

# ▶ OPTIMASS series

Complete portfolio of Coriolis mass flowmeters



**KROHNE**

▶ measure the facts

- For all process and custody transfer (CT) applications
- Mass, volume flow, density and concentration measurement of liquids and gases
- Various designs: from twin bent to single straight tube
- Continuous flow measurement, even with entrained gas of up to 100% (EGM™)





## KROHNE – measure the facts

Welcome to KROHNE. As a leader in process measurement technology, we're at home in a wide variety of industries worldwide. The name KROHNE has stood for **innovative and reliable solutions since 1921**. The company now offers a whole spectrum of instruments for **flow, level, temperature and pressure measurement as well as process analysis**. Our portfolio is rounded off by comprehensive services and consulting.

The centre of excellence for Coriolis mass flowmeters is located in the United Kingdom. KROHNE launched the first commercially available single straight tube Coriolis meter and holds many patents that make possible the natural evolution of unique designs. KROHNE has over 3 decades of experience in developing the most innovative Coriolis meters.

**Furthermore, the OPTIMASS series uses a single straight or multiple straight or bent tube design with proven, patented flow splitter technology for minimum pressure loss. The latest launch is the magnificent four straight tube meter design.**

## Coriolis mass flowmeters: One solution for all process applications

When it comes to selecting a flowmeter for your application, the OPTIMASS series covers all bases. Our engineers have developed a family of meters from small to large, for high pressure, cryogenic temperatures and high temperatures.

All meters have been designed to reduce constraints on the user with regards to installation – simply follow good engineering practice to obtain the desired results.



Within the system, the diagnostics software monitors a series of process and auxiliary values in order to ultimately confirm the condition of the process medium. OPTIMASS can even generate intelligent warning messages when a certain proportion of gas bubbles or solids is exceeded, providing valuable information about the process itself.



### Typical applications:

- Measurement of liquids, gases and liquids with entrained gas
- Bulk loading
- Oil and gas
- Food and beverage
- Chemical
- Pharmaceutical
- Petrochemical
- Marine
- Power plants
- Pulp and paper

## Innovative construction for better results

The OPTIMASS series is available in sizes 1 to 400 mm (1/25" to 16") and in 6 different materials: 316L, duplex and super-duplex stainless steels, Hastelloy®, titanium, and tantalum. The OPTIMASS series conforms to the standard installation lengths according to NAMUR NE 132 "Coriolis Mass Meter (CMM)".

### Superior performance – even with quick temperature and media changes

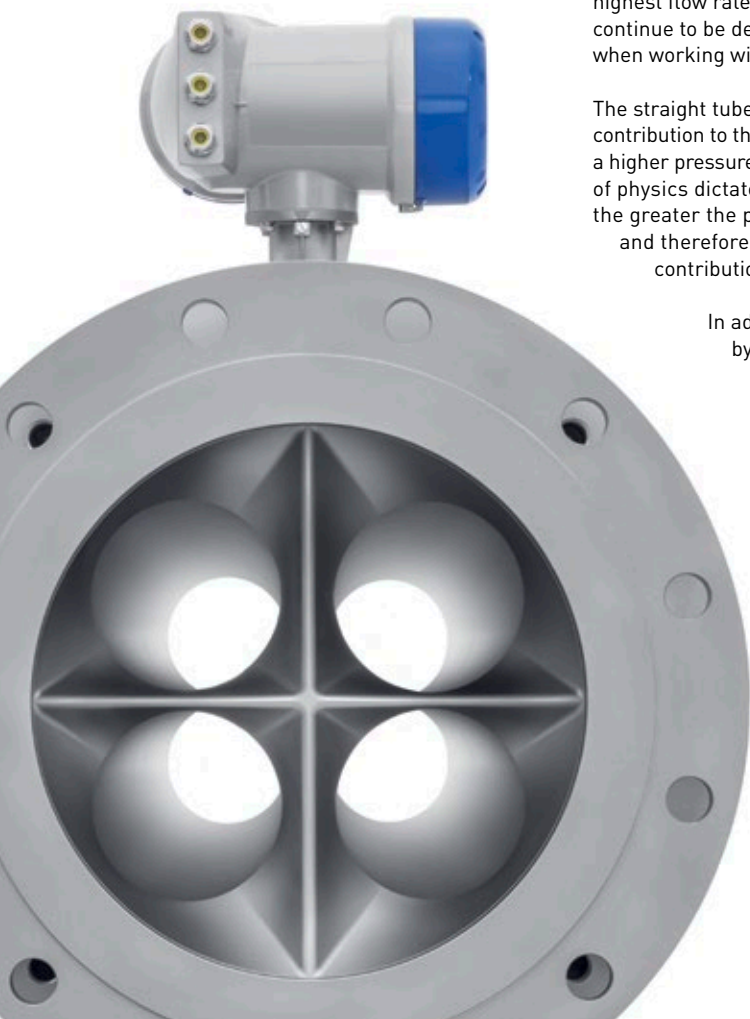
Just how accurate and reliable a mass flowmeter actually is becomes obvious when constant parameters such as medium, temperature or pressure undergo sudden changes. The OPTIMASS series from KROHNE sets the standard.

KROHNE offers superior mass flowmeters with straight and bent tube designs, so the customer can choose the best meter for their application. We offer a unique straight tube design for minimal pressure drop, highly viscous, corrosive and slurry applications. The superior bent tube design is suitable for cryogenic, high temperature and extremely high pressure applications.

So, whatever your requirements, you can be assured that your OPTIMASS meter has been made to the highest standards and that no compromises have been made on quality.



## Innovative construction



Design engineers are constantly striving to reduce overall system pressure drop and the correct flowmeter can play a vital part in achieving this. The OPTIMASS 2000 S400 has a unique four straight tube design with an optimised flow splitter giving it the lowest pressure drop of any high-capacity Coriolis mass flowmeter on the market. It also has the highest flow rate at up to 4600 t/h / 169021 lb/min. As large line size Coriolis flowmeters continue to be developed, there needs to be a different approach to viewing pressure drop when working with straight tube and bent tube flowmeter designs.

The straight tube flowmeter design fits the pipe profile and makes almost no additional contribution to the overall system pressure drop. The bent tube flowmeter design generates a higher pressure drop than straight tube designs for the same size or capacity. The laws of physics dictate that the higher the number of bends and the tighter the bend angles, the greater the pressure drop created. Flow splitters contribute to the pressure drop and therefore the OPTIMASS flow splitter design has been optimised to reduce this contribution further.

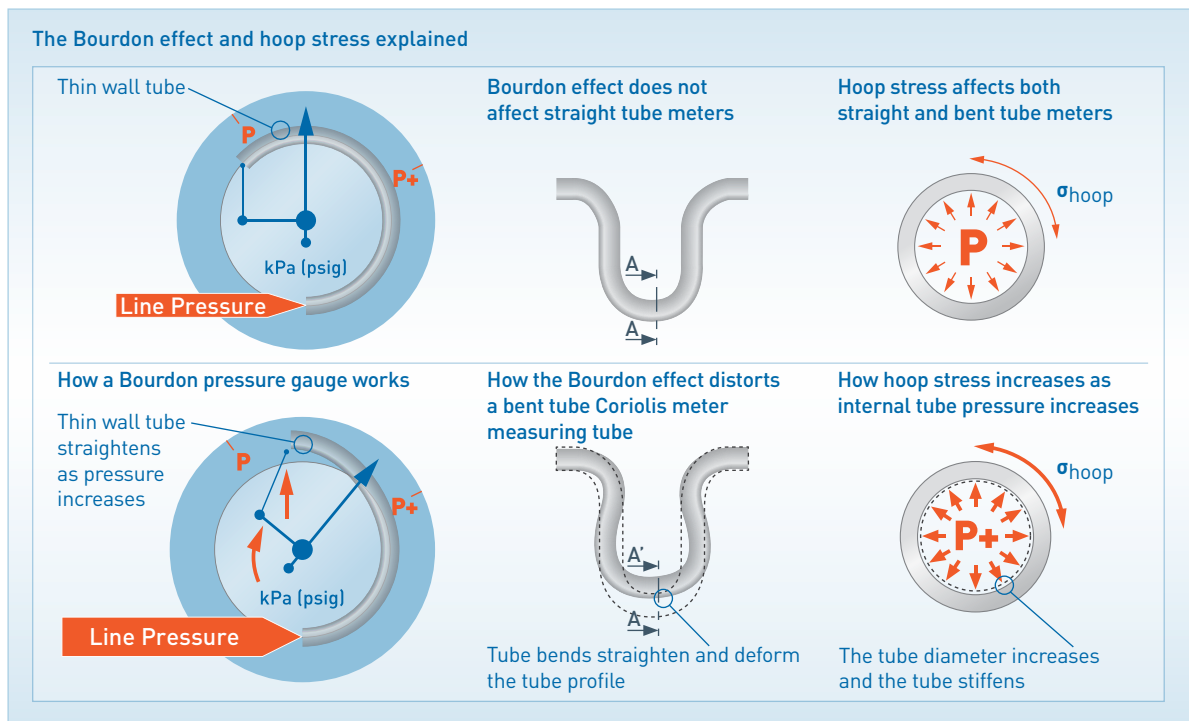
In addition, where bent tube designs require elevated pipework there will, by definition, be an increase in pipeline length and the number of angled fittings required to achieve the installation. This in turn provides an additional contribution to the overall pressure drop calculation required for bent tube meters.

The greater the overall pressure drop of the flowmeter installed, the higher the costs for investment in more powerful pumps, for energy consumption, and, important for the offshore and marine markets, the greater the weight that is added to the platform or vessel.

## Highest capacity

The OPTIMASS 2000 S400 is the highest capacity Coriolis mass flowmeter available on the market with flow rates up to 4600 t/h / 169021 lb/min.

Integral pressure compensation reduces the pressure effect. Unlike bent tube meters, the OPTIMASS 2400 straight tube design is not susceptible to the Bourdon effect. Circumferentially mounted strain gauges on the measuring tubes of the 2400 compensate for hoop stress, making the meter less sensitive to changes in the process pressure.





+ 1.803  $\frac{\text{kg}}{\text{s}}$

0% 50 100

← →

ESC



## Superior performance for simple task completion

The new MFC 400 mass flow signal converter is an electronic device which is perfect for all high-tech measuring tasks.

The MFC 400 offers a high performance when entrained gas is present, providing continuous measurement with gas entrainment from 0-100%. It also offers excellent zero-level stability and state-of-the-art density measurement.

Compatible with the complete range of OPTIMASS process meters, the MFC 400 features push button and optical keys in its standard configuration.

It is approved according to ATEX, IECEx, EAC Ex, NEPSI and cFMus and has been granted other national approvals as well. The MFC 400 converter is available in compact and remote mount design and has state-of-the-art measurement capability and stability, providing unrivalled density measurement. Its high-level diagnostics providing condition-based monitoring and its robust design make it a valuable tool for measurements which are not affected by gas entrainment.

In the unlikely event that the electronics develop a fault, the complete electronics module can be conveniently replaced on site. And thanks to redundant storage, the data is simply transferred from the backplane memory of the housing to the new signal converter. This way the process is only interrupted for a short period of time.



**MFC 400 C**  
Compact installation  
on the sensor



**MFC 400 F**  
Separate installation up to a max.  
of 20 m / 65.6 ft from the sensor

## PROFINET I/O

The MFC 400 signal converter is now available with PROFINET I/O option. This means all OPTIMASS x400 Coriolis mass flowmeters can be equipped with Industrial Ethernet communication, complementing the existing HART® 7, FOUNDATION™ fieldbus, PROFIBUS® PA and DP as well as Modbus communication options.

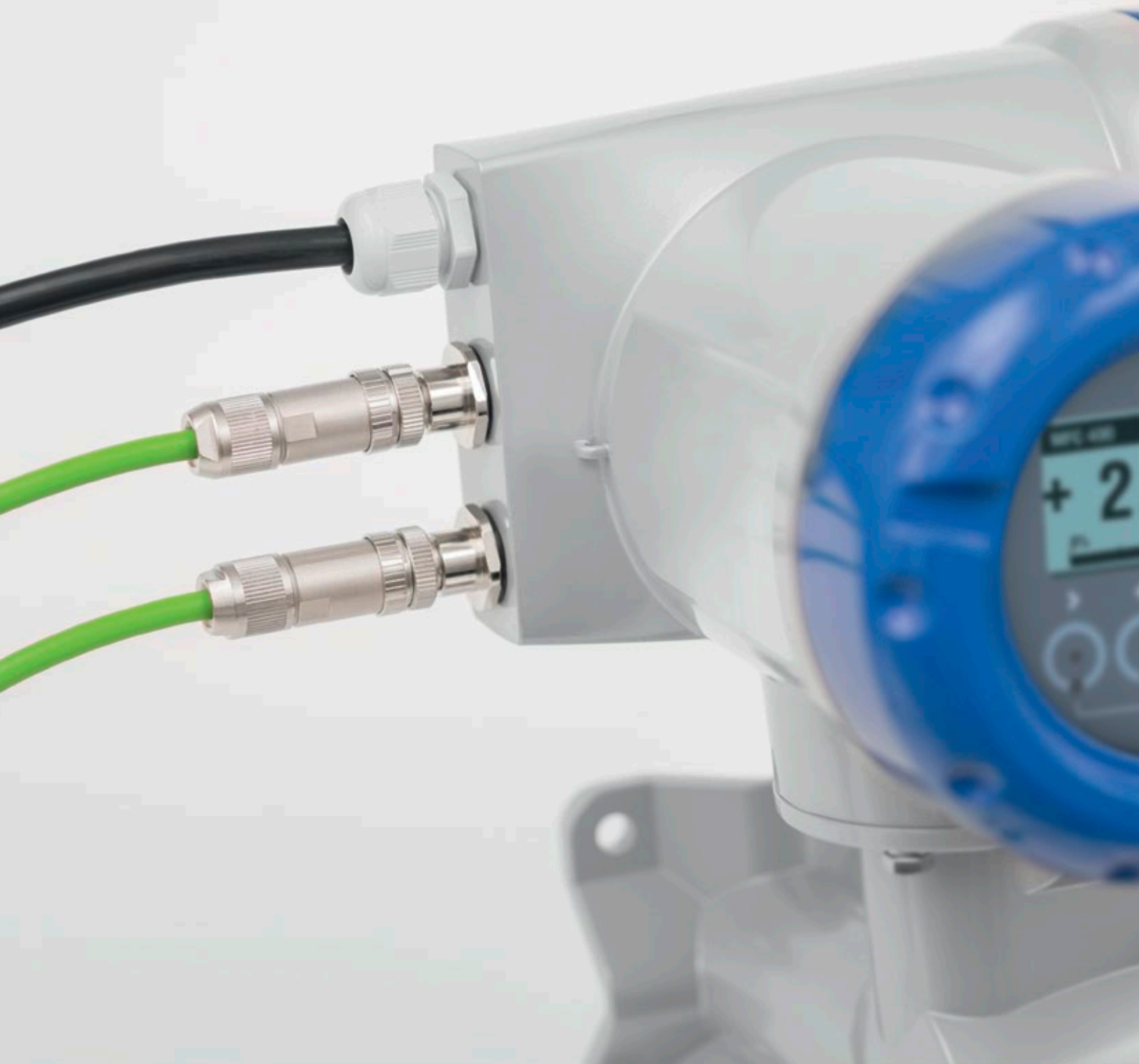
With PROFINET I/O, all measuring, process and diagnostic information from the meter is available in real time via a single communication channel, allowing for convenient integration of new meters: the MFC 400 supports network functions such as Auto-Negotiation, Auto-Crossover, Auto-Polarity and Network diagnostics, and is automatically added to the communication path topology when connected to the network. It also supports Media Redundancy Protocol: in the event of a line or device failure, the MFC 400 instantly switches to an alternative communication path when installed in supporting topologies. A web server is not required, standard functions such as zero-flow calibration or counter reset can be performed directly.



MFC 400 F PROFINET  
Wall mounting for  
non-hazardous areas

One single or two M12 (D coded) connectors allow the installation of the device in all topologies with data transfer speeds of up to 100 MBps. An additional external switch is not required as the converter features an integrated managed Ethernet switch, which provides additional functionality including diagnostics: the MFC 400 conforms to the NAMUR NE 107 standard for status and error handling, and thus provides extensive self-checking of internal circuits and information regarding the health of the measuring sensor as well as information about current process conditions, e.g. indication of 2-phase flows, density or temperature.

- Industrial Ethernet for all OPTIMASS Coriolis mass flowmeters with MFC 400 signal converter
- All measuring, process and diagnostic information available in real time via single communication channel
- One single or two connectors, integrated managed Ethernet switch



# Functional safety

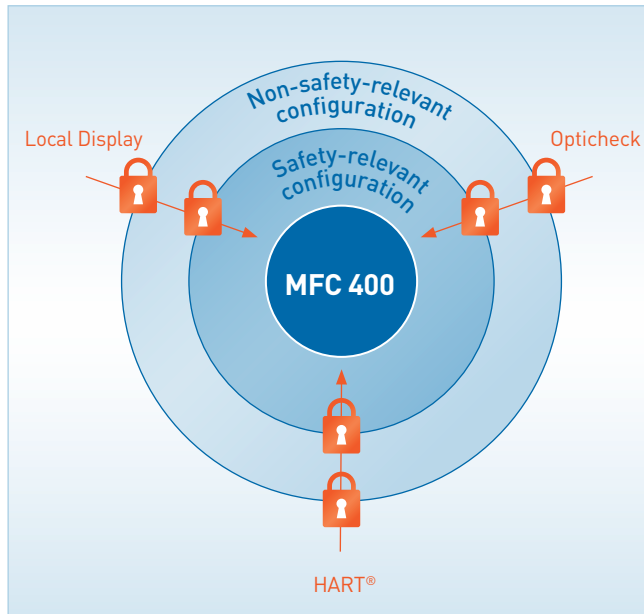
## OPTIMASS series developed to conform to IEC 61508

The upgraded version of the MFC 400 converter is fully developed for safety applications acc. to the latest IEC 61508 2010 standard. A comprehensive safety concept with proven diagnostic coverage of >96% and an internal diagnostic test interval of less than one minute has been developed. It even allows the OPTIMASS 6400 to be used in SIL 3 applications or in continuous demand mode, the highest specified level of operation.



Many additional novel technologies and features have been implemented in order to achieve maximum versatility as well as the highest safety standards:

- Comprehensive authentication concept
- Configuration wizard for safe parametrization
- Enhanced online diagnostics
- Certified partial proof test concept
- Redundant storage of all device configuration data



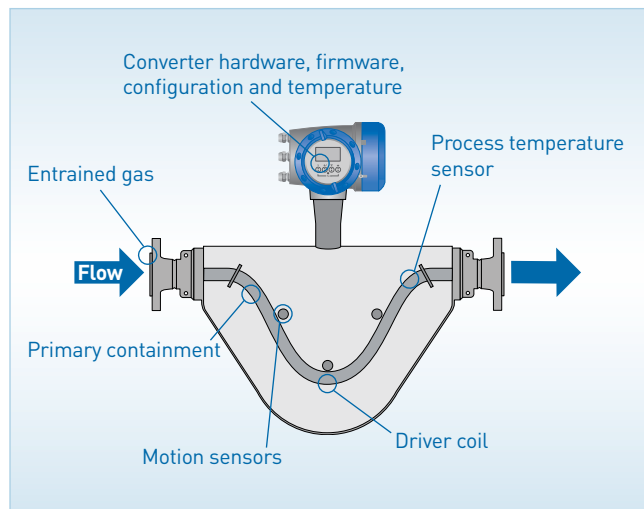
## Comprehensive authentication concept

The development of the MFC 400 converter required a completely new concept for access levels in order to fulfil one major customer demand: the possibility to change safety-relevant data without the need to enter the data in the field via the device's display. The MFC 400 allows safety-relevant data to be changed via HART® signals using an FSK modem, even from the control room.

### Enhanced online diagnostics

In order to achieve diagnostic coverage of >96%, it was necessary to integrate measures such as continuous signal monitoring, redundant references and calibrations. All measurable parameters, electronic components such as CPUs, memory and internal bus connections, as well as all sensors are monitored continuously during operation.

Redundant storage of all device configuration data allows the converter to be replaced at any time without the need for manual reconfiguration.



### Partial proof test

A proof test and a partial proof test procedure have been developed in conjunction with TÜV Rheinland for the OPTIMASS Coriolis flowmeters manufactured by KROHNE. Proof test coverage (PTC) of up to 82% is thus provided without the need to remove the device.

This ensures the safe operation of any safety-relevant function involving Coriolis flow measurement and helps to lengthen full proof test intervals.

### Proof test coverage

	Action	
1.	Perform power cycle	
2.	4-point current output check: 3.6/4/20/22 mA Calibrated current meter or OPTICHECK must be used	
3.	Comparison of actual density with the expected density	
4.	Check mass flow measurement accuracy against a calibration rig with at least 2 measuring points	

\*partial proof test coverage

\*\*full proof test coverage

## Entrained Gas Management (EGM™)



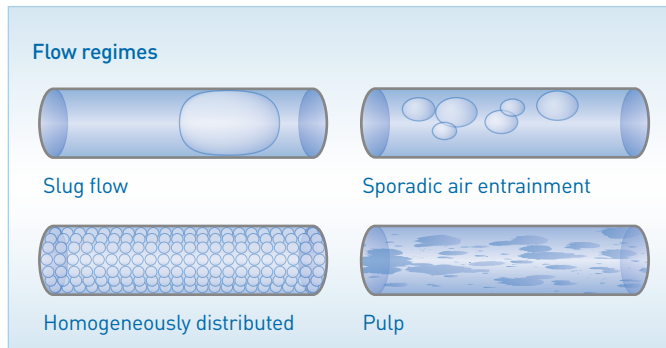
KROHNE's OPTIMASS series with Entrained Gas Management (EGM™) functionality is the only range of meters to offer a solution for all flow conditions at a gas volume fraction (GVF) from 0 to 100% as a standard feature (not a cost-adder option).

- Applications with entrained gas can easily be resolved using OPTIMASS with EGM™
- Enhanced diagnostics with 2-phase signal
- Diagnostics in accordance with NAMUR NE 107 requirements
- Continuous measurement with 0 to 100% gas entrainment
- Works across the full OPTIMASS temperature range from -200 to +400 °C / -328 to +752 °F

### New opportunities with EGM™ functionality

The difficulty of measuring a liquid with entrained gas increases with the fraction of gas. A number of other process factors such as temperature, increased viscosity, pressure, and the relative velocity between liquid and gas also affect the resulting flow regime. Today, OPTIMASS Coriolis flowmeters with Entrained Gas Management can provide repeatable measurement in situations like:

- liquids mixed with gas
- slurries with gases
- highly viscous fluids with gas entrainments

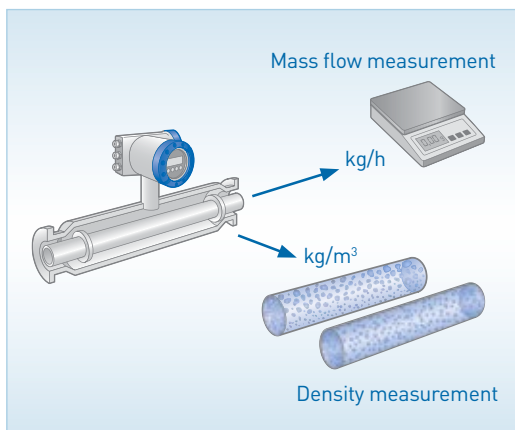
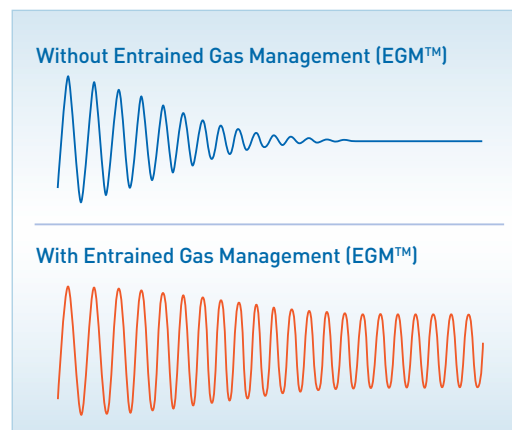


## Entrained Gas Management – the secret of 2-phase flow measurement

Without entrained gas, we have the desired regular oscillation of the tubes in the Coriolis mass flowmeter.

Gas entrained in the liquid dampens this regular oscillation of the measuring tubes, and as the gas content increases, the oscillation can come to a complete stop. To overcome this, KROHNE has developed powerful control algorithms. These algorithms allow the meter to maintain the oscillation and continue to measure even with complex flow regimes.

Even during a complete transition from a pure liquid phase to a gas phase and back, i.e. from 0 to 100% gas content, the device will continue to measure without stopping.



## Mass or density – both are possible even with gas entrainment

Coriolis meters can measure the mass flow, volume flow and density of any fluid, whether it is aerated or not.

Density measurement of single-phase fluids is common practice, but for traditional meters it becomes challenging with entrained gas.

In many applications where entrained gas is present, meters with EGM™ show excellent performance and repeatability for process control, batching, loading, offloading and transfer measurement.

## Calibration from KROHNE: Certainty you can count on

Calibration is one of KROHNE's core areas of expertise. When you buy a KROHNE product, you will get a measuring device that performs accurately with low uncertainty under real process conditions.

It takes a very large calibration rig to calibrate the largest Coriolis mass flowmeters available on the market. At the KROHNE production facility in Wellingborough in the UK, where KROHNE's centre of excellence for Coriolis mass flowmeters is located, we developed the largest mass flow calibration rig in the world to take on this challenge. To calibrate a flowmeter to  $\pm 0.05\%$  accredited measurement uncertainty, the calibration rig has to be at least three times more accurate. The new large gravimetric calibration rigs are accredited according to ISO/EN 17025 to an expanded uncertainty of less than 0.017%.

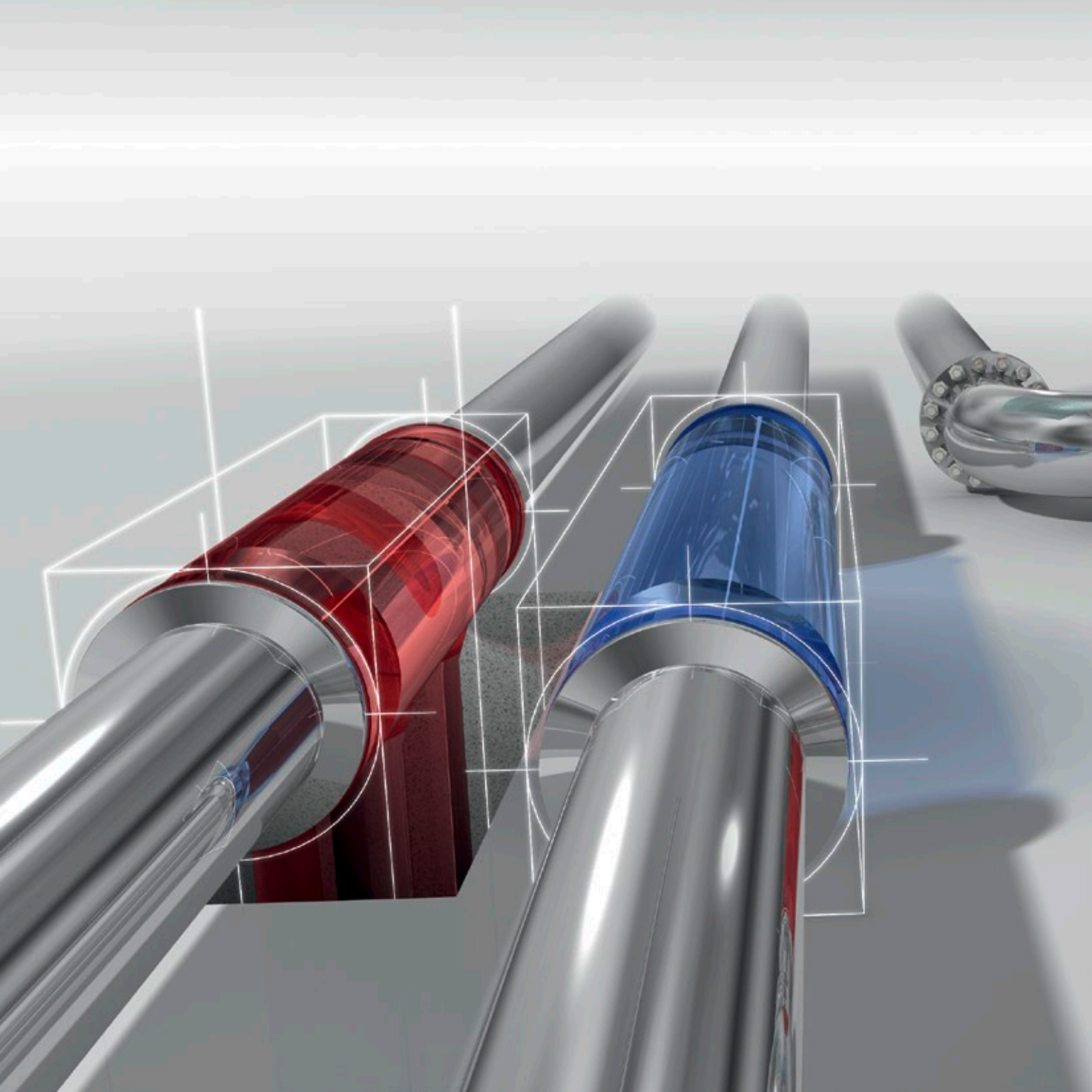
The new calibration rigs allow the OPTIMASS 2400 S400 / 16 inch Coriolis mass flowmeter to be calibrated for flows up to its nominal capacity.

### Certified technology for fiscal & custody transfer applications

Our meters can be calibrated and certified according to various standards such as OIML, Measuring Instruments Directive (MI-002 & 005), and comply with API and AGA. The standards we use for calibration are ISO/IEC 17025 accredited and traceable to international or national standards. Regular inspections by national metrology institutes, round robin tests and alignments with national and international metrological standards guarantee the quality and comparability of our calibration rigs.







## Easy to install

One of the biggest challenges when it comes to installing Coriolis flowmeters, especially high-capacity models, is installation space. Obstructions to the linear pipeline or other architectural features can limit locations and/or increase the number of connections. Until recently, the rule was that the bigger the flowmeter, the greater the space required. Traditional high-capacity mass flowmeters have bent tubes and large installation envelopes that require additional engineering and/or complex pipe layouts. The latest OPTIMASS 2400 straight tube flowmeters, shown in blue in the middle of the image, have a compact installation envelope that fits perfectly with the pipeline and require no additional engineering or pipeline adaptations, saving valuable space.

By reducing the number of pipeline elevations, bends and supports required for installation, OPTIMASS 2400 straight tube flowmeters offer considerable savings in both material and labour costs compared to traditional meters. Pressure drop is also reduced, which further contributes to cost savings. System designers also benefit from the possibility to install straight tube meters in tight spaces such as below walkways, overhead, or in existing pipelines where bent tube meters would not fit. For maximum installation flexibility, converters can be remote mounted.

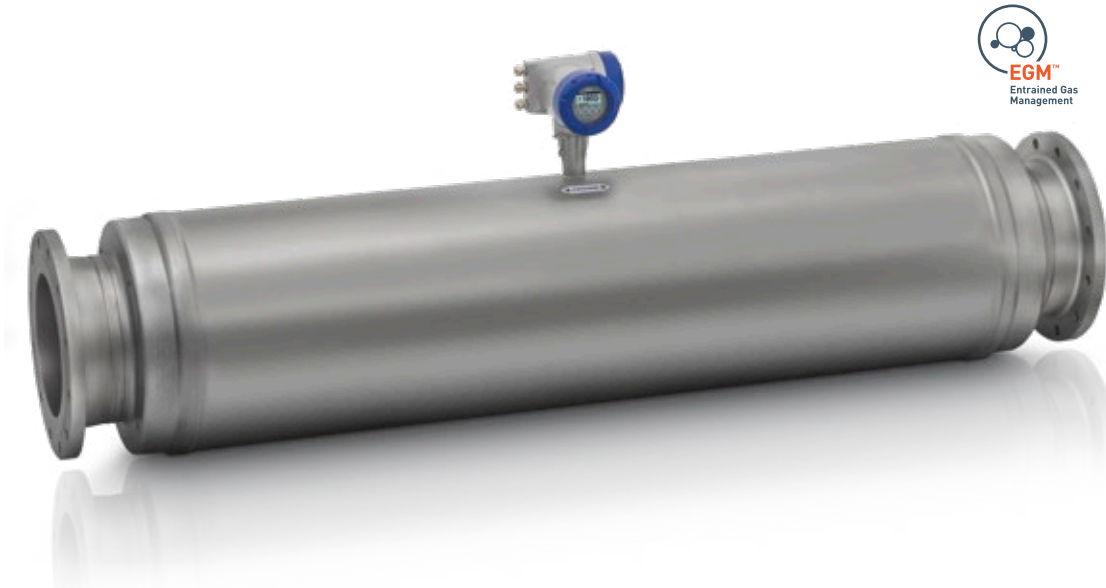
No other large Coriolis meters can be installed with such a compact and small footprint without any heavy and solid foundations. No need for holes in the basement or costly structures to elevate the pipelines.

No other large Coriolis meters can build such compact, easy to install metering skids.

## Intelligent modularity to suit user needs and fulfil requirements

When it comes to selecting the correct flowmeter, the OPTIMASS series meets the needs of industrial users worldwide. KROHNE offers superior straight and bent tube design Coriolis flowmeters in sizes 1 to 400mm / 1/2" to 16" covering flow rates from 0.3 to 4,600,000 kg/h / 0.011 to 169,021 lb/min. All applications are covered including custody transfer and problematic applications such as highly viscous media, non-homogenous mixtures, media with solid content and entrained gas.

With no straight inlet/outlet requirements and a compact design, OPTIMASS flowmeters place minimum constraints on installation, making it easy for you to select the best meter for your application.



### OPTIMASS 2400

Dual or four straight tube design for bulk flows for custody transfer up to DN400/16"



**OPTIMASS 1400**  
The standard device with an excellent price-performance ratio



**OPTIMASS 3400**  
Suitable for extremely low flow rates


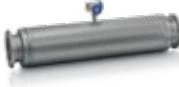



**OPTIMASS 7400**  
For advanced applications, with single straight measuring tube in four tube materials







**OPTIMASS 6400**  
The standard high-performance meter for the process industry, up to DN300/12"

## Technical Data OPTIMASS portfolio

	For universal applications and process control	Dual or four straight tube design for bulk flows for custody transfer up to DN400/16"	For low flow and dosing applications
	OPTIMASS 1400	OPTIMASS 2400	OPTIMASS 3400
			
Measuring accuracy	Liquid: $\pm 0.15\%$ gas: 0.35% density: $\pm 2 \text{ kg/m}^3$	Liquid: $\leq 0.1\%$ (optional: $\pm 0.05\%$ ) gas: $\leq 0.35\%$ density: $\pm 1 \text{ kg/m}^3$ ( $\pm 0.2 \text{ kg/m}^3$ )	Liquid: $\pm 0.1\%$ gas: $\pm 0.5\%$ density: $\pm 2 \text{ kg/m}^3$ ( $\pm 0.5 \text{ kg/m}^3$ )
Outputs	Current, pulse/frequency, status	Current, pulse/frequency, status	Current, pulse/frequency, status
Inputs	Binary	Binary	Binary
Communication	HART®, FF, PA, DP, Modbus, PROFINET®	HART®, FF, PA, DP, Modbus, PROFINET®	HART®, FF, PA, DP, Modbus, PROFINET®
Power supply	85...250 VAC; 11...31 VDC; 20.5...26 VAC/DC	85...250 VAC; 11...31 VDC; 20.5...26 VAC/DC	85...250 VAC; 11...31 VDC; 20.5...26 VAC/DC
Protection category: Compact (C) Field (F) Wall (W) Rack (R)	IP66, 67; NEMA4, 4X, 6 IP66, 67; NEMA4, 4X, 6 IP65; NEMA4, 4X IP20; NEMA1	IP66, 67; NEMA4, 4X, 6 IP66, 67; NEMA4, 4X, 6 IP65; NEMA4, 4X IP20; NEMA1	P66, 67; NEMA4, 4X, 6 IP66, 67; NEMA4, 4X, 6 IP65; NEMA4, 4X IP20; NEMA1
Device, EN 1092-1	DN15...50	DN100...400	DN1...4
Connection EN 1092-1	DN15...100	DN100...400	DN15
Device, ASME B16.5	1/2...2"	4...16"	1/25...4/25"
Connection ASME B16.5	1/2...4"	4...16"	1/2"
Screw-on connector NPT	-	-	1/4" (up to 300 bar/4351 psi)
Pressure rating EN 1092-1	PN40, 63, 100	PN16, 40, 63, 100, 160	PN40, 63
Pressure rating ASME B16.5	CL 150, 300, 600	CL 150, 300, 600, 900, 1500	CL 150, 300, 600
Secondary pressure containment	100 bar/1450 psi	40 bar/580 psi (opt. 150 bar/2175 psi)	30 bar/435 psi
Measuring ranges	48...170000 kg/h	1560...4600000 kg/h	0.3...450 kg/h
Process temperature	-40...+130 °C/-40...+266 °F	-40...+130 °C/-40...+266 °F	-40...150 °C/-40...+300 °F
Ambient temperature	-40...+65 °C/-40...+149 °F	-40...+65 °C/-40...+149 °F	-40...65 °C/-40...+149 °F
Sensor materials	Stainless steel	Stainless steel, duplex, super duplex	Stainless steel, Hastelloy® C22
Protection category sensor	IP67; NEMA4X	IP67; NEMA4X	IP67; NEMA4X
Ex-Approvals	ATEX, FM, CSA, NEPSI, IECEx	ATEX, FM, CSA, NEPSI, IECEx	ATEX, FM, CSA, NEPSI
Sanitary & material approvals	3A, EHEDG	NACE	NACE
Custody transfer	NTEP, MC	OIML R117, Inmetro, NTEP, MI 005, MI 002	-

# Technical Data OPTIMASS portfolio

The standard high-performance meter for the process industry, up to DN300/12"	For advanced applications, with single straight measuring tube up to DN300/12"	Specially designed for linear and rotating filling machines	Specially designed for CNG and LPG in dispensing systems
OPTIMASS 6400	OPTIMASS 7400	OPTIBATCH 4011	OPTIGAS 4010
			
Liquid: $\pm 0.1\%$ (optional: $\pm 0.05\%$ ) gas: 0.35% density: $\pm 1 \text{ kg/m}^3$ ( $\pm 0.2 \text{ kg/m}^3$ )	Liquid: $\pm 0.1\%$ gas: 0.35% density: $\pm 2 \text{ kg/m}^3$ ( $\pm 0.5 \text{ kg/m}^3$ )	Liquid: mass: $\pm 0.15\%$ volume: $\pm 0.2\%$	Liquid: $\pm 0.5\%$ per batch gas: $\pm 0.5\%$ per batch
Current, pulse/frequency, status	Current, pulse/frequency, status	Pulse/frequency	-
Binary	Binary	-	-
HART®, FF, PA, DP, Modbus, PROFINET®	HART®, FF, PA, DP, Modbus, PROFINET®	Modbus (configuration)	Modbus
85...250 VAC; 11...31 VDC; 20.5...26 VAC/DC	85...250 VAC; 11...31 VDC; 20.5...26 VAC/DC	24 VDC	12 VDC
IP66, 67; NEMA4, 4X, 6 IP66, 67; NEMA4, 4X, 6 IP65; NEMA4, 4X IP20; NEMA1	IP66, 67; NEMA4, 4X, 6 IP66, 67; NEMA4, 4X, 6 IP65; NEMA4, 4X IP20; NEMA1	IP67; NEMA6 - - -	IP67; NEMA4X - - -
DN8...250	DN6...80	DN8...15	DN15
DN10...250	DN10...100	-	-
1/2...10"	1/4...3"	-	1/2"
1/2...10"	1/2...4"	-	-
-	-	-	3/4"
PN16, 40, 63, 100, 160	PN40, 63, 100	Process pressure: up to 40 bar / 580 psi	Process pressure: 350 bar/ 5076 psi static, 300 bar/4351 psi cyclical
CL 150, 300, 600, 900, 1500	CL 150, 300, 600	-	-
-	100 bar/1450 psi	-	-
5...1500000 kg/h	9.5...560000 kg/h	6...4320 kg/h	60...4200 kg/h
-200...+400 °C/-328...752 °F	-40...+150 °C/-40...+302 °F	0...+100 °C/+32...+212 °F	-40...+93 °C/-40...+200 °F
-40...+65 °C/-40...+149 °F	-40...+65 °C/-40...+149 °F	-40...+55 °C/-40...+131 °F	-40...+55 °C/-40...+131 °F
Stainless steel, Hastelloy® C22, duplex steel	Duplex steel, Hastelloy® C22, titanium, tantalum	Stainless steel	Stainless steel
IP67; NEMA4X	IP67; NEMA4X	IP67; NEMA4X	IP67; NEMA4X
ATEX, cFMus, IECEx, NEPSI	ATEX, FM, CSA, NEPSI, IECEx	-	ATEX, NEPSI
3A, EHEDG, NACE	EHEDG, 3A, ASME Bioprocessing	3A, ASME Bioprocessing, EHEDG	-
OIML R117, OIML R137, Inmetro, NTEP, MI 005, MI 002	OIML R117, Inmetro, NTEP, MI 005	-	PTB, OIML

## KROHNE – Products, Solutions and Services

- Complete product portfolio: flow, level, temperature, pressure, process analytics
- Application-specific system solutions for various industries
- Services for instrumentation projects

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