Technical Information
TI 049D/06/en
50097005

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

Flow rate measurement in chemical or process applications

Features and benefits
- Nominal diameters DN 25...200
- PFA or PTFE lining
- PFA for high-temperature applications up to +180 °C (Ex: up to +150 °C)
- Fitting lengths to DVGW and ISO
- Measuring accuracy: ± 0.5%
- Robust field housing, IP 67, with separate terminal compartment
- "Touch control": operation without opening the housing - also for Ex-rated applications
- 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 DC
  – Ex environment: 13.9...30 V DC
- Connecting to all mainstream transmitter power supplies and input cards of process control systems
- Reduced installation and operation costs

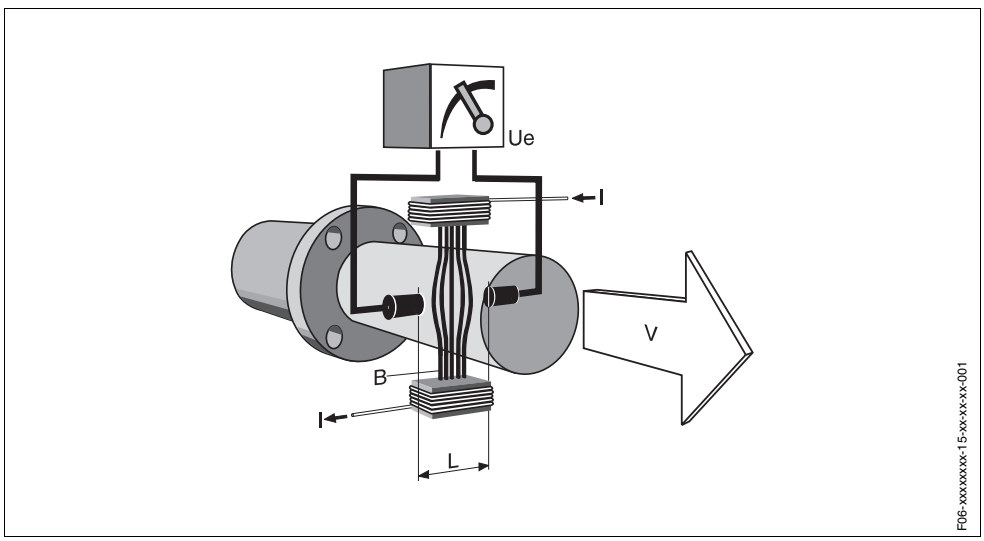
Application
All fluids with a minimum conductivity of ≥ 50 µS/cm can be measured:
- acids
- alkalis
- paints, lacquers
- water, etc.

Endress + Hauser
The Power of Know How

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.



$Ue = B \cdot L \cdot v$
$Q = A \cdot v$

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

Measuring system

The measuring system consists of a transmitter and a sensor.
Compact version: transmitter and sensor form a single mechanical unit.

- Transmitter:
Promag 23 ("Touch Control" without opening the housing, four-line display)

- Sensor
Promag P (DN 25...200)

Input

Measured variable

Flow rate (proportional to induced voltage)

Measuring range

Typically v = 0.01...10 m/s with the specified measuring precision

Operable flow range

Over 1000 : 1

Output

Output signal

- Current output:
  Applied direct current 4...20 mA, input from DC voltage source.
  Terminal voltage: 12...30 V DC, 13.9...30 V DC (Ex i)

- Frequency output:
  Open collector, passive, galvanically isolated, 30 V DC, 100 mA (250 mA / 20 ms)

  Optional configurable as:
  – Frequency output:
  Full scale frequency 500...10000 Hz (f_{max} = 12.5 Hz)
  or
  – Pulse output:
  Pulse value and pulse polarity adjustable, pulse width adjustable (0.01...10 s), pulse frequency max. 50 Hz
  or
  – Status output:
  E.g. for error messages, Empty Pipe Detection, flow direction recognition, limit value configurable

- Ex i version:
  – Power-supply, 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 following 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

see Page 5

Low flow cut off

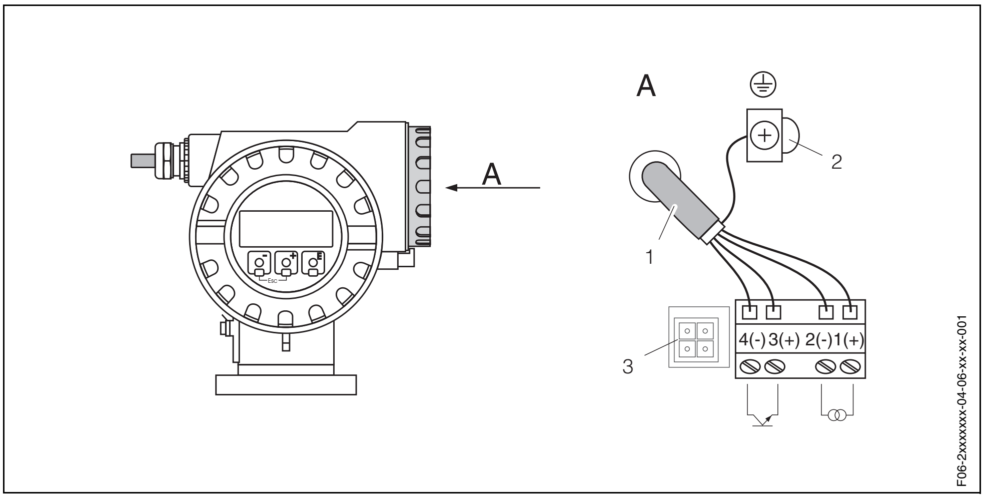
Switch points for low flow cut off are selectable.

Galvanic isolation

Outputs are galvanically isolated from sensor and from each other.

Power supply

Electrical connection measuring unit



1 *Shielded 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(–)**: frequency output*
2 *Grounding terminal for signal-cable shield*
3 *Service plug*

Outputs	**Terminal No.**	
Order variant	**1(+) / 2(–)**	**3(+) / 4(–)**
23***-***********W	*Current output HART*	–
23***-***********A	*Current output HART*	*Frequency output*

Mandatory:
A common connecting cable carries supply voltage and measuring output signal:
Current output (passive)
galvanically isolated: 12...30 V DC (Ex i: 13,9...30 V DC), 4...20 mA

Optional:
A binary output can be used as an option. It can be configured as a standard impulse output, a frequency output or a switching output:
Frequency output (passive)
galvanically isolated: max. 30 V DC, 100 mA, Open Collector
- Frequency operating mode: limit frequency 500...10000 Hz (f_{max} = 12500 Hz)
- Pulse operating mode: pulse frequency max. 50 Hz
- Status operating mode: yes

We recommend shielded signal cables as a general principle.

Load

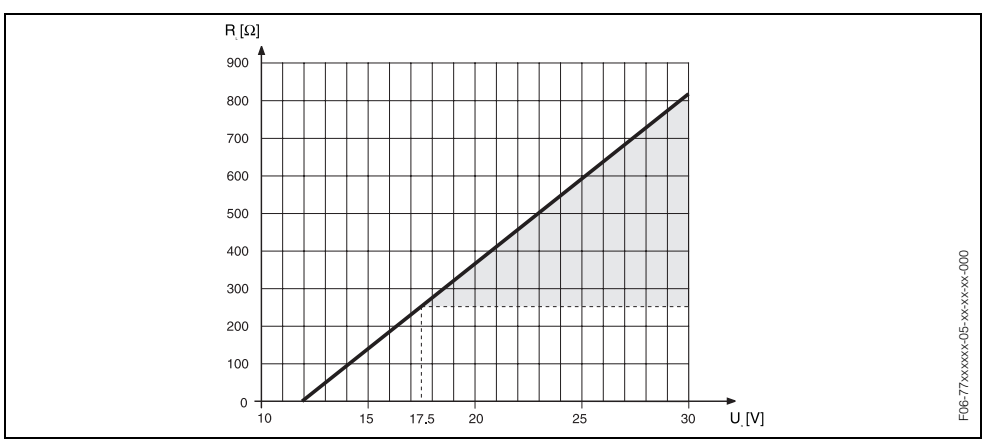
The load has to be calculated as follows:

Non Ex area: $R_L[\Omega] = \frac{U_S[V] - U_V[V]}{I_M[A]} = \frac{U_S[V] - 12[V]}{0,022[A]}$

Ex area (Ex i): $R_L[\Omega] = \frac{U_S[V] - U_V[V]}{I_M[A]} = \frac{U_S[V] - 13,9[V]}{0,022[A]}$

$R_L[\Omega]$ = max. load resistance, load (cable resistance)
$U_S[V]$ = external supply voltage of 12...30 V DC (outgoing supply voltage, transmitter supply unit)
$U_V[V]$ = min. supply voltage of 12 V DC
min. supply voltage of 13,9 V DC (Ex i)
(required supply voltage, transmitter)
$I_M[A]$ = max. signal transmission current
(failsafe mode current output: 22 mA max. current)

Note:
The minimum load resistance (R_L) necessary for a data transfer via HART protocol by way of the current signal cable is 250 Ω. The minimum external supply voltage (U_S) therefore has to be 17,5 V DC (non Ex).



Load at the analog current output (non Ex)
– R_L – max. load resistance (with HART: min. 250 Ω)
– U_S – external supply voltage (non Ex)

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 area: 12...30 V DC (with HART: 17.5...30 V DC)
Ex area (Ex i): 13.9...30 V DC (with HART: 19.4...30 V DC)

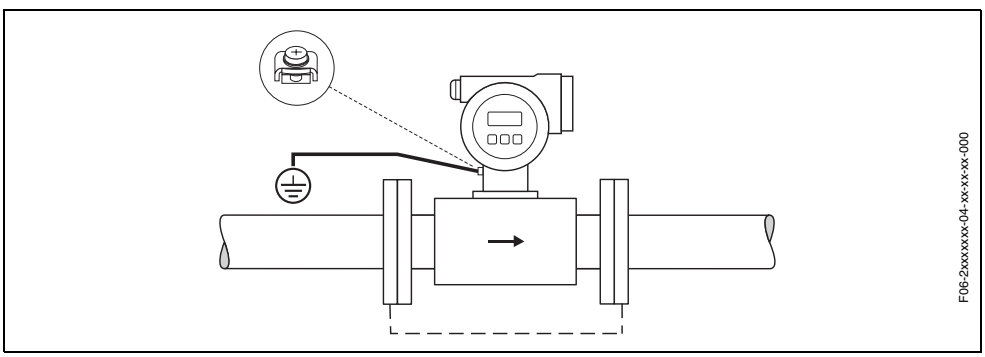
Power supply failure

- 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.)

Potential equalisation

Standard case
Perfect measurement is only ensured when the medium and the sensor have the same electrical potential. Most Promag sensors have a standard installed reference electrode which guarantees the required potential matching. This usually means that additional potential matching measures are unnecessary.

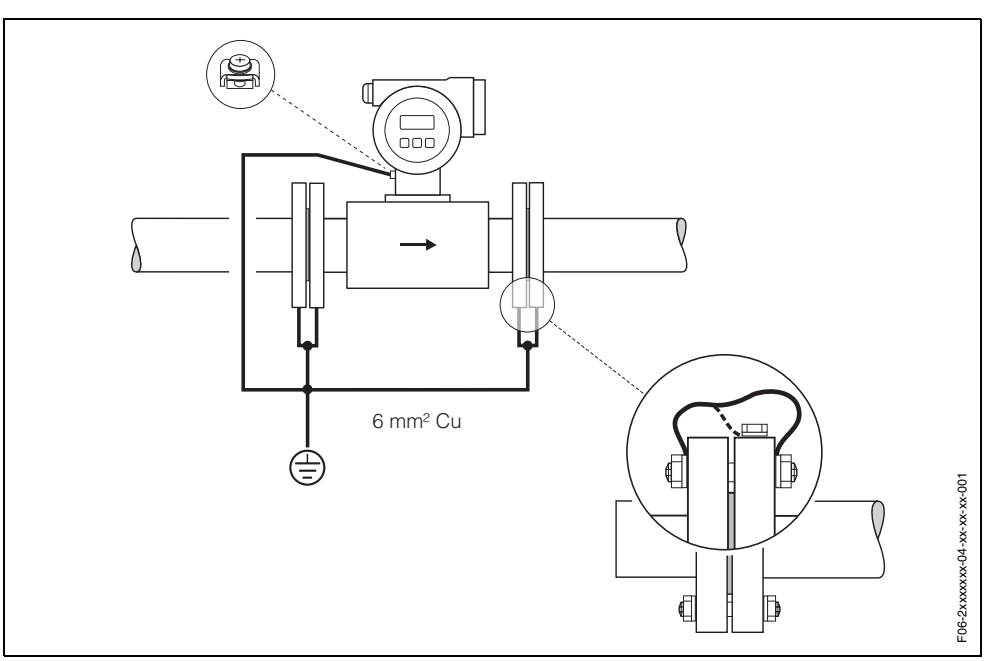
Note:
For installation in metal pipes, it is advisable to connect the ground terminal of the transmitter housing to the piping.



Caution:
For sensors without reference electrodes or without metal process terminals, carry out potential matching as per the instructions for special cases described below. These special measures are particularly important when standard grounding practice cannot be ensured or extremely strong matching currents are expected.

Metal, ungrounded piping
In order to prevent outside influences on measurement, it is advisable to use ground 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 ground terminal provided for the purpose.

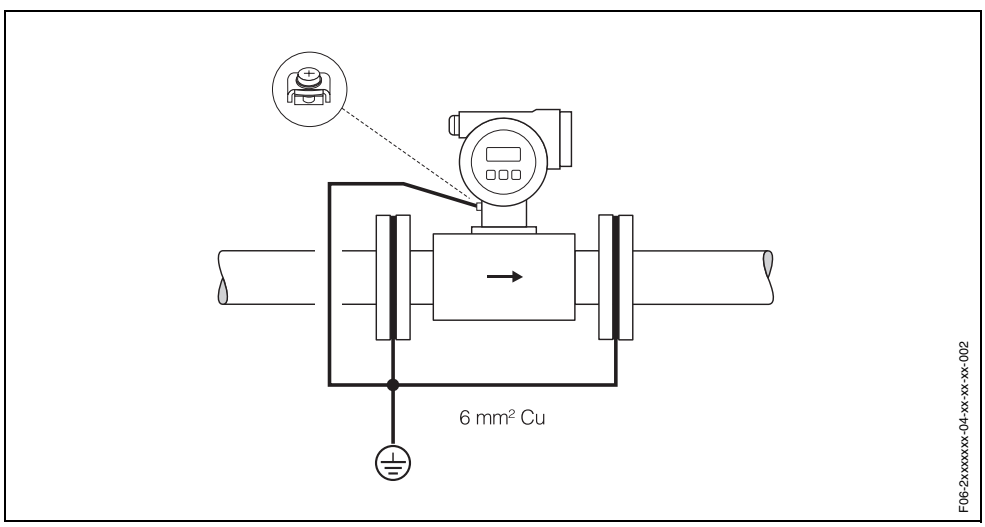
Note:
The ground cable for flange-to-flange connections can be ordered separately as an accessory from E+H.
The ground cable is in direct connection with the conductive flange coating and is secured by the flange screws.



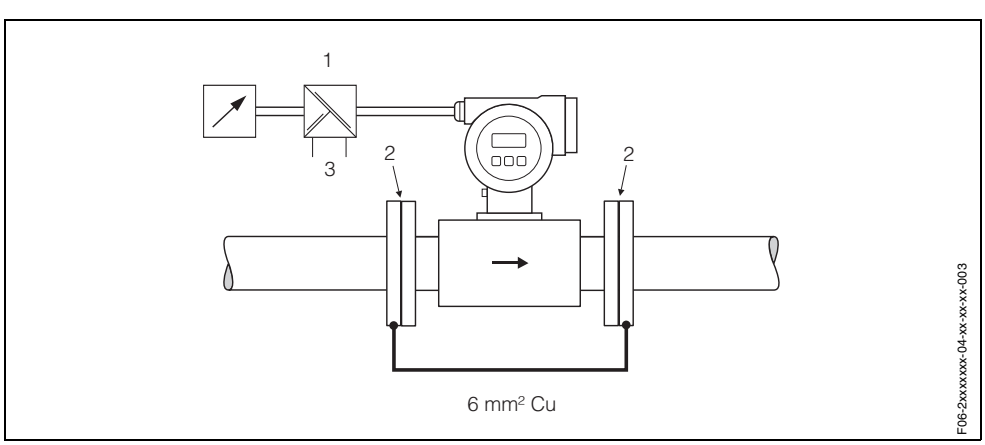
Plastic pipes and isolating lined pipes
Normally, potential is matched using the reference electrodes in the measuring tube. However, in exceptional cases it is possible that, due to the grounding plan of a system, large matching currents flow over the reference electrodes. This can lead to destruction of the sensor, e.g. through electrochemical decomposition of the electrodes. In such cases, e.g. for fibre-glass or PVC piping, it is recommended that you use additional ground disks for potential matching.

When using ground disks, note the following points:
- Ground disks (DN 25...200) can be ordered separately from E+H as an accessory.
- Ground disks (incl. seals) increase the installation length. You can find the dimensions of ground disks on Page 18.

Caution:
Risk of damage from electrochemical corrosion. Note the electrochemical insulation rating, if the ground disks and measuring electrodes are made of different materials.



Pipes with cathodic protection
In such cases, install the measuring instrument without potential in the piping:
² When installing the measuring device, make sure that there is an electrical connection between the two piping runs (copper wire, 6 mm²).
² 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.
² Also comply with the regulations applicable to potential-free installation.



1 power supply (unit)
2 electrically insulated
3 external power supply

Measuring accuracy

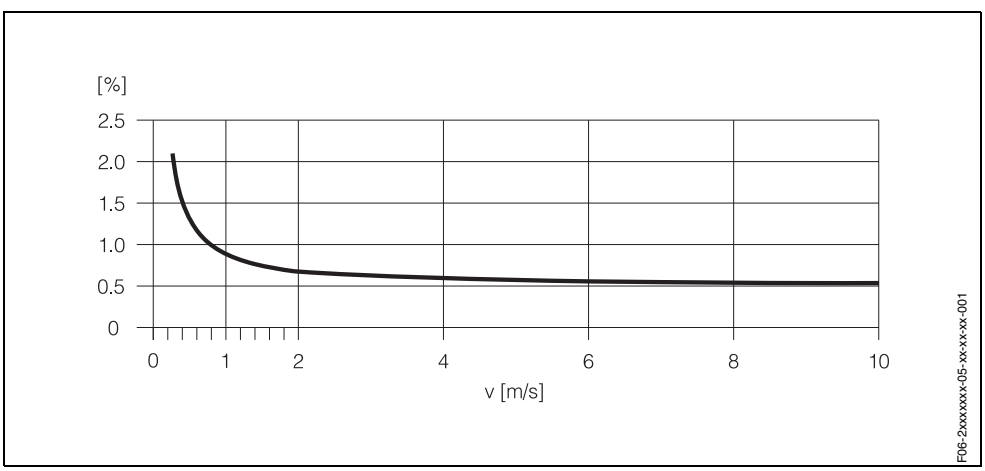
Reference operating conditions

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

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

Max. measured error

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



Max. measured error in [%] of reading

Repeatability

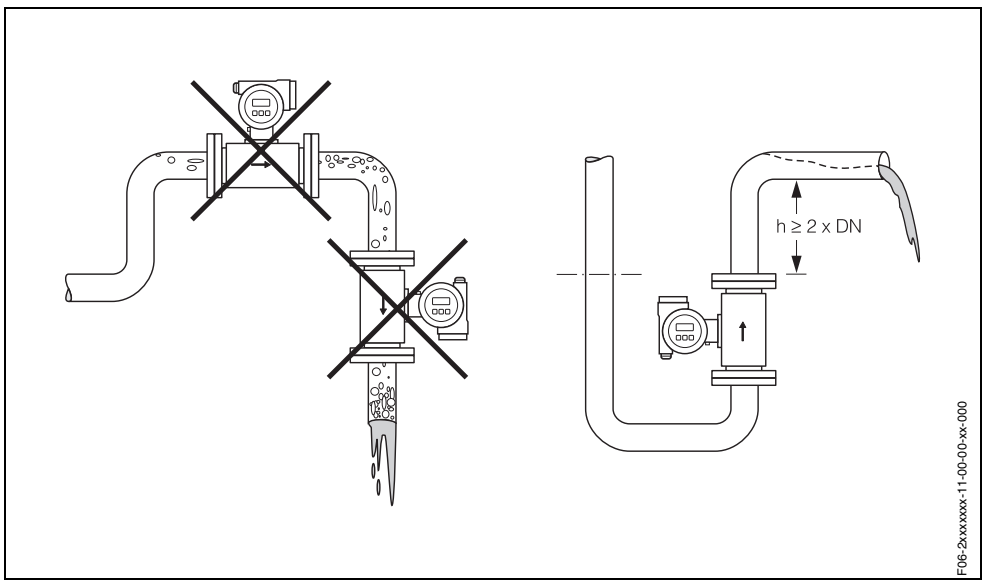
max. ± 0.25% o.r. ± 2 mm/s (o.r. = of reading)

Installation conditions

Installation instructions

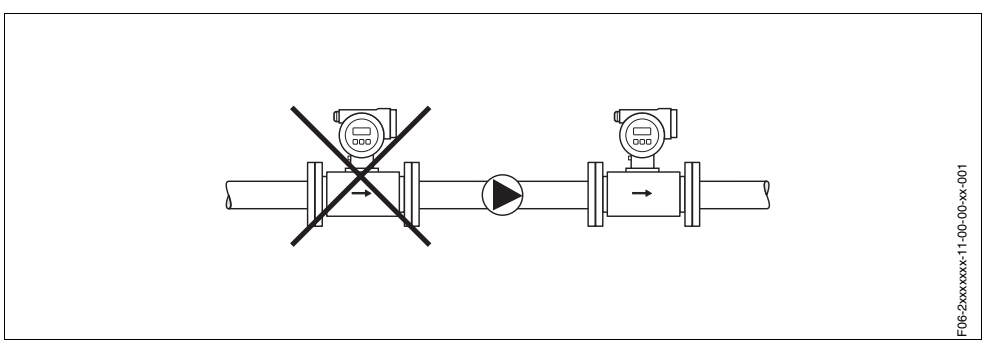
Mounting location

Correct measuring is possible only if the pipe is full. Avoid the following locations:
- Highest point of a pipeline. Risk of air accumulating.
- Directly upstream of a free pipe outlet in a down pipe.



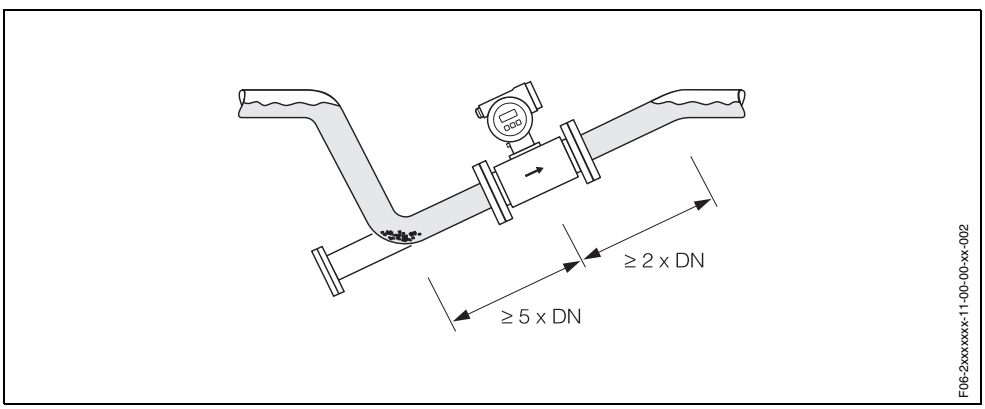
Installation of pumps

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 shock can be found on Page 14.

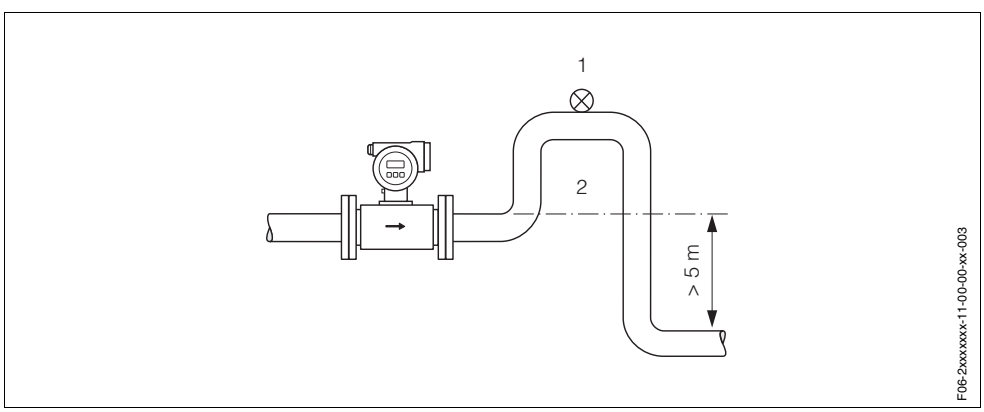


Partially filled pipes
Partially filled pipes with gradients necessitate a drain-type configuration. The Empty Pipe Detection (EPD) function offers additional protection by detecting empty or partially filled pipes.

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.



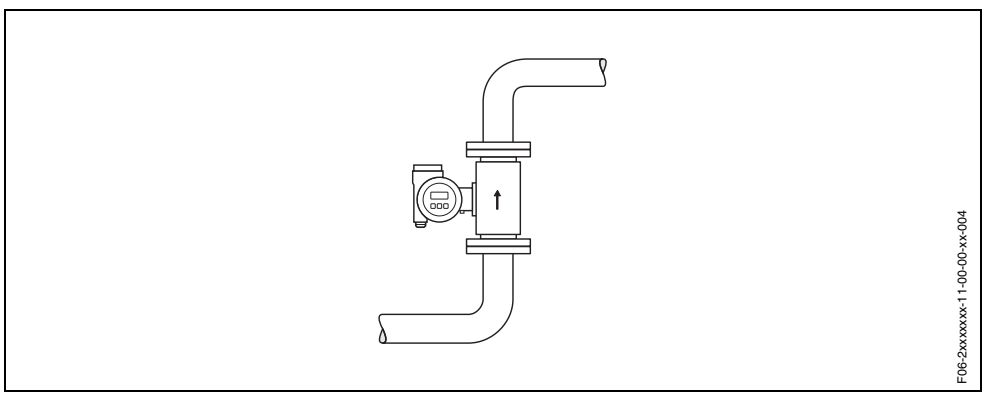
Down pipes
Install a siphon (2) or a vent valve (1) downstream of the sensor in down pipes longer than 5 meters. This precaution is to avoid low pressure and the consequent risk of damage to the lining of the measuring tube. These measures also prevent the system losing prime, which could cause air inclusions.



1 vent valve
2 siphon

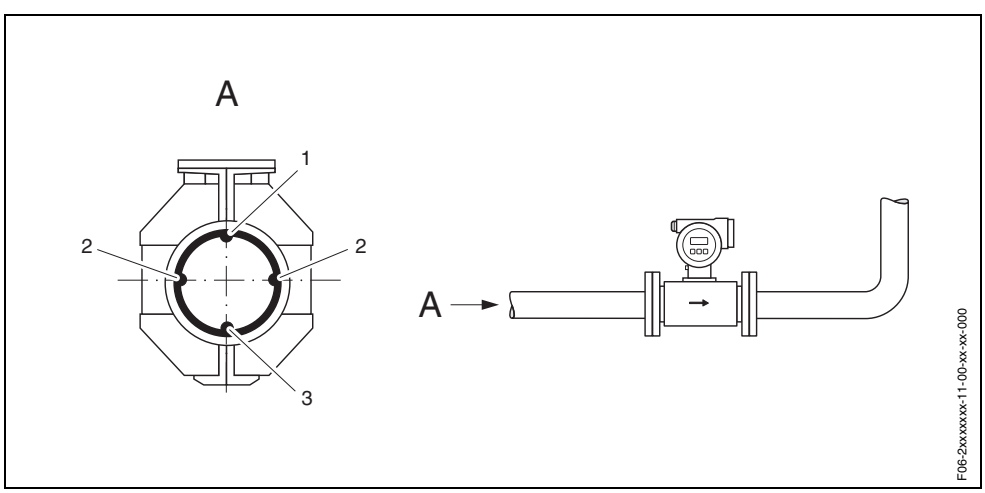
Orientation
An optimum orientation position helps avoid gas and air accumulations and deposits in the measuring tube. Promag, nevertheless, supplies a range of functions and accessories for correct measuring of problematic fluids:
Empty Pipe Detection (EPD) ensures the detection of partially filled measuring tubes, e.g. in the case of degassing fluids or varying process pressures

Vertical orientation:
This orientation is ideal for self-emptying piping systems and for use in conjunction with Empty Pipe Detection.



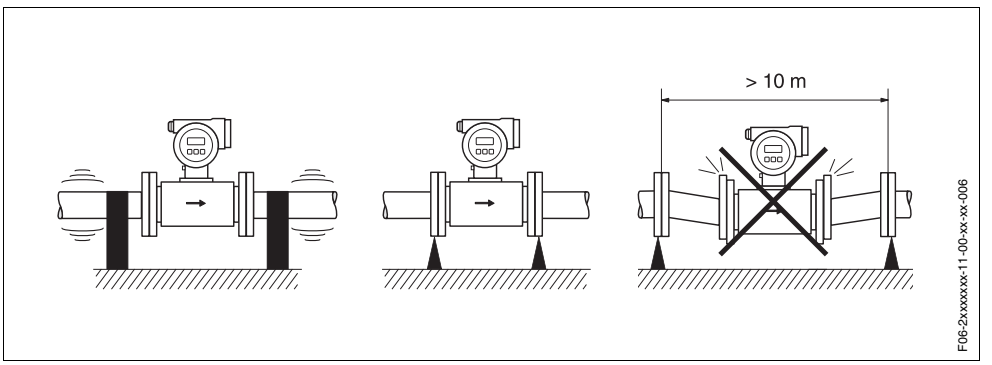
Horizontal orientation:
The measuring electrodes should be on a horizontal plane. This prevents brief insulation of the two electrodes by entrained air bubbles.

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.



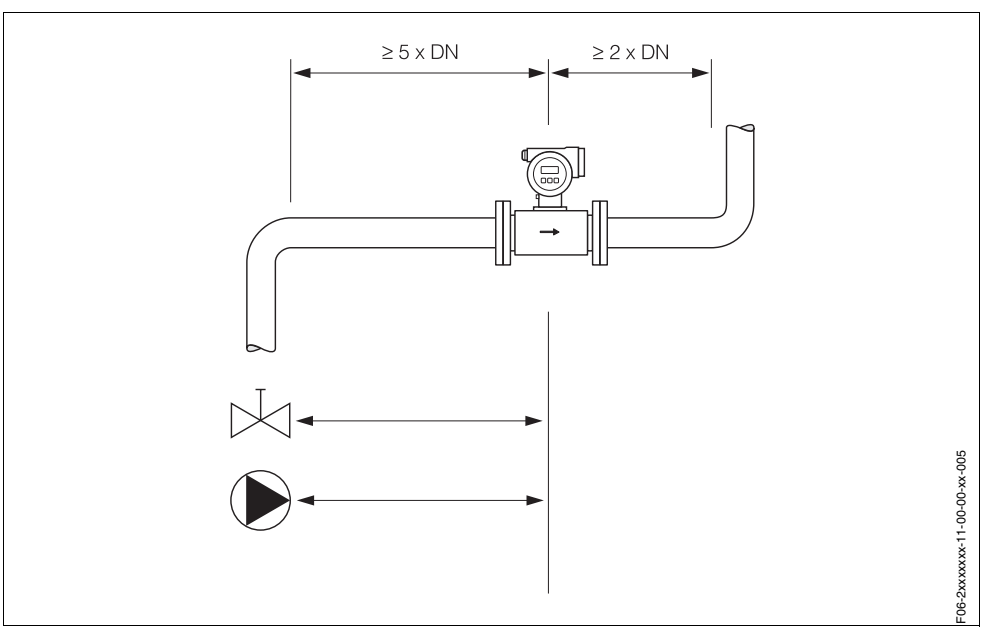
1 EPD electrode for the detection of empty pipes
2 Measurement electrodes for the signal acquisition
3 Reference electrode for the potential equalisation

Vibrations
Secure the piping and the sensor if vibration is severe. Information on resistance to vibration and shock can be found on Page 14.



Inlet and outlet runs

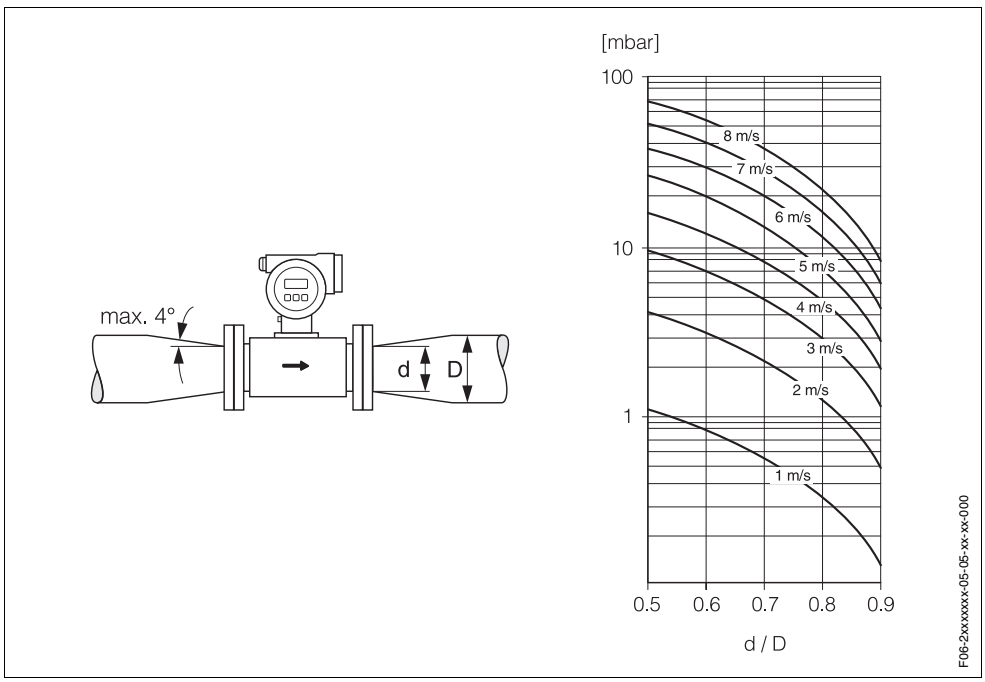
If possible, install the sensor well clear of fittings such as valves, T-pieces, elbows, etc. Compliance with the following requirements for the inlet and outlet runs is necessary in order to ensure measuring accuracy:
- Inlet run: ≥ 5 x DN
- Outlet run: ≥ 2 x DN



Adapters

Suitable adapters to (E) DIN EN 545 (double-flange junction sections) 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 only 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.



Pressure loss

- No pressure loss if the sensor is installed in a pipe of the same nominal diameter.
- Pressure losses for configurations incorporating adapters according to (E) DIN EN 545 (see “Adapters” on Page 13)

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
(High temperature version: no appropriate data available)

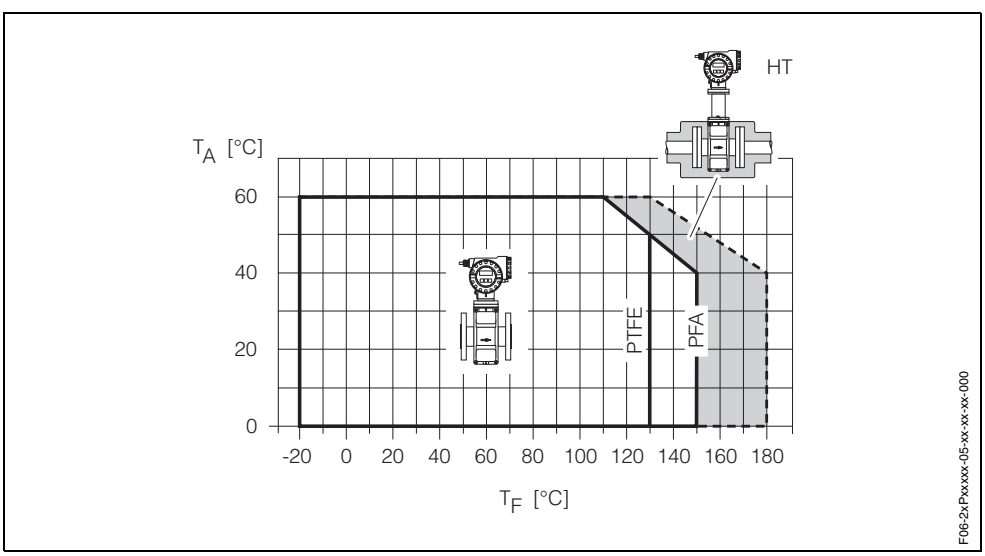
Electromagnetic compatibility (EMC)

To EN 61326 and NAMUR recommendation NE 21

Process conditions

Medium temperature range

The permissible medium temperature depends on the measuring-tube lining:
- PTFE: –40...+130 °C
- PFA: –20...+180 °C (Ex i: –20...+150 °C)
  for restrictions → see diagram



T_A = ambient temperature
T_F = medium temperature
HT = high temperature version, with insulation

Conductivity

Minimum conductivity ≥ 50 µS/cm (for fluids in general)

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)

Pressure tightness (liner)

Nominal diameter		**Measuring tube lining**	**Resistance to partial vacuum of measuring tube lining** Limit values for abs. pressure [mbar] at various fluid temperatures					
[mm]	[inch]		25 °C	80 °C	100 °C	130 °C	150 °C	180 °C
25	1"	PTFE / PFA	0 / 0	0 / 0	0 / 0	100 / 0	– / 0	– / 0
32	–	PTFE / PFA	0 / 0	0 / 0	0 / 0	100 / 0	– / 0	– / 0
40	1 1/2"	PTFE / PFA	0 / 0	0 / 0	0 / 0	100 / 0	– / 0	– / 0
50	2"	PTFE / PFA	0 / 0	0 / 0	0 / 0	100 / 0	– / 0	– / 0
65	–	PTFE / PFA	0 / 0	*	40 / 0	130 / 0	– / 0	– / 0
80	3"	PTFE / PFA	0 / 0	*	40 / 0	130 / 0	– / 0	– / 0
100	4"	PTFE / PFA	0 / 0	*	135 / 0	170 / 0	– / 0	– / 0
125	–	PTFE / PFA	135 / 0	*	240 / 0	385 / 0	– / 0	– / 0
150	6"	PTFE / PFA	135 / 0	*	240 / 0	385 / 0	– / 0	– / 0
200	8"	PTFE / PFA	200 / 0	*	290 / 0	410 / 0	– / 0	– / 0

* No value can be specified.

Limiting flow

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. The velocity of flow (v), moreover, has to be matched to the physical properties of the medium:
- v < 2 m/s: for abrasive mediums
- v > 2 m/s: for accretive mediums

Flow characteristics of Promag P (SI units)

Nominal diameter		Recommended flow rate	Factory settings		
[mm]	[inch]	Min./max. full scale value (v ~ 0.3 or 10 m/s)	Full scale value (v ~ 2.5 m/s)	Pulse weighting (~ 2 pulse/s)	Creepage (v ~ 0.04 m/s)
25	1"	9…300 dm³/min	75 dm³/min	0.50 dm³	1 dm³/min
32	1 1/4"	15…500 dm³/min	125 dm³/min	1.00 dm³	2 dm³/min
40	1 1/2"	25…700 dm³/min	200 dm³/min	1.50 dm³	3 dm³/min
50	2"	35…1100 dm³/min	300 dm³/min	2.50 dm³	5 dm³/min
65	2 1/2"	60…2000 dm³/min	500 dm³/min	5.00 dm³	8 dm³/min
80	3"	90…3000 dm³/min	750 dm³/min	5.00 dm³	12 dm³/min
100	4"	145…4700 dm³/min	1200 dm³/min	10.00 dm³	20 dm³/min
125	5"	220…7500 dm³/min	1850 dm³/min	15.00 dm³	30 dm³/min
150	6"	20…600 m³/h	150 m³/h	0.025 m³	2.5 m³/h
200	8"	35…1100 m³/h	300 m³/h	0.05 m³	5.0 m³/h

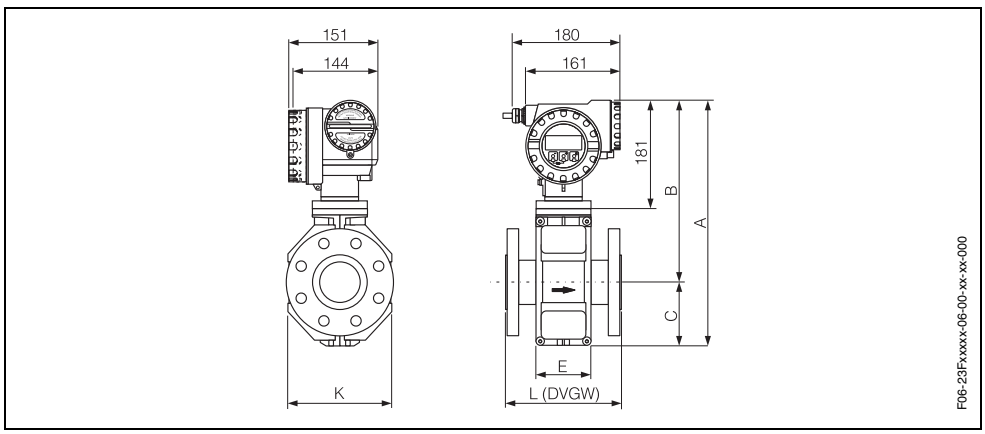
Flow characteristics of Promag P (US units)

Nominal diameter		Recommended flow rate	Factory settings		
[inch]	[mm]	Min./max. full scale value (v ~ 0.3 or ~ 10 m/s)	Full scale value (v ~ 2.5 m/s)	Pulse weighting (~ 2 pulse/s)	Creepage (v ~ 0.04 m/s)
1"	25	2.5…80 gal/min	18 gal/min	0.20 gal	0.25 gal/min
1 1/4"	32	4…130 gal/min	30 gal/min	0.20 gal	0.50 gal/min
1 1/2"	40	7…190 gal/min	50 gal/min	0.50 gal	0.75 gal/min
2"	50	10…300 gal/min	75 gal/min	0.50 gal	1.25 gal/min
2 1/2"	65	16…500 gal/min	130 gal/min	1 gal	2.0 gal/min
3"	80	24…800 gal/min	200 gal/min	2 gal	2.5 gal/min
4"	100	40…1250 gal/min	300 gal/min	2 gal	4.0 gal/min
5"	125	60…1950 gal/min	450 gal/min	5 gal	7.0 gal/min
6"	150	90…2650 gal/min	600 gal/min	5 gal	12 gal/min
8"	200	155…4850 gal/min	1200 gal/min	10 gal	15 gal/min

Mechanical construction

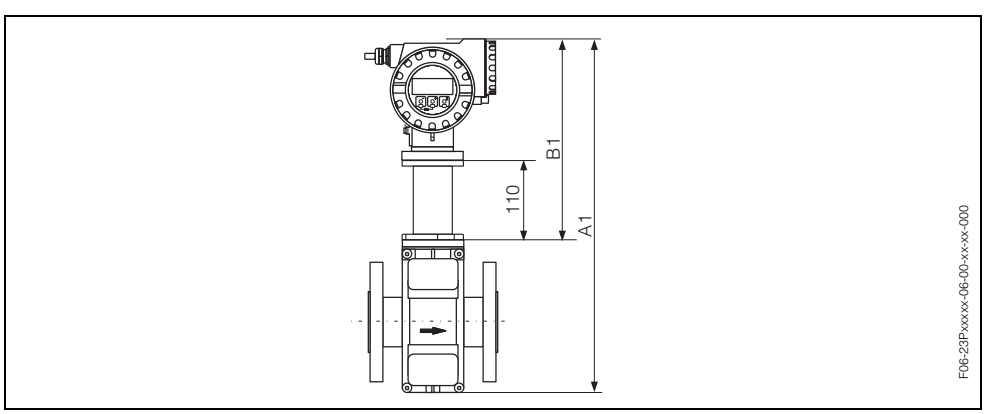
Design / dimensions

Promag P / DN 25...200



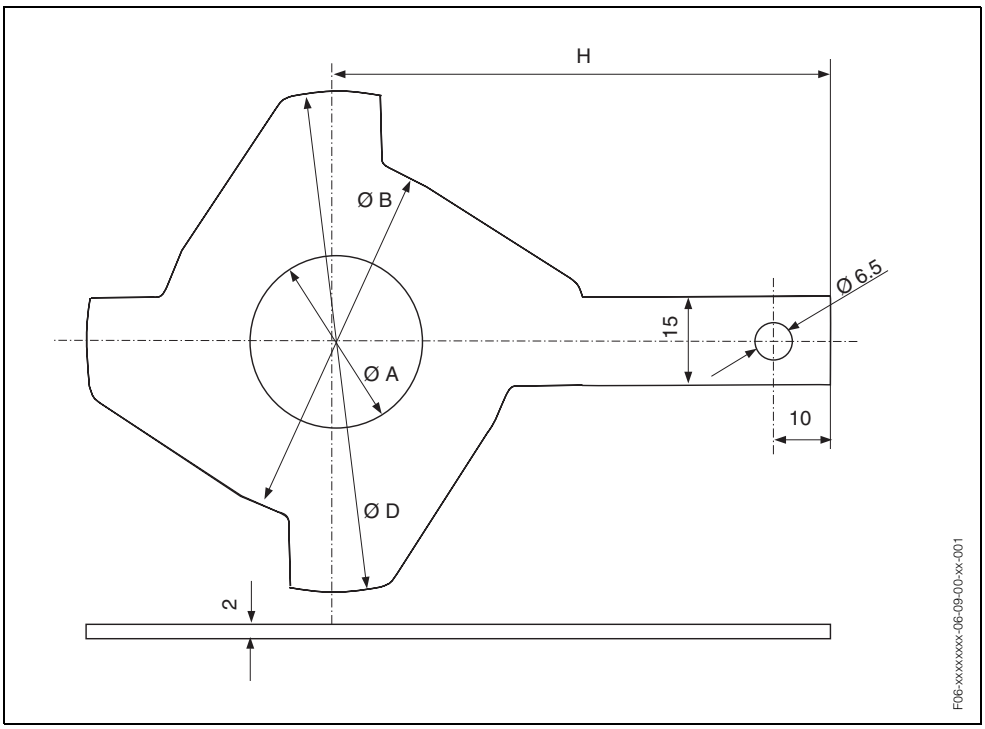
DN		L	A	B	C	K	E
DIN [mm]	ANSI [inch]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
25	1"	200	365	281	84	120	94
32	–	200	365	281	84	120	94
40	1 1/2"	200	365	281	84	120	94
50	2"	200	365	281	84	120	94
65	–	200	415	306	109	180	94
80	3"	200	415	306	109	180	94
100	4"	250	415	306	109	180	94
125	–	250	496	346	150	260	140
150	6"	300	496	346	150	260	140
200	8"	350	551	371	180	324	156
The fitting length (L) is always the same, regardless of the pressure rating.							

Promag P / DN ≤ 300 (high temperature version)



Dimensions of high temperature version (Promag P)
Dimensions A1, B1 = A, B of standard version plus 110 mm

Ground disk (DN 25...200)



Dimensions of ground disks (Promag P / DN 25…200)

DN [1]		A	B	D	H
DIN [mm]	ANSI [inch]	[mm]	[mm]	[mm]	[mm]
25	1"	30	62	77.5	87.5
32	–	38.5	80	87.5	94.5
40	1 1/2"	44.5	82	101	103
50	2"	56.5	101	115.5	108
65	–	72.5	121	131.5	118
80	3"	85	131	154.5	135
100	4"	110	156	186.5	153
125	–	135	187	206.5	160
150	6"	163	217	256	184
200	8"	210.5	267	288	205

[1] Ground disks can be used for all suppliable flange standards / pressure ratings.

Weight

Weight data of Promag P in kg

Nominal diameter		Compact version			
		DIN		ANSI	
[mm]	[inch]				
25	1"	PN 40	7,3	Class 150	7,3
32	1 1/4"		8,0		–
40	1 1/2"		9,4		9,4
50	2"		10,6		10,6
65	2 1/2"	PN 16	12,0		–
80	3"		14,0		14,0
100	4"		16,0		16,0
125	5"		21,5		–
150	6"		25,5		25,5
200	8"	PN 10	45		45

High temperature version: +1.5 kg
(Weight data valid for standard pressure ratings and without packaging material)

Materials

Transmitter housing:
Powder-coated die-cast aluminum

Sensor housing:
Powder-coated die-cast aluminum

Measuring tube:
Stainless steel 1.4301 or 1.4306/304L
(with non-stainless flange material with Al/Zn protective coating)

Flanges:
- DIN : Stainless steel 1.4571, ST37 / FE 410W B (with Al/Zn protective coating)
- ANSI: A105, 316L (with Al/Zn protective coating)
- JIS: S20C, SUS 316L (with Al/Zn protective coating)

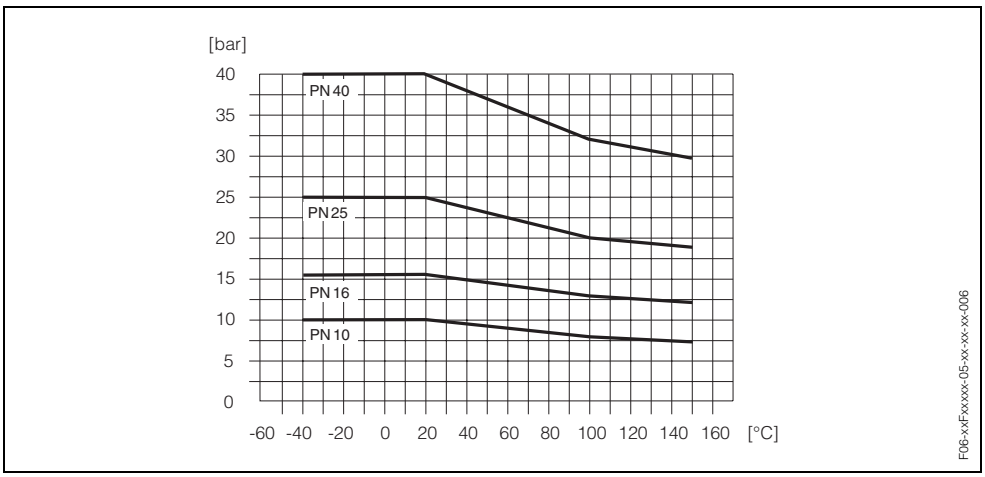
Ground disks:
- Standard: 1.4435/316L
- Option: Alloy C-22

Electrodes:
- Standard: 1.4435, platinum/rhodium 80/20
- Option: Alloy C-22, tantalum

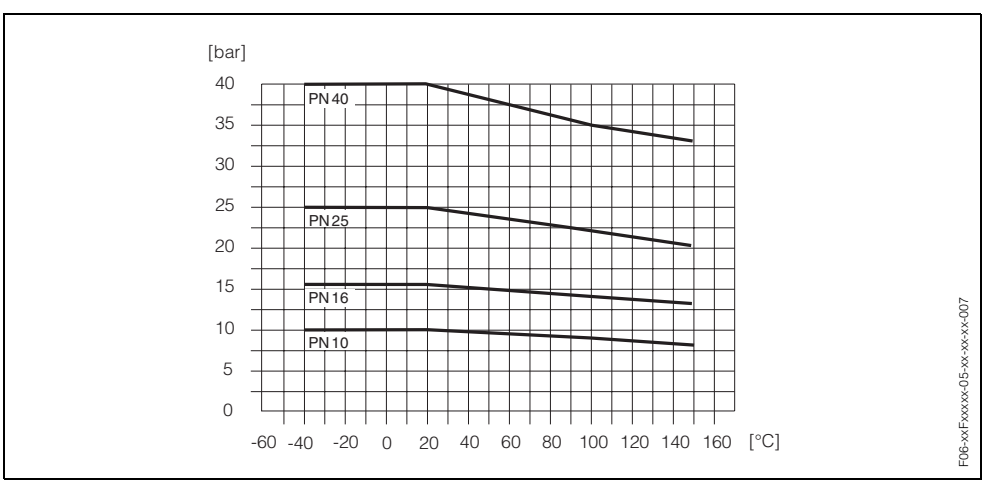
Seals to DIN 2690

Material load curves

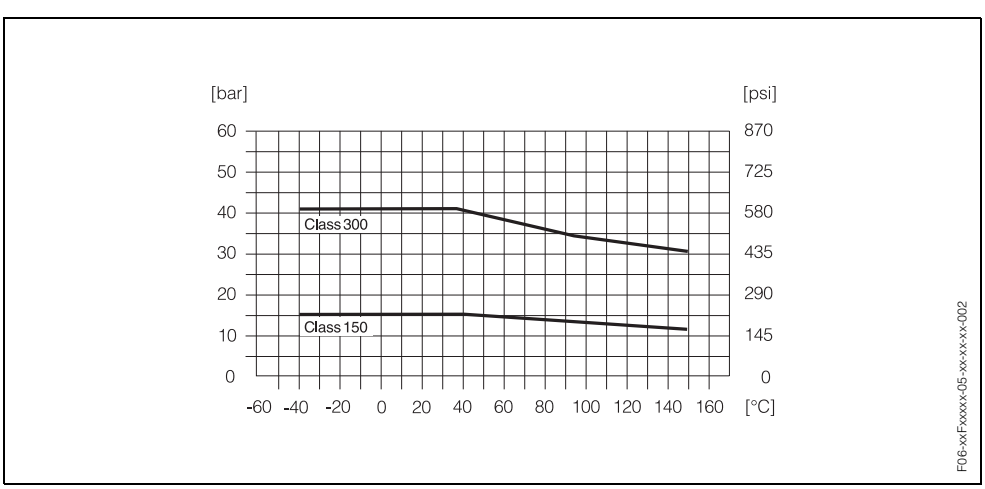
Flange material: steel 37
to DIN 2413 and 2505



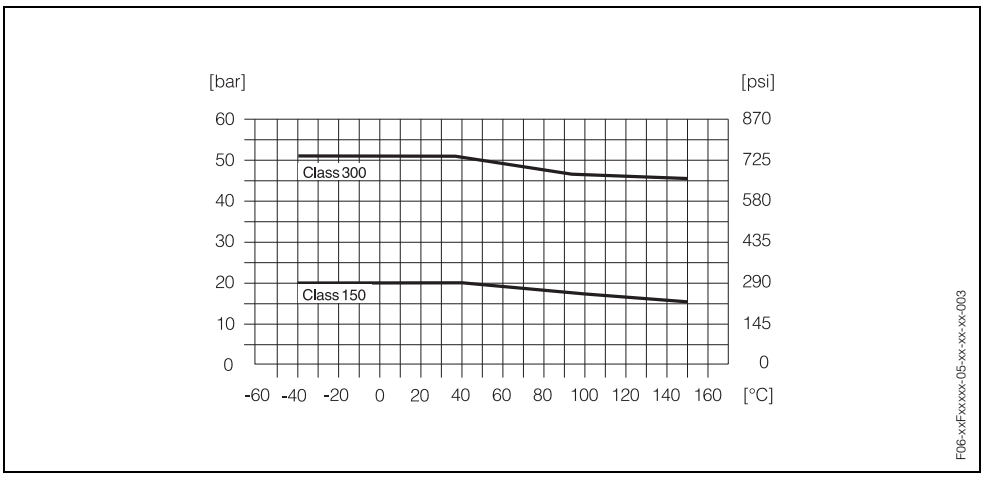
Flange material: stainless steel 1.4571
to DIN 2413 and 2505



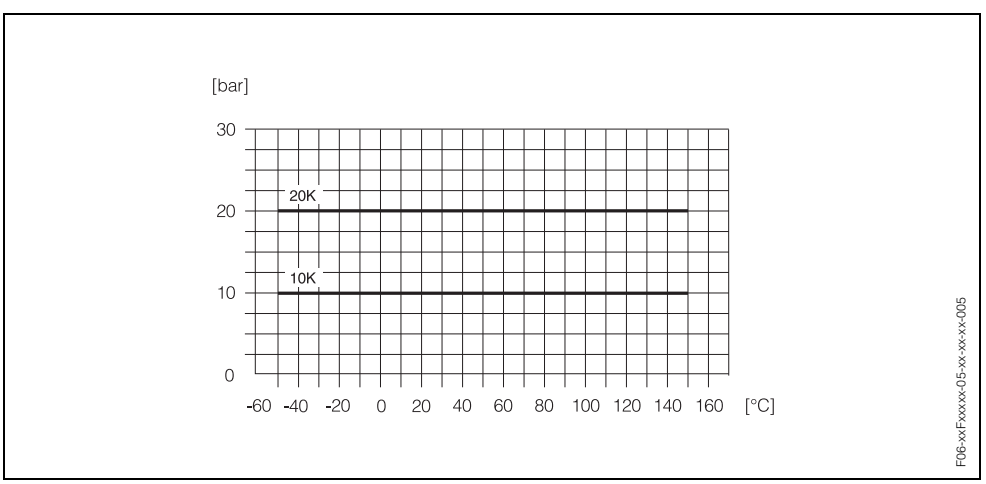
Flange material: steel 316L
to ANSI B16.5



Flange material: steel A105
to ANSI B16.5



Flange material: S20C / SUS 316L
to JIS B2238



Fitted electrodes

Measuring, reference and EPD electrodes:
- Standard: available with 1.4435, Alloy C-22, tantalum
- Optional: reference electrode and EPD electrodes made of platinum/rhodium 80/20

Process connection

Flange connection: DIN (dimensions to DIN 2501), ANSI, JIS

Surface roughness

- PFA liner: ≤ 0.3 µm
- Electrodes:
  – 1.4435, Alloy C-22: ≤ 0.4 µm
  – Tantalum, platinum/rhodium: ≤ 0.8 µm
- Process connection Promass H: ≤ 0.8 µm

(all data relate to parts in contact with medium)

Human interface

Display elements
- Liquid-crystal display: four lines with 16 characters per line
- Custom configurations for presenting different measured values and status variables
- 2 totalizers

Operating elements
Unified (PROline-) operation concept:
Local operation with three optical keys (–, +, E)

Remote operation
Operation via HART

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.

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.

Other standards and guidelines
EN 60529:
Degrees of protection by housing (IP code)

EN 61010:
"Protection Measures for Electrical Equipment for Measurement, Control, Regulation and Laboratory Procedures".

EN 61326 (IEC 1326):
Electromagnetic compatibility (EMC requirements)

NAMUR NE 21:
Association for Standards for Control and Regulation in the Chemical Industry

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.

Subject to modification

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TI 049D/06/en/08.01
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FM+SGML 6.0