M-PHASE 5000

Magnetic resonance multiphase flowmeter for the simultaneous measurement of oil, gas and water

- Single measurement principle, no radioactive source
- Fully automated inline fluid characterisation
- Large dynamic range up to 1:60, full bore design
- Enhanced reservoir management
KROHNE Oil & Gas –
Your partner for the right measurement solution

KROHNE Oil & Gas is a dedicated expert division which puts one of the industry’s largest engineering teams to work on the technologies that matter most to the businesses we serve.

For all of our clients’ processes, from the well head, through pipelines, onto tankers and into the terminals and refineries, accurate and reliable measurement is essential to achieving the operational excellence they strive for.

In a continuously evolving cycle of innovation, KROHNE Oil & Gas Division provides the entire spectrum of process instrumentation and measurement solutions our clients need to gather the data and control the processes essential to running their businesses profitably.

The M-PHASE 5000 is our latest innovation and truly represents the KROHNE spirit of driving technology forward. It features brand new multiphase flow measurement using magnetic resonance technology and was developed specifically for the oil and gas industry.
M-PHASE 5000 –
Pure profit from the well

With the introduction of the M-PHASE 5000, KROHNE brings cutting-edge science to flowmeter design, which delivers tangible economic advantage to our oil and gas customers.

Accuracy that matters at the bottom line

Getting the most from a well requires careful management of the reservoir, for example by applying gas lift or water injection. These processes are cost factors which severely impact the bottom line. Knowing exactly how much lift and injection is needed to produce the maximum amount of oil is essential.

Even small reductions can have a substantial impact: A well that produces 10,000 barrels per day at a price of $50/barrel generates $500,000 revenue per day. A performance gain of just a few percent can save several $10,000 per day.

M-PHASE 5000 provides real-time access to the data needed to precisely manage costs and improve the profitability of individual wells.

Value-added applications

- Continuous well performance monitoring
- Production optimisation (gas lift, water injection, water breakthrough detection)
- Flow assurance (blockage detection, e.g. due to wax, hydrates, asphaltenes)
- Well testing (mobile and fixed installations)
- Production allocation
- Accurate measurements at high water cut
- Inline fluid characterisation makes taking samples obsolete
How less can do more, faster

When you can do more with less you save big on space, time and money. The M-PHASE 5000 reduces the amount of measuring equipment needed and lets you manage wells more efficiently.

The test separator replacement

M-PHASE 5000 is preferable to the use of test separators for several reasons. Test separators create bulky configurations which can be a serious problem offshore because space is at a premium. They require long stabilisation times when wells are switched, which delays access to critical data. Plus you are faced with increased maintenance because various valves and flowmeters are needed.

Better flow control

Keep things moving right along. M-PHASE 5000 ensures that you become aware of problems such as blockages and water breakthroughs in a timely fashion, so that you can address these issues immediately and avoid costly production downtime.

In some cases, several wells owned by different companies flow to a central processing site where separation takes place. In order to properly allocate revenues it is important to know what each well is producing. The M-PHASE 5000 can do just that.

One meter for the lifetime of the well

Over the 10-30 year lifespan of a well, production levels will vary greatly. The conditions change from high flow rates in the beginning; dropping rates a few months later, and back to higher flow rates in mature wells when e.g. gas lift is applied. As a result, meters usually have to be replaced when conditions change. The unprecedented dynamic range of the M-PHASE 5000 means that no matter what stage of its lifecycle an individual well is in, only a single meter is ever needed.
Reservoir management is tricky. In maturing oil fields, the amount of water produced together with the oil generally increases. However, at high water cut, the cost of water handling outweighs the additional oil yield from a well. Closing the well before that leaves valuable oil in the reservoir, closing it later results in losses – profitability becomes a question of timing.

Thanks to the magnetic resonance technology of the M-PHASE 5000, the device is able to precisely measure very small fractions of oil in water in real time. M-PHASE 5000 can therefore deliver the just-in-time data for making the crucial decision to close a well the moment it ceases to be profitable.

### Why timing is everything

<table>
<thead>
<tr>
<th>Losses due to early or late well shut-in on high water cut</th>
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</thead>
<tbody>
<tr>
<td><img src="image" alt="Graph showing losses vs. water cut" /></td>
</tr>
</tbody>
</table>
Engineered for efficiency

The accuracy and versatility of the M-PHASE 5000 is simply unrivalled and make it a particularly attractive solution for the oil and gas industry. Finally, there is a device which uses a single measurement principle to measure multiphase flow. Well known from its application in medical imaging, the magnetic resonance technology of the M-PHASE 5000 makes it possible to measure oil, gas and water flow rates simultaneously and makes test separators practically obsolete.

Oil and gas production is tough work and often takes place in very harsh environments. To ensure that the M-PHASE 5000 works reliably even under the most adverse conditions, it has undergone extensive testing in the field and in highly specialised laboratories.

The robust device is EMC certified, operates reliably in ambient temperatures ranges of -40 to +65 °C / -40 to +149 °F. M-PHASE 5000 withstands even severe shocks and vibrations of up to 10 g and is designed for applications with explosive atmospheres (zone I).
M-PHASE 5000 represents a highly economical value proposition. Unlike conventional meters, it features an uncommonly large dynamic range, which means that it is the only flowmeter ever needed on a well over its entire lifetime.

Its ability to measure with a high degree of accuracy under a wide range of conditions entails a number of advantages that directly translate into tangible cost savings.

M-PHASE 5000 features comprehensive inline fluid characterisation, which in effect eliminates the need to take samples and the sample handling processes associated with it.

The flowmeter automatically compensates for changes in conditions, such as a change in the salinity of water. Emulsions can be measured irrespective of an oil continuous or water continuous mixture. Sand, scaling, wax or hydrates have no effect on the measured liquid flow rate and only have a minor impact on gas flow rates.

Since magnetic resonance technology works on a molecular level, the flowmeter is able to handle a wide range of flow regimes, and the full bore design virtually eliminates pressure drops.
Nobel Prize winning science for the oil and gas industry

M-PHASE 5000 is designed to replace conventional multiphase flowmeters, which generally fall into two categories – inline flowmeters, which combine several measurement modalities including radioactive sources, and separation based flowmeters in which fluids have to be partially separated before they are measured.

Because of the advantages it represents, KROHNE has chosen to apply Magnetic Resonance as the single measurement principle to simultaneously measure oil, gas and water flow rates with one device.

In simple terms, Magnetic Resonance (MR) is a physics principle well known from its application in medical imaging and has been the subject of several Nobel Prize-winning research endeavours.

MR makes use of a fundamental property of atoms and in effect makes it possible to “count” hydrogen atoms. Since oil, gas and water all contain hydrogen, multiphase flow can also be measured using MR. For this purpose the fluids are magnetised and subsequently excited by radio frequency pulses. The hydrogen atoms respond to the pulses and send back echoes which are recorded. The amplitude of the echoes and the rate at which they decay is used to calculate the flow rates of oil, gas and water.
The hydrogen atoms respond to the RF pulses by sending back weak echo signals at the same (Larmor) frequency. By measuring the amplitude of the echoes and by measuring the decay of the signal, the flow rate of oil, gas and water can be determined.
Built for performance that lasts

The M-PHASE 5000 is designed as a high accuracy and durable inline flowmeter, resistant to wear and protected from adverse outside forces and which can be installed in the often harsh environments of oil and gas production.

Its full bore, straight tube design does not restrict the flow line and eliminates wear of internal parts and pressure drops.

The durable internal flow tube is made of corrosion-resistant GRE (Glass fibre Reinforced Epoxy) which is fully certified for application in the oil and gas industry.

Magnetic resonance technology places all sensors outside of the flow. They are not in contact with the fluids, which effectively puts an end to the abrasion and contamination issues of sensors found in conventional inline flowmeters.
Keeping the production environment safe, all electronics are housed inside explosion-safe boxes on the flowmeter.

For maximum integrity, all external forces such as thermal expansion of outside piping are guided through the stainless steel housing of the flowmeter so that internal parts are not exposed to these forces.

Using a Hallbach principle magnet design, a homogeneous magnetic field is maintained inside the bore while cancelling the magnetic field outside the housing of the instrument.
Less time, less effort, more profit

As a single device multiphase flowmeter which can perform inline fluid characterisations of oil, water and gas, the M-PHASE 5000 holds several key advantages over competitive meters. It is a highly effective, low-maintenance instrument which demonstrably helps reduce costs.

No samples needed

Use of the M-PHASE 5000 completely eliminates the need to take samples and all the complex logistics and processes associated with that procedure alone. Since the fluid characterisation takes place at actual line conditions, the extra step of a conversion from lab conditions to actual line conditions is eliminated.

No radioactive source

Maintenance becomes a straightforward task. The absence of the radioactive sources means that the complex maintenance procedures around that become a thing of the past.
**Transparent measurement**

Overall, the M-PHASE 5000 introduces a never-before attained level of ease and transparency to the measurement of fluid fraction and velocity with a single measurement principle.

**Fits in perfectly**

One of the design goals for the M-PHASE 5000 as a stand-alone flowmeter was to make its physical integration into any environment as simple as possible – the flowmeter is installed horizontally, connected to the piping with two flanges.

**Puts safety first**

All electronic and computing components are housed inside explosion-safe boxes on the flowmeter. In the end, there are only two cables that need to be connected – a power cable and a data cable.

**Always stable**

For mobile applications, or to protect the flowmeter from extra harsh conditions, it can optionally be installed in a dedicated frame.
## Operating conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>Oil / water/ gas</td>
</tr>
<tr>
<td>Gas volume fraction</td>
<td>0...95%</td>
</tr>
<tr>
<td>Water cut</td>
<td>0...100%</td>
</tr>
<tr>
<td>Process temperature</td>
<td>0...+93°C; +32...+200°F</td>
</tr>
<tr>
<td>Minimum process pressure</td>
<td>8 bar(g); 116 psi(g) (for accurate gas measurement)</td>
</tr>
<tr>
<td>Maximum process pressure</td>
<td>224 bar(g); 3250 psi(g)</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>-40...+65°C; -40...+149°F</td>
</tr>
<tr>
<td>Ingress protection</td>
<td>IP66</td>
</tr>
<tr>
<td>Flow</td>
<td>Unidirectional</td>
</tr>
<tr>
<td>Inlets and outlets</td>
<td>0DN / 0DN</td>
</tr>
</tbody>
</table>
# Technical data

| Measurement uncertainty       | Liquid: 3-5% MV  
|                              | Oil: 3-5% MV (with minimum of 2% of total liquid MV)  
|                              | Gas: 8-10% MV  |
| Diameter range               | 2”, 3” and 4”  |
| Pressure classes             | 150; 300; 600; 900; 1500 lbs  |
| Flange connection            | RF or RTJ connection  
|                              | 316L (other connections or materials on request)  |
| Flow tube                    | GRE  |
| Housing                      | Stainless steel AISI 316  |
| Dimensions (L x W x H)       | 3.5 x 0.8 x 0.9 m; 11.5 x 2.6 x 3.0 ft  |
| Weight                       | 1150 kg; 2535 lb  |
| Mounting position            | Horizontal  |
| Sensors                      | Integrated temperature and pressure sensor  |
| Signal output                | Modbus via RS-485 and Ethernet  
|                              | (other interfaces on request)  |
| Power supply                 | 90 – 260 VAC 50 / 60 Hz; 18 – 36 VDC  |
| Power consumption            | 180 W (average)  |
| Explosion safety             | Zone 1, Ex db e mb, group IIB T4 Gb  |
KROHNE –
Process instrumentation and Measurement solutions

• Flow
• Level
• Temperature
• Pressure
• Process analysis
• Services