Roxar Multiphase and Wetgas Metering Solutions

Sturle Haaland
Outline

• Emerson and Roxar at a glance
• History of multiphase meters and world wide references
• Introduction to multiphase metering, applications and use
• MPFM 2600 technology and measurement principle
• Operating range and performance
• Installation options
• Add-on modules and options
• Application examples
• Production facilities
• Summary
Emerson At-A-Glance

2014 Key Facts

**2014 RECOGNITION**

#121 AMONG FORTUNE 500 OF AMERICA’S LARGEST CORPORATIONS

FORTUNE WORLD’S MOST ADMIREDPANIES

THOMSON REUTERS TOP 100 GLOBAL INNOVATORS

**GLOBAL MANUFACTURING AND SALES PRESENCE**

150+ COUNTRIES

220 MANUFACTURING LOCATIONS

**DIVERSIFIED GLOBAL MANUFACTURER AND TECHNOLOGY PROVIDER**

OUR PEOPLE

115,000+ WORLDWIDE

**FOUNDED**

1890

HEADQUARTERS IN ST. LOUIS, MO USA

**$24.5 BILLION IN GLOBAL SALES**

58 YEARS

CONSECUTIVE YEARS OF INCREASED DIVIDENDS

NYSE: EMR
Roxar Overview

Maximum Reservoir Performance

20+ Years Providing Industry Leading Technology

~20% Of Sales Devoted to Research & Development

25+ Services & Support Centers Covering All Major Regions
Innovative Roxar Solutions - Empowering Enhanced Decision Making for Oil and Gas Production and Integrity

Roxar Software Solutions
A Global Leader in
3D Reservoir Geological
Modeling and Integrated Simulation

Roxar Flow Measurement
Offers a Comprehensive Suite of Topside, Subsea and Downhole Metering and Monitoring Products
Roxar’s Global Presence

- Headquarter, Stavanger Norway
- Centre of Excellence, Multiphase metering, Bergen, Norway
- Main regional hubs
- Service and Sales locations
- Emerson Roxar Europe Manufacturing Site, Cluj-Napoca, Romania
The history of Roxar Multiphase flow meters

1981-1987
Multi-Fluid and Fluenta begins early research on Multiphase meter technology

1992
Multi-Fluid and Fluenta launches their 1st generation Multiphase meters to the market

1996-1998
Multi-Fluid and Fluenta launch 1st generation Multiphase meters to the market

1999
Smedvig Technologies merges with Multi-Fluid and becomes Roxar

2001
Roxar acquires Fluenta. Launch 2nd generation Multiphase meter (subsea and topside)

2009
Launch 3rd generation Multiphase meter. Roxar acquired by Emerson
MPFM 2600 Installations And References
400+ Meters Sold To 70+ Operators
Some advantages of using a Multiphase meter over a test separator

<table>
<thead>
<tr>
<th>Challenge / Aspect</th>
<th>Test Separator</th>
<th>Inline MPFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial investment (CAPEX)</td>
<td>High ($800k to $1,500k)</td>
<td>Low ($100k and upwards)</td>
</tr>
<tr>
<td>Liquid carry-over</td>
<td>Prone to / potential issue - Will affect the single phase measurements</td>
<td>No issue / not relevant</td>
</tr>
<tr>
<td>Gas carry-under</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inability to separate the liquid</td>
<td>Prone to / potential issue - Will affect the single phase measurements</td>
<td>No issue / not relevant</td>
</tr>
<tr>
<td>(water in oil, oil in water)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test stabilization time required</td>
<td>High (up to several hours) - for good separation, long residence time is needed</td>
<td>No issue - Fast response and consequently frequent testing can be done with improved efficiency</td>
</tr>
<tr>
<td>Remote / un-manned location operations</td>
<td>Difficult / Not possible</td>
<td>Conceivable, remote access sufficient to start a test</td>
</tr>
<tr>
<td>Size and Weight</td>
<td>Large (5 to 20 tonnes for vessel, piping, valves, pipe supports), dimension 3x3x12 meters</td>
<td>Small (150-500 kg), &lt; 1 meter length</td>
</tr>
<tr>
<td>Operating cost (OPEX)</td>
<td>Often substantial amount of maintenance during field life</td>
<td>Lower maintenance needs (typically once per year)</td>
</tr>
<tr>
<td>Operation</td>
<td>Potentially labor intensive</td>
<td>Limited labor needed</td>
</tr>
<tr>
<td>HS&amp;E</td>
<td>Need utility and safety ‘services’ i.e. air, heat, ESD isolation, blow-down, fire and gas protection/detection, PCS control, firewater</td>
<td>Improves the safety of the testing operation</td>
</tr>
<tr>
<td>Pressure drop</td>
<td>High – could affect low flowing / low producing wells</td>
<td>Low (&lt; 0.5 bars typically)</td>
</tr>
</tbody>
</table>

Suggested further reading: A.M. Eltayef (former Qatar Petroleum Ops. Eng.): “Technical & economical comparison between installations of multi phase test separator or multiphase flow meters on gas wells installation”
MPFM 2600 Major Components

- Rosemount MVT Transmitter
- Compact CCIMS Block & Bleed Manifold Valve
- Exi Field Electronics
- Field Replaceable Insert Venturi Sleeve
- PEEK w/ Impedance Dual Plane 2+6 Electrodes
- Compact Cs-137 Gamma System
Measurement Principle Overview

Water fraction (WLR):
- Capacitive measurement in oil continuous
- Conductive measurement in water continuous

Gas/Liquid Fraction (GVF):
- Gamma densitometer

Velocity:
- Venturi and Cross correlation
### Measurement Principle – Fraction Measurement Summary

<table>
<thead>
<tr>
<th></th>
<th>Oil</th>
<th>Water</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density [kg/m³]</strong></td>
<td>700 - 1000</td>
<td>1000 - 1040</td>
<td>50</td>
</tr>
<tr>
<td><strong>Dielectric constant</strong></td>
<td>2</td>
<td>&gt; 70</td>
<td>1</td>
</tr>
</tbody>
</table>

**GVF:** Gamma attenuation

**WLR:** Electrical impedance

**Total:**

- Water + Oil + Gas = 100%

100% - Water - Gas = Oil

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<p>| | | |</p>
<table>
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<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Water</td>
<td>%Water</td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>%Oil</td>
<td></td>
</tr>
<tr>
<td>Gas</td>
<td>%Gas</td>
<td></td>
</tr>
</tbody>
</table>
```

Liquid

Gas

Water

HC

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Measurement Principle - Finding the Liquid Velocity: Venturi

- The Venturi effect is the **reduction in fluid pressure** (from HP to LP) that results when a fluid flows through a constricted section of a pipe.
- By measuring the **change in pressure**, the flow rate can be determined, as the dP across a Venturi is proportional to the kinetic energy of a mixture passing through.
- The Roxar MPFM 2600 uses a modified venturi equation for use in three-phase flows (it takes into account the **gas volume fraction** (GVF) of the flow).
Phase Slip In Multiphase Flow: The Ratio Between Gas Velocity And Liquid Velocity Is Known As The Slip Ratio

- Gas rises faster than liquid due to buoyancy effects and pipe wall friction (on the liquid)

- This effect is more prominent in low-pressure applications as the density of liquid is many times that of gas

\[
v_D = Velocity \ of \ dispersed \ (D) \ phase \ (oil, \ water, \ and \ small \ bubbles)\]

\[
v_B = Velocity \ of \ large \ bubbles \ (B)\]
Measures **gas velocity** (and therefore phase slip) independently of liquid velocity.

This method of **directly measuring the gas velocity** is known as cross-correlation and high accuracy can only be achieved by using **sensors with high resolution**, i.e. with a fast sampling rate.

Roxar MPFM’s sensors are capable of measuring the electrical properties of flowing media at an rate of **200,000 measurements per second**.
Measurement Principle Summary

Venturi

Velocities

Time series / cross correlation

Capacitance / conductance

Fractions

Density

Flow rates

Qoil

Qwater

Qgas
Roxar MPFM 2600 – key elements

Simple, light-weight design, 80% weight reduction and half the length compared to the previous generation

- The image shows the relative difference in size for a typical 3” meter
- Weight: 550 vs. 130 kg
- Length: 1300 vs. 650 mm

Added value:
- Simple installation
- Easy handling
- Greater flexibility
Roxar MPFM 2600 – key elements

Field replaceable insert venturi
• Four pressure tapping’s and ring chamber improves accuracy and stability (same design as for subsea meters)
• A field replaceable insert venturi sleeve
• Added value:
  – Extended service life
  – Extended operating range – can easily be replaced in the field
  – Removes uncertainties when sizing meters based on predicted production forecasts
Compact, integrated measurement solution for pressure, differential pressure and temperature

- Rosemount Multivariable transmitter
- Enables highly sensitive, accurate, DP, P and T measurements
- No impulse lines

Added value:
- Combines the best features from remote seal solutions and open impulse tubing
- Limits the potential for clogging
- Easy field replacement
Roxar MPFM 2600 – key elements

- Non-gamma option – suited for single well installations < 85% GVF
- For multi-well applications and/or GVF > 85%, the gamma version is recommended
- **Added value:**
  - No source handling, paper work or import licenses needed
  - The gamma system can easily be retrofitted if and when flow conditions so dictate
  - Redundancy in the measurement of GLR

Upgrade with mini-gamma system = Roxar MPFM 2600 – key elements
Installation Recommendations

- **A**: 1 meter length, ID ~same as the MPFM
- **B**: 5 x ID of MPFM, ID ~same as the MPFM
- **Outlet**: Maintain MPFM ID throughout 90 degree bend before expander
Installation Options

- Hub
- X/O w/ Weldneck
- X/O w/ ANSI Flange
- Skid mounted
Optional Modules Extending Operating Range and Adds Increased Flexibility

• **Wetgas software** for high GVF / Wetgas applications

• **Non-Gamma software** that can replace the gamma source

• A dedicated **salinity probe** for measuring water conductivity/salinity in multiphase flow

• **Roxar’s Fieldwatch Software** for improved handling, monitoring, configuring and operation of all Roxar instruments
Emerson Manufacturing Profile – Roxar Products

**Cluj, Romania**

- Sand/Pig & Erosion
- Topside Multiphase
- Corrosion Solutions
- Skid Design & Manufacture

- 2100+ employees on campus
- 30+ business units present
- 9 operating business units
- 10 000+ Roxar products shipped

**Stavanger, Norway**

- Subsea Multiphase
- Subsea Wetgas
- Watercut Meter
- Downhole Instrumentation

- 20 0000+ hours of subsea meter testing
- 200 000+ assembly man hours for subsea meters
- 6 800 000 meter of downhole cable installed
- 600 000 downhole clamps installed
Emerson Production Campus in Cluj, Romania

Roxar Production Facilities

- Storage/stock facilities
- Electronic (ESD) production
- Mechanical assembly/production
- Pressure testing facilities (20,000 psi / 1,380 bar)
- Temperature and calibration facilities (-40°C up to +180°C)
- FAT area
- ISO 9001/2008, ATEX / IECEx certified
Summary

• 30 years of innovation and field experience has provided Roxar with unparalleled knowledge on Multiphase and Wetgas flow metering

• The MPFM 2600 from Roxar provides:
  – Enhanced measurement accuracy
  – Extended operating range (Multiphase & Wetgas modes)
  – Direct salinity measurement
  – Gamma / non-gamma options
  – Lightweight, compact and robust design

• Several ongoing developments ensuring the full product range offered by Roxar remains in the forefront of innovative high technology solutions, moving possibilities forward for the oil and gas industry