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Weatherford

Field Testing an Accurate , Non-nuclear , Inline Wet Gas Multiphase Meter

DID YOU KNOW?

- FORESITE FLOW
  - NON-NUCLEAR
  - FULL RANGE 0-100% GVF
  - Same Technology, Same Hardware

CONTENTS

- Introduction
- VSR Technology
- Field Testing
- Results
- Conclusions

INTRODUCTION

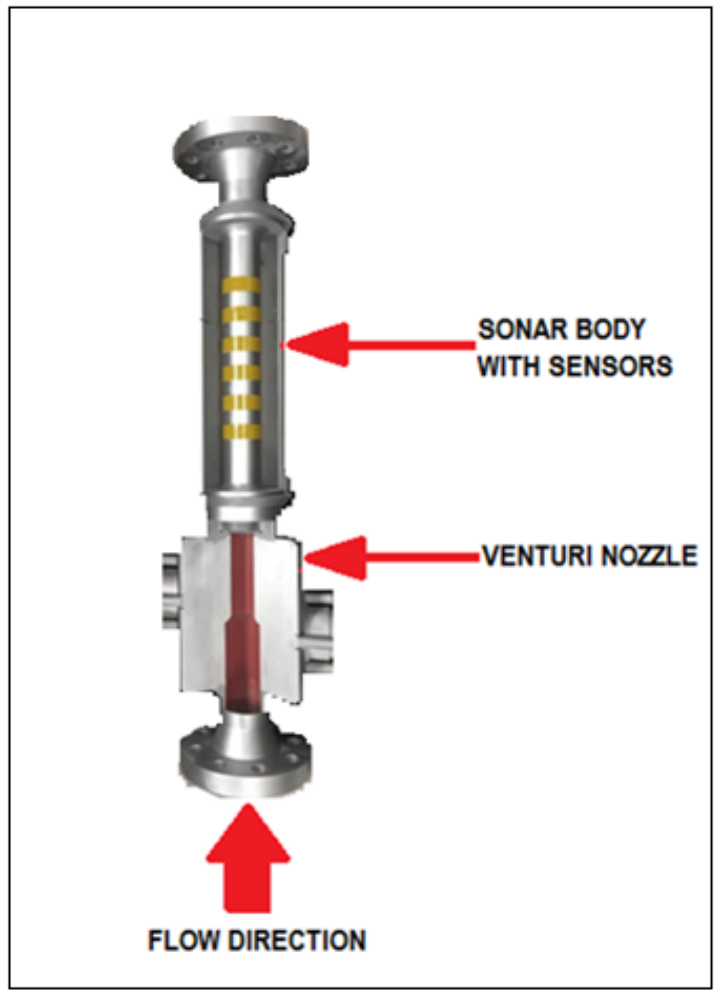
- What is wet gas?
  - GVF>90%
  - $X_{LM} \leq 0.3$
- Applications:
  - Well Testing
  - Production Optimization
  - Allocation Metering
  - Process Metering
- Challenges in wet gas measurement.

VSR Technology

- Key Features
  - Compact
  - Non-nuclear
  - Minimal calibration requirements
  - Low power consumption
  - Broad ambient-temperature ratings
  - Easy maintenance

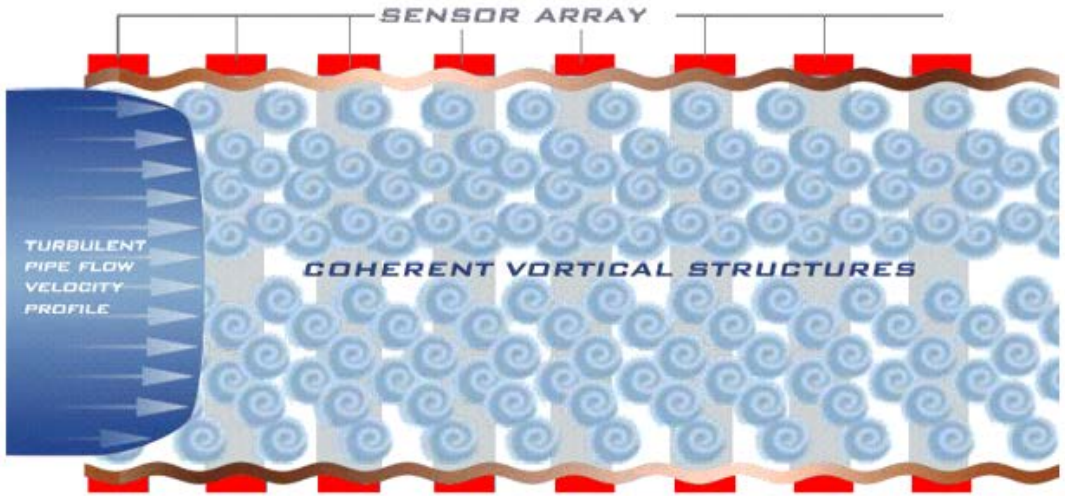
VSR TECHNOLOGY

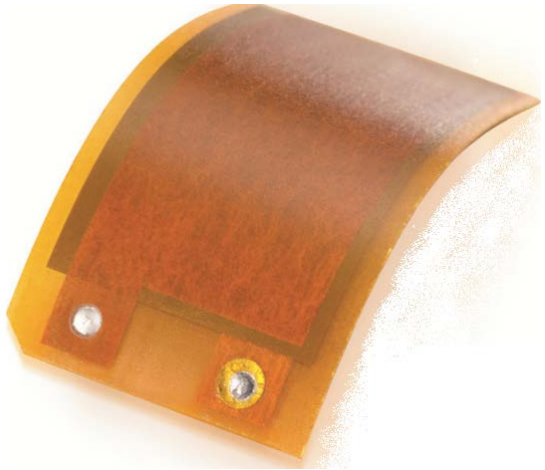
- Ideal DP element
  - Low pressure loss
  - Natural mixing
  - Very robust
  - Handle low flows
- Measurement of flow momentum
- Mixture density and gas volume fraction (GVF)



VSR TECHNOLOGY

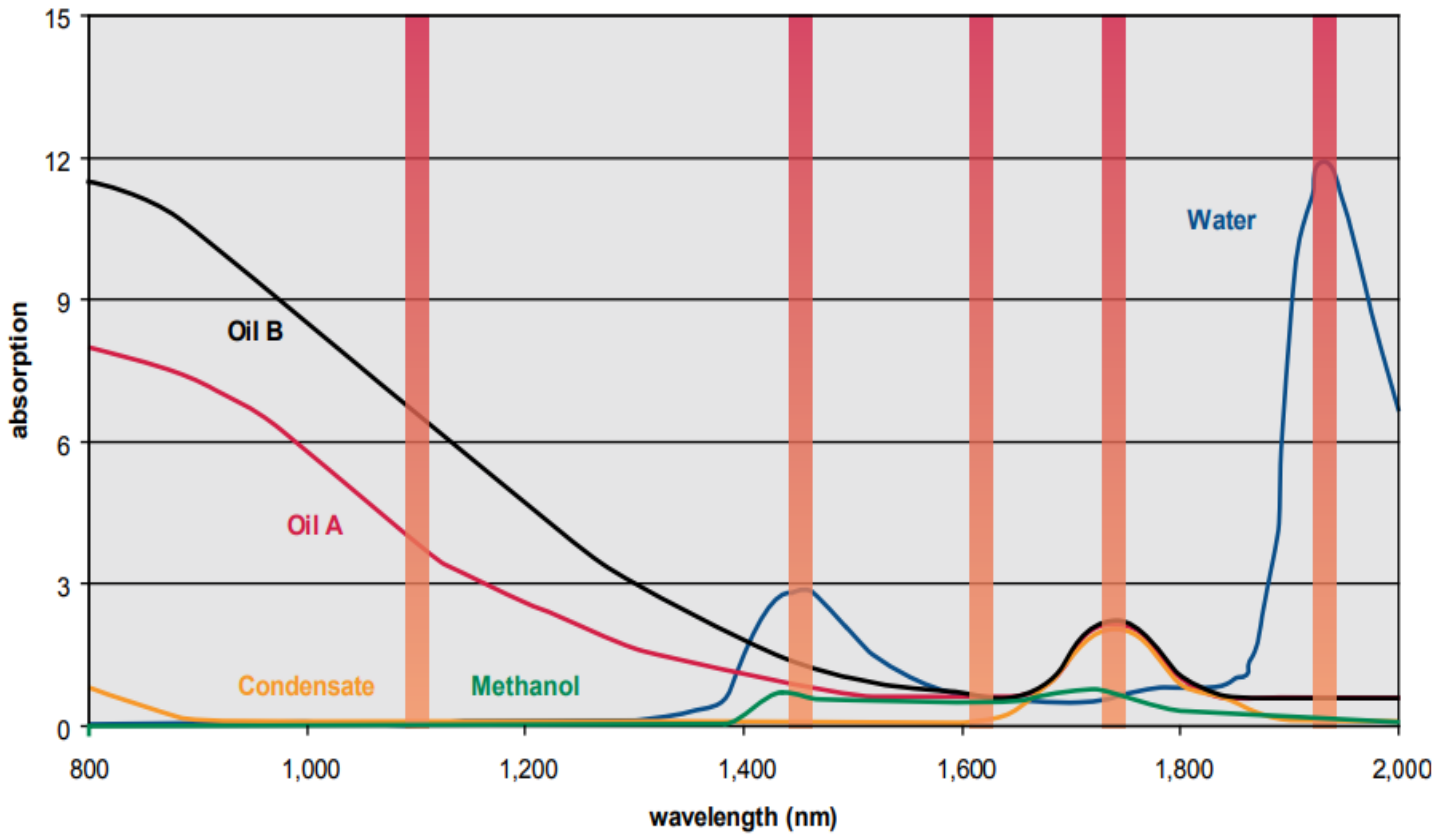
- Piezoceramic sensors
- Phased array processing algorithm
- Convective flow velocity and Volumetric flow rate
- Non-intrusive.





VSR TECHNOLOGY

- NIR Absorption
- 0-100% WC
- Upto 99.9% GVF
- Emulsion and Sand effect
- Water-salinity effect
- H2S and CO2 effect
- All crude oil types

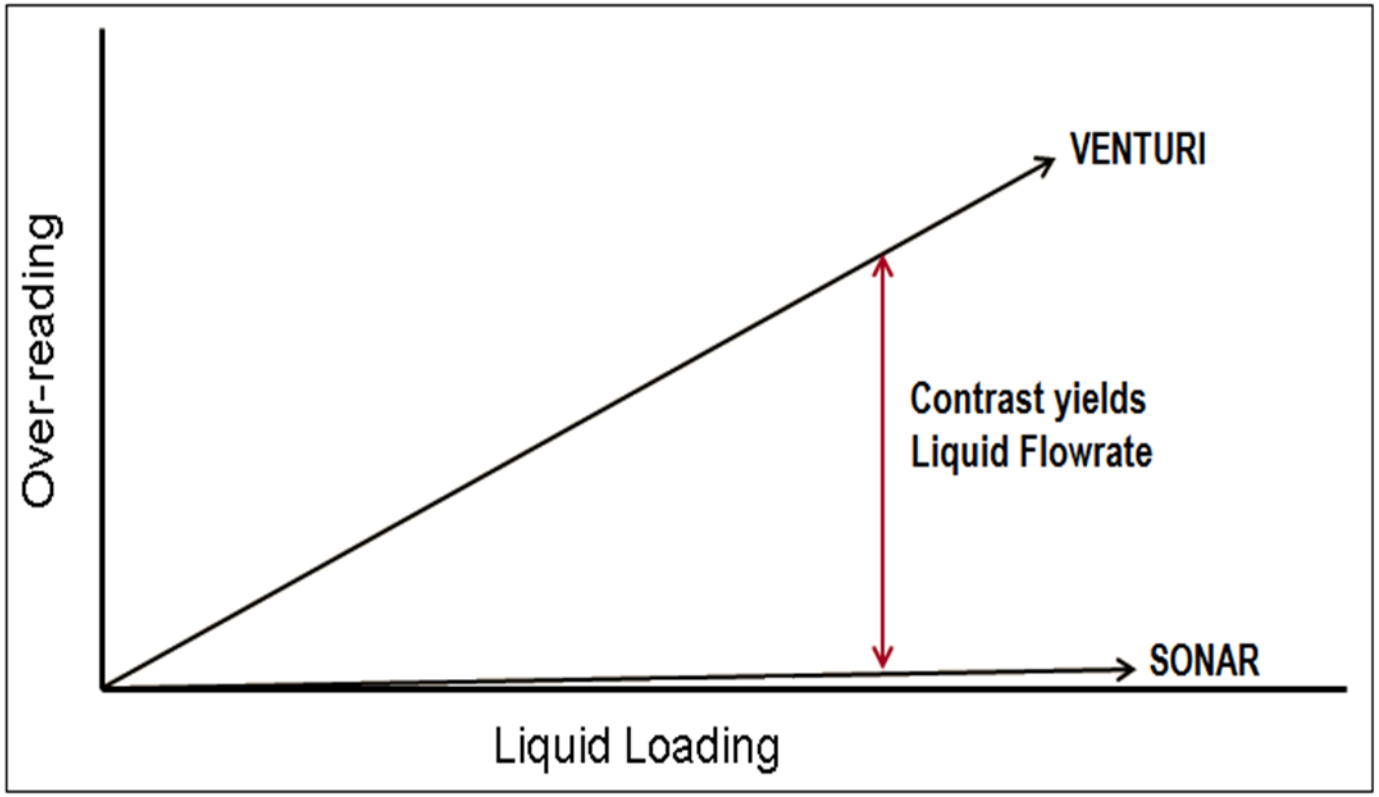


VSR TECHNOLOGY

- Venturi (V)
  - Well documented performance
  - Sensitive to liquid content
- Sonar (S)
  - Based on downhole fiber optic multiphase flowmeter technology
  - Relatively insensitive to liquid content
  - Large turndown ratio
- RedEye (R)
  - Based on Near-Infrared Technology
  - 0-100% Water Cut (WC).

VSR TECHNOLOGY

- Over-reading
- Primarily dependent on liquid loading
- ORV and ORS
- Better contrast than alternative technology.



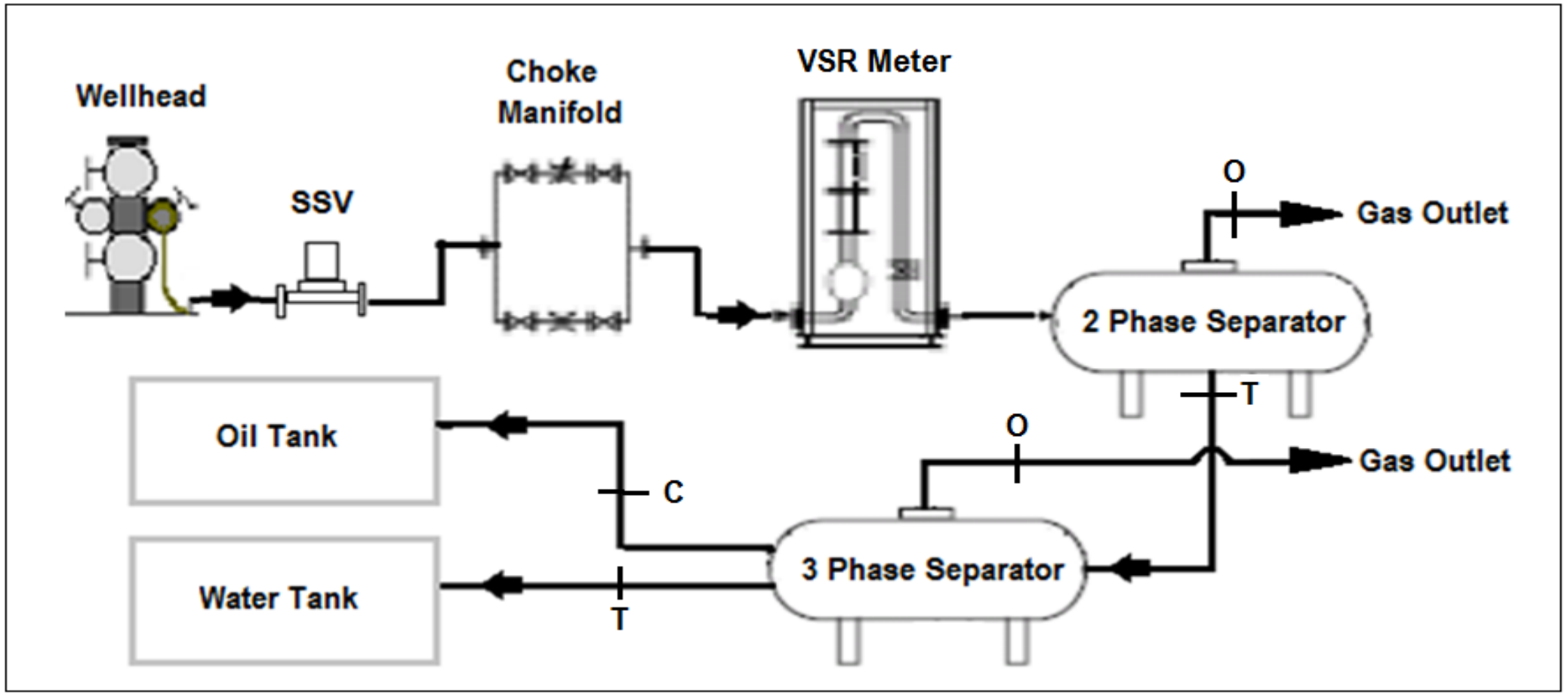
VSR TECHNOLOGY

FIELD TESTING

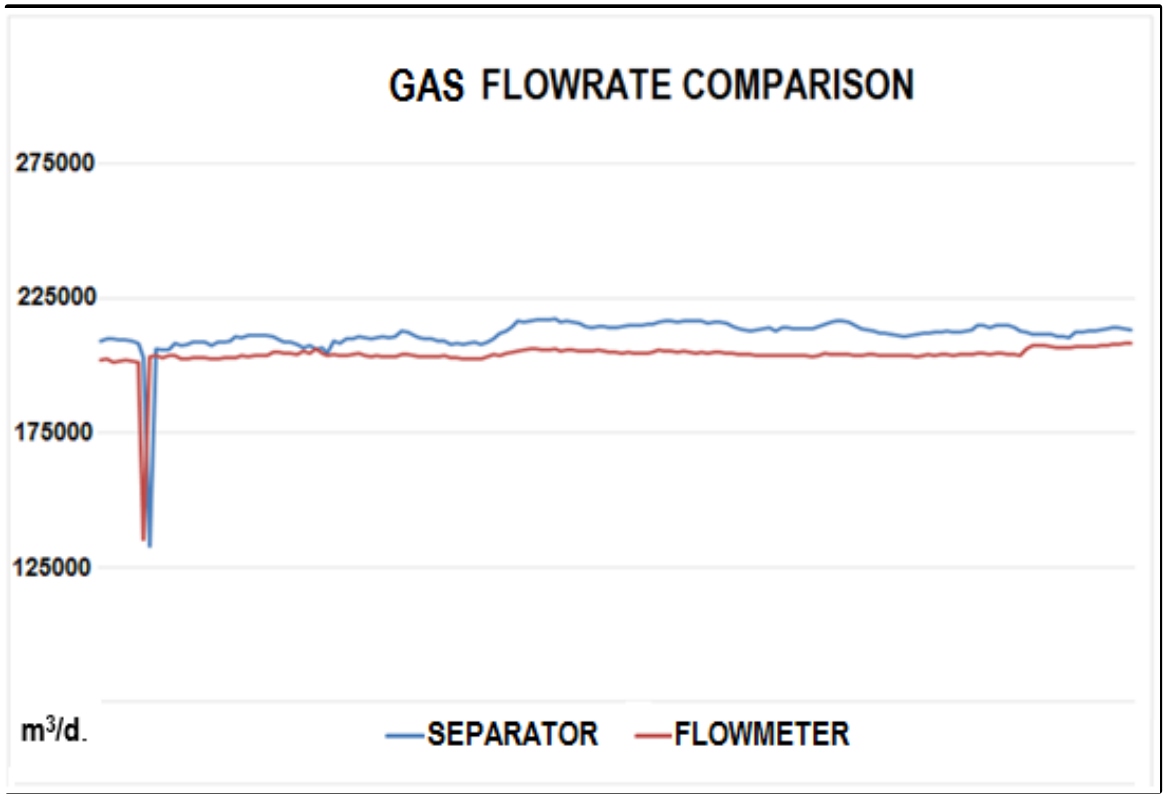
- Objective & Need
- 2-inch ANSI 600# VS, RE MP Meter
- Process flow conditions:

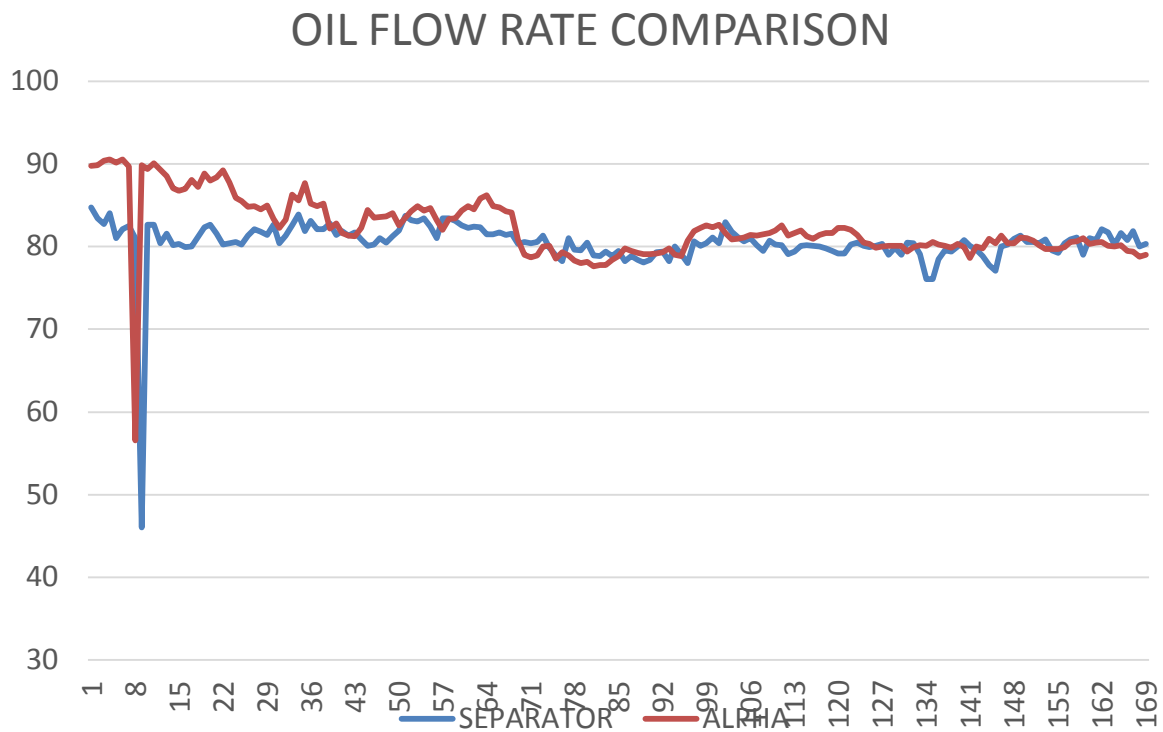
PARAMETER	RANGE
Pressure	80 - 90 bara
Temperature	47 – 52 °C
Water Cut	2 – 10 %
Liquid Flowrate (at std conditions)	80-95 m^3/day
GVF	95 – 98 %
Oil Density	67 °API
Gas Specific Gravity	0.72

FIELD TESTING

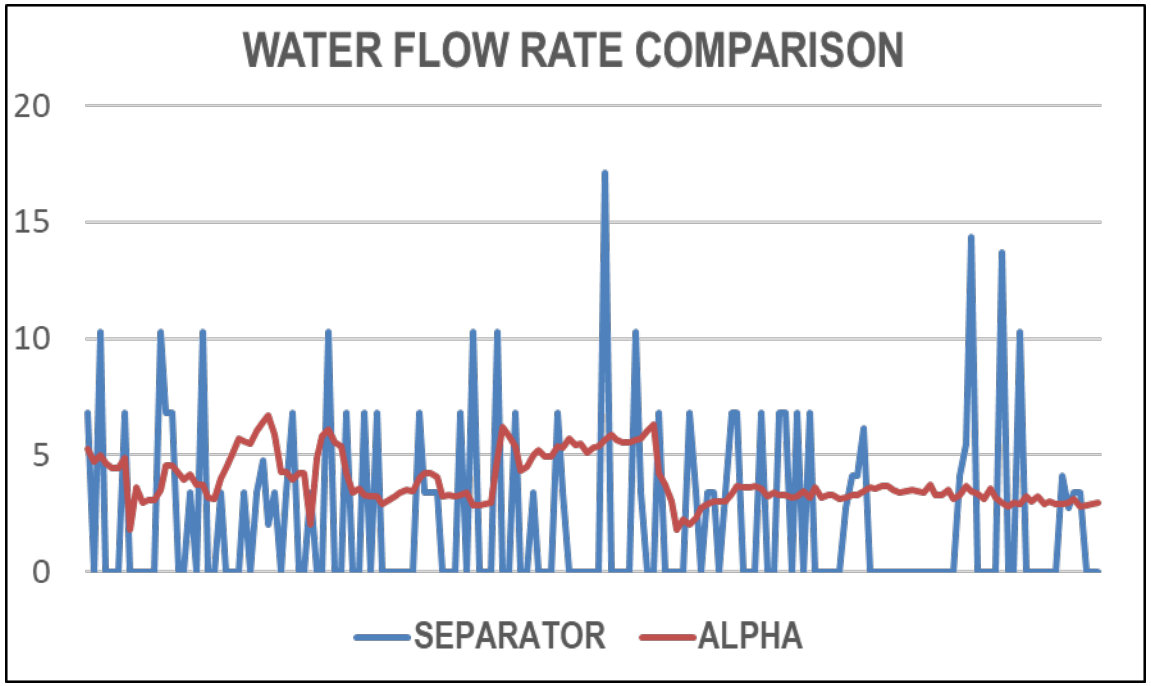


RESULTS


GAS FLOWRATE COMPARISON
275000
225000
175000
125000
m³/d.
SEPARATOR
FLOWMETER


OIL FLOW RATE COMPARISON
100
90
80
70
60
50
40
30
1
8
15
22
29
36
43
50
57
64
71
78
85
92
99
106
113
120
127
134
141
148
155
162
169
SEPARATOR
ALPHA

RESULTS



Parameter	Gas Flowrate	Oil Flowrate	Water Flowrate
% Deviation	-4%	+2%	-6%

CONCLUSIONS

- Good agreement between separator and VSR meter.
- VSR meter provided steadier water flowrate measurement.
- For light oil applications, two-stage separators versus ‘single’ VSR meter.

CONCLUSIONS

- No operational problems were observed.

- Replace test separator
  - accurate measurement
  - continuous monitoring
  - significantly reduces CAPEX and OPEX
  - increased operational reliability.

ACKNOWLEDGEMENTS

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DP model

$$\dot{m}_{total} = Cm * Cd * \mathrm{E} * \varepsilon * A_{throat} * \sqrt{2 * \rho * \Delta P}$$

ΔP: *Inlet to throat pressure difference*

ρ: *gas density*

ε: *compressibility effects*

E, A_{throat}: *Geometry*

Cd: *Viscous Losses*

Cm: *Wet Gas Losses (DP over − read model)*

Sonar model

$$\dot{m}_{total} = Q_g * \rho_g + Q_l * \rho_l$$

$$Q_{total} = Q_g + Q_l$$

$$Q_g = V_g * A_g$$

$$Q_l = V_l * A_l$$

$$Slip = \frac{V_g}{V_l} \text{ (wet gas slip model)}$$

$$V_g = V_{sonar} \text{ (wet gas velocity model)}$$

WET GAS MODEL IMPROVEMENT

Then

- Published DP and slip models
  - e.g. de Leeuw
- Size and pressure specific DP models
- Non-convergence for near dry gas conditions
  - Elevated liquid loading uncertainty above 98% GVF

Now

- Custom DP and slip models
  - Developed from larger database of flow loop testing
  - Optimized for VS spool geometry and orientation
  - Generalized across nominal sizes and operating pressures
- Enhanced iteration method
  - Faster and more robust convergence.
- Reduced liquid rate uncertainty

THANK YOU