Intelligent technology for optimizing production
Measurement solutions for unconventional energy resources
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As a world leader in industrial process instrumentation KROHNE provides an extensive range of solutions and products for analysis, flow, level, temperature, in-line real-time viscosity and pressure measurement for a wide variety of applications and operating environments.

With more than 3,000 employees across the world, we provide our services on a global scale. When it comes to process measurement, our level of expertise is unique – not just with standard applications but, in particular, with any challenges that demand customized solutions for even the harshest conditions.

Our portfolio covers all sectors of the oil and gas industry: from exploration and production to transportation; from refining to distribution; and from storage to retail.

Consistently accurate results, reliable operation with minimum downtime and maintenance are key for any production environment. KROHNE develops and manufactures all critical hardware and software products in-house. This means that we are able to commit ourselves to the highest level of support you will experience from any single partner.

Contact us to discuss your measurement challenges now. We will be pleased to tell you more about what we can do for you.
The huge amounts of drilling fluids or “muds” used for different functions such as the removal, suspension and release of cuttings, control of formation pressures, maintaining wellbore stability as well as cooling and lubricating the bit and drilling assembly are critical for the efficiency of the drilling process. Choosing the correct drilling fluids (e.g. water-, oil- or synthetic-based muds) and the composition of each fluid poses a real challenge to the operator.

This challenge also applies to the measurement of drilling fluids. Medium consistency is an important factor and has to be considered when choosing the right flowmeter. Another aspect is the formation of bubbles in the medium. Devices that do not detect the entrained gas or cannot compensate for changes in density may cause measurement errors that eventually lead to decreased efficiency and loss of money.

The reliable measurement of the quality and/or flow rate allows operators to effectively manage their drilling fluids. Lost circulation and kicks can be detected and weighting materials added accurately. This results in improved safety, control and cost effectiveness for the operator.
Both the new OPTIMASS 2400 and OPTIMASS 6400 are the perfect choice for flow measurement of the drilling fluids. These Coriolis mass flowmeters perfectly handle changes in the composition and consistency of the medium.

The formation of bubbles is no longer an issue. With Entrained Gas Management (EGM™), both mass flowmeters ensure reliable measurement results even with high entrained gas contents up to 100%. The drive system can be optimized depending on the application to compensate for less-than-ideal operating conditions.

OPTIMASS flowmeters combine up to seven measuring functions in a single device: mass flow rate, mass counter, density, temperature, volume flow rate, volume counter, and concentration of fluids and gases.

In case of unexpected low flowing velocities, the meter will still measure flow accurately – both meters are capable of high turndown ratios and offer flow rates from 5 kg/h to 2300 t/h / 11 lb/hr to 5 million lb/hr.

OPTIMASS 2400 and OPTIMASS 6400 come with an extensive diagnostics package for the flowmeter and process conditions. The built-in software logs the temperature, density, concentration, velocity and state of the fluid medium. This allows for the identification of gas and solid inclusions.

OPTIMASS flowmeters can be integrated into virtually any process, regardless of the type of installation or external influences such as pipeline vibrations. Since there are no inlet and outlet runs, the compact design and minimal weight of the sensor are a huge advantage during installation.

OPTIMASS 2400
Straight tube Coriolis mass flowmeter

- Large diameter for bulk measurement and custody transfer of liquids and gases
- Easy to drain and clean
- Continuous measurement even with entrained gas from 0 % up to 100 % and/or unstable density
- Excellent capability of high turndown ratios

OPTIMASS 6400
Coriolis mass flowmeter

- Gas and liquid custody transfer approvals
- Continuous measurement even with entrained gas from 0 % up to 100 % and/or unstable density
- Excellent capability of high turndown ratios
Industry standards for the density measurement while drilling are based on off-line measurements, using available tools that are adapted to the rugged environment. They generate viscosity numbers only for the few fixed flowing situations. These sampled measurements at three viscosity points can only provide a rough estimate of the real situation in what is a rapidly changing dynamic environment. What is truly needed is a complete description of the viscosity throughout the full range of the shear rate.

The best answer to this requirement is to provide in-line equipment that can deliver a viscosity measurement throughout the complete sweep of process shear rates.

This is what our VISCOLINE does for the mud. The innovative in-line process rheometer provides accurate and repeatable viscosity measurements for all fluids as a function of the real-time rate of shear. Based on this information, operators can monitor any number of critical viscosity-related processes such as produced oil, drilling mud, fracking fluid blending or diluent fluid handling for optimized performance – dramatically reducing operating costs and waste.
Each VISCOLINE unit is engineered for its specifically intended application or range of applications. The fluid flows through a continuous pipe containing two low pressure drop static mixers. The sensor device measures the pressure drop at both static mixers by means of two differential pressure measurements: \( \Delta P_1 \) and \( \Delta P_2 \). Precise pipe flow rate measurement results are obtained from the integrated OPTIMASS 7000 straight tube Coriolis meter, which is uniquely insensitive to fluid viscosity effects.

From the two pressure drop measurements and the flow rate reading, the fluid flow parameters are processed in the system and the pipeline viscosity is determined. A temperature reading can be useful for thermal correction when a reference measurement is required. Such corrections require laboratory thermal characterization or dual measurement. No mechanical modification is required for accurate measurements of different fluids.
Each wellbore has different properties, so the cement used to support the casing and isolate porous formations also differs. The various cement classes as well as the composition of a cement with additives influence the medium parameters and call for accurate monitoring.

The reliable monitoring of the volume and density makes cementing more efficient. As the operator always knows what and how much of it has been pumped down the wellbore, waste and rework are avoided. When changes are detected, actions can be taken to adjust the cement’s properties. Nevertheless, it is crucial that the measurement devices withstand the harsh conditions such as the abrasion of cement and the high pressure applied during the pumping of the displacement fluid.
Advanced measurement –
OPTIMASS 2400, OPTIMASS 6400, OPTIMASS 7300

The OPTIMASS series set the standard when it comes to the measuring of cement. Mass flow rate, mass counter, density, temperature, volume flow rate, volume counter and concentration are measured in a single device. This allows for an accurate monitoring of the volume and density during cementing, making your process more efficient.

KROHNE offers superior straight or bent tube design mass flowmeters, so customers can choose the best meter for their application. We offer a uniquely straight tube design for minimal pressure drop, high viscous and slurry applications.

The MFC 400 converter offers excellent zero stability, advanced density measurement and a high performance with air entrainment. With the new Entrained Gas Management (EGM™) technology, meters are now able to measure gas entrainment from 0 % up to 100 %.

ALTOFLUX M40 –
Performing under pressure

ALTOFLUX M40 is an electromagnetic flowmeter for the most stringent demands. With its special design, it even withstands working pressures up to 1,422 bar / 20,624 psi and vibrations up to 6g.

Turbine flowmeters that are often used during high-pressure pumping have the disadvantage that they feature a limited resistance to abrasion; therefore, the devices have to be replaced several times per year. Furthermore, their sensitivity to viscosity can lead to measurement errors of up to 5 %. The irethane liner of the ALTOFLUX M40 makes the meter resistant to abrasion, and due to the measurement principle used the influence of viscosity has been eliminated.

These advantages make the ALTOFLUX M40 unique – and the perfect choice for the pumping of displacement and frac fluids.
A lot of equipment is used to perform hydraulic fracturing. This includes trucks or skids for hydrating the concentrates, adding chemicals, blending the frac fluid and pumping the fluid with high pressure. It is critical that each unit properly works independently and in combination with the other units involved in the process.

Each unit used during hydraulic fracturing has different requirements with respect to the instrumentation. The handling of chemicals, on the one hand, and abrasive media like sand and slurries, on the other, require the installation of measurement devices that are designed to match the respective application.
Hydraulic fracturing

Well

Water, sand and chemicals injected into well

Fissures

Shale

Gas flow out

Hydraulic fracturing process
Instrumentation for every stage of hydraulic fracturing

<table>
<thead>
<tr>
<th>Hydration</th>
<th>Chemical mixing</th>
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<tbody>
<tr>
<td><strong>OPTIMASS flowmeters</strong></td>
<td><strong>OPTIMASS flowmeters</strong></td>
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<tr>
<td>For the hydration of the frac concentrate it</td>
<td>Measurements on the chemical mixing unit</td>
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<tr>
<td>is essential to accurately detect the volume</td>
<td>have to be highly precise and the devices</td>
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<tr>
<td>of concentrate and water. The OPTIMASS series</td>
<td>used have to withstand the effects of</td>
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<tr>
<td>is the perfect choice for this application as</td>
<td>different chemicals.</td>
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<td>it includes concentration measurement and</td>
<td>Our OPTIMASS 6400 and OPTIMASS 7300</td>
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<td>offers an extremely high reliability.</td>
<td>Coriolis mass flowmeters are capable to</td>
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<td>meet both requirements in an excellent</td>
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<td>way.</td>
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<td><strong>OPTIMASS 1300</strong></td>
<td><strong>OPTIMASS 6400</strong></td>
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<td><strong>OPTIMASS 2400</strong></td>
<td><strong>OPTIMASS 7300</strong></td>
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<td><strong>OPTIMASS 6400</strong></td>
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<td><strong>OPTIMASS 7300</strong></td>
<td><strong>OPTIMASS 7300</strong></td>
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<tr>
<td><strong>OPTIFLUX 2300 flowmeter</strong></td>
<td>The OPTIMASS 7000 sensor is available in</td>
</tr>
<tr>
<td>The volume of water used during hydration is</td>
<td>duplex stainless steel as well as in</td>
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<tr>
<td>measured with the OPTIFLUX 2300, a reliable</td>
<td>Hastelloy®, titanium and tantalum making</td>
</tr>
<tr>
<td>electromagnetic meter for standard water</td>
<td>it the ideal meter for applications in</td>
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<tr>
<td>applications.</td>
<td>demanding chemical environments.</td>
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<td><strong>OPTIFLUX 2300</strong></td>
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<td><strong>OPTIFLEX level meters</strong></td>
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<td>For continuous measurement of water tank</td>
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<td>levels, guided wave radar (TDR) instruments</td>
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<td>such as the cost effective OPTIFLEX 1100</td>
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<td>and the modular OPTIFLEX 2200 are an accurate</td>
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<tr>
<td>and reliable alternative to traditional</td>
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<td>mechanical or other types of level devices.</td>
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<tr>
<td><strong>OPTIFLEX 1100</strong></td>
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<td><strong>OPTIFLEX 2200</strong></td>
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<tr>
<td>Blending</td>
<td>Pumping</td>
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<tr>
<td>---------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>OPTIFLUX 5300 flowmeter</strong></td>
<td><strong>ALTOFLUX M60 flowmeter</strong></td>
</tr>
<tr>
<td>During blending, the measuring devices face the abrasive effect of the slurry. Due to its highly resistant ceramic liner, the OPTIFLUX 5300 is the perfect solution for the highly abrasive media.</td>
<td>Given the pressure extremes in this stage of the process, only a nominal flow rate of the frac fluid can be determined by monitoring the speed of the pump motor since direct measurement is not considered possible. ALTOFLUX M60 electromagnetic flowmeter withstands even pressures up to 2,500 bar / 36,000 psi* and vibrations up to 6g. The polyurethane liner makes the device resistant to abrasion resulting in very low maintenance requirements. This makes the ALTOFLUX M60 unique and the perfect choice for the measuring of frac fluids during injection.</td>
</tr>
<tr>
<td><img src="OPTIFLUX_5300.png" alt="OPTIFLUX 5300" /></td>
<td><img src="ALTOFLUX_M60.png" alt="ALTOFLUX M60" /></td>
</tr>
<tr>
<td><strong>OPTIFLUX 7300 flowmeter</strong></td>
<td></td>
</tr>
<tr>
<td>For acids and other highly corrosive fluids, the OPTIFLUX 7300 also features a ceramic liner but with a non contacting capacitive signal pick-up instead of conventional electrodes. This device can also be used in cases where the fluid conductivity is as low as 0.05 μS/cm.</td>
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</tr>
<tr>
<td><img src="OPTIFLUX_7300.png" alt="OPTIFLUX 7300" /></td>
<td></td>
</tr>
<tr>
<td><strong>OPTIMASS 2400 flowmeter</strong></td>
<td></td>
</tr>
<tr>
<td>OPTIMASS 2400 straight tube Coriolis mass flowmeter with very high measuring accuracy, integrated density measurement and high resistance against abrasion is designed for slurry measurement where noise and damping accrue.</td>
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</tr>
<tr>
<td><img src="OPTIMASS_2400.png" alt="OPTIMASS 2400" /></td>
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<tr>
<td><strong>VISCOLINE rheometer</strong></td>
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<tr>
<td>VISCOLINE is an innovative in-line process rheometer that provides accurate and repeatable viscosity measurements.</td>
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<td><img src="VISCOLINE.png" alt="VISCOLINE" /></td>
<td></td>
</tr>
</tbody>
</table>

* detailed specifications according to customer needs
For us, service starts at our first contact with you and lasts as long as the life of our systems installed at your plant.

Quality and reliability are key to maintaining the highest service standards. All KROHNE feeder factories are ISO 9001 certified. In fact, long before ISO 9000 existed, KROHNE was already manufacturing to the highest industrial standards. Today, certification exists in every factory to demonstrate that we not only fulfil ISO requirements but have passed the ISO certification procedure every three years since the standard was introduced.

But it’s not simply a one-way process. We actively encourage companies like yours to participate in our research and development activities. Many of our products that are today considered the pinnacle of excellence were developed in cooperation with our customers.

**Engineering services through all project stages**

- Project management
- Control and asset management systems in project concept phase
- Basic engineering based on the specification required by the user
- Detail engineering phase
- Commissioning services
- On-site start-up and commissioning
- Product training (on-site)
- Calibration services
Proven quality

Before shipping, every meter is thoroughly inspected. This rigorous programme of specific measurements, tests and factory inspections is called KROHNE proved.

So, if you install and operate any KROHNE product by following our operating instructions correctly, problems shouldn’t occur. If they do, we will provide you with all the technical support and service you need.

Choose from maintenance and service contracts tailored to suit all business sizes and needs:

- Spare parts and consumables
- Field service and on-site repair
- Returns
- Workshop repair
- Helpdesk

KROHNE Academy and KROHNE Academy online

The KROHNE Academy is a series of seminars organized in collaboration with leading automation companies aimed at plant engineers, operators and contractors across the process industries. It brings industry experts together to provide an insight into the various technologies, industrial standards and procedures that plant operators can find themselves faced with.

Taking place in various countries, KROHNE Academy seminars address key operating issues, from plant safety to ways of increasing plant efficiency and controlling costs, and show possible solutions. They also provide an ideal opportunity for you to speak to the experts and benefit from their vast application knowledge.

Learn more about KROHNE Academy at www.krohne.com

Additional online services:

- Configure It
  Configure It is a highly advanced online configuration tool for standard devices offering free 2D/3D CAD data of KROHNE flow devices for planning engineers. It enables you to configure any KROHNE product to handle your application in a few simple steps.

- KROVASYS 4
  Selection and calculation tool for variable area flowmeters.

- Planning tool for water & wastewater industry
  The planning tool for wastewater treatment plants as well as water and wastewater applications for generating tender documents covering flow, level, analysis, pressure and temperature.

- PiCK
  Get any information related to your KROHNE product from our dedicated online resource PiCK. Just enter your serial number, and key material like manuals, Quick Starts and calibration documents is at your fingertips.
# Measurement solutions for unconventional resources

<table>
<thead>
<tr>
<th>Electromagnetic flowmeters</th>
<th>Rheometer</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPTIFLUX 2300</td>
<td>OPTIFLUX 5300</td>
</tr>
</tbody>
</table>

## Recommended applications

<table>
<thead>
<tr>
<th></th>
<th>OPTIFLUX 2300</th>
<th>OPTIFLUX 5300</th>
<th>OPTIFLUX 7300</th>
<th>ALTOFLUX M40/M60</th>
<th>VISCOLINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling</td>
<td></td>
<td></td>
<td></td>
<td>x (M40)</td>
<td>x</td>
</tr>
<tr>
<td>Cementing</td>
<td>x</td>
<td></td>
<td></td>
<td>x (M40)</td>
<td>x</td>
</tr>
<tr>
<td>Hydraulic fracturing</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Hydration</td>
<td>x</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Chemical mixing</td>
<td>x</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Blending</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
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<tr>
<td>Pumping</td>
<td></td>
<td></td>
<td></td>
<td>x (M60)</td>
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</tbody>
</table>

## Process conditions

<table>
<thead>
<tr>
<th></th>
<th>OPTIFLUX 2300</th>
<th>OPTIFLUX 5300</th>
<th>OPTIFLUX 7300</th>
<th>ALTOFLUX M40/M60</th>
<th>VISCOLINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature range</td>
<td>-5...+90°C; +23...+194°F</td>
<td>-40...+180°C; -76...+356°F</td>
<td>-40...+100°C; -40...+212°F</td>
<td>-5...+60°C; +23...+140°F</td>
<td>-90...+400°C; -130...+752°F</td>
</tr>
<tr>
<td>Maximum pressure</td>
<td>PN40; 580 psi</td>
<td>PN40; 580 psi</td>
<td>PN40; 580 psi</td>
<td>M40: 1,422 bar; 20,624 psi</td>
<td>0.69 bar; 10 psi to class 600</td>
</tr>
<tr>
<td>Measuring range</td>
<td>-12...12 m/s; -40...+40 ft/s</td>
<td>-12...12 m/s; -40...+40 ft/s</td>
<td>-12...12 m/s; -40...+40 ft/s</td>
<td>-12...12 m/s; -40...+40 ft/s</td>
<td>50...200,000 cp</td>
</tr>
<tr>
<td>Diameter to EN 1092-1</td>
<td>DN25...3000; 1...120”</td>
<td>DN15...300; 1...12”</td>
<td>DN25...100; 1...4”</td>
<td>DN50...300; 2...12”</td>
<td>DN25...150; 1...6”</td>
</tr>
</tbody>
</table>

## Technical data

<table>
<thead>
<tr>
<th></th>
<th>OPTIFLUX 2300</th>
<th>OPTIFLUX 5300</th>
<th>OPTIFLUX 7300</th>
<th>ALTOFLUX M40/M60</th>
<th>VISCOLINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet and outlet section</td>
<td>≥5DN/≥2DN</td>
<td>≥5DN/≥2DN</td>
<td>≥5DN/≥2DN</td>
<td>≥5DN/≥2DN</td>
<td>none</td>
</tr>
<tr>
<td>Digital communication</td>
<td>HART®, FF, PA, DP, Modbus</td>
<td>HART®, FF, PA, DP, Modbus</td>
<td>HART®, FF, PA, DP, Modbus</td>
<td>HART®, FF, PA, DP, Modbus</td>
<td>Outputs: mA, Ethernet</td>
</tr>
<tr>
<td>Accuracy</td>
<td>±0.2% of measured value</td>
<td>±0.15% of measured value</td>
<td>±0.5% of measured value, ±5 mm/s</td>
<td>±0.5% of measured value, ±5 mm/s</td>
<td>0.4% Newtonian fluids, 0.2% repeatability</td>
</tr>
</tbody>
</table>

## Highlights

- All-round solution for water metering
- Compliant with requirements for custody transfer
- Long-term reliability and negligible maintenance
- Highly resistant ceramic liner for most aggressive/abrasive fluids
- Exceptional long-term stability and accuracy
- Insensitive against temperature shocks
- Also available in sandwich version
- Ceramic liner with non wetted electrodes
- No insulation, wear or corrosion of the electrodes
- Low conductivities to 0.05 μS/cm
- M40: ethylene liner, M60: polyurethane liner
- High pressure connections
- Robust, heavy duty construction
- All stainless steel, other materials on request
- No moving parts: direct installation in a main process line or on a slip stream

*Detailed specifications according to customer needs*
Coriolis mass flowmeters | Level meters

<table>
<thead>
<tr>
<th>OPTIMASS 1300</th>
<th>OPTIMASS 2400</th>
<th>OPTIMASS 6400</th>
<th>OPTIMASS 7300</th>
<th>OPTIFLEX 1100</th>
<th>OPTIFLEX 2200</th>
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-40...+130°C; -40...+266°F
-40...+130°C; -40...+266°F
-200...+400°C; -328...+752°F
-40...+150°C; -40...+302°F
-50...+100°C; -58...212°F
-50...+150°C; -58...302°F, optional +300°C; +572°F

PN100; CL 600
PN160; CL 1500
PN160; CL 1500
PN100; CL 600
-1...16 barg; -14.5...232 psig
-1...40 barg; -14.5...580 psig

48...170,000 kg/h
1,560...2,300,000 kg/h
5...1,500,000 kg/h
9.5...560,000 kg/h
0.7...20 m; 2.3...65.6 ft
0.6...40 m; 2...131 ft

DN15...50; 1/2...4”
DN100...250; 4...10”
DN08...100; 1/2...12”
DN06...100; 1/2...4”
Screw-on flanges available as accessories
DN25...150 in PN10...40, DN200 in PN16, 40 others on request; 1...8” in 150 lb/300 lb, others on request

- HART®, FF, PA, DP, Modbus
- HART®, FF, PA, DP, Modbus
- HART®, FF, PA, DP, Modbus
- HART®, FF, PA, DP, Modbus
- Outputs: mA
- Outputs: mA

Liquid: ±0.15%
Gas: 0.35%
Density: ±2 kg/m³
Liquid: ±0.1%
Gas: 0.35%
Density: ±1 kg/m³ [±0.2 kg/m³]
Liquid: ±0.1%
Gas: 0.35%
Density: ±1 kg/m³ [±0.2 kg/m³]
Liquid: ±0.1%
Gas: 0.35%
Density: ±2 kg/m³ [±0.5 kg/m³]

±10 mm; ±0.4” (liquids)
±20 mm; ±0.8” (solids)

- Standard meter in the process industry
- Excellent price-performance ratio
- Supplied standard with secondary containment housing
- Large diameter for bulk measurement and custody transfer of liquids and gases
- Easy to drain and clean
- Continuous measurement even under conditions with entrained gas
- Excellent capability of high turndown ratios
- The high performance meter for the process industry
- Cryogenic, high-temperature and high-pressure options
- Supreme liquid and gas performance with CT approval
- Single straight measuring tube in titanium, HASTELLOY® or stainless steel
- Sterilizable and cleanable
- Continuous level measurement
- Cost-effective, 2-wire loop-powered
- Intuitive 5-step quick setup procedure
- Modular housing and probe design
- Quick coupling system: removal of the converter under process conditions
KROHNE

product overview

- Electromagnetic flowmeters
- Variable area flowmeters
- Ultrasonic flowmeters
- Mass flowmeters
- Vortex flowmeters
- Flow controllers
- Level meters
- In-line rheometers
- Temperature meters
- Pressure meters
- Analysis products
- Products and systems for the oil and gas industry
- Measuring systems for the marine industry