An economical subsea wet gas flow meter:
reliable well production solutions for a low cost environment

Subsea Controls Down Under
Perth, October 2016
What is a wet gas?

API RP17S – Recommended Practice for the Design & Operation of Subsea Multiphase Flow Meters

1.2.19 multiphase flow  Flow of a composite fluid that includes natural gas, hydrocarbon liquids, water, and injected fluids, or any combination of these.

1.2.41 wet gas  A subset of multiphase flow in which the dominant fluid is gas and in which there is a presence of some liquid.
Flow Map - Horizontal
Flow Map - Vertical
99.9% GVF

P = 40 Bara
Qg = 1800 m³/hr

GVF = 99.90%
WLR = 100%
99.5% GVF

P = 25 Bara
Qg = 1000 m3/hr

GVF = 99.47%
WLR = 30.0%
Why do we measure wet gas?

• Reservoir management
  • optimise production
  • obtain long term reservoir recovery
  • Detection of water breakthrough

• Production allocation
  • extremely important in the development of marginal fields
How should we measure it?
From ISO 5167:

\[ Q_m = \frac{C}{\sqrt{1 - \beta^4}} \varepsilon \frac{\pi d^2}{4} \sqrt{2\rho \Delta P} \]
Wet Gas Correction:

\[ Q_{gm} = \frac{Q_{gi}}{WGC} \] (for wet gas)

EVALUATING AND IMPROVING WET GAS CORRECTIONS FOR HORIZONTAL VENTURI METERS
Alistair Collins, Mark Tudge, Carol Wade (Solartron ISA)
COST EFFECTIVE INTELLIGENCE

DUALSTREAM 1 (ADVANCED)

- High Accuracy
- Low CAPEX
- Low OPEX
- Low Power
Pressure Profile
Pressure Loss Ratio

The ratio of the total differential pressure ($DP_t$) across the Venturi to the standard Venturi differential pressure ($DP_v$)

\[ PLR = \frac{DP_t}{DP_v} \]

PLR used to quantify water content
Dualstream 1 (Advanced)

(Simplified Diagram)
PLR from industry

de Leeuw paper at 1997 NSFMW
Section 4.3 Venturi Pressure Loss Ratio

ASME MFC 19G-2008
Section 6.2.2 and Appendix J.2

ISO/TR 11583:2012
Section 6.4.5 Use of the Pressure Loss Ratio to determine X (Lockhart-Martinelli parameter)

ISO TR 12748:2015
Section 6.5.2 Differential pressure meter classical DP/permanent pressure loss wet gas meters

NSFMW 2015 - Impact of using ISO/TR 11583 for a Venturi Tube in 3-phase Wet Gas Conditions
Section 3.2 Correlation Developed for Determining the Wetness
Wet Gas Calibration
Wet Gas Calibration – PLR

Differing Flow Conditions

Amount of Liquid
Wet Gas Calibration – PLR

Suite of curves are used to form algorithm – calibration optimises for specific field conditions
Performance:

Gas Rate ± 2%

Water Rate ± 1 am3/h
Water Sensitivity ± 0.2 am3/h

‘Well management / flow assurance applications are defined by the need to track changes...Tracking the difference between measurements over a period of time, rather than the validity of an individual measurement, is of greatest concern.’

*API RP 17S*
“In deepwater areas, the cost of well intervention is a formidable barrier. A single intervention can cost many millions of dollars, and in many cases, the result is uncertain. There are no guarantees.”

Dick Ghiselin, Offshore Magazine, 7th October 2013
Redundancy vs Replacement

**REDUNDANT INSTRUMENTS**
- Redundant instruments online
- Ready to swap
- Multiple communications paths

**REPLACEABLE INSTRUMENTS**
- Replace electronics or pull tree?
- How much?!
- How long before it’s fully working again?
Long term stability

SST3010DP
• Based on Yokogawa DP Cells
• Full welded construction
• Accurate and Stable

Data from long term stability test
Water Accuracy vs. PVT Sensitivity

Shift on O/P Water Volume Flow (am3/h) for 5% shift in CGMR

Gas Mass Fraction

Water/Liquid Ratio

- 0.0-1.0
- 0.8-0.9
- 0.7-0.8
- 0.6-0.7
- 0.5-0.6
- 0.4-0.5
- 0.3-0.4
- 0.2-0.3
- 0.1-0.2
- 0.0-0.1
Venturi – Resilience to Erosion
Dualstream Diagnostics

The Diagnostic Pi ($\pi$)

Healthy Status

- THROAT DEBRIS
- WET GAS CORRECTION
- BLOCKED IMPULSE LINES
- SATURATED DP
- DRIFTING DP
- INCORRECTLY SPANNED DP
- VENTURI CD PIPE DIAMETER (D)
- THROAT DIAMETER (d)
- METER INCORRECTLY INSTALLED
- CALCULATION ERROR
- DP TRANSMITTER MALFUNCTION

Warning Status

- WET GAS CORRECTION
- BLOCKED IMPULSE LINES
- SATURATED DP
- DRIFTING DP
- INCORRECTLY SPANNED DP
- VENTURI CD PIPE DIAMETER (D)
- THROAT DIAMETER (d)
- METER INCORRECTLY INSTALLED
- CALCULATION ERROR
- DP TRANSMITTER MALFUNCTION

Alarm Status
Summary

Even in a low cost environment you can get valuable multiphase data for wet gas wells
THANK YOU – Any questions?

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