Technical
Information
TI 049D/24/ae

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

Flow measurement in chemical or process applications

Features and benefits

- Nominal diameters 1” to 8”
- PTFE or PFA lining
- PFA for high temperature applications up to 355°F (up to 300°F for hazardous areas)
- Fitting lengths to ISO and DVGW
- Measuring accuracy of ± 0.5%
- Robust field housing, NEMA 4X (IP 67) with separate terminal compartment
- Touch Control: operation without opening the housing, also in hazardous areas
- Connection to all mainstream transmitter power supplies and input cards of process control systems
- Communication via HART® is standard
- Intrinsically safe for installation in Division 1 (FM, CSA, ATEX, etc.)
- Transmitter supply:
  - Non-hazardous areas: 12 to 30 VDC
  - Hazardous areas: 13.9 to 30 VDC
- Reduced installation and operation cost

Application

All fluids with a minimum conductivity of ≥ 50 µS/cm can be measured:

- Acids
- Alkalis
- Paint, lacquers
- Water, etc

Endress+Hauser

The Power of Know How

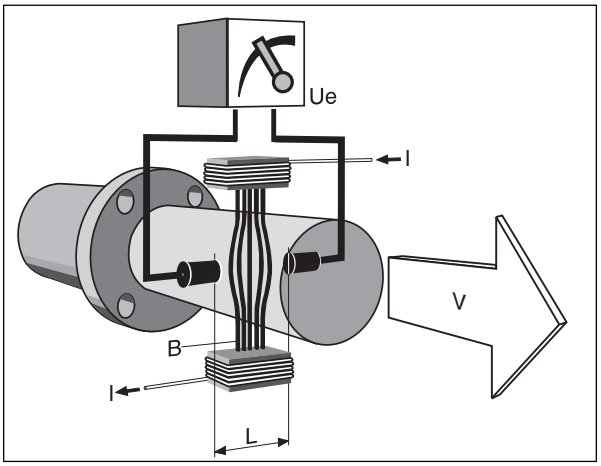
Function and system design

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 · L · v
Q = A · 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).
- Promag 23 transmitter
- Promag P sensor, 1" to 8"

Input variables

Measured variable

Flow rate (proportional to induced voltage)

Measuring range

Typically v = 0.033 to 33 ft/s (0.01 to 10 m/s) with the specified measuring accuracy

Operable flow range

Over 1000 : 1

Output variables

Output signal

- Applied direct current 4 to 20 mA. Input from DC voltage source.
  Terminal voltage, 12 to 30 VDC; Intrinsically safe version, 13.9 to 30 VDC
  Resolution: 4.4 µA
- Pulse/frequency output:
  Open collector, passive, galvanically isolated, 30 VDC, 10 mA, configurable as
  Status output: e.g. for error message, empty pipe detection, direction of flow, limit value
  Frequency output: full scale frequency 500 to 10,000 Hz (f_{max} = 12,500 Hz), on/off ratio 1:1, pulse width max. 10 s.
  Pulse output: pulse value and pulse polarity adjustable, pulse width adustable (0.01 to 10 s), above a frequency of 1 / (2 x pulse width) the on/off ratio is 1:1, pulse frequency max. 50 Hz.

Intrinsically safe version: power supply and signal circuits and pulse output with "intrinsically safe" protection rating, 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 is negligible, effective internal capacitance, $C_i \leq$ 25 nF.
Pulse output: maximum values: U_i = 30 V, I_i = 10 mA, P_i = 1W.
Effective internal inductance is negligible, effective internal capacitance is negligible.

Low flow cutoff

Switch points for low flow cutoff are selectable

Galvanic isolation

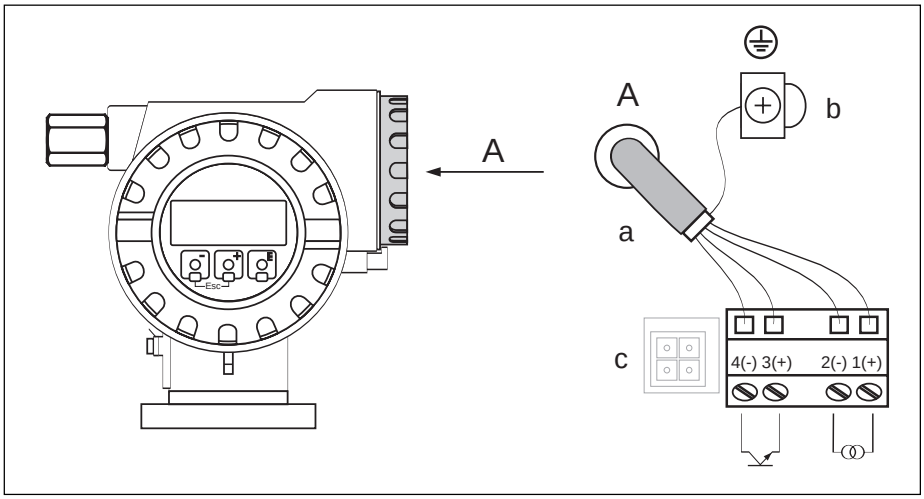
Outputs are galvanically isolated from sensor and each other.

Signal on alarm

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

Power supply

Electrical connection measuring unit



A = View A (field housing)

a Signal cable (the intrinsically safe 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

Terminal assignment Promag 23 P

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

Mandatory:
A common connecting cable carries power supply voltage and measuring output signal:
Current output (passive) galvanically isolated: 12 to 30 VDC (IS, 13.9 to 30 VDC), 4 to 20 mA.

Optional:
A binary output can be used as an option, and configured as a standard pulse output, a frequency output or a switching output:
Frequency output (passive) galvanically isolated: maximum 30 VDC, 100 mA, open collector.
- Frequency operating mode: limit frequency 500 to 10,000 Hz (f_{max} = 12,500 Hz)
- Pulse operating mode: pulse frequency maximum 50 Hz
- Status operating mode: yes

Shielded signal cables are recommended as standard practice.

Load

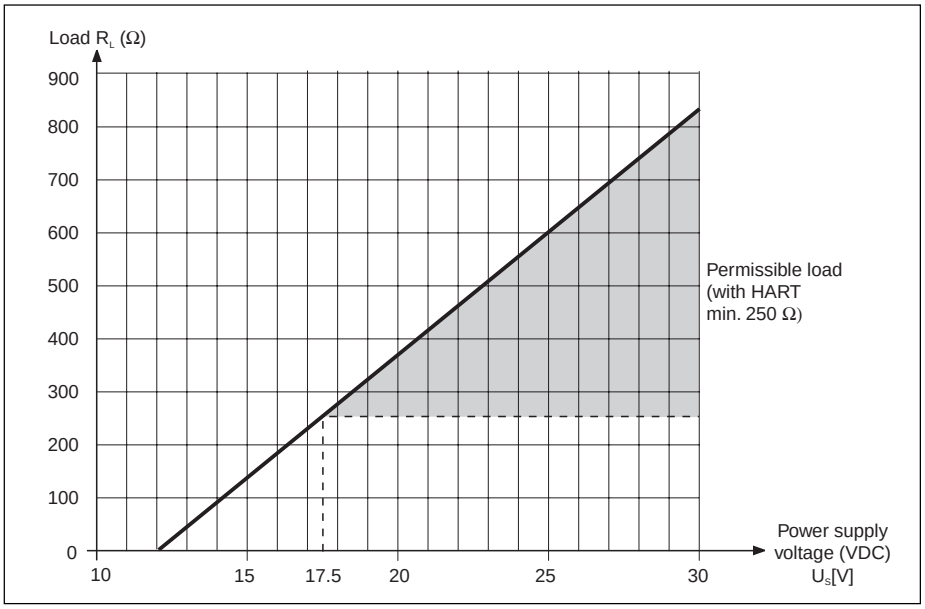
The load can be calculated as follows:

Non-hazardous area: $R_L[\Omega] = \frac{U_S[V] - U_V[V]}{I_M[A]} = \frac{U_S[V] - 12[V]}{0.022[A]}$

Intrinsically safe area: $R_L[\Omega] = \frac{U_S[V] - U_V[V]}{I_M[A]} = \frac{U_S[V] - 13.9[V]}{0.022[A]}$

$R_L[\Omega]$ = Maximum load resistance, load (cable resistance)
$U_S[V]$ = External supply voltage of 12 to 30 VDC (outgoing supply voltage, transmitter supply unit)
$U_V[V]$ = Minimum supply voltage of 12 VDC, 13.9 VDC for intrinsically safe unit (required supply voltage, transmitter)
$I_M[A]$ = Maximum signal transmission current (failsafe mode current output: 22 mA maximum current)

Caution!
The minimum load resistance (R_L) necessary for a data transfer via HART® protocol by way of the current signal cable is 250Ω. The minimum external supply voltage (U_S) therefore, has to be 17.5 VDC (non-hazardous)



Load at the analog current output (non-hazardous)
R_L maximum load resistance (with HART®, minimum 250Ω)
U_S external supply voltage (non-hazardous)

Cable entry

1/2" NPT

Cable specifications

Use shielded cables

Supply voltage

Non-hazardous area, 12 to 30 VDC (with HART: 17.5 to 30 VDC)
Intrinsically safe area, 13.9 to 30 VDC (with HART: 19.4 to 30 VDC)

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 equalization

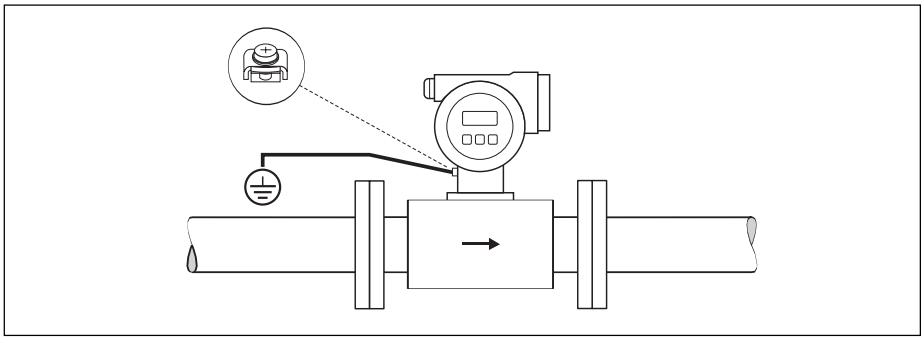
Standard case

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

If the medium flows through unlined and grounded metallic pipes, it is enough to connect the grounding terminal of the transmitter housing (see illustration below) to the potential-equalization line. In the case of the remote version, this connection is established by means of the ground terminal on the transmitter connection housing.

Caution:

For sensors without reference electrodes or without metal process connections, 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.

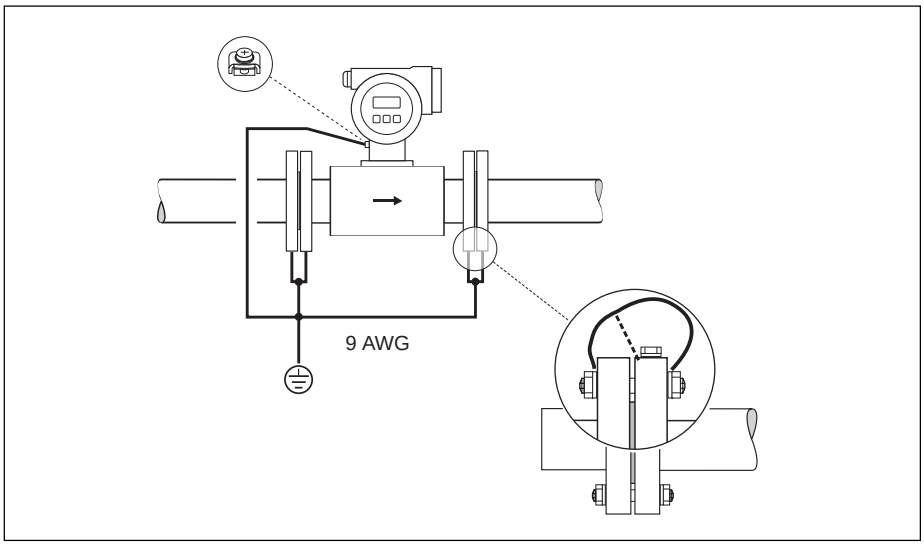


Metallic, ungrounded pipes

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 by means of the grounding terminal provided for that purpose.

Note:

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



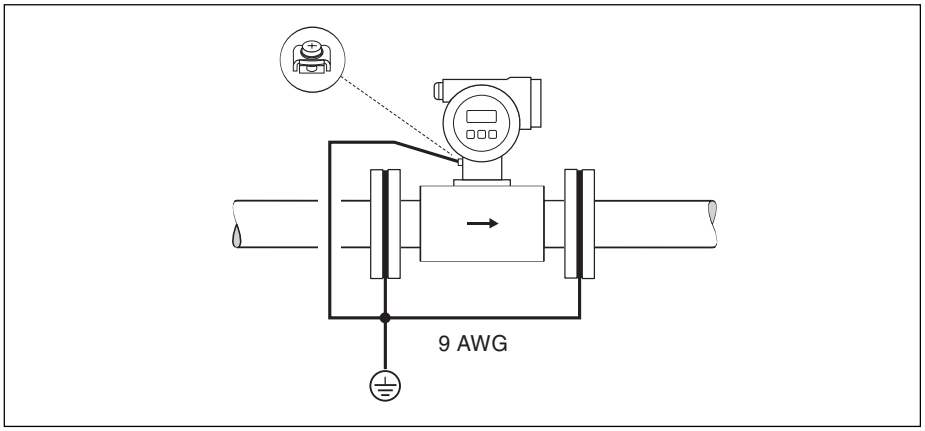
Plastic pipes and lined pipes

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 electro-chemical decomposition of the electrodes. In such cases, e.g. for fiber-glass or PVC piping, it is recommended to use additional ground disks for potential matching.

When using ground disks, note the following points:
- Ground disks (1" to 8") can be ordered separately from Endress+Hauser as an accessory.
- Ground disks (including seals) increase the installation length. Refer to the dimensions for ground disks on page 14.

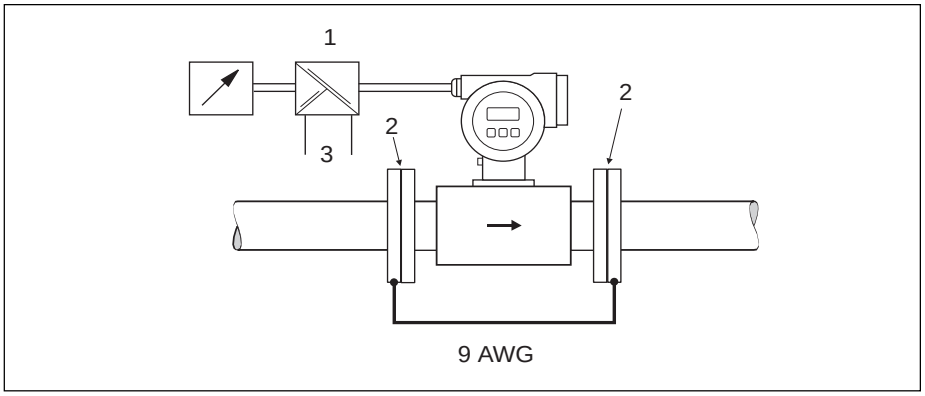
Caution:

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



Pipes with cathodic 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, 9 AWG copper wire (6 mm^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.
- Also comply with the regulations applicable to potential-free installation.



1 Power supply (unit)
2 Electrically insulated
3 External power supply

Measuring accuracy

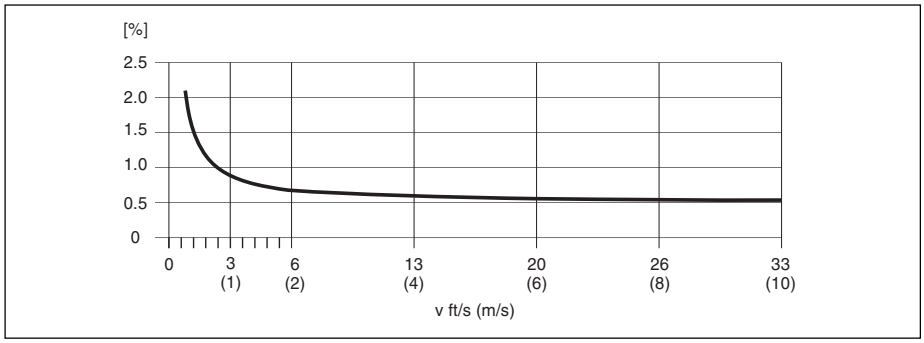
Reference conditions

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

Measured error

Signal output: ± 0.5% o.r. ± 0.04% of max. full scale (o.r. = of reading), fluctuations in voltage supply have no effect within the specified range.



Measured error in [%] of reading

Repeatability

± 0.25% o.r. ± 0.02% of max. full scale (o.r. = of reading)

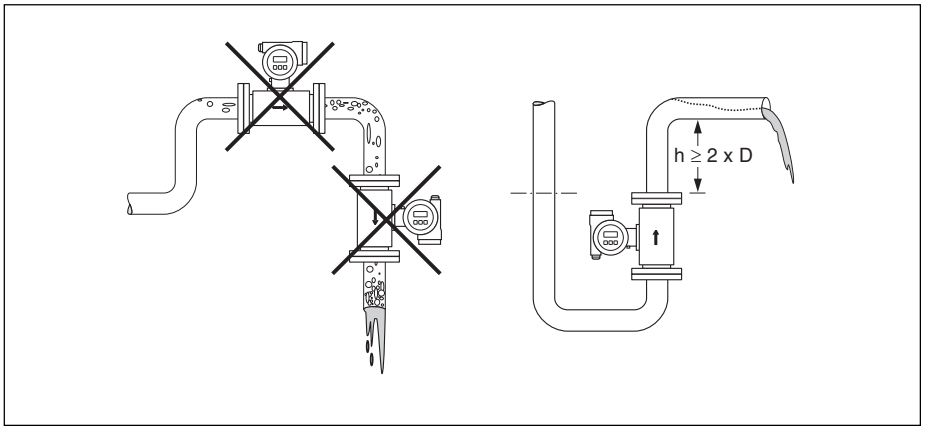
Installation conditions

Installation instructions

Mounting location

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

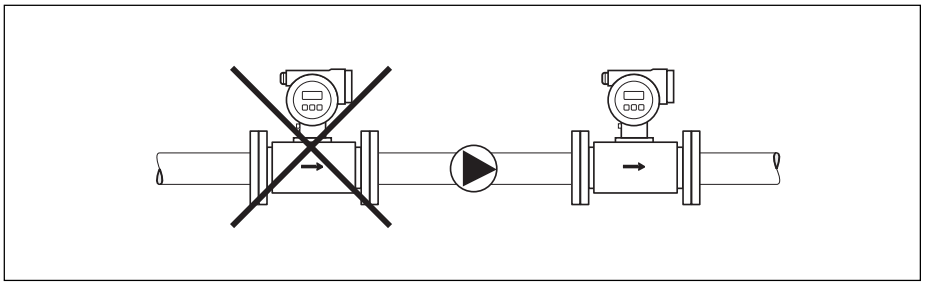
- Highest point in the run. Risk of air accumulating
- Directly upstream from an open pipe outlet in a down pipe



Installation of pumps

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

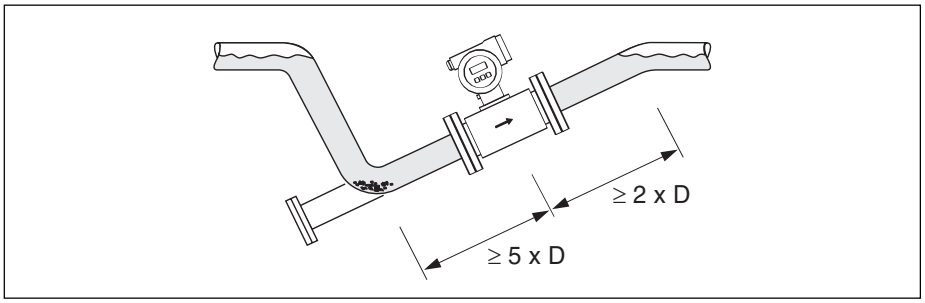
It might be necessary to install pulse dampers in systems incorporating reciprocating, diaphragm or peristaltic pumps. The sensor is shock and vibration resistant for acceleration up to 2 g in accordance with IEC 68-2-6.



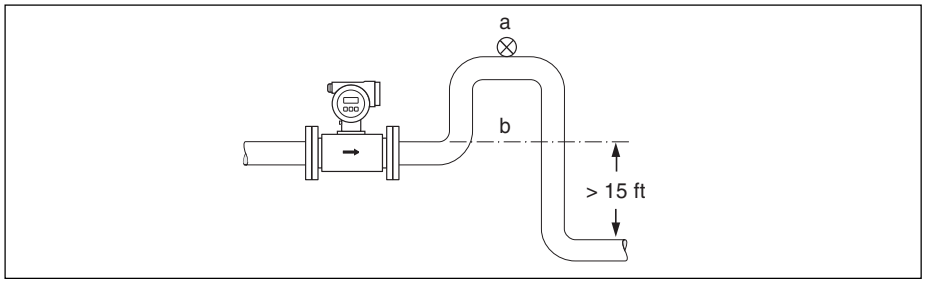
Partially filled pipes

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:
To avoid the risk of solids accumulating, do not install the sensor at the lowest point in the drain. It is advisable to install a cleaning valve.



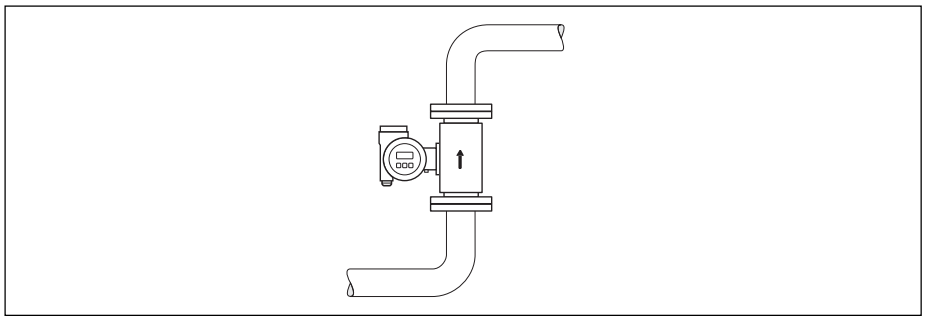
Down pipes
Install a siphon (b) or a vent valve (a) downstream of the sensor in down pipes longer than 15 feet (5 meters). This precaution is to avoid low pressure and the consequent risk of damage to the lining of the measuring tube. These measures also prevent the system losing prime, which could cause air inclusions.



a = vent valve, b = siphon

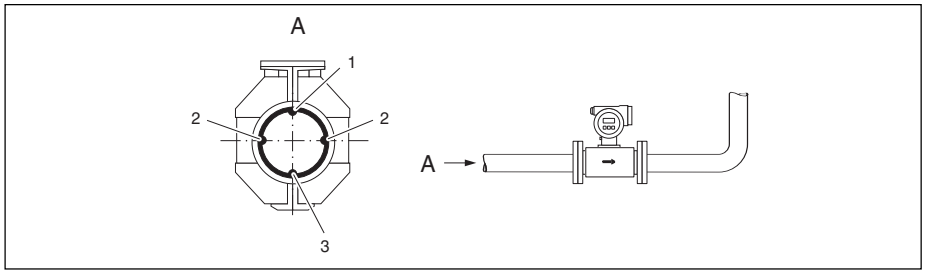
Orientation
An optimum orientation helps avoid gas and air accumulations and deposits in the measuring tube. Promag, nevertheless, supplies a range of functions and accessories for correct measuring of problematic fluids:
Empty Pipe Detection (EPD) ensures the detection of partially filled measuring 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 electrode-plane should be horizontal. This prevents brief insulation of the two electrodes by entrained air bubbles.

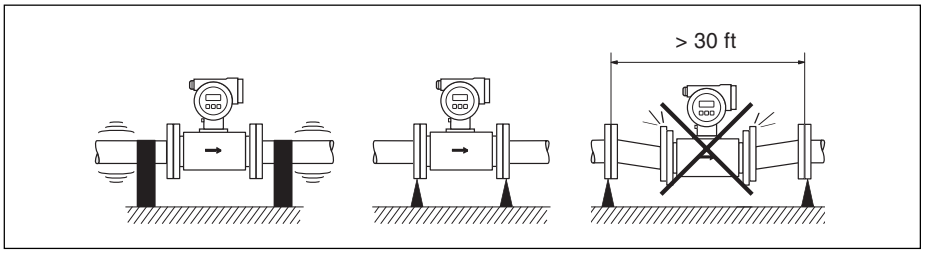
Caution:
Empty Pipe Detection functions correctly only when the measuring device is installed horizontally and the transmitter housing is facing upward. Otherwise, there is no guarantee that Empty Pipe Detection will respond if the measuring tube is only partially filled or empty.



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

Vibrations

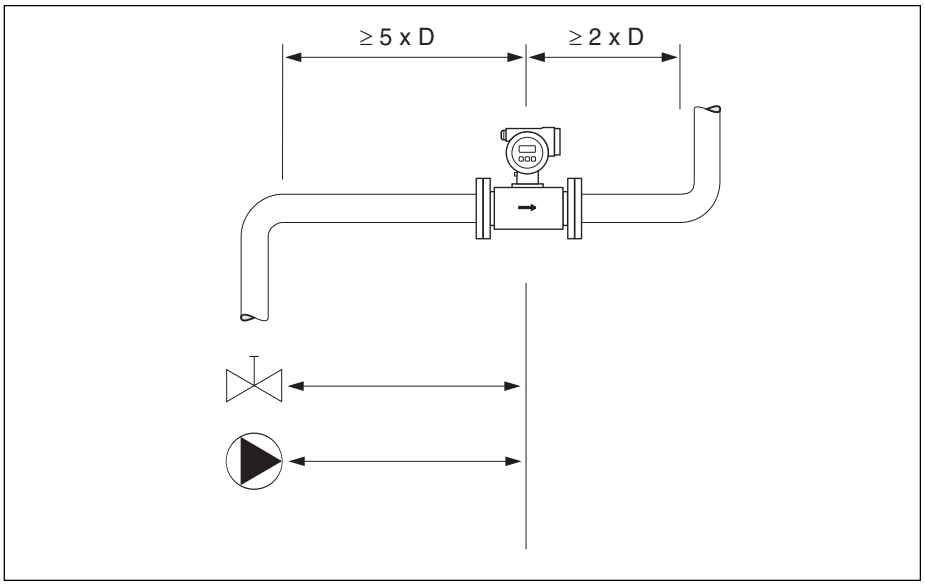
Secure the piping and the sensor if vibration is severe. The sensor is shock and vibration resistant for acceleration up to 2 g in accordance with IEC 68-2-6.



Inlet and outlet runs

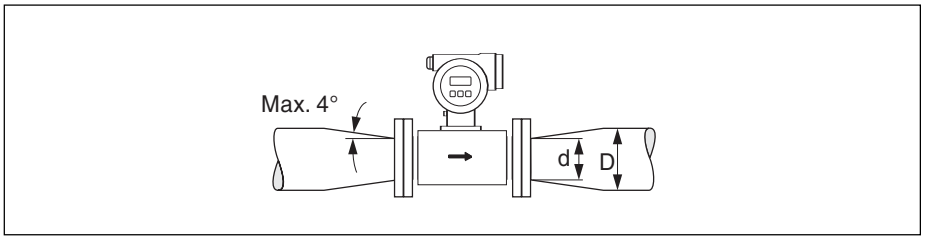
If possible, install the sensor well clear of fittings such as valves, T-pieces, elbows, etc. Compliance with the following requirements for the inlet and outlet runs is necessary in order to ensure measuring accuracy:

- Inlet run ≥ 5 x pipe diameter
- Outlet run ≥ 2 x pipe diameter



Adapter pieces

With the help of the appropriate adapter pieces (reducers and expanders) the sensor can be mounted in a pipeline of a larger diameter. For slowly flowing fluids, the resulting higher velocity increases the measuring accuracy.



Ambient conditions

Ambient temperature

-5° to +140°F (-20° to +60°C) for sensor and transmitter

Note the following points:
Install the device at a shady location. Avoid direct sunlight, particularly in warm climatic regions.

Storage temperature

15° to + 120°F (-10° to +50°C), 70°F (20°C) is the preferable storage temperature.

Degree of protection

NEMA 4X (IP 67)

Shock and vibration resistance

Acceleration up to 2 g in accordance with IEC 68-2-6

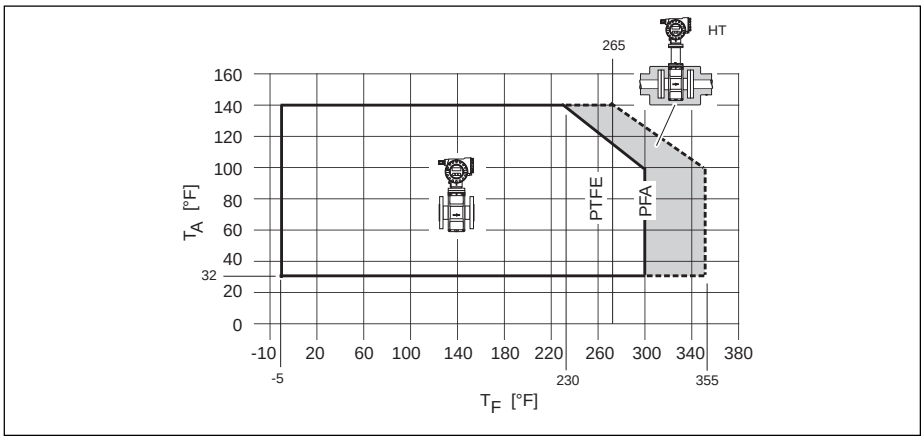
Electromagnetic compatibility (EMC)

To EN 61326 and NAMUR recommendation NE 21

Process conditions

Medium temperature range

The permissible medium temperature depends on the measuring tube liner:
- PTFE, -40° to +265°F (-40° to +130°C)
- PFA, -5° to +355°F (-20° to +180°C). For intrinsically safe areas, -5° to +300°F (-20 to +150°C), refer to graph.



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

Conductivity

Minimum conductivity:
≥ 50µS/cm → for fluids in general

Medium pressure range (nominal pressure)

ANSI B16.5:
Class 150
Class 300

Pressure tightness (liner)

Size	Measuring tube lining	Resistance to partial vacuum of measuring tube lining limit values for abs. pressure (psia) at various fluid temperatures					
		75°F	175°F	212°F	265°F	300°F	355°F
1”	PTFE/PFA	0 / 0	0 / 0	0 / 0	1.5 / 0	- / 0	- / 0
1-1/2”	PTFE/PFA	0 / 0	0 / 0	0 / 0	1.5 / 0	- / 0	- / 0
2”	PTFE/PFA	0 / 0	0 / 0	0 / 0	1.5 / 0	- / 0	- / 0
3”	PTFE/PFA	0 / 0	*	0.6 / 0	1.9 / 0	- / 0	- / 0
4”	PTFE/PFA	0 / 0	*	2.0 / 0	2.5 / 0	- / 0	- / 0
6”	PTFE/PFA	2.0 / 0	*	3.5 / 0	5.6 / 0	- / 0	- / 0
8”	PTFE/PFA	2.9 / 0	*	4.2 / 0	5.9 / 0	- / 0	- / 0

* No value can be specified

Flow limit

As a rule, the pipeline diameter determines the sensor diameter. With a known flowrate and the help of the Endress+Hauser Flow Applicator, the best size can be selected. Generally, a velocity range of 6 to 10 ft/sec should be selected.

Nominal diameter		Recommended flow rate	Factory settings		
inch	mm	Min./max. full scale value (v ~ 1.0 or 33 ft/s)	Full scale value (v ~ 8 ft/s)	Pulse weighting (~ 2 pulses/s)	Creepage (~ 0.1 ft/s)
1	25	2.5 to 80 gpm	18 gpm	0.20 gal	0.25 gpm
1-1/2	40	7 to 190 gpm	50 gpm	0.50 gal	0.75 gpm
2	50	10 to 300 gpm	75 gpm	0.50 gal	1.25 gpm
3	80	24 to 800 gpm	200 gpm	2 gal	2.5 gpm
4	100	40 to 1250 gpm	300 gpm	2 gal	4.0 gpm
6	150	90 to 2650 gpm	600 gpm	5 gal	12 gpm
8	200	155 to 4850 gpm	1200 gpm	10 gal	15 gpm

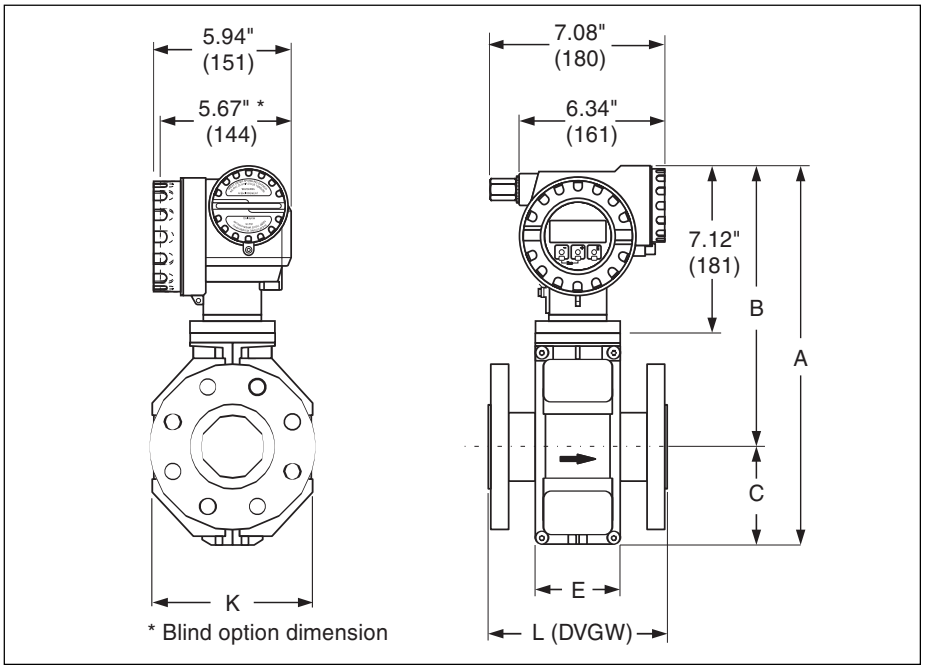
Pressure loss

No pressure loss if the sensor is installed in a pipe of the same nominal diameter. Pressure losses occur in configurations incorporating adapters (reducers, expanders). Contact your Endress+Hauser representative or Endress+Hauser for information.

Mechanical construction

Dimensions / mounting details

Promag P compact



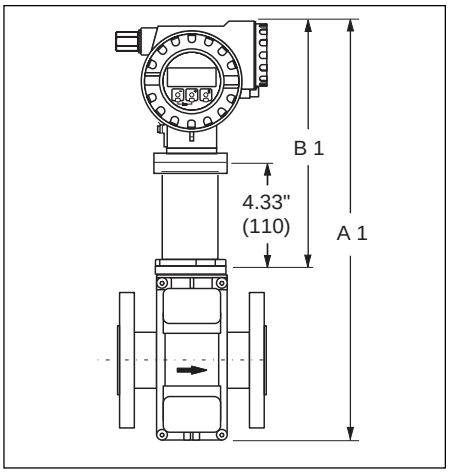
Dimensions in inches (mm)

Nominal Size		L		A		B		C		K		E		Weight	
inches	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	lb	kg
1	25	7.87	200	14.3	365	11.1	281	3.31	84	4.72	120	3.70	94	16	7.3
1-1/2	40	7.87	200	14.3	365	11.1	281	3.31	84	4.72	120	3.70	94	21	9.4
2	50	7.87	200	14.3	365	11.1	281	3.31	84	4.72	120	3.70	94	23	10.6
3	80	7.87	200	16.3	415	12.0	306	4.29	109	7.08	180	3.70	94	31	14
4	100	9.84	250	16.3	415	12.0	306	4.29	109	7.08	180	3.70	94	35	16
6	150	11.8	300	19.5	496	13.6	346	5.90	150	10.2	260	5.51	140	56	25.5
8	200	13.8	350	21.7	551	14.6	371	7.08	180	12.7	324	6.14	156	99	45

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

Promag P high temperature version

Measurement A1, B1: refer to compact version dimension chart bottom of page 12, add 4.33" (110 mm) to dimensions A and B for high temperature unit.



Weight

Refer to dimension chart on page 12. Weight data valid for 150 lb ANSI. For high temperature version, add 3 lb. (1.5 kg)

Materials

Transmitter housing:
Powder coated die-cast aluminum

Sensor housing:
Powder coated die-cast aluminum

Measuring tube:
304 SS or 304L SS with Al/Zn protective coating when supplied with non-stainless flange material

Flanges:
A105 CS (with Al/Zn protective coating) or 316L SS

Electrodes:
316L SS, Alloy C-22, tantalum, platinum/rhodium 80/20

Seals:
Seals to DIN 2690

Ground disks:
316L SS or Alloy C-22

Fitted electrodes

Measuring, reference and Empty Pipe Detection electrodes:
- Standard, 316L SS, Alloy C-22 or tantalum
- Optional, measuring electrodes with EPD and/or reference electrodes made of platinum/rhodium 80/20

Process connections

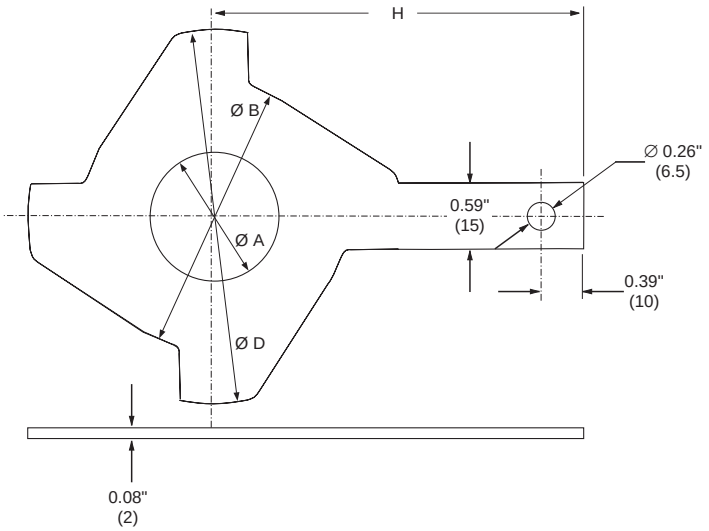
Flange connections: ANSI

Surface roughness

- PFA liner: ≤ 12 µin (0.3 µm)
- Electrodes:
  - 316L SS, Alloy C-22: ≤ 16 µin (0.4 µm)
  - Tantalum, platinum/rhodium: ≤ 32 µin (0.8 µm)

All data relate to wetted parts

Ground disks



Nominal size [1]	A		B		D		H	
	in	mm	in	mm	in	mm	in	mm
1	1.18	30	2.44	62	3.05	77.5	3.44	87.5
1-1/2	1.75	44.5	3.23	82	3.98	101	4.06	103
2	2.22	56.5	3.98	101	4.55	115.5	4.25	108
3	3.35	85	5.16	131	6.08	154.5	5.31	135
4	4.33	110	6.14	156	7.34	186.5	6.02	153
6	6.42	163	8.54	217	10.1	256	7.24	184
8	8.29	210.5	10.5	267	11.3	288	8.07	205

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

Human interface

Display elements

- Liquid crystal display, four lines with 16 characters per line
- Custom configurations for presenting different measured value and status variables
- Flow rate: 5 digits with sign and units
- Two totalizers (7-digit plus 7-digit overflow with sign and units)

Operating elements

- Local operation with Touch Control (-, +, E)

Remote operation

Remote operation via HART®

Certificates and approvals

Hazardous area approvals

Information on the currently available hazardous area rated versions (FM, CSA, ATEX, etc.) is available on request from Endress+Hauser. All information relevant to explosion protection is available in separate documentation.

CE mark

By attaching the CE mark, Endress+Hauser confirms that the instrument fulfills all the requirements of the relevant EC directives.

Other standards and guidelines

Housing protection ratings (IP code), EN 60529

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

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

Association for Standards for Control Regulation in the Chemical Industry, NAMUR NE 21.

Ordering information

Promag 23 P Two-wire Electromagnetic flowmeter

Promag 23 P [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13]

Nominal Diameter

1
- 25 1”
- 40 1-1/2”
- 50 2”
- 80 3”
- 1H 4”
- 1F 6”
- 2H 8”

2 Liner
- A PFA liner, standard
- B PFA liner, high temperature version
- E PTFE

3 Process Connection
- L Class 150 ANSI B 16.5, A105 CS flanges
- M Class 300 ANSI B 16.5, A 105 CS flanges (not for 8”)
- R Class 150 ANSI B 16.5, 316L SS
- S Class 300 ANSI B 16.5, 316L SS (not for 8”)
- 9 Other

4 Electrodes / Material
- 0 Measuring, reference and EPD electrodes / 316L SS
- 1 Measuring, reference and EPD electrodes / Alloy C-22
- 2 Measuring, reference and EPD electrodes / tantalum
- 3 Measuring electrodes only / Platinum/Rhodium 80/20%
- 4 Measuring and reference electrodes only / Platinum/Rhodium 80/20%
- 5 Measuring, reference and EPD electrodes / Platinum/Rhodium 80/20%
- 9 Other

5 Calibration
- A 0.5% calibration, 3-point
- D SCS/A2LA 3-point 0.5% calibration (ISO/IEC 17025)) with certificate traceable according to ISO 9000 (specify flow range)
- 9 Other

6 Certificates
- 1 Standard, no certificate
- 2 3.1B material certificate for pipe and flanges
- 3 2.3 pressure test certificate (1.5 x PN, 3 minutes)
- 4 3.1B material certificate and 2.3 pressure test certificate
- 5 CRN approval (only for ANSI flanges)
- 8 CRN approval, 3.1B material and pressure test certificate (1.5 x PN) (only for ANSI flanges)

7 Approvals
- A For use in non-hazardous areas
- N FM intrinsically safe, Class I, Div. 1 / CSA Class I, Div. 1 for 1” to 4” sizes only
- R FM non-incendive, Class I, Div. 2 / CSA Class I, Div. 2

8 Protection Type / Version
- A NEMA 4X (IP 67) / Compact, aluminum field housing
- 9 Other

9 Cable for Remote Version
- 0 Without cable

10 Cable Entries
- 2 1/2” NPT
- B 2 pieces, 1/2” NPT
- X Sensor only
- 9 Other

11 Display / Power Supply / Operation
- 0 Without display / loop-powered / remote configuration only
- 2 With display / loop-powered / Touch Control operation
- X Sensor only (without transmitter)

12 Software
- A Standard, English/German
- X Sensor only

13 Outputs / Inputs
- W Current / HART®
- A Current / HART®, passive pulse
- X Sensor only

Accessories

Various accessories, which can be ordered from Endress+Hauser, are available for the transmitter and the sensor. Contact your local representative or Endress+Hauser for detailed information.

Supplemental documentation

- ☐ Promag 23 H Technical Information (TI 051D/24/ae)
- ☐ Promag 23 P Operating Instructions (BA 045D/06/en and BA 050D/06/en)
- ☐ Hazardous Area Approvals Documentation (FM, CSA, ATEX, etc.)

For application and selection assistance,
call 888-ENDRESS

For total support of your installed base,
24 hours a day, call 800-642-8737

Visit us on our web site, www.us.endress.com

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