

Electromagnetic Flow Measurement System – Two-wire, loop-powered *promag 23 P*

Flow measurement in chemical or process applications



Features and benefits

- Nominal diameters DN 25...200
- PTFE or PFA lining
- PFA for high-temperature applications up to +180 °C (Ex: up to +150 °C)
- Fitting lengths to DVGW and ISO
- Measuring accuracy: $\pm 0.5\%$
- Robust field housing, IP 67, with separate terminal compartment
- “Touch control”: operation without opening the housing - also in Ex-environment
- Quick Setup menu for straightforward commissioning in the field (in preparation)
- Connecting to all mainstream transmitter power supplies and input cards of process control systems
- Communication: HART is standard

- Intrinsically safe Ex ia for installation in zone 1 (ATEX, FM, CSA, etc.)
- Transmitter supply:
 - Non-Ex environment: 12...30 V
 - Ex environment: 13.9...30 V
- Reduced installation and operation costs

Application

All fluids with a minimum conductivity of $\geq 50 \mu\text{S}/\text{cm}$ can be measured:

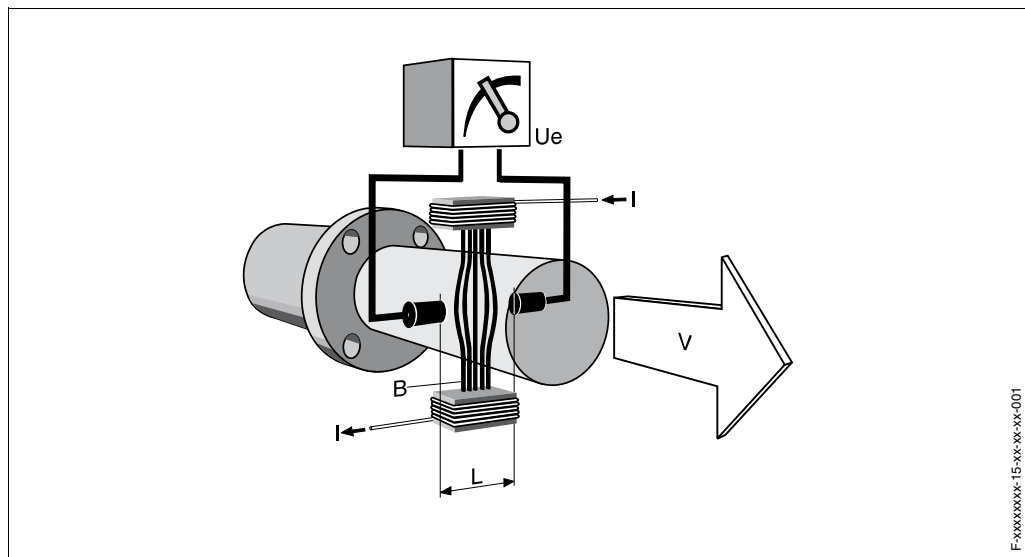
- acids
- alkalis
- paints, lacquers
- water, etc.

Function and system design

Measuring principle

Faraday's law of induction states that a voltage is induced in a conductor moving in a magnetic field.

In electromagnetic measuring, the flowing medium corresponds to the moving conductor. The induced voltage is proportional to the flow velocity and is detected by two measuring electrodes and transmitted to the amplifier. Flow volume is computed on the basis of the pipe's diameter. The constant magnetic field is generated by a switched direct current of alternating polarity.



$$U_e = B \cdot L \cdot v$$

$$Q = A \cdot v$$

U_e = induced voltage
 B = magnetic induction (magnetic field)
 L = electrode gap
 v = flow velocity
 Q = volume flow
 A = pipe cross-section
 I = current

Measuring system

The measuring system consists of a transmitter and a sensor (compact version).

- Promag 23 transmitter
- Promag P sensor (DN 25...200)

Input variables

Measured variable

Flow rate (proportional to induced voltage)

Measuring range

Typically $v = 0.01 \dots 10$ m/s with the specified measuring precision

Operable flow range

Over 1000 : 1

Output variables

Output signal

- Applied direct current 4...20 mA. Input from DC voltage source.
Terminal voltage: 12...30 V, 13.9...30 V (Ex i)
Resolution: 4.4 μ A
- Pulse/frequency output:
open collector, passive, galvanically isolated, 30 V DC, 10 mA,
configurable as status output: e.g. for error message, empty pipe detection, direction of flow,
limit value
Frequency output:
full scale frequency 2...10000 Hz ($f_{\max} = 12500$ Hz), on/off ratio 1:1, pulse width max. 10 s.
Pulse output:
pulse value and pulse polarity adjustable, pulse width adjustable (0.05...2 s), above a fre-
quency of $1 / (2 \times \text{pulse width})$ the on/off ratio is 1:1, pulse frequency max. 50 Hz
- Ex i version:
 - Power-supply and signal circuits and pulse output with "intrinsically safe" protection rating,
EEx ia IIC and EEx ia IIB, only for connection to certified, intrinsically safe circuits with the fol-
lowing maximum values: $U_i = 30$ V, $I_i = 150$ mA, $P_i = 810$ mW
Effective internal inductance: negligible
Effective internal capacitance: $C_i \leq 25$ nF
 - Pulse output
Maximum values: $U_i = 30$ V, $I_i = 10$ mA, $P_i = 1$ W
Effective internal inductance: negligible
Effective internal capacitance: negligible

Signal on alarm

- Current output → failure response selectable
- Pulse/frequency output → failure response selectable
- Status output → "non-conductive" by fault or power supply failure

Load

With HART generally: $R_L \geq 250 \Omega$

$$\text{Non-Ex environment: } R_L = \frac{U_s - 12}{0,022}$$

$$\text{Ex environment: } R_L = \frac{U_s - 13,9}{0,022}$$

R_L = load, load resistance

U_s = supply voltage (12...30 V, 13.9...30 V for Ex i)

Low flow cutoff

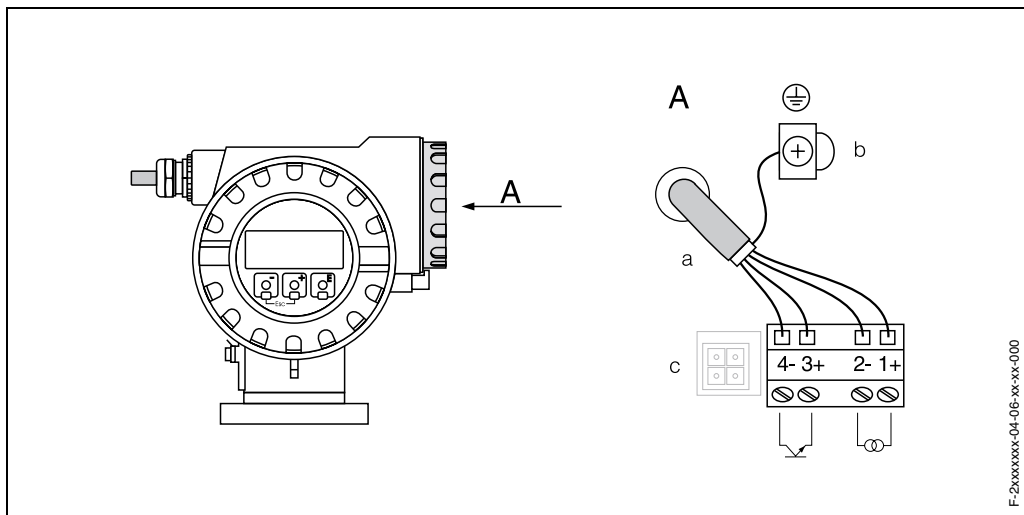
Switch points for low flow cutoff are selectable

Galvanic isolation

Inputs/outputs are galvanically isolated from sensor and from each other.

Power supply

Electrical connection measuring unit



- a Signal cable (the Ex version requires the use of separate cables for transmitter supply and frequency output):
Terminal **No. 1+ / 2-**: transmitter supply / current output
Terminal **No. 3+ / 4-**: pulse / frequency output
- b Grounding terminal for signal-cable shield
- c Service plug

Outputs / inputs	Terminal No.	
	1+ / 2-	3+ / 4-
23**_***** W	Current output HART	-
23**_***** A	Current output HART	Pulse/frequency output

Potential equalisation

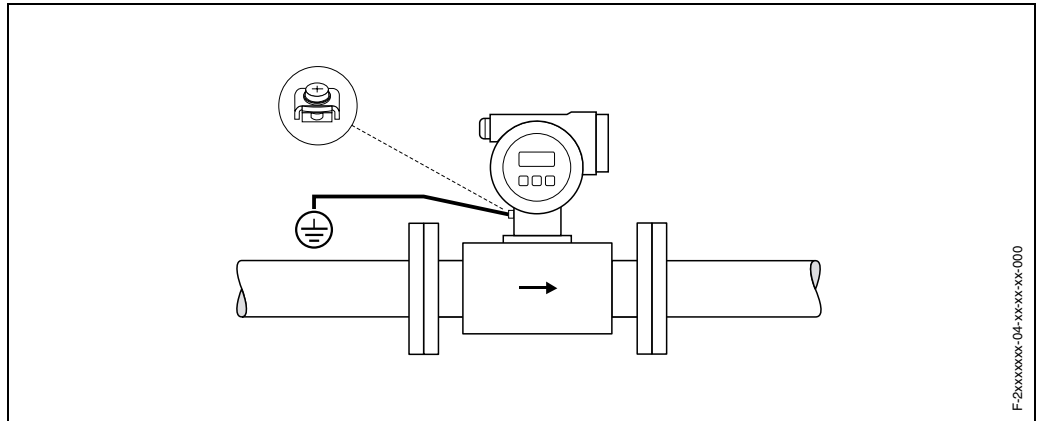
Standard

Sensor and medium must have the same electrical potential in order to ensure measuring accuracy and avoid corrosion damage to the electrodes. Potential equalisation is achieved by means of the reference electrode installed as standard in the sensor.

If the medium flows through metallic, unlined and grounded pipes, it is enough to connect the grounding terminal of the transmitter housing (see illustration) to the potential-equalisation terminal.

Caution:

Always install grounding disks if correct grounding of the medium cannot be ensured, or if equalizing currents of significant level are to be expected.

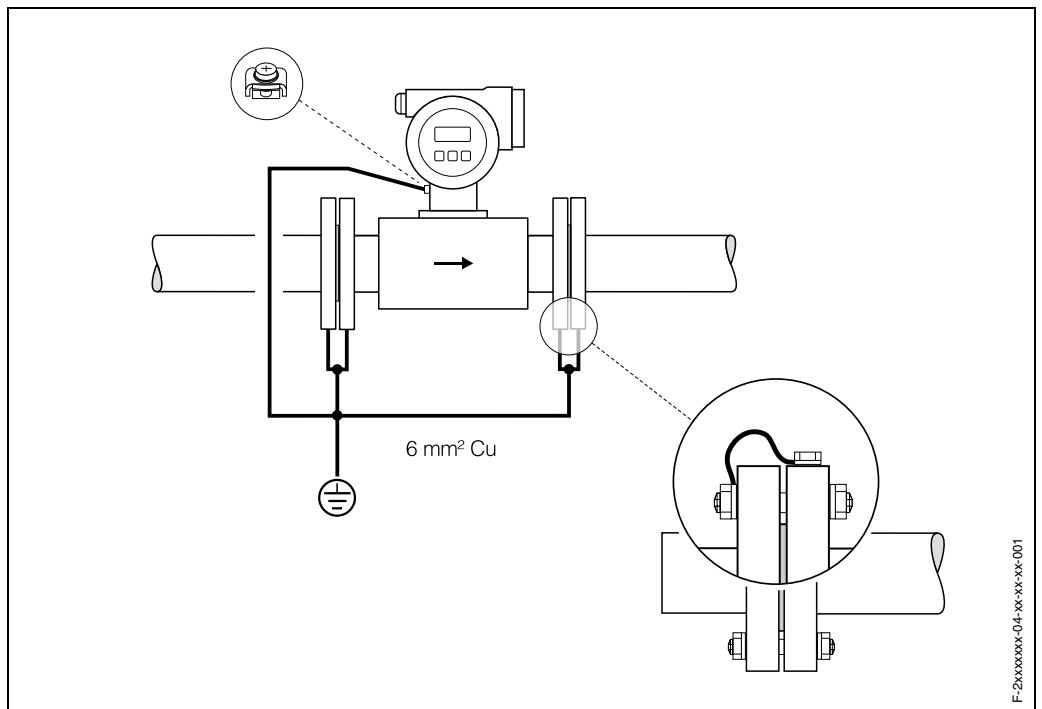


Equalising currents in metallic, ungrounded pipes

In order to avoid errors in measurement, use grounding cables to connect each sensor flange to its corresponding pipe flange and ground the flanges. Connect the transmitter or sensor connection housing, as applicable, to ground potential by means of the grounding terminal provided for the purpose.

Note:

The grounding cable for flange-to-flange connections can be ordered separately as an accessory from E+H. The grounding cable is in direct connection with the conductive flange coating and is secured by the flange screws.

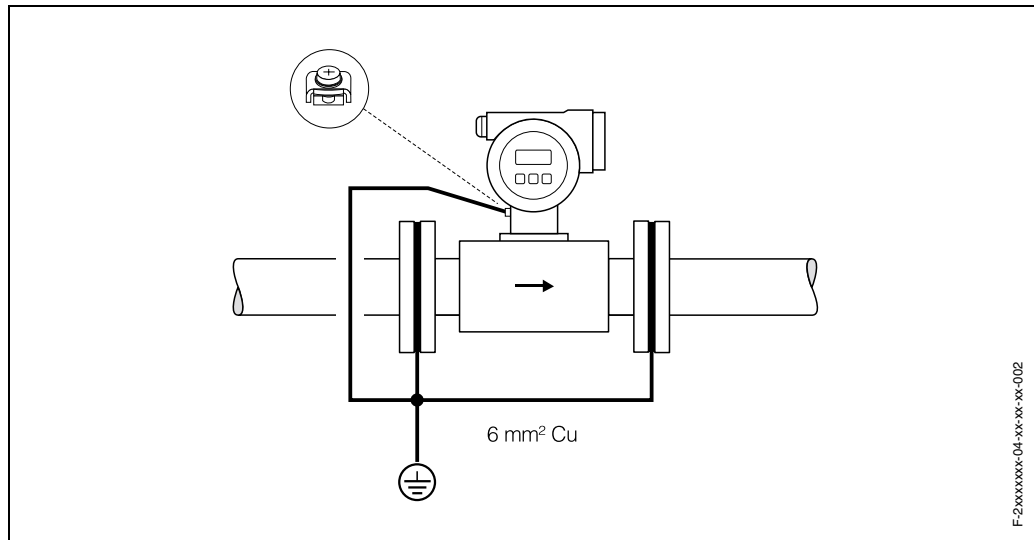


Plastic pipes and lined pipes

The use of grounding disks is compulsory if the pipe materials are nonconductive (see illustration). This applies in all cases in which the medium can carry equalizing currents that could destroy the reference electrode by electro-chemical corrosion. Typical piping systems of this nature include those with electrically insulating linings and pipes made of fiberglass or PVC.

Caution:

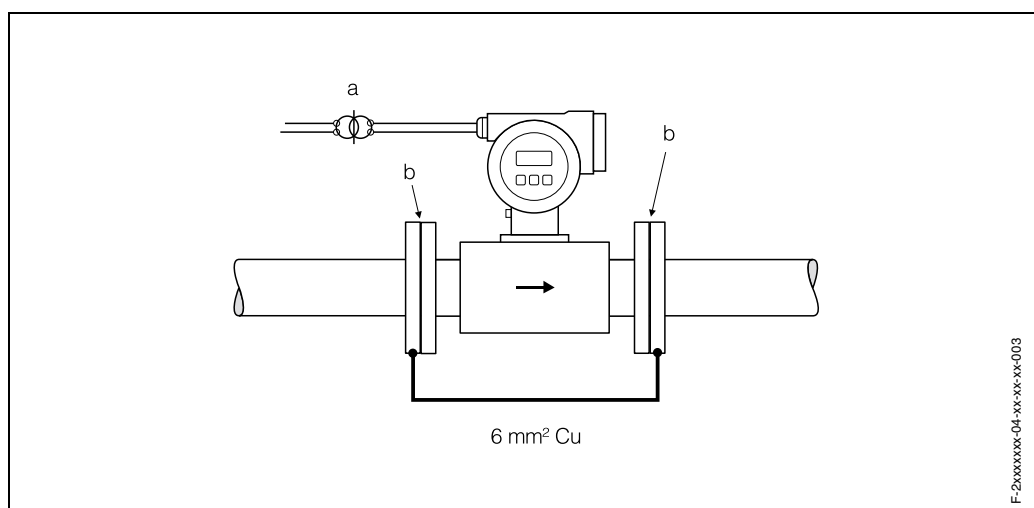
Risk of damage by electro-chemical corrosion. Note the electro-chemical series of metals, if the grounding disks and measuring electrodes are made of different materials.



Lined pipes (cathode protection)

If the medium cannot be grounded for process-related reasons, the measuring device must be installed in such a way as to be potential-free:

- When installing the measuring device, make sure that there is an electrical connection between the two piping runs (copper wire, 6 mm²).
- Make sure that the installation materials do not establish a conductive connection to the measuring device and that the installation materials withstand the tightening torques applied when the threaded fasteners are tightened.
- Also comply with the regulations applicable to potential-free installation.



a = galvanically isolated power supply (safety transformer)

b = electrically insulated

- Cable entry**
- Cable entry M20 x 1.5 (8...12 mm)
 - Threads for cable entries, Pg 13.5 (5...15 mm), 1/2" NPT, G 1/2"

Cable specifications Use shielded cables.

Supply voltage Non-Ex environment: 12...30 V
Ex environment (Ex i): 13.9...30 V

- Power supply failure**
- T-DAT™ saves measuring system data if power supply fails
 - S-DAT™ = exchangeable data storage chip which stores the data of the sensor: nominal diameter, serial number, calibration factor, zero point, etc.

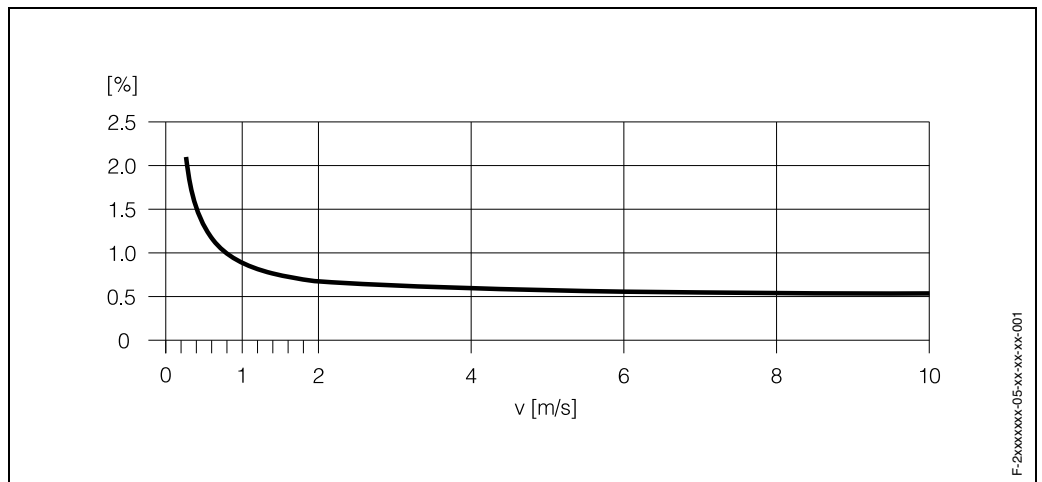
Measuring accuracy

- Reference conditions** To DIN 19200 and VDI/VDE 2641:
- Medium temperature: +28 °C ± 2 K
 - Ambient temperature: +22 °C ± 2 K
 - Warm-up time: 30 minutes

Installation:

- Inlet run > 10 x DN
- Outlet run > 5 x DN
- Sensor and transmitter grounded.
- Sensor centered relative to the pipe.

Measured error Signal output: ± 0.5% o.r. ± 4 mm/s (o.r. = of reading),
fluctuations in voltage supply have no effect within the specified range.



Measuring error in [%] of reading

Repeatability ± 0.25% o.r. ± 2 mm/s (o.r. = of reading)

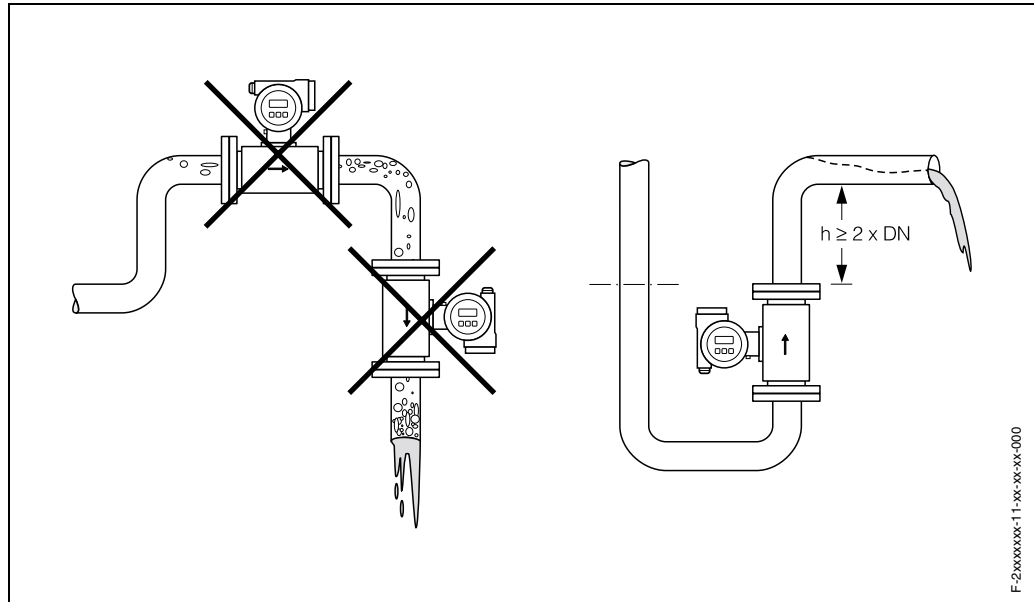
Conditions for operation (installation conditions)

Installation instructions

Mounting location

Correct measuring is possible only if the pipe is full. Avoid the following locations:

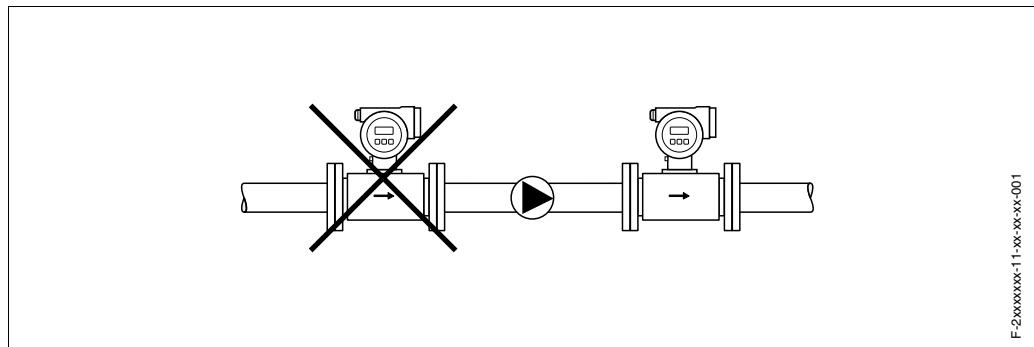
- Highest point in the run. Risk of air accumulating
- Directly upstream from an open pipe outlet in a down pipe.



Installation of pumps

Do not install the sensor on the intake side of a pump. This precaution is to avoid low pressure and the consequent risk of damage to the lining of the measuring tube.

It might be necessary to install pulse dampers in systems incorporating reciprocating, diaphragm or peristaltic pumps. Information on the measuring system's resistance to vibration and surge can be found on Page 13.

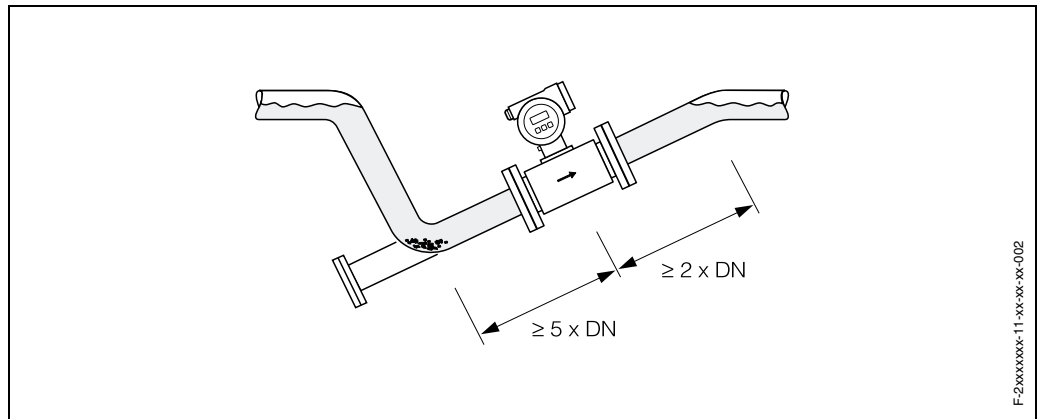


Partially filled pipes

Partially filled pipes with gradients necessitate a drain-type configuration. The Empty Pipe Detection (EPD) function offers additional protection by detecting empty or partially filled pipes.

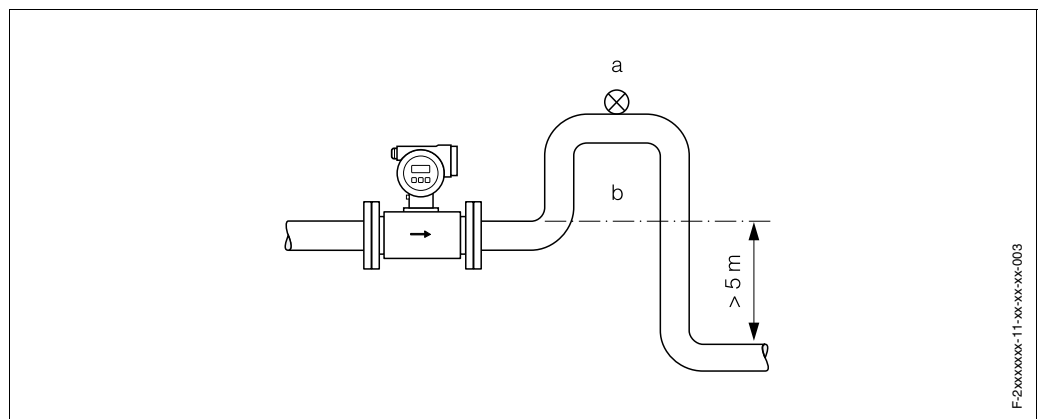
Caution:

Risk of solids accumulating. Do not install the sensor at the lowest point in the drain. It is advisable to install a cleaning valve.



Down pipes

Install a siphon (b) or a vent valve (a) downstream of the sensor in down pipes longer than 5 meters. This precaution is to avoid low pressure and the consequent risk of damage to the lining of the measuring tube. This measure also prevents the system losing prime, which could cause air inclusions.



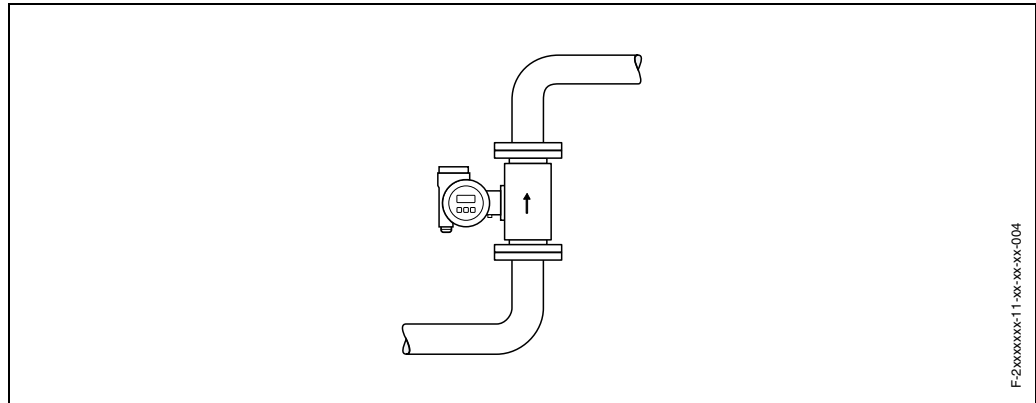
a = vent valve, b = siphon

Orientation

An optimum orientation helps avoid gas and air accumulations and deposits in the measuring tube.

Vertical orientation:

This orientation is ideal for self-emptying piping systems and for use in conjunction with Empty Pipe Detection (EPD).

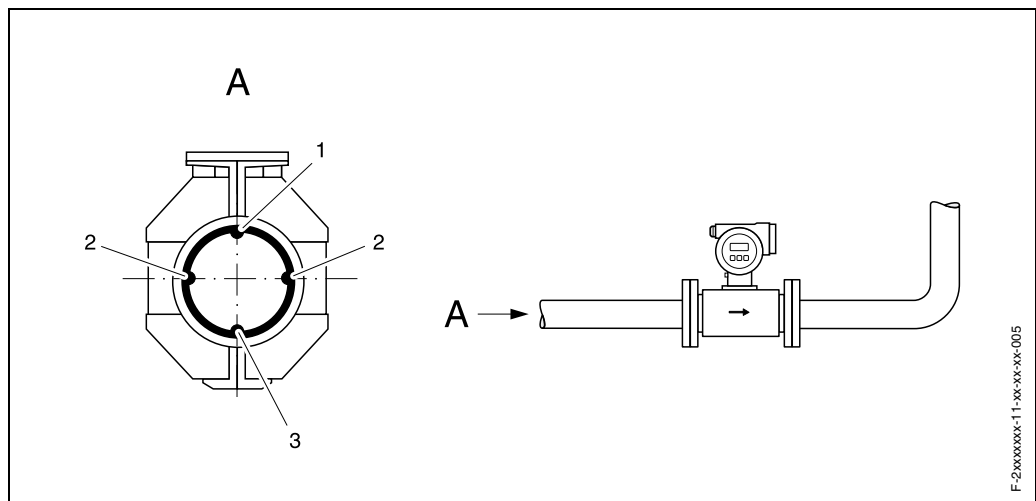


Horizontal orientation:

The measuring electrodes should be on a horizontal plane. This prevents brief insulation of the two electrodes by entrained air bubbles.

Caution:

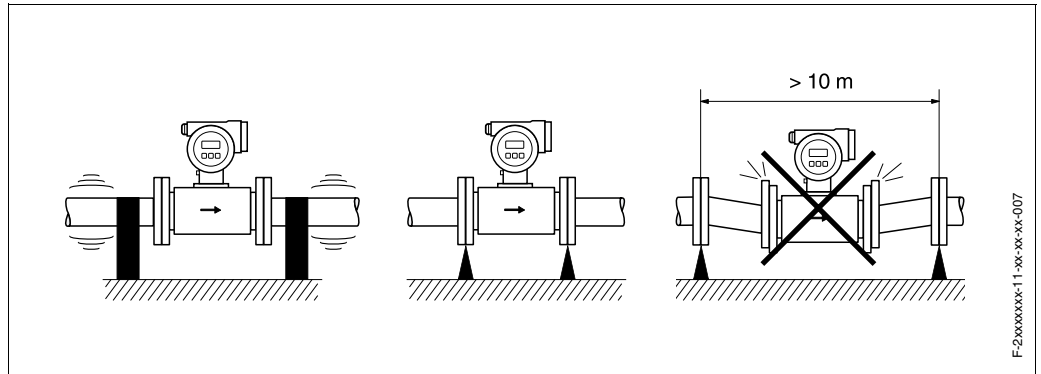
Empty Pipe Detection functions correctly only when the measuring device is installed horizontally and the transmitter housing is facing upward. Otherwise there is no guarantee that Empty Pipe Detection will respond if the measuring tube is only partially filled or empty.



- 1 = EPD electrode (Empty Pipe Detection)
- 2 = Measuring electrodes (signal detection)
- 3 = Reference electrode (potential equalisation)

Vibrations

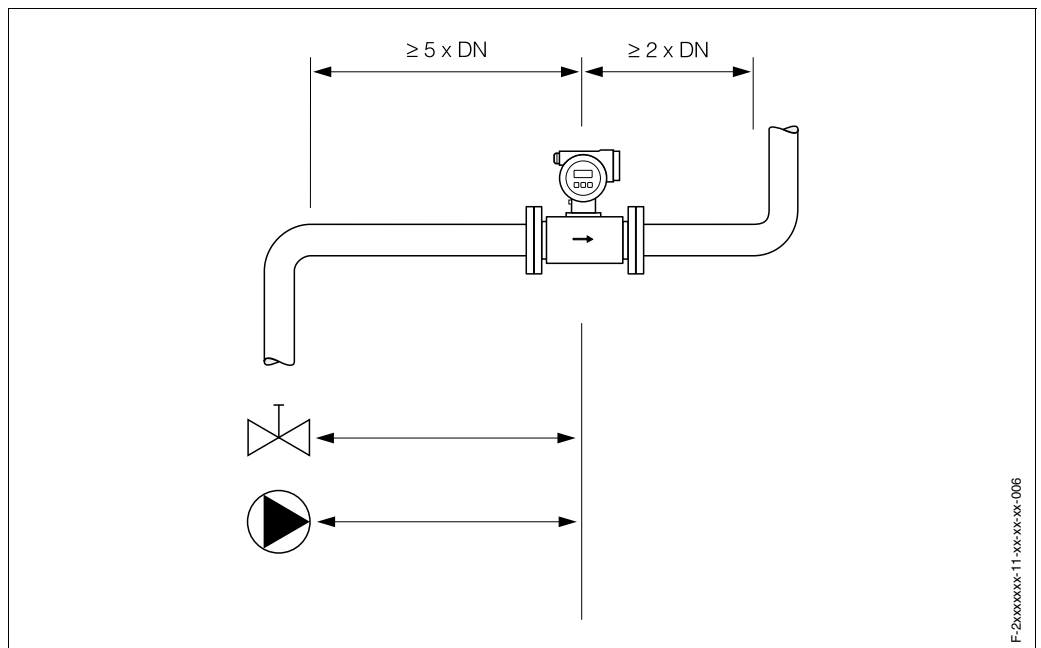
Secure the piping and the sensor if vibration is severe. Information on resistance to vibration and shock can be found on Page 13.



Inlet and outlet runs

If possible, install the sensor well clear of fittings such as valves, T-pieces, elbows, etc. Compliance with the following requirements for the inlet and outlet runs is necessary in order to ensure measuring accuracy:

- Inlet run: $\geq 5 \times \text{DN}$
- Outlet run: $\geq 2 \times \text{DN}$

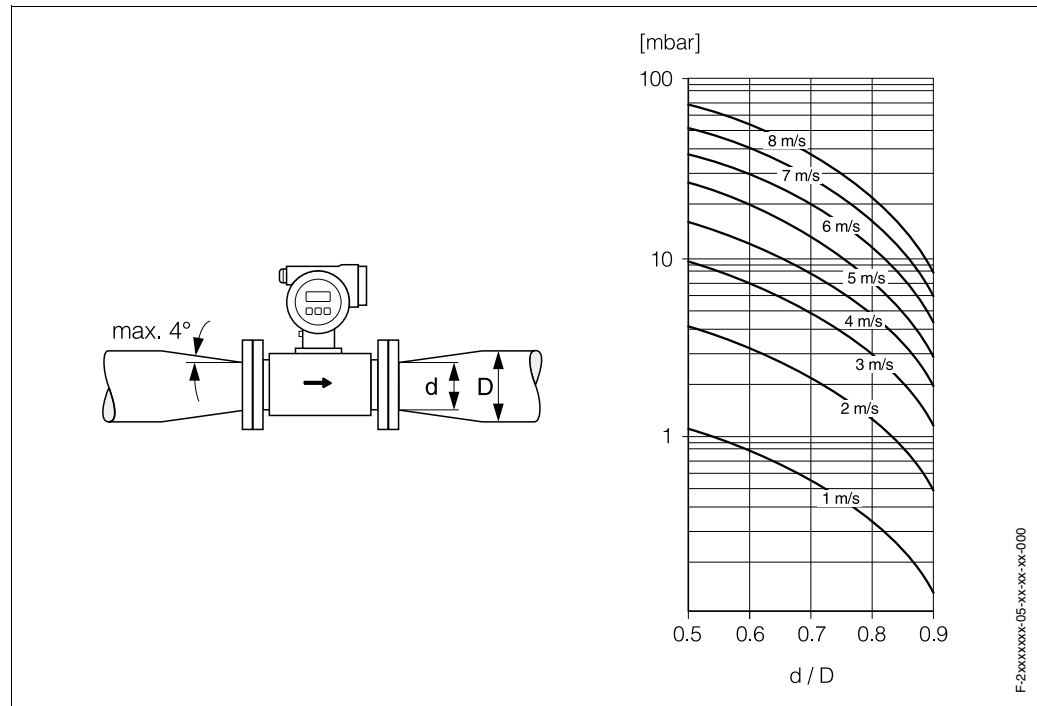


Adapters

Suitable adapters to DIN 28545 (reducers and expanders) can be used to install the sensor in larger-diameter pipes. The resultant increase in the rate of flow improves measuring accuracy with very slow-moving fluids.

The nomogram shown here can be used to calculate the pressure loss caused by reducers and expanders. The nomogram applies to fluids of viscosity similar to water.

1. Calculate the ratio of the diameters d/D .
2. From the nomogram read off the pressure loss as a function of flow velocity (downstream from the reduction) and the d/D ratio.

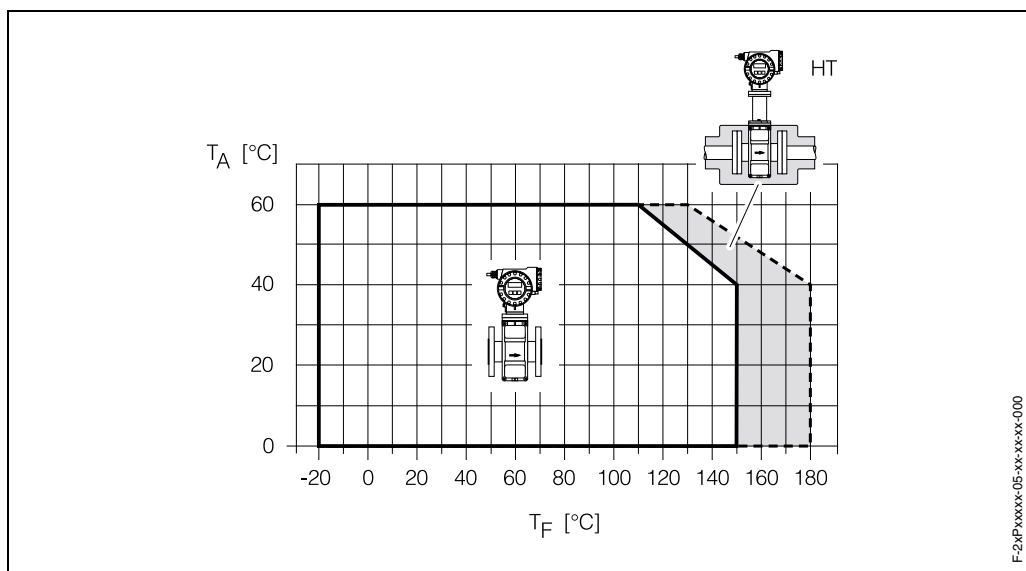


Conditions for operation (ambient conditions)

Ambient temperature	-20...+60 °C
	Install the device at a shady location. Avoid direct sunlight, particularly in warm climatic regions.
Storage temperature	-10...+50 °C (preferably +20 °C)
Degree of protection	IP 67 (NEMA 4X)
Shock and vibration resistance	Acceleration up to 2 g by analogy with IEC 68-2-6
Electromagnetic compatibility (EMC)	To EN 61326 and NAMUR recommendation NE 21

Conditions for operation (process conditions)

Medium temperature range	The permissible medium temperature depends on the measuring-tube lining: <ul style="list-style-type: none"> • PTFE: -40...+130 °C • PFA: -20...+180 °C (Ex: -20...+150 °C), details → see graph
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T_A = ambient temperature
 T_F = medium temperature
 HT = high-temperature version, with insulation

Conductivity	Minimum conductivity $\geq 50 \mu\text{S/cm}$ (for fluids in general)
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**Medium pressure range
(nominal pressure)**

DIN 2501:
 PN 10 (DN 200)
 PN 16 (DN 65...200)
 PN 25 (DN 200)
 PN 40 (DN 25...150)

ANSI B16.5:
 Class 150 (1...8")
 Class 300 (1...8")

JIS B2238:
 10K (DN 50...200)
 20K (DN 25...200)

Flow limit

The diameter of the pipe and the flow rate determine the nominal diameter of the sensor.
 The optimum velocity of flow is 2...3 m/s.

Nominal diameter		Flow in [m ³ /h]		
[mm]	[inch]	Flow at v = 0.3 m/s	Default at v ~ 2.5 m/s	Flow at v = 10 m/s
25	1"	0.5301	4.418	17.67
32	1 1/4"	0.8686	7.238	28.95
40	1 1/2"	1.357	11.31	45.24
50	2"	2.121	17.67	70.69
65	2 1/2"	3.584	29.87	119.5
80	3"	5.429	45.24	181.0
100	4"	8.482	70.69	282.7
125	5"	13.25	110.5	441.8
150	6"	19.09	159.0	636.2
200	8"	33.93	282.7	1131

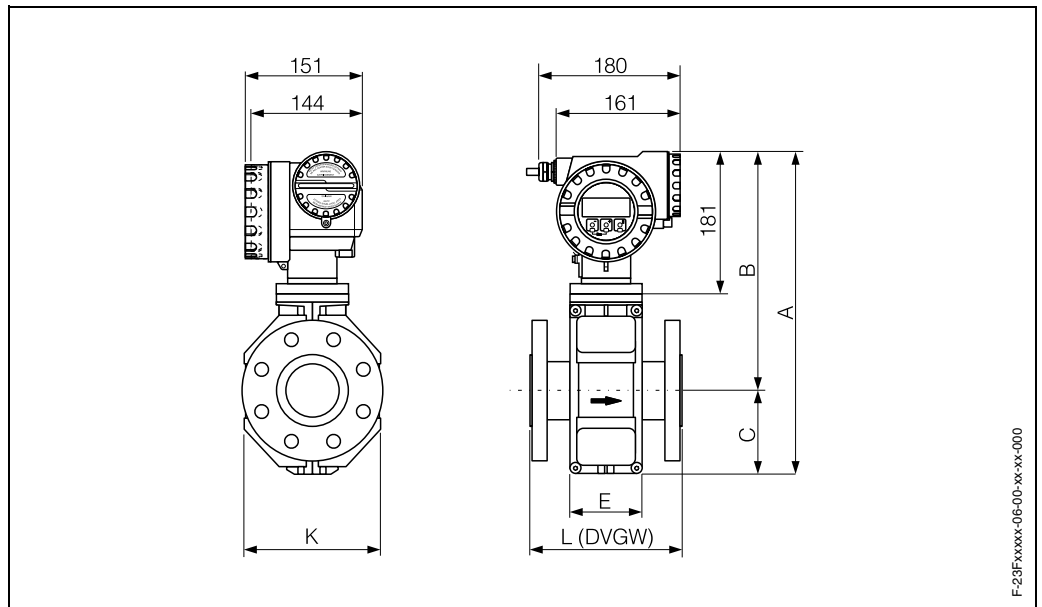
Pressure loss

- No pressure loss if the sensor is installed in a pipe of the same nominal diameter.
- Pressure losses for configurations incorporating adapters (reducers, expanders)
 → see Page 12

Mechanical construction

Design / dimensions

Promag P / DN 25...200



F-29Fxxxx-06-00-xx-xx-000

DN		L	A	B	C	K	E	Weight
DIN [mm]	ANSI [inch]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[kg]
25	1"	200	365	281	84	120	94	7.1
32	–	200	365	281	84	120	94	8.0
40	1 1/2"	200	365	281	84	120	94	9.1
50	2"	200	365	281	84	120	94	10.3
65	–	200	415	306	109	180	94	12.0
80	3"	200	415	306	109	180	94	14.0
100	4"	250	415	306	109	180	94	16.0
125	–	250	496	346	150	260	140	21.2
150	6"	300	496	346	150	260	140	25.2
200	8"	350	551	371	180	324	156	35.0

The fitting length (L) is always the same, regardless of the pressure rating.

Weight see Page 15

Materials Transmitter housing:
Powder-coated die-cast aluminum

Sensor housing:
Powder-coated die-cast aluminum

Flange material:

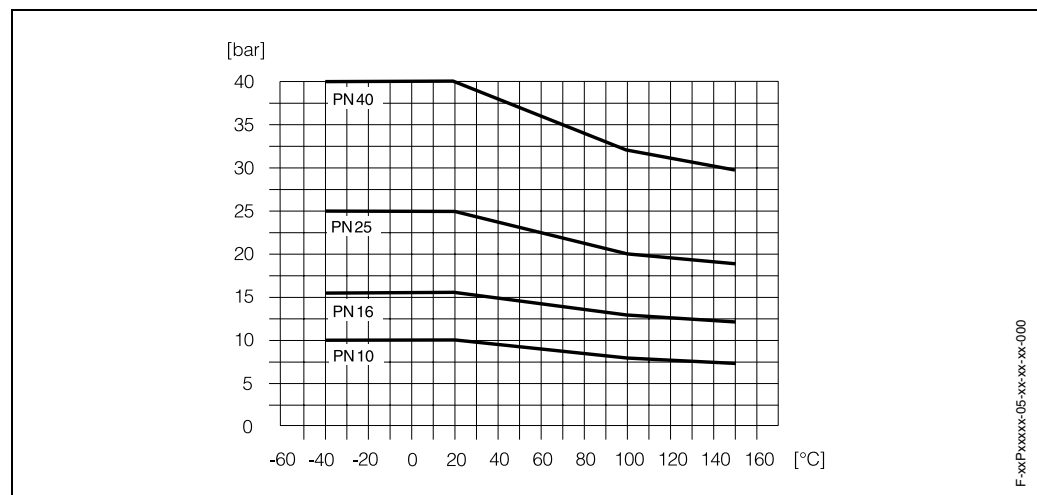
- DIN: stainless steel 1.4571, ST37-2
- ANSI: A105, 316L
- JIS: S20C, SUS 316L

Electrode material:
1.4435; Hastelloy C-22; tantalum, platinum/rhodium 80/20

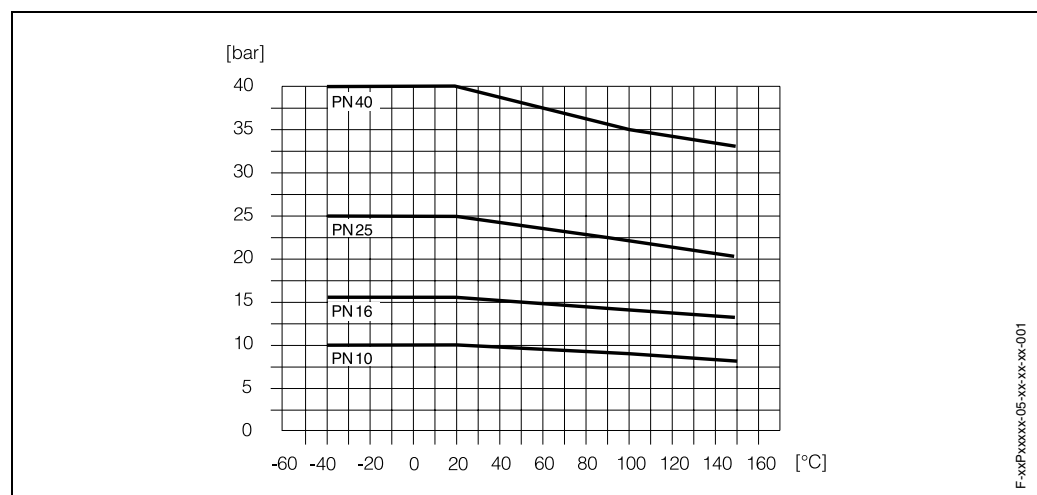
Seal material:
Seals to DIN 2690

Material load curves

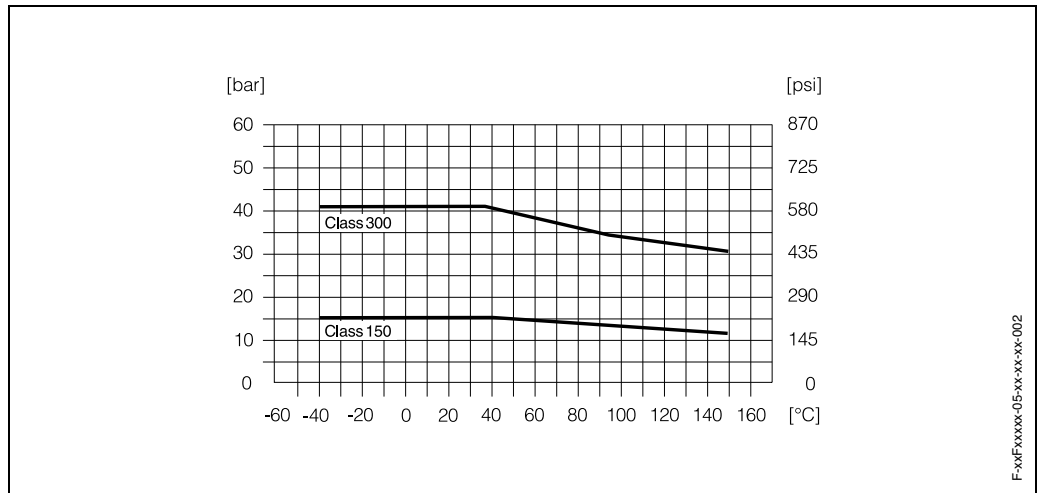
Flange material: steel 37.2
(to DIN 2413 and 2505)



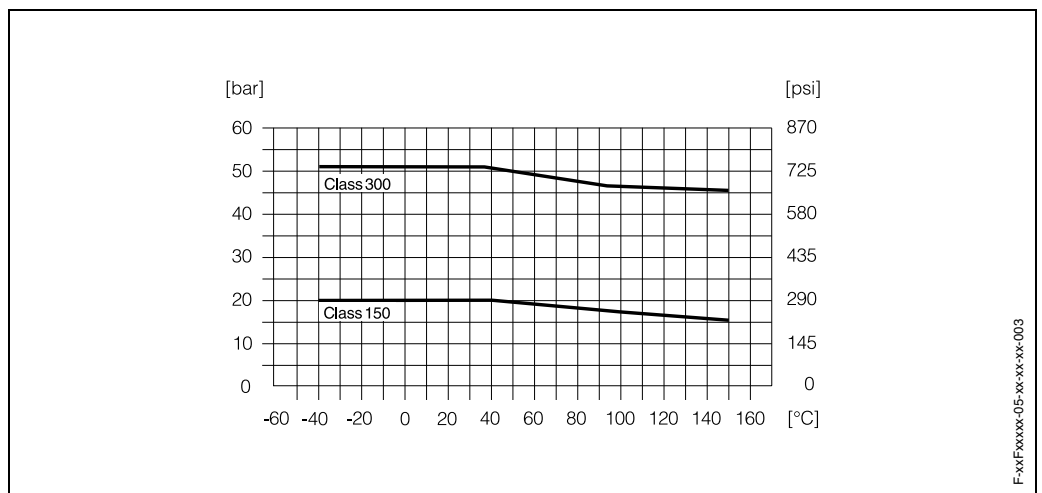
Flange material: stainless steel 1.4571
(to DIN 2413 and 2505)



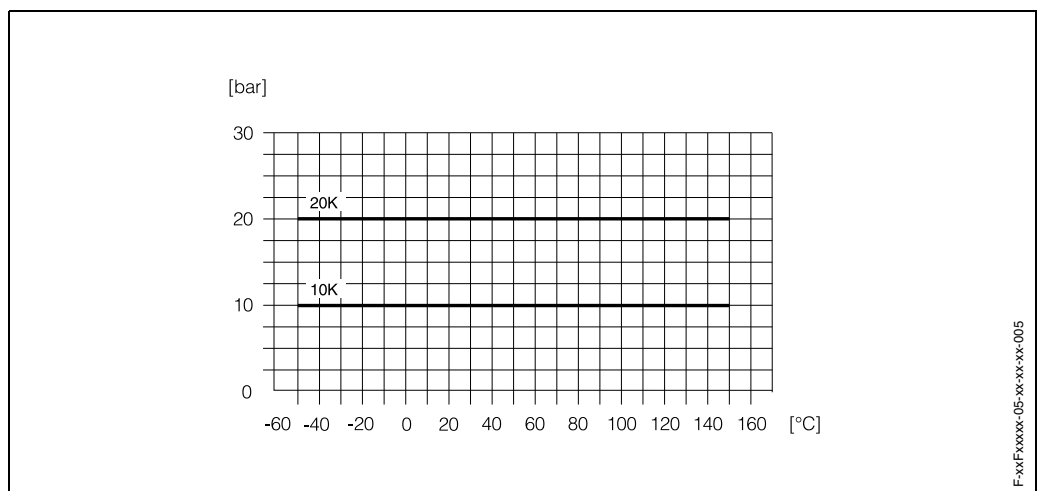
Flange material: steel 316L
(to ANSI B16.5)



Flange material: steel A105
(to ANSI B16.5)



Flange material: S20C / SUS 316L
(to JIS B2238)



Fitted electrodes	Measuring, reference and EPD electrodes: <ul style="list-style-type: none"> • Standard with: 1.4435, Hastelloy C-22, tantalum • Optional: Reference electrode and EPD electrode made of platinum/rhodium 80/20
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Process connection	Flange connections: DIN, ANSI, JIS
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Display and user interface

Display elements	<ul style="list-style-type: none"> • Liquid-crystal display: four lines with 16 characters per line • Custom configurations for presenting different measured-value and status variables
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Controls	<ul style="list-style-type: none"> • Local operation with three virtual sensor keys (-, +, E) • Application-specific Quick Setup menus for straightforward commissioning (in preparation)
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Remote operation	Remote operation via HART
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Certificates and approvals

Ex approval	Information on the currently available Ex-rated versions (ATEX, FM, CSA, etc.) is available on request from your E+H sales outlet. All information relevant to explosion protection is available in separate Ex documents that you can order as necessary.
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CE mark	The measuring system is in conformity with the statutory requirements of the EC Directives. Endress+Hauser confirms successful testing of the device by affixing to it the CE mark.
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Other standards and guidelines	<p>EN 60529: Degrees of protection by housing (IP code)</p> <p>EN 61010: "Protection Measures for Electrical Equipment for Measurement, Control, Regulation and Laboratory Procedures".</p> <p>EN 61326 (IEC 1326): Electromagnetic compatibility (EMC requirements)</p> <p>NAMUR NE 21: Association for Standards for Control and Regulation in the Chemical Industry</p>
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Ordering information

The E+H service organization can provide detailed ordering information and information on the order codes on request.

Accessories

Various accessories, which can be ordered separately from Endress+Hauser, are available for the transmitter and the sensor. The E+H service organisation can provide detailed information on request.

Supplementary documentation

- System Information Promag (SI 028D/06/en)
- Technical Information Promag 23 H (TI 051D/06/en)
- Operating Instructions Promag 23 (BA 045D/06/en and BA 050D/06/en)
- Supplementary documentation on Ex-ratings: ATEX, FM, CSA, etc.

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