Level measurement

Level limit detection and continuous level measurement in liquids and bulk solids
What is Endress+Hauser’s complete product offering? Many of our customers ask this question. After all, our competence in products, solutions and services is not always appreciated. We have developed from a supplier of instrumentation, to a provider of complete systems with the goal of serving our customers throughout the entire life-cycle of their plants and help increase their industrial productivity. We have arranged our activities in accordance with core processes: development, production and delivery of quality products, solutions and services. Wherever level, pressure, flow, temperature, analytical and recording data is needed and systems, components and solutions are used, many companies appreciate the experience of Endress+Hauser. This is one of the reasons why we are a leading global provider of measurement, control and automation solutions for process industry production and logistics.

Curious? Visit us at www.us.endress.com

We are a family enterprise with a staff of more than 6,000 world-wide and sales of $838.2 million in 2003. Our global presence with 19 production sites (Product Centers) in Europe, Asia and the US, as well as sales and service organizations in almost all countries of the world, ensures constant communication with our customers. This enables Endress+Hauser to consistently support the competitiveness of our customers with the highest degree of quality, safety and efficiency.

Continuous optimization of our processes and the use of innovative state-of-the-art technology enable us to extend the frontiers of measurement, control and automation engineering and to find safe and efficient solutions for the benefit of our customers. We ensure the compatibility of our processes with the environment to save energy and resources.

With more than 30 years’ experience in microwave technology, Endress+Hauser has a wealth of application know-how in all industries. As the market leader with over 50,000 guided level radar instruments installed, Endress+Hauser has the most extensive application experience in the market. More than 35 years of successful development, production and marketing of ultrasonic instruments as well as more than 400,000 applications underline the competence of Endress+Hauser.

All this makes our customers confident that they will also be able to rely on us in the future as “People for Process Automation!”
Contents

Product Center 4
Level measurement and segmentation 5
Measuring principles 6

Continuous measurement methods

- Time of Flight method 7
- Radar level measurement 10
- Guided radar level measurement 12
- Ultrasonic level measurement 14
- Capacitance level measurement 16
- Hydrostatic measurement 18

Level limit detection

- Vibronic 20
- Capacitance 26
- Conductive 28
- Paddle switches 29
- Quality 30
- Safety 31
The Product Center for level and pressure

Continuous level measurement of bulk solids and liquids, safe level limit detection and pressure measurement in tanks and pipes constitute central tasks of process engineering.

The production facility located in Greenwood, Indiana utilizes state-of-the-art production techniques and manufacturing technologies to ensure the quality of the instrumentation produced, as well as the safety of employees and the environment. Continuous investments in the design and development of computer driven test and assembly equipment allows for the quality validation directly in the work cell, while maintaining rapid delivery. The field instrumentation produced is subject to tough application and environmental conditions, from extreme temperature fluctuations and exposure to hazardous environments, to mechanical stresses. The Endress+Hauser production meets the challenge of these demanding requirements as attested to by our installed base of over six million level measuring points worldwide.

Level and pressure instrumentation
Endress+Hauser offers instrumentation for the measurement of level limits and levels in liquids and bulk solids using eight measurement principles with 11 different product families. Also measurable is pressure, absolute pressure and differential pressure by ceramic-capacitive or piezo-resistive sensors.

Real solutions
Wherever material is transported and stored, high-performance and precise inventory management is the key to smooth production. Endress+Hauser leads the way with the development of sophisticated inventory control systems which assume part of real-time logistic process control.

Milestones in level measurement
1953 Foundation of the company with capacitive probes for level measurement
1962 First radiometric measuring line
1968 Soliphant – first vibration limit switch for bulk solids
1969 First sonic sensor for continuous level measurement
1983 Liquiphant – first vibration limit switch for liquids
1993 Micropilot – first level radar for non-contact measurement
1998 Levelflex – first guided level radar for the present world market leader
2002 Fieldgate – worldwide remote inquiry, diagnosis and configuration of sensors
2004 Guided level radar for 750°F (400°C) and 5,800 psi (400 bar)
Constant product quality, plant safety and economic efficiency are all important aspects for any level measuring point. Levels of liquids, pastes, bulk solids or liquefied gases are often measured in tanks, silos or movable containers. From the chemical, petrochemical and energy industries to the pharmaceutical, food and environmental industries, applications range from -330°F to 750°F (-200°C to 400°C) and from -15 psi to 7,250 psi (-1 bar to 500 bar).

Finding the ideal solution is easy with the broad range of measuring principles available from Endress+Hauser. No principle is suited for all areas of application, therefore, measuring systems have to be selected which work reliably under the conditions of a particular application and, at the same time, meet the economic considerations of the future.

As the market leader in level measurement, Endress+Hauser supports you from planning and commissioning, to the maintenance of your measuring point. In addition, we assist you in automation, asset management and visualizing of process data.

Endress+Hauser's level instrumentation has a strong presence in all areas of process automation.

Level measurement – still leading the way

Segmentation
“You only pay for what you really need.” We take this statement seriously at Endress+Hauser and offer our instruments in three different segments.

S-M-T segment
The classification in these 3 segments allows you to select an instrument tailor-made to your requirements. Our products always stand for high quality and reliability irrespective of the segment you choose. The instruments of the S and M segments have a modular design and offer a variety of:
- Process connections
- Sensor materials
- Housings
- Electronic interfaces
- Certificates and approvals
- Special designs
Level measurement applications are divided into four areas: liquids including liquefied gases, bulk solids, continuous measurement and point level limit detection.

**Continuous measurement**
Continuous level measurement determines the level of media – it actually measures the length. The measuring ranges cover from a few inches for control tasks, typically 6 to 30 ft (2 to 10 m) for liquid applications and up to 230 ft (70 m) in bulk solids such as in grain silos for an example. Apart from direct level measurement in feet, the product volume in a tank may be determined indirectly. The geometric form and dimensions of the tank, as well as medium properties must be taken into consideration for this. Inventory management applications often demand increased accuracy of up to ±.04 in (±1 mm).

**Point level limit detection**
The essential tasks are to avoid overfilling or excessive emptying of tanks and to protect pumps from running dry. Fast and safe functioning and high reproducibility are of great importance in level limit detection.
Time of Flight method

Three measuring principles – one philosophy

Level measurement in the most varied applications

Radar pulses or ultrasonic waves are emitted by a sender, reflected by the product surface and again detected by a receiver. From the Time of Flight (ToF) of the pulse, the distance between the sender and the surface is determined using the known velocity of propagation. Taking the tank height into consideration, the level can be calculated from this value.

Advantages at a glance
- No mechanical moving parts, leading to low maintenance costs
- High accuracy due to independence of medium properties (for example: density and conductivity)
- No calibration required in changing media

The three Time of Flight principles
Different requirements in continuous level measurement of liquids and bulk solids require special measuring principles. For example, radar technology has established itself in large areas of the chemical industry. New developments extend the range of applications to bulk solids. Guided level radar has its place both in silo applications and in liquid media. Ultrasonics constitute the standard in bulk solids measurement and in the area of water and wastewater treatment. With Micropilot S/M, Levelflex M and Prosonic S/M/T, Endress+Hauser offers the optimum solution for many applications.

Micropilot M/S
Non-contact radar level measurement

Levelflex M
Guided level radar measurement

Prosonic S/M/T
Ultrasonic radar level measurement
Time of Flight method

Three measuring principles – one operating philosophy

Uniform operation

The uniform operating philosophy of all Endress+Hauser level instruments facilitates fast and easy configuration.

Menu-guided commissioning
The uniform operating standard for Endress+Hauser’s three different Time of Flight measurements has a plain text display to guide you simply and safely through configuration and commissioning. Integrated help text and clear error instructions reduce search times. Obtaining information on the application (storage, buffer, agitator) and tank geometries the PulseMaster® software sets the required parameter automatically at the instrument.

Plausibility check
The envelope curve representation (echo curve) on the instrument display facilitates fast and safe plausibility checks on-site as well as in hazardous areas. There is no additional equipment required. Even in sophisticated measuring tasks, the software provides input proposals based on the experience of our service technicians.

Communication protocols
Configuration, diagnosis and documentation may be comfortably handled from the control room via the HART® signal. This is superimposed on the current signal (4 - 20 mA) already in standard design. The optional communication protocols of PROFIBUS® and FOUNDATION™ Fieldbus facilitate simple digital integration into visualization and distributed control systems.

Advantages at a glance
- Fast and safe commissioning due to step-by-step menu-guided operation in national languages
- Envelope curve – you see what the instrument sees
- Simple plausibility check on-site
- Comfortable configuration from the control room
Configuration, diagnosis and documentation

From the control room

**ToF operating software**
This software comes free-of-charge with every Time of Flight instrument purchased. It allows remote configuration via your PC and is normally connected via HART® or a digital fieldbus. The Time of Flight software tool offers additional benefits:
- Menu-guided configuration with graphic support and online help
- Simple and safe diagnosis via extensive envelope curve analysis, graphic evaluation assistance and event-driven data recording
- Detailed measuring point documentation

**Configuration**
With the support of the connection assistant, the connection from the PC to the instrument is established first. The configuration editor then guides you from basic calibration to measuring point optimization. The menu of the software is structured in a similar way to the display but offers context-dependent help text for additional support. Clearly structured diagrams assist in the entry of respective parameters. Of course, all instrument information may be stored (uploaded) and, if required, rewritten into the instrument (downloaded).

**Measuring point documentation**
ToF operating software generates documentation in PDF format. All of the information, for example, all instrument parameters and the envelope curves are represented. The cover sheet of documentation can be individually designed to include a company logo or a photograph for example. The memory-saving PDF format simplifies electronic archiving.

**Diagnosis functions**
The graphic representation of the envelope curve and the various analysis functions are an integral part of this ToF software and facilitate easy diagnosis of all aspects of the measuring point. They permit, for example, an assessment of the signal quality and thus of the reliability of measurements, the analysis of process influences or the storage (also time or event-controlled) and retrieval of envelope curves.

The most important parameters are displayed by the envelope curve
Radar level measurement

Micropilot S/M

Non-contact measurement in liquids and bulk solids

Radar level measurement is a safe solution for liquids under extreme process conditions (pressure, temperature) and vapors. The development of this measuring principle led to its use in bulk solids applications as it is unaffected by dust and noise.

Advantages at a glance
- Non-contact measurement (free of wear and tear) that can be used in extreme process conditions
- Vapors or dusty media do not affect the measurement
- Safe measurement in vessels with changing product

Functional principle
Micropilot uses high-frequency radar pulses which are emitted from an antenna and reflected by the product surface. The Time of Flight $t_o$ of the reflected radar pulses is directly proportional to the path traveled $d$.

$$d = \frac{c \cdot t_o}{2}$$

$c =$ speed of light 186,400 miles/s (300,000 km/s)

Taking the tank geometry into consideration, the level can be calculated from this value.

Measuring frequencies
The frequencies used by radar instruments are approximately 6 and 26 GHz.

26 GHz
- Unaffected by tank baffles due to small beam angles starting at 4°
- High accuracy starting from .12 in (3 mm)

6 GHz
- Low impairment through boiling, turbulent surfaces as well as condensate, build-up or foam
**Micropilot M in liquids**
2-wire radar level gauge for storage and process applications.
- Different antenna designs, suitable for aggressive media
- Flush fitting for hygiene applications
- Gas-tight feed-through for toxic and aggressive media
- Antistatic rod antenna

**Micropilot M in bulk solids**
2-wire radar level gauge for powders and bulk solids.
- Parabolic antenna for large measuring ranges up to 230 ft (70 m)
- Integrated purging air connection
- Alignment device for adjustment to product surface

**Micropilot S**
Radar level device for precision measurement in inventory management (tank gauging).
- Accuracy ±.04 in (±1 mm) in 130 ft (40 m) measuring range
- Approved for custody transfer
- Numerous national calibration certificates

---

<table>
<thead>
<tr>
<th>Type</th>
<th>FMR230</th>
<th>FMR231</th>
<th>FMR240</th>
<th>FMR244</th>
<th>FMR245</th>
<th>FMR250</th>
<th>FMR 530/531/532/533</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring range - ft (m)</td>
<td>65 ft (optional 115 ft) (20 m (optional 35 m))</td>
<td>230 ft (70 m)</td>
<td>130 ft (40 m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature - °F (°C)</td>
<td>-76° to 752°F (-60° to 400°C)</td>
<td>-40° to 302°F (-40 to 150°C)</td>
<td>-40° to 302°F (-40 to 150°C)</td>
<td>-40° to 266°F (-40 to 130°C)</td>
<td>-40° to 302°F (-40 to 150°C)</td>
<td>-40° to 392°F (-40 to 200°C)</td>
<td>-40° to 392°F (-40 to 200°C)</td>
</tr>
<tr>
<td>Pressure - psi (bar)</td>
<td>-15 to 320 psi (-1 to 22 bar)</td>
<td>-15 to 580 psi (-1 to 40 bar)</td>
<td>-15 to 580 psi (-1 to 40 bar)</td>
<td>-15 to 45 psi (-1 to 3 bar)</td>
<td>-15 to 230 psi (-1 to 16 bar)</td>
<td>-15 to 230 psi (-1 to 16 bar)</td>
<td>-15 to 930 psi (-1 to 64 bar)</td>
</tr>
<tr>
<td>Accuracy - in (mm)</td>
<td>±.39 in (±10 mm)</td>
<td>±.12 in (±3 mm)</td>
<td>±.59 in (±15 mm)</td>
<td>±.04 in (±1 mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>4 – 20 mA/HART®, PROFIBUS-PA, FOUNDATION™ Fieldbus</td>
<td>4 – 20 mA/HART®</td>
<td>4 – 20 mA/HART®</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Guided radar level measurement

Levelflex M

Measurement in liquids and bulk solids

Guided radar pulse measurement is suited for both bulk solids (cable probes) and liquids (rod and coax probes). The surface condition of the medium is of minor importance due to the safe guidance of the reflected waves. Different angled surfaces or outflow funnels in bulk solids do not influence measurement. Reliable measurement is safeguarded in turbulent liquid surfaces or foam formation.

Advantages at a glance

- Safe measurement in bulk solids and in applications with strong dust formation
- Reliable measurement in liquids with turbulent surfaces and foam formation
- Simple commissioning due to pre-calibrated sensor
- High reliability due to automatic probe monitoring (patented EOP Algorithm)

Functional principle

Levelflex M uses high-frequency radar pulses guided along a probe. The characteristic impedance changes as pulses meet the surface of the medium and part of the transmitted pulses are reflected. The time between transmission and reception of the reflected pulse is measured and analyzed by the instrument which provides a direct value for the distance between the process connection and the medium surface.

Liquids or Solids
Levelflex M
- Rod version: replaces traditional measurement methods in liquids (for example: bubblers or floaters)
- Cable version: predominantly in powdery to granular bulk solids
- Coax version: unaffected by all baffles in liquid tanks

Levelflex M
PFA/PTFE-coated rod and cable probe.
- For aggressive and corrosive liquids
- Meets the highest hygiene requirements by FDA-listed materials and process connection

Levelflex M
High pressure/high temperature probe for liquids.
- Ideal replacement for mechanical methods in bypasses (displacers)
- Second gas-tight feed-through guarantees safe feed-through sealing in toxic media

<table>
<thead>
<tr>
<th>Type</th>
<th>FMP40</th>
<th>FMP41C</th>
<th>FMP45</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cable</td>
<td>Rod</td>
<td>Coax</td>
</tr>
<tr>
<td>Measuring range - ft (m)</td>
<td>115 ft (35 m)</td>
<td>13 ft (4 m)</td>
<td>13 ft (4 m)</td>
</tr>
<tr>
<td>Temperature - °F (°C)</td>
<td>-40° to 302°F (-40 to 150°C)</td>
<td>-40° to 302°F (-40 to 200°C)</td>
<td>-330° to 752°F (-200° to 400°C)</td>
</tr>
<tr>
<td>Pressure - psi (bar)</td>
<td>-15 to 580 psi (-1 to 40 bar)</td>
<td>-15 to 580 psi (-1 to 40 bar)</td>
<td>-15 to 5,800 psi (-1 to 400 bar)</td>
</tr>
<tr>
<td>Min. Δk value</td>
<td>1.6</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Output</td>
<td>4 - 20 mA/HART®, PROFIBUS-PA, FOUNDATION™ Fieldbus</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Ultrasonic level measurement

Prosonic S/M/T

Non-contact measurement in liquids, pastes and bulk solids

The ultrasonic method is a tried and tested, as well as cost-effective solution for level measurement in liquids and bulk solids. Instruments are available as compact or remote versions. This measuring principle is characterized by easy planning and assembly, fast and safe commissioning, as well as a long service life and reduced maintenance expenditure. Typical applications are abrasive and aggressive media, but Prosonic can also be used in harsh environments.

Functional principle
The Prosonic family works with ultrasonic pulses which are reflected from the medium surface by the density change between air and the medium. The time between transmission and reception of the pulse is measured and analyzed by the instrument, which then provides a direct value for the distance between the sensor diaphragm and the medium surface.

Advantages at a glance
• Unaffected by product properties (for example: dielectric constant, density or moisture)
• Easy and fast commissioning due to preset application parameters
• Calibration without filling or discharging

Liquids or Solids
**Prosonic T**
2-wire ultrasonic device with compact design.
- For simple applications in open tanks and storage tanks
- As a relay variant for level limit detection (for example: at belt feed points)

**Prosonic M**
2-wire or 4-wire device with compact design.
- For sophisticated level measurement in liquids and bulk solids in storage tanks, agitators, on stockpiles and conveyor belts

**Prosonic S**
Ultrasonic measuring system for demanding applications, consisting of a transmitter (in a top-hat rail or field housing) and a sensor.
- Level measurement
- Flow measurement in open channels
- Pump and screen control

<table>
<thead>
<tr>
<th></th>
<th><strong>Prosonic T</strong></th>
<th><strong>Prosonic M</strong></th>
<th><strong>Prosonic S</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>FMU230</td>
<td>FMU231</td>
<td>FMU90</td>
</tr>
<tr>
<td><strong>Measuring range</strong></td>
<td>13 ft (4 m)</td>
<td>23 ft (7 m)</td>
<td>16 ft (5 m)</td>
</tr>
<tr>
<td>liquid</td>
<td>16 ft (8 m)</td>
<td>33 ft (10 m)</td>
<td>40 ft (15 m)</td>
</tr>
<tr>
<td>solids</td>
<td>6.5 ft (2 m)</td>
<td>11 ft (3.5 m)</td>
<td>16 ft (5 m)</td>
</tr>
<tr>
<td></td>
<td>23 ft (7 m)</td>
<td>33 ft (10 m)</td>
<td>49 ft (15 m)</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>-40° to 176°F (−40° to 80°C)</td>
<td>-40° to 176°F (−40° to 80°C)</td>
<td>-40° to 203°F (−40° to 95°C)</td>
</tr>
<tr>
<td><strong>Pressure</strong></td>
<td>10 to 44 psi (0.7 to 3 bar)</td>
<td>10 to 44 psi (0.7 to 3 bar)</td>
<td>10 to 44 psi (0.7 to 3 bar)</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td>4 - 20 mA/FOUNDATION™ Fieldbus</td>
<td>4 - 20 mA/HART®, PROFIBUS-PA,</td>
<td>4 - 20 mA/HART®, PROFIBUS-DP</td>
</tr>
</tbody>
</table>
Capacitance

Multicap family

Measurement in liquids

Capacitive level measurement covers a wide range of applications which are not limited to process engineering. Simple and cost-effective probes offer a wealth of possibilities for level monitoring in liquids, particularly in small tanks, build-up forming media and extremely high temperatures.

Advantages at a glance
- Accurate measurement in small tanks due to short response times
- Measurement from probe end to process connection, no blocking distance
- Technology tried and tested in millions of applications
- Interface measurement independent of emulsion layers

Functional principle
The principle of capacitive level measurement is based on capacity change. An insulated electrode makes a capacitor with the tank. The capacitance depends on the product level – an empty tank has a lower capacitance while a filled tank has a higher capacitance.
**Multicap**
Diverse instrument variants combined in a modular system.
- Different probe designs
- Self-compensating cone seal safeguards long-term stability
- Gas-tight feed-through protects against toxic media

**High temperature probe**
Design and materials allow use under extreme process conditions.
- Process temperatures up to 752°F (400°C)
- Process pressures up to 7,250 psi (500 bar)

<table>
<thead>
<tr>
<th>Multicap family</th>
<th>Probes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>DC12Tx</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td>Rod probe</td>
</tr>
<tr>
<td><strong>Measuring range - ft (m)</strong></td>
<td>10 ft (3 m)</td>
</tr>
<tr>
<td><strong>Temperature - °F (°C)</strong></td>
<td>-110° to 392°F (-80° to 200°C)</td>
</tr>
<tr>
<td><strong>Pressure - psi (bar)</strong></td>
<td>-15 to 360 psi (-1 to 25 bar)</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td>4 - 20 mA/HART®, PFM, 3-wire, PROFIBUS-PA</td>
</tr>
</tbody>
</table>

[Icons]
Hydrostatic level measurement

Waterpilot, Deltapilot S, Deltabar S

Level measurement in liquids

Hydrostatic pressure sensors for level measurement may be used in virtually all liquid media, from water to pastes and sludges. Even under difficult process conditions these sensors may be adjusted to the application in an optimum fashion. Differential pressure transmitters are used for level measurement in pressurized tanks as well as in abrasive and corrosive media.

Advantages at a glance
- Tried and tested measuring principle for temperatures up to 662°F (350°C) and pressures up to 6,100 psi (40 bar)
- Measurement unaffected by tank design or surface foam
- Hygienic instrument designs
- Water/wastewater designs
- Process industry designs

Functional principle
Hydrostatic level measurement is based on the determination of hydrostatic pressure generated by the height of the column of fluid. The pressure is calculated on the basis of the following formula:

\[ P = h \cdot \rho \cdot g \]

- \( P \) = Pressure
- \( h \) = Level
- \( \rho \) = Specific weight (density)
- \( g \) = Gravity (constant)

In constant medium density the height \( h \) is the only variable in this equation. The pressure is thus a direct level measure. Hydrostatic pressure sensors consist either of a dry capacitive measuring diaphragm of ceramics or a silicon sensor with a metal diaphragm.
**Waterpilot**
Level measurement in fresh water, wastewater and salt water.
- Durable 316 SS housing in configurations for fresh water, wastewater and salt water
- Robust housing with the smallest probe diameter (.87 inch (22 mm))
- High accuracy ceramic sensor
- Integrated temperature sensor optional
- Drinking water certificate

**Deltapilot S**
CONTITE™ measuring cell – condensate-resistant, high long-term stability.
- Hygienic instrument design for foods and pharmaceuticals – fast recovery after CIP
- Compact design
- Remote housing design for wash down applications
- Active temperature compensation

**Deltabar S**
Applications in pressurized tanks, for example, in the chemical and petrochemical industry.
- Robust sensor technology with high overload resistance
- High accuracy and long-term stability
- Fault and performance monitoring from the measuring cell to electronics

<table>
<thead>
<tr>
<th></th>
<th>Waterpilot</th>
<th>Deltapilot S</th>
<th>Deltabar S</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>FMX167</td>
<td>DB50S</td>
<td>DB50</td>
</tr>
<tr>
<td><strong>Measuring range – psi (bar)</strong></td>
<td>1.5 to 290 psi (3 ft H₂O min) (0.1 to 20 bar)</td>
<td>1.5 to 60 psi (40 in H₂O min) (0.1 to 4 bar)</td>
<td>Up to 43.5 psi (Up to 3 bar)</td>
</tr>
<tr>
<td><strong>Temperature – °F (°C)</strong></td>
<td>-4° to 158°F (-20° to 70°C)</td>
<td>14° to 212°F (-10° to 100°C)</td>
<td>14° to 176°F (-10° to 80°C)</td>
</tr>
<tr>
<td><strong>Sensor</strong></td>
<td>Ceramic</td>
<td>CONTITE™</td>
<td>Ceramic</td>
</tr>
<tr>
<td><strong>Accuracy (%)</strong></td>
<td>0.2</td>
<td>0.2 (option of 0.1)</td>
<td>0.075</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td>4 – 20 mA</td>
<td>4 – 20 mA/HART®, PROFIBUS-PA, FOUNDATION™ Fieldbus</td>
<td></td>
</tr>
</tbody>
</table>
One measuring principle for many different applications

Mechatronics – the solution for level limit detection in liquids and solids

Endress+Hauser led the way for safe and reliable level monitoring worldwide with the invention of the vibration principle almost 40 years ago. Today, level limit detection has become an indispensable variable in process engineering. Float switches, capacitive, inductive, optical and ultrasonic switches are among those used for this purpose. The application and medium limitations of purely mechanical or purely electronic systems prompted Endress+Hauser to combine both systems into one measuring principle – the vibrating limit switches for liquids and bulk solids. State-of-the-art development tools such as the Finite Element Method, new production technologies and constant development have made a mechatronic success story of these limit switches.

Advantages at a glance

- Reliable in more than 3 million applications worldwide
- Safe operation due to mechatronics
- May be used in all industries independent of media
- Safety-oriented switching without calibration – also in case of an error
- Automatic monitoring is included in every Liquiphant or Soliphant M instrument
- Universal in any medium

- Universally useable in the presence of air bubbles and foam (foam is not recognized as liquid)
- Universally useable for the detection of solids under water
- Universally useable in all pumpable liquids up to a viscosity of 10,000 mm²/s (cSt)
- Universally useable because of the independence of flow properties of bulk solids
- Universally useable in solids level measurement

Limit switches for liquids register the frequency shift which occurs as the fork is submerged in liquid.

In limit switches for bulk solids, damping of the oscillation is recognized and a switching signal is issued if it falls below a certain amplitude.
In any industry

Competence in liquids
Safe measurement in demanding applications

Increased process temperatures
Level limit measurement at process temperatures up to 536°F (280°C) (572°F (300°C) for maximum 40 hours) are no problem for the Liquiphant S FTL70/71. The requirements of materials and the development of instruments increase drastically in process temperatures above 390°F (200°C). Extreme requirements can only be realized by careful selection of suitable materials using state-of-the-art technologies and load simulation. Perfectly matched materials are required for permanent and reliable performance in extreme temperature fluctuations.

Hygiene design
The Liquiphant hygiene line meets food requirements with polished sensors, respective connections and stainless steel housings.
- Common connections, for example, sanitary, Varivent, DRD, TriClamp™ and NEUMO guarantee conformity.
- The stainless steel housing is characterized by its resistance to aggressive cleaning agents and offers the benefits of no dead space, due resistance and easy cleaning.

3.1.B certified materials
Process safety and reproducibility are terms which are becoming increasingly important, therefore, Endress+Hauser offers all parts in contact with the medium. For example, sensor and welding supplies in 3.1.B certified materials.

Second process separation
A pressure, gas or diffusion-tight feed-through as second line of defense prevents the medium from escaping into the atmosphere. Liquiphant M offers this second line of defense as an option and it comes standard in Liquiphant S FTL70/71.

In any industry
A decisive advantage of the vibration principle is its mode of operation. Level limits are recognized and remain unaffected by the physical properties of the medium such as conductivity, dielectric constant, viscosity, changes in density, pressure or temperature. In addition, turbulence, foam or bubbles do not impair the operation. These unique performance features allow Liquiphant and Soliphant to be used in all process engineering industries.

The most important industries include
- Chemical/petrochemical industry
- Pharmaceuticals (3.1.B and C.O.C)
- Foods
- Environment
- Energy
- Primaries

No mechanically moving parts and no need for calibration are some benefits of choosing vibration limit switches. Together with integrated automatic monitoring, this leads to a reliable system which has gained great recognition in process automation.
Vibrating level measurement

Liquiphant S/M/T

Level limit detection in liquids

The instruments of the Liquiphant family reliably monitor the level limits of all pumpable liquids in tanks and pipes. There are numerous applications from simple operational level limit detection (minimum and maximum control), WHG-certified leakage monitoring and overspill protection through to protective equipment in plant parts subject to Safety Integrity Levels.

Advantages at a glance
- Unaffected by medium properties such as conductivity, dielectric constant, viscosity, pressure and temperature
- Highest degree of reliability and service life, even under extreme process conditions
- Tried and tested instruments

Functional principle
A tuning fork sensor is excited to its resonant frequency. The drive works piezoelectrically. The oscillating frequency or the amplitude changes as the fork enters the medium. The change is analyzed and translated into a switching signal.
**Liquiphant T**
Compact instrument for simple and hygienic applications.
- Very small instrument dimensions
- Hygienic stainless steel design
- External function testing

**Liquiphant M**
Diverse instrument variants in a modular system.
- Different construction lengths
- Process connections, housings
- Numerous electronic interfaces
- Special designs

**Liquiphant S**
For highest process requirements and safety.
- Process temperatures up to 540°F (280°C)
- Recurrent examination according to WHG is not required (FDL60/61)
- Functional safety SIL3

---

<table>
<thead>
<tr>
<th>Type</th>
<th>Liquiphant T</th>
<th>Liquiphant M</th>
<th>Liquiphant S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>FTL20</td>
<td>FTL260</td>
<td>FTL0/FTL60</td>
</tr>
<tr>
<td>Sensor length - in (mm)</td>
<td>1.5 in (38 mm)</td>
<td>5 in (128 mm)</td>
<td>2.5/6 to 235 in (65/148 to 6,000 mm)</td>
</tr>
<tr>
<td>Temperature - °F (°C)</td>
<td>-40° to 300°F (-40° to 150°C)</td>
<td>-60° to 300°F (-50° to 150°C)</td>
<td>-70° to 540°F (-60° to 280°C)</td>
</tr>
<tr>
<td>Pressure - psi (bar)</td>
<td>-14.5 to 580 psi (-1 to 40 bar)</td>
<td>-14.5 to 928 psi (-1 to 64 bar)</td>
<td>-14.5 to 580 psi (-1 to 100 bar)</td>
</tr>
<tr>
<td>Process connections</td>
<td>G ½&quot;, ¾&quot;, 1&quot; Hygiene</td>
<td>G ½&quot;, 1&quot;, Flange DIN/EN, ANSI, JIS</td>
<td>G 1&quot;, Flange DIN/EN, ANSI, JIS</td>
</tr>
<tr>
<td>Output</td>
<td>AC, DC, ASi-Bus</td>
<td>AC, DC, AC/DC relay, NAMUR, 8/16 mA, PFM, PROFIBUS-PA</td>
<td>PFM</td>
</tr>
</tbody>
</table>
Vibrating level measurement

Soliphant II/T

Level limit detection in bulk solids

The Soliphant range offers robust level limit switches for applications in powdery, fine-grained and lumpy bulk solids and solids with low density, for example, caused by fluidizing. The different designs allow application diversity – Soliphant can even be used in hazardous areas. Typical examples are found in primaries (cement, plaster), the chemical industry (plastic granules, detergents), the food industry (flour, sugar) and animal feed production (wheat, corn).

Advantages at a glance
- Unaffected by medium properties such as conductivity, dielectric constant, pressure and temperature
- Large range of applications due to fork and single-rod oscillation system
- Highest degree of reliability and service life, even under extreme process conditions

Functional principle
A single-rod or fork oscillating system is used as a sensor in the Soliphant family. The oscillating system (single rod/fork) is excited to its resonant frequency. The oscillation amplitude is damped as the product covers the sensor. Maintenance and calibration or specific settings are not required. External vibration or flow properties of the medium do not impair measurement.
### Soliphant T
Compact single-rod sensor or with tube extension.
- No incorrect switching due to jamming medium
- Unaffected by external vibration due to detached drive

### Soliphant II
Cost-effective vibration level switch for fine-grained bulk solids.
- Different construction lengths
- Process connections, housings
- Numerous electronic interfaces
- Special designs

### Further applications
- Filling nozzle disconnection at a loading station
- Solids detection underwater

---

<table>
<thead>
<tr>
<th></th>
<th>Soliphant T</th>
<th>Soliphant II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>FTM20</td>
<td>FTM30/50</td>
</tr>
<tr>
<td>Sensor length - in</td>
<td>10 in (250 mm)</td>
<td>8.5/9 in (215/230 mm)</td>
</tr>
<tr>
<td>(mm)</td>
<td>20/40/60 in (500/1,000/1,500 mm)</td>
<td>8 to 155 in (200 to 4,000 mm)</td>
</tr>
<tr>
<td>Temperature - F° (°C)</td>
<td>-40° to 300°F (-40° to 150°C)</td>
<td>-40° to 300°F (-40° to 150°C)</td>
</tr>
<tr>
<td>Pressure - psi (bar)</td>
<td>-14.5 to 360 psi (-1 to 25 bar)</td>
<td>-14.5 to 230 psi (-1 to 16 bar)</td>
</tr>
<tr>
<td>Density - lb/ft³ (g/l)</td>
<td>From 12.5 lb/ft³ (200 g/l)</td>
<td>From 1.2 lb/ft³ (20 g/l)</td>
</tr>
<tr>
<td>Output</td>
<td>DC, AC/DC relay</td>
<td>AC, DC, AC/DC relay, 8/16 mA, NAMUR, PFM</td>
</tr>
</tbody>
</table>
Capacitance

Minicap, Nivector, Solicap M, Multicap family

Level limit detection in liquids and bulk solids

Capacitive level measurement covers a wide range of applications which are not limited to process engineering. Simple and cost-effective probes offer many possibilities for level limit detection in liquids and bulk solids. This measuring principle is particularly suited to applications involving aggressive media and heavy build-up.

Functional principle

The capacitive level measurement principle is based on the capacity change of a capacitor due to a change in level. The probe (rod or cable) and the silo wall form the two electrodes of a capacitor. As product (dielectric constant > 1) enters the electric field between the probe and the silo wall the capacity increases. This capacity change is analyzed and leads, with the appropriate setting, to switching.

Advantages at a glance

- Tried and tested technology
- Universally adaptable probes
- Reliable performance also in viscous media or heavy build-up

The sensors are largely unaffected by low build-up formation as long as the product does not create a bridge between the probe and the silo wall. Probes with active build-up compensation are used for media prone to strong build-up.
**Multicap family**
Modular family system for applications in highly viscous liquids.
- Temperatures from -112° to 39°F (-80° to 00°C)
- Reliable level limit detection due to active build-up compensation
- Self-compensating cone construction for high long-term stability

**Nivector, Minicap**
Preferred in small tanks with powdery to fine-grained bulk solids.
- Calibration not required
- Small, compact design
- Easy sensor exchange in full silo by protector
- Integrated active build-up compensation

**Solicap M, high temperature probes**
Robust instrument design for fine-grained to coarse-grained bulk solids.
- Rod, sword and cable design
- Modular system
- High tensile strength up to 6 t
- Process temperatures up to 752°F (400°C)

---

**Type** | Nivector | Minicap | Solicap M | Multicap
--- | --- | --- | --- | ---
**Design** | FTC968 | FTC60 | FTC51 | FTC53 | DC16Tx | DC16, DC16Ex
**Sensor length - in (mm)** | Compact | Compact | Cable | Rod | Cable | Rod | Rod
- Front-flush | 5.5 in (140 mm) | 8 to 236 in (200 to 6,000 mm) | 8 to 157 in (200 to 4,000 mm) | 20 to 866 in (500 to 22,000 mm) | 4 to 120 in (100 to 3,000 mm) | 4 to 157 in (100 to 4,000 mm)
**Temperature - °F (°C)** | -4° to 176°F (-20° to 80°C) | -40° to 248°F (-40° to 120°C) | -40° to 176°F (-40° to 80°C) | -4° to 176°F (-20° to 80°C) | -4° to 248°F (-20° to 120°C) | -40° to 392°F (-40° to 200°C) | -112° to 392°F (-80° to 200°C)
**Pressure - psi (bar)** | -14.5 to 90 psi (-1 to 6 bar) | -14.5 to 360 psi (-1 to 25 bar) | -14.5 to 90 psi (-1 to 6 bar) | -14.5 to 145 psi (-1 to 10 bar) | Unpressurized | -14.5 to 360 psi (-1 to 25 bar) | -14.5 to 1,450 psi (-1 to 100 bar)
**Output** | DC, AC | DC, AC/DC relay | DC, AC/DC relay, PFM | DC, AC/DC relay, PFM, 3-wire
Liquipoint T, Probes
Level limit detection in liquids

The conductive measuring principle offers the possibility for simple, safe detection of a limit value in conductive liquids. From secure inventories (minimum quantity) and the avoidance of tank overflow, to two-point and multi-point control (pump control), Liquipoint T performs.

Advantages at a glance
- Simple, cost-effective principle
- Multi-point detection with one process connection
- Liquid food applications with FDA-compliant materials

Functional principle
A change in resistance between two conductors (electrodes) due to the presence or absence of a medium leads to a switching signal. In single-rod probes, the metallic tank wall serves as a counter electrode. If the probe is not covered, the resistance between probe and wall is theoretically infinite. As the medium covers the probe (conductive connection to the tank), the resistance assumes a finite value. A current flows and is translated into a switching signal. The smallest medium conductibility which can be calibrated amounts to 5 µS/cm.

Liquipoint T, Probes
Modular probe system for optimum adaptation to the application.
- 1 to 5 rod and cable probes
- Compact or separate instrumentation
- Front-flush solution for pipes

<table>
<thead>
<tr>
<th>Type</th>
<th>Measuring range (mm)</th>
<th>Temperature (°F/°C)</th>
<th>Pressure (psi/bar)</th>
<th>Process connections</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTW31 [rod]</td>
<td>4 to 157 in (100 to 4,000 mm)</td>
<td>-40° to 158°F (-40° to 70°C)</td>
<td>-14.5 to 145 psi (-1 to 10 bar)</td>
<td>G 1½&quot;</td>
<td>DC, AC/DC relay, NAMUR, switching unit FTW325</td>
</tr>
<tr>
<td>FTW32 (cable)</td>
<td>10 to 590 in (250 to 15,000 mm)</td>
<td>-4° to 212°F (-20° to 100°C)</td>
<td>-14.5 to 145 psi (-1 to 10 bar)</td>
<td>G ¾&quot;</td>
<td>AC/DC relay</td>
</tr>
<tr>
<td>FTW360</td>
<td>Front-flush</td>
<td>14° to 212°F (-10° to 100°C)</td>
<td>-14.5 to 145 psi (-1 to 10 bar)</td>
<td>G ½&quot;</td>
<td>Switching unit FTW325</td>
</tr>
<tr>
<td>11371</td>
<td>2 to 79 in (50 to 2,000 mm)</td>
<td>-328° to 482°F (-200° to 250°C)</td>
<td>-14.5 to 2,320 psi (-1 to 160 bar)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11961Z</td>
<td>6 to 79 in (150 to 2,000 mm)</td>
<td>-38° to 48°F (-0° to 50°C)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Paddle switch

Soliswitch
Level limit detection in bulk solids

The universally usable paddle limit switch is employed as a full, empty and requirement alarm in silos with bulk solids. It is ideal for flowing bulk solids up to a grain size of 2" (50 mm).

Functional principle
The principle is based on the moment of resistance change of a rotating paddle in air or a medium. The electrically driven, slowly rotating paddle (frequency < 1 Hz) is on the level of the selected limit. The rising product brakes the rotation, the hinge-mounted drive system changes its position and triggers a microswitch. As the level moves down, the drive returns to its original position by spring force and the microswitch restarts the motor.

Advantages at a glance
- Simple and cost-effective
- Tried and tested in operation

<table>
<thead>
<tr>
<th>Soliswitch</th>
<th>FTE30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>FTE30</td>
</tr>
<tr>
<td>Sensor length - in (mm)</td>
<td>3 to 79 in (75 to 2,000 mm)</td>
</tr>
<tr>
<td>Temperature - °F (°C)</td>
<td>-4° to 176°F (-20° to 80°C)</td>
</tr>
<tr>
<td>Pressure - psi (bar)</td>
<td>-7 to 12 psi (-0.5 to 0.8 bar)</td>
</tr>
<tr>
<td>Process connections</td>
<td>G 1½&quot;</td>
</tr>
<tr>
<td>Output</td>
<td>Potential-free change-over contact</td>
</tr>
</tbody>
</table>

Diverse instrument designs allow use in different application conditions.
- Slip clutch prevents impact on the paddle
- Reinforced instrument design (lateral load max 1500 N) for coarse-grained bulk solids
Certified quality

Our goal is performance
Test Center: Endress+Hauser USA

The Endress+Hauser Test Center (internationally accredited: DATECH, FM, CSA) has three laboratories – for instrument safety, application engineering and electromagnetic compatibility. The different test facilities enable us to ensure and improve the reliability and the quality of Endress+Hauser instruments under realistic test conditions. In addition, the instruments can be tested for new applications in advance, for example, during their development phase. In different “endurance tests” they are exposed to the same extreme conditions which are expected in later applications. These include tests involving dust (explosion protection), abrasion and attrition, temperature and moisture, mechanical stress tests and splash water. Apart from a fully automatic tank test facility of 1,585 gallons which enables us to simulate even the most difficult applications, the Endress+Hauser Test Center also operates an accredited EMC laboratory.

Advantages at a glance
- Measurements are traceable and reproducible at any time
- Combined theoretical and practical instrument safety
- Accredited EMC laboratory according to EN 45 001 requirements

Calibration

Quality has many components. On a company radar reference section, instruments are calibrated (if requested, under the supervision of a Bureau of Standards officer) with an absolute accuracy of 0.5 mm (2 sigma value) based on the international OIML R85 requirements. This calibration is recognized by numerous national calibration authorities (PTB, NMI, BEV, etc.) and constitutes the basis for the employment of the instruments in public custody transfer applications, for example, tank farms, ports, airports. Endress+Hauser offers complete inventory management systems for such applications.
Safety starts with selection

Endress+Hauser’s broad range of measuring principles offers users a custom-made solution for their applications. A solution which not only satisfies the technical requirements, but also provides the right price-performance ratio.

Software tools for safe selection

Applicator
Our Applicator program for the selection and design of process instruments has been tried and tested in practical applications for more than 20 years. Step-by-step, Applicator requests details on all important parameters. After the process limits have been entered, Applicator proposes suitable measuring principles or instrument range for the application.

But Applicator can do more than that:
- Easy and safe design of measuring points
- Project documentation (acquisition, archiving and retrieval of design results)
- Extensive databases with details of more than 300 media
- Conversion function for physical units

Safety-oriented instrumentation with SIL

The process industry demands the highest degree of safety and reliability from the components of distributed control systems (DCS). Endress+Hauser is the leading provider of SIL-certified instruments (Safety Integrity Level) in level, pressure, flow and temperature sensor technology.

The safety level required for a process plant is classified according to the international IEC 61511 standard and depends on the risk inherent in the plant. In order to reduce the risk to people, the environment and the plant, IEC 61508, the international standard for functional safety, describes the guidelines for instruments in protective functions. A DCS protection facility usually consists of an instrument, a control part and an actuator. Both standards subdivide plants and equipment into four safety categories – from SIL1 for low risks through to SIL4 for very high risks.

W@M
Web-Enabled Asset Management

To achieve the efficient asset management of instruments, access to all traceable technical and commercial data that pertains to each instrument’s life-cycle is of the utmost importance. Our W@M (Web-enabled Asset Management) is an enterprise portal, available on Internet, which enables a real-time access to all relevant data for the instrument’s maintenance until its replacement. From the time the instrument is selected until it is removed from the process, including procurement, installation, start-up and operation, you may link to the Endress+Hauser databases to access all technical documentation relative to the device and get all relevant information for easy follow-up of its measurement.
Endress+Hauser’s product portfolio

**Level**
- Capacitance (RF)
- Conductive
- Mechanical
- Vibrating
- Ultrasonic
- Radar
- Guided radar (TDR)
- Hydrostatic

**Pressure**
- Gauge/absolute
- Differential pressure
- Hydrostatic

**Flow**
- Electromagnetic
- Vortex shedding
- Coriolis mass flow
- Ultrasonic
- Open channel
- D/P flow

**Liquid Analysis**
- Conductivity
- pH/ORP
- Chlorine
- Dissolved oxygen
- Turbidity
- Chemical analyzers
- Nitrate/organic sensors
- Sludge level

**Temperature**
- Temperature transmitters
- RTDs/thermocouples
- Sensors

**Components**
- Displays
- Active barriers
- Process transmitters
- Power supplies

**Service**
- Start-up
- Training
- Calibration
- Maintenance contracts
- Instrument Management Solutions

**Recorders**
- Paperless recorders
- Visual data managers
- Safety data managers

**Endirect**
www.us.endress.com/e-direct
- Shop on-line for low-cost instruments, devices and components

---

<table>
<thead>
<tr>
<th><strong>USA</strong></th>
<th><strong>Canada</strong></th>
<th><strong>Mexico</strong></th>
<th><strong>International</strong></th>
</tr>
</thead>
</table>
| Endress+Hauser, Inc.  
2350 Endress Place 
Greenwood, IN 46143 
Tel. 317-535-7138 
Sales 888-ENDRESS 
Service 800-642-8737 
Fax 317-535-8498 
inquiry@us.endress.com 
www.us.endress.com | Endress+Hauser Canada  
1075 Sutton Drive 
Burlington, ON L7L 5Z8 
Tel. 905-681-9292 
800-668-3199 
Fax 905-681-9444 
www.ca.endress.com | Endress+Hauser Mexico, S.A. de C.V. 
Av. Gustavo Baz No. 43 
Fracc. Bosques de Ecatepec 
Naucalpan de Juárez, C.P. 53310, 
Estado de México 
MEXICO 
Tel. (5) 55-5371-1110 
Fax (5) 55-5371-1128 
eh.mexico@mx.endress.com | For International locations 
visit: www.endress.com/worldwide |

---

For International locations
visit: www.endress.com/worldwide

---

Endress+Hauser
People for Process Automation