JUMO

Liquid level measurement

PR 40023 EN

JUMO – your partner for liquid level measurement

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Tradition meets unlimited possibilities

With an increasingly dynamic market, progressing globalization and the associated competitive and cost pressure, complete uniform solution concepts with synergistic effects are becoming increasingly important.

To meet our customers' needs and respond to their innovative tasks, JUMO offers a complete portfolio covering every step of the measurement chain. In addition to a wide range of sensors for recording various measurement variables such as pressure, temperature, and pH, we also offer a large selection of transmitters and display, evaluation and control instruments. Comprehensive customer service rounds out our range of services.

JUMO also offers complete uniform solution concepts for pressure and liquid level measuring instruments.

Sophisticated technologies have been setting standards in pressure and hydrostatic liquid level measuring technology for more than 30 years. The knowledge and experience of more than 1650 employees. JUMO has the production flexibility thanks to our great manufacturing depth. We expect the highest standards of quality, implemented with our own sensor manufacturing and modern production lines.

To consolidate and expand our quality standards, measuring instruments are subject to extensive tests in our own test lab.

Hydrostatic pressure as described in this brochure can be measured with conventional level probes featuring a design with numerous options developed for relevant applications.

Precise technical descriptions of our measuring instruments can be found on the Internet under the specified type number at www.jumo.net.

Contents

"... because the whole is more than the sum of the parts."

(Aristoteles)

Chapter I:

The first chapter covers the basic principles of hydrostatic liquid level measurements. The principle of the relevant measurement technology is also discussed.

Chapter II:

The second chapter provides an overview of technical features as well as information about applications. This is useful when selecting the right product for an application.

Chapter III:

The third chapter rounds out the complete uniform product range of liquid level measurement with accessories and supplementary products.

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General information

General operating conditions

Level probes are used for hydrostatic liquid level measurement of ventilated tanks or to determine level in open waters. If the liquid level measurement includes superimposed pressure measurement in closed tanks this can be implemented with differential pressure transmitters such as the JUMO dTRANS p20 DELTA (type 403022) or JUMO MIDAS DP 10 (type 401050).
If the measurement is performed externally, for example for hygienic reasons, the JUMO dTRANS p30 (type 404366) or the JUMO dTRANS p20 (type 403025) can be used.

Hydrostatic liquid level measurement

Hydrostatic pressure in a liquid is produced by the force of the weight of the column of liquid above an immersed object (unit of measure: meters of water column).
Pressure increases as the depth increases regardless of direction. A column of water 10 meters in depth (mWC) corresponds to 0.98 bar (approximately 1 bar).
The hydrostatic pressure is derived from the conditions of equilibrium of forces with the weight. It is calculated based on the ambient pressure, the density of the liquid and liquid level.

Piezoresistive silicon sensor

Once the level probe reaches the immersion depth, the hydrostatic pressure acts on its stainless steel separating diaphragm. This pressure is transferred via filling oil to the sensor with a resistance measuring bridge. The modified mobility of electrons in the silicon crystal structure of the sensor results in a measurable change in resistance (piezoresistive effect).
Specially adapted compensation and amplifier electronics converts this delta into electrical output signals, which in turn provide a direct measure of the level when the density of the liquid is known.
Small dimensional parts and parts in contact with medium made of stainless steel ensure suitability for numerous applications.

Capacitive ceramic sensor

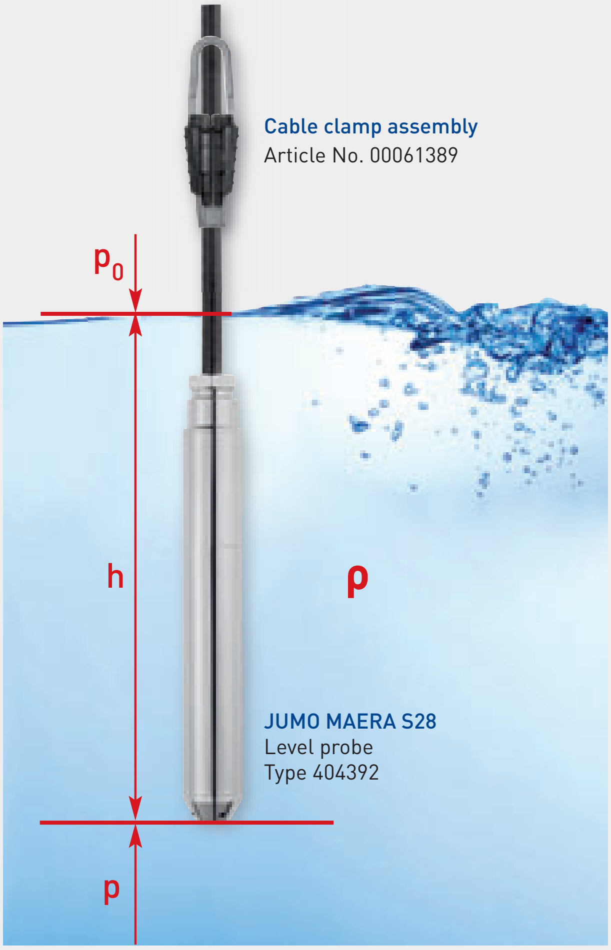
In electrical terms, the ceramic-capacitive pressure measurement represents a plate capacitor with two highly resistant ceramic plates (AL_2O_3) that are isolated from each other. The change in capacitance is a measure of the change in pressure and thereby of the level. Using AL_2O_3 makes it possible to achieve a highly precise measurement through linear deflection.
Capacitive ceramic sensors are used when there are high requirements for corrosion resistance or when separating diaphragms are exposed to high mechanical loads. They can provide almost 80 times the overload protection.

Calculation: Hydrostatic pressure

$p = p_0 + \rho \times g \times h$

Gravitational acceleration: **g = 9,81 m/s²**

This formula applies to liquids at rest in containers or open water.



Ambient pressure: $p_0 = 0$ for relative pressure measurement

Density of the liquid: ρ

Level: h

Overview of level probe products

+ Suitable
– Unsuitable

Application	External assembly[1]	–	–	+	+	+
	Internal assembly[1]	+	+	+	+	+
	ATEX	–	–	–	–	+
	Integrated over-voltage protection	–	–	–	+	–
	Temperature sensor Pt100 (optional)	–	–	+	+	–
	Aggressive media (for example plating baths, acids)	–	–	+	+	+
	Medium: Spring water, well water or rainwater[1]	+	+	–	+	–
	Medium: Wastewater[1]	–	–	+	+	+
	Medium: Heating oil[1]	+	+	–	–	–
	Medium: Swimming pool water (disinfectant Chlor)[1]	–	+	–	+	–
Type	Data sheet	40.1015	40.2090	40.4391	40.4392	40.4753
	Designation	**JUMO MAERA S25**	**JUMO MAERA S26**	**JUMO MAERA F27**	**JUMO MAERA S28**	**JUMO dTRANS p33**
Technical data	Measuring range	0.25 to 1 bar	0.25 to 6 bar	0.05 to 1.6 bar	0.25 to 25 bar	0.25 to 600 bar
	Mediumtemperature	0 to 50 °C	0 to 50 °C	–20 to +60 °C	0 to 50 °C	–40 to + 70 °C
	Sensors	Piezoresistive silicon sensor	Piezoresistive silicon sensor	Capacitive ceramic sensor	Piezoresistive silicon sensor	Piezoresistive silicon sensor
	Accuracy Linearity as a % of final value (FV)	±0.3 %	±0.2 % (> 2.5 bar), ±0.3 % (≤ 2.5 bar)	±0.2 %	±0,2 % (> 2,5 bar), ±0,3 % (≤ 2,5 bar)	±0,5 %
	Overall accuracy at 20 °C as a % of final value (FV)[2]	±0.5 %	±0.3 % (>2.5 bar), ±0.5 % (≤ 2.5 bar)	±0.4%	±0,3 % (>2,5 bar), ±0,5 % (≤ 2,5 bar)	±0,6%
	Overall accuracy at 0 to 50 °C as a % of the final value(FS)[2]	±1.0 %	±0.8 % (≥ 4.0 bar), ±1.1 % (> 0.6 bar / ≤ 2.5 bar), ±1.3 % (= 0.6 bar), ±1.6 % (≤ 0.4 bar)	±0.6 % (> 0.6 bar), ±1.3 % (≤ 0.6 bar)	±0.8 % (≥ 4.0 bar), ±1.1 % (> 0.6 bar / ≤ 2.5 bar), ±1.3 % (= 0.6 bar), ±1.6 % (≤ 0.4 bar)	±1.0 % (> 0.4 bar), ±1.3 % (≤ 0.4 bar)
	Output signals	4 to 20 mA (2-wire), 0 to 10 V (3-wire)	0 to 20 mA (3-wire), 4 to 20 mA (2-wire or 3-wire), 0.5 to 4.5 V (3-wire), 0 to 10 V (3-wire), 1 to 5.0 V (3-wire), 1 to 6.0 V (3-wire)	4 to 20 mA (2-wire), 0.5 to 4.5 V (3-wire)	4 to 20 mA (2-wire)	4 to 20 mA (2-wire)

[1] These recommendations are based on many years of experience. Deviations are possible in some cases. We would be happy to provide you with additional information or details of other applications.

[2] Includes: linearity, hysteresis, repeatability, deviation from initial (zero point) and measuring span.

Information about selecting products

Information about selecting the measurement range

The selection of a relative pressure measuring range depends on the maximum column of liquid to be measured as well as the density and temperature of the liquid.

Effect of density on the liquid level

The density of a liquid depends on the temperature. These dependencies are presented in a system of tables. According to these tables, the density of water at 5 °C is 999.964 kg/m³. After being heated to 30 °C the density drops to 995.645 kg/m³. Thus the temperature-dependent density has an effect on the accuracy of the liquid level measurement and thereby on the level.

Example

A cylindrical rainwater cistern with cold water at 10 °C has a height of 2.20 m The integrated overflow is located at a height of 2.00 m, thus corresponding to the maximum column of liquid.
The diagram of the side represents the relationship between temperature and density for liquid water. At a temperature of 10 °C, the density of water is 999.699 kg/m³. The maximum hydrostatic pressure acting on the separating diaphragm is expressed by the formula:

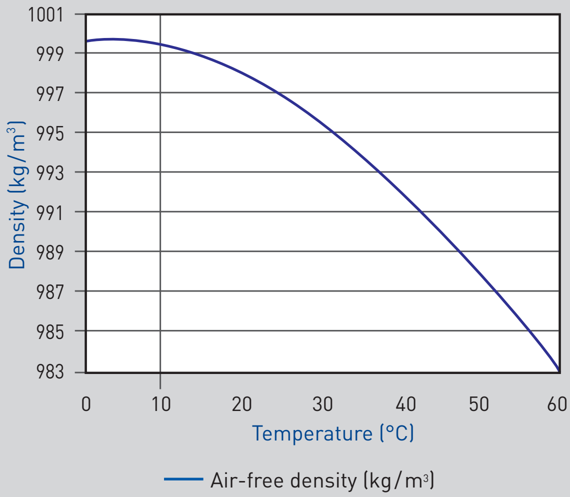
$$p = p_0 + \rho \times g \times h$$

Taking into consideration the relative pressure $p_0 = 0$, the following result is obtained:

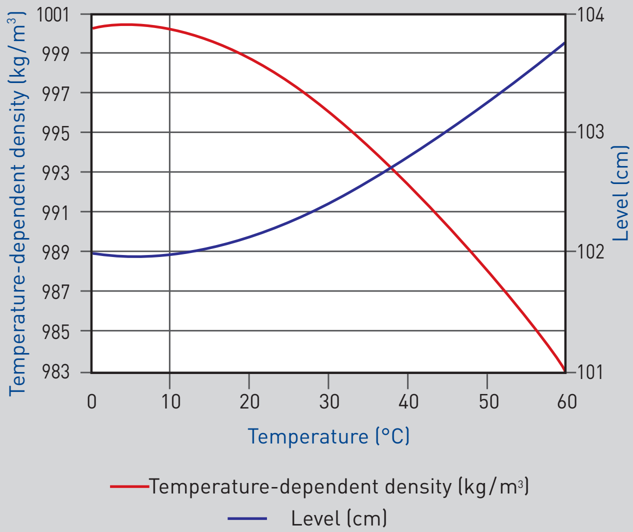
$$p = \rho \times g \times h$$
$$p = 999.699\ kg/m^3 \times 9.81\ m/s^2 \times 2\ m$$
$$p = 19614\ kg/(m \times s^2) = 19614\ Pa = 196.14\ mbar$$

For use in a rainwater cistern we recommend the JUMO MAERA S25 level probe with a polyethylene protective tube. At a maximum hydrostatic pressure of 196.14 mbar the standard measurement range of 250 mbar can be used.

Temperature-dependent density (kg/m³) based on the example of water



Level at 100 mbar taking into consideration the temperature-dependent density, based on the example of water



Information about selecting products

Process connection

The process connection system should be selected based on the liquid and substrate of the probe.
A closed connection protects the diaphragm from damage. On the other hand, an open system offers advantages for contaminated or high-viscosity media or if there is a danger of deposits. A process connection with an inner thread can be used to fasten the level probe onto the base of the tank.

Cable

With the exception of the JUMO MAERA S25 (type 401015) and the PE-EX cable, any cable can be provided with any level probe. Pressure compensation is implemented by an integrated polyamide pressure compensation hose which is impenetrable to moisture.

+ Suitable
– Unsuitable

For JUMO dTRANS p33 only
Type 404753

Type	Cable designation	PE-EX	PUR	PE	C-PE
Type	JUMO order details	13	14	15	19
Gen.	Long-term temperature range[1]	−40 to +70 °C	−40 to +70 °C	−40 to +70 °C	−40 to +70 °C
Gen.	UV resistance	–	per DIN ISO 4892-2	–	per DIN ISO 4892-2
Application	Wastewater	+	+	–	+[2]
Application	Well water, mine water	–	+	+	–
Application	Gray water, domestic waste water, feces	–	–	–	+[2]
Application	Swimming pool water Disinfectant: Chlorine	+	–	+	–
Application	Brine	–	+	+	–
Application	Diesel oil	+[2]	–	–	+[2]
Application	Heating oil (derived from lignite and oil)	+[2]	–	–	+[2]
Application	Mineral oil (test liquid IRM902)	–	–	–	+[4]
Application	Heavy oils	–	–	–	+[2]
Application	Greases	–	+	–	–
Application	Coolants and lubricants	+	+	–	–
Application	Industrial liquids with acids and bases	–	–	–	+[2]
Application	Bioethanol	–	–	–	+[2]
Application	Ethanol ET85	+[2]	–	–	–
Application	Fuels (test liquid IRM903)	–	–	–	+[3]

[1] A restriction may be required depending on the medium, [2] to 30 °C, [3] to 70 °C, [4] to 100 °C

Evaluation information

As explained in the "Information about selecting products," density is dependent on temperature. It thus affects the selection of a measurement range and accordingly the resulting level.

Example

The hydrostatic pressure acting on the level probe in a cylindrical tank is 100 mbar relative pressure. The tank filled with cold water at 5 °C has a density of $\rho = 999.964\,kg/m^3$. The hydrostatic pressure is expressed by:

$$p = p_0 + \rho \times g \times h$$

Solving the formula for h, the level, and taking into account the relative pressure ($p_0 = 0$) the following equation is obtained:

$$h = p/(\rho \times g)$$

And with conformity to SI:

$$100\,mbar = 10000\,Pa = 10000\,kg/(m \times s^2)$$

the formula for the level h is:

$$h = 10000\,kg/(m \times s^2)/(999.964\,kg/m^3 \times 9.81\,m/s^2)$$
$$h = 1.01\,m = 101.94\,cm$$

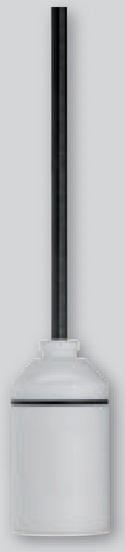
Assuming that the water is heated to 30 °C and then has a density of $995.645\,kg/m^3$, the level would be 102.38 cm. The difference in temperature causes an effect of 0.89cm in the medium level. The digital indicator, JUMO di308 [type 701550], can be used to calculate this effect.
Two functions referred to as math channels can be entered in this instrument. A channel can be used to determine the temperature-dependent density by means of the quadratic function.
The temperature is recorded by an integrated temperature sensor as in the JUMO MAERA F27 and JUMO MAERA S28 or it can be taken by an additional temperature sensor.
The second channel then calculates the level taking into consideration the result of channel 1.
If there are known measured value pairs, customer-specific linearization can also be included. It interpolates a graph to determine levels by a saved assignment of measured values to display values.

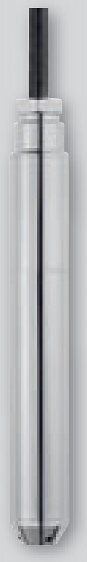
Technical descriptions can be downloaded under the specified type number from www.jumo.net.

JUMO di 308
Digital indicator, integrated 2-wire power supply for level probes, RS interface,
10 measured value pairs, math function
(2 channels, optional)
Type 701550

JUMO MAERA F27
Level probe with temperature probes Pt 100 (optional)
Type 404391

JUMO MAERA S28
Level probe with temperature probes Pt 100 (optional)
Type 404392





Application: Run-of-the-river hydroelectric power plant

JUMO MAERA S28
Level probe
Type 404392

Application

Energy has been derived from flowing water for centuries. Before the days of electrical power, mills not only powered local industries, but also inspired many songs and poems. Today run-of-the-river hydroelectric power plants are used in applications with large volumes of water with comparatively little difference in height, for example in rivers and ocean straits.

In this system a river is dammed and water is directed at the turbine (for example a Kaplan turbine) at low pressure as it flows out. The turbine is protected by an upstream raked bar screen cleaning device.

The difference determined between the level before and after raking is an indicator of the degree of contamination, which in turn can be used to control the cleaning process. A greater degree of contamination is present when the upper water level drops slowly behind the raking. After cleaning it is the same again as the level before raking.

The purpose of the run-of-the-river hydroelectric power plant is to derive electrical energy from kinetic energy by means of a generator from a variable flow of water with a differing drop height with optimum efficiency. To do this the position of the guide blades on the distributor and the position of the impeller blades must be coordinated to achieve the best possible efficiency.

When the system is placed in operation the guide blades and impeller blades are adjusted incrementally and the results are recorded in propeller curves and selectively compared in terms of turbine output, drop height (difference between upper and lower water level), and the flow of water.

The result is operational control with optimized efficiency.

Applications

Rake control

- Upper water level before raking
- Lower water level after raking

Run-of-the-river hydroelectric power plant

- Upper water level
- Lower water level

Solution

Under the motto "All for one and one for all," the JUMO MAERA S28 level probe represents the ideal solution for all applications. Levels can be calculated to an accuracy within 0.2 % of the final value. Assembly outdoors is possible due to the sturdy design and choice of materials, but use of a sounding pipe should be considered due to external influences. Based on outside assembly, overvoltage protection is integrated to protect the level measuring probe in case of indirect lightning strike.

Technical descriptions can be downloaded under the specified type number from www.jumo.net.

Accessories

Terminal box with pressure compensation element

The terminal box ensures secure installation of the probe cables. The end of the pressure compensation tube is always protected from deposits and condensate (IP65). The remaining distribution can be performed with a cable, without a pressure compensation hose.

Screw plug

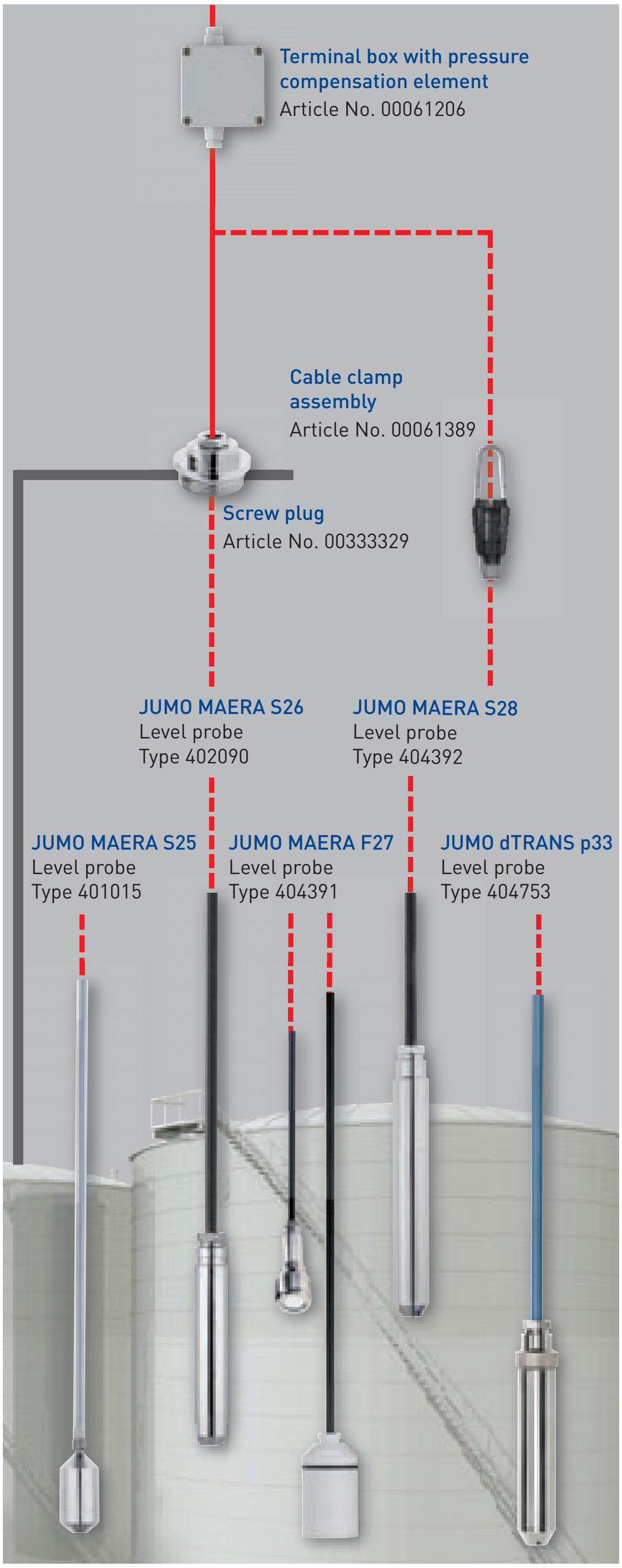
For closed containers or wells with a well head, the cable should be led through and fastened by a screw plug.

Cable clamp assembly

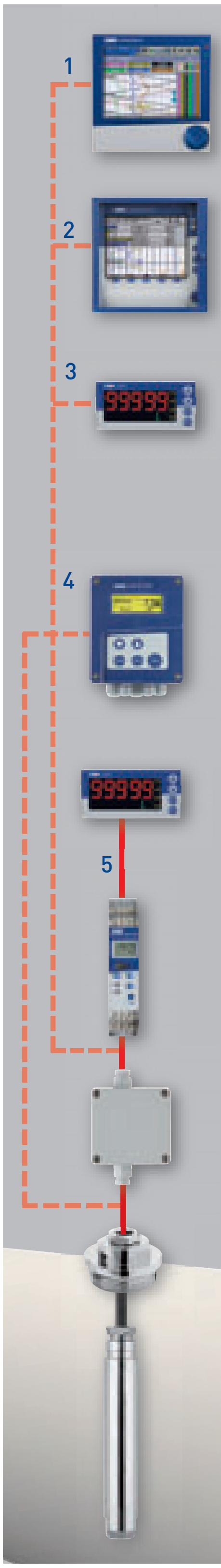
The cable helps to immerse the probe in the liquid. When making the connection for fastening, make certain the cable is not deformed. A compatible cable clamp assembly with a clamping range from 5.5 to 10.5 mm and a maximum tension load of 2.5 kN will prevent such occurrences. Consisting of clamping jaws and guide chambers and made of fiberglass-reinforced polyamide, it is available in a hot-dip galvanized version or in stainless steel.

Hose endpiece

The hose endpiece is designed for use with the JUMO MAERA S25 level probe. To optimize cost, the standard line is encased in a protective tube. The hose endpiece prevents the protective tube which serves to compensate pressure from being pinched off or otherwise damaged when it is guided through a wall. The hose endpiece may be guided through a wall for example for use with stonework or brickwork, for clamping/compression ring connections into a tank or for cable glands in a control cabinet.



Application: Heating oil tank



JUMO LOGOSCREEN nt
Paperless recorder with TFT display and CompactFlash® card, USB, RS and Ethernet interface as well as math function (18 channels, optional)
Type 706581

JUMO LOGOSCREEN 500 cf
Paperless recorder with storage medium, CompactFlash® Card, lifecycle data management, RS and Ethernet interface as well as math function (6 channels, optional)
Type 706510

JUMO di 308
Digital indicator, integrated 2-wire power supply for level probes, RS interface, 10 measured value pairs, math function (2 channels, optional)
Type 701550

JUMO AQUIS 500 AS
Display and switching device in IP67 wall-mounted housing with pressure compensation element, integrated 2-wire power supply for level probes, linearization function for liquid level/level with 20 measured value pairs
Type 202568

JUMO di 308
Digital indicator, integrated 2-wire power supply for level probes, RS interface, 10 measured value pairs, math function (2 channels, optional)
Type 701550

JUMO dTRANS T02
Programmable transmitter, 40 measured value pairs
Type 707020/21/22

Terminal box with pressure compensation element
Article No. 00061206

Screw plug
Article No. 00333329

JUMO MAERA S26
Level probe
Type 402090

Product selection

The ideal and most cost effective solution for a closed yet ventilated heating oil tank with access from the top of the tank is hydrostatic liquid level measurement with a level probe.
Taking into consideration the measurement material and its temperature, use of JUMO MAERA S26 (type 402090) level probes with a special polyethylene cable (C-PE) is recommended for an application temperature range of 0 °C to +30 °C.
It is also possible to use the JUMO MAERA S25 (type 401015) with polyamide protective tube for the selected measurement ranges and cable and hose lengths.

Liquid level visualization and measured value documentation taking the tank geometry into consideration

The preferred display accuracy is a criterion when selecting the visualization and recording instrument for measured data.
A horizontal cylindrical tank with a dished end exhibits a non-linear increase in volume with respect to level. To ensure correct modeling and documentation, customer-specific linearization can be used or a math function can be integrated into paperless recorders and indicators.
Customer-specific linearization uses a number of measured value pairs to interpolate the display graph with a display value assigned to a measured signal. Because of this, an increasing number of measured value pairs always has a positive effect on the accuracy of displayed values. In actual practice an extension of the measured value pairs can be achieved by including a programmable transmitter in the circuit before the indicator (connection variant 5).
Instruments with a math function provide a convenient and highly precise variant for determining liquid level. Linearization is calculated by a formula that takes the tank geometry into consideration.
The JUMO di 308 (type 701550) digital indicator features optional customer-specific linearization or two math channels. It can be used to feed an integrated two-wire power supply to level probes as well as the JUMO AQUIS 500 AS (type 202568) display and switching device. Volumes up to 99.999 can also be shown on the 5-digit display.

Technical descriptions of indicators and paperless recorders can be downloaded from www.jumo.net.

http://brochures.jumo.info

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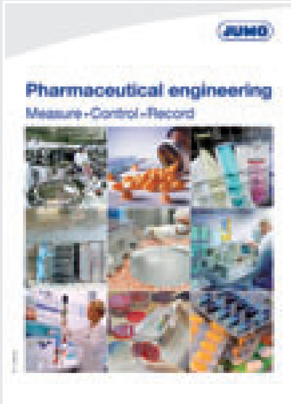

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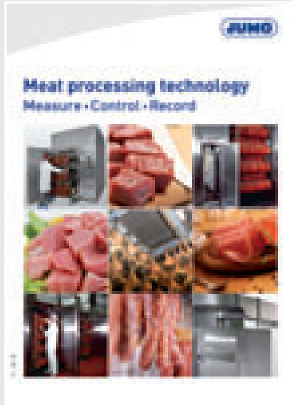

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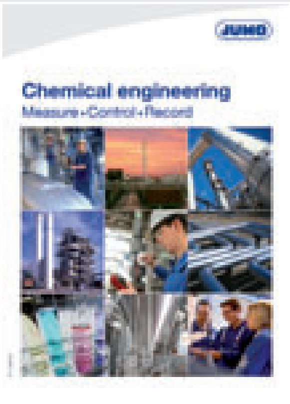

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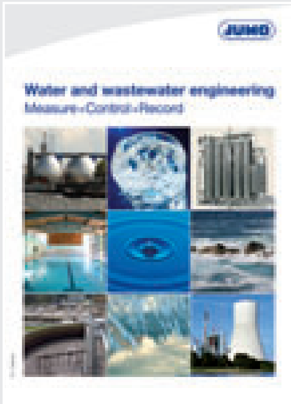

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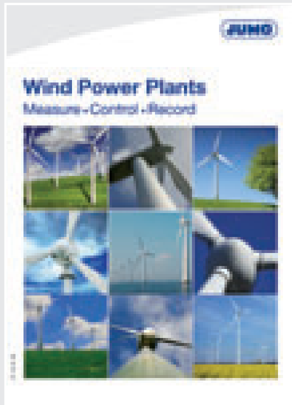

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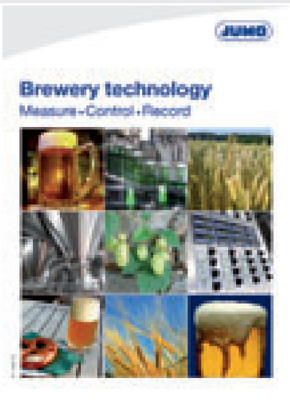

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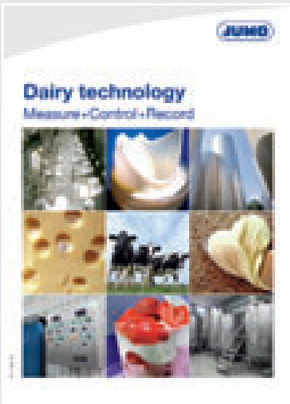

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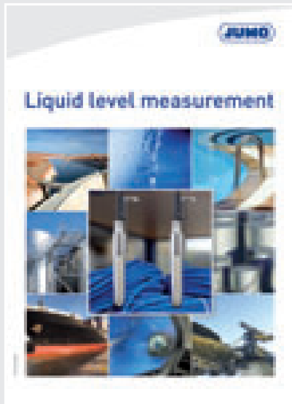

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