Data sheet I Technical Description and Installation Instructions

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From serial number: xxx1000

DML02 | DML02_ex version:
Density sensor DLO-M2 | DLO-M2_ex

Rethink Sensing

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Notes about the data sheet

Use and safekeeping

- This data sheet is an integral component of the density sensor.
- Keep the data sheet in the immediate vicinity of the place of use.
- In case of transfer to third parties, pass on data sheet or relevant content to them.
- Read the data sheet carefully.
- We reserve the right to make changes.

⚠ WARNING

Use of the DLO-M2_ex version

This document, in conjunction with the DLO-M2_ex, is valid with the XA safety documentation only.

Function

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

Symbols used

The following symbols are used in the data sheet to draw attention to dangerous situations and to indicate instructions for action:

Symbol	Description
⚠ WARNING	Leads to death or serious injury if not avoided.
NOTICE	Information on facts that do not involve physical injury.
▶	Single-step handling instruction
1. / 2. / 3.	Multi-step handling instruction

Safety notes

Intended use

- Depending on the ordered version, the measuring instrument can also measure explosive and inflammable media.
- Measuring instruments for use in hazardous areas are specially marked on the type plate.
- The density sensor is to be used exclusively for measuring the density of fluids. Only permitted media may be used.
- Check by means of the type plate whether the ordered measuring instrument can be used for its intended purpose in the area relevant for approval (e.g. explosion protection).
- Failure to observe the area of application can impair safety. The manufacturer shall not be held liable for damage arising from improper use.

Qualification of personnel

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

Operating safety

- The owner/operator is responsible for interference-free operation of the density sensor.
- Only operate the density sensor in a technically perfect and safe operating condition.
- In case of increased medium temperature, ensure protection against accidental contact to avoid burns.
- Unauthorized modifications or repairs to the density sensor are not permitted and can lead to unforeseeable dangers.

Product safety

- The density sensor complies with the guidelines listed in the EU Declaration of Conformity. By affixing the CE mark, TrueDyne Sensors AG confirms this fact.

Product description

Overview

The density sensor was designed for measuring the density of fluids. This takes place using a microelectromechanical system (MEMS) with a microchannel shaped liked the Greek letter omega (omega chip), which is built into an internal bypass.

When the medium flows through the density sensor, the bypass arrangement generates a pressure gradient via the microchannel, which allows the medium to reach the omega chip. The medium influences the physical properties of the excited sensor (resonance frequency and quality), and these are digitized and evaluated in the microcontroller. The measured values can be read out via the serial interface (RS-485, Modbus).

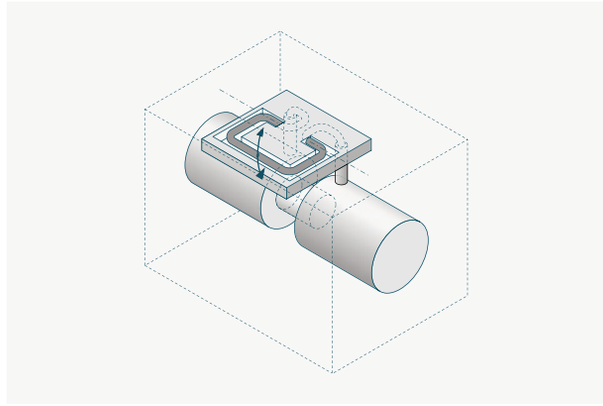
Density measurements in the range 600 to 1000 kg/m³ (further options see product specifications) can be realized at a flow rate of 0 to 10 l/h.

Omega chip

The omega chip, a vibronic microsystem, is the heart of the measuring system and is used for sensor signal generation in the overall system. An essential component of this microsystem is a silicon tube (microchannel), which is electrostatically set into oscillation in a vacuum atmosphere. To compensate for temperature effects, a platinum resistor is integrated, which allows local real-time temperature measurement. The omega chip essentially consists of crystalline silicon and glass.

Density measurement

The density sensor uses the omega chip for density measurement. For this purpose, the filled microchannel is brought to resonant oscillation and analyzed.



Measuring principle (omega chip)

The resulting natural frequency of the microchannel depends on the mass and thus on the density of the medium in the microchannel: The lower the density of the medium, the lower the natural frequency. Thus the natural 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 = natural frequency, $E \cdot I$ = stiffness of the tube, ρ_{Tube} = tube density, A_{Tube} = tube cross-section, ρ_{Fluid} = medium density, A_{Fluid} = medium cross-section

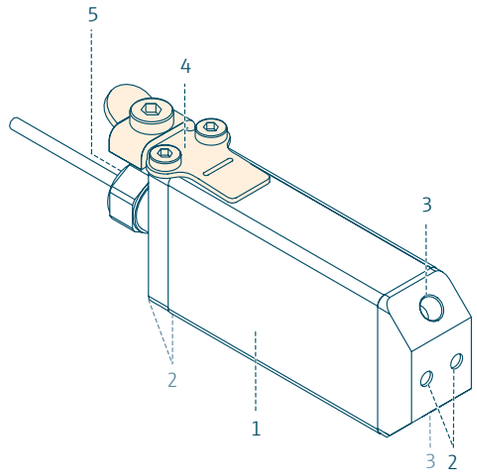
Possible applications

The density sensor can be used for direct and indirect density measurements. While a product property or quality can be determined with the direct density measurement, an indirect density measurement using tables and calculation algorithms makes it possible to determine the concentration of liquid mixtures.

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

- Addition of volumetric flow measurement in orifices, turbines or displacement devices to enable mass measurement. The density sensor takes temperature changes and (if an additional pressure sensor is connected) pressure changes into account.
- Monitoring and controlling the quality of fuel mixtures such as E10 or biodiesel.

Product design



Product design of density sensor DLO-M2 | DLO-M2_ex

1 Density sensor DLO-M2(_ex)
2 Mounting holes for mechanical fastening (6 x M3 threaded holes)
3 Fluid interface (2 x M5 threaded holes)
4 Clamp on grounding plate with screws M3×8 TORX
5 Electronic interface for communication and power supply

NOTICE

For the DLO-M2 (non-Ex), item 4 (clamp on grounding plate with screws M3×8 TORX) is not applicable. Marked orange in the graphic.

Scope of delivery

- Density sensor (including transport safety devices)

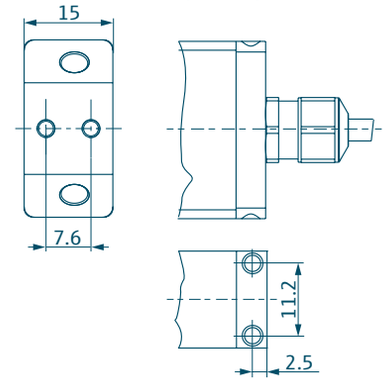
Product identification

The density sensor is identified by a consecutive, eleven-digit serial number. This is installed on the outside of the housing and can also be viewed via Modbus.

Installation, start-up and uninstallation

Fastening the density sensor mechanically

- ▶ Fix the density sensor with M3 screws using the provided mounting holes (4 mm depth). Maximal tightening torque 30 cNm (typically 15 to 20 cNm)



Dimensions in mm for mechanical fastening

Making the fluid connections for the density sensor

- With a flow rate >10 l/h, installation in a bypass line is recommended to limit the flow rate through the density sensor to <10 l/h.
- The bypass line can be led to a collecting tank or back to the main line.

⚠ WARNING

Danger of injury due to dangerous process conditions and pipe break

- ▶ Empty and depressurize the pipeline before installing the density sensor.
- ▶ Take high temperatures into account.
- ▶ If necessary, fasten the density sensor mechanically.

NOTICE

Clogging of the microchannel

- ▶ If necessary, install a filter upstream of the density sensor to prevent the microchannel from clogging.

NOTICE

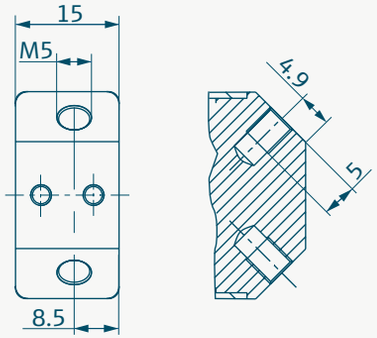
Delayed measurement signal for installation in bypass

- ▶ Note the time delay, for example for open-loop process control.

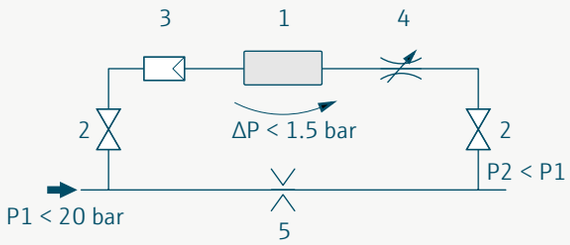
1. Remove all remaining packaging materials.

2. Remove transportation safety devices on fluid connections.

3. Install the density sensor at fluid connections with M5 connectors (thread depth 5 mm) in the pipeline, whereby flow and installation direction are not relevant. Also follow the instructions in the operating manual of the connector used.



Dimensions in mm for fluid installation



Installation example: 1 = Density sensor; 2 = Valve; 3 = Filter; 4 = Flow restrictor; 5 = Orifice

Making the electrical connections for the density sensor

⚠ WARNING

Death or severe injury due to incorrect connection

- Electrical connection work may be carried out by correspondingly trained specialist personnel only.
- Observe installation codes and requirements valid in the respective country.
- Comply with local occupational safety requirements.

⚠ WARNING

No current-limiting fuse

- Ensure overcurrent protection (I_{max} = 500 mA) through external circuit.

⚠ WARNING

Use in areas with an explosion hazard

The density sensor DLO-M2 has no approval for use in hazardous areas.

- When operating in areas with an explosion hazard, ensure explosion protection.

- Connect the density sensor to the higher-level system. In doing so, note the cable assignment, see „Kabelbelegung“ auf Seite 12.

NOTICE

RS-485 point-to-point connection

- The DLO-M2_ex variant is designed for an RS-485 point-to-point connection.
- On the client side, a 330 Ω terminating resistor must be inserted between the RS-485 lines (D0 and D1).

The serial interface is based on the "MODBUS over serial line" specification.

Integrating the density sensor into the system

The density sensor sends the measured data to the readout system via the data line in Modbus RTU transmission mode. General settings of the serial Modbus RTU interface:

NOTICE

- Modbus RTU protocol implemented in accordance with Specification V1.1b3
- Modbus registers refer to the start value 0
- For the sensor, the typical response time is 10 to 20 ms

Default settings:

Baud rate	19200 BAUD
Data bits	8
Parity	Even
Byte order	1-0-3-2
Stop bits	1 bit
Modbus address	247
FlowControl	None (0)
Transmission type	Modbus RTU (protocol)
Temperature unit	°C
Pressure unit	bar

Density unit	kg/m³
Reference temperature unit	°C
Reference temperature	15 [°C]
Reference pressure unit	bar
Reference pressure	1.01325 [bar]
Concentration min	0 [%]
Concentration max	100 [%]

The following Modbus RTU functions are supported:

Code	Name	Description
0x01	Read Coils	Read one or more coils
0x03	Read Holding Registers	Read a consecutive holding register block
0x04	Read Input Registers	Read one or more successive registers
0x05	Write Single Coil	Write one coil
0x06	Write single register	Write one single register
0x0F	Write Multiple Coils	Write multiple successive coils
0x10	Write Multiple Registers	Write multiple successive registers

NOTICE

The following Modbus RTU functions are not supported

- 0x02 Read Discrete Inputs
- 0x07 Read Exception Status
- 0x08 Diagnostics
- 0x0B Get Comm Event Counter
- 0x0C Get Comm Event Log

Modbus RTU register information with read/write access:

Name	Address	Data type	Selection/ input
Baud rate	4912	UINT8	3: 9600 4: 19200 5: 38400 6: 57600 7: 115200
Parity	4914	UINT8	0: None / 2 stop bits 1: Even / 1 stop bit 2: Odd / 1 stop bit 3: None / 1 stop bit
Byte order	4915	UINT8	0 = 0-1-2-3 1 = 3-2-1-0 2 = 2-3-0-1 3 = 1-0-3-2
Modbus address	4910	UINT8	1 - 247
Device tag	4901	STRING16	
Temperature unit	2109	UINT8	0: °C 1: K 2: °F 3: °R
Pressure value	5185	FLOAT32	
Pressure unit	2130	UINT8	0: bar abs 1: bar gauge 2: psi abs 3: psi gauge 4: kPa abs 5: kPa gauge
Density unit	2107	UINT8	0: g/cm³ = g/cc 1: Reserved 2: kg/l = g/cm³ 3: kg/m³ 4: lb/ft³ 5: lb/gal 6: Reserved 7: Specific gravity
Enter access code	2177	UINT16	

NOTICE

Specific gravity (SG) is calculated with the current temperature.

$$SG = \frac{\rho_{medium}(T)}{\rho_{water}(T)}$$

Modbus RTU register information with read access:

Name	Address	Data type	Selection/ input
Density	2013	FLOAT32	

Concentration	2598	FLOAT32	
Temperature	2017	FLOAT32	
Pressure	2089	FLOAT32	
Memory version	100	UINT8	
Serial number	101	STRING14	
Software version	108	UINT16	
Software build	109	UINT16	
Device identity	1	UINT16	
Software Version (string)	1021	STRING6	
Access rights operating software	2178	UINT8	0: Operator 1: Administrator

NOTICE

The density sensor does not have a pressure sensor.

Switching on the density sensor

- Switch on the power supply. After the power supply is switched on, the density sensor starts automatically after an initialization routine.

Uninstalling the density sensor

⚠ WARNING

Danger to personnel and environment from media that are hazardous to health

- Ensure that no media hazardous to health or the environment can escape when loosening the fluid connection.
- Ensure that no residues of hazardous substances can escape from the density sensor when the mechanical fastenings are loosened by changing their position.

1. Disconnect the cable connections of the electrical connections from the density sensor.
2. Disconnect the fluid connections.
3. Undo the mechanical fastening.

Cleaning and repair

Carrying out cleaning of the housing

NOTICE

Cleaning agents may cause damage to the housing

- Do not use high-pressure steam.
- Use only permitted cleaning agents.
- Permitted cleaning agents:
  - Mild soap solutions
  - Methyl or isopropyl alcohol
  - Water

Carrying out cleaning of the microchannel

NOTICE

Damage to the microchannel possible

- Use only permitted cleaning agents.

1. Flush with permitted cleaning agents.
   Permitted cleaning agents:
   - isopropanol (IPA), ethanol, petroleum ether (e.g. petroleum 80 to 110), acetone and hexane
2. Then, flush with dry air until there is no more cleaning agent in the microchannel.
3. Fill the density sensor with fluid with a known density value. Deviations from the nominal density value that are greater than the specified maximum measuring deviation indicate residues in the microchannel.

Disposal

Disposing of the density sensor

⚠ WARNING

Danger to personnel and environment from media that are hazardous to health

- Ensure that the density sensor and all cavities are free of any residues of the measuring medium that are hazardous to health or the environment.
- Send density sensor components for recycling. Observe codes and requirements valid in the respective country.

Product specification

General

Measured variable

Density and variables derived from it (e.g. standard density, concentration, etc.)

Permitted media

NOTICE

Damage to the microchannel possible.

- ▶ Do not use helium.

Particle-free (<30 µm) hydrocarbons e.g.

- Gasoline E5 / E10 / E85
- Diesel B7 / B10 / XTL
- Jet-A1 (also F-35 or JP-8)
- M100 (methanol)
- Isopropanol
- OME* (synthetic fuel)
- LPG*

Aqueous media such as:

- AdBlue®*
- Glycol blends*

Additional media can be used after individual clarification where applicable. *Optional

Measurement performance

Max. measurement deviation

- Density: ±0.5 kg/m³
- Temperature: ±0.3 °C

Option

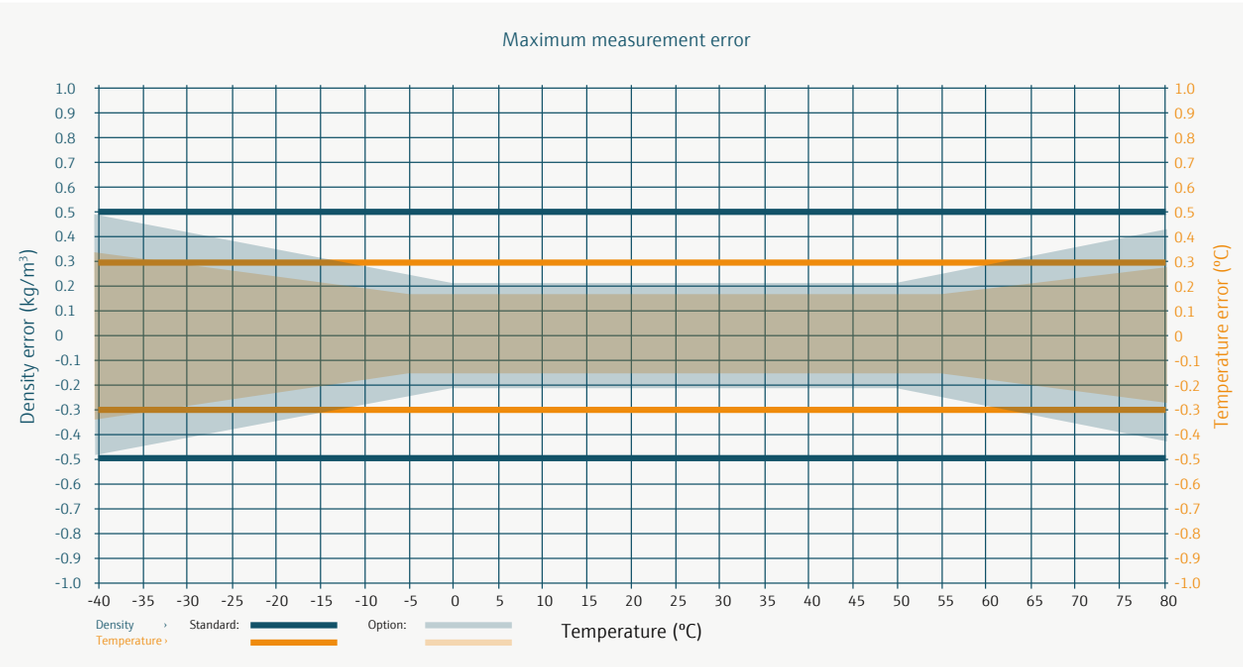
- Density: ±0.2 or ±[0.0075 x abs(T-25°C)] °C if the value is >0.2
- Temperature: ±0.15 or ±[0.005 x abs(T-25°C)] °C if the value is >0.15

NOTICE

Pressure-dependent density measurement accuracy

The density sensor is calibrated to 1 bar (abs) by default. At higher pressure the density sensor indicates a density that is too low. At pressure change Δp, the density deviation is Δp:

$$\Delta\rho = (0.07 \pm 0.02)\ \frac{\text{kg}}{\text{m}^3 \cdot \text{bar}} \cdot \Delta p$$



Max. measurement deviation: Density and temperature

- Note pressure-dependent density measurement accuracy.
- If necessary, correct the measured density value due to the influence of pressure:

  $\rho_{Fluid} = \rho_{mess} + \Delta\rho$

  Here, ρ_{Fluid} is the actual density at process pressure and ρ_{meas} is the density measured by the density sensor.
- Order option: Calibration to desired pressure (1 to 20 bar (abs)).

Repeatability	▪ Density: ±0.1 kg/m³ ▪ Temperature: ±0.05 °C

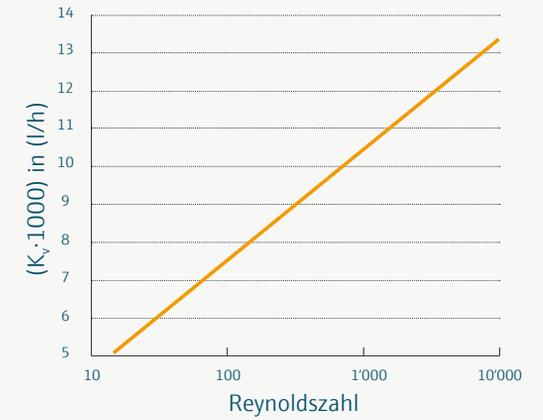
Temperature conditions

Permitted medium temperature	-40 to +60 °C
Permitted ambient temperature	-40 to +60 °C
Permitted storage temperature	-40 to +60 °C

Area of application

Permitted measured density value	600 to 1000 kg/m³ (Optionally 0 to 1200 kg/m³)
Permitted viscosity range	0.3 to 5 mPa s (Optionally 0.3 to 50 mPa s)
Permitted medium density	0 to 20 bar (abs) Burst pressure 80 bar (abs)
Permitted particle size	Max. 30 µm
Permitted flow range	0 to 10 l/h
Vibrations	Vibrations (<20 kHz) have no influence on the measuring accuracy due to the high working frequency of the microchannel.
Inlet and outlet runs	Inlet and outlet runs have no influence on the measuring accuracy.
	NOTICE Permissible means that the measuring accuracy of the sensor is within the given specifications.
Flow/pressure loss conditions	**NOTICE** To ensure proper operation, the flow rate (Q) must not exceed 10 l/h.
Units	$[K_v]$= m³/h, $[Q]$=l/h, $[\Delta p]$=bar, $[\rho]$=kg/m³, $[\eta]$= mPa s

Flow/pressure loss conditions



Flow factor versus Reynolds number (K_v (Re) = [1.28ln (Re) + 1.60] ± 10%)

Determining the flow factor (K_v·1000 l/m³)	The flow factor can be read by means of the Reynolds number (*Re*) via the Fig. Flow / pressure loss conditions.
Determination of *Re* via *Q*, *ρ* and *η*	$Re \cong \frac{Q \cdot \rho}{2 \cdot \eta}$
Determination of *Q* via *Δp*	$Q = K_v \cdot 1000\ l/m^3 \sqrt{\frac{\Delta p}{1\ bar} \cdot \frac{1000\ kg/m^3}{\rho}}$
Determination of *Δp* via *Q*	$\Delta p = \left(\frac{Q}{K_v \cdot 1000\ l/m^3}\right)^2 \cdot \frac{\rho}{1000}$

Calculation	If one of the needed factors such as *Q* is not available, several iteration steps are needed.
Response time	▪ The density is recorded with a measuring rate of at least 30 Hz. As a result of internal processing and filtering, the maximum group delay is 1 s. ▪ The temperature is recorded with a measuring rate of 2 Hz. As a result of internal processing and filtering, the maximum group delay is 2.5 s.

Ambient conditions

Climate class	Not yet defined
Electromagnetic compatibility	EMC 2014/30/EU (EN 61326-1)
Vibration and shock resistance	Not yet defined
Protection class	IP54 (IEC 60529)

Materials

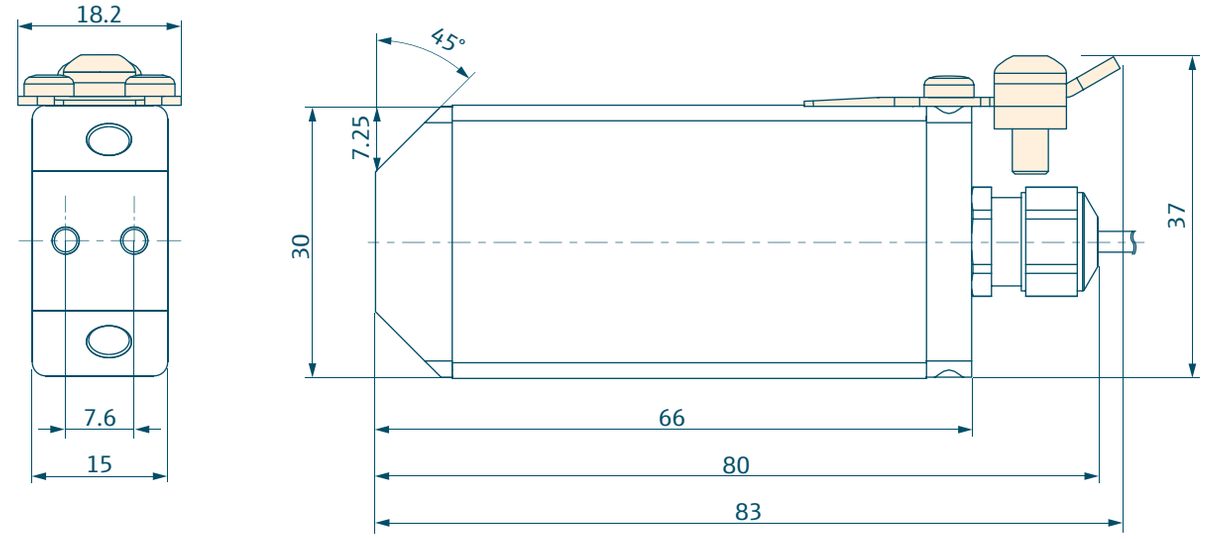
Housing	▪ Stainless steel: – 1.4404 (316L) – 1.4542 (AISI/SUS 630)
Wetted parts	▪ Stainless steel: – 1.4542 (AISI/SUS 630) ▪ BOROFLOAT® 33 glass ▪ Silicon ▪ Epoxy resin

Dimensions

Dimensions	30 x 66 x 15 mm³ (without cable, cable gland and connection for protective ground)
Weight	<200 g
Dimensions of measurement channel	160 x 200 µm (500 nl)

Fluid interface

Fluid interfaces	2 x M5 threaded holes at a 45° angle to the side and front surface



Design, dimensions in mm
(orange range valid only for DLO-M2_ex)

Electrical interface

Cable design	Permanently installed cable. Connecting cable type KS-Li-9YD11Y 4xAWG 28, manufacturer: Kabel Sterner
Cable length	3 m (optionally up to 30 m)
Cable outer diameter	2.3 mm
Wire diameter	4 x AWG 28

Level control	Digital communication lines and power supply in one common shielded cable ▪ Unidirectional, RS-485 **NOTICE** For the variant DLO-M2_ex ▸ Provide a 330 Ω termination resistor on the client side (see Page 6) For the variant DLO-M2 ▸ For the non-Ex variant, a terminating resistor of 150 Ω is recommended

Energy supply	Maximum current draw 26 mA, maximum power consumption 350 mW. **NOTICE** For the variant DLO-M2_ex ▸ Supply: 9.4 V to 13.3 V (typical: 12 V) **⚠ WARNING** **For DLO-M2_ex XA, observe safety notes** ▸ Zener barriers (supply and RS485)
Dielectric strength (continued)	The reference potential (GND) is connected to the housing and the ground connection (see product design). There is no galvanic isolation between the supply circuits, the communication interface and GND.

Cable assignment

Wire color	Assignment
yellow	RS485 B, D1
green	RS485 A, D0
brown	GND (signal ground), common
white	V_{DD} (supply voltage)

Certificates and approvals

CE marking	The density sensor meets the legal requirements of the EC directives. TrueDyne Sensors AG confirms the successful testing of the density sensor with the attachment of the CE mark.
IECEX, ATEX	**⚠ WARNING** Applies for the DLO-M2_ex version

Depending on the version, the product complies with the following directives:

		DLO-M2	DLO-M2_ex
ATEX	2014/34/EU(L96/309)		✔
LVD	2014/35/EU(L96/357)	✔	✔
EMC	2014/30/EU (L96/79)	✔	✔
RoHS	2011/65/EU(L174/88)	✔	✔

The following standards are complied with:

	DLO-M2	DLO-M2_ex
EN 61010-1: 2010	✔	✔
EN IEC 60079-0: 2019		✔
EN 60079-11: 2012		✔
EN 61326-1: 2013	✔	✔
EN 61326-2-3: 2013	✔	✔
EN 50581: 2012	✔	✔

Legal restrictions

Fields of industry

The density sensor cannot be used in the following fields of industry for legal reasons:

- Military (any applications in the military field whatsoever, including airplanes, vehicles or military structures. This does not include fuel delivery and fuel dispensing when refueling on the ground)
- Aerospace (applications in flying objects of any kind. Excluded from this is fuel delivery and fuel dispensing when refueling on the ground)
- Fuel cells (use in stationary or mobile fuel cells)
- Medical devices (objects or substances used for medical purposes for human beings - the pharmaceutical industry is not affected)

Download area

On our website www.truedyne.com you will find this document and other useful documents in our download area.

https://www.truedyne.com/dlo-m2_ex_download_en

Documents and files

Product information

- Data sheet
- Safety notes
- Data sheet
- STEP file
- Calibration certificate (optional)

Declarations of conformity

- CE marking EU declaration of conformity
- RoHS III EU declaration of conformity

Training courses

- Basics of density measurement training

Website

Are you looking for more innovative sensors for density and viscosity? Visit our website www.truedyne.com and learn more about our current product portfolio

Product portfolio

Sensors for measuring fluids

For example:

- DLO-M1 density sensor
- VLO-M1 viscosity and density sensor

Sensors for measuring gases

- DGF-I1 density sensor
- Nanomass density sensor

- www.truedyne.com

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