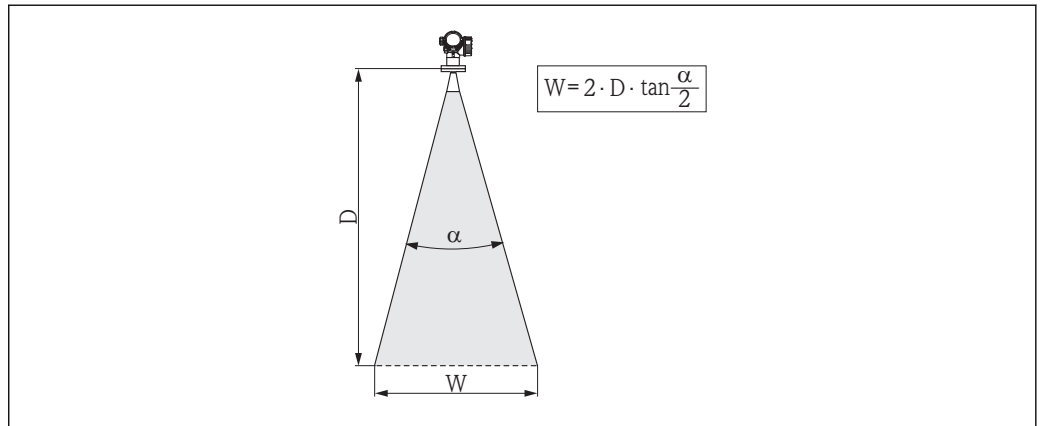
If the outer wall of the vessel is made of a non-conductive material (e.g. GRP), microwaves can also be reflected off interfering installations outside the signal beam (e.g. metallic pipes (1), ladders (2), grates (3), ...). Therefore, there should be no such interfering installations in the signal beam. Please contact Endress+Hauser for further information.



**Optimization options**

- Antenna size  
The bigger the antenna, the smaller the beam angle  $\alpha$  and the fewer interference echoes (→ [Fig 35](#)).
- Mapping  
The measurement can be optimized by means of electronic suppression of interference echoes.
- Antenna alignment  
Take into account the marker on the flange or threaded connection (→ [Fig 37](#)) (→ [Fig 39](#)).
- Stilling well  
A stilling well can be applied to avoid interferences (→ [Fig 42](#)).
- Metallic screens mounted at a slope  
They spread the radar signals and can, therefore, reduce interference echoes.

**Beam angle**



A0016891

11 Relationship between beam angle  $\alpha$ , distance  $D$  and beamwidth diameter  $W$

The beam angle is defined as the angle  $\alpha$  where the energy density of the radar waves reaches half the value of the maximum energy density (3-dB-width). Microwaves are also emitted outside the signal beam and can be reflected off interfering installations.

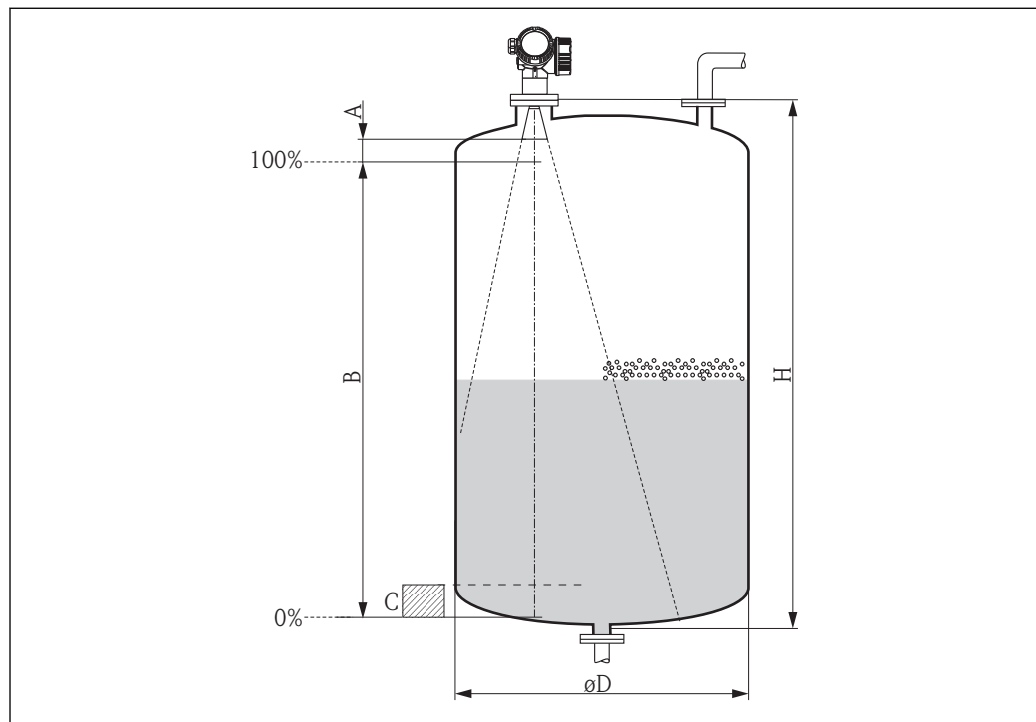
Beam diameter  $W$  as a function of beam angle  $\alpha$  and measuring distance  $D$ :

FMR53	
Beam angle $\alpha$	23°
Measuring distance (D)	Beamwidth diameter W
3 m (9.8 ft)	1.22 m (4 ft)
6 m (20 ft)	2.44 m (8 ft)
9 m (30 ft)	3.66 m (12 ft)
12 m (39 ft)	4.88 m (16 ft)
15 m (49 ft)	6.1 m (20 ft)
20 m (66 ft)	8.14 m (27 ft)

FMR54 - Horn antenna			
Antenna size	150 mm (6 in)	200 mm (8 in)	250 mm (10 in)
Beam angle $\alpha$	23°	19°	15°
Measuring distance (D)	Beamwidth diameter W		
3 m (9.8 ft)	1.22 m (4 ft)	1 m (3.3 ft)	0.79 m (2.6 ft)
6 m (20 ft)	2.44 m (8 ft)	2.01 m (6.6 ft)	1.58 m (5.2 ft)
9 m (30 ft)	3.66 m (12 ft)	3.01 m (9.9 ft)	2.37 m (7.8 ft)
12 m (39 ft)	4.88 m (16 ft)	4.02 m (13 ft)	3.16 m (10 ft)
15 m (49 ft)	6.1 m (20 ft)	5.02 m (16 ft)	3.95 m (13 ft)
20 m (66 ft)	8.14 m (27 ft)	6.69 m (22 ft)	5.27 m (17 ft)

### Measuring conditions

- In case of **boiling surfaces, bubbling** or tendency for **foaming** use FMR53 or FMR54. Depending on its consistence, foam can either absorb microwaves or reflect them off the foam surface. Measurement is possible under certain conditions. For FMR50, FMR51 and FMR52, the additional option "Advanced dynamics" is recommended in these cases (feature 540: "Application Package", option EM).
- In case of heavy **steam development** or **condensate**, the maximum measuring range of FMR50, FMR51 and FMR52 may decrease depending on density, temperature and composition of the steam → use FMR53 or FMR54.
- For the measurement of absorbing gases such as **ammonia NH<sub>3</sub>** or some **fluorocarbons**<sup>2)</sup>, please use Levelflex or Micropilot FMR54 in a stilling well.
- The measuring range begins, where the beam hits the tank bottom. Particularly with dish bottoms or conical outlets the level cannot be detected below this point.
- For stilling well applications, the zero should be positioned at the end of the tube, as the electromagnetic waves do not propagate completely outside the tube. It must be taken into account that the accuracy may be reduced in the area **C**. In order to guarantee the required accuracy in these cases, it is recommended to position the zero-point at a distance **C** above the end of the tube (see figure).
- In case of media with a low dielectric constant ( $\epsilon_r = 1.5$  to  $4$ )<sup>3)</sup> the tank bottom can be visible through the medium at low levels (low height **C**). Reduced accuracy has to be expected in this range. If this is not acceptable, we recommend positioning the zero point at a distance **C** (see figure) above the tank bottom in these applications.
- In principle it is possible to measure up to the tip of the antenna with FMR51, FMR53 and FMR54. However, due to considerations regarding corrosion and build-up, the end of the measuring range should not be chosen any closer than **A** (see figure) to the tip of the antenna.
- When using FMR54 with planar antenna, especially for media with low dielectric constants, the end of the measuring range should not be closer than 1 m (3.28 ft) to the flange.
- The smallest possible measuring range **B** depends on the antenna version (see figure).
- The tank height should be at least **H** (see table).



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Device	A [mm (in)]	B [m (ft)]	C [mm (in)]	H [m (ft)]
FMR53	50(1.97)	> 0.5 (1.6)	150 to 300 (5.91 to 11.8)	> 1.5 (4.9)
FMR54				

2) Affected compounds are e.g. R134a, R227, Dymel 152a.

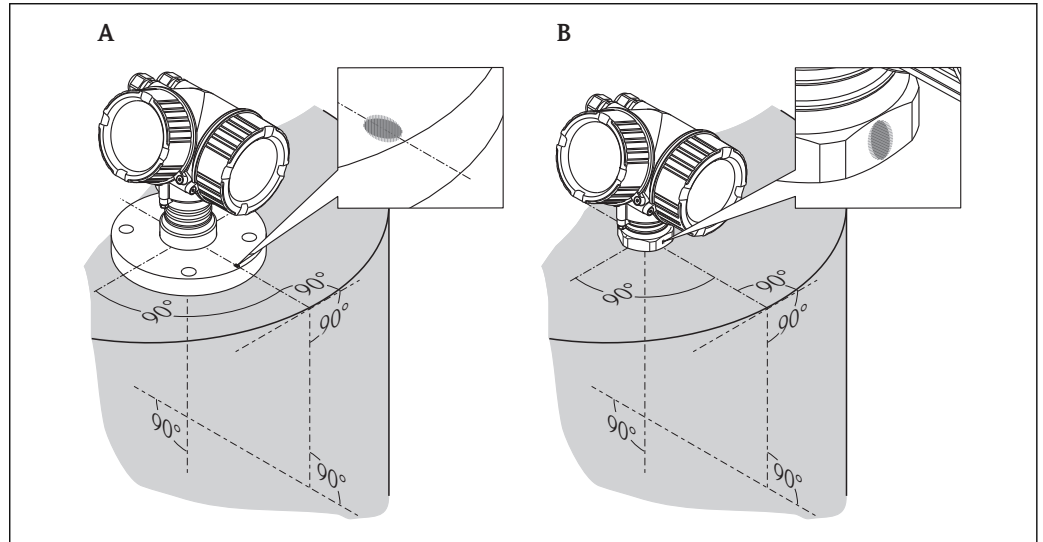
3) Dielectric constants of important media commonly used in the industry are summarized in the document SD106F, which can be downloaded from the Endress+Hauser web page ([www.endress.com](http://www.endress.com)).

**Installation in vessel (free space)**

**Rod antenna (FMR53)**

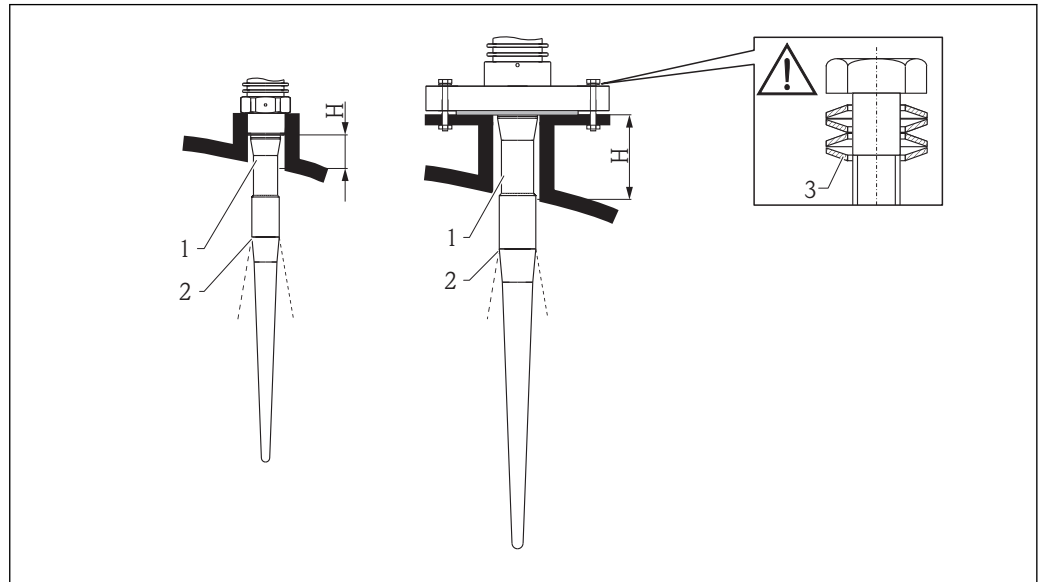
*Alignment*

- Align the antenna vertically to the product surface.
- A marking at the flange or the boss enables alignment of the antenna. This marking must be aligned towards the tank wall.



A0018974

*Nozzle mounting*




A0016821

12 Nozzle height and diameter for the rod antenna (FMR53)

- 1 Inactive length of the antenna
- 2 Beam launched here
- 3 Spring washers

<b>Antenna length</b>	390 mm (15.4 in)	540 mm (21.3 in)
<b>H</b>	< 100 mm (3.94 in)	< 250 mm (9.84 in)

 The inactive part (1) of the rod antenna must extend below the nozzle.

 For flanges with PTFE cladding: Use spring washers (see figure) to compensate for the sagging of the cladding.

It is recommended to tighten the the flange bolts periodically, depending on process temperature and pressure.

Recommended torque: 60 to 100 Nm (44.25 to 73.75 lbf ft)

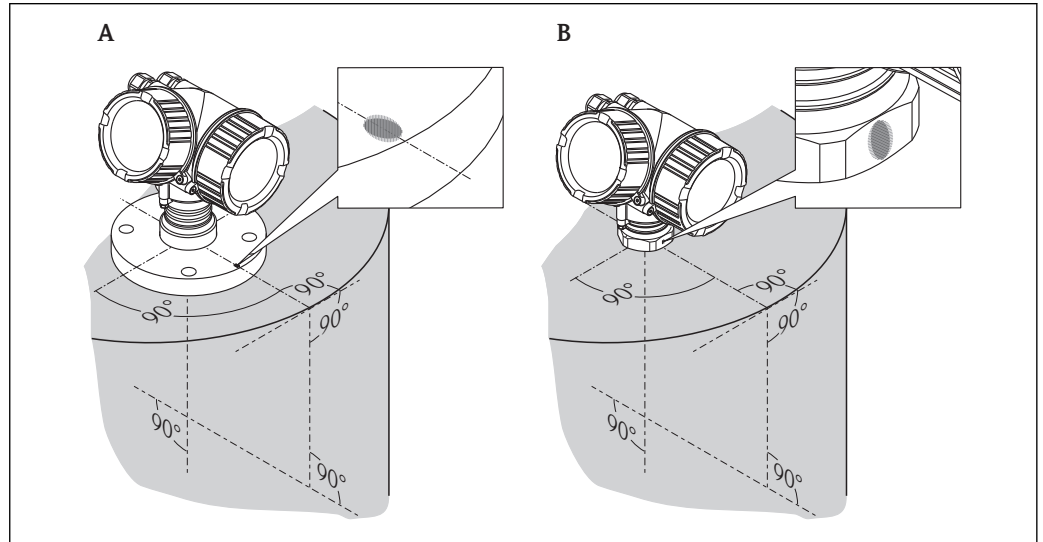
#### *Threaded connection*

- Tighten with the hexagonal nut only.
- Tool : Hexagonal wrench 55 mm
- Maximum permissible torque:
  - Thread PVDF: 35 Nm (26 lbf ft)
  - Thread 316L: 60 Nm (44 lbf ft)

### Horn antenna (FMR54)

#### Alignment

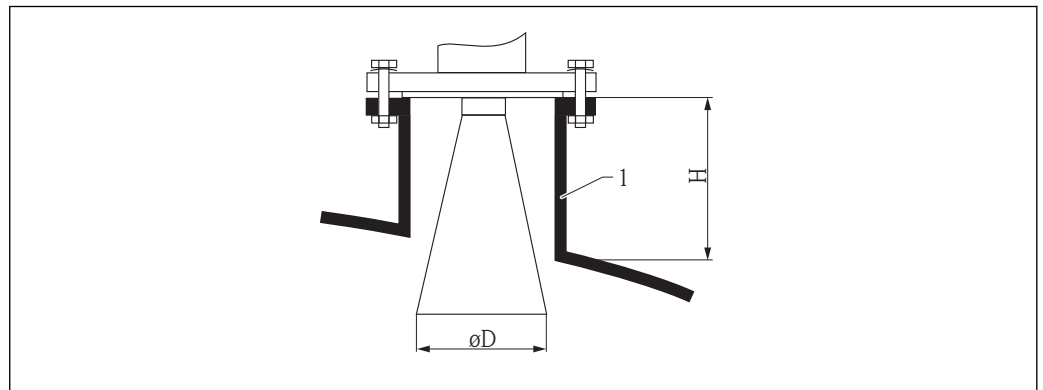
- Align the antenna vertically to the product surface.
- A marking at the flange enables alignment of the antenna. This marking must be aligned towards the tank wall.



A0018974

#### Nozzle mounting

The horn antenna must extend below the nozzle; if necessary select the device version with antenna extension 100 to 400 mm (4 to 16 in) <sup>4)</sup>.



A0016822

13 Nozzle height and diameter for the horn antenna (FMR54)

1 Mounting nozzle

Antenna size	150 mm (6 in)	200 mm (8 in)	250 mm (10 in)
<b>D</b>	146 mm (5.75 in)	191 mm (7.52 in)	241 mm (9.49 in)
<b>H</b>	< 205 mm (8.07 in)	< 290 mm (11.4 in)	< 380 mm (15 in)

4) See product structure: feature 610 "Accessory Mounted", options OM, ON, OR, OS.

*Measurement from the outside through plastic walls*

- If possible use the 250 mm (10 in) antenna.
- The distance between the lower edge of the antenna and the tank should be about 100 mm (4 in).
- If possible, avoid mounting location where condensation or build-up might occur.
- In case of outdoor mounting, the space between antenna and vessel has to be protected from the elements.
- Do not mount any potential reflectors (e.g. pipes) outside the tank in the signal beam.

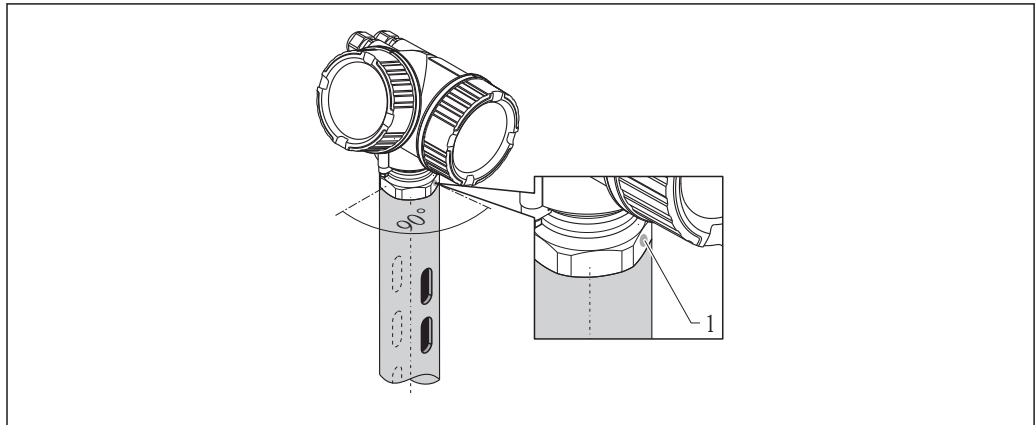
*Suitable thickness of the tank ceiling*

Penetrated material	PE	PTFE	PP	Plexiglas
DK / $\epsilon_r$	2.3	2.1	2.3	3.1
Optimum thickness	16 mm (0.65 in)	17 mm (0.68 in)	16 mm (0.65 in)	14 mm (0.56 in)



**Planar antenna (FMR54)**

The planar antenna is only suited for stilling well applications (→  42). It can not be used for free space applications.

**Installation in stilling well**

A0016841

**14** *Installation in stilling well***1** *Marking for antenna alignment*

- For horn antenna: Align the marking towards the slots of the stilling well.
- No alignment is required for planar antennas.
- Measurements can be performed through an open full bore ball valve without any problems.
- After mounting, the housing can be turned 350° in order to simplify access to the display and the terminal compartment.

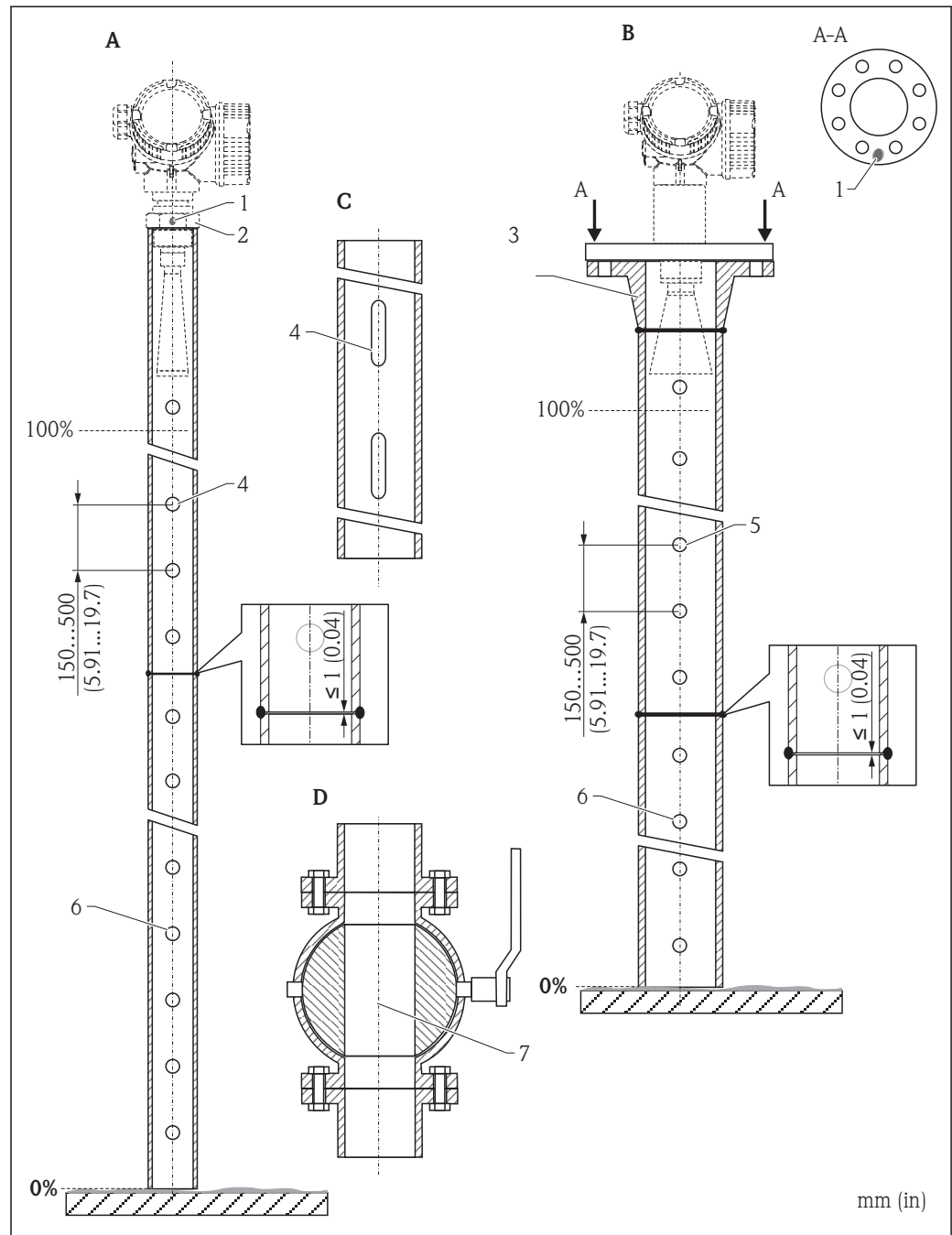
### Recommendations for the stilling well

- Metal (no enamel coating; plastic on request).
- Constant diameter.
- Diameter of stilling well not larger than antenna diameter.
- Weld seam as smooth as possible and on the same axis as the slots.
- Slots offset 180° (not 90°).
- Slot width or diameter of holes max. 1/10 of pipe diameter, de-burred. Length and number do not have any influence on the measurement.
- Select horn antenna as big as possible. For intermediate sizes (e.g. 180 mm (7 in)) select next larger antenna and adapt it mechanically (for horn antennas)
- At any transition (i.e. when using a ball valve or mending pipe segments), no gap may be created exceeding 1 mm (0.04 in).
- The stilling well must be smooth on the inside (average roughness  $R_z \leq 6.3 \mu\text{m}$  (248  $\mu\text{in}$ )). Use extruded or parallel welded stainless steel pipe. An extension of the pipe is possible with welded flanges or pipe sleeves. Flange and pipe have to be properly aligned at the inside.
- Do not weld through the pipe wall. The inside of the stilling well must remain smooth. In case of unintentional welding through the pipe, the weld seam and any unevenness on the inside need to be carefully removed and smoothed. Otherwise, strong interference echoes will be generated and material build-up will be promoted.
- Particularly on smaller nominal widths it needs to be observed that flanges are welded to the pipe such that they allow for a correct orientation (marker aligned toward slots).



The performance of Micropilot FMR54 with planar antenna is not dependent on the alignment or geometry of standard stilling wells. No special alignment is required. However, make sure that the planar antenna is installed vertically relative to the stilling well axis.

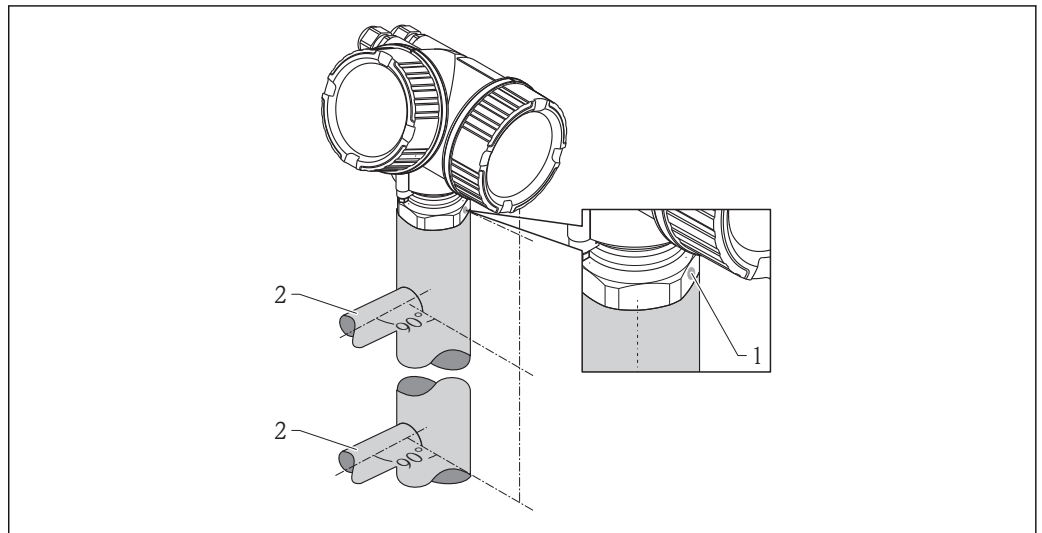
Examples for the construction of stilling wells



A0019009

- A Micropilot FMR50/FMR51: Horn 40mm(1½")
- B Micropilot FMR50/FMR51/FMR52/FMR54: Horn 80mm(3")
- C Stilling well with slots
- D Full bore ball valve
- 1 Marking for axial alignment
- 2 Threaded connection
- 3 e.g. welding neck flange DIN2633
- 4  $\varnothing$  hole max. 1/10  $\varnothing$  stilling well
- 5  $\varnothing$  hole max. 1/10  $\varnothing$  stilling well; single sided or drilled through
- 6 Inside of holes deburred
- 7 Diameter of opening of ball valve must always be equivalent to pipe diameter; avoid edges and constrictions.

### Installation in bypass



A0019446

#### 15 Installation in bypass

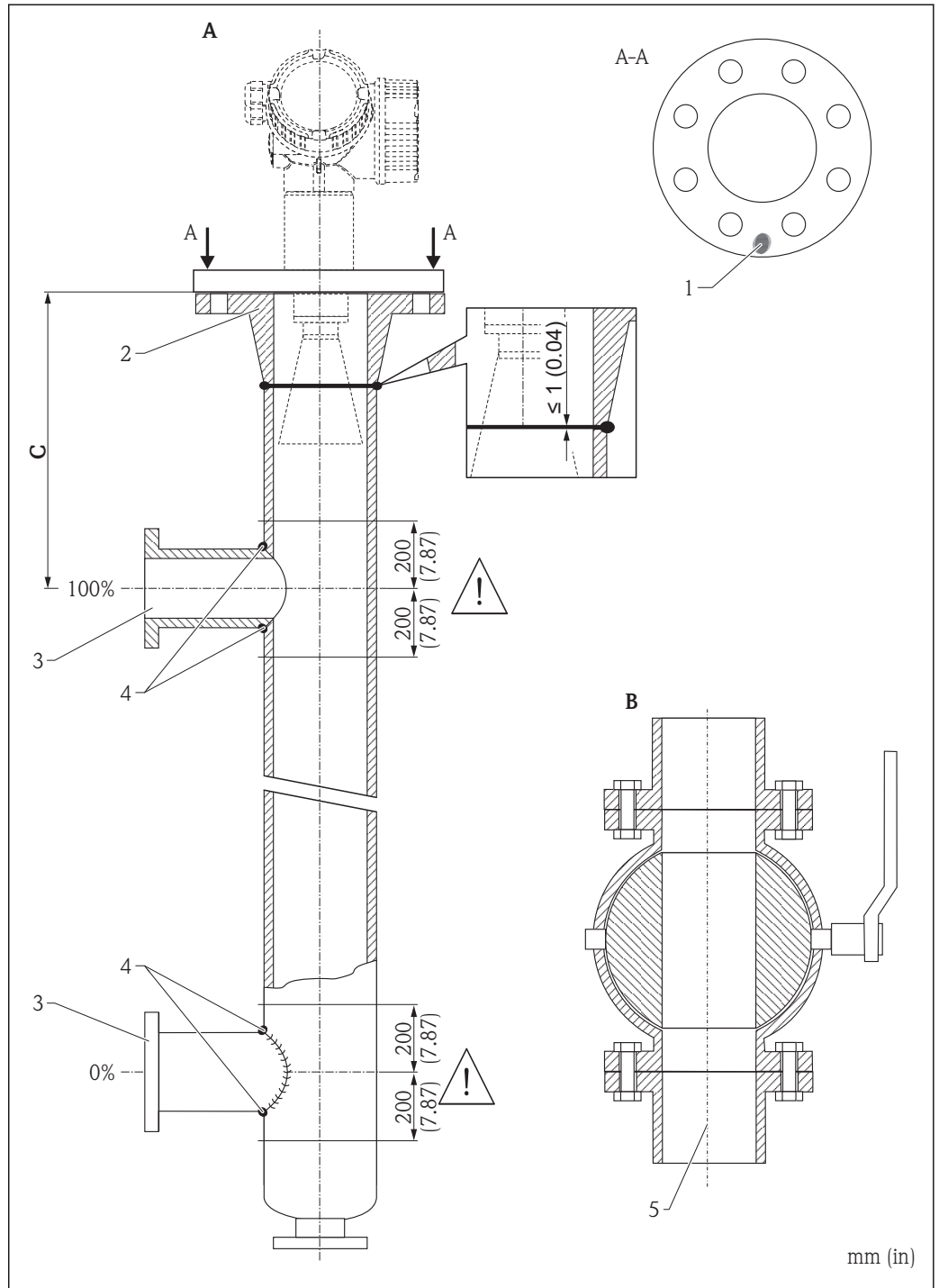
- 1 Marking for antenna alignment
- 2 Tank connectors

- Align the marker perpendicular (90°) to the tank connectors.
- Measurements can be performed through an open full bore ball valve without any problems.
- After mounting, the housing can be turned 350° in order to simplify access to the display and the terminal compartment.

**Recommendations for the bypass pipe**

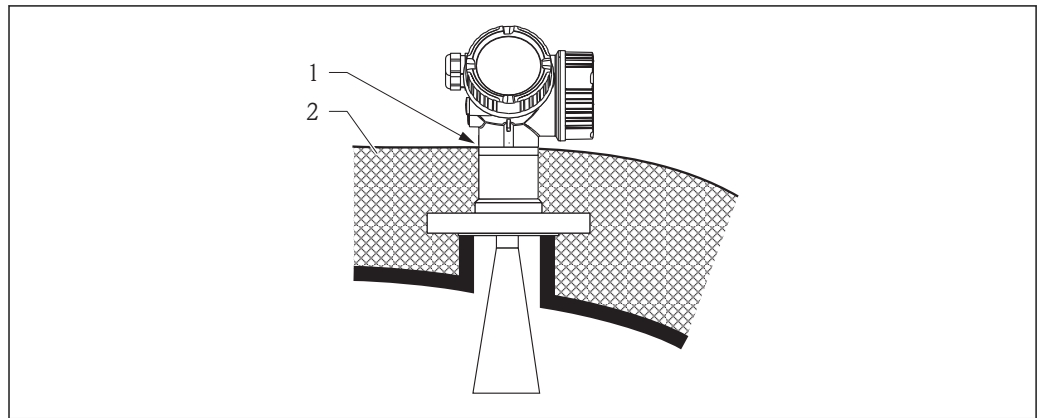
- Metal (no plastic or enamel coating).
- Constant diameter.
- Select horn antenna as big as possible. For intermediate sizes (e.g. 95 mm (3.5 in)) select next larger antenna and adapt it mechanically (for horn antennas).
- At any transition (i.e. when using a ball valve or mending pipe segments), no gap may be created exceeding 1 mm (0.04 in).
- In the area of the tank connections ( $\sim \pm 20$  cm (7.87 in)) a reduced accuracy of the measurement has to be expected.

Example for the construction of a bypass



- A Micropilot FMR50/FMR51/FMR52/FMR54: Horn 80mm(3")  
 B Full bore ball valve  
 C Minimum distance to upper connection pipe: 400 mm (15,7 in)  
 1 Marking for axial alignment  
 2 e.g. welding neck flange DIN2633  
 3 Diameter of the connection pipes as small as possible  
 4 Do not weld through the pipe wall; the inside of the bypass must remain smooth.  
 5 Diameter of opening of ball valve must always be equivalent to pipe diameter. Avoid edges and constrictions.

A0019010

**Vessels with heat insulation**

A0019142

If process temperatures are high, the device must be included in normal tank insulation to prevent the electronics heating up as a result of heat radiation or convection. The insulation may not exceed beyond the neck of the housing.



## Environment


### Ambient temperature range

<b>Measuring device</b>	-40 to +80 °C (-40 to +176 °F); -50 °C (-58 °F) with manufacturer declaration on request
<b>Local display</b>	-20 to +70 °C (-4 to +158 °F), the readability of the display may be impaired at temperatures outside the temperature range.

When operating the device in the open with strong sunlight:

- Mount the device in a shady position.
- Avoid direct sunlight, especially in warmer regions.
- Use a weather protection cover (see accessories).

### Ambient temperature limits

 The following diagrams take into account only function requirements. There may be further restrictions for certified device versions. Please refer to the separate Safety Instructions (→ 87).

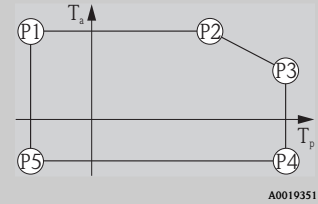
With a temperature ( $T_p$ ) at the process connection the admissible ambient temperature ( $T_a$ ) is reduced according to the following diagram (temperature derating):

*Information concerning the derating tables*

Option	Meaning
A	2-wire; 4-20 mA HART
B	2-wire; 4-20 mA HART, switch output
C	2-wire; 4-20 mA HART, 4-20 mA
E	2-wire; FF, switch output
G	2-wire; PA, switch output
K	4-wire 90-253VAC; 4-20 mA HART
L	4-wire 10, 4-48VDC; 4-20 mA HART

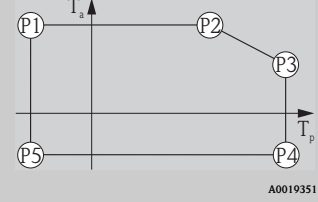
Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	$T_p$	$T_a$	$T_p$	$T_a$	$T_p$	$T_a$	$T_p$	$T_a$	$T_p$	$T_a$	$T_p$	$T_a$
A	-40 (-40)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output not used	-40 (-40)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output used	-40 (-40)	77 (171)	77 (171)	77 (171)	80 (176)	76 (169)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 not used	-40 (-40)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 used	-40 (-40)	79 (174)	79 (174)	79 (174)	80 (176)	79 (174)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output not used	-40 (-40)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output used	-40 (-40)	78 (172)	78 (172)	78 (172)	80 (176)	78 (172)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
K, L	-40 (-40)	77 (171)	77 (171)	77 (171)	80 (176)	77 (171)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-

**FMR53**  
**Process connection: Thread PVDF**  
**Housing: GT19 (Plastics PBT)**  
**Temperature unit: °C (°F)**



Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-40 (-40)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output not used	-40 (-40)	76 (169)	76 (169)	76 (169)	80 (176)	75 (167)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output used	-40 (-40)	60 (140)	60 (140)	60 (140)	80 (176)	58 (136)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 not used	-40 (-40)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 used	-40 (-40)	74 (165)	74 (165)	74 (165)	80 (176)	73 (163)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output not used	-40 (-40)	79 (174)	79 (174)	79 (174)	80 (176)	79 (173)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output used	-40 (-40)	63 (145)	63 (145)	63 (145)	80 (176)	60 (140)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-

**FMR53**  
**Process connection: Thread PVDF**  
**Housing: GT20 (Alu, coated)**  
**Temperature unit: °C (°F)**



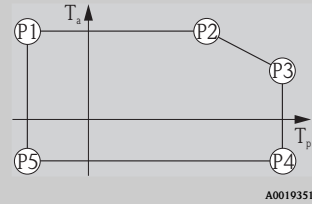
Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-40 (-40)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output not used	-40 (-40)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output used	-40 (-40)	77 (171)	77 (171)	77 (171)	80 (176)	76 (169)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 not used	-40 (-40)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 used	-40 (-40)	79 (174)	79 (174)	79 (174)	80 (176)	79 (174)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output not used	-40 (-40)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output used	-40 (-40)	78 (172)	78 (172)	78 (172)	80 (176)	78 (172)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
K, L	-40 (-40)	77 (171)	77 (171)	77 (171)	80 (176)	77 (171)	80 (176)	-40 (-40)	-40 (-40)	-40 (-40)	-	-

**FMR53**

**Process connection:**

- Thread 316L
- Flange

**Housing: GT18 (316 L)**  
**Temperature unit: °C (°F)**



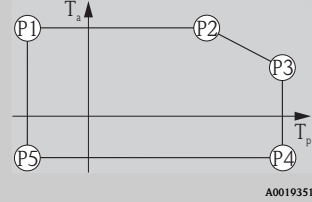
Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-40 (-40)	81 (178)	81 (178)	81 (178)	150 (302)	65 (149)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output not used	-40 (-40)	82 (180)	82 (180)	82 (180)	150 (302)	66 (151)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output used	-40 (-40)	77 (171)	77 (171)	77 (171)	150 (302)	59 (138)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 not used	-40 (-40)	82 (180)	82 (180)	82 (180)	150 (302)	66 (151)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 used	-40 (-40)	79 (174)	79 (174)	79 (174)	150 (302)	62 (144)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output not used	-40 (-40)	82 (180)	82 (180)	82 (180)	150 (302)	67 (153)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output used	-40 (-40)	78 (172)	78 (172)	78 (172)	150 (302)	61 (142)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
K, L	-40 (-40)	77 (171)	77 (171)	77 (171)	150 (302)	60 (140)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-

**FMR53**

**Process connection:**

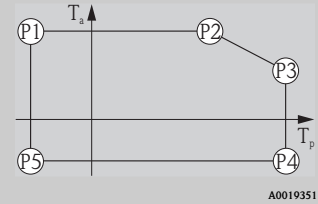
- Thread 316L
- Flange

**Housing: GT19 (Plastics PBT)**  
**Temperature unit: °C (°F)**



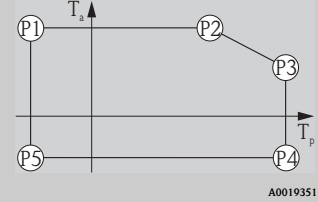
Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-40 (-40)	80 (176)	80 (176)	80 (176)	150 (302)	55 (131)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output not used	-40 (-40)	76 (169)	76 (169)	76 (169)	150 (302)	55 (131)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output used	-40 (-40)	60 (140)	60 (140)	60 (140)	150 (302)	37 (99)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 not used	-40 (-40)	82 (180)	82 (180)	82 (180)	150 (302)	55 (131)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 used	-40 (-40)	74 (165)	74 (165)	74 (165)	150 (302)	54 (129)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output not used	-40 (-40)	79 (174)	79 (174)	79 (174)	150 (302)	55 (131)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output used	-40 (-40)	63 (145)	63 (145)	63 (145)	150 (302)	40 (104)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-

**FMR53**  
**Process connection:**  
 ■ Thread 316L  
 ■ Flange  
**Housing: GT20 (Alu, coated)**  
**Temperature unit: °C (°F)**



Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-40 (-40)	81 (178)	81 (178)	81 (178)	150 (302)	68 (154)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output not used	-40 (-40)	82 (180)	82 (180)	82 (180)	150 (302)	69 (156)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output used	-40 (-40)	77 (171)	77 (171)	77 (171)	150 (302)	63 (145)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 not used	-40 (-40)	82 (180)	82 (180)	82 (180)	150 (302)	69 (156)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 used	-40 (-40)	79 (174)	79 (174)	79 (174)	150 (302)	65 (149)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output not used	-40 (-40)	83 (181)	83 (181)	83 (181)	150 (302)	70 (158)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output used	-40 (-40)	78 (172)	78 (172)	78 (172)	150 (302)	64 (147)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
K, L	-40 (-40)	77 (171)	77 (171)	77 (171)	150 (302)	64 (147)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-

**FMR54**  
**Horn antenna**  
**Seal:**  
 ■ Viton  
 ■ EPDM  
 ■ Kalrez  
**Housing: GT18 (316 L)**  
**Temperature unit: °C (°F)**



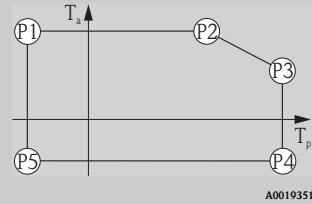
Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-40 (-40)	81 (178)	81 (178)	81 (178)	200 (392)	52 (126)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output not used	-40 (-40)	82 (180)	82 (180)	82 (180)	200 (392)	52 (126)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output used	-40 (-40)	77 (171)	77 (171)	77 (171)	200 (392)	46 (115)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 not used	-40 (-40)	82 (180)	82 (180)	82 (180)	200 (392)	52 (126)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 used	-40 (-40)	79 (174)	79 (174)	79 (174)	200 (392)	49 (120)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output not used	-40 (-40)	83 (181)	83 (181)	83 (181)	200 (392)	52 (126)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output used	-40 (-40)	78 (172)	78 (172)	78 (172)	200 (392)	48 (118)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
K, L	-40 (-40)	77 (171)	77 (171)	77 (171)	200 (392)	47 (117)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-

**FMR54**  
Horn antenna

Seal:

- Viton
- EPDM
- Kalrez

Housing: GT19 (Plastics PBT)  
Temperature unit: °C (°F)



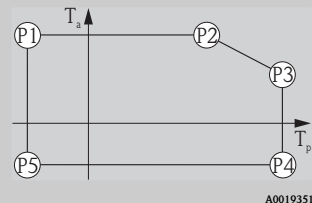
Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-40 (-40)	80 (176)	80 (176)	80 (176)	200 (392)	29 (84)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output not used	-40 (-40)	76 (169)	76 (169)	76 (169)	200 (392)	29 (84)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output used	-40 (-40)	60 (140)	60 (140)	60 (140)	200 (392)	23 (73)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 not used	-40 (-40)	82 (180)	82 (180)	82 (180)	200 (392)	29 (84)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 used	-40 (-40)	74 (165)	74 (165)	74 (165)	200 (392)	29 (84)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output not used	-40 (-40)	79 (174)	79 (174)	79 (174)	200 (392)	29 (84)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output used	-40 (-40)	63 (145)	63 (145)	63 (145)	200 (392)	26 (79)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-

**FMR54**  
Horn antenna

Seal:

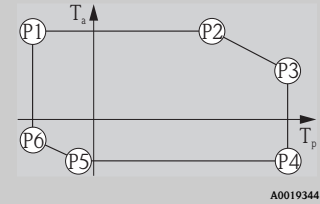
- Viton
- EPDM
- Kalrez

Housing: GT20 (Alu, coated)  
Temperature unit: °C (°F)



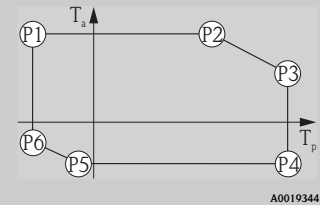
Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-40 (-40)	81 (178)	81 (178)	81 (178)	200 (392)	57 (135)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output not used	-40 (-40)	82 (180)	82 (180)	82 (180)	200 (392)	58 (136)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output used	-40 (-40)	77 (171)	77 (171)	77 (171)	200 (392)	52 (126)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 not used	-40 (-40)	82 (180)	82 (180)	82 (180)	200 (392)	58 (136)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 used	-40 (-40)	79 (174)	79 (174)	79 (174)	200 (392)	54 (129)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output not used	-40 (-40)	83 (181)	83 (181)	83 (181)	200 (392)	58 (136)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output used	-40 (-40)	78 (172)	78 (172)	78 (172)	200 (392)	54 (129)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
K, L	-40 (-40)	77 (171)	77 (171)	77 (171)	200 (392)	53 (127)	200 (392)	-40 (-40)	-40 (-40)	-40 (-40)	-	-

**FMR54**  
**Horn antenna**  
**Seal: Graphite -196 to 280 °C (-321 to 536 °F)**  
**Housing: GT18 (316 L)**  
**Temperature unit: °C (°F)**



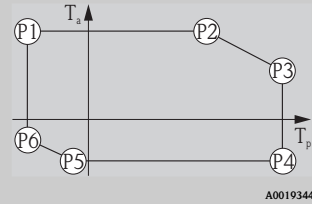
Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-196 (-321)	81 (178)	81 (178)	81 (178)	280 (536)	46 (115)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-9 (16)
B Switch output not used	-196 (-321)	82 (180)	82 (180)	82 (180)	280 (536)	46 (115)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-9 (16)
B Switch output used	-196 (-321)	77 (171)	77 (171)	77 (171)	280 (536)	42 (108)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-9 (16)
C Channel 2 not used	-196 (-321)	82 (180)	82 (180)	82 (180)	280 (536)	46 (115)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-9 (16)
C Channel 2 used	-196 (-321)	79 (174)	79 (174)	79 (174)	280 (536)	44 (111)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-9 (16)
E, G Switch output not used	-196 (-321)	83 (181)	83 (181)	83 (181)	280 (536)	46 (115)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-9 (16)
E, G Switch output used	-196 (-321)	78 (172)	78 (172)	78 (172)	280 (536)	44 (111)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-9 (16)
K, L	-196 (-321)	77 (171)	77 (171)	77 (171)	280 (536)	43 (109)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-9 (16)

**FMR54**  
**Horn antenna**  
**Seal: Graphite -196 to 280 °C (-321 to 536 °F)**  
**Housing: GT19 (Plastics PBT)**  
**Temperature unit: °C (°F)**



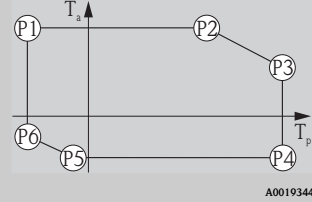
Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-196 (-321)	80 (176)	80 (176)	80 (176)	280 (536)	13 (55)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	18 (64)
B Switch output not used	-196 (-321)	76 (169)	76 (169)	76 (169)	280 (536)	13 (55)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	18 (64)
B Switch output used	-196 (-321)	60 (140)	60 (140)	60 (140)	280 (536)	13 (55)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	18 (64)
C Channel 2 not used	-196 (-321)	82 (180)	82 (180)	82 (180)	280 (536)	13 (55)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	18 (64)
C Channel 2 used	-196 (-321)	74 (165)	74 (165)	74 (165)	280 (536)	13 (55)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	18 (64)
E, G Switch output not used	-196 (-321)	79 (174)	79 (174)	79 (174)	280 (536)	13 (55)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	18 (64)
E, G Switch output used	-196 (-321)	63 (145)	63 (145)	63 (145)	280 (536)	13 (55)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	18 (64)

**FMR54**  
**Horn antenna**  
**Seal: Graphite -196 to 280 °C (-321 to 536 °F)**  
**Housing: GT20 (Alu, coated)**  
**Temperature unit: °C (°F)**



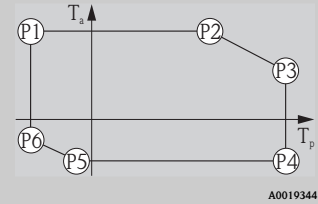
Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-196 (-321)	81 (178)	81 (178)	81 (178)	280 (536)	54 (129)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-15 (+5)
B Switch output not used	-196 (-321)	82 (180)	82 (180)	82 (180)	280 (536)	54 (129)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-15 (+5)
B Switch output used	-196 (-321)	77 (171)	77 (171)	77 (171)	280 (536)	49 (120)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-15 (+5)
C Channel 2 not used	-196 (-321)	82 (180)	82 (180)	82 (180)	280 (536)	54 (129)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-15 (+5)
C Channel 2 used	-196 (-321)	79 (174)	79 (174)	79 (174)	280 (536)	51 (124)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-15 (+5)
E, G Switch output not used	-196 (-321)	83 (181)	83 (181)	83 (181)	280 (536)	54 (129)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-15 (+5)
E, G Switch output used	-196 (-321)	78 (172)	78 (172)	78 (172)	280 (536)	50 (122)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-15 (+5)
K, L	-196 (-321)	77 (171)	77 (171)	77 (171)	280 (536)	50 (122)	280 (536)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-15 (+5)

**FMR54**  
**Horn antenna**  
**Seal: Graphite -196 to 400 °C (-321 to 752 °F)**  
**Housing: GT18 (316 L)**  
**Temperature unit: °C (°F)**



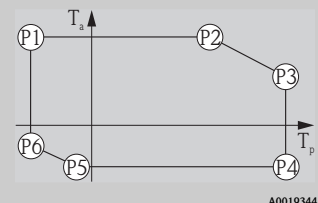
Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-196 (-321)	81 (178)	81 (178)	81 (178)	400 (752)	31 (88)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-13 (+9)
B Switch output not used	-196 (-321)	82 (180)	82 (180)	82 (180)	400 (752)	31 (88)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-13 (+9)
B Switch output used	-196 (-321)	77 (171)	77 (171)	77 (171)	400 (752)	29 (84)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-13 (+9)
C Channel 2 not used	-196 (-321)	82 (180)	82 (180)	82 (180)	400 (752)	31 (88)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-13 (+9)
C Channel 2 used	-196 (-321)	79 (174)	79 (174)	79 (174)	400 (752)	31 (88)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-13 (+9)
E, G Switch output not used	-196 (-321)	83 (181)	83 (181)	83 (181)	400 (752)	31 (88)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-13 (+9)
E, G Switch output used	-196 (-321)	78 (172)	78 (172)	78 (172)	400 (752)	31 (88)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-13 (+9)
K, L	-196 (-321)	77 (171)	77 (171)	77 (171)	400 (752)	30 (86)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-13 (+9)

**FMR54**  
**Horn antenna**  
**Seal: Graphite -196 to 400 °C (-321 to 752 °F)**  
**Housing: GT19 (Plastics PBT)**  
**Temperature unit: °C (°F)**



Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-196 (-321)	80 (176)	80 (176)	80 (176)	400 (752)	-19 (-2)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	11 (52)
B Switch output not used	-196 (-321)	76 (169)	76 (169)	76 (169)	400 (752)	-19 (-2)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	11 (52)
B Switch output used	-196 (-321)	60 (140)	60 (140)	60 (140)	400 (752)	-19 (-2)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	11 (52)
C Channel 2 not used	-196 (-321)	82 (180)	82 (180)	82 (180)	400 (752)	-19 (-2)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	11 (52)
C Channel 2 used	-196 (-321)	74 (165)	74 (165)	74 (165)	400 (752)	-19 (-2)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	11 (52)
E, G Switch output not used	-196 (-321)	79 (174)	79 (174)	79 (174)	400 (752)	-19 (-2)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	11 (52)
E, G Switch output used	-196 (-321)	63 (145)	63 (145)	63 (145)	400 (752)	-19 (-2)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	11 (52)

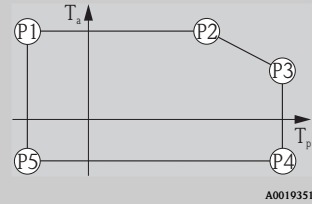
**FMR54**  
**Horn antenna**  
**Seal: Graphite -196 to 400 °C (-321 to 752 °F)**  
**Housing: GT20 (Alu, coated)**  
**Temperature unit: °C (°F)**



Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-196 (-321)	81 (178)	81 (178)	81 (178)	400 (752)	42 (108)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-19 (-2)
B Switch output not used	-196 (-321)	82 (180)	82 (180)	82 (180)	400 (752)	42 (108)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-19 (-2)
B Switch output used	-196 (-321)	77 (171)	77 (171)	77 (171)	400 (752)	39 (102)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-19 (-2)
C Channel 2 not used	-196 (-321)	82 (180)	82 (180)	82 (180)	400 (752)	42 (108)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-19 (-2)
C Channel 2 used	-196 (-321)	79 (174)	79 (174)	79 (174)	400 (752)	41 (106)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-19 (-2)
E, G Switch output not used	-196 (-321)	83 (181)	83 (181)	83 (181)	400 (752)	42 (108)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-19 (-2)
E, G Switch output used	-196 (-321)	78 (172)	78 (172)	78 (172)	400 (752)	40 (104)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-19 (-2)
K, L	-196 (-321)	77 (171)	77 (171)	77 (171)	400 (752)	40 (104)	400 (752)	-40 (-40)	-40 (-40)	-40 (-40)	-196 (-321)	-19 (-2)

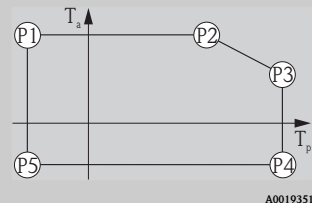


**FMR54**  
**Planar antenna**  
**Housing: GT18 (316 L)**  
**Temperature unit: °C (°F)**



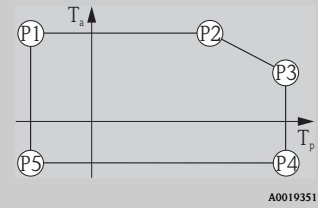
Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-40 (-40)	81 (178)	81 (178)	81 (178)	150 (302)	69 (156)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output not used	-40 (-40)	82 (180)	82 (180)	82 (180)	150 (302)	69 (156)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output used	-40 (-40)	77 (171)	77 (171)	77 (171)	150 (302)	63 (145)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 not used	-40 (-40)	82 (180)	82 (180)	82 (180)	150 (302)	70 (158)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 used	-40 (-40)	79 (174)	79 (174)	79 (174)	150 (302)	66 (151)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output not used	-40 (-40)	83 (181)	83 (181)	83 (181)	150 (302)	71 (160)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output used	-40 (-40)	78 (172)	78 (172)	78 (172)	150 (302)	65 (149)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
K, L	-40 (-40)	77 (171)	77 (171)	77 (171)	150 (302)	64 (147)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-

**FMR54**  
**Planar antenna**  
**Housing: GT19 (Plastics PBT)**  
**Temperature unit: °C (°F)**



Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-40 (-40)	80 (176)	80 (176)	80 (176)	150 (302)	60 (140)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output not used	-40 (-40)	76 (169)	76 (169)	76 (169)	150 (302)	60 (140)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output used	-40 (-40)	60 (140)	60 (140)	60 (140)	150 (302)	41 (106)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 not used	-40 (-40)	82 (180)	82 (180)	82 (180)	150 (302)	60 (140)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 used	-40 (-40)	74 (165)	74 (165)	74 (165)	150 (302)	57 (135)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output not used	-40 (-40)	79 (174)	79 (174)	79 (174)	150 (302)	60 (140)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output used	-40 (-40)	63 (145)	63 (145)	63 (145)	150 (302)	44 (111)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-

**FMR54**  
**Planar antenna**  
**Housing: GT20 (Alu, coated)**  
**Temperature unit: °C (°F)**



Power Supply; Output (Pos. 2 of the product structure)	P1		P2		P3		P4		P5		P6	
	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>	T <sub>p</sub>	T <sub>a</sub>
A	-40 (-40)	81 (178)	81 (178)	81 (178)	150 (302)	71 (160)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output not used	-40 (-40)	82 (180)	82 (180)	82 (180)	150 (302)	72 (162)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
B Switch output used	-40 (-40)	77 (171)	77 (171)	77 (171)	150 (302)	66 (151)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 not used	-40 (-40)	82 (180)	82 (180)	82 (180)	150 (302)	72 (162)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
C Channel 2 used	-40 (-40)	79 (174)	79 (174)	79 (174)	150 (302)	68 (154)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output not used	-40 (-40)	83 (181)	83 (181)	83 (181)	150 (302)	73 (163)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
E, G Switch output used	-40 (-40)	78 (172)	78 (172)	78 (172)	150 (302)	68 (154)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-
K, L	-40 (-40)	77 (171)	77 (171)	77 (171)	150 (302)	67 (153)	150 (302)	-40 (-40)	-40 (-40)	-40 (-40)	-	-

**Storage temperature** -40 to +80 °C (-40 to +176 °F)

**Climate class** DIN EN 60068-2-38 (test Z/AD)

**Geometric height according to IEC61010-1 Ed.3** Up to 2000 m (6600 ft) above MSL.

Can be expanded to 3000 m (9800 ft) above MSL by application of an overvoltage protection, e.g. HAW562 or HAW569.

**Degree of protection**

- With closed housing tested according to:
  - IP68, NEMA6P (24 h at 1.83 m under water surface)
  - For plastic housing with transparent cover (display module): IP68 (24 h at 1.00 m under water surface)<sup>5)</sup>
  - IP66, NEMA4X
- With open housing: IP20, NEMA1 (also ingress protection of the display)



Degree of protection IP68 NEMA6P applies for M12 PROFIBUS PA plugs only when the PROFIBUS cable is plugged in and is also rated IP68 NEMA6P.

**Vibration resistance**

DIN EN 60068-2-64 / IEC 68-2-64: 20 to 2000 Hz, 1 (m/s<sup>2</sup>)/Hz

**Cleaning the antenna**

The antenna can get contaminated, depending on the application. The emission and reception of microwaves can thus eventually be hindered. The degree of contamination leading to an error depends on the medium and the reflectivity, mainly determined by the dielectric constant  $\epsilon_r$ .

If the medium tends to cause contamination and deposits, cleaning on a regular basis is recommended. Care has to be taken not to damage the antenna in the process of a mechanical or hose-down cleaning. The material compatibility has to be considered if cleaning agents are used! The maximum permitted temperature at the flange should not be exceeded.

5) This restriction is valid if the following options of the product structure have been selected at the same time: 030("Display, Operation") = C("SD02") or E("SD03"); 040("Housing") = A("GT19").

**Electromagnetic compatibility (EMC)**

Electromagnetic compatibility to all relevant requirements of the EN 61326- series and NAMUR recommendation EMC (NE21). For details see declaration of conformity. <sup>6)</sup>.

If only the analogue signal is used, unshielded interconnection lines are sufficient for the installation. In case of using the digital signal (HART/ PA/ FF) use shielded interconnection lines. Use a shielded cable when working with a digital communications signal.

Max. fluctuations during EMC- tests: < 0.5 % of the span. As an exception to this, the maximum fluctuations may amount to 2 % of the span for devices with plastic housing and see-through lid (integrated display and operating module SD02 or SD03) if strong electromagnetic interferences in the frequency range of 1 to 2 GHz are present.

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6) Can be downloaded from [www.endress.com](http://www.endress.com).

## Process

### Process temperature range

Sensor	Process Connection	Process temperature range
FMR53	Thread PVDF	-40 to +80 °C (-40 to +176 °F)
	Other process connections	-40 to +150 °C (-40 to +302 °F)

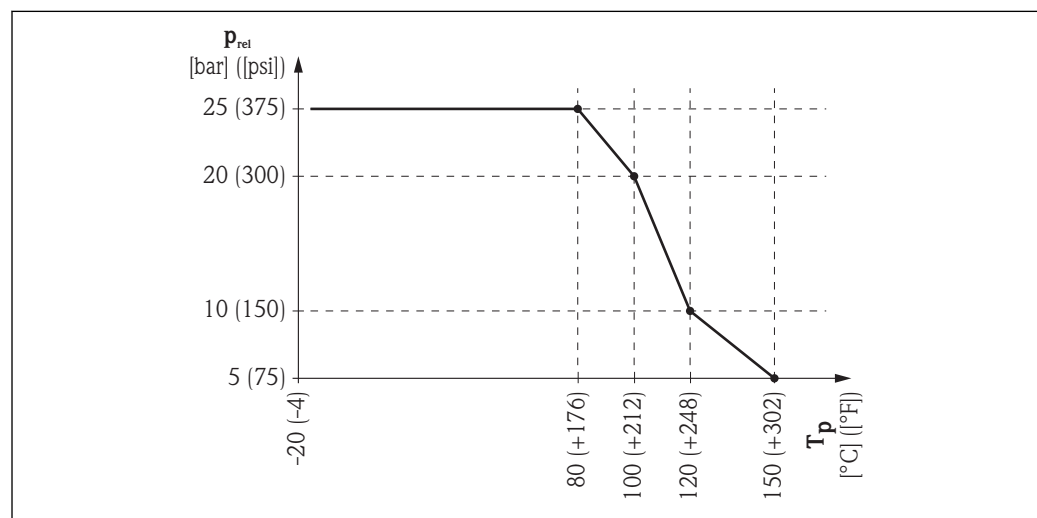
Sensor	Antenna	Seal	Process temperature range
FMR54	Horn	Viton	-40 to +200 °C (-40 to +392 °F) <sup>1)</sup>
		EPDM	-40 to +150 °C (-40 to +302 °F)
		Kalrez	-20 to +200 °C (-4 to +392 °F) <sup>1)</sup>
		Graphite XT	-196 to +280 °C (-321 to 536 °F)
		Graphite HT	-196 to +400 °C (-321 to 752 °F)
	Planar	Viton	-20 to +150 °C (-4 to +302 °F)

1) bei leitfähigen Medien maximal 150 °C (302°F)

### Process pressure range

Sensor	Process connection	Process pressure range
FMR53	Thread PVDF	$p_{rel} = -1$ to 3 bar (-14.5 to 43.5 psi) $p_{abs} < 4$ bar (58 psi)
	<ul style="list-style-type: none"> <li>■ Thread 316L</li> <li>■ Flange 316L</li> </ul>	$p_{rel} = -1$ to 40 bar (-14.5 to 580 psi)

Sensor	Antenna	Seal	Process pressure range
FMR54	Horn	<ul style="list-style-type: none"> <li>■ Viton</li> <li>■ EPDM</li> <li>■ Kalrez</li> </ul>	$p_{rel} = -1$ to 64 bar (-14.5 to 928 psi)
		Graphite (XT)	$p_{rel} = -1$ to 100 bar (-14.5 to 1 450 psi)
		Graphite (HT)	$p_{rel} = -1$ to 160 bar (-14.5 to 2 320 psi)
	Planar	Viton	depending on the process temperature; see diagram



16 Admissible process pressure  $p_{rel}$  as a function of the process temperature  $T_p$  for FMR54 with planar antenna



This range may be reduced by the selected process connection. The pressure rating (PN) specified on the flanges refers to a reference temperature of 20 °C, for ASME flanges 100 °F. Pay attention to pressure-temperature dependencies.

Please refer to the following standards for the pressure values permitted for higher temperatures:

- EN 1092-1: 2001 Tab. 18  
With regard to their temperature stability properties, the materials 1.4435 and 1.4404 are grouped under 13E0 in EN 1092-1 Tab. 18. The chemical composition of the two materials can be identical.
- ASME B 16.5a - 1998 Tab. 2-2.2 F316
- ASME B 16.5a - 1998 Tab. 2.3.8 N10276
- JIS B 2220

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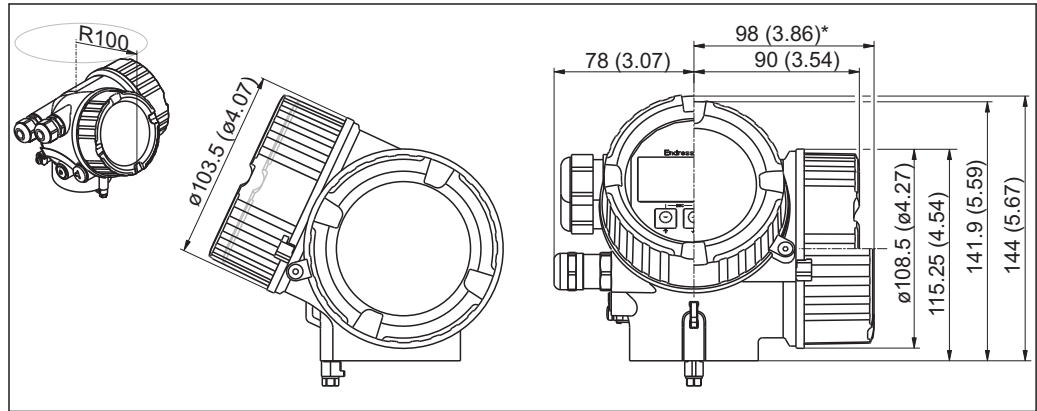
**Dielectric constant**

- **For liquids**
  - $\epsilon_r \geq 1.9$  in free-field applications
  - $\epsilon_r \geq 1.4$  in stilling well
- **For bulk solids**
  - $\epsilon_r \geq 1.6$

## Mechanical construction

### Dimensions

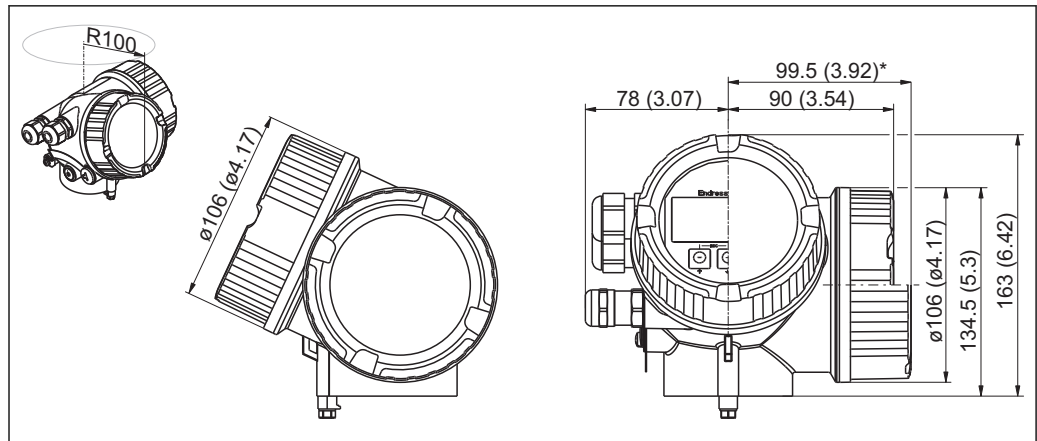
#### Dimensions of the electronics housing



A0011600

17 Housing GT18 (316L); Dimensions in mm (in)

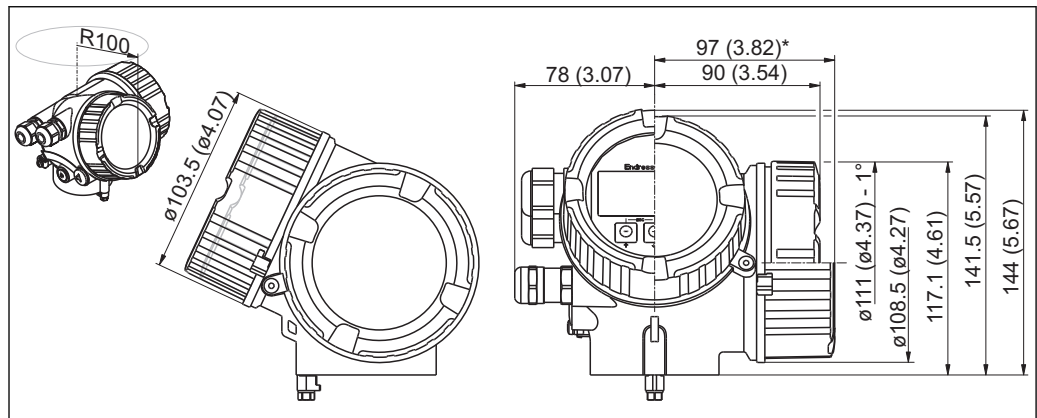
\*This measure is valid for devices with integrated overvoltage protection.



A0011340

18 Housing GT19 (Plastics PBT); Dimensions in mm (in)

\*This measure is valid for devices with integrated overvoltage protection.

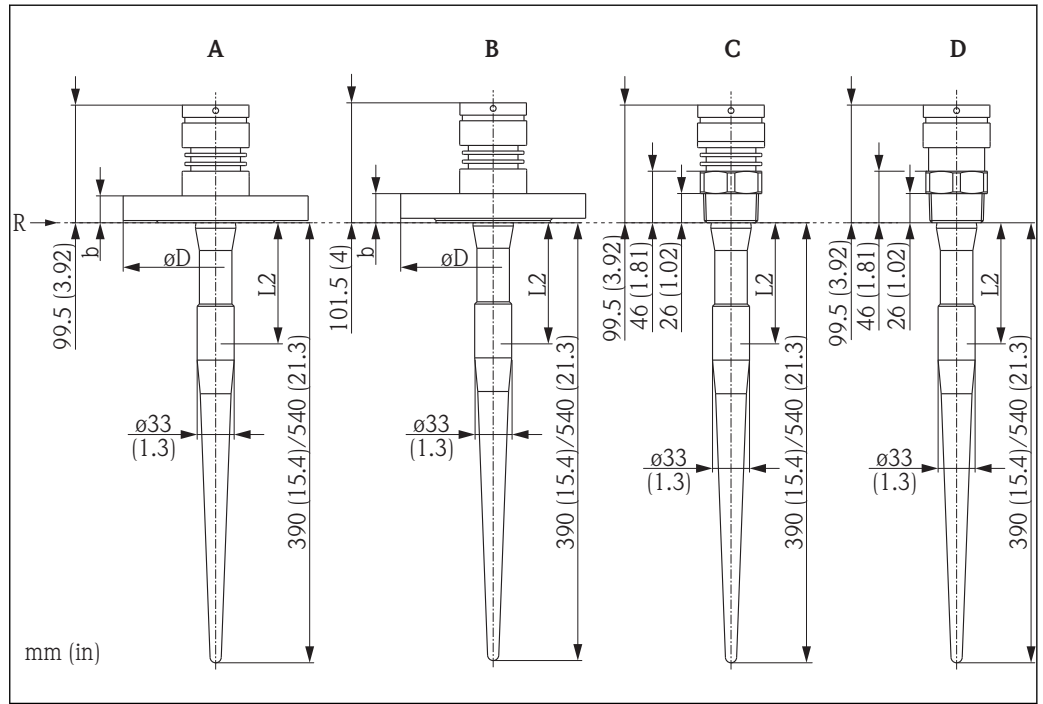


A0011605

19 Housing GT20 (Alu coated); Dimensions in mm (in)

\*This measure is valid for devices with integrated overvoltage protection.

**Dimensions FMR53 (process connection/antenna)**



- A Flange version
- B Flange version, coated
- C Threaded connection, stainless steel
- D Threaded connection, PVDF
- L2 Inactive length

*Flanges according to EN1092-1 (suitable for DIN2527)*

Dimension	Version	DN50	DN80	DN100	DN150
b	PN16	20 mm (0.79 in)	20 mm (0.79 in)	20 mm (0.79 in)	22 mm (0.87 in)
øD		ø165 mm (6.5 in)	ø200 mm (7.87 in)	ø220 mm (8.66 in)	ø285 mm (11.2 in)
b	PN40	-	24 mm (0.94 in)	-	-
øD		-	ø200 mm (7.87 in)	-	-

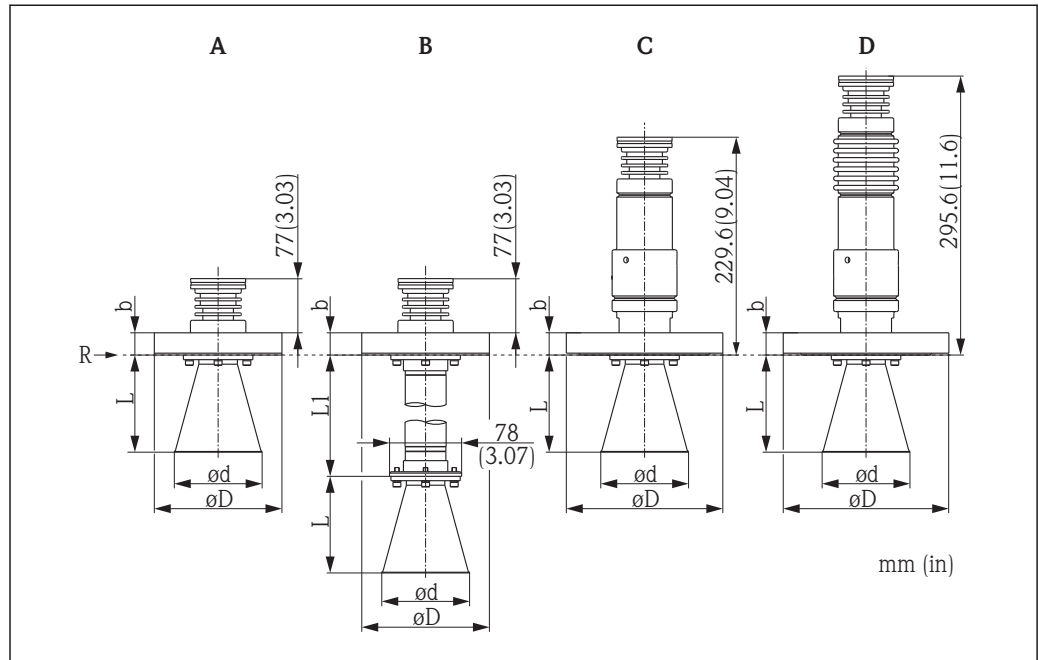
*Flanges according to ANSI B16.5*

Dimension	Version	2"	3"	4"	6"
b	150 lbs	19.1 mm (0.75 in)	23.9 mm (0.94 in)	23.9 mm (0.94 in)	25.4 mm (1 in)
øD		ø152.4 mm (6 in)	ø190.5 mm (7.5 in)	ø228.6 mm (9 in)	ø279.4 mm (11 in)
b	300 lbs	-	28.4 mm (1.12 in)	31.8 mm (1.25 in)	-
øD		-	ø209.5 mm (8.25 in)	ø254 mm (10 in)	-

*Flanges according to JIS B2220*

Dimension	Version	DN50	DN80	DN100	DN150
b	10 K	16 mm (0.63 in)	18 mm (0.71 in)	18 mm (0.71 in)	22 mm (0.87 in)
øD		ø155 mm (6.1 in)	ø185 mm (7.28 in)	ø210 mm (8.27 in)	ø280 mm (11 in)

**Dimensions FMR54 (process connection/antenna)**



A0017809

- A Compact version with flange
- B Compact version with flange and antenna extension
- C Version XT 280°C (536°F) with flange (and with an optional antenna extension)
- D Version HT 400° (752°F) with flange (and with an optional antenna extension)
- L1 Antenna extension; standard lengths: 100 mm (3.94 in), 200 mm (7.87 in), 300 mm (11.8 in) or 400 mm (15.7 in)
- R Reference point of the measurement

*Horn antenna*

Dimension	80 mm (3")	100 mm (4")	150 mm (6")	200 mm (8")	250 mm (10")
L	68 mm (2.68 in)	105 mm (4.13 in)	185 mm (7.28 in)	268 mm (10.6 in)	360 mm (14.2 in)
ød	ø75 mm (2.95 in)	ø95 mm (3.74 in)	ø145 mm (5.71 in)	ø190 mm (7.48 in)	ø240 mm (9.45 in)

*Flanges according to EN1092-1 (suitable for DIN2527)*

Dimension	Version	DN80	DN100	DN150	DN200	DN250
b	PN16	20 mm (0.79 in)	20 mm (0.79 in)	22 mm (0.87 in)	24 mm (0.94 in)	26 mm (1.02 in)
øD		ø200 mm (7.87 in)	ø220 mm (8.66 in)	ø285 mm (11.2 in)	ø340 mm (13.4 in)	ø405 mm (15.9 in)
b	PN40	24 mm (0.94 in)	24 mm (0.94 in)	-	-	-
øD		ø200 mm (7.87 in)	ø235 mm (9.25 in)	-	-	-

*Flanges according to ANSI B16.5*

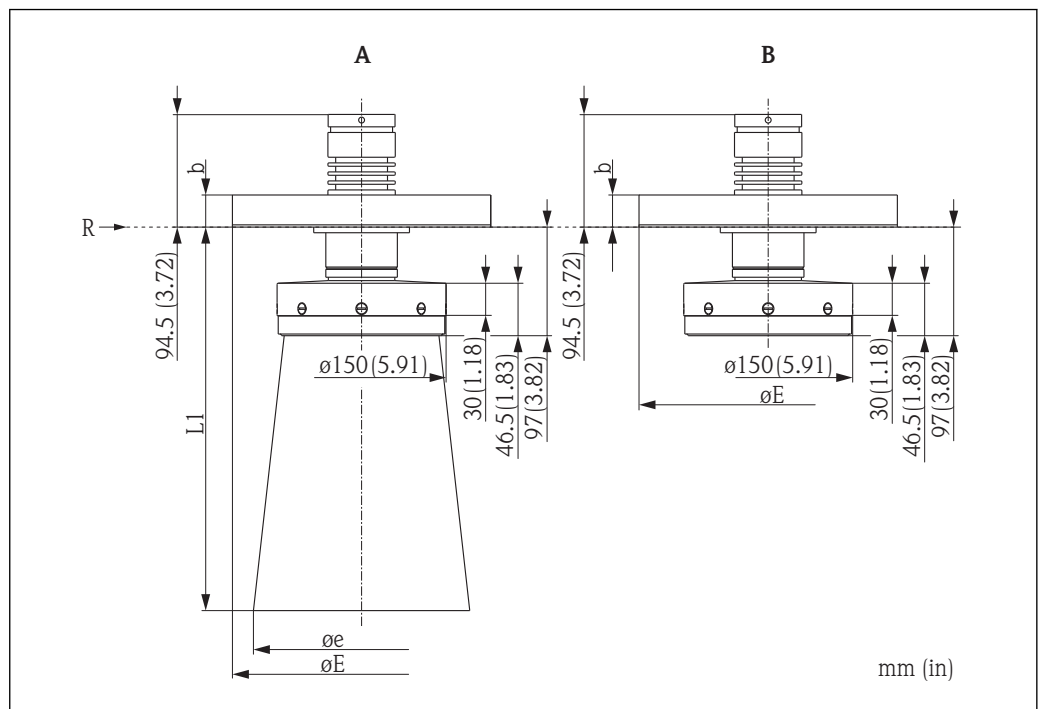
Dimension	Version	3"	4"	6"	8"	10"
b	150 lbs	23.9 mm (0.94 in)	23.9 mm (0.94 in)	25.4 mm (1 in)	28.4 mm (1.12 in)	30.2 mm (1.19 in)
øD		ø190.5 mm (7.5 in)	ø228.6 mm (9 in)	ø279.4 mm (11 in)	ø342.9 mm (13.5 in)	ø406.4 mm (16 in)



Dimension	Version	3"	4"	6"	8"	10"
b	300 lbs	28.4 mm (1.12 in)	31.8 mm (1.25 in)	-	-	-
øD		ø209.5 mm (8.25 in)	ø254 mm (10 in)	-	-	-

Flanges according to JIS B 2220

Dimension	Version	DN80	DN100	DN150	DN200	DN250
b	10 K	18 mm (0.71 in)	18 mm (0.71 in)	22 mm (0.87 in)	22 mm (0.87 in)	24 mm (0.94 in)
øD		ø185 mm (7.28 in)	ø210 mm (8.27 in)	ø280 mm (11 in)	ø330 mm (13 in)	ø400 mm (15.7 in)



A0017810

- A Planar (drip-off) version with flange and horn
- B Planar (drip-off) version with flange, without horn
- R Reference point of the measurement

Antenna version

Dimension	DN200 (8")	DN250 (10")	DN300 (12")
e	192 mm (7.56 in)	242 mm (9.53 in)	292 mm (11.5 in)
L1	341 mm (13.4 in)	494 mm (19.4 in)	521 mm (20.5 in)

Flanges according to EN1092-1 (suitable for DIN2527)

Dimension	Version	DN150	DN200	DN250	DN300
b	PN16	22 mm (0.87 in)	24 mm (0.94 in)	26 mm (1.02 in)	28 mm (1.1 in)
øE		ø285 mm (11.2 in)	ø340 mm (13.4 in)	ø405 mm (15.9 in)	ø460 mm (18.1 in)
b	PN25	28 mm (1.1 in)	30 mm (1.18 in)	-	-
øE		ø300 mm (11.8 in)	ø360 mm (14.2 in)	-	-

*Flanges according to ANSI B16.5*

Dimension	Version	6"	8"	10"	12"
b	150 lbs	25.4 mm (1 in)	28.4 mm (1.12 in)	30.2 mm (1.19 in)	31.8 mm (1.25 in)
øE		ø279.4 mm (11 in)	ø342.9 mm (13.5 in)	ø406.4 mm (16 in)	ø482.6 mm (19 in)
b	300 lbs	36.6 mm (1.44 in)	41.1 mm (1.62 in)	-	-
øE		ø317.5 mm (12.5 in)	ø381 mm (15 in)	-	-

*Flanges according to JIS B2220*

Dimension	Version	DN150	DN200	DN250
b	10 K	22 mm (0.87 in)	22 mm (0.87 in)	24 mm (0.94 in)
øE		ø280 mm (11 in)	ø330 mm (13 in)	ø400 mm (15.7 in)
b	20 K	28 mm (1.1 in)	30 mm (1.18 in)	-
øE		ø305 mm (12 in)	ø350 mm (13.8 in)	-

**Weight***Housing*

Part	Weight
Housing GT18 - stainless steel	approx. 4.5 kg (9.9 lbs)
Housing GT19 - plastic	approx. 1.2 kg (2.7 lbs)
Housing GT20 - aluminium	approx. 1.9 kg (4.2 lbs)

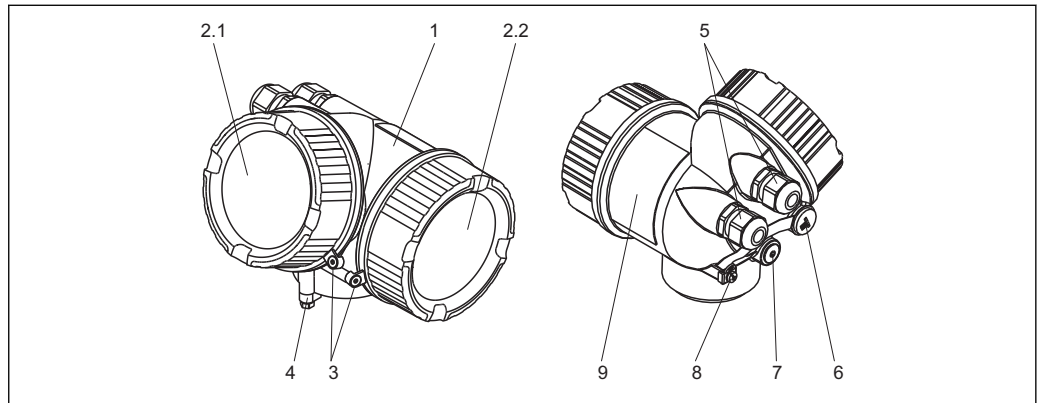
*Antenna and process connection*

Device	Weight of antenna and process connection
FMR53	max. 3.0 kg (6.6 lbs) + weight of flange <sup>1)</sup>
FMR54	max. 9 kg (19.9 lbs) + weight of flange <sup>1)</sup>

1) For the weight of the flange refer to Technical Information TI00426F.

**Materials**

**Housing**



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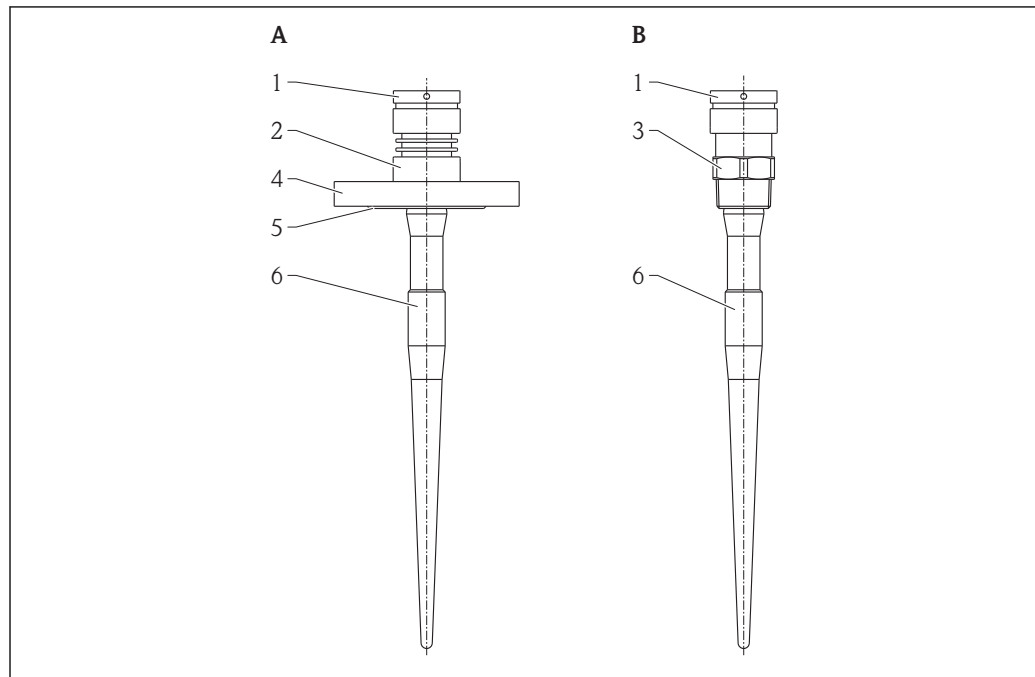
Housing GT18 - stainless steel, corrosion-resistant			
No.	Part: material	No.	Part: material
1	Housing: 316L (CF-3M, 1.4404)	5	Cable entry <ul style="list-style-type: none"> <li>■ Sealing: EMPB</li> <li>■ Cable gland: 316L (1.4404)</li> <li>■ Adapter: 316L (1.4435)</li> </ul>
2.1	Cover of the electronics compartment <ul style="list-style-type: none"> <li>■ Cover: 316L (CF-3M, 1.4404)</li> <li>■ Window: glass</li> <li>■ Cover seal: EPDM</li> </ul>	6	Dummy plug: 316L (1.4404)
2.2	Cover of the terminal compartment <ul style="list-style-type: none"> <li>■ Cover: 316L (CF-3M, 1.4404)</li> <li>■ Cover seal: EPDM</li> </ul>	7	Pressure relief stopper: 316L (1.4404)
3	Cover lock <ul style="list-style-type: none"> <li>■ Screw: A4</li> <li>■ Clamp: 316L (1.4404)</li> </ul>	8	Ground terminal <ul style="list-style-type: none"> <li>■ Screw: A4</li> <li>■ Spring washer: A4</li> <li>■ Clamp: 316L (1.4404)</li> <li>■ Holder: 316L (1.4404)</li> </ul>
4	Turn housing <ul style="list-style-type: none"> <li>■ Screw: A4-70</li> <li>■ Clamp: 316L (1.4404)</li> </ul>	9	Identification <ul style="list-style-type: none"> <li>■ Nameplate: 304 (1.4301)</li> <li>■ Groove pin: A2</li> </ul>

Housing GT19 - plastic			
No.	Part: material	No.	Part: material
1	Housing: PBT	5	Cable entry <ul style="list-style-type: none"> <li>■ Sealing: EMPB</li> <li>■ Cable gland: polyamide (PA), nickel-plated brass (CuZn)</li> <li>■ Adapter: 316L (1.4435)</li> </ul>
2.1	Cover of the electronics compartment <ul style="list-style-type: none"> <li>■ Cover:                             <ul style="list-style-type: none"> <li>- PA (see-through cover)</li> <li>- PBT (non-transparent cover)</li> </ul> </li> <li>■ Cover seal: EPDM</li> </ul>	6	Dummy plug: nickel-plated brass (CuZn)
2.2	Cover of the terminal compartment <ul style="list-style-type: none"> <li>■ Cover: PBT</li> <li>■ Cover seal: EPDM</li> </ul>	7	Pressure relief stopper: nickel-plated brass (CuZn)
4	Turn housing <ul style="list-style-type: none"> <li>■ Screw: A4-70</li> <li>■ Clamp: 316L (1.4404)</li> </ul>	8	Ground terminal <ul style="list-style-type: none"> <li>■ Screw: A2</li> <li>■ Spring washer: A4</li> <li>■ Clamp: 304 (1.4301)</li> <li>■ Holder: 304 (1.4301)</li> </ul>
		9	Identification Nameplate: sticker

Housing GT20 - die-cast aluminum, powder-coated, seawater-resistant			
No.	Part: material	No.	Part: material
1	Housing: AlSi10Mg(<0.1% Cu) Coating: polyester	5	Cable entry <ul style="list-style-type: none"> <li>■ Sealing: EMPB</li> <li>■ Cable gland: polyamide (PA), nickel-plated brass (CuZn)</li> <li>■ Adapter: 316L (1.4435)</li> </ul>
2.1	Cover of the electronics compartment <ul style="list-style-type: none"> <li>■ Cover: AlSi10Mg(&lt;0.1% Cu)</li> <li>■ Window: glass</li> <li>■ Cover seal: EPDM</li> </ul>	6	Dummy plug: nickel-plated brass (CuZn)
2.2	Cover of the terminal compartment <ul style="list-style-type: none"> <li>■ Cover: AlSi10Mg(&lt;0.1% Cu)</li> <li>■ Cover seal: EPDM</li> </ul>	7	Pressure relief stopper: nickel-plated brass (CuZn)
3	Cover lock <ul style="list-style-type: none"> <li>■ Screw: A4</li> <li>■ Clamp: 316L (1.4404)</li> </ul>	8	Ground terminal <ul style="list-style-type: none"> <li>■ Screw: A2</li> <li>■ Spring washer: A2</li> <li>■ Clamp: 304 (1.4301)</li> <li>■ Holder: 304 (1.4301)</li> </ul>
4	Turn housing <ul style="list-style-type: none"> <li>■ Screw: A4-70</li> <li>■ Clamp: 316L (1.4404)</li> </ul>	9	Identification Nameplate: sticker

**Antenna and process connection**

*FMR53*



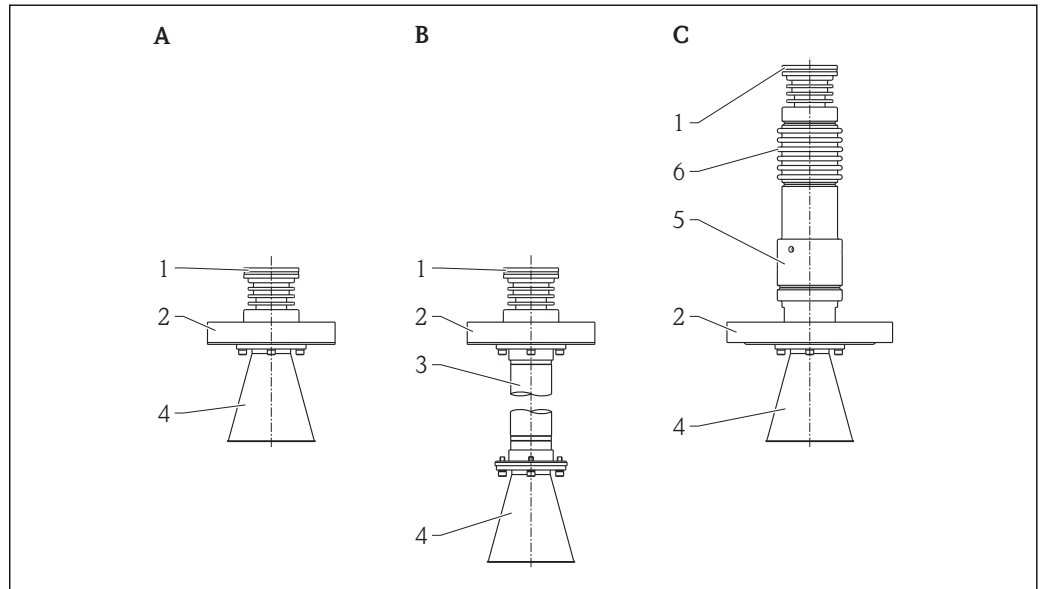
A0018954

- A Flange version
- B Version with threaded connection

Pos.	Part	Material
1	Housing adapter	316L (1.4404)
2	Connection	316L (1.4404)
3	Connection	316L (1.4404) PVDF
4	Flange	316L (1.4404/1.4435)

Pos.	Part	Material
5	Cladding	PTFE
6	Rod antenna	PTFE

*FMR54 mit Hornantenne*

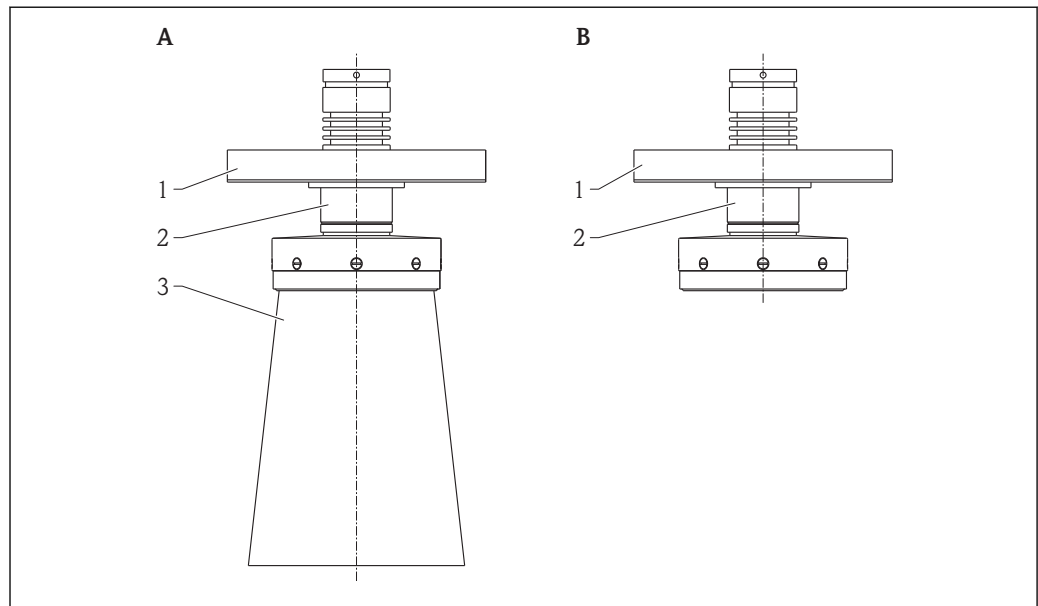


A0018950

- A Compact version
- B Version with antenna extension
- C High temperature version

Pos.	Part	Material	
1	Sensor adapter	316L (1.4404)	
2	Flange	316L (1.4404/1.4435)	
3	Antenna extension	316L (1.4435)	
	Screw	A4	
	Spring-lock washer	A4	
4	Horn antenna	316L (1.4404)	
	Screw	A4	
	Spring-lock washer (compact)	A4	
	Nordlock washer (XT and HT version)	A4	
	Process separation cone	Compact version: PTFE	High temperature version: Al <sub>2</sub> O <sub>3</sub>
	Seal	Compact version: FKM, FFKM, EPDM	High temperature version: Graphite
5	Process separation	316L (1.4404)	
6	Temperature reduction	316L (1.4404)	

*FMR54 with planar or drip-off antenna*

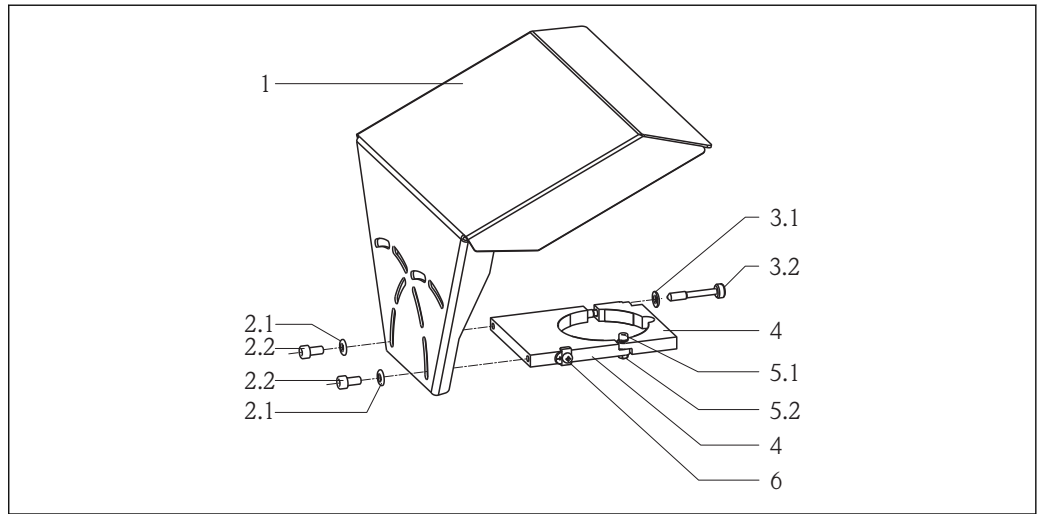


A0018957

- A Version with horn  
 B Version without horn

Pos.	Part	Material
1	Flange	316L (1.4404/1.4435)
	Adapter	316L (1.4404)
2	Housing adapter	316L (1.4404)
	Sensor adapter	316L (1.4404)
	Housing and retaining ring	316L (1.4404)
	Screw	A2
	Planar antenna	PTFE
	Sealing ring	FKM
3	Horn antenna	316L (1.4404)

**Weather protection cover**



A0015473

Weather protection cover			
Nr.	Part: material	Nr.	Part: material
1	Protection cover: 304 (1.4301)	4	Bracket: 304 (1.4301)
2.1	Washer: A2	5.1	Cheese head screw: A2-70
2.2	Cheese head screw: A4-70	5.2	Nut: A2
3.1	Washer: A2	6	Ground terminal ■ Screw: A4 ■ Spring washer: A4 ■ Clamp: 316L (1.4404) ■ Holder: 316L (1.4404)
3.2	Tightening screw: 304 (1.4301)		

## Operability

### Operating concept

#### Operator-oriented menu structure for user-specific tasks

- Commissioning
- Operation
- Diagnostics
- Expert level

#### Quick and safe commissioning

- Guided menus ("Make-it-run" wizards) for applications
- Menu guidance with brief explanations of the individual parameter functions

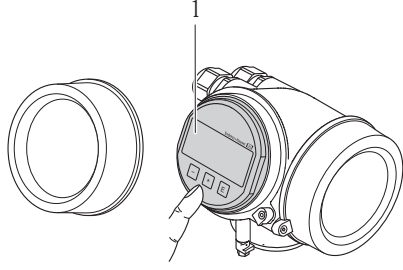
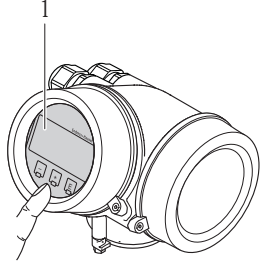
#### Reliable operation

- Local operation in different languages (see product structure, feature "Additional Operation Language")
- Standardized operation at the device and in the operating tools
- Data storage device (HistoROM) for process and measuring device data with event logbook available at all times - even if electronics modules are replaced

#### Efficient diagnostics increase measurement reliability

- Remedy information is integrated in plain text
- Diverse simulation options and line recorder functions

### Local operation

Order code for "Display; Operation", option <b>C</b> "SD02"	Order code for "Display; Operation", option <b>E</b> "SD03" (in preparation)
 <p style="text-align: right; font-size: small;">A0015544</p>	 <p style="text-align: right; font-size: small;">A0015540</p>
1 Operation with pushbuttons	1 Operation with touch control

#### Display elements

- 4-line display
- In the case of order code for "Display; Operation", option **E**: white background lighting; switches to red in event of device errors (in preparation)
- Format for displaying measured variables and status variables can be individually configured
- Permitted ambient temperature for the display:  $-20$  to  $+60$  °C ( $-4$  to  $+140$  °F)  
The readability of the display may be impaired at temperatures outside the temperature range.

#### Operating elements

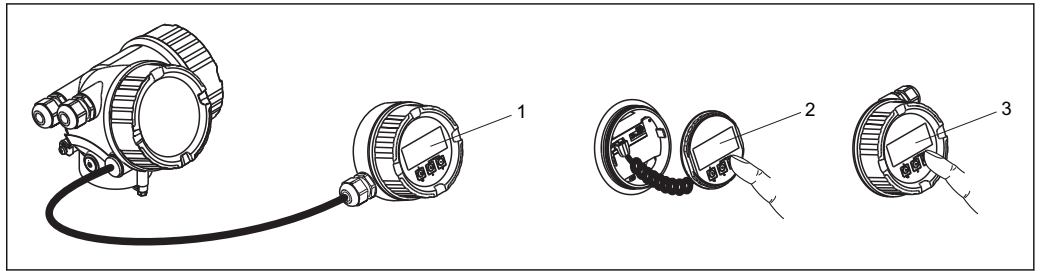
- In the case of order code "Display; Operation", Option **C**: local operation with 3 push buttons (⊖, ⊕, ⊞)
- In the case of order code for "Display; Operation", option **E**: external operation via touch control; 3 optical keys: ⊖, ⊕, ⊞ (in preparation)
- Operating elements also accessible in various hazardous areas

#### Additional functionality

- Data backup function  
The device configuration can be saved in the display module.
- Data comparison function  
The device configuration saved in the display module can be compared to the current device configuration.
- Data transfer function  
The transmitter configuration can be transmitted to another device using the display module.



**Operation with remote display and operating module FHX50**



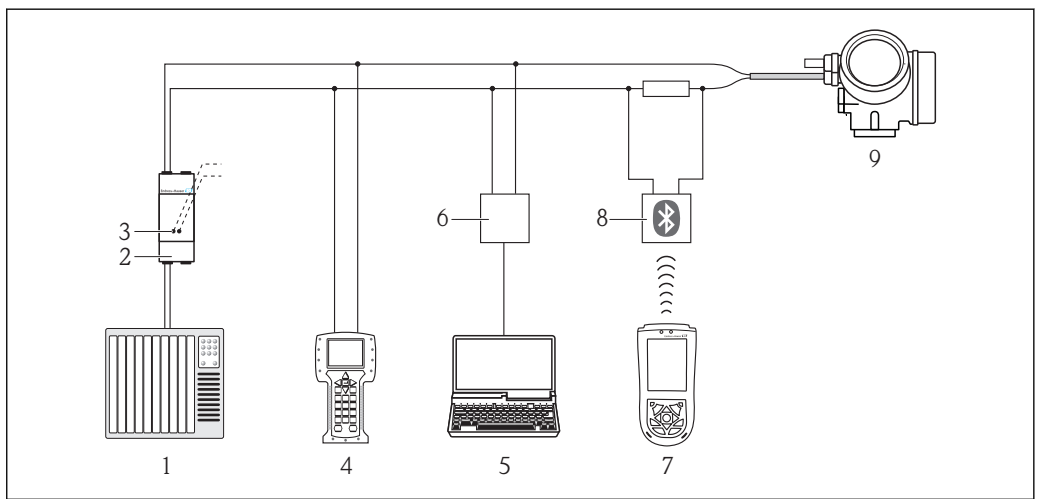
A0013137

20 FHX50 operating options

- 1 Housing of the remote display and operating module FHX50
- 2 Display and operating module SD02, push buttons; cover must be removed
- 3 Display and operating module SD03, optical keys; can be operated through the glass of the cover (in preparation)

**Remote operation**

**Via HART protocol**

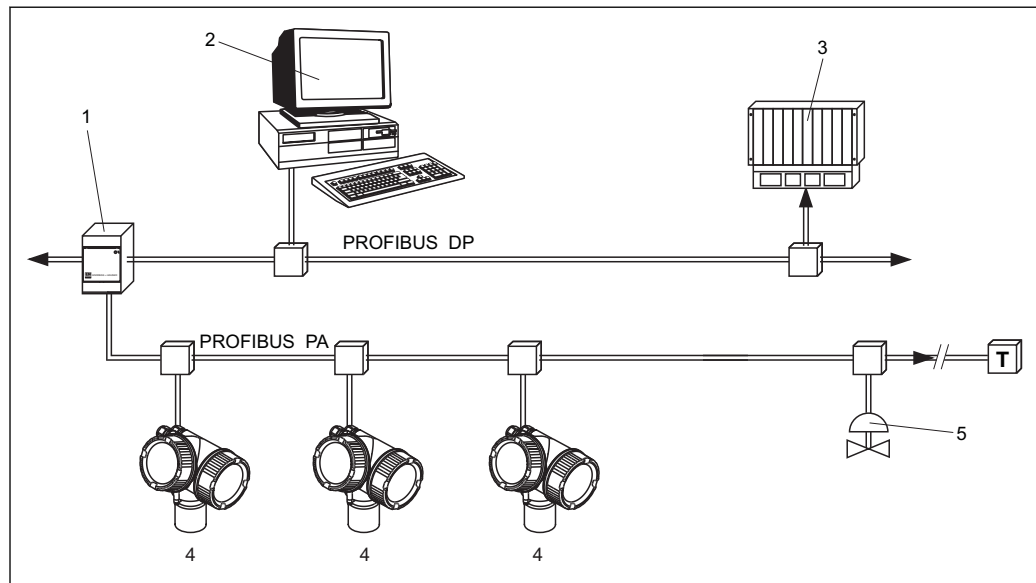


A0013764

21 Options for remote operation via HART protocol

- 1 PLC (programmable logic controller)
- 2 Transmitter power supply unit, e.g. RN221N (with communication resistor)
- 3 Connection for Commubox FXA191, FXA195 and Field Communicator 375, 475
- 4 Field Communicator 375, 475
- 5 Computer with operating tool (e.g. FieldCare, AMS Device Manager, SIMATIC PDM)
- 6 Commubox FXA191 (RS232) or FXA195 (USB)
- 7 Field Xpert SFX100
- 8 VIATOR Bluetooth modem with connecting cable
- 9 Transmitter

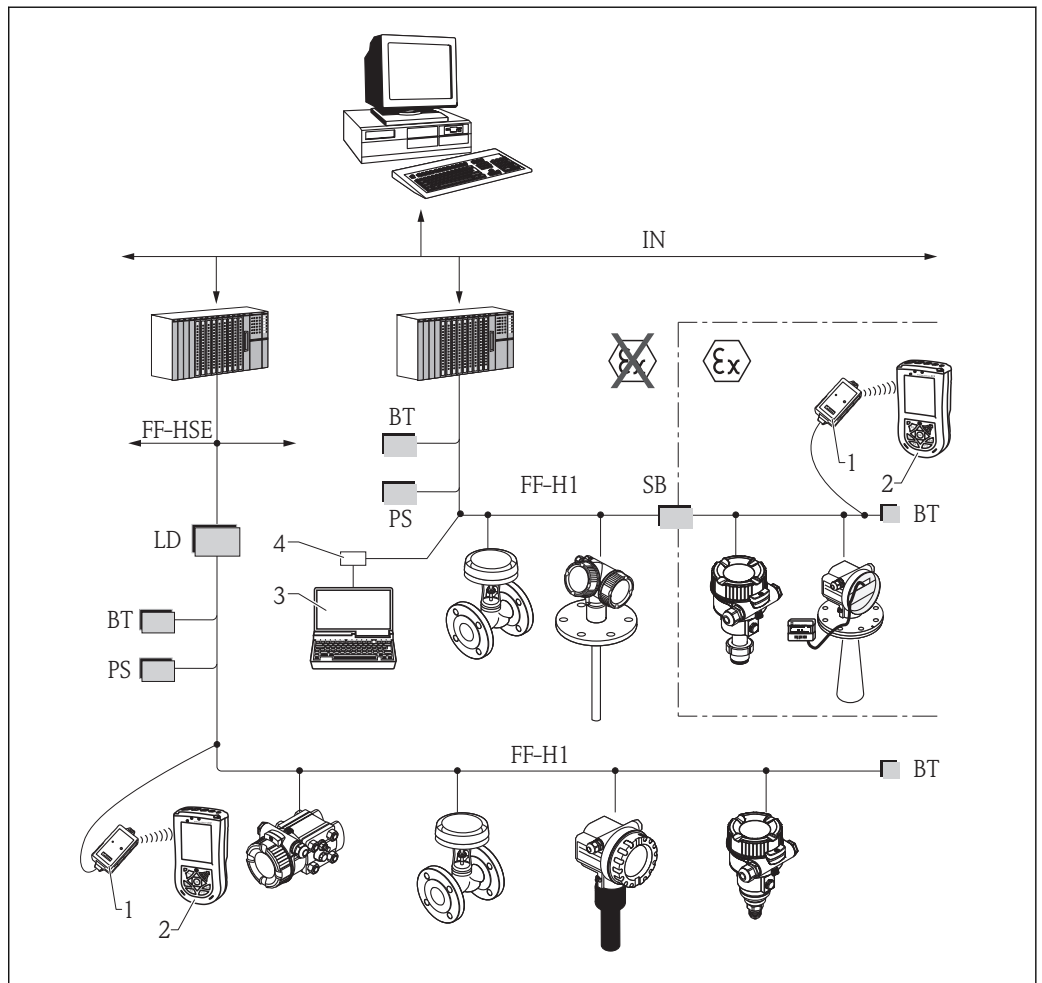
Via PROFIBUS PA protocol (in preparation)



A0015775

- 1 Segment coupler
- 2 Computer with Profiboard/Proficard and operating tool (e.g. FieldCare)
- 3 PLC (Programmable Logic Controller)
- 4 Transmitter
- 5 Additional functions (valves etc.)

Via FOUNDATION Fieldbus (in preparation)

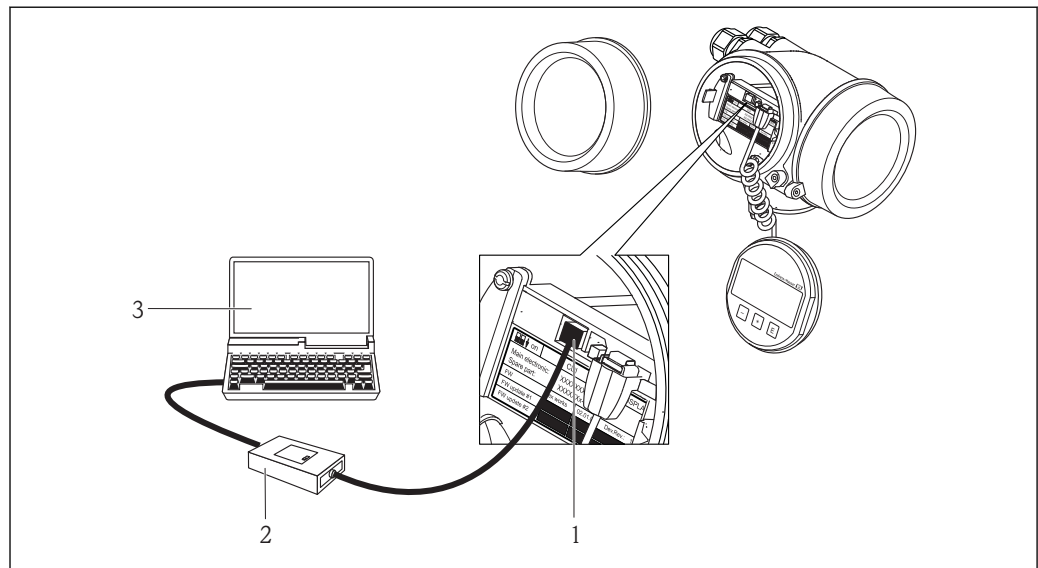


A0017188

22 FOUNDATION Fieldbus system architecture with associated components

- IN Industrial network
- FF- High Speed Ethernet
- HSE
- FF- FOUNDATION Fieldbus-H1
- H1
- LD Linking Device FF-HSE/FF-H1
- PS Bus Power Supply
- SB Safety Barrier
- BT Bus Terminator
- 1 FFblue Bluetooth modem
- 2 Field Xpert SFX100
- 3 FieldCare
- 4 NI-FF interface card

**Via service interface (CDI)**

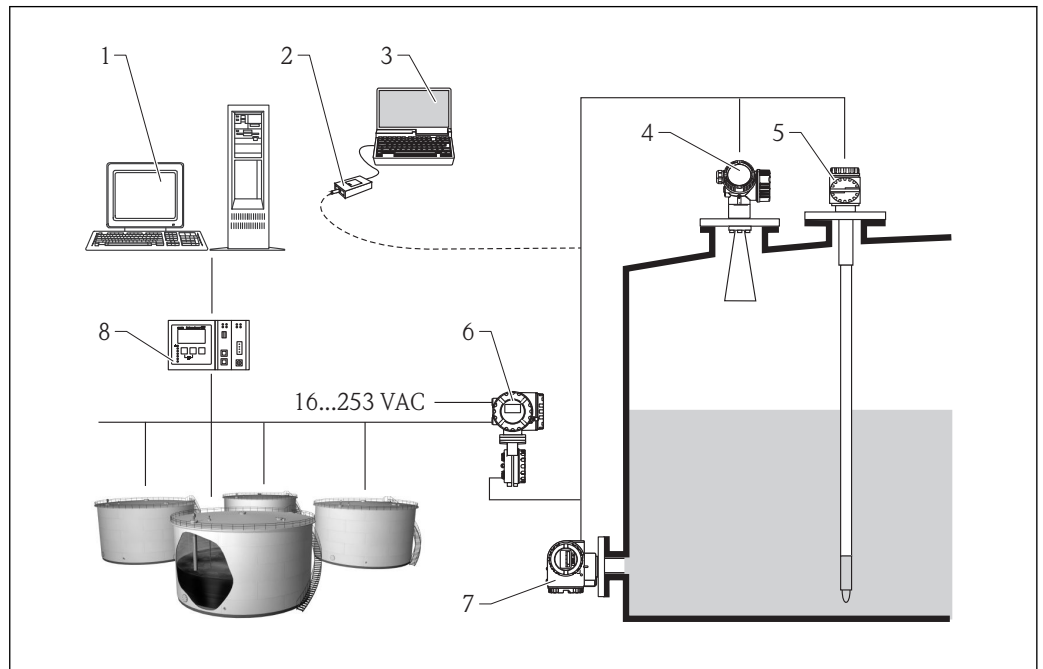


A0014019

- 1 Service interface (CDI) of the measuring device (= Endress+Hauser Common Data Interface)
- 2 Commubox FXA291
- 3 Computer with "FieldCare" operating tool

**Integration in tank gauging system**

The Endress+Hauser Tank Side Monitor NRF590 provides integrated communications for sites with multiple tanks, each with one or more sensors on the tank, such as radar, spot or average temperature, capacitive probe for water detection and/or pressure sensors. Multiple protocols out of the Tank Side Monitor guarantee connectivity to nearly any of the existing industry standard tank gauging protocols. Optional connectivity of analog 4...20 mA sensors, digital I/O and analog output simplify full tank sensor integration. Use of the proven concept of the intrinsically safe HART bus for all on-tank sensors yields extremely low wiring costs, while at the same time providing maximum safety, reliability and data availability.



A0017982

23 The complete measuring system consists of:

- 1 Tankvision workstation
- 2 Commubox FXA195 (USB) - optional
- 3 Computer with operating tool (ControlCare) - optional
- 4 Level measuring device
- 5 Temperature measuring device
- 6 Tank Side Monitor NRF590
- 7 Pressure measuring device
- 8 Tankvision Tank Scanner NXA820

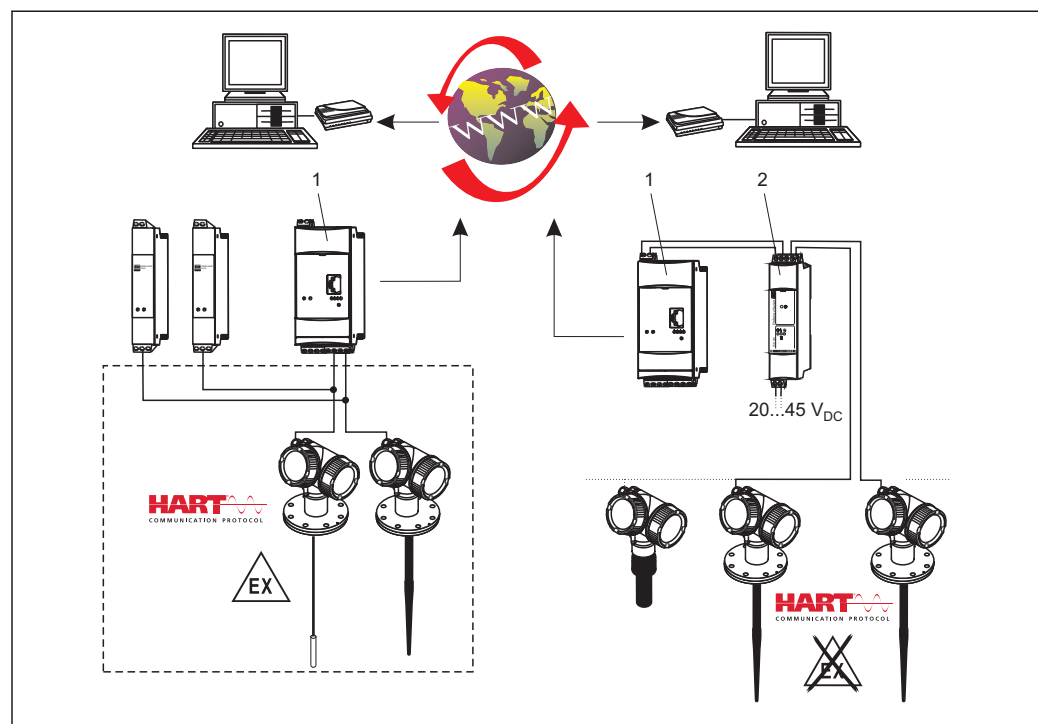
## System integration via Fieldgate

### Vendor Managed Inventory

By using Fieldgates to interrogate tank or silo levels remotely, suppliers of raw materials can provide their regular customers with information about the current supplies at any time and, for example, account for them in their own production planning. For their part, the Fieldgates monitor the configured level limits and, if required, automatically activate the next supply. The spectrum of options here ranges from a simple purchasing requisition via e-mail through to fully automatic order administration by coupling XML data into the planning systems on both sides.

### Remote maintenance of measuring equipment

Fieldgates not only transfer the current measured values, they also alert the responsible standby personnel, if required, via e-mail or SMS. In the event of an alarm or also when performing routine checks, service technicians can diagnose and configure connected HART devices remotely. All that is required for this is the corresponding HART operating tool (e.g. FieldCare, ...) for the connected device. Fieldgate passes on the information transparently, so that all options for the respective operating software are available remotely. Some on-site service operations can be avoided by using remote diagnosis and remote configuration and all others can at least be better planned and prepared.





24 The complete measuring system consists of devices and:

- 1 Fieldgate FXA520
- 2 Multidrop Connector FXN520

**i** The number of instruments which can be connected in mutidrop mode can be calculated by the "FieldNetCalc" program. A description of this program can be found in Technical Information TI 400F (Multidrop Connector FXN520). The program is available from your Endress+Hauser sales organisation or in the internet at: [www.de.endress.com/Download](http://www.de.endress.com/Download) (text search = "Fieldnetcalc").

## Certificates and approvals

<b>CE mark</b>	<p>The measuring system meets the legal requirements of the applicable EC guidelines. These are listed in the corresponding EC Declaration of Conformity together with the standards applied.</p> <p>Endress+Hauser confirms successful testing of the device by affixing to it the CE mark.</p>
<b>C-Tick symbol</b>	<p>The measuring system meets the EMC requirements of the "Australian Communications and Media Authority (ACMA)".</p>
<b>Ex approval</b>	<ul style="list-style-type: none"> <li>■ ATEX</li> <li>■ IEC Ex</li> <li>■ CSA (in Vorbereitung)</li> <li>■ FM (in Vorbereitung)</li> <li>■ NEPSI (in Vorbereitung)</li> <li>■ TIIS (in Vorbereitung)</li> </ul> <p>Additional safety instructions must be observed for applications in hazardous areas. They are contained in the separate "Safety Instructions" (XA) document, which is included in the scope of delivery. Reference is made to the XA on the nameplate of the device.</p> <p> Details on the available certificates as well as the associated XAs can be found in the <b>Associated documentation</b> chapter in the <b>Safety instructions</b> section: (→  87).</p>
<b>Dual seal according to ANSI/ISA 12.27.01</b>	<p>The devices Micropilot FMR5x have been designed according to ANSI/ISA 12.27.01 as dual seal devices, allowing the user to waive the use and save the cost of installing external secondary process seals in the conduit as required by the process sealing sections of ANSI/NFPA 70 (NEC) and CSA 22.1 (CEC). These instruments comply with the North-American installation practice and provide a very safe and cost-saving installation for pressurized applications with hazardous fluids.</p> <p>Further information can be found in the control drawings of the relevant devices.</p>
<b>Functional Safety</b>	<p>Used for level monitoring (MIN, MAX, range) up to SIL 3 (homogeneous or inhomogeneous redundancy), independently assessed by TÜV Rhineland as per IEC 61508. Other information see documentation SD01087F: "Functional Safety Manual".</p>
<b>Sanitary compatibility</b>	<p>FMR53 with antenna made of PTFE conforms to FDA 21 CFR 177.1550 and USP &lt;88&gt; Class VI.</p>
<b>AD2000</b>	<p>The pressure retaining material 316L (1.4435/1.4404) corresponds to AD2000 - W2/W10.</p>
<b>Pressure Equipment Directive</b>	<p>The Micropilot is not subject to the scope of the Pressure Equipment Directive 97/23/EC, as it does not have a pressure-bearing housing according to article 1, section 2.1.4 of the directive.</p>
<b>Marine certificate (in preparation)</b>	<p>in preparation</p>
<b>Radio standard EN302372-1/2</b>	<p>The devices Micropilot FMR50, FMR51, FMR52, FMR53, FMR54, FMR56 and FMR57 are conform with the TLPR (Tanks Level Probing Radar) standard EN302372-1/2 and can always be used in closed tanks or bins. For installation, points a to f in Annex B of EN302372-1 have to be taken into account.</p>
<b>FCC / Industry Canada</b>	<p>This device complies with Part 15 of the FCC rules. 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 that may cause undesired operation.</p> <p><b>Canada CNR-Gen Section 7.1.3</b></p> <p>This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) This device may not interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.</p> <p><i>Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.</i></p>

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[Any] changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

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**CRN approval** in preparation

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**Track record** FMR5x is the upgrade model of the corresponding FMR2xx series.

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**Other standards and guidelines**

- EN 60529  
Degrees of protection by housing (IP code)
- EN 61010-1  
Protection Measures for Electrical Equipment for Measurement, Control, Regulation and Laboratory Procedures.
- IEC/EN 61326  
"Emission in accordance with Class A requirements". Electromagnetic compatibility (EMC requirements)
- NAMUR NE 21  
Electromagnetic compatibility (EMC) of industrial process and laboratory control equipment.
- NAMUR NE 43  
Standardization of the signal level for the breakdown information of digital transmitters with analog output signal.
- NAMUR NE 53  
Software of field devices and signal-processing devices with digital electronics
- NAMUR NE 107  
Status classification as per NE107
- NAMUR NE 131  
Requirements for field devices for standard applications
- IEC61508  
Functional safety of electrical/electronic/programmable electronic safety-related systems



## Ordering information

### Ordering information


Detailed ordering information is available from the following sources:

- In the Product Configurator on the Endress+Hauser website: [www.endress.com](http://www.endress.com) → Select country → Instruments → Select device → Product page function: Configure this product
- From your Endress+Hauser Sales Center: [www.endress.com/worldwide](http://www.endress.com/worldwide)

#### Product Configurator - the tool for individual product configuration

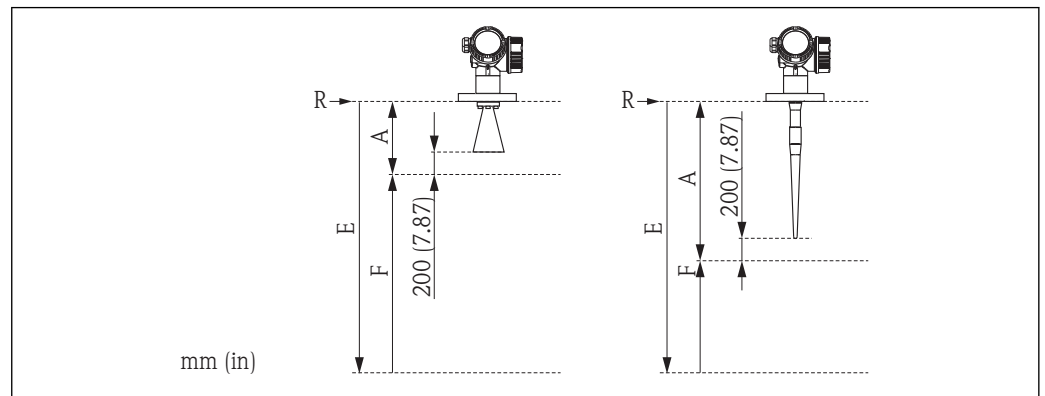
- Up-to-the-minute configuration data
- Depending on the device: Direct input of measuring point-specific information such as measuring range or operating language
- Automatic verification of exclusion criteria
- Automatic creation of the order code and its breakdown in PDF or Excel output format
- Ability to order directly in the Endress+Hauser Online Shop

### 5-point linearity protocol (in preparation)


 The following notes must be taken into account if option F4 ("5 point linearity protocol") has been selected in feature 550 ("Calibration").


The five points of the linearity protocol are evenly distributed across the measuring range (0% to 100%). In order to define the measuring range, **Empty calibration** (E) and **Full calibration** (F) have to be specified <sup>7)</sup>.

The following restrictions have to be taken into account when defining E and F:



Minimum distance between reference point (R) and 100% level	Minimum span	Maximum value for "empty calibration"
A ≥ Length of antenna + 200 mm (8 in) Minimum value: 400 mm (16 in)	F ≥ 400 mm (16 in)	E ≤ 20 m (66 ft)

 The linearity is checked under reference conditions.

 The selected values of **Empty calibration** and **Full calibration** are only used to record the linearity protocol and are reset to their antenna specific default values thereafter. If values different from the default are required, they must be ordered as a customized parametrization (→ [82](#)).

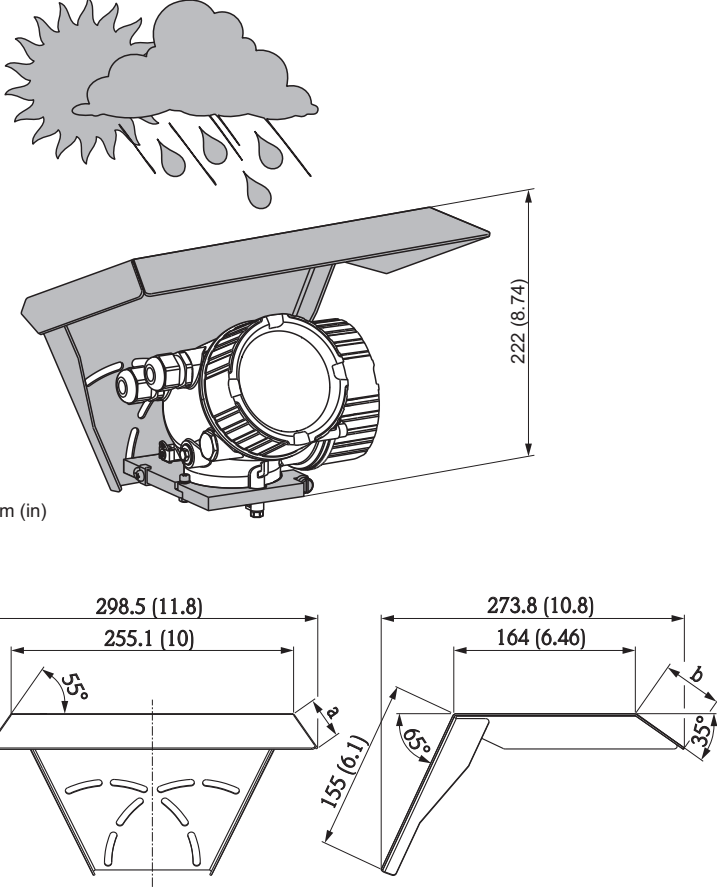

7) If E and F are not specified, antenna dependent default values will be used instead.

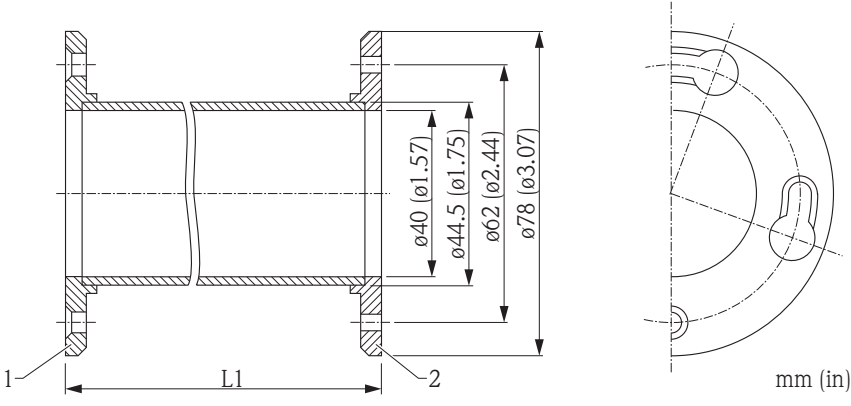
**Customized parametrization**

If the option IJ "Customized parametrization HART", IK "Customized parametrization PA" or IL "Customized parametrization FF" has been selected in feature 570 "Service", customer specific presettings can be selected for the following parameters:

Parameter	Communication	Selection list / range of values
Setup → Distance unit	<ul style="list-style-type: none"> <li>■ HART</li> <li>■ PA</li> <li>■ FF</li> </ul>	<ul style="list-style-type: none"> <li>■ in</li> <li>■ mm</li> </ul>
Setup → Empty calibration	<ul style="list-style-type: none"> <li>■ HART</li> <li>■ PA</li> <li>■ FF</li> </ul>	0 to 70 m (0 to 230 ft)
Setup → Full calibration	<ul style="list-style-type: none"> <li>■ HART</li> <li>■ PA</li> <li>■ FF</li> </ul>	0 to 70 m (0 to 230 ft)
Setup → Adv. Setup → Current output 1/2 → Damping	HART	0 to 999,9 s
Setup → Adv. Setup → Current output 1/2 → Failure mode	HART	<ul style="list-style-type: none"> <li>■ Min</li> <li>■ Max</li> <li>■ Last valid value</li> </ul>
Expert → Comm. → HART config. → Burst mode	HART	<ul style="list-style-type: none"> <li>■ Off</li> <li>■ On</li> </ul>

## Accessories

Accessory	Description
Weather protection cover	 <p>The diagram illustrates the weather protection cover for the Micropilot FMR53 and FMR54. It includes a weather icon (sun, cloud, rain) and a perspective view of the cover installed on the device. The perspective view shows a height of 222 mm (8.74 in). Below this are two detailed views: a top view and a side view. The top view shows a trapezoidal shape with a top width of 298.5 mm (11.8 in), an inner width of 255.1 mm (10 in), and a 55° angle. The side view shows a depth of 164 mm (6.46 in), a 65° angle, and a 35° angle. A dimension 'a' is shown for the top edge and 'b' for the bottom edge. A 155 mm (6.1 in) dimension is also indicated for the side view.</p> <p>mm (in)</p> <p>mm (in)</p> <p><i>a</i> 37.8 mm (1.49 in)  <i>b</i> 54 mm (2.13 in)</p> <p> The weather protection cover can be ordered together with the device (product structure, feature 620 "Accessory Enclosed", option PB "Weather Protection Cover"). Alternatively, it can be separately ordered as an accessory; order code 71132889.</p>

Accessory	Description
<p>Antenna extension FAR10 (for FMR54)</p>	<div style="display: flex; justify-content: space-around; align-items: flex-start;">  </div> <p>1 Instrument connection 2 Horn connection</p> <p><b>Material:</b></p> <ul style="list-style-type: none"> <li>■ 316L (1.4404)</li> <li>■ Alloy B2</li> <li>■ Alloy C4</li> </ul> <p><b>Length L1:</b></p> <ul style="list-style-type: none"> <li>■ 100 mm (4 in)</li> <li>■ 200 mm (8 in)</li> <li>■ 300 mm (12 in)</li> <li>■ 400 mm (16 in)</li> </ul> <p>Detailed ordering information is available from the following sources:</p> <ul style="list-style-type: none"> <li>■ In the Product Configurator on the Endress+Hauser website: <a href="http://www.endress.com">www.endress.com</a> → Select country → Instruments → Select device → Product page function: Configure this product</li> <li>■ From your Endress+Hauser Sales Center: <a href="http://www.endress.com/worldwide">www.endress.com/worldwide</a></li> </ul>

A0018879


Accessory	Description
Remote display FHX50	<div style="text-align: center;"> </div> <p style="text-align: right;">A0019128</p> <ul style="list-style-type: none"> <li>■ Material:             <ul style="list-style-type: none"> <li>– Plastics PBT</li> <li>– 316L (in preparation)</li> </ul> </li> <li>■ Suitable for the display modules:             <ul style="list-style-type: none"> <li>– SD02 (push buttons)</li> <li>– SD03 (touch control) (in preparation)</li> </ul> </li> <li>■ Connection cable:             <ul style="list-style-type: none"> <li>– Cable with M12 plug; supplied with the FHX50; up to 30 m (98 ft)</li> <li>– Customer supplied standard cable; up to 60 m (196 ft)</li> </ul> </li> </ul> <p><b>i</b> ■ If the remote display is to be used, the Micropilot must be ordered in the version "Prepared for display FHX50" (feature 030, option L or M). For the FHX50, on the other hand, the option A: "Prepared for display FHX50" has to be selected in feature 050: "Option Measurement Device".</p> <p>■ If a Micropilot has not been ordered in the version "Prepared for display FHX50", but is nevertheless to be equipped with an FHX50, it is essential to select the option B: "Not prepared for display FHX50" in feature 050: "Option Measurement Device" of the FHX50. In this case, a retrofit kit, needed to prepare the Micropilot for the remote display, is supplied together with the FHX50.</p> <p><b>i</b> For details refer to the document SD01007F.</p>


**Communication-specific accessories**


Accessory	Description
Commubox FXA195 HART	For intrinsically safe HART communication with FieldCare via the USB interface. <b>i</b> For details refer to Technical Information TI00404F


Accessory	Description
Commubox FXA291	Connects Endress+Hauser field devices with CDI interface (= Endress+Hauser Common Data Interface) to the USB interface of a computer. <b>i</b> For details refer to Technical Information TI00405C

Accessory	Description
HART Loop Converter HMX50	Evaluates the dynamic HART variables and converts them to analog current signals or limit values. <b>i</b> For details refer to Technical Information TI00429F and Operating Instructions BA00371F


Accessory	Description
WirelessHART Adapter SWA70	<p>Connects field devices to a WirelessHART network. The WirelessHART adapter can be mounted directly at a HART device and is easily integrated into an existing HART network. It ensures safe data transmission and can be operated in parallel with other wireless networks.</p> <p> For details refer to Operating Instructions BA00061S</p>

Accessory	Description
Fieldgate FXA320	<p>Gateway for remote monitoring of connected 4-20mA measuring devices via web browser.</p> <p> For details refer to Technical Information TI00025S and Operating Instructions BA00053S</p>




Accessory	Description
Fieldgate FXA520	<p>Gateway for remote diagnosis and parametrization of connected HART measuring devices via web browser.</p> <p> For details refer to Technical Information TI00025S and Operating Instructions BA00051S</p>

Accessory	Description
Field Xpert SFX100	<p>Compact, flexible and robust industry handheld terminal for remote parametrization and measured value inspection via the HART output or via FOUNDATION Fieldbus .</p> <p> For details refer to Operating Instructions BA00060S</p>

**Service-specific accessories**

Accessory	Description
FieldCare	<p>Endress+Hauser's FDT-based Plant Asset Management tool. Helps to configure and maintain all field devices of your plant. By supplying status information it also supports the diagnosis of the devices.</p> <p> For details refer to Operating Instructions BA00027S and BA00059S.</p>

**System components**

Accessory	Description
Graphic Data Manager Memograph M	<p>The graphic data manager Memograph M provides information on all the relevant process variables. Measured values are recorded correctly, limit values are monitored and measuring points analyzed. The data are stored in the 256 MB internal memory and also on an SD card or USB stick.</p> <p> For details refer to Technical Information TI00133R and Operating Instructions BA00247R</p>
RN221N	<p>Active barrier with power supply for safe separation of 4 to 20 mA current circuits. Provides bi-directional HART transmission.</p> <p> For details refer to Technical Information TI00073R and Operating Instructions BA00202R</p>
RNS221	<p>Transmitter supply for 2-wire sensors or transmitters exclusively for non-Ex areas. Provides bi-directional communication using the HART communication sockets.</p> <p> For details refer to Technical Information TI00081R and Operating Instructions KA00110R</p>

## Documentation



The following document types are available:

- On the CD supplied with the device
- In the Download Area of the Endress+Hauser Internet site: [www.endress.com](http://www.endress.com) → Download

### Standard documentation

#### Micropilot FMR53, FMR54

Correlation of documentations to the device:

Device	Power supply, output	Communication	Document type	Document code
FMP53	A, B, C, K, L	HART	Operating Instructions	BA01050F/00/EN
			Brief Operating Instructions	KA01101F/00/EN
			Description of Device Parameters	GP01014F/00/EN
	G	PROFIBUS PA (in preparation)	Operating Instructions	BA01126F/00/EN
			Brief Operating Instructions	KA01130F/00/EN
			Description of Device Parameters	GP01018F/00/EN
	E	FOUNDATION Fieldbus (in preparation)	Operating Instructions	BA01122F/00/EN
			Brief Operating Instructions	KA01126F/00/EN
			Description of Device Parameters	GP01017F/00/EN

### Supplementary documentation

Device	Document type	Document code
Fieldgate FXA520	Technical Information	TI369F/00/EN
Tank Side Monitor NRF590	Technical Information	TI402F/00/EN
	Operating Instructions	BA256F/00/EN
	Description of Device Parameters	BA257F/00/EN

### Safety Instructions (XA)

Depending on the approval, the following Safety Instructions (XA) are supplied with the device. They are an integral part of the Operating Instructions.

Feature 010	Approval	Available for	Safety Instructions HART	Safety Instructions PROFIBUS FOUNDATION Fieldbus
BA	ATEX: II 1 G Ex ia IIC T6 Ga	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00677F	XA00685F
BB	ATEX: II 1/2 G Ex ia IIC T6-T1 Ga/Gb	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00677F	XA00685F
BC	ATEX: II 1/2 G Ex d [ia] IIC T6-T1 Ga/Gb	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00680F	XA00688F
BD	ATEX: II 1/2/3 G Ex ic [ia Ga] IIC T6-T1 Ga/Gb/Gc	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00678F	XA00686F
BE	ATEX: II 1 D Ex ta IIIC T500 xx°C Da	FMR54	XA00682F	XA00690F
BF	ATEX: II 1/2 D Ex ta IIIC Txx°C Da/Db	FMR54	XA00682F	XA00690F
BG	ATEX: II 3 G Ex nA IIC T6-T1 Gc	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00679F	XA00687F
BH	ATEX: II 3 G Ex ic IIC T6-T1 Gc	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00679F	XA00687F
BL	ATEX: II 1/2/3 G Ex nA [ia Ga] IIC T6-T1 Ga/Gb/Gc	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00678F	XA00686F
B2	ATEX: II 1/2 G Ex ia IIC T6-T1 Ga/Gb ATEX: II 1/2 D Ex ia IIIC Txx°C Da/Db	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00683F	XA00691F

Feature 010	Approval	Available for	Safety Instructions HART	Safety Instructions PROFIBUS FOUNDATION Fieldbus
B3	ATEX: II 1/2 G Ex d [ia] IIC T6-T1 Ga/Gb ATEX: II 1/2 D Ex ta IIIC Txx°C Da/Db	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00684F	XA00692F
B4	ATEX: II 1/2 G Ex ia IIC T6-T1 Ga/Gb ATEX: II 1/2 G Ex d [ia] IIC T6-T1 Ga/Gb	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00681F	XA00689F
IA	IECEX: Ex ia IIC T6-T1 Ga	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00677F	XA00685F
IB	IECEX: Ex ia IIC T6-T1 Ga/Gb	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00677F	XA00685F
IC	IECEX: Ex d [ia] IIC T6-T1 Ga/Gb	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00680F	XA00688F
ID	IECEX: Ex ic [ia Ga] IIC T6-T1 Ga/Gb/Gc	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00678F	XA00686F
IE	IECEX: Ex ta IIIC T <sub>500</sub> xx°C Da	FMR54	XA00682F	XA00690F
IF	IECEX: Ex ta IIIC Txx°C Da/Db	FMR54	XA00682F	XA00690F
IG	IECEX: Ex nA IIC T6-T1 Gc	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00679F	XA00687F
IH	IECEX: Ex ic IIC T6-T1 Gc	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00679F	XA00687F
IL	IECEX: Ex nA [ia Ga] IIC T6-T1 Ga/Gb/Gc	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00678F	XA00686F
I2	IECEX: Ex ia IIC T6-T1 Ga/Gb IECEX: Ex ia IIIC Txx°C Da/Db	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00683F	XA00691F
I3	IECEX: Ex d [ia] IIC T6-T1 Ga/Gb IECEX: Ex ta IIIC Txx°C Da/Db	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00684F	XA00692F
I4	IECEX: Ex ia IIC T6-T1 Ga/Gb IECEX: Ex d [ia] IIC T6-T1 Ga/Gb	<ul style="list-style-type: none"> <li>■ FMR53</li> <li>■ FMR54</li> </ul>	XA00681F	XA00689F

 For certified devices the relevant Safety Instructions (XA) are indicated on the nameplate.

If the device is prepared for the remote display FHX50 (product structure: feature 030: Display, Operation", option L or M), the Ex marking of some certificates changes according to the following table<sup>8)</sup>:

Feature 010 ("Approval")	Feature 030 ("Display, Operation")	Ex marking
BG	L oder M	ATEX II 3G Ex nA [ia Ga] IIC T6 Gc
BH	L oder M	ATEX II 3G Ex ic [ia Ga] IIC T6 Gc
B3	L oder M	ATEX II 1/2G Ex d [ia] IIC T6 Ga/Gb, ATEX II 1/2D Ex ta [ia Db] IIIC Txx°C Da/Db
IG	L oder M	IECEX Ex nA [ia Ga] IIC T6 Gc
IH	L oder M	IECEX Ex ic [ia Ga] IIC T6 Gc
I3	L oder M	IECEX Ex d [ia] IIC T6 Ga/Gb, IECEX Ex ta [ia Db] IIIC Txx°C Da/Db

## Registered trademarks

### HART®

Registered trademark of the HART Communication Foundation, Austin, USA

8) The marking of certificates not mentioned in this table are not affected by the FHX50.



**PROFIBUS®**

Registered trademark of the PROFIBUS User Organization, Karlsruhe, Germany

**FOUNDATION™ Fieldbus**

Registered trademark of the Fieldbus Foundation, Austin, Texas, USA

**KALREZ®, VITON®**

Registered trademark of DuPont Performance Elastomers L.L.C., Wilmington, USA

**TEFLON®**

Registered trademark of E.I. DuPont de Nemours & Co., Wilmington, USA

**TRI CLAMP®**

Registered trademark of Alfa Laval Inc., Kenosha, USA

## Patents

This product may be protected by at least one of the following patents.

Further patents are pending.

US Patents	EP Patents
5.948.979	882 957
6.087.978	955 527
6.140.940	-
6.155.112	834 722
-	882 955
6.266.022	1 083 413
6.295.874	210 567
6.512.358	1 301 914
6.606.904	-
6.640.628	-
6.679.115	1 360 523
-	1 389 337
6.779.397	-
7.201.050	-
7.412.337	-
7.552.634	-
7.730.760	-
7.819.002	-
-	1 774 616
7.966.141	-
8.040.274	-
8.049.371	-

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