Technical Information
Nanomass Gas Density
MEMS Coriolis density meter

The device for inline gas density measurement

Applications

- The measuring principle operates in a 0 to 30 kg/m^3 density range, considering pressure and temperature
- Highly accurate density and concentration measurement of non-corrosive, inflammable and non-inflammable gases and gas mixtures

Device properties
- Integrated pressure and temperature measurement
- Different hazardous area approvals available
- Only a very small medium amount required
- 2-line, backlit display with push buttons
- RS232 interface, USB and several outputs
- Integrated data logger

Your benefits

- High process safety and product quality – permanent process monitoring in real-time
- High availability - low-maintenance
- Increased process productivity – no time-consuming laboratory analysis
- Fully traceable density measurement – calibration facilities
- Easy implementation in various kinds of processes – compact device design
- Easy installation – without additional equipment

Endress+Hauser
People for Process Automation

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Document information

Symbols and abbreviations used

Electrical symbols

Symbol	Meaning
A0011197	**Direct current** A terminal to which DC voltage is applied or through which direct current flows.
 A0011198	**Alternating current** A terminal to which alternating voltage is applied or through which alternating current flows.
 A0017381	**Direct current and alternating current** ▪ A terminal to which alternating voltage or DC voltage is applied. ▪ A terminal through which alternating current or direct current flows.
 A0011200	**Ground connection** A grounded terminal which, as far as the operator is concerned, is grounded via a grounding system.

Symbols for certain types of information

Symbol	Meaning
 A0011182	**Permitted** Indicates procedures, processes or actions that are permitted.
 A0011183	**Preferred** Indicates procedures, processes or actions that are preferred.
 A0011184	**Forbidden** Indicates procedures, processes or actions that are forbidden.
 A0011193	**Tip** Indicates additional information.
 A0011194	**Reference to documentation** Refers to the corresponding device documentation.
 A0011195	**Reference to page** Refers to the corresponding page number.

Symbols in graphics

Symbol	Meaning
1, 2, 3,...	Item numbers
A, B, C, ...	Views
A-A, B-B, C-C,..	Sections
 A0013441	Flow direction
 A0011187	**Hazardous area** Indicates a hazardous area.
 A0011188	Safe area (non-hazardous area) Indicates the non-hazardous area.

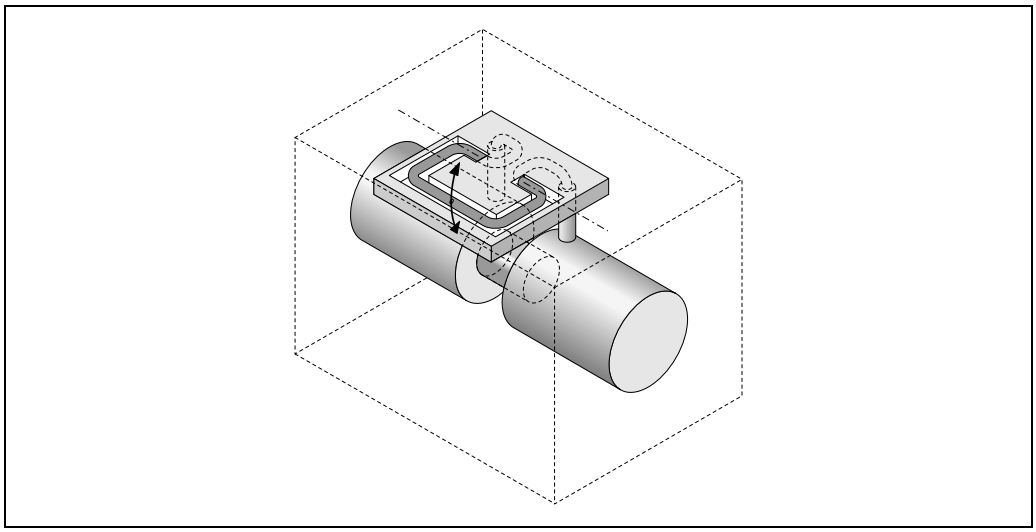
Abbreviations

Abbreviation	Meaning
MEMS	Micro-Electro-Mechanical System

Function and system design

Measuring principle

The measurement method is based on a micro-channel which is caused to oscillate at resonance frequency. The micro-channel is part of a micro-electro mechanical system (MEMS). The micro-channel is integrated in an internal bypass. When fluid flows through the measuring device, the bypass arrangement causes a pressure drop across the micro-channel, causing the medium to enter the micro-channel.



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Density measurement

The density measurement is performed by determining the eigenfrequency of the micro-channel, which itself depends on the mass or the density of the fluid in the micro-channel. The higher the fluid density, the lower the eigenfrequency. The eigenfrequency is thus a function of the fluid density.

$$f \propto \sqrt{\frac{E \cdot I}{\rho_{Tube} \cdot A_{Tube} + \rho_{Fluid} \cdot A_{Fluid}}}$$

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f = eigenfrequency, $E \cdot I$ = pipe rigidity, ρ_{Tube} = pipe density, A_{Tube} = pipe cross-section, ρ_{Fluid} = fluid density, A_{Fluid} = fluid cross-section

Temperature measurement

The temperature of the micro-channel is determined in order to calculate the compensation factor due to temperature effects. This signal corresponds to the fluid temperature in the micro-channel and it is also available as an output signal.

Pressure measurement

As the gas density depends heavily on the pressure, a pressure sensor measures the pressure during the density measurement. The pressure is also available as an output signal.

Derived measured variables

A reference density and the average molar mass can be derived from the measured density, temperature and pressure according to the ideal gas laws. In addition, in the case of binary gas mixtures a concentration can be determined according to a user-configurable model.

Measuring system

The measuring device uses a micro-electro mechanical system (MEMS) for density and temperature measurement, and a capacitance pressure sensor for pressure measurement. The components of the measuring device form an inseparable unit.

The MEMS chip consists of an oscillatory micro-channel, an oscillation generator, an oscillation detector and an integrated temperature sensor. The MEMS chip and the pressure sensor are connected to the electronics system and can be controlled and read by it.

The fluid is directed into the micro-channel via an internal bypass. In this way, the measuring device can also be used for large flow rates. Furthermore, any unnecessary pressure loss in the process pipe is also prevented.

Input

Measured variable

Direct measured variables

- Density
- Temperature (at density measurement)
- Pressure (at density measurement)

As the ambient temperature can influence the medium temperature in the micro-channel, the measured temperature can deviate from the actual process temperature.

Derived measured variables

- Reference density according to the ideal gas law
- Average molar mass according to the ideal gas law
- Concentration according to user-configurable model in the case of binary gas mixtures

Measuring range

Measuring range for gases

Range for full scale values (density) ρ_{min} to ρ_{max}	0 to 30 kg/m³ (0 to 0.03 g/cm³, 0 to 0.03 SGU)

Output

Output signal

Current output

Current output	2× 4-20 mA (passive)
Maximum output values	23 mA
Load	0 to 700 Ω
Resolution	8 µA
Damping	Configurable: 0 to 120 s
Assignable measured variable	▪ Density ▪ Reference density ▪ Concentration ▪ Temperature ▪ Pressure

Signal on alarm

Failure information is displayed as follows.

Current output

Failure mode	Choice of failure information (in accordance with NAMUR Recommendation NE 43) if the tube does not oscillate correctly or a value is outside the density range: ▪ Minimum value: 2 mA ▪ Maximum value: 22 mA (not Namur: 23 mA)
Breakdown of power supply	Breakdown information during disconnection of power supply: ▪ <1 mA

Local display

Plain text display	Error message on operational display.

"Nanomass Communication" operating tool

Status information	Error message with status information

Light emitting diodes (LED)

Status information	Status indicated by two light emitting diodes (in accordance with NAMUR Recommendation NE 43). The light emitting diodes indicate the following information: ▪ Supply voltage active ▪ Data transmission active ▪ Device alarm/error has occurred

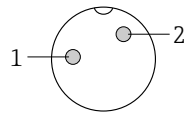
Galvanic isolation

The current outputs are galvanically isolated from the rest of the system.

Power supply

Pin assignment of connector

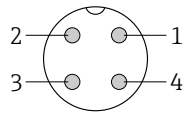
Connector for supply voltage



Pin	Assignment		Coding, connector face	Connector/ socket
1	L-	DC 8 to 30 V	A	Connector
2	L+			

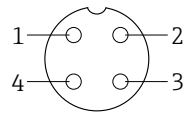
Connector for signal transmission

4-20 mA connector



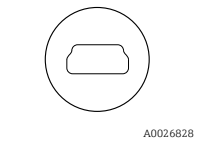
Pin	Assignment		Coding, connector face	Connector/ socket
1	+/-	Current output 1, 4-20 mA (passive)	A	Connector
2	-/+	Current output 1, 4-20 mA (passive)		
3	+/-	Current output 2, 4-20 mA (passive)		
4	-/+	Current output 2, 4-20 mA (passive)		

RS232 device socket



Pin	Assignment	Coding, connector face	Connector/ socket
1	Shield	A	Socket
2	Txout (transmitted data)		
3	Rxin (received da)		
4	Common ground		

USB device socket



Assignment	Connector/socket
Mini-USB, type B, Buccaneer	Socket

Supply voltage

Power connection	DC 8 to 30 V, the power unit must be tested to ensure it meets safety requirements (e.g. PELV, SELV)
USB port (optional)	DC 5 V

Power consumption

Maximum power consumption	400 mW

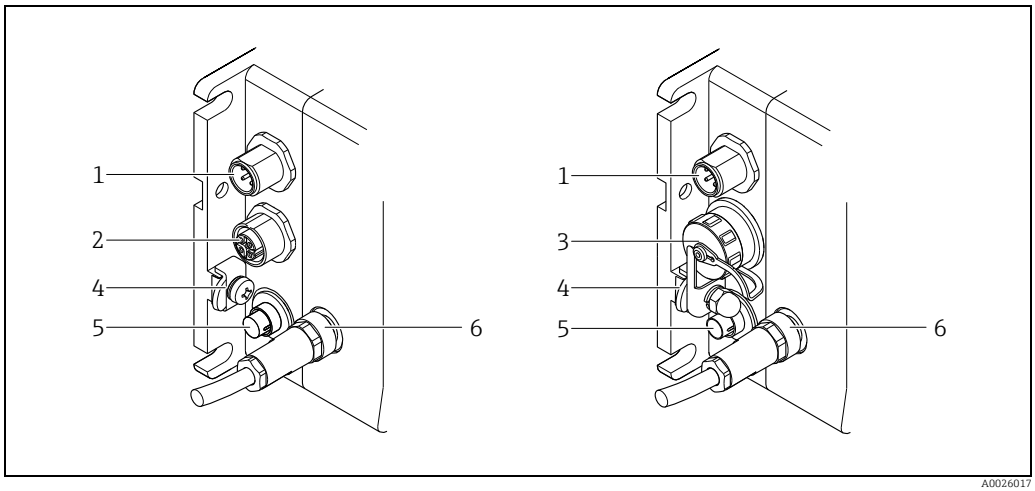
Current consumption

Maximum switch-on current	1 A (< 0.125 ms)

Power supply failure

- The configuration and recorded data are retained in the data memory.
- Internal real-time clock is battery-backed and continues to run. The operating life of the real-time battery is 10 years.

Electrical connection



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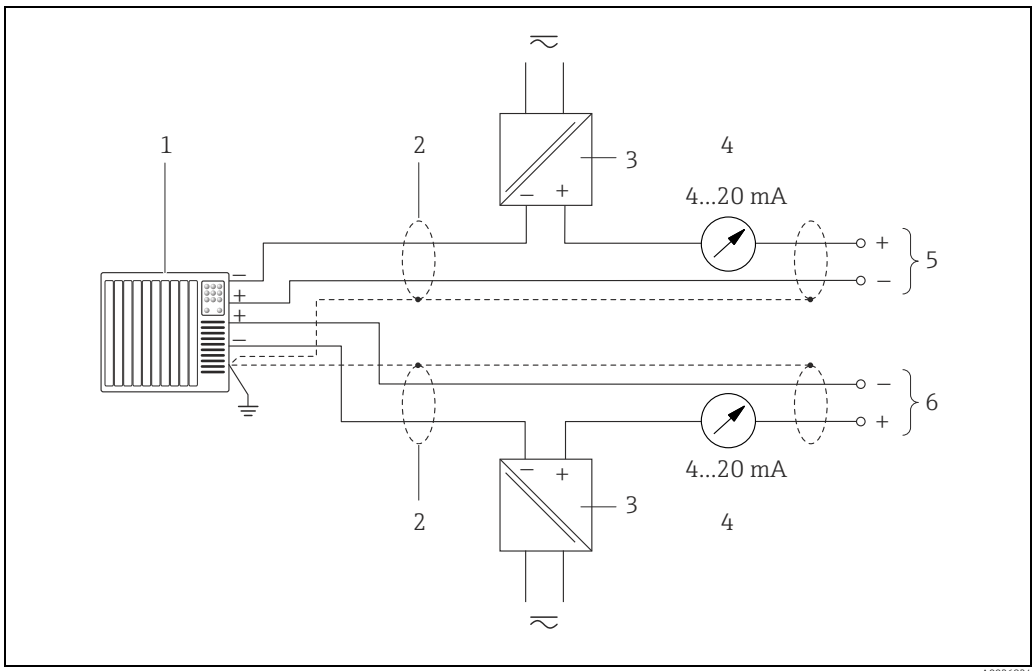
1 = Connector for 4-20 mA; 2 = RS232 interface (optional); 3 = USB port (optional); 4 = Grounding clamp
5 = Connector for supply voltage; 6= Connector for pressure sensor (connected on delivery)

Pin assignment of connector (→ 🖹 6).

Connection example for 4-20 mA current output



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1 = Automation system with current input (e.g. PLC); 2 = Cable shield, see cable specification (→ 🖹 8)
3 = Power supply 12 to 24 V; 4 = Analog display unit, observe maximum load (→ 🖹 5)
5 = Measuring device, current output 1 (pin 1 and 2, protected against reverse polarity); 6 = Measuring device, current output 2 (pin 3 and 4, protected against reverse polarity)

Cable connection

Power connection	M9, 2-pin (connector)
4-20 mA	M12, 4-pin (connector)
USB port (optional)	Mini-USB, type B (socket)
RS232 interface (optional)	M12, 4-pin (socket)

Cable specification

Permitted temperature range

- −40 to 80 °C (−40 to 176 °F)
- Minimum requirement: cable temperature range ≥ ambient temperature + 20 K

Power supply cable

Outer diameter	3.5 to 5 mm
Number of cores	Min. 2
Cable resistance	77.8 Ω/km at 20 °C
Shielding	Single shielding

Signal cable

Shielding	A shielded cable is recommended. Observe grounding concept of the plant.

USB cable

Cable type	Mini USB, type B, Buccaneer; standard USB, type A
Cable length	Max. 5 m

RS232 cable

Cable type	M12, 4-pin; D-Sub, 9-pin
Cable length	Max. 5 m
Transmission rate	57600 Bd

Performance characteristics

Reference operating conditions

- Gases with density <30 kg/m^3; temperature +5 to +60 °C (+59 to +113 °F); pressure 0 to 20 bar (0 to 290 psi)
- Specifications as per calibration protocol

Maximum measured error

Base accuracy under reference operating conditions

Density (gases)

±0.1 kg/m^3 (±0.0001 g/cm^3)

At field density calibration: ±0.05 kg/m^3 (±0.00005 g/cm^3)(applies after field density calibration under process conditions)

The relative accuracy of the density measurement increases with increasing system pressure.

Temperature (at density measurement)

±0.5 °C

Pressure (at density measurement)

±0.05 bar

Accuracy of outputs

o.r. = of measuring range of current output

In the case of analog outputs, take the accuracy of the output into consideration for the inaccuracy specification.

Current output

Max. ±0.1 % o.r. or ±15 µA

Repeatability

Base repeatability under reference operating conditions

Density (gases)

±0.05 kg/m^3 (±0.00005 g/cm^3)

Temperature

±0.25 °C

Pressure

±0.02 bar

Response time

500 ms

Influence of medium temperature

The medium temperature does not affect the measuring accuracy. The effects of temperature are compensated for by measuring the temperature in the micro-channel.

Influence of variations in the medium temperature

If the medium temperature changes quickly (>2 C°/min), the measured error can be higher than specified under reference operating conditions.

Influence of ambient temperature

o.r. = of measuring range of current output

Current output

Temperature coefficient	Max. +50 ppm/°C o.r. or ±1 µA/°C

Influence of medium pressure

Pressure effects are compensated for by measuring the pressure. The medium pressure therefore does not affect the absolute measuring accuracy.

Influence of variations in the medium pressure

In the case of the derived measured variables (concentration, reference density and molar mass), the accuracy can be affected if the medium pressure changes quickly (>0.1 bar/s).

Installation

Mounting location

The measuring device is usually installed in a bypass line. If flow rates are low, the device can also be installed in the main pipe.

Installation in a bypass line is recommended in the following cases:
- Flow rate >1 l/min (0.26 gal/min.)
- Pipeline diameter >6 mm (0.24 in)

Orientation

The orientation of the device does not affect the measuring accuracy.

Flow direction

The flow direction does not affect the measuring accuracy.

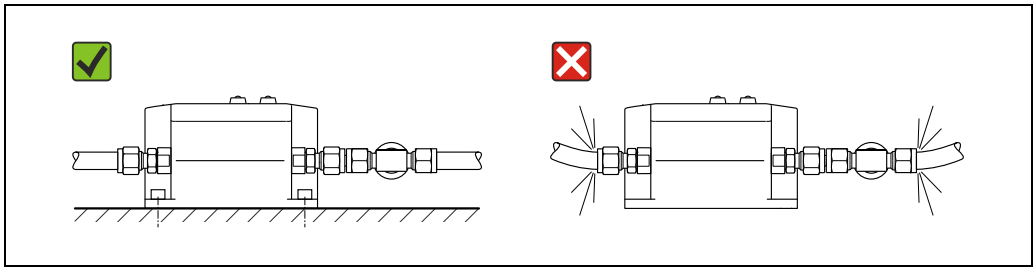
Inlet and outlet runs

Inlet and outlet runs do not affect the measuring accuracy.

Special mounting instructions

Wall mounting

Use drill holes and M6 screws to secure the filter to a wall or a secure base.



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Pipe mounting

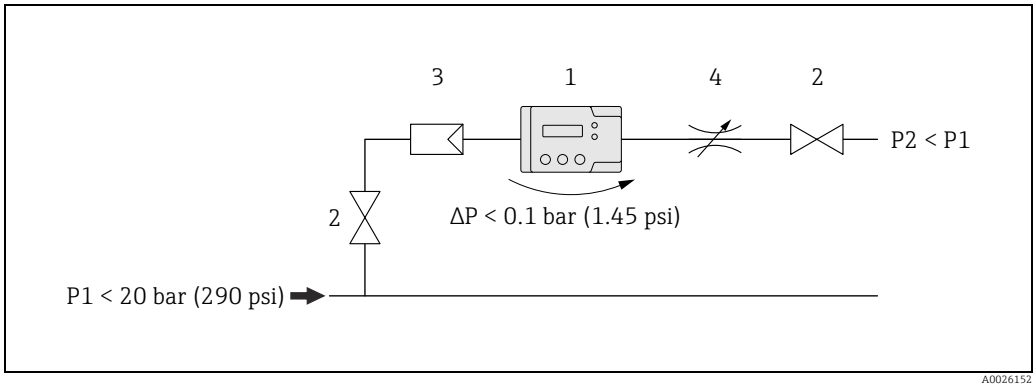
Use the "pipe mounting kit" accessory to secure to a pipe or post.

Installation in a bypass

Note the following when installing in a bypass line:
- A pressure drop must be created for the medium to flow through the measuring device.
- The maximum permissible pressure drop of 0.1 bar (1.45 psi) across the measuring device may not be exceeded.
- The bypass line can be routed to the atmosphere or back to the process pipe.

Examples:

- Create necessary pressure drop with throttle (or flow monitor) downstream from the measuring device.



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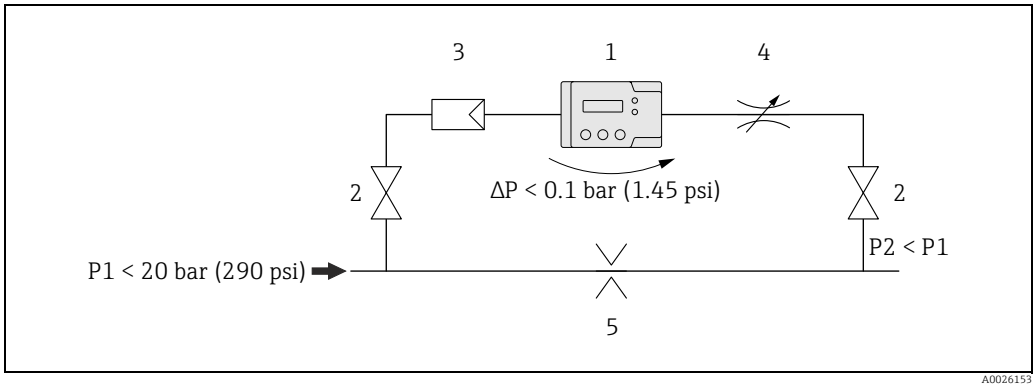
1 = Nanomass; 2 = Valve; 3 = Filter; 4 = Throttle

- Create necessary pressure drop with orifice plate in process pipe and with throttle (or flow monitor) downstream from the measuring device.



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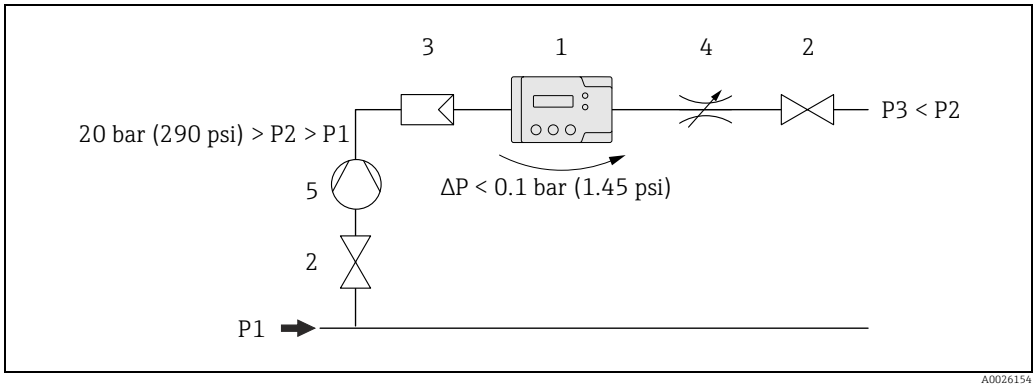
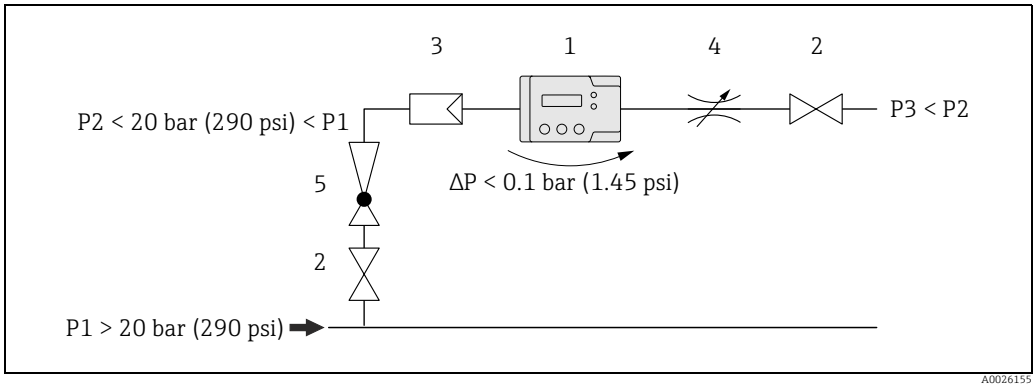
1 = Nanomass; 2 = Valve; 3 = Filter; 4 = Throttle; 5 = Orifice plate

- Create necessary pressure drop with compressor upstream and throttle (or flow monitor) downstream from the measuring device.



1 = Nanomass; 2 = Valve; 3 = Filter; 4 = Throttle; 5 = Compressor

- If process pressure > 20 bar: create necessary pressure drop with pressure reduction valve upstream and throttle (or flow monitor) downstream from the measuring device.



1 = Nanomass; 2 = Valve; 3 = Filter; 4 = Throttle; 5 = Pressure reduction valve

Filter

To prevent the micro-channel from clogging, it is advisable to install a filter upstream from the measuring device. The filter is included in the delivery.

- Recommended filter pore size: ≤15 µm

Swagelok pipe fitting

The measuring device and the filter supplied are mounted in the pipe using a ¼" Swagelok pipe fitting.

Environment

Ambient temperature range

Non-Ex version	−20 to +60 °C (−4 to +140 °F)
Ex ia IIC T4 version	−20 to +60 °C (−4 to +140 °F)

- If operating via USB port: operating temperature is limited to 0 to 60 °C (32 to 140 °F).
- If operating outdoors: avoid direct sunlight, particularly in warm climatic regions.

Storage temperature

−20 to +60 °C (−40 to +140 °F), preferably +20 °C

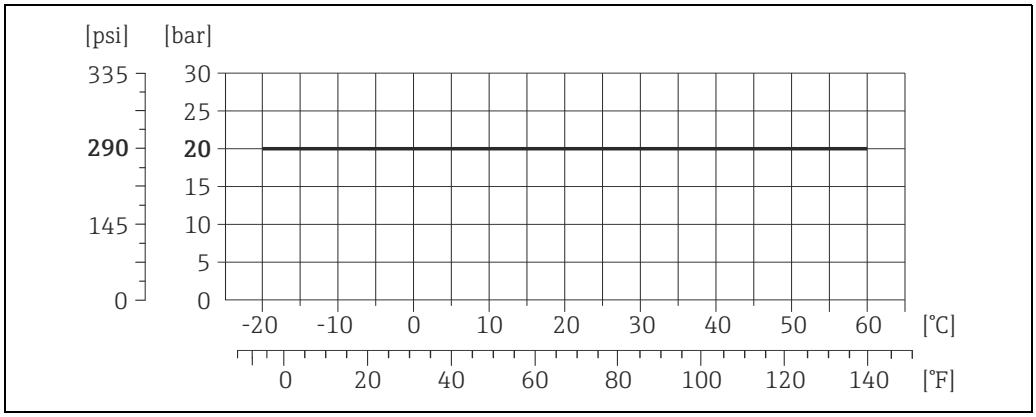
Climate class	DIN EN 60068-2-38 (test Z/AD)
Degree of protection	IP65/67
Shock resistance	As per IEC/EN 60068-2-31
Interior cleaning	Permitted cleaning agents: ▪ Isopropyl alcohol (IPA) ▪ Acetone ▪ Hexane
Electromagnetic compatibility (EMC)	▪ According to IEC/EN 61326 ▪ Complies with emission limit for industry as per EN 550011 (Class A) For details, please refer to the Declaration of Conformity.

Process

Media	Permitted media are the gases listed below with the following features: ▪ Noncorrosive ▪ Absolute humidity < 10 g/m^3 (dew point < 11 °C) ▪ Relative humidity (non-condensing) < 80% ▪ Concentration of helium < 50 ppm (pure helium is not permitted) Permitted gases or mixtures of such gases: ▪ Nitrogen (N_2) ▪ Oxygen (O_2) ▪ Air ▪ Carbon dioxide (CO_2) ▪ Neon (Ne) ▪ Argon (Ar) ▪ Krypton (Kr) ▪ Xenon (Xe) ▪ Hydrogen (H_2) ▪ Methane (CH_4) ▪ Natural gas (maximum permitted helium concentration: 50 ppm) ▪ Ethyne (acetylene) (C_2H_2) ▪ Ethylene (C_2H_4) ▪ Ethane (C_2H_6) ▪ Propene (C_3H_6) ▪ Propane (C_3H_8) ▪ Butane (C_4H_{10}) ▪ LPG (supplied as gas) If you are using gases other than those indicated above, please contact your Endress+Hauser Sales Center at: www.endress.com/worldwide.
Medium temperature range	−20 to +60 °C (−4 to +140 °F)
Medium density range	0 to 30 kg/m^3 (0 to 1.9 lb/ft^3)

Pressure-temperature ratings

The following pressure/temperature diagram refers to the entire device and not just the process connection.



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Secondary containment pressure rating

The sensor housing is filled with dry nitrogen on delivery and protects the electronics and mechanics inside.

The housing does not have pressure vessel classification.

Flow limit

Recommended max. flow for complete accuracy	1 l/min (0.26 gal/min)

Pressure loss

Recommended max. pressure drop across the measuring device for complete accuracy	0.1 bar (1.45 psi)

System pressure

Permitted absolute system pressure	Max. 20 bar (290 psi)

The relative accuracy of the density measurement increases with increasing system pressure.

Thermal insulation

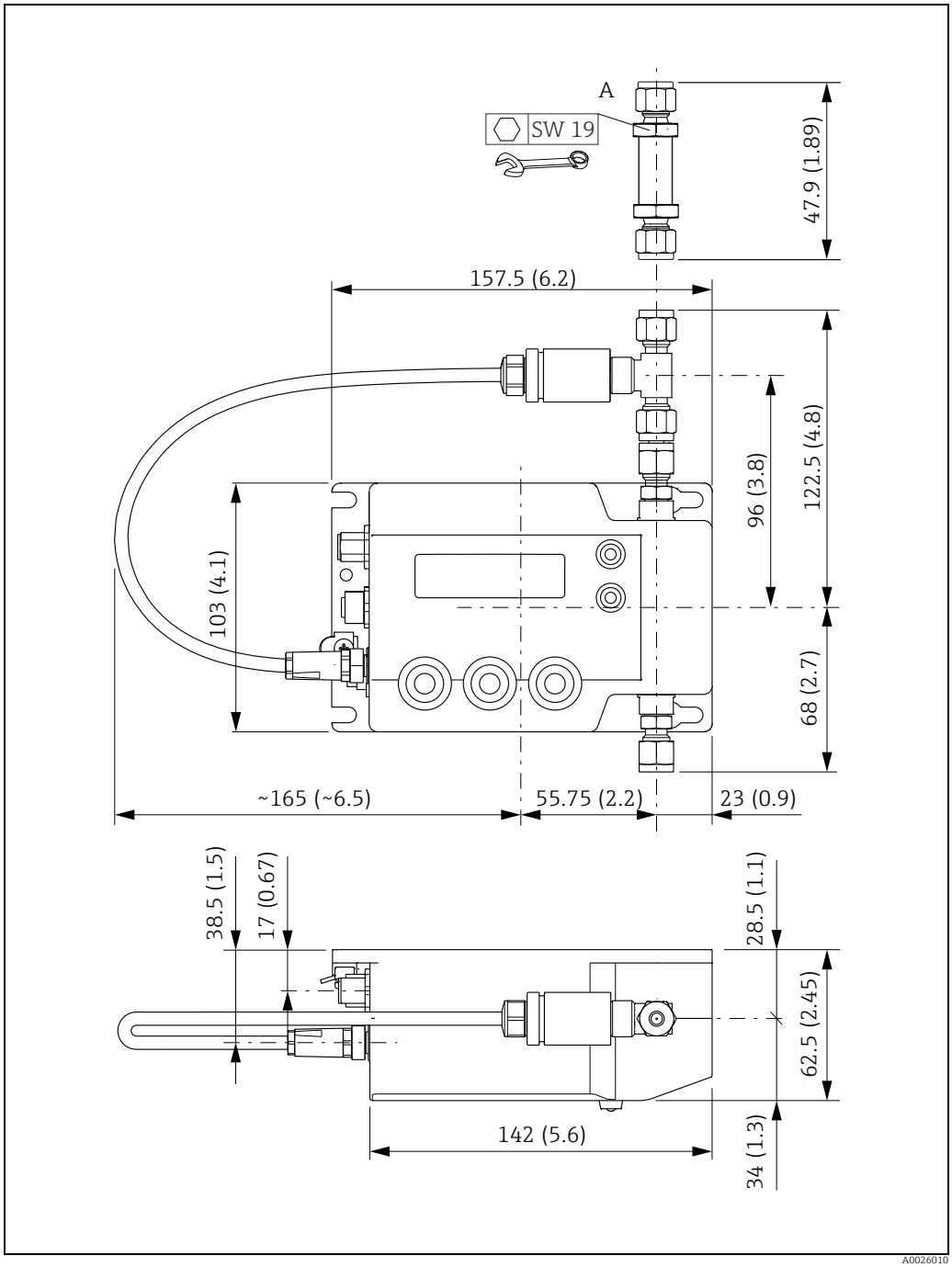
Due to a low thermal capacity of the medium, the medium temperature can be greatly affected by the ambient temperature through the supply line and the measuring device. The influence of the ambient temperature on the medium temperature can be reduced by insulating the supply line.

Vibrations

Due to the high operating frequency of the micro-channel, vibrations (<20 kHz) do not affect measuring accuracy.

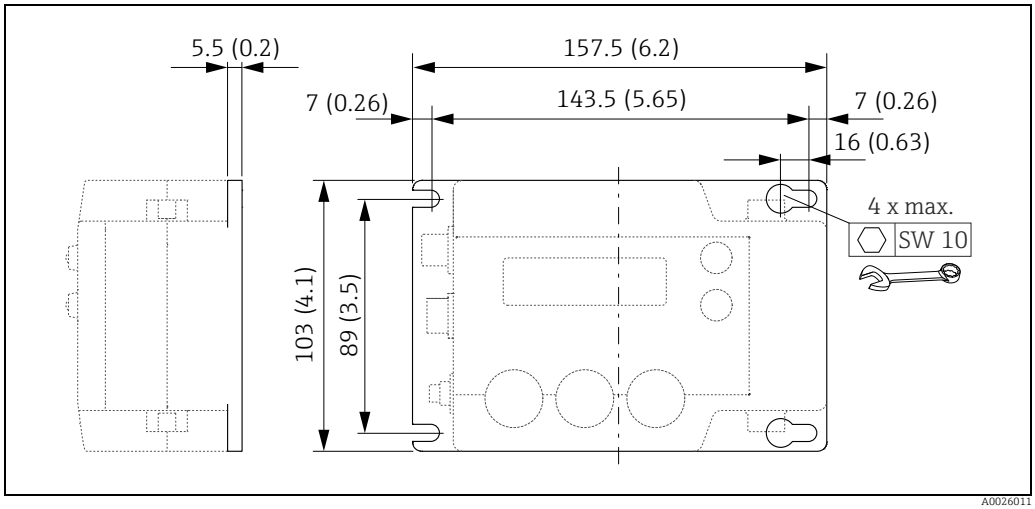
Mechanical construction

Design, dimensions



Dimensions in mm (in)

A = ¼" Swagelok in-line filter SS-4F-15



Mounting holes, dimensions in mm (in)

Weight

Ca. 1.5 kg (3.3 lb)

Materials

Housing

- Aluminum, powder-coated
- Window material: polycarbonate

Connections

4-20 mA connection	▪ Socket: die-cast zinc, nickel-plated ▪ Contact housing: polyamide ▪ Contacts: brass, gold-plated
RS232 interface	▪ Socket: die-cast zinc, nickel-plated ▪ Contact housing: polyamide ▪ Contacts: brass, gold-plated
USB port	▪ Socket: polyester ▪ Contact housing: polyester ▪ Contacts: copper base alloy, gold-plated ▪ Protection cap: polyester
Power connection	▪ Socket: brass, nickel-plated ▪ Contact housing: polyamide ▪ Contacts: brass, gold-plated
Pressure sensor connection	▪ Socket: brass, nickel-plated ▪ Contact housing: polyamide ▪ Contacts: brass, gold-plated

Wetted parts, fluidic system

Process connection	Stainless steel, 1.4404 (316L)
Manifold	Stainless steel, 1.4542 (17-4 PH)
MEMS chip	▪ Silicon ▪ BOROFLOAT 33 glass ▪ Epoxy
Pressure sensor	▪ Stainless steel, 1.4404 (316L) ▪ Ceramic (AI_2O_3) ▪ Viton
Threaded seals	PTFE

Process connection

¼" Swagelok pipe fitting

Operability

Local display

Display elements

- 2-line liquid crystal display with 16 characters per line.
- Format for displaying various measured variables can be individually configured.

Operating elements

Local operation with three keys (⊟⊞Ⓔ).

Remote control

- Operation via "Nanomass Communication" operating tool for Windows desktops.

Reliable operation

- If the power supply fails, data stored in the measuring device and device configurations are retained.

Languages

The operating language is English.

Certificates and approvals

CE mark

The measuring system meets the legal requirements of the EC Directives.
Endress+Hauser confirms that the device has been successfully tested by applying the CE mark.

C-Tick symbol

The measuring system complies with the EMC requirements of the "Australian Communications and Media Authority (ACMA)".

CRN approval

As an option, the measuring system can also be ordered with CRN approval (Canadian Registration Number).

Ex approval

Information about currently available Ex versions (ATEX, FM, CSA, IECEx, NEPSI etc.) can be supplied by your E+H Sales Center on request. All explosion protection data are given in a separate Ex documentation, which is available upon request.

Other standards and guidelines

- EN 60529
  Degrees of protection provided by enclosures (IP code)
- IEC/EN 60068-2-6
  Environmental testing: Test procedure - Test Fc: vibration (sinusoidal).
- IEC/EN 60068-2-31
  Environmental testing: Test procedure - Test Ec: rough handling shocks, primarily for equipment-type specimens.
- EN 61010-1
  Safety requirements for electrical equipment for measurement, control and laboratory use – general requirements
- IEC/EN 61326
  "Emission in accordance with Class A requirements". Electromagnetic compatibility (EMC requirements)
- NAMUR NE 43
  Standardization of the signal level for the breakdown information of digital transmitters with analog output signal

Ordering information

Detailed ordering information is available from the following sources:
- In the Product Configurator on the Endress+Hauser website: www.endress.com → Select country → Instruments → Select device → Product page function: Configure this product
- From your Endress+Hauser Sales Center: www.endress.com/worldwide

Product Configurator - the tool for individual product configuration

- Up-to-the-minute configuration data
- Depending on the device: direct input of information specific to measuring point, such as measuring range or operating language
- Automatic verification of exclusion criteria
- Automatic creation of the order code and its breakdown in PDF or Excel output format

Application packages

Application packages are available for the device to extend the device functionality, where needed. The application packages can be ordered with the device or subsequently from Endress+Hauser. Detailed information on the appropriate order code is available from your local Endress+Hauser Sales Center or on the product page of the Endress+Hauser website: www.endress.com.

Package	Description
Concentration Measurement	**Concentrations are calculated and displayed.** Using the application package, the measuring device can output the concentration of a gas in a binary mixture. Certain mixtures are already preprogrammed in the measuring device. Furthermore, the concentration of any binary gas mixture can be determined by entering coefficients. Your Endress+Hauser Sales Center can provide you with the information that is needed to determine the coefficients, which must be stored in the measuring device to calculate the concentration.
Datalog function	**Retrieval and Saving of measuring data.** Via the "Measuring data retrieval" function area, measuring data that are saved in the internal data memory can be retrieved. This also includes the saving of measuring data to a text file that can be imported into a database.

Accessories

Various accessories are available for the device, and can be ordered with the device or at a later stage from Endress+Hauser. Detailed information on the appropriate order code is available from your local Endress+Hauser Sales Center or on the product page of the Endress+Hauser website: www.endress.com.

Device-specific accessories

Accessories	Description
Power cable	Cable of 5 m (15 ft) length for power supply.
Power connector	Connector for power cable, 2-pin.
RS232 service cable	Cable of 2 m (6 ft) length for communication with Nanomass Communication.
RS232 connector	Connector for service cable.
4-20mA connector	Kit of 2 connectors for connecting the analog measuring signal with a higher-order system.
USB cable	Cable of 2 m (6 ft) length for power supply and communication with Nanomass Communication.
Grounding clamp	Grounding clamp for RS232 or USB version.
¼"-Swagelok pipe fitting	For the mounting of the measuring device and the filter in the pipeline.

Accessories	Description
Filter cartridge	Kit of 3 spare filter cartridges to change the used filters.
Pipe mounting set	To secure to a pipe or post.
Tabletop stand	To secure to a tabletop.

Service-specific accessories

Accessories	Description
Applicator	Software for selecting and sizing Endress+Hauser measuring devices: ▪ Calculation of all the necessary data for identifying the optimum flowmeter: e.g. nominal diameter, pressure loss, accuracy or process connections. ▪ Graphic illustration of the calculation results Administration, documentation and access to all project-related data and parameters throughout the entire life cycle of a project. Applicator is available: ▪ Via the Internet: https://wapps.endress.com/applicator ▪ On CD-ROM for local PC installation
W@M	Life cycle management for your plant. W@M supports you with a wide range of software applications over the entire process: from planning and procurement, to the installation, commissioning and operation of the measuring devices. All the relevant device information, such as the device status, spare parts and device-specific documentation, is available for every device over the entire life cycle. The application already contains the data of your Endress+Hauser device. Endress+Hauser also takes care of maintaining and updating the data records. W@M is available: ▪ Via the Internet: www.endress.com/lifecyclemanagement ▪ On CD-ROM for local PC installation

System components

Accessories	Description
Memograph M graphic display recorder	The Memograph M graphic display recorder provides information on all relevant measured variables. Measured values are recorded correctly, limit values are monitored and measuring points analyzed. The data are stored in the 256 MB internal memory and also on a SD card or USB stick. For details, see "Technical Information" TI00133R and Operating Instructions BA0024TR.

Documentation

For an overview of the scope of the associated Technical Documentation, refer to the following:
- CD-ROM provided.
- *W@M Device Viewer*: enter the serial number indicated on the nameplate (www.endress.com/deviceviewer).
- *The Endress+Hauser Operations App*: enter the serial number indicated on the nameplate or scan the 2-D matrix code (QR code) provided on the nameplate.

Standard documentation

Document type	Documentation code
Operating Instructions	BA01449D
Brief Operating Instructions	KA01192D

Supplementary device-dependent documentation

Document type	Documentation code
Safety Instructions, Cl.I, Div.1, Zone 0 for IS	XA01376D

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