Data sheet I Technical description and installation instructions

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Density sensor DLO-M1

Rethink Sensing

Contents

General information on the data sheet

Usage and storage

- This data sheet is a fixed component of the density sensor.
- The data sheet must be stored near the location of use.
- If the density sensor is passed to third parties, the data sheet or relevant contents must be passed onto them, too.
- Read the data sheet carefully.
- We reserve the right to make changes at any time.

Document function

The data sheet provides information about safe use and installation of the density sensor.

Symbols used

The following symbols are used within the data sheet to indicate hazardous situations and to mark instructions for action:

Symbol	Description
⚠ WARNING	Failure to avoid this situation will result in serious or fatal injury.
NOTICE	Information on procedures and other facts, which do not result in personal injury.
▶	Single step
1. / 2. / 3.	Series of steps

Safety instructions

Designated use

- The density sensor is exclusively intended for the density measurement of fluids. Only permitted media are allowed.
- Non-designated use can compromise the safety. The manufacturer is not liable for damage caused by improper or non-designated use.

Requirements for personnel

- The density sensor may only be installed by qualified personnel.

Operational safety

- The operator is responsible for the trouble-free operation of the density sensor.
- Only operate the density sensor in a technically flawless and reliable condition.
- If fluid temperatures are elevated, ensure full protection against contact to prevent burns.
- Unauthorized modifications or repairs to the density sensor are not permitted and can lead to unforeseeable dangers.

Product safety

- The density sensor is compliant with the guidelines listed in the EU Declaration of Conformity. TrueDyne Sensors AG confirms this by affixing the CE mark to the density sensor.

Product description

Overview

The density sensor was designed to measure the density of fluids. The measurement takes place in a microelectromechanical system (MEMS) with an omega-shaped micro channel (omega chip). This system is installed in an internal bypass.

If media is flowing through the density sensor a pressure drop is generated by the micro channel because of the bypass arrangement. Thus, the media arrives at the omega chip that generates the measured value information. Subsequently, the values are transferred as a signal through a RS232 interface to the superior system. For this purpose, an ASCII command protocol in the TrueDyne Sensors standard is used.

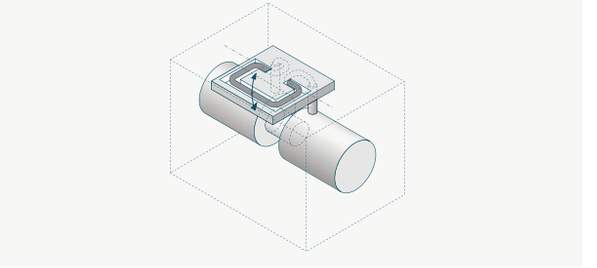
Therefore, density measurements ranged from 600 to 1000 kg/m^3 (for more options please see "product specification") and a flow rate ranged from 0 to 10 l/h can be feasible. The continuous data output takes place with a measurement of 10 Saps.

Omega chip

The omega chip is a vibronic microsystem and the heart of the measuring system. It provides the generation of the sensor signal within the entire system. An essential component part of this micro system is a silicon tube (micro channel), which is electrostatically set to vibrate in a vacuum atmosphere. To compensate the effects of temperature, a platinum resistor, which allows the recording of the local real-time temperature is integrated. Primarily, the omega chip consists of crystalline silicon and glass.

Density measurement

The density sensor uses the omega chip for the density measurement. For this purpose, the filled micro channel is set into resonant vibration and will be analyzed. The frequency and the vibration quality are determined.



Measuring principle (omega chip)

The resulting resonance frequency of the micro channel is dependent upon the mass and thus upon the density of the medium in the micro channel. The bigger the medium density, the smaller the resonance frequency. Therefore, the resonance frequency is a function of the medium density.

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

f = resonance frequency, $E \cdot I$ = pipe rigidity, ρ_{Tube} = pipe density, A_{Tube} = pipe cross section, ρ_{Fluid} = medium density, A_{Fluid} = medium cross section

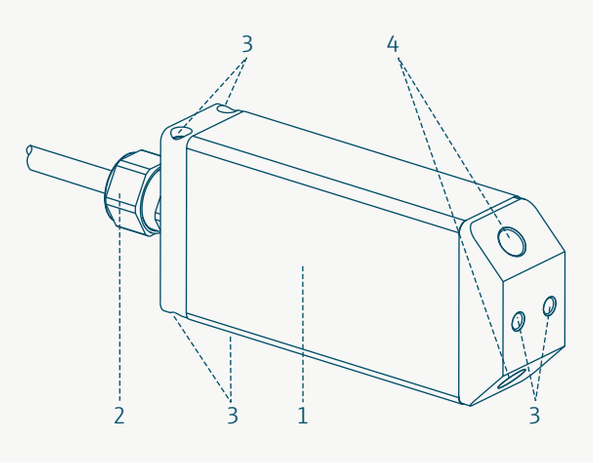
Application range

The density sensor can be used for direct and indirect density measurements. While the quality of a product can be identified through direct density, indirect density measurements allow to identify the concentration of fluid mixtures which can be determined by means of tables and calculation algorithms.

For example, the density sensor can be used in the following applications:

- Addition to volumetric flow rate measurement to create a mass measurement within bezels, turbines or repression devices. The density sensor takes changes of temperature and pressure into account.
- Monitoring and quality control of fuel mixtures such as E10 or biodiesel.

Product design



Product design density sensor DLO-M1

1 Housing
2 Electronic interface for communication and power supply
3 Drill holes for mechanical mounting (6 x M3 threaded holes)
4 Fluidic interface (2 x M5 threaded holes)

Scope of delivery

- Density module (incl. transportation locks)
- Information sheet with download links

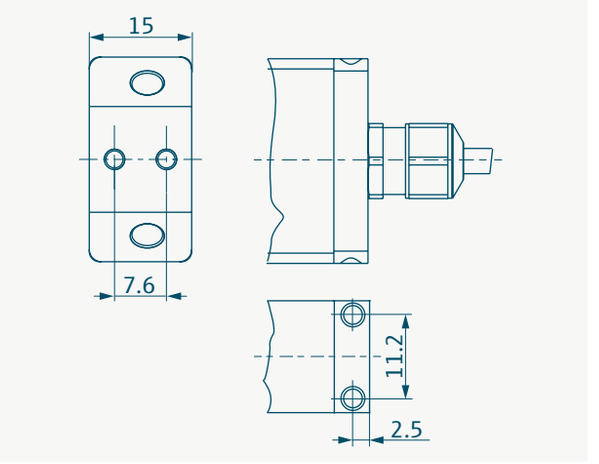
Product identification

The product can be identified through a continuous thirteen-digit serial number. The number is located on the outside of the housing and can also be found via the digital output string.

Installation, commissioning and uninstallation

Mechanical mounting of density sensor

- ▶ Mount viscosity sensor using the provided drill holes (4 mm depth) with M3 screws. Maximum tightening torque 30 cNm (typical 15 ... 20 cNm).



Dimensions in mm for the mechanical mounting

Fluidic installation of density sensor

- If the flow rate is >10 l/h, the installation in a bypass line is recommended, in order to limit the flowrate throuhg the density sensor <10 l/h
- The bypass line can be lead to a drainage container or back to the main pipe.

⚠ WARNING

Hazardous process conditions and burst pipes can cause injury

- ▶ Before mounting the density sensor, depressurize and empty the pipe.
- ▶ Beware of high temperatures.
- ▶ Mechanically mount the density sensor where necessary.

NOTICE

Clogging of the micro channel

- ▶ Where necessary, install a filter upstream from the density sensor to prevent clogging the micro channel.

NOTICE

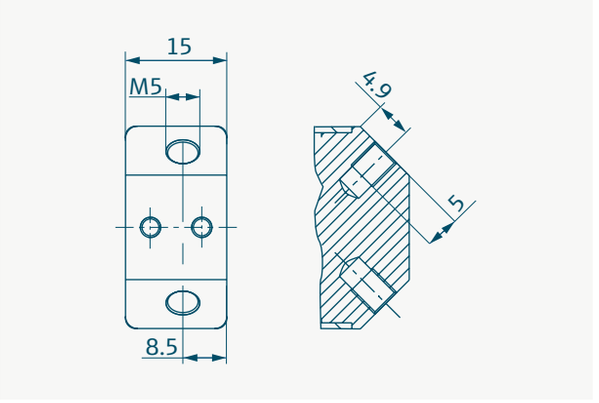
Delayed measuring signal if mounted into bypass

- ▶ Beware of time delay, for example in process control.

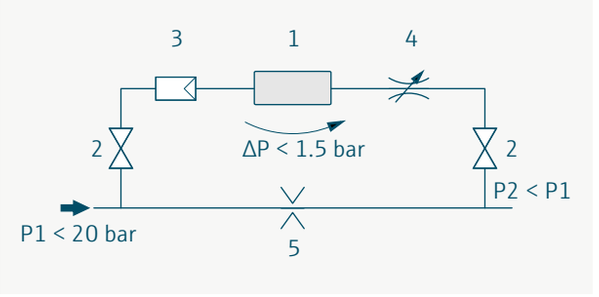
1. Remove all remaining transport packaging.

2. Remove all transportation locks on the fluidic connections.

3. Use M5 connectors (5 mm thread depth) to couple the density sensor to the pipeline at the fluidic connection. Mounting and flow direction are not relevant. Additionally, refer to the instruction manual of the used connector.



Dimensions in mm for fluidic installation



Installation example: 1 = density sensor; 2 = valve; 3 = filter; 4 = throttle; 5 = bezel

Electrical installation of density sensor

⚠ WARNING

Improper connection may result in serious injury or death

- Electrical connection work must only be carried out by correspondingly qualified specialists.
- Observe applicable national installation codes and regulations.
- Comply with local occupational safety regulations.

⚠ WARNING

No current limiting fuse

- Ensure overcurrent protection (I_{max} = 500 mA) with external wiring.

⚠ WARNING

Use in hazardous areas

The density sensor is not approved for use in hazardous areas.

- If operated in hazardous areas, ensure explosion protection.

- Connect density sensor to superior system. Note the cable occupation, see "Cable occupation" on page 10.

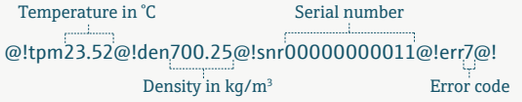
Integration of density sensor into system

The density sensor doesn't offer its own operating options. The data is read out via a serial communication in the RS232 standard. Therefore, a readout system is required. Via the data line, the density sensor transmits an output string with ASCII standard to the readout system. The units of the measured values cannot be modified.

General settings for the serial interface:

Baud rate	19200
Data bits	8
Stop bits	1
Parity bit	none (0)
FlowControl	none (0)
Transmission mode	by packet (char = 8 bit or 1 byte)

The output string can be interpreted as follows:



Output string

The output string contains an error code, which transmits the following information:

Error code	Measuring tube not oscillating	Outside density range	Outside temperature range
0			
1	x		
2		x	
3	x	x	
4			x
5	x		x
6		x	x
7	x	x	x

Switching on the density sensor

- Switch on power supply. By switching on the power supply, the density sensor starts automatically after an initialization routine.

Removing the density sensor

⚠ WARNING

Risk to personnel and environment by hazardous fluids

- Ensure that hazardous fluids to health and environment cannot leak out by removing the fluidic connection.
- Ensure that through dislocation, no residues of hazardous materials can leak out by removing the mechanical connections.

1. Disconnect the cable connections of the density sensor at the electrical connections.
2. Disconnect the fluidic connections.
3. Disconnect the mechanical connections.

Cleaning and repair

Cleaning the housing

NOTICE

Cleaning agents can damage the housing

- Do not use high-pressure steam.
- Use only approved cleaning agents.

- Approved cleaning agents:
  - Mild soap solutions
  - Methyl alcohol or isopropyl alcohol

Cleaning the micro channel

NOTICE

Risk of damaging the micro channel

- Never clean with water.
- Use only approved cleaning agents.

1. Rinse with approved cleaning agent.
   Approved cleaning agents:
   - Isopropanol (IPA), ethanol, benzine (e.g., gasoline 80 to 110), acetone and hexane
2. Then blow it out with dry air until the micro channel is completely free of cleaning agents.
3. When the density of ~ 1.2 kg/m³ is displayed, the microchannel is clean. If there is a deviation, there are still detergent residues in the microchannel.

Disposal

Disposing of the density sensor

⚠ WARNING

Danger to personnel and environment from hazardous fluids to health

- Ensure that the density sensor and all cavities are free from fluid residues, which are hazardous to health or the environment.

- Recycle components of density sensor. Observe valid national regulations.

Product specification

General

Measured variable	Density and several metries derived from them (e.g. standard density, concentration, etc.)
Permitted media	**NOTICE** **Risk of damaging the micro channel** ▶ Do not use aquerous media. ▶ Do not use helium. Particel free (<30 µm) hydrocarbons like for eg. ▪ petrol E5 / E10 / E85 ▪ diesel B7 / B10 / XTL ▪ Jet-A1 (also F-35 or JP-8) ▪ M100 (methanol) ▪ isopropanol If necessary, media that deviate from the listed may be used, after individual clarification

Measurement performance

Accuracy of measurement	▪ density: ±0,5 kg/m³ ▪ temperature: ±0,3 °C Option ▪ density: ±[0.2 or 0.01 x abs (T-25°C)] kg/m³ if the value is >0.2[3] ▪ temperature: ±0.15 or. ±[0.0075 x abs(T-25°C)] °C if the value is >0.15
Accuracy of measurement	**NOTICE** **Accuracy of density measurement depending on pressure** By default, the density sensor is calibrated to 1 bar (absolute). At a higher pressure, the density sensor shows a lower density than the actual values. The density dependency $\Delta\rho$ in case of a pressure deviation Δp is: $\Delta\rho = (0.07 \pm 0.02)\ \frac{kg}{m^3 \cdot bar} \cdot \Delta p$ ▶ Beware of pressure dependent accuracy of density measurement. ▶ If necessary, correct the pressure influence on the density value: $\rho_{Fluid} = \rho_{mess} + \Delta\rho$ ρ_{Fluid} describes the actual density at process pressure. ρ_{mess} describes the density measured by the density sensor. ▶ Order option: Calibration to desired pressure (1 to 20 bar (absolute)).
Repeatability	▪ density: ±0,25 kg/m³ ▪ temperature: ±0,1 °C Option ▪ density: ±0,1 kg/m³ ▪ temperature: ±0,05 °C

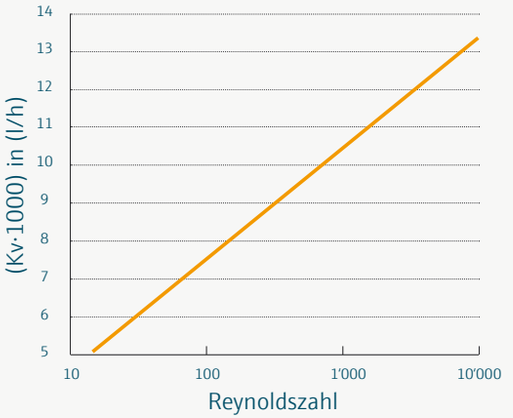
Temperature conditions

Permitted medium temperature	-20 to +60 °C
Permitted ambient temperature	-20 to +60 °C
Permitted storage temperature	-20 to +60 °C

Range of application

Permitted density measurement range	600 to 1000 kg/m³ (Option 0 to 1000 kg/m³)
Permitted viscosity range	0,3 to 50 mPa s (Option output viscosity)
Permitted process pressure range	0 to 20 bar (absolute) Bursting pressure 80 bar (abs.)
Permitted particle size	Max. 30 µm
Permitted flow range	0 to 10 l/h
Vibrations	Due to the high operating frequency of the micro channel, vibrations (<20 kHz) do not affect the measuring accuracy.
Inlet and outlet runs	Inlet and outlet runs do not affect the measuring accuracy.
	NOTICE Admissible means, that the measuring accuracy of the sensor is within the specifications.

Flow / pressure loss conditions



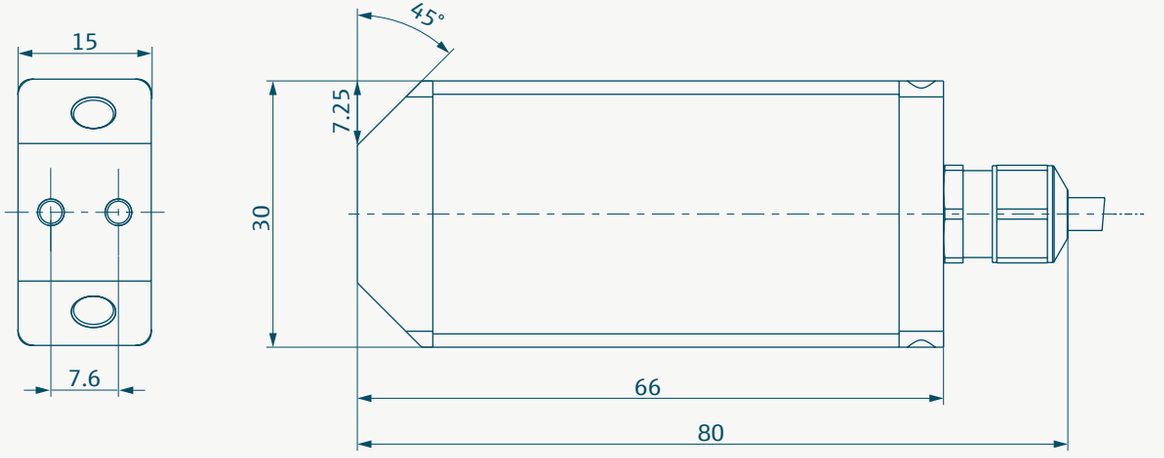
Flow condition versurs reynolds number (Kv (Re) = [1.28ln (Re) + 1.60] ± 10%)

Flow / pressure loss conditions	**NOTICE** To ensure proper operation, the flow rate (Q) 10 l/h should not be exceeded
Units	[Kv]= m^3/h, [Q]=l/h, [Δρ]=bar, [ρ]=kg/m^3, [μ]= mPa s
Determination of Flow Factor (Kv·1000 l/m^3)	The flow factor can be read using the Reynolds number (Re) via the flow / pressure loss conditions.
Determination of Re over Q, ρ and μ	$Re \cong \frac{Q \cdot \rho}{2 \cdot \mu}$

Determination of Q over Δρ	$Q = Kv \cdot 1000\ l/m^3 \sqrt{\frac{\Delta\rho}{1bar} \cdot \frac{1000\ kg/m^3}{\rho}}$
Determination of Δρ over Q	$\Delta\rho = \left(\frac{Q}{Kv \cdot 1000\ l/m^3}\right)^2 \cdot \frac{\rho}{1000}$
Calculation	If one of the required factors, such as Q, is not available, several iterations are needed

Ambient conditions

Climate class	▪ IEC/EN 60068-2-1 ▪ IEC/EN 60068-2-2 ▪ IEC/EN 60068-2-30
Electromagnetic compatibility	EMV 2014/30/EU (EN 61326-1)
Vibration and shock resistance	▪ IEC/EN 60068-2-6 ▪ IEC/EN 60068-2-27 ▪ IEC/EN 60068-2-64



Design, dimensions in mm

Materials

Housing	▪ Stainless steel: – 1.4404 (316L) – 1.4542 (AISI/SUS 630)
Medium wetted material	▪ Stainless steel: – 1.4542 (AISI/SUS 630) ▪ BOROFLOAT® 33 glass ▪ Silicon ▪ Epoxy resin

Dimensions

Dimensions density sensor	30 x 66 x 15 mm^3 (without cable and cable bushing)
Weight density sensor	<150 g
Dimensions measuring channel	160 x 200 µm (500 nl)
Housing protection	IPx4, IPx5, IPx6, IPx7 (IEC 60529)

Fluidic interfaces

Fluidic interfaces	2 x M5 threaded holes with an angle of 45° to the side and the front surface

Electrical interfaces

Cable type	Fixed installed cable
Cable length	3 m
Outer diameter of cable	2.3 mm
Diameter of cores	4 x AWG 28
Lead of gage	Digital communication line and power supply in a common shielded cable
Communication	▪ Continuous, without the need for a command from the outside ▪ Hardware standard RS232 ▪ Proprietary ASCII output string, see illustration "Output string" on page 6
Power supply	Power connection DC 5 to 12 V (max. 400 mW) via power unit with safety extra low voltage (SELV) or protective extra low voltage (PELV)
Data rate	10 Saps (Option acyclique with 100 ms response time)

Cable occupation	**wire color**	**occupation**
	white	V_{DD} (supply voltage)
	brown	GND (signal ground)
	green	RX (intput)
	yellow	RX (output)

NOTICE

The cable assignment corresponds to the view of the sensor (DLO-M1)

Certificates and approvals

CE mark	The density sensor meets the legal requirements of the EC Directives. TrueDyne Sensors AG confirms that the density sensor has been successfully tested by applying the CE mark.
RoHS	All installed components meet the requirements of the RoHS directive.
Electromagnetic compatibility	EMV 2014/30/EU (EN 61326-1)

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