JUMO Level Probes

Hydrostatic level measurement

B.Eng. René Krug
Product Manager
Level
Phone: +49 661 6003-9144
Email: rene.krug@jumo.net

Dear Reader,

In this brochure we focus on the basic principles of hydrostatic level measurement, with a particular emphasis on level probes. We also elaborate on a few helpful details concerning the selection of a suitable level probe. As JUMO is both a component supplier and a system supplier, we will present options for the implementation of complete measuring point solutions and provide an insight into the diverse applications of hydrostatic level measurement.
With our worldwide sales structure and expert service, we provide reliable support to meet your needs. Here, comments, suggestions, or individual solutions can be discussed because, as Henry Ford once said, "problems are solutions in disguise."
We view consistent product quality, high plant availability, and maximum cost effectiveness of your plants as being at the heart of a successful collaboration. Consequently, we place the highest demands on ourselves by introducing, continuously assessing, and improving quality standards. One result of this philosophy is that the measuring devices are subject to thorough testing and detailed inspection at our own test laboratory.

Our status as a reliable partner for our customers – which is ensured both by our products and by our employees – represents an important cornerstone of our family company. A key aspect here is our decades of experience in the area of pressure measurement technology, which is the field in which hydrostatic level measurement is based.

Yours sincerely,

René Krug

Further information about our products can also be found at **www.jumo.net**.

Contents

Basic principles of level probes – continuous level measurement

Level probes are used for continuous level measurement in ventilated tanks or to determine the level in open waters. The measuring principle is based on hydrostatic level measurement using relative pressure. This involves the complete immersion of the level probe in the liquid. For applications in pressurized tanks such as steam boilers, we offer differential pressure transmitters for determining the level. If the pressure transmitter needs to be installed from the outside (e.g. due to hygiene reasons) we provide pressure measuring devices with corresponding certificates.

Measuring method for ventilated tank with level probe or pressure transmitter

Measuring method for closed tank with differential pressure transmitter

JUMO – your partner for level measurement

Calculation of the hydrostatic pressure: $p = p_0 + \rho \times g \times h$

Hydrostatic level measurement

Level probes continuously measure hydrostatic pressure. Here, the gravitational pressure of the liquid column located above the sensor is measured. With this measuring principle liquids and gases can be measured. The most commonly used units are meter water column (mWS), bar, pound-force per square inch (psi), and megapascal (MPa).

For the purpose of calculating the current level height h, the

formula $h = \frac{(\rho - p_0)}{(\rho \times g)}$ [m]

is applied. In this formula, p represents the current measured pressure, p_0 stands for the ambient pressure, ρ denotes the medium density, and g constitutes the constant acceleration due to gravity.

This formula refers to undisturbed liquids in containers or open waters.

As measurements with level probes are generally relative pressure measurements, the influences of the ambient pressure p_0 are automatically compensated and, as a result, $p_0 = 0$. This is achieved using a special cable with a pressure equalization hose. The sensor in the medium is therefore connected to the ambient pressure at the end of the cable via the pressure equalization hose. Fluctuations in air pressure occur as a result of the weather conditions and the geographical height at the changing operating location. For example, the atmospheric pressure on Mont Blanc (4810 m) is around 540 mbar while on Mount Everest (8848 m) it is only 320 mbar.

The measured pressure is converted into a current standard signal in the level probe by means of corresponding electronics. This signal is transmitted via the special cable. With the help of an interposed terminal case, evaluation can subsequently be performed by such tools as an indicating device or a recorder.

Level probe product overview

✓ Suitable
– Not suitable

	Description	JUMO MAERA S25	JUMO MAERA S26	JUMO MAERA F27
	Type/data sheet	401015	402090	404391
Application	Outdoor mounting [1] Indoor mounting [1]	– ✓	– ✓	✓ ✓
Application	Approval	–	–	–
Application	Integrated overvoltage protection	–	–	✓[2]
Application	Temperature probe Pt100 (optional)	–	–	✓[2]
Technical data	Measuring range	2.5 to 10 mWS 0.25 to 1 bar	2.5 to 10 mWS 0.25 to 2.5 bar	0.5 to 16 mWS 0.05 to 1.6 bar
Technical data	Medium temperature	0 to +50 °C		-20 to +60 °C
Technical data	Sensor	Piezoresistive silicon sensor		Capacitive ceramic sensor
Technical data	Accuracy (linearity)	±0.3 %	±0.2 % (> 0.4 bar) ±0.3 % (≤ 0.4 bar)	±0.2 %
Technical data	Output signals	4 to 20 mA zl 0 to 1 V dl 0.5 to 4.5 V dl 1 to 5 (6) V dl	0 to 20 mA dl 4 to 20 mA zl or dl 0.5 to 4.5 V dl 0 to 1 V dl 1 to 5 (6) V dl	4 to 20 mA zl 0.5 to 4.5 V dl
Technical data	Cable material	PE, PA	PE, FEP, PUR	
Technical data	Housing material	Stainless steel		Stainless steel or PTFE

1 These recommendations are based on many years of experience. However, in individual cases they may not be fully applicable. We would be happy to provide further information, including additional applications.

2 Only for stainless steel version with an output signal of 4 to 20 mA zl.

✓ Suitable
– Not suitable

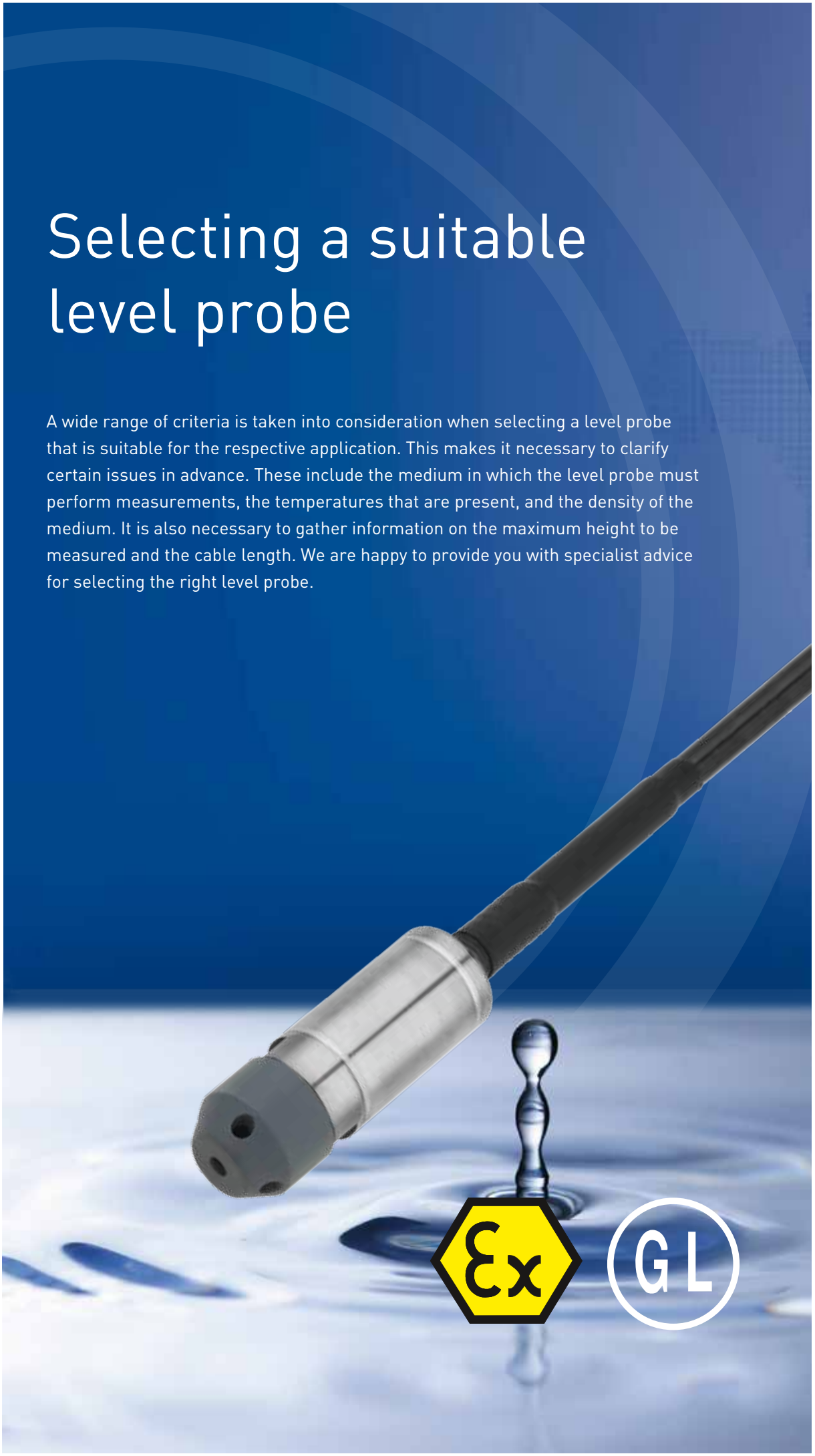
	Description	JUMO MAERA S28	JUMO MAERA S29 SW	JUMO dTRANS p33
Application	Type/data sheet	404392	404393	404753
	Outdoor mounting [1] Indoor mounting [1]	✓ ✓	– ✓	– ✓
	Approval	–	GL, ATEX	ATEX
	Integrated overvoltage protection	✓[2]	–	–
	Temperature probe Pt100 (optional)	✓[2]	–	–
Technical data	Measuring range	2.5 to 100 mWS 0.25 to 10 bar	1 to 100 mWS 0.1 to 10 bar	2.5 to 100 mWS 0.25 to 10 bar
	Medium temperature	0 to +50 °C		
	Sensor	Piezoresistive silicon sensor		
	Accuracy (linearity)	±0.2 % (> 2.5 bar) ±0.3 % (≤ 2.5 bar)	±0.3 %	±0.5 %
	Overall accuracy at 20 °C in % of the end value	±0.3 % (> 2.5 bar) ±0.5 % (≤ 2.5 bar)	±0.5 %	±0.6 %
	Output signal	4 to 20 mA zl		
	Cable material	PE, FEP, PUR, EPR	FEP	PE
	Housing material	Stainless steel	Titanium	Stainless steel

1 These recommendations are based on many years of experience. However, in individual cases they may not be fully applicable. We would be happy to provide further information, including additional applications.

2 Only for stainless steel version with an output signal of 4 to 20 mA zl.

Selecting a suitable level probe

A wide range of criteria is taken into consideration when selecting a level probe that is suitable for the respective application. This makes it necessary to clarify certain issues in advance. These include the medium in which the level probe must perform measurements, the temperatures that are present, and the density of the medium. It is also necessary to gather information on the maximum height to be measured and the cable length. We are happy to provide you with specialist advice for selecting the right level probe.



The level probe

Closed system

Open system

Protective cap

Sensor (measuring cell)

When using the level probe with an integrated measuring cell, you can choose between different materials that are in contact with the medium based on the application in question. Variants made of stainless steel, ceramic, and titanium are therefore available. Depending on requirements, sensors can be implemented according to the capacitive or the piezoresistive measuring principle.

The measuring range to be selected depends on the maximum liquid column that is to be measured as well as the density and temperature of the medium. The density of a medium is temperature-dependent. These dependencies are listed in tables. For example, the density of water is 999.964 kg/m³ at 5 °C. When it is heated by 25 K, the density falls to 995.645 kg/m³. The formula for hydrostatic pressure is applied to calculate the suitable measuring range (see page 4).

Process connection

The process connection of the level probe must be selected according to the features of the liquid and its condition on the base of the container. A closed connection protects the measuring cell from damage (e.g. due to relatively large solids in the medium). On the other hand, an open system offers advantages for contaminated or high-viscosity media or if a risk of deposit formation exists. A process connection with a thread can be used to fasten the level probe on the base of the tank.

Notes on product selection

End of cable with pressure equalization hose

Overvoltage protection in event of lighting strike

Cable

Special cables are normally used for transmitting the measurement data of a level probe. These cables are routed outdoors and in the tank or water well. As a result, various influences act on the cable. These include solar radiation, temperature fluctuations, and the respective medium.

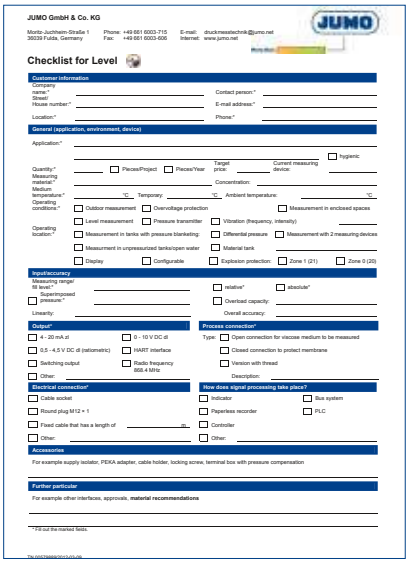
The primary factor when selecting the cable material is its chemical resistance to the medium while taking account the temperatures and concentrations of this medium. Cable sheaths must be chosen according to the application in question. UV resistance is indicated for all cables. To prevent problems ranging from measuring value errors to failure of the device, pressure compensation is achieved using an integrated pressure equalization hose that does not allow any moisture to penetrate. The penetration of liquid into the pressure equalization hose can be prevented using a pressure compensation filter. Furthermore, the bending radius of the cable must not fall below the preset value, as otherwise insufficient ambient pressure compensation due to kinking might occur. The cable can also be lengthened for signal transmission in a cost-effective manner by using the optionally available terminal case with pressure compensation.

Overvoltage protection

Overvoltage protection or lighting protection is recommended above all for outdoor applications. This includes applications in deep water wells or free-field measurements. The overvoltage protection protects the level probe from destruction caused by possible lightning striking the surrounding body of water. Overvoltage protection is already integrated into the JUMO MAERA S28 and JUMO MAERA F27 level probes.

Integrated temperature probe

Approvals


JUMO GmbH & Co. KG

Moritz-Juchheim-Straße 1
36039 Fulda, Germany

Phone: +49 661 6003-715
Fax: +49 661 6003-606

E-mail: druckmesstechnik@jumo.net
Internet: www.jumo.net

Checklist for Level

Customer information

Company name:*
Street/ House number:*
Location:*
Contact person:*
E-mail address:*
Phone:*

General (application, environment, device)

Application:*
hygienic
Quantity:*
Pieces/Project
Pieces/Year
Target price:
Current measuring device:
Measuring material:*
Concentration:
Medium temperature:*
°C
Temporary:
°C
Ambient temperature:
°C
Operating conditions:*
Outdoor measurement
Overvoltage protection
Measurement in enclosed spaces
Operating location:*
Level measurement
Pressure transmitter
Vibration (frequency, intensity)
Measurement in tanks with pressure blanketing:
Differential pressure
Measurement with 2 measuring devices
Measurement in unpressurized tanks/open water
Material tank
Display
Configurable
Explosion protection
Zone 1 (21)
Zone 0 (20)

Input/accuracy

Measuring range/ fill level:*
Superimposed pressure:*
relative*
absolute*
Overload capacity:
Linearity:
Overall accuracy:

Output*

4 - 20 mA at
0 - 10 V DC di
0.5 - 4.5 V DC di (ratiometric)
HART interface
Switching output
Radio frequency 868.4 MHz
Other:

Process connection*

Type:
Open connection for viscose medium to be measured
Closed connection to protect membrane
Version with thread
Description:

Electrical connection*

Cable socket
Round plug M12 + 1
Fixed cable that has a length of
m
Other:

How does signal processing take place?

Indicator
Bus system
Paperless recorder
PLC
Controller
Other:

Accessories

For example supply isolator, PEKA adapter, cable holder, locking screw, terminal box with pressure compensation

Further particular

For example other interfaces, approvals, **material recommendations**

* Fill out the marked fields.

Approvals

Checklist

Integrated temperature probe

The temperature probe integrated into the level probe measures the medium temperature. This is important in applications featuring changes in temperature as the temperature-dependent density influences the accuracy of the measurement. As a result, it is possible to combine two measurands in one product so that a straightforward installation is possible

Approvals

Numerous applications make increased demands on the products. Some of these include explosion protection, drinking water, and shipbuilding. Suitable level probes can be individually configured according to your requirements.

This way to your product

The "Level" checklist is a tool you can use to compile all the relevant requirements of your application in a clear and concise manner. This ultimately leads to fast and efficient order processing. The checklist can be accessed using the following link: http://www.jumo.de/en_DE/support/product-service/checklist.html.

Recommendations for the use of level probes

✓ Suitable
– Not suitable

	Description	JUMO MAERA S25 Type 401015		JUMO MAERA S26 Type 402090		JUMO MAERA F27 Type 404391	
		Probe	Cable	Probe	Cable	Probe	Cable
Application	Wastewater	–	–	✓	FEP	✓	FEP
	Well water (without salt content)	✓	PE	✓	PE	✓	FEP
	Drinking water	–	–	✓[1]	PE	–	–
	Heating oil	✓	PA	✓	FEP	✓	FEP
	Car washes	✓	PE	✓	PE	✓	FEP
	Fuel: gasoline	–	–	–	–	–	–
	Fuel: diesel	✓	PA	✓	FEP	✓	FEP
	Seawater	–	–	–	–	✓[2]	FEP
	Caustic soda (20 %, 20 °C)	–	–	✓[1]	PE	✓[1,2]	PE
	Rainwater	✓	PE	✓	PE	–	–
	Sulphuric acid (50 %, 20 °C)	–	–	–	–	✓[2]	PE
	Swimming pools (disinfectant: chlorine)	–	–	–	–	✓[2]	FEP

These recommendations are based on many years of experience. However, in individual cases they may not be fully applicable.
We would be happy to provide further information, including additional applications.

[1] Seal: EPDM.
[2] PTFE variant.

✓ Suitable
– Not suitable

	Description	JUMO MAERA S28 Type 404392		JUMO MAERA S29 Type 404393		JUMO dTRANS p33 Type 404753	
		Probe	Cable	Probe	Cable	Probe	Cable
Application	Wastewater	✓	FEP	✓	FEP	✓	PE
	Well water (without salt content)	✓[1]	FEP	✓	FEP	✓	PE
	Drinking water	✓[1]	PE	–	–	–	–
	Heating oil	–	–	✓	FEP	✓	PE
	Car washes	✓	PE	✓	FEP	✓	PE
	Fuel: gasoline	–	–	–	–	✓	PE
	Fuel: diesel	✓	FEP	✓	FEP	–	–
	Seawater	–	–	✓	FEP	–	–
	Caustic soda (20 %, 20 °C)	✓[1]	PE	✓	FEP	–	–
	Rainwater	✓	PUR	✓	FEP	✓	PE
	Sulphuric acid (50 %, 20 °C)	–	–	–	–	–	–
	Swimming pools (disinfectant: chlorine)	–	–	✓	FEP	–	–

These recommendations are based on many years of experience. However, in individual cases they may not be fully applicable.
We would be happy to provide further information, including additional applications.
[1] Seal: EPDM.

More than just a measuring point

The level probe is a component of a complete measuring point solution. It is accompanied by accessories that ensure optimum installation and evaluation units such as recorders, indicators, and controllers. Consequently, a system that is ideally tailored to your requirements is manufactured, delivered, and maintained by a single source.

Accessories

Terminal case with pressure compensation element

The terminal case acts as a link between the end of the level probe cable and the cable to the downstream evaluation unit (such as a recorder). Optimum positioning outside the medium but as near as possible to its surface provides technical and economic benefits. For example, quicker pressure compensation compared with longer cables is achieved. Additionally, costs can be lowered due to a shorter special cable. The terminal case features protection type IP65.

Cable clamp

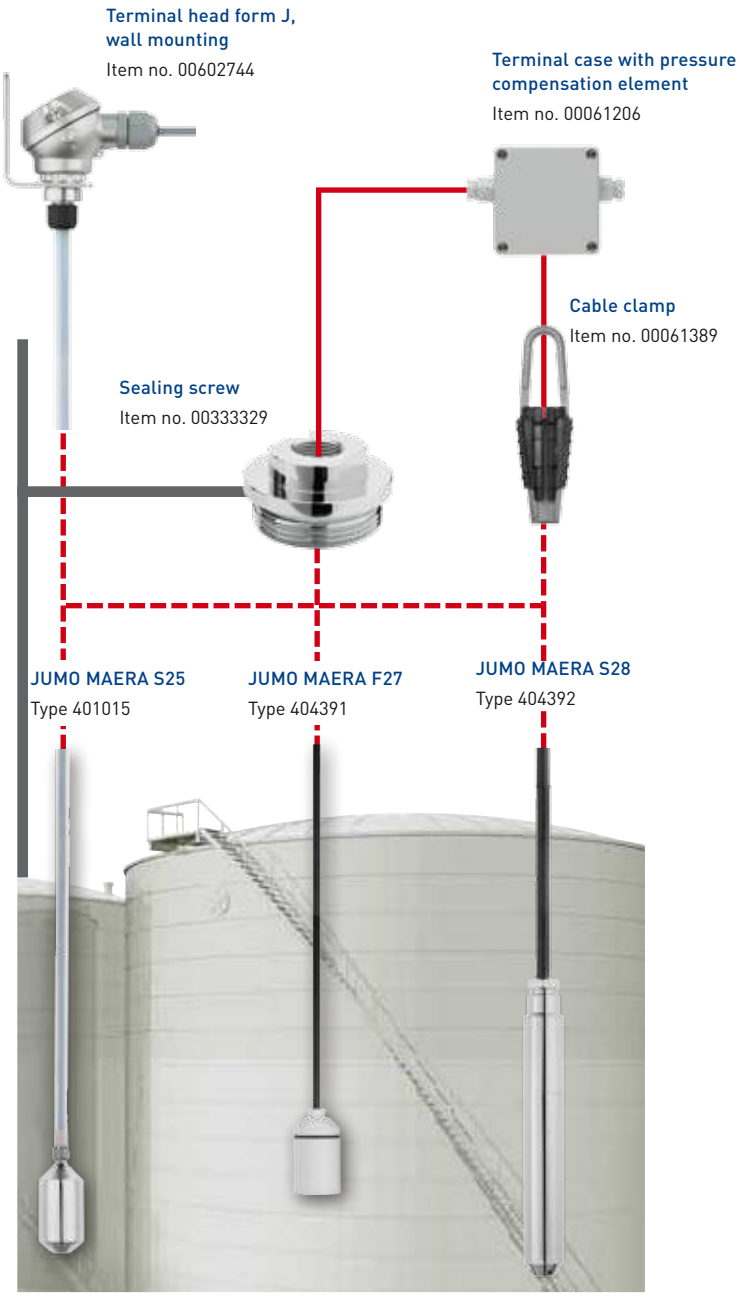
The cable clamp holds the level probe in a liquid at a defined depth. As a result, an individually suitable probe height above the base of the tank during installation can be achieved. The cable clamp also protects the cable by ensuring strain relief.

Sealing screw

The sealing screw acts as a cable passage and cable fastening for such applications as closed containers or water wells with a well head. This screw, therefore, makes a contribution to a secure installation by protecting the cable sheath against damage.

Terminal head

The terminal head is applied with the level probe JUMO MAERA S25 (type 401015). This terminal head is used to mount the level probes in the best possible way and features protection type IP67. Tank cover and wall mounting variants are available. Rapid pressure compensation can be achieved by positioning close to the level probe. Furthermore, the direction (to the control cabinet, for example) can be individually specified. Any liquid that forms is absorbed by the drying capsule contained in the cover. The capsule changes color to indicate the level of saturation. Specifications for the electrical connection and further technical information can be found in the installation instructions.



Evaluation units

JUMO di 308

Digital indicator, integrated two-wire voltage supply for level probes, RS interface, 10 pairs of measured values, math function (2 channels, optional)

Type 701550

JUMO LOGOSCREEN 600

Paperless recorder with innovative operating concept

Type 706520

Technical descriptions can be accessed by entering the relevant type number at www.jumo.net

As shown in the "Basic principles of level probes", the decisive factors for the selection of the measuring range are the maximum level height and also the temperature-dependent density. The temperature dependence can be automatically accounted for and offset within the measuring chain using suitable products.

Example

The hydrostatic pressure in a cylindrical tank equates to a relative pressure of 200 mbar. The tank filled with cold water at a temperature of 5 °C shows a density of ρ = 999.964 kg / m³. The hydrostatic pressure is calculated using the following formula:

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

After conversion of the formula according to h, the level height, taking into account the relative pressure ($p_0 = 0$), the following equation is reached: h = p / (ρ × g).

After taking into account the SI conformity of 200 mbar = 20,000 Pa = 20,000 kg / (m × s2), the result for the level height is h = 203.88 cm.

In the event of the water being heated by 25 K and an associated change in density to 995.645 kg/m³, the level height would be 204.77 cm. If the temperature was not included in the measurement, the measured and documented value would deviate by 0.89 cm from the actual level height.

Measure

To take the influence of the temperature into consideration, the digital indicator JUMO di 308 (type 701550) can be used in conjunction with a suitable level probe. Two functions can be defined in the "math channels" of the indicating device. One channel can be used to calculate the temperature-dependent density with the help of a quadratic function. Temperature can be recorded using an integrated temperature probe, such as the JUMO MAERA F27 and JUMO MAERA S28 level probes. The second channel then calculates the level height, taking into account the result for channel 1. Customer-specific linearization can also be entered for known pairs of measured values.

Complete solution – JUMO Engineering

JUMO Engineering, the JUMO service area, combines the expertise and industry-specific experience of our employees in one team. Our engineers and technicians develop customized solutions that are consistently based on your requirements. The JUMO Engineering team strongly believes in the importance of providing personalized support and consulting to its customers from initial contact through to startup.

When carrying out the many different industry applications, we always strive for maximum customer benefits. Our innovative engineering services allow us to achieve this goal. We are therefore able to provide comprehensive support from delivery of the right level probe through to fully automated level monitoring in your plants. Here, we work together with you to develop solutions.

Our services

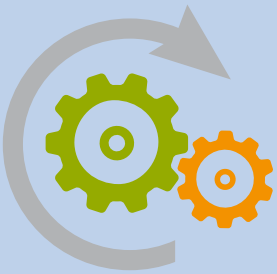
- Feasibility analysis
- Creating a technical concept including product requirements / specification sheet
- Complete project planning and documentation
- Project planning incl. PLC programming, visualization, network technology, etc.
- Continuous project management
- On-site startup
- Training course and support

Your advantages

- JUMO, as the central contact partner, develops a technical system solution for you
- You benefit from our team's extensive expertise with all measurement and automation devices
- A global network of support from experienced specialists
- A flexible, tailored solution to suit your individual needs and application

In a nutshell

- Precise and prompt communication channels:
  This saves you time and prevents mistakes!
- Highly developed expertise for maximum flexibility:
  You benefit from fully reliable and secure project planning!
- Technology that has proven itself over decades reduces downtimes:
  This provides you with high plant availability and process reliability!



Diesel tank application

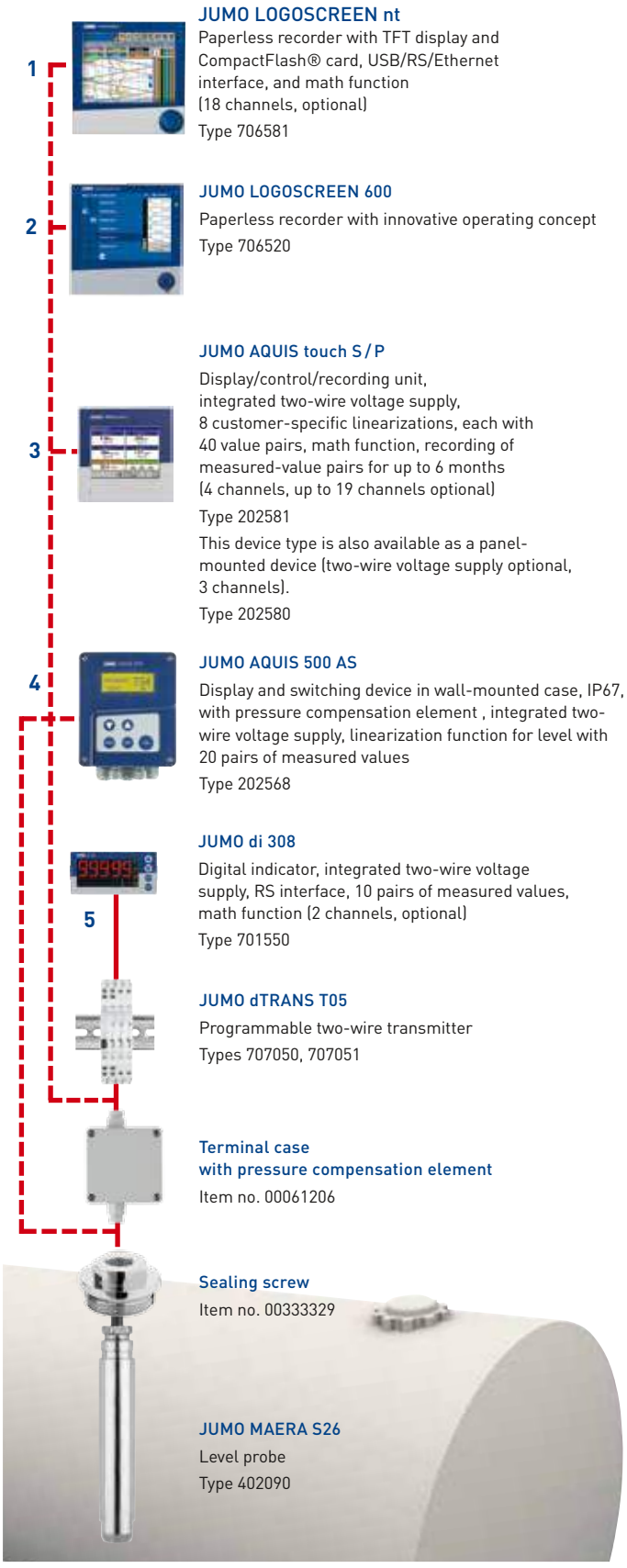
The availability of fossil fuels is limited. This fact is reflected in long-term increases in the price of fuel. Needs-based planning of deliveries can be optimized when the current level is known. Level monitoring in diesel storage tanks plays a central role in the application described below.

Application

In regions with poor infrastructure, plants are often operated using diesel engines. Operation, maintenance, and repair are particularly costly factors in this case. One example here is the filling of the diesel tanks. As a result of large distances between the individual plants, secure knowledge of the current level in the tanks is particularly important for safe plant operation as well as the involved costs. For example, the correct information can help the supplier or your own personnel in performing efficient route planning for tank filling. In addition, our JUMO mTRON T system enables further options such as alarm messages via texts/emails as well as paperless recorder functions including web server. The connection of proven measurement technology and state of the art automation solutions in the form of inventory monitoring opens the door to Industry 4.0. JUMO level probes make a decisive contribution to the cost-effectiveness and secure availability of a plant.

Special case: horizontal tank

If a liquid is stored in a horizontal cylindrical tank, it must be taken into account that the fill volume will not change in linear proportion to the level height. To ensure a user-friendly display or recording of the measured values, a customer-specific linearization or an integrated math function can be applied. Connection variant 5 (see figure) is briefly explained as an example: the level probe measures the pressure caused by the liquid column. A terminal case acts as a link between the level probe and the JUMO dTRANS T05 transmitter. JUMO dTRANS T05 scales the corresponding standard signal in such a way that a display in liters or cubic meters can be implemented using the JUMO di 308.



Deep water well application

The key cornerstone of life is water. It is of elementary importance, not only for us as human beings but also for ecological balance. The following application example demonstrates the contribution made by level probes to maintaining this balance.

JUMO MAERA S28
Level probe
Type 404392

Level measurement for dry-running protection of the pumps and for recording the groundwater level

Application

Mineral water manufacturers and water suppliers have to monitor and check the groundwater level using deep water well or groundwater measuring points.

To obtain mineral water or supply drinking water, water wells are drilled. Water is then removed from these wells using powerful pumps. However, this removal of water must not be performed in an arbitrary manner, as this could cause long-term damage to the natural balance of the Earth's water cycle (the transport and storage of water). Therefore, level probes are lowered into the water well/borehole in addition to the pump to measure the groundwater level. If, in dry periods or in the event of excessive water removal, an insufficient amount of water is formed as a result of which the groundwater level falls below a specific limit value, then measurements will quickly detect this state and the pump will be switched off.

In regular operation, on the other hand, the volume of water that is pumped away is recorded using magnetic inductive flowmeters such as the JUMO flowTRANS MAG S01. This enables precise detection of the flow volume or the flow velocity to ensure optimum use of the water well capacity.

Mine shaft application

A similar principle is also applied in mine shafts. In this context, however, water is pumped in as opposed to being removed. The water contributes to the stabilization of the shaft, protecting people and nature against potentially fatal catastrophes.

Level monitoring application with the aid of an automation system

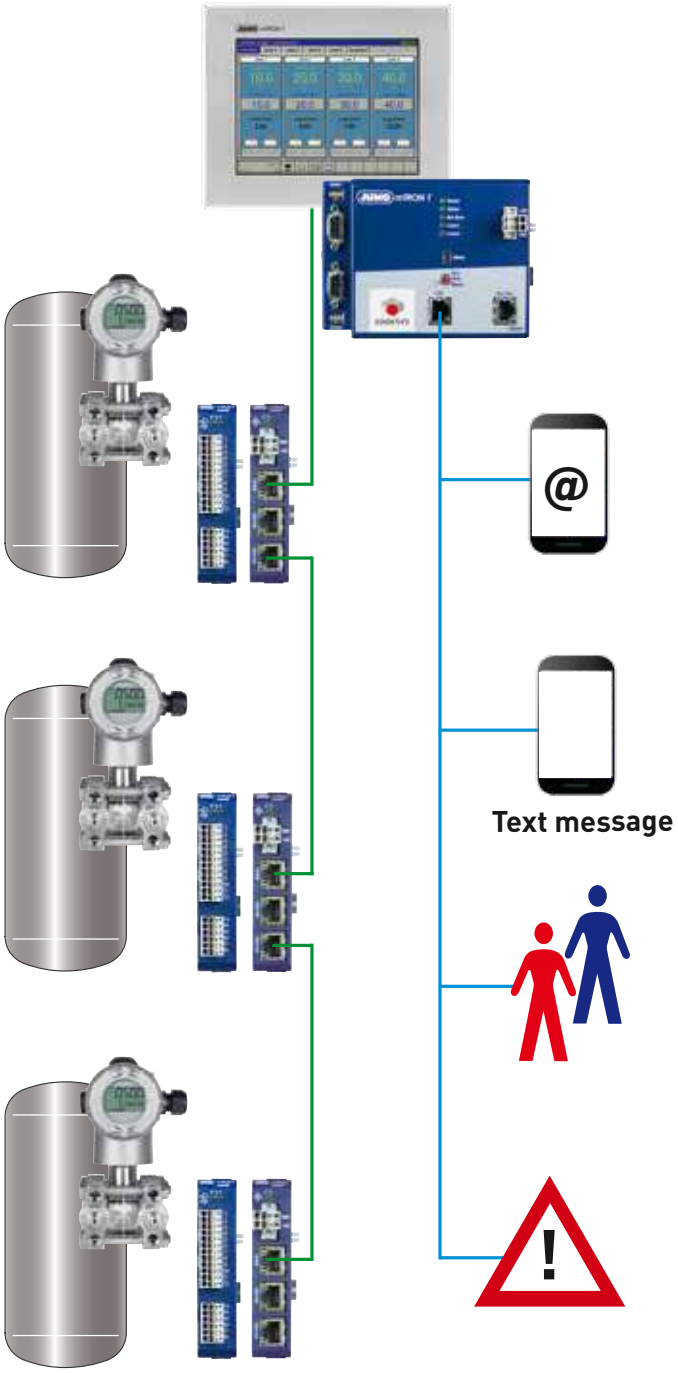
The following application example provides a look at further level applications with measurement technology from JUMO. Here, the measurement solution was developed for requirements in plants on the factory premises of our headquarters and has already proven reliable over many years of use.

Application

Nitrogen tanks are monitored at the JUMO company premises thanks to the JUMO dTRANS p20 DELTA differential pressure transmitter and the JUMO mTRON T automation system. Further applications can be found in energy technology when looking at steam boilers, which are influenced by high pressures and temperatures.

The fundamental task is the performance of level measurement in pressurized tanks. Here, in addition to the medium, a (gas) pressure must also be taken into account in this regard. In conjunction with the automation system, numerous other functions ranging through to automated inventory monitoring can be performed using this process. These also include recording functions of a fully-fledged paperless recorder, including a web server. Process data can be conveniently displayed online in this way through such devices as a smartphone. This can also be complemented by the transmission of alarm messages using text messages or email. If, for example, level limit values fall short when storing substances in tanks, orders can be issued to the supplier automatically via email.

The networking of products and ultimately even of companies, as shown in this example, demonstrates the benefits and options that a system supplier is able to provide.



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