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

FOUNDED
1890
HEADQUARTERS IN
ST. LOUIS, MO
USA

DIVERSIFIED GLOBAL MANUFACTURER
AND TECHNOLOGY PROVIDER

OUR PEOPLE
115,000+
WORLDWIDE

$24.5
BILLION
IN GLOBAL SALES

58
YEARS
CONSECUTIVE YEARS OF INCREASED DIVIDENDS

NYSE:
EMR

2014 RECOGNITION

#121
AMONG
FORTUNE 500
OF AMERICA'S LARGEST CORPORATIONS

FORTUNE
WORLD'S MOST ADMIRED COMPANIES

THOMSON REUTERS
TOP 100 GLOBAL INNOVATORS

GLOBAL MANUFACTURING
AND SALES PRESENCE

150+
COUNTRIES

220
MANUFACTURING LOCATIONS

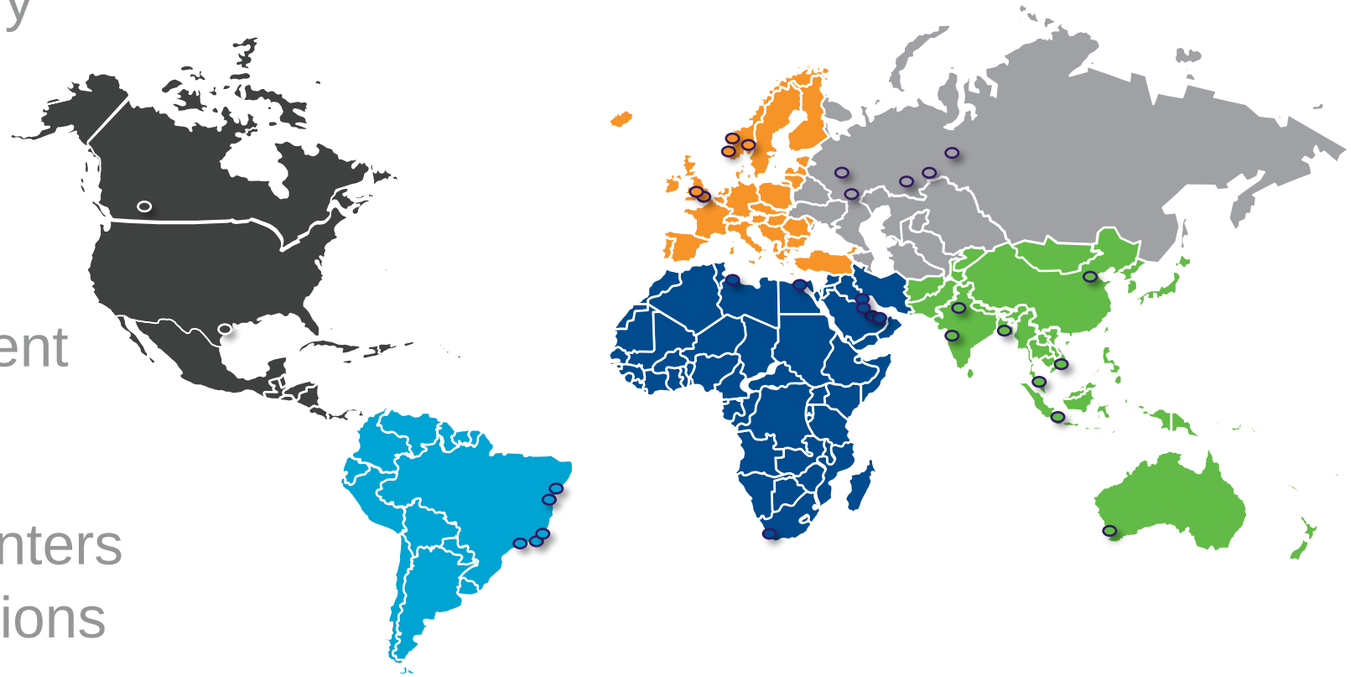
Roxar Overview

Maximum Reservoir Performance

20+ Years Providing Industry Leading Technology

~20% Of Sales Devoted to Research & Development

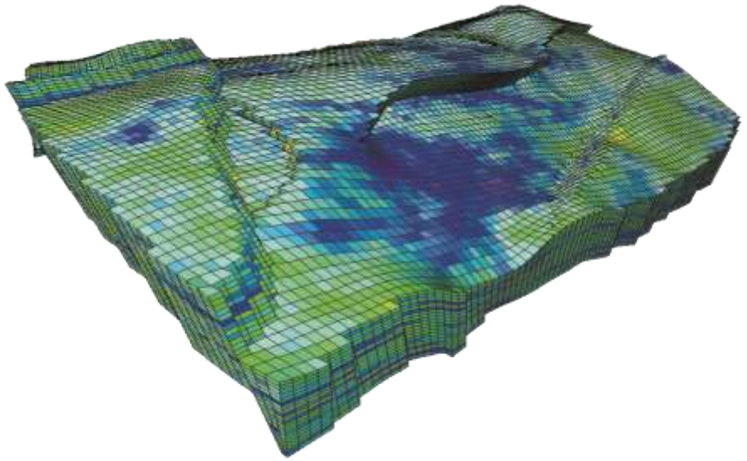
25+ Services & Support Centers Covering All Major Regions



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

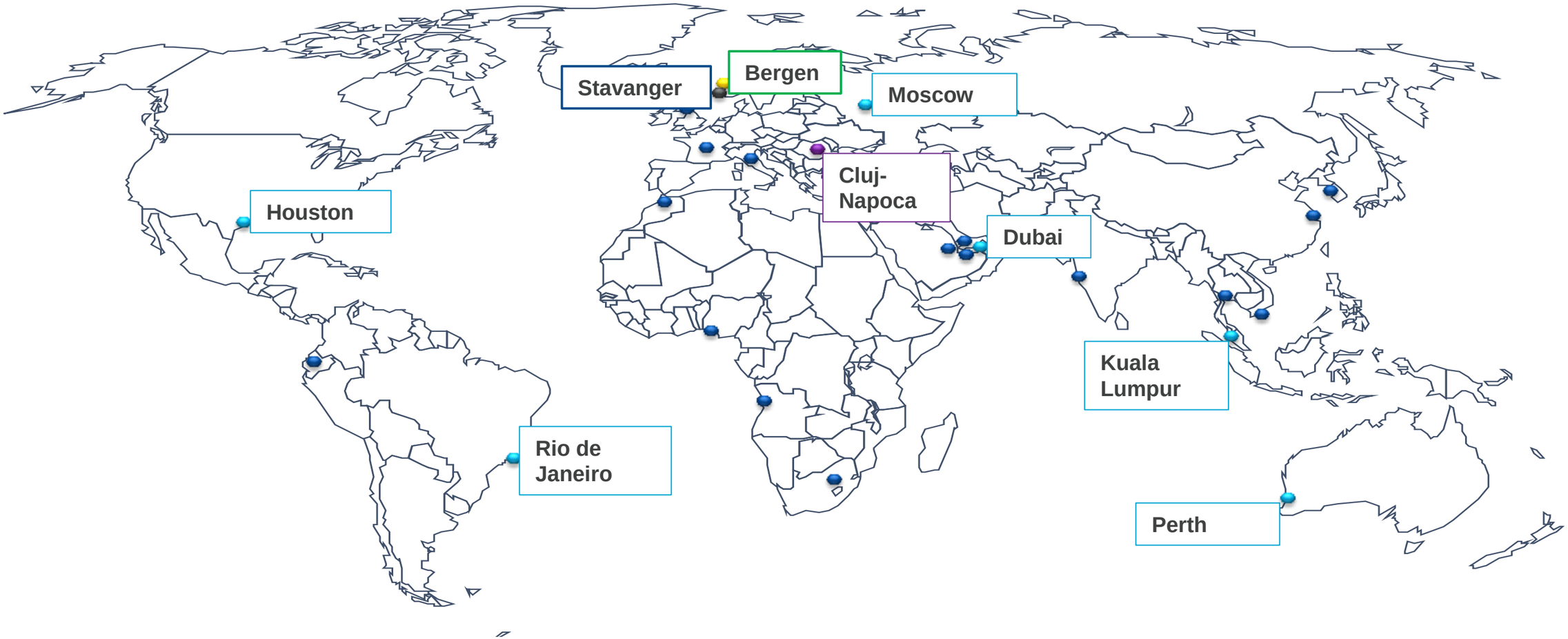


Roxar Flow Measurement

Offers a Comprehensive Suite of Topside, Subsea and Downhole Metering
and Monitoring Products

EMERSON

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

EMERSON

The history of Roxar Multiphase flow meters

MULTI-FLUID

FLUENTA

Smedvig + MULTI-FLUID = ROXAR

ROXAR + FLUENTA

EMERSON Process Management + ROXAR

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** launches their 1st generation Subsea 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**

EMERSON

MPFM 2600 Installations And References
400+ Meters Sold To 70+ Operators

ADCO
ADMA
AFREN
JX Nippon Oil & Gas Exploration
PEMEX Petróleos Mexicanos
PETRONAS
TNK-BP
Bennu Oil & Gas
CNOOC
Chevron
Karachaganak
MAERSK
PremierOil
ROSNEFT
TODD
TOTAL
Tengizchevroil
CARDON IV
CAIRN Energy for India
Eni
Husky Energy
LUKOIL OIL COMPANY
OMV
PetroChina
sonatrach
Saudi Aramco
VERMILION ENERGY
eQ enQuest
FREEPORT-McMoRan
HESS
HOANG · LONG
Lundin
OXY
ONGC
QGC
Santos
شركة تطوير حقل زاكوم [زادكو]
Zakum Development Company [ZADCO]

Some advantages of using a Multiphase meter over a test separator

Challenge / Aspect	Test Separator	Inline MPFM
Initial investment (CAPEX)	High ($800k to $1,500k)	Low ($100k and upwards)
Liquid carry-over Gas carry-under	Prone to / potential issue - Will affect the single phase measurements	No issue / not relevant
Inability to separate the liquid (water in oil, oil in water)	Prone to / potential issue - Will affect the single phase measurements	No issue / not relevant
Pre-test stabilization time required	High (up to several hours) - for good separation, long residence time is needed	No issue - Fast response and consequently frequent testing can be done with improved efficiency
Remote / un-manned location operations	Difficult / Not possible	Conceivable, remote access sufficient to start a test
Size and Weight	Large (5 to 20 tonnes for vessel, piping, valves, pipe supports), dimension 3x3x12 meters	Small (150-500 kg), < 1 meter length
Operating cost (OPEX)	Often substantial amount of maintenance during field life	Lower maintenance needs (typically once per year)
Operation	Potentially labor intensive	Limited labor needed
HS&E	Need utility and safety ‘services’ i.e. air, heat, ESD isolation, blow-down, fire and gas protection/detection, PCS control, firewater	Improves the safety of the testing operation
Pressure drop	High – could affect low flowing / low producing wells	Low (< 0,5 bars typically)

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

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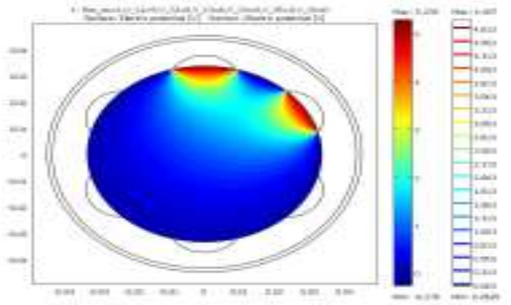
Measurement Principle Overview



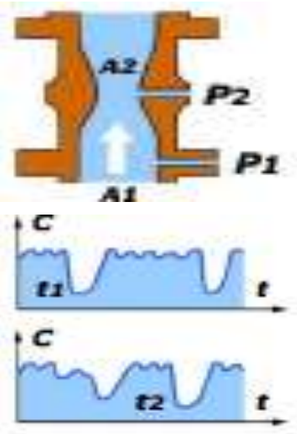
Water fraction (WLR):

-Capacitive measurement in oil continuous

-Conductive measurement in water continuous

Gas/Liquid Fraction (GVF):

-Gamma densitometer



Velocity:

- Venturi and Cross correlation

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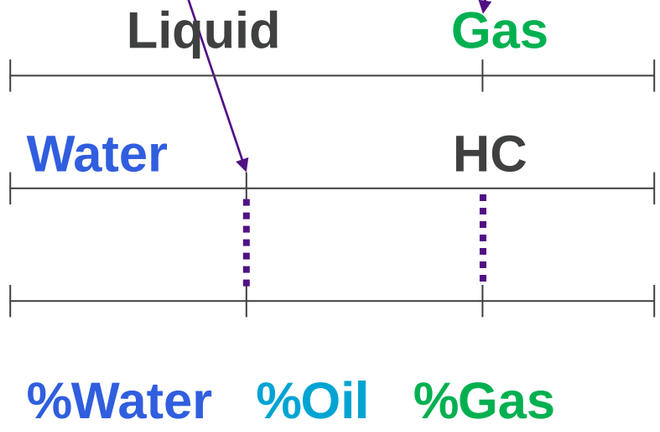
Measurement Principle –
Fraction Measurement Summary

	Oil	Water	Gas
Density [kg/m^3]	700 - 1000	1000 - 1040	50
Dielectric constant	2	> 70	1

GVF: Gamma attenuation

WLR: Electrical impedance

Total:

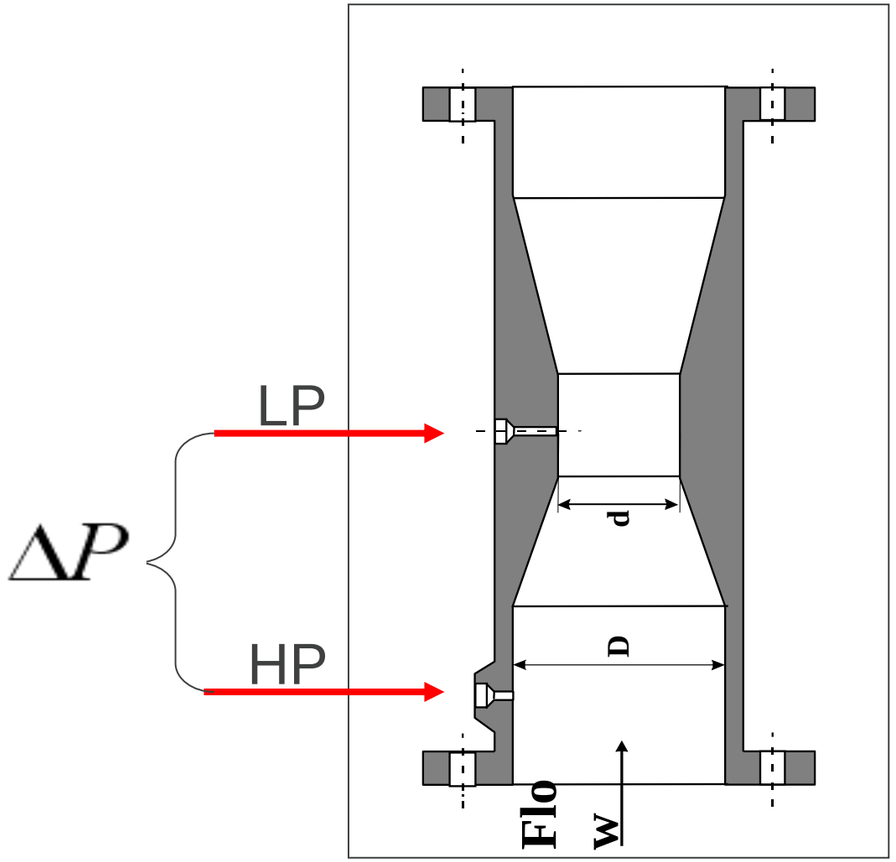


water + oil + gas = 100%

100% - water - gas = oil

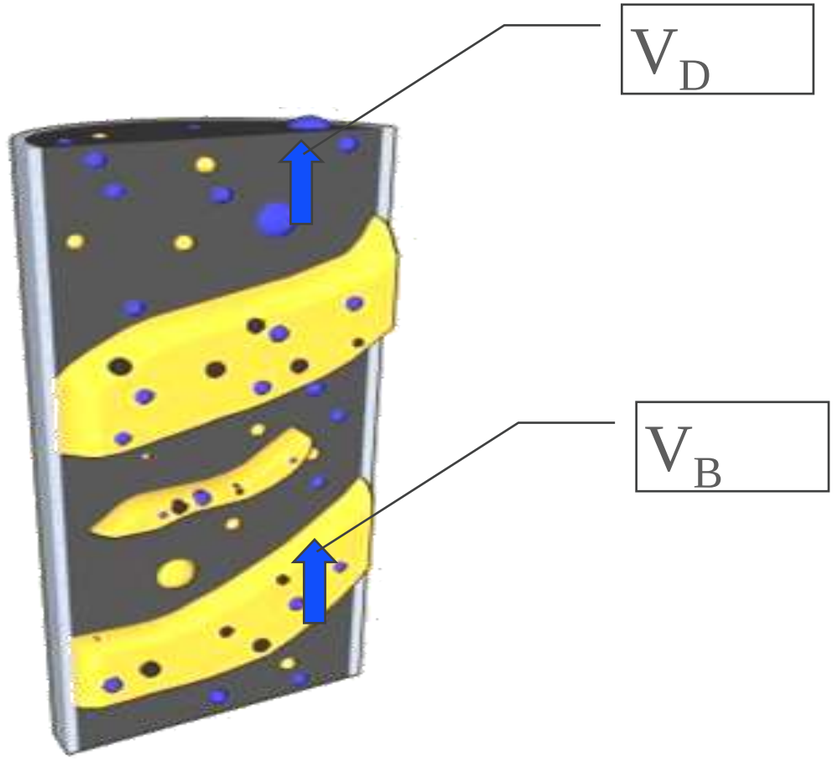
Measurement Principle - Finding the Liquid Velocity: Venturi

- 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)*

$V_B \neq V_D$

Slip

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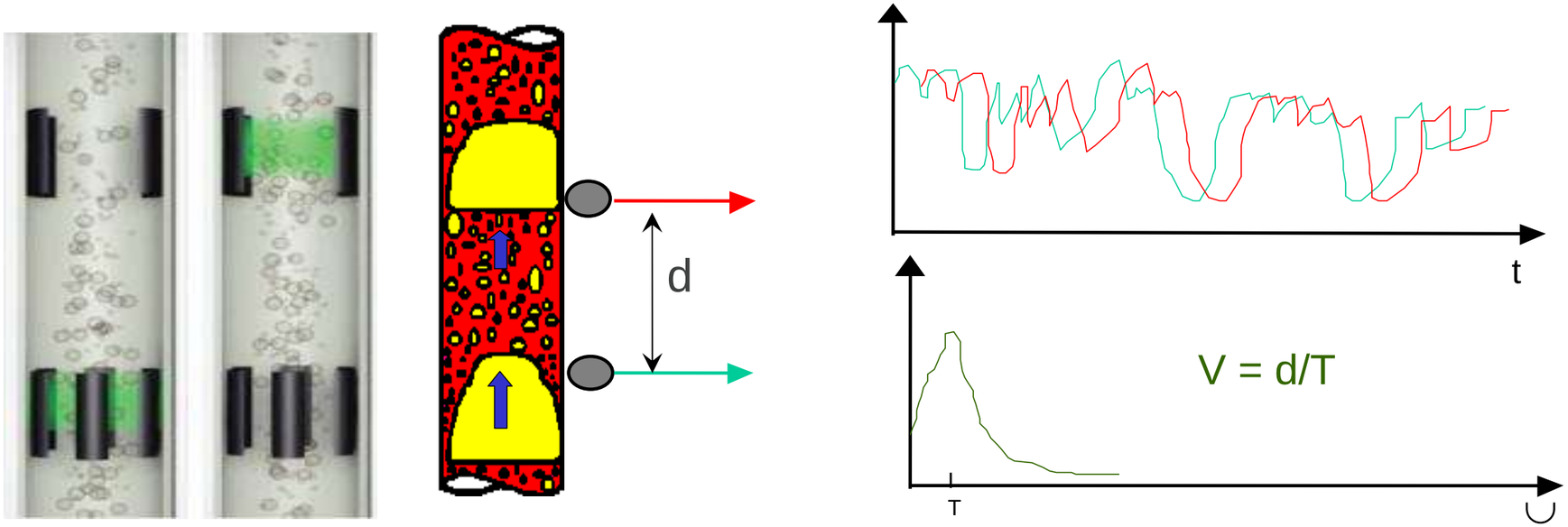
Measurement Principle - Finding the Gas Velocity: Cross Correlation



- Measures **gas velocity (and therefor 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**

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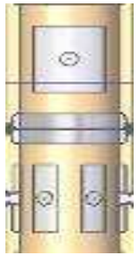
Measurement Principle Summary



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

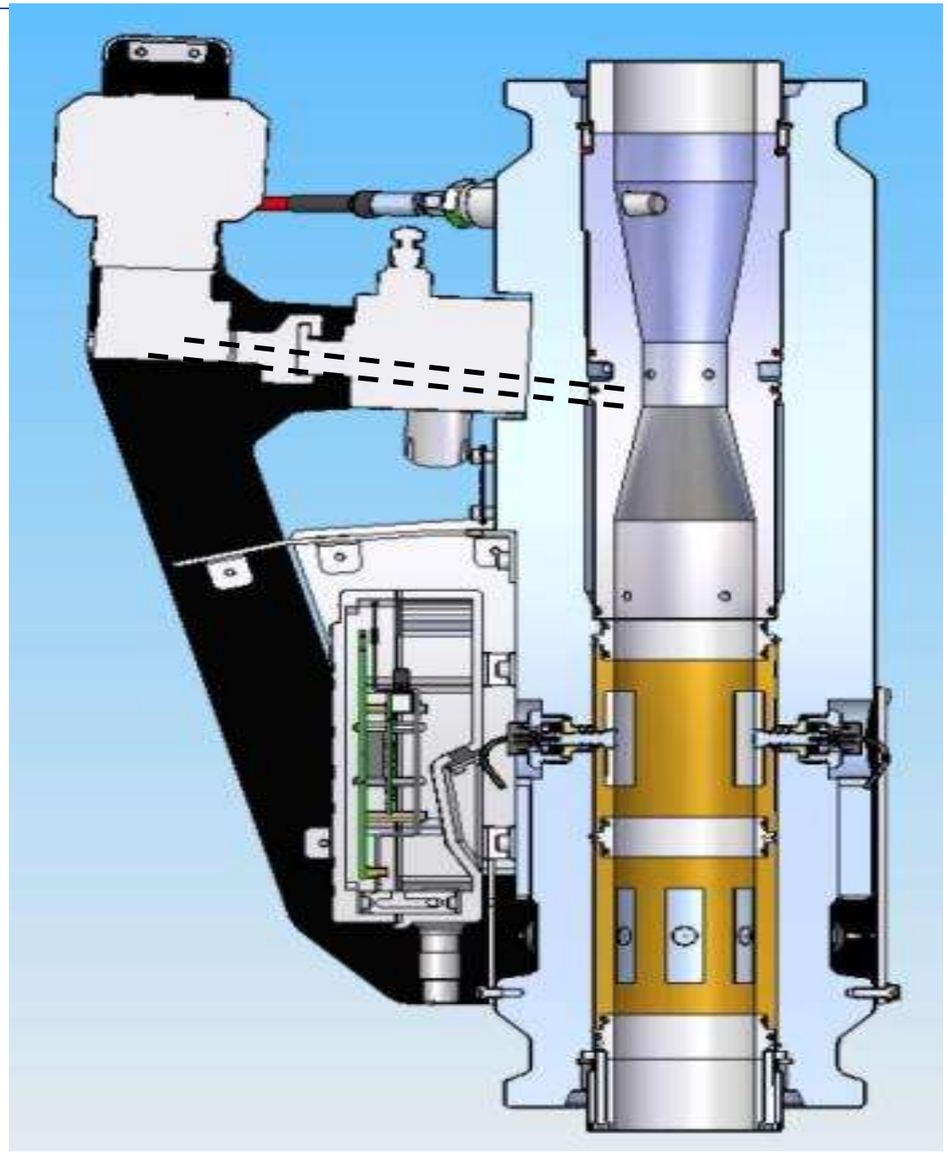
✓ Easy handling

✓ Greater flexibility

Roxar MPFM 2600 – key elements

Field replaceable insert venturi

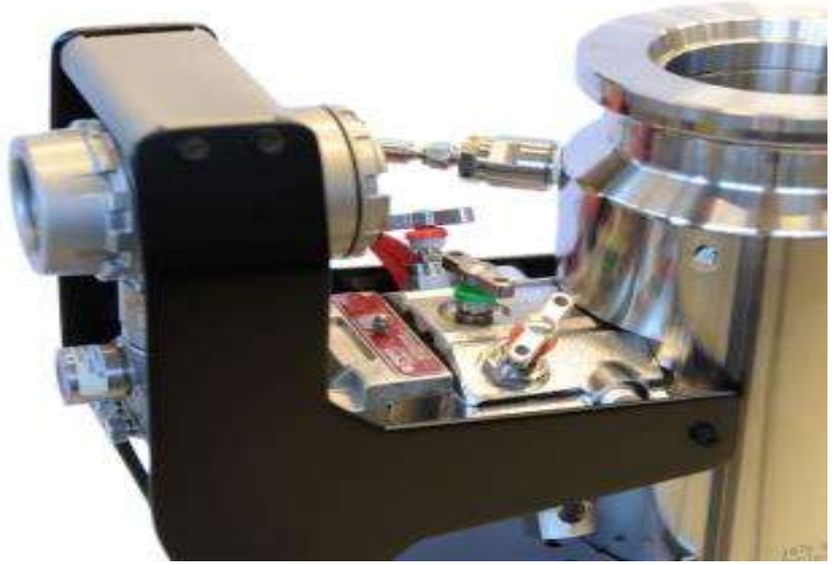
- Four pressure tapping’s and ring chamber improves accuracy and stability (same design as for subsea meters)
- A field replaceable insert venturi sleeve
- Added value:
  - Extended service life
  - Extended operating range – can easily be replaced in the field
  - Removes uncertainties when sizing meters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



Roxar MPFM 2600 – key elements

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

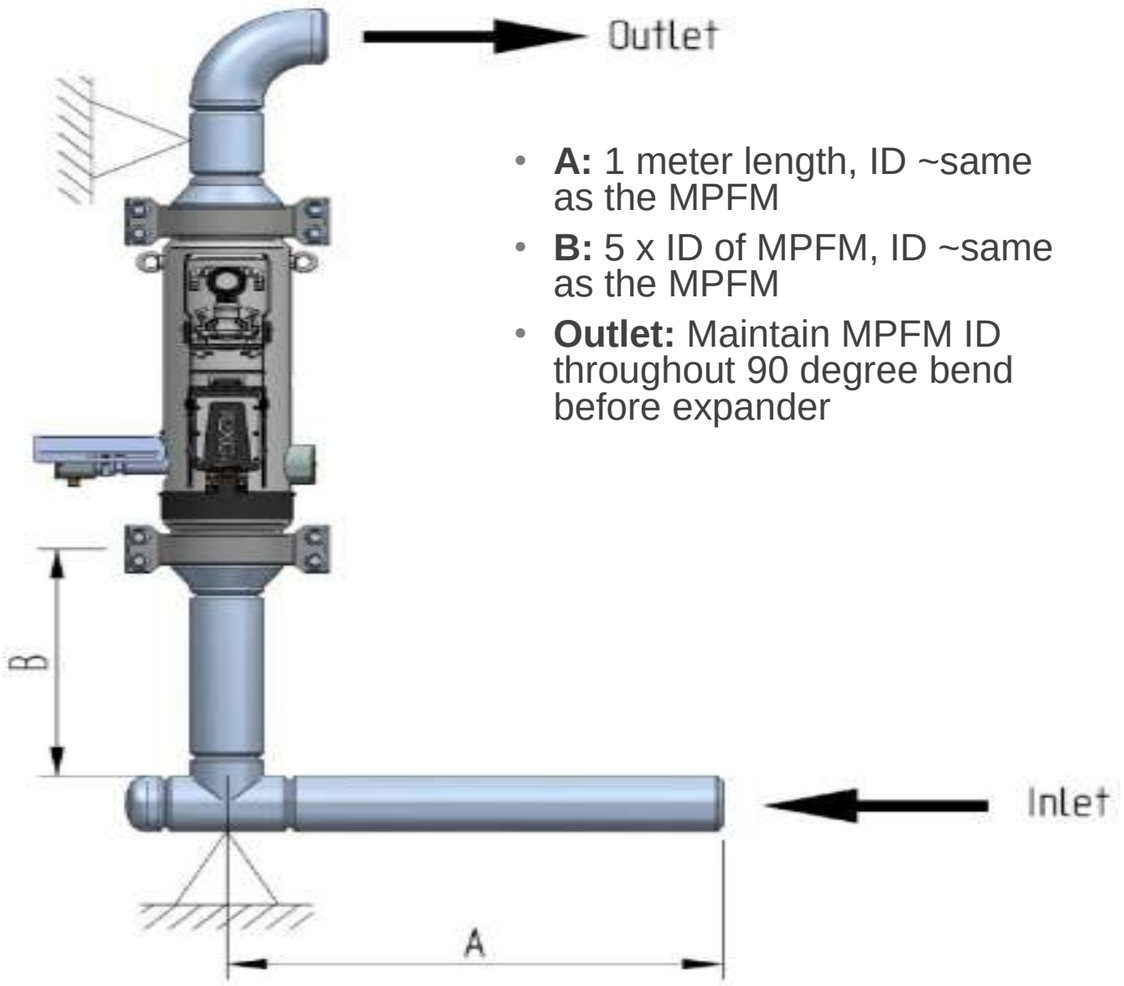
- Non-gamma option – suited for single well installations < 85% GVF
- For multi-well applications and/or GVF >85%, the gamma version is recommended
- **Added value:**
  - No source handling, paper work or import licenses needed
  - The gamma system can easily be retrofitted if and when flow conditions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

+

Upgrade with mini-gamma system

=

Installation Recommendations

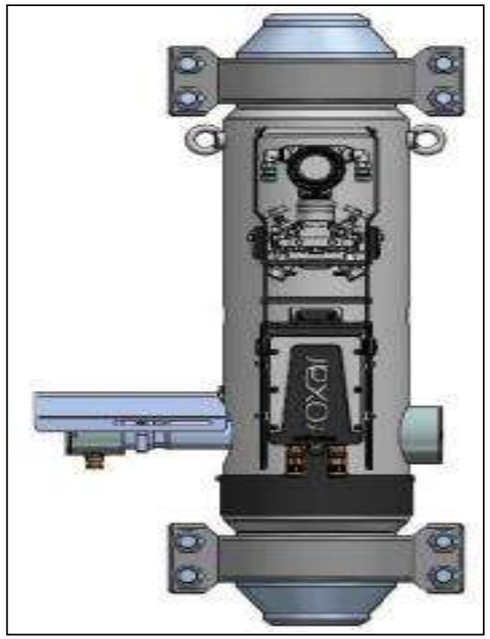


- **A:** 1 meter length, ID ~same as the MPFM
- **B:** 5 x ID of MPFM, ID ~same as the MPFM
- **Outlet:** Maintain MPFM ID throughout 90 degree bend before expander

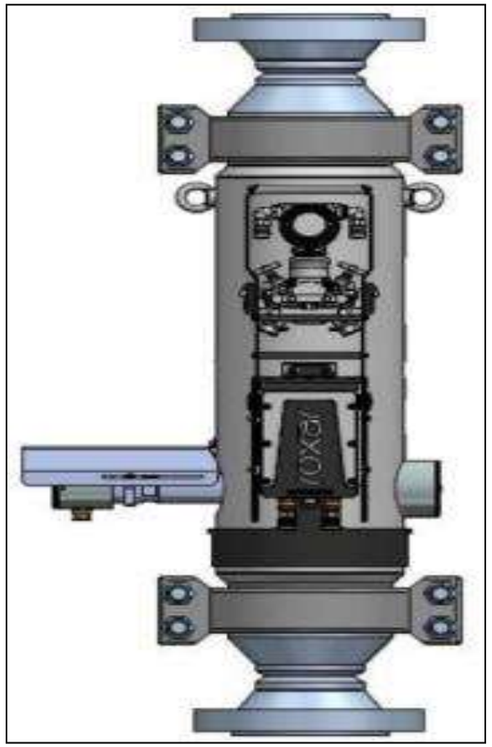
Inline

Installation Options

Hub



X/O w/ Weldneck



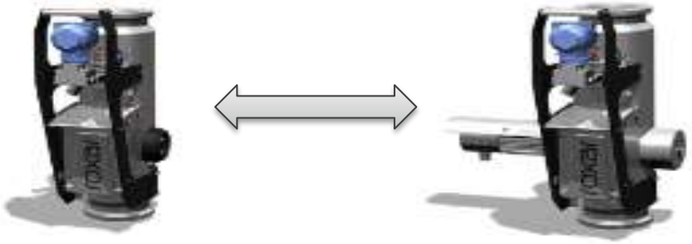
X/O w/ ANSI Flange

Skid mounted

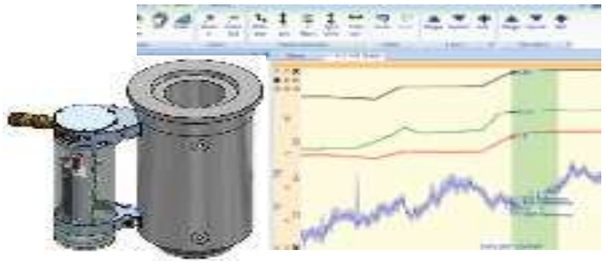
Optional Modules Extending Operating Range and Adds Increased Flexibility

- **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

30+
business units present

9
operating business units

2100+
employees on campus

10 000+
Roxar products shipped

Stavanger, Norway

Subsea Multiphase

Subsea Wetgas

Watercut Meter

Downhole Instrumentation

20 0000+
hours of subsea meter testing

6 800 000 meter
of dowhnhole cable installed

200 000+
assembly man hours for subsea meters

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