M-Flow: Repeatable, affordable, accurate measurement at the wellhead

M-Flow avoids flow regime uncertainty in multiphase measurement.

Using a unique carbon fibre construction to create a transparent window on the pipe flow, M-Flow has made it possible to deploy sensor systems fully protected from aggressive production fluids. This creates highly accurate, robust and reliable meters, with a small installation footprint and no need for repeated post-installation intervention.

M-Flow’s multiphase system

**Direct measurements:**
- Continual water cut
- Continual gas fraction
- Accurate to +/-1%

**Inferred measurements:**
- Water breakthrough & GOR changes
- Flow rate changes

**Data integration:**
- Downhole and process data

M-Flows Multiphase Meter focuses on delivering value via accurate, repeatable, 24/7, phase fraction data such as water cut and gas fraction. These can be used to monitor key reservoir and production changes including water breakthrough, gas breakout as well as providing indicators of flow rate changes.

M-Flow has avoided the two major sources of multiphase measurement uncertainty: Damage and calibration change to the meter and flow regime influences. As well as protecting sensitive measurement elements, composites allow whole pipe measurements to be made avoiding the uncertainty of spot and chordal measurements.

**Analysis and data management of full production profile**
Water cut and GOR changes are a key VFM input.

- Production separator
- Gas
- Water
- Oil
- Constant overall output
- Constant well monitoring
- Periodic well test data
- Periodic well test data
- Water cut
- Gas fraction
- Oil
- Water

M-Flow Wellhead Monitoring
Reliable, accurate, 24/7 multiphase fraction measurement at the wellhead unlocks value through improved production, optimised reserves recovery, avoided infrastructure and reduced manning.

- Improved production and reserves from 24/7 data
- Improved accuracy at lower cost
- Reduced manning and HSE exposure

M-Flow’s composites deliver highly reliable and repeatable measurement systems in two ways.

**Using carbon fibre composite technology removes sensitive sensors from the flow delivering:**

- Zero maintenance
- Zero recalibration
- Consequently high accuracy and repeatability

**Improved accuracy is made possible by M-Flow’s fresh thinking that delivers:**

- A simpler less complex meter
- Accurate and repeatable data
- High levels of mechanical reliability reducing interventions to a minimum
- Digital integration collating data via the internet of the oil field and virtual flow metering

**Lowering of costs:**

- Avoided infrastructure costs – test separators
- Direct lower capital cost of equipment
- Heavily reduced operational cost over system lifetime
- Reduced site footprint
M-Flow’s wellhead multiphase fraction meter is a high accuracy, highly repeatable, non-intrusive full-bore phase fraction meter, giving water cut and gas void outputs to operators.

Continual wellhead monitoring is key to “Smart Field” optimization. Well by well production data, measured directly, is key to unlocking value.

It covers the full range from 0% to the water in oil inversion point, in conditions of 0–98% Gas Void, in a single device, delivering accuracies of +/-1% in most multiphase conditions.

Inferred measurements of water breakthrough, GOR changes and flow rate changes, give additional valuable data outputs for operators.

Instrument performance

<table>
<thead>
<tr>
<th>Water Cut Range</th>
<th>Void Fraction Range</th>
<th>Water cut uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to inversion point</td>
<td>0 to 98% (typical GVF range 0 to 99.7% GVF depending on slip ratio) and 100%</td>
<td></td>
</tr>
<tr>
<td>Inversion point varies for different oil types and it can be as high as 80% Typically it is between 35–60%.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Ranges</td>
<td>Oil density: 0.6 to 1 g/cc (10 to 100 API)</td>
<td></td>
</tr>
<tr>
<td>Water density: 0.99–1.124 g/cc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independent Validated Measurement Accuracy*</td>
<td>Water cut range</td>
<td>Void fraction range</td>
</tr>
<tr>
<td>0 to 30%</td>
<td>0 to 80% (~ 90% GVF)</td>
<td></td>
</tr>
<tr>
<td>0 to 30%</td>
<td>90 to 98% (90 to 99.7% GVF)</td>
<td></td>
</tr>
<tr>
<td>Effect of Fluid Density Pressure and Temperature</td>
<td>Component density changes are modelled using a PVT model. This requires composition information for the installation in question</td>
<td></td>
</tr>
</tbody>
</table>

*Uncertainty quoted is 2 x SD to 95% confidence. Figures quoted for 3 inch unit and versus the NEL rig reference data for superficial liquid velocities greater than 2 m/s. Please contact M-Flow for Gas void Fraction uncertainty as this is application dependent.
M-Flow’s multiphase fraction meter reduces maintenance, running costs and HSE exposure.

With incorporated temperature and pressure instruments within the pipe spool, the risk of measurement errors are greatly reduced.

M-Flow’s multiphase meters use a microwave resonant cavity and a small nucleonic source to give repeatable, continuous phase fraction data.
M-Flow delivers reliable measurement

Measurement reliability

- No corrosion, erosion, scaling, wax or asphaltenes fouling of the sensor elements, a key cause of calibration variations
- Absolute accuracy
- Delivers consistent and repeatable measurement even with heavy crude and sour service
- Sensors are sited outside the flow, measuring a ‘whole pipe view’
- Composite construction enables the unique use of dual sensors, to provide: cross validation through simultaneous measurement, improved accuracy and identification of poor fluid mixing

Zero intervention

The M-Flow Multi-phase Meter’s sensors do not intrude into the flow, making the meter immune to sensor probe damage and eliminating production interruptions.
Composite meter construction minimises operational costs

- Non-intrusive sensors
- Continuous production
- Repeatable, accurate measurement
- Cleaning and repair free
- No impact from \( \text{H}_2\text{S} \), wax or solids
- Transparent carbon fiber structure

Microwave resonant cavity provides highly accurate data
M-Flow’s multiphase meter technology

The M-Flow Multiphase Meter consists of three modules:

**Flow computer enclosure**
- Data processing, logging, display screen and instrument communications are provided via a flow computer mounted in a separate EXd enclosure
- The flow computer enclosure with its built-in screen can be mounted in a convenient location for ease of operator access

**Analytical electronics enclosure**
- The M-Flow Water Cut Meter provides data and diagnostics through existing data systems, e.g., Modbus to a SCADA, or using the M-Flow smart data reporting system
- Analytical electronics are mounted in an EXd enclosure installed close-coupled to the piping spool
- The M-Flow Water Cut Meter has the ability to implement in-service software upgrades to eliminate process downtime

**Piping spool sensor**
- The spool is solid state and permanently installed in the piping run, and the meter’s composite construction means it does not have to be removed for maintenance, cleaning or calibration
- The piping spool is rated for applications up to 5,000 psi and can be delivered for any piping class, flange arrangement or pipe material
M-Flow’s multiphase configuration options

M-Flow can deliver a stand-alone phase fraction solution, or can be used in conjunction with known flow measurement technology such as Coriolis, Venturi or orifice plate meters to deliver complimentary and corrected data sets including net oil mass flow and corrected wet gas measurement.

<table>
<thead>
<tr>
<th>Multiphase Measurement</th>
<th>Multiphase Phase Fraction</th>
<th>Multiphase Water Breakthrough</th>
<th>Multiphase Low GVF Flow Measurement</th>
<th>Wet Gas WLR and Liquid Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microwave - Gamma density</td>
<td>Microwave</td>
<td>Coriolis</td>
<td>Microwave - Gamma density</td>
<td>Venturi</td>
</tr>
</tbody>
</table>

**Operating envelope**

- **Gas**
  - Oil
  - Water
- **Gas**
  - Oil
  - Water
- **Gas**
  - Oil
  - Water
- **Gas**
  - Oil
  - Water

**Benefit**

- **Constant well monitoring in a true multiphase environment**
  - Flow profile definition
- **With known GOR, constant well monitoring is achievable**
  - Highly repeatable, accurate water cut measurement
- **Gas density compensation measurement taken from Coriolis**
  - Cost effective solution for full productive measurement
- **Constant well monitoring in a wet gas environment**
  - Reliable trending data for production measurement
Installation and certification

System integration
All components can be installed manually in any piping class or flange arrangement or material. Electronics modules can be exchanged or upgraded by an operator or contract local technician without any additional training.

Diagnostics, calibration changes and data analysis
M-Flow meters contain powerful onboard diagnostics data gathering and calibration facilities. These can be accessed using a simple web interface direct via a TCP/IP network or utilising a hazardous area laptop or handheld device. Data can also be gathered in this way and sent to M-Flow’s office for analysis.

Calibration and communication protocol changes can be implemented on site via a user friendly interface or via configuration files provided by M-Flow.

North American, ATEX and ISO
M-Flow Water Cut Meters can be delivered as ATEX certified Zone 1 or Zone 2 and to full Canadian Environmental requirements.

M-Flow Water Cut Meter systems are all built and tested to the highest quality standards within M-Flow’s ISO 9001 compliant QHSE system.