Level | Pressure | Flow | Temperature | Liquid Analysis | Registration | Systems Components | Services | Solutions

Technical Information

CNGmass

Coriolis mass flow measuring system
For fueling with Compressed Natural Gas (CNG)

Applications
The Coriolis measuring principle works independently of the physical fluid properties.

- Specially designed flowmeter for fueling vehicles with CNG (compressed natural gas)
- Fluid temperature up to +125 °C (+257 °F)
- Process pressures up to 350 bar (5080 psi)
- Mass flow measurement up to 150 kg/min (330 lb/min)

Approvals for hazardous area:
- ATEX, FM, CSA, NEPSI

Connection to common control systems:
- MODBUS RS485

Your benefits
The Promass measuring devices allow you record multiple process variables (mass/density/temperature) simultaneously during operation for diverse process conditions.

The **transmitter concept** comprises:
- FieldCare for onsite operation and diagnosis
- Very low energy consumption

The **Promass sensors**, tried and tested in over 100000 applications, offer:
- Space-saving and compact design
- Insensitivity to vibrations thanks to balanced twin-tube measuring system
- Easy installation without taking inlet or outlet runs into account

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Endress+Hauser
People for Process Automation

Table of contents

Function and system design

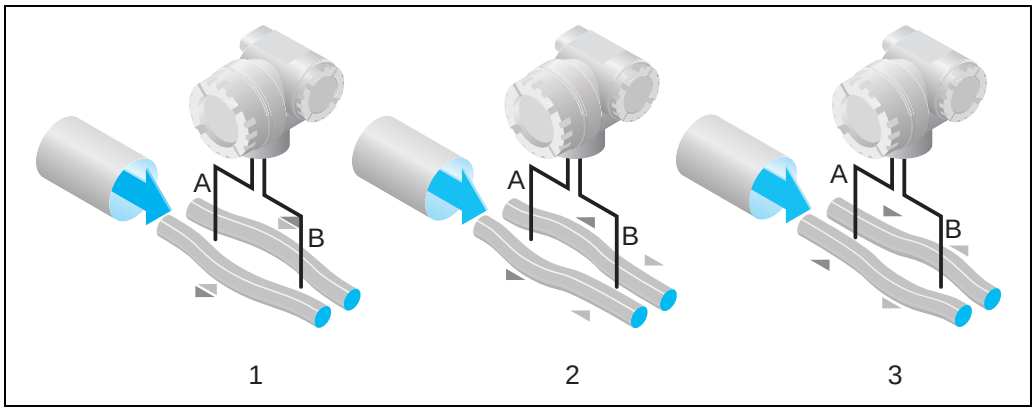
Measuring principle

The measuring principle is based on the controlled generation of Coriolis forces. These forces are always present when both translational and rotational movements are superimposed.

$F_C = 2 \cdot \Delta m\ (v \cdot \omega)$
F_C = Coriolis force
Δm = moving mass
ω = rotational velocity
v = radial velocity in rotating or oscillating system

The amplitude of the Coriolis force depends on the moving mass Δm, its velocity v in the system, and thus on the mass flow. Instead of a constant angular velocity ω, oscillation occurs.

In the sensor, two parallel measuring tubes containing flowing fluid oscillate in antiphase, acting like a tuning fork. The Coriolis forces produced at the measuring tubes cause a phase shift in the tube oscillations (see illustration):
- At zero flow, in other words when the fluid is at a standstill, the two tubes oscillate in phase (1).
- Mass flow causes deceleration of the tube oscillation at the inlet (2) and acceleration at the outlet (3).



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The phase difference (A-B) increases with increasing mass flow. Electrodynamic sensors register the tube oscillations at the inlet and outlet. System balance is ensured by the antiphase oscillation of the two measuring tubes. The measuring principle works independently of temperature, pressure, viscosity, conductivity and flow profile.

Density measurement

The measuring tubes are always excited at their resonance frequency. A change in the mass and thus the density of the oscillating system (comprising measuring tubes and fluid) results in a corresponding, automatic adjustment in the exciter frequency. Resonance frequency is thus a function of fluid density. The microprocessor utilizes this relationship to obtain a density signal.

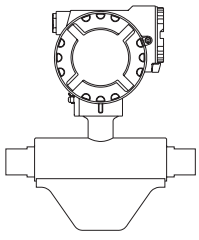
Temperature measurement

To make calculations to compensate for temperature effects, the temperature of the measuring tubes is measured. This signal corresponds to the process temperature and is also available as an output signal.

Measuring system

The measuring system consists of a transmitter and a sensor, which form a mechanical unit.

Measuring system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- Without onsite operation
- Configuration via MODBUS RS485 and FieldCare
- Limiting medium pressure range max. 350 bar (5080 psi)
- Ambient temperature range: –40 to +60 °C (–40 to +140 °F)

Input

Measured variable

- Mass flow (proportional to the phase difference between two sensors mounted on the measuring tube to register a phase shift in the oscillation)
- Volume flow (calculated using mass flow and density)
- Fluid density (proportional to the resonance frequency of the measuring tube)
- Fluid temperature (measured with temperature sensors)

Measuring range

Measuring ranges for Compressed Natural Gas (CNG), non-custody transfer operation.

DN		Range for full scale values $\dot{m}_{min(F)}$ to $\dot{m}_{max(F)}$	
[mm]	[inch]	[kg/min]	[lb/min]
08	3/8"	0 to 30	0 to 66
15	½"	0 to 80	0 to 175
25	1"	0 to 150	0 to 330

Note!
The values of the corresponding custody transfer certificate apply for custody transfer operation.

Operable flow range

1:100

Output

Output signal

Pulse/frequency output
- passive
- galvanically isolated
- Open Collector
- max. 30 V DC
- max. 25 mA
- Frequency output: end frequency 100 to 5000 Hz, on/off ratio 1:1, pulse width max. 2 s
- Pulse output: pulse value and pulse polarity selectable, pulse width configurable (0.1 to 1000 ms)

Status output
- passive
- Open Collector
- max. 30 V DC
- max. 25 mA

MODBUS RS485
- MODBUS device type: slave
- Address range: 1 to 247
- Functions codes supported: 03, 04, 06, 08, 16, 23
- Broadcast: supported with the function codes 06, 16, 23
- Physical interface: RS485 in accordance with standard EIA/TIA-485
- Baudrate supported: 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200 Baud
- Transmission mode: RTU or ASCII
- Response time: typically 5 ms

Signal on alarm

Pulse/frequency output
De-energized in the event of fault or power supply failure

Status output
De-energized in the event of fault or power supply failure

MODBUS RS485
De-energized in the event of fault or power supply failure

Load

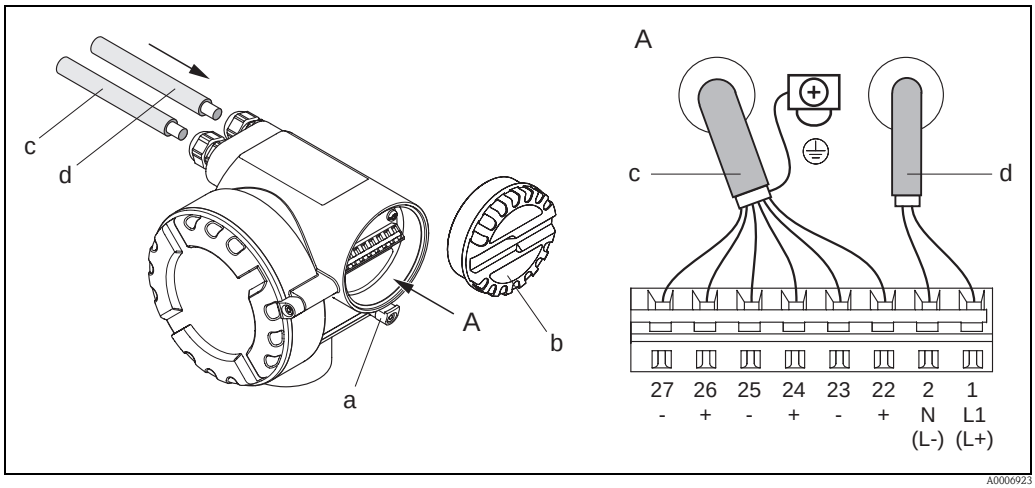
→ "Output signal"

Galvanic isolation

All circuits for outputs, and power supply are galvanically isolated from each other.

Power supply

Electrical connection, measuring unit



Connecting the transmitter, cable cross-section: max. 2.5 mm² (14 AWG)

A View A

a Safety claw
b Connection compartment cover
c Signal cable: terminal Nos. 22 to 27
(shield for MODBUS RS485 is mandatory; shield for pulse, frequency and status outputs is not required, but recommended)
d Cable for power supply: 20 to 28 V AC, 10 to 30 V DC
– Terminal No. 1: L1 for AC, L+ for DC
– Terminal No. 2: N for AC, L- for DC

Electrical connection, terminal assignment

	Terminal No. (outputs)		
Order version	**22 (+) / 23 (-)**	**24 (+) / 25 (-)**	**26 (+) / 27 (–)**
Fixed communication board (permanent assignment)			
8FF**-**********N	Pulse / frequency /status output 2	Pulse / frequency /status output 1	MODBUS RS485

Supply voltage

24 V DC nominal voltage (10 to 30 V DC) / 24 V AC nominal voltage (20 to 28 V AC)

Cable entries

Power supply and signal cables (outputs):
- Cable entry M20 × 1.5 (8 to 12 mm / 0.31 to 0.47")
- Threads for cable entries, ½" NPT, G ½"

Cable specifications

Each compatible cable, with a temperature specification at least +20 °C (+68 °F) higher than the ambient temperature prevailing in the application. We recommend using a cable with a temperature specification of +80 °C (+176 °F).

MODBUS RS485 (cable type A):

- Characteristic impedance: 120 Ω
- Cable capacity: < 30 pF/m (< 9.2 pF/ft)
- Core cross-section: > 0.34 mm² (AWG 22)
- Cable type: twisted pairs
- Loop-resistance: ≤ 110 Ω/km (≤ 0.034 Ω/ft)
- Signal damping: max. 9 dB along the entire length of the cable cross-section
- Shield: Copper braided shielding or braided shielding and foil shielding

Power consumption

AC: < 4.0 VA
DC: < 3.2 W

Typical switch-on current at 24 V DC nominal voltage at R_i = 0.1 Ω of the source.

t [ms]	I [A]
0	10.0
0.1	8.0
0.2	7.5
0.5	7.0
1.0	6.0
2.0	4.0
5.0	1.5
10.0	0.125 (operating current)

Note!
The internal resistance of the source may not exceed R_i = 10 Ω.

Power supply failure

Lasting min. 20 ms.
All measuring cell and measuring point data are maintained.

Potential equalization

This measuring instrument is suitable for potentially explosive atmospheres; refer to the correspondingly information in the specific Ex-specific supplementary documentation.

Performance characteristics

Reference operating conditions for factory calibration

Error limits following ISO/DIS 11631:

- Fluid: water
- 15 to 45 °C (59 to 113 °F); 2 to 6 bar (29 to 87 psi)
- Calibration rigs returned to national calibration standards
- Zero point calibrated under operating conditions
- Density adjustment carried out

Maximum measured error

Mass flow:
±0.5% of the quantity filled in typical CNG fueling with the coefficients determined during factory calibration.

Repeatability

Mass flow:
±0.25% of the quantity filled in typical CNG fueling.

Influence of medium temperature

When there is a difference between the temperature for zero point adjustment and the process temperature, the typical measured error is ±0.0003% of the full scale value / °C.

Influence of medium pressure

The following section shows the effect on accuracy of mass flow due to a difference between calibration pressure and process pressure is negligible.

Density

±20 kg/m^3 (±0.02 SGU) or ±1 kg/m^3 (±0.001 SGU) nach FDC (field density calibration)

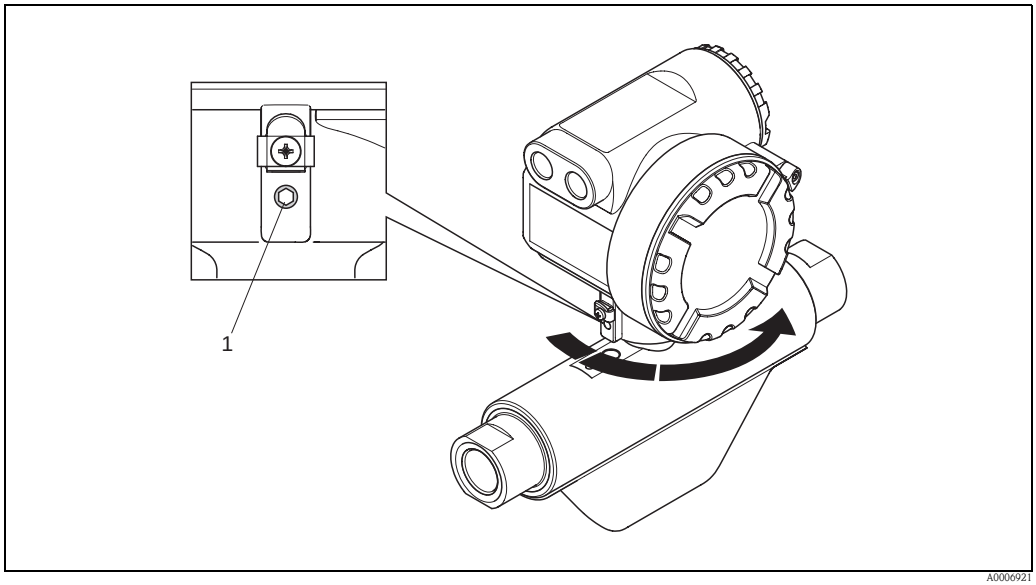
Operating conditions: Installation

Installation instructions

Note the following points:
- No special measures such as supports are necessary. The housing absorbs external forces.
- The high oscillation frequency of the measuring tubes ensures that the correct operation of the measuring system is not influenced by pipe vibrations.
- No special precautions need to be taken for fittings which create turbulence (valves, elbows, T-pieces etc.).

Turning the transmitter housing

The transmitter housing can be rotated counterclockwise continuously up to 360°.

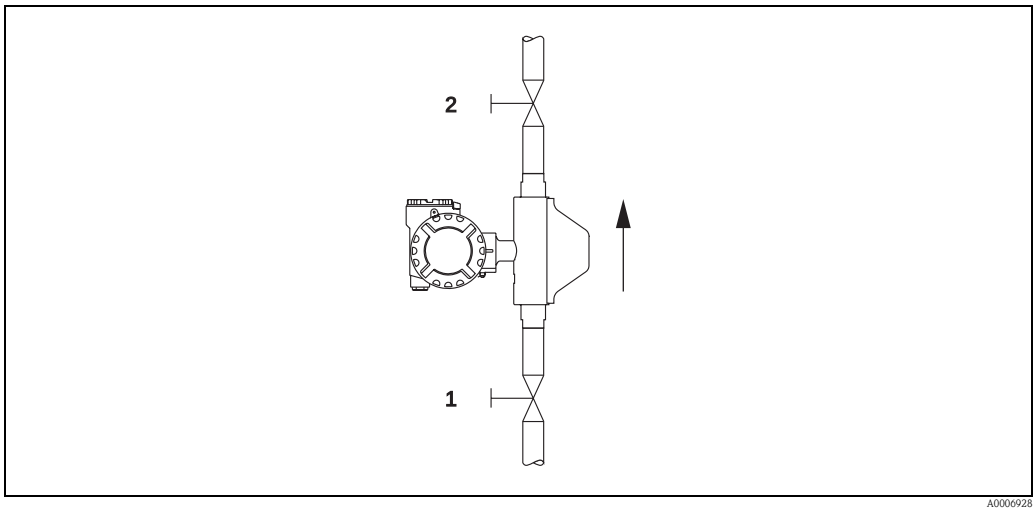


1 = Allen screw

Zero point adjustment

All measuring devices are calibrated using state-of-the-art technology. The zero point obtained in this way is printed on the nameplate. Calibration takes place under reference conditions (→ 🖹 6).
Therefore, a zero point adjustment is generally **not** required!

If a zero point adjustment is desired, please note the following points before performing one:
- Adjustment can only be performed under stable pressure conditions.
- The zero point adjustment takes place at zero flow. This can be achieved, for example, with shutoff valves upstream and/or downstream of the sensor or by using existing valves and gates.
  – Normal operation → valves 1 and 2 open
  – Zero point adjustment *with* process pressure → Valve 1 open / valve 2 closed
  – Zero point adjustment *without* process pressure → Valve 1 closed / valve 2 open
- A zero point adjustment is **not** possible if the SECURITY function is enabled or if an error message is pending.



Zero point adjustment and shutoff valves

Inlet and outlet runs

There are no installation requirements regarding inlet and outlet runs.

Operating conditions: Environment

Ambient temperature range

Sensor and transmitter:
–40 to +60 °C (–40 to +140 °F)

Note!
- Install the device in a shady location. Avoid direct sunlight, particularly in warm climatic regions.

Storage temperature

–40 to +80 °C (–40 to +175 °F), preferably at +20 °C (+68 °F)

Degree of protection

Standard: IP 67 (NEMA 4X) for transmitter and sensor

Shock resistance

According to IEC 68-2-31 and EN 60721 (Class 2M3)

Vibration resistance

According to IEC 68-2-31 and EN 60721 (Class 2M3)

Electromagnetic compatibility (EMC)

As per IEC/EN 61326

Operating conditions: Process

Medium temperature range

–50 to +125 °C (–58 to +257 °F)

Fluid pressure range (nominal pressure)

Measuring tubes, connector: max. 350 bar (5080 psi)

Pressure loss (SI units)

Pressure loss depends on the fluid properties and on the flow rate.
It can be approximately calculated with the following formula:

$$\Delta p = K \cdot \nu^{0.25} \cdot \dot{m}^{1.85} \cdot \rho^{-0.86}$$

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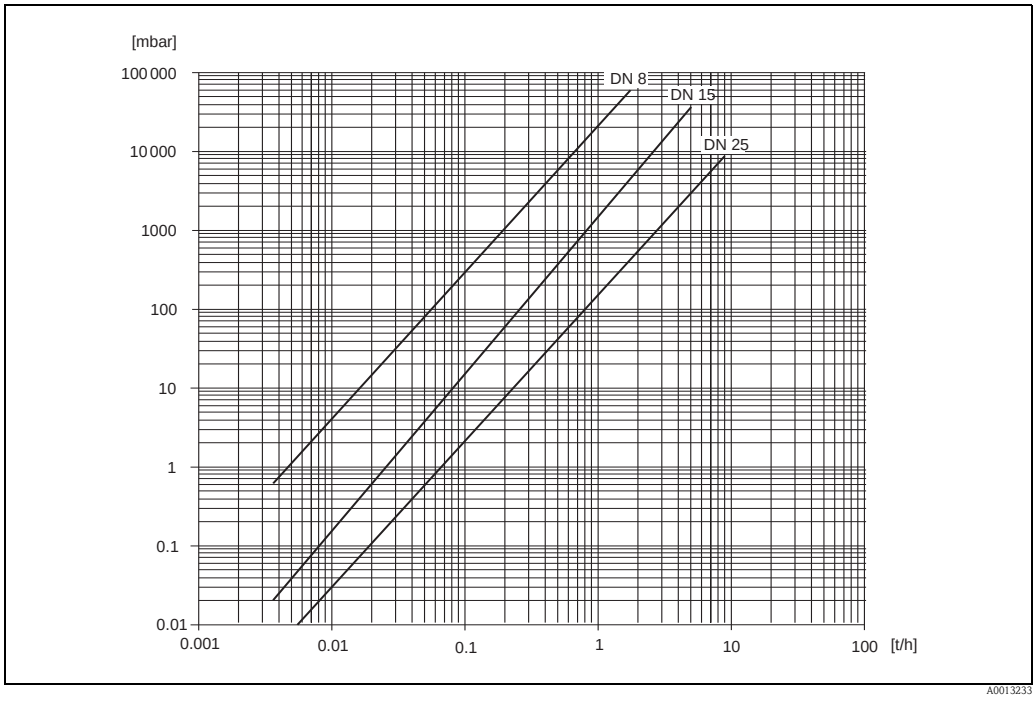
Δp = pressure loss [mbar]
ν = kinematic viscosity [m^2/s]
$\dot{m}$ = mass flow [kg/s]
ρ = density [kg/m^3]
K = constant (depending on nominal diameter)

DN		K
[mm]	[inch]	
08	3/8"	$2.46 \cdot 10^8$
15	½"	$3.13 \cdot 10^7$
25	1"	$6.60 \cdot 10^6$



Pressure loss diagram with methane (200 bar / 2900 psi , 20 °C / 68 °F)

Pressure loss (US units)

Pressure loss depends on the nominal diameter and the fluid properties.
The "Applicator" PC software is available from Endress+Hauser and can be used to calculate the pressure loss in US units. The "Applicator" program contains all the important device data which allows the measuring system arrangement to be optimized.

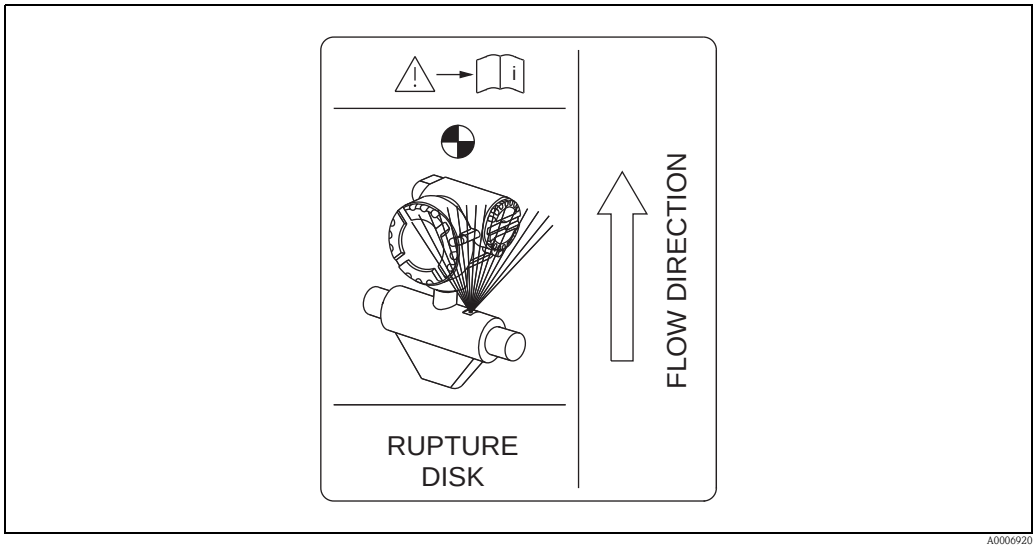
The software is used for the following calculations:
- Nominal diameter of the sensor with fluid properties such as viscosity, density etc.
- Pressure loss downstream from the measuring point
- Conversion of mass flow to volume flow etc.
- Simultaneous display of variables determined by different measuring devices
- Determining measuring ranges

The Applicator program runs on any IBM-compatible PC with Windows.

Rupture disk in the sensor housing

Triggering pressure in the housing 10 to 15 bar (145 to 218 psi)

The position of the rupture disk is indicated by an adhesive label on top of the disk. If the rupture disk is triggered, the adhesive label is damaged and can thus be visually monitored.



Additional sign regarding the position of the rupture disk (RUPTURE DISK)

Limiting flow

→ 📄 4, "Measuring range"

Custody transfer measurement

CNGmass is a flowmeter for Compressed Natural Gas (CNG) that is suitable for custody transfer measurement.

Custody transfer variables

Mass flow

Suitability for custody transfer measurement, approval by the Standards Authorities, repeated calibration due to legal metrology controls

All flowmeters are typically verified on site using reference measurements. Only once it has been approved by the authority for legal metrology controls may the measuring device be regarded as verified and used for applications subject to legal metrology controls. The associated seal on the measuring device ensures this status.

Approval for custody transfer

The following guidelines for the custody transfer process were developed in accordance with the following authorities for legal metrology controls:

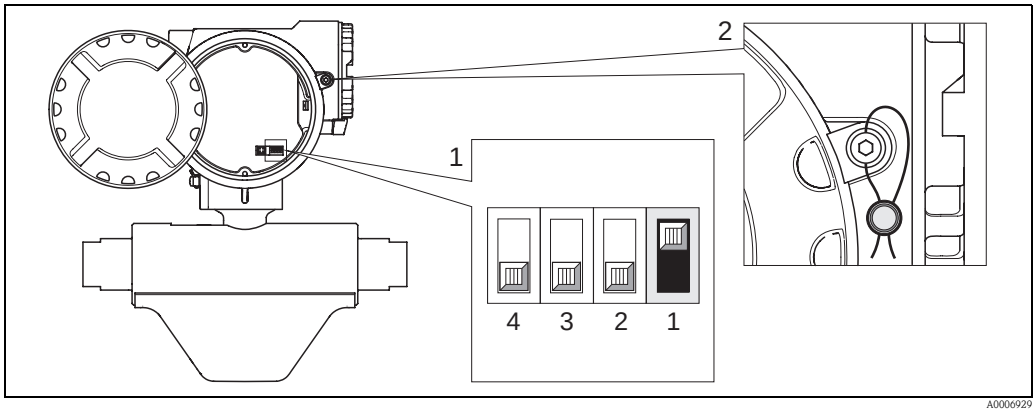
■ **PTB**	Germany	■ **METAS**	Switzerland	■ **NTEP**	USA
■ **NMi**	Netherlands	■ **BEV**	Austria	■ **MC**	Canada

Verification process

The verification process is regulated by national rules or regulations.

Setting up custody transfer mode

The flowmeter must be locked for custody transfer measurement. For this purpose, the switch **1** are moved to the position shown below (1). You receive confirmation from the status LED (→ 14). Then, fit the cover and have the safety claw sealed by a person authorized to do so (2).

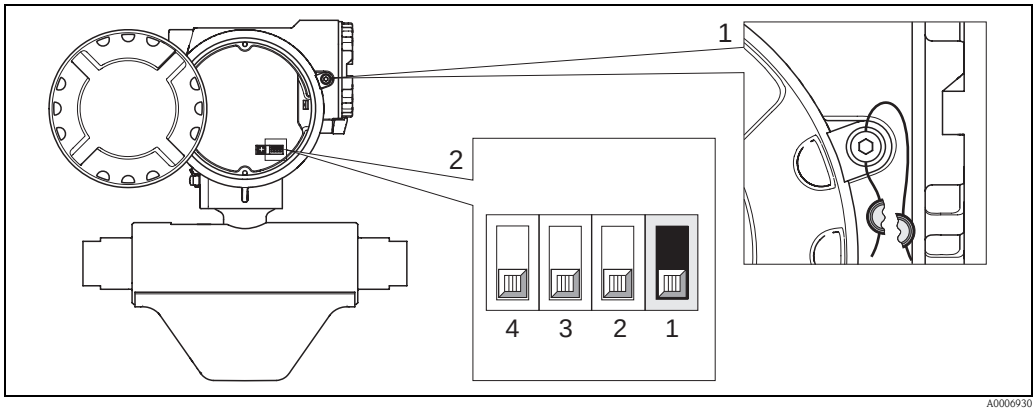


Switch locked

Disabling custody transfer mode

The flowmeter can be reset to exit custody transfer mode.

To do so, destroy and remove the seal on the safety claw (1). This process may be carried out by authorized personnel only. Open the cover. Return switch **1** to the position shown below (2). You receive confirmation from the status LED (→ 14).

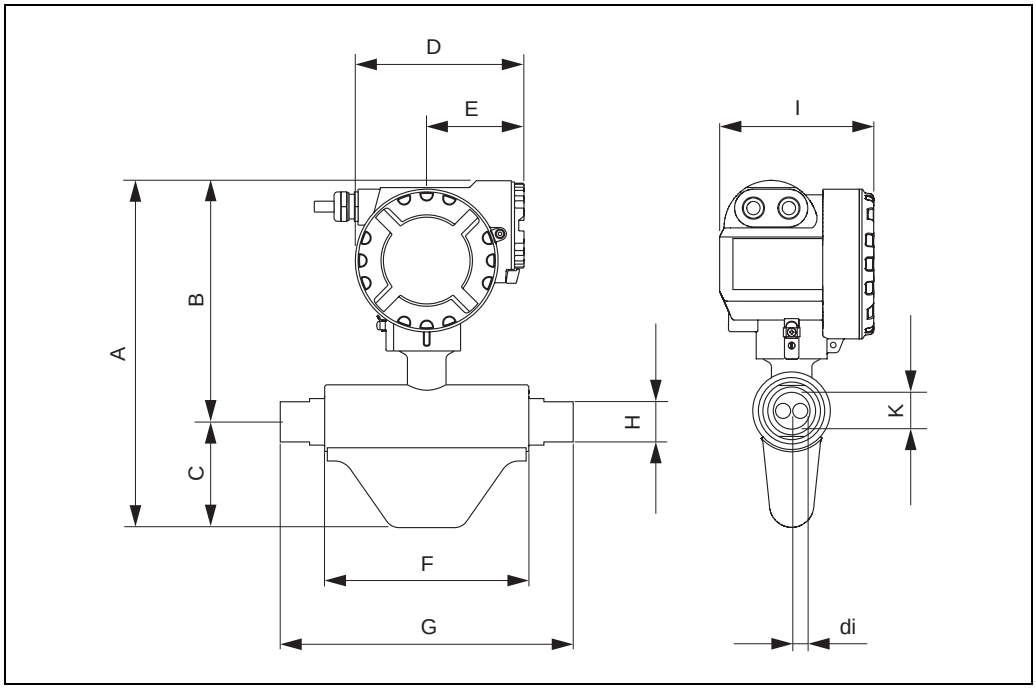


Switch unlocked

Mechanical construction

Design/dimensions

Field housing compact version (non-hazardous area II2G / zone 1)



Dimensions in SI units

DN	A	B	C	D	E	F	G	H	I	K	di
08	308	208	100	160	92	150	214	32	139	G½"	3.87
15	308	208	100	160	92	193	267	41	139	G¾"	6.23
25	313	208	105	160	92	244	316	46	139	G1"	8.8

All dimensions in [mm]

Dimensions in US units

DN	A	B	C	D	E	F	G	H	I	K	di
3/8"	12.1	8.2	3.9	6.3	3.6	5.9	8.4	1.3	5.5	G½"	0.152
½"	12.1	8.2	3.9	6.3	3.6	7.6	10.5	1.6	5.5	G¾"	0.245
1"	12.3	8.2	4.1	6.3	3.6	9.6	12.4	1.8	5.5	G1"	0.346

All dimensions in [inch]

Weight

DN in mm (inch)	08 (3/8")	15 (½")	25 (1")
Weight in kg (pounds)	6.4 (14.1)	8.3 (18.3)	9.3 (20.5)

Material

Transmitter housing:
Powder coated die-cast aluminum

Sensor housing:
Acid-resistant and alkali-resistant external surface, stainless steel 1.4301/304

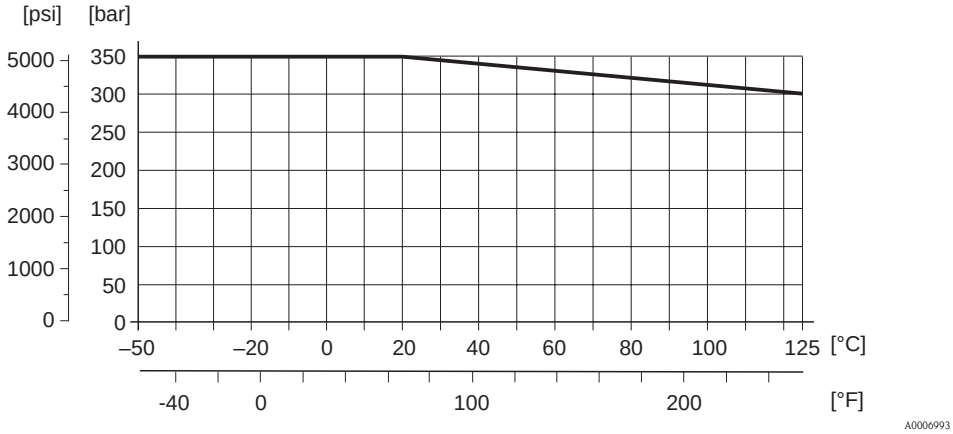
Process connection:
Stainless steel 1.4404/316

Measuring tubes:
Stainless steel 1.4435/316L

Material load diagram

CNGmass process connections

Connection material: 1.4404/316



Process connections

Cylindrical internal thread BSP (G) in accordance with ISO 228-1 with sealing surfaces in accordance with DIN 3852-2/ISO 1179-1:

- G ½" for DN 08
- G ¾" for DN 15
- G 1" for DN 25

Note!
Sealed with profile seal as in accordance with DIN 3869 or copper disk or steel seal disk with plastic lip.

Human interface

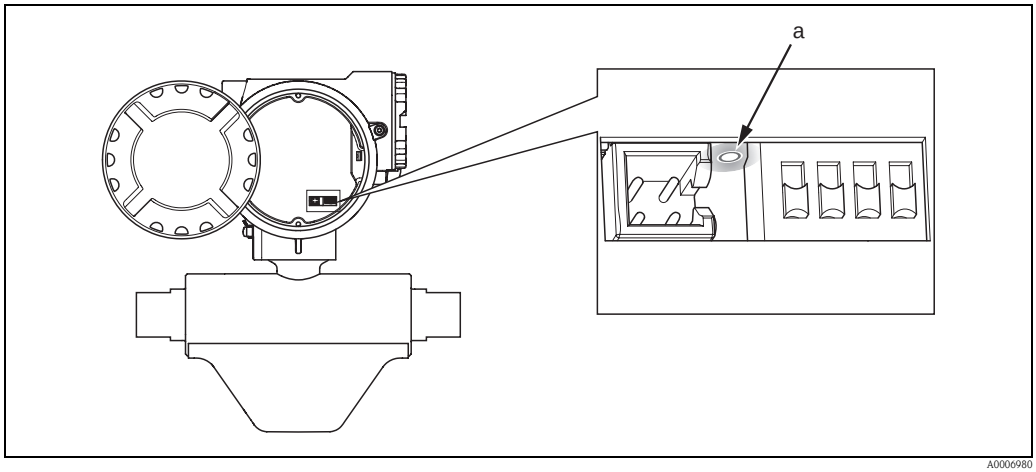
Display element

Status LED

There is a Light Emitting Diode (LED) on the meter electronics board that allows simple fault diagnostics:

- If the status output was not configured to output errors or notes.
- If fault diagnostics are no longer possible via the Fieldtool operating program.

⚠ Warning!
Risk of explosion! The electronics compartment may not be opened while there is an explosive atmosphere. This type of fault diagnostics can no longer be carried out in Ex-protected areas.

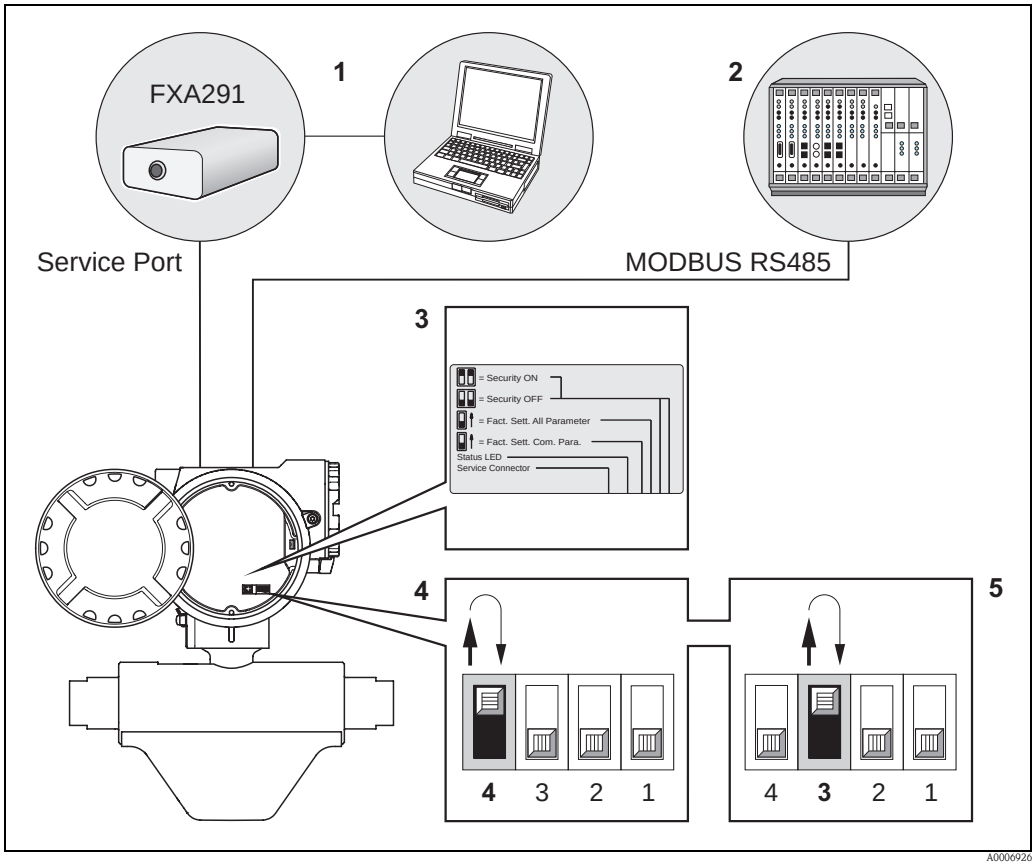


Fault diagnostics using light emitting diode (a)

Status of light emitting diode (LED)	Status of measuring system
LED illuminated in green	Measuring system OK, creepage is active
LED flashes green (once per second)	Measuring system OK, operation
LED not illuminated	Measuring system no longer working
LED flashes red (three times per second)	– Operation not possible – Error (fault message) pending
LED flashes red/green (once per second)	– Operation possible, but may be limited by application conditions – Notice message pending
LED flashes red/green (three times per second)	Zero point adjustment running
LED flashes green/orange (approx. 3 seconds long)	Custody transfer mode started
LED flashes red/orange (approx. 3 seconds long)	Custody transfer mode exited
LED flashes red/(pause)/green (approx. 3 seconds long)	SW update active

Remote operation

You have the following option for configuring and commissioning the device:



Method of operating MODBUS RS485 devices

1 Configuration/operating program for operating via the service interface FXA291 (e.g. FieldCare)
2 Operation via MODBUS RS485 process control system
3 Situation sticker of the various DIP switch positions and their function
4 Operation via device-internal DIP switch (4):
If the DIP switch (4) is switched upwards, the device restores the factory settings of the communication parameters of the MODBUS RS485 (return it afterwards to its original lower position).
5 Operation via device-internal DIP switch (3):
If the DIP switch (3) is switched upwards, the device restores the factory settings of all communication parameters of the MODBUS RS485 (return it afterwards to its original lower position).

Note!
The DIP switches must stay at least 2 second in the desired position, until the appropriate reaction takes place. Setting back parameters can require several minutes, followed by a start-up of the device. Meanwhile the light emitting diode permanently shines orange.
The power supply must not be switched off while the factory settings are being restored.

Certificates and approvals

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.
C-Tick symbol	The measuring system meets the EMC requirements of the Australian Communications and Media Authority (ACMA).
Ex approval	Information about currently available Ex versions (ATEX, FM, CSA etc.) can be supplied by your Endress+Hauser sales office on request. All information relevant to explosion protection is available in separate Ex documents that you can order as necessary.
MODBUS certification	The measuring device meets all the requirements of the MODBUS/TCP conformity and integration test and has the "MODBUS/TCP Conformance Test Policy, Version 2.0". The measuring device has successfully passed all the test procedures carried out and is certified by the "MODBUS/TCP Conformance Test Laboratory" of the University of Michigan.
Pressure Equipment Directive	Measuring devices with a nominal diameter smaller than or equal to DN 25 (1") correspond to Article 3(3) of the EC Directive 97/23/EC (Pressure Equipment Directive) and have been designed and manufactured according to good engineering practice.
Functional safety	SIL 2: in accordance with IEC 61508/IEC 61511-1 (FDIS)
Other standards and guidelines	■ EN 60529: Degrees of protection provided by enclosures (IP code) ■ EN 61010-1: Safety requirements for electrical equipment for measurement, control and laboratory use ■ IEC/EN 61326: "Emission in accordance with Class A requirements". Electromagnetic compatibility (EMC- requirements) ■ EN 60721: Shock and vibration resistance ■ OIML R139: Suitability for custody transfer measurement

Ordering information

The Endress +Hauser service organization can provide ordering information and detailed information on the order code.

Accessories

Various accessories, which can be ordered separately from Endress+Hauser, are available for the transmitter and the sensor.

Note!
The Endress +Hauser service organization can provide detailed information on the relevant order codes.

Documentation

- ❑ Flow measurement (FA005D/06)
- ❑ Operating Instructions incl. Device Functions (BA123D/06)
- ❑ Ex-Supplementary documentation ATEX (II2G): (XA115D/06)
- ❑ Ex-Supplementary documentation FM, CSA (Div. 1): (XA116D/06)
- ❑ Ex-Supplementary documentation NEPSI (Zone 1, Zone 21): (XA123D/06)

Registered trademarks

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Instruments International

Endress+Hauser
Instruments International AG
Kaegenstrasse 2
4153 Reinach
Switzerland

Tel. +41 61 715 81 00
Fax +41 61 715 25 00
www.endress.com
info@ii.endress.com

Endress+Hauser

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