AMETEK® OIL & GAS

solartron ISA

An economical subsea wet gas flow meter:

reliable well production solutions for a low cost environment

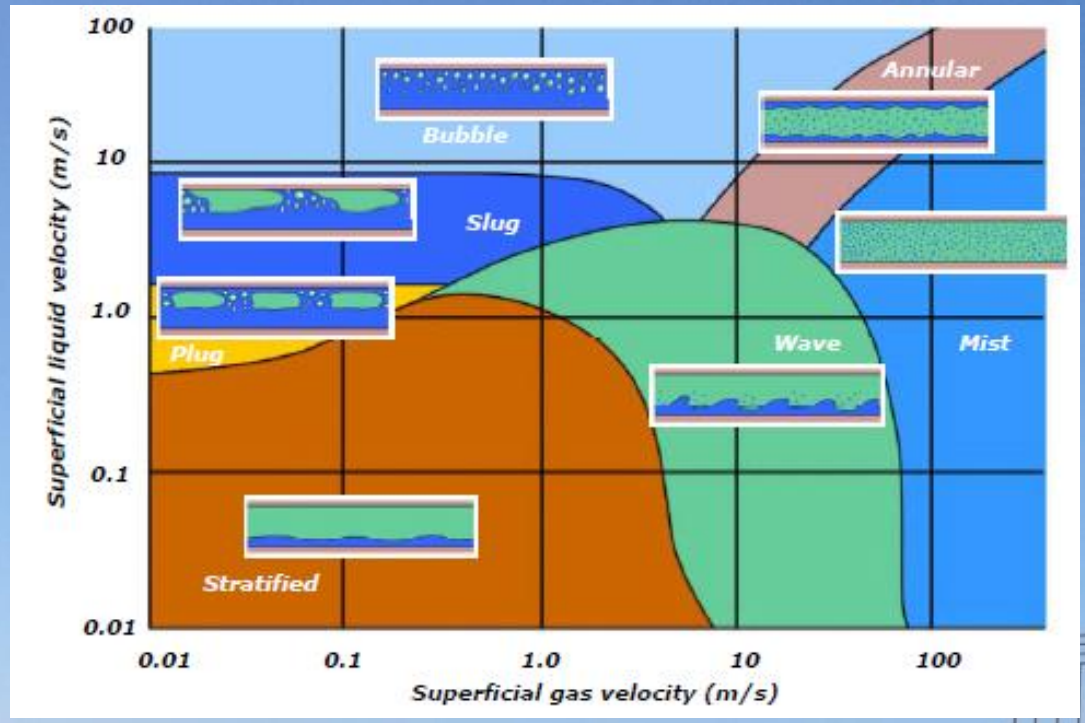
Subsea Controls Down Under
Perth, October 2016

What is a wet gas ?

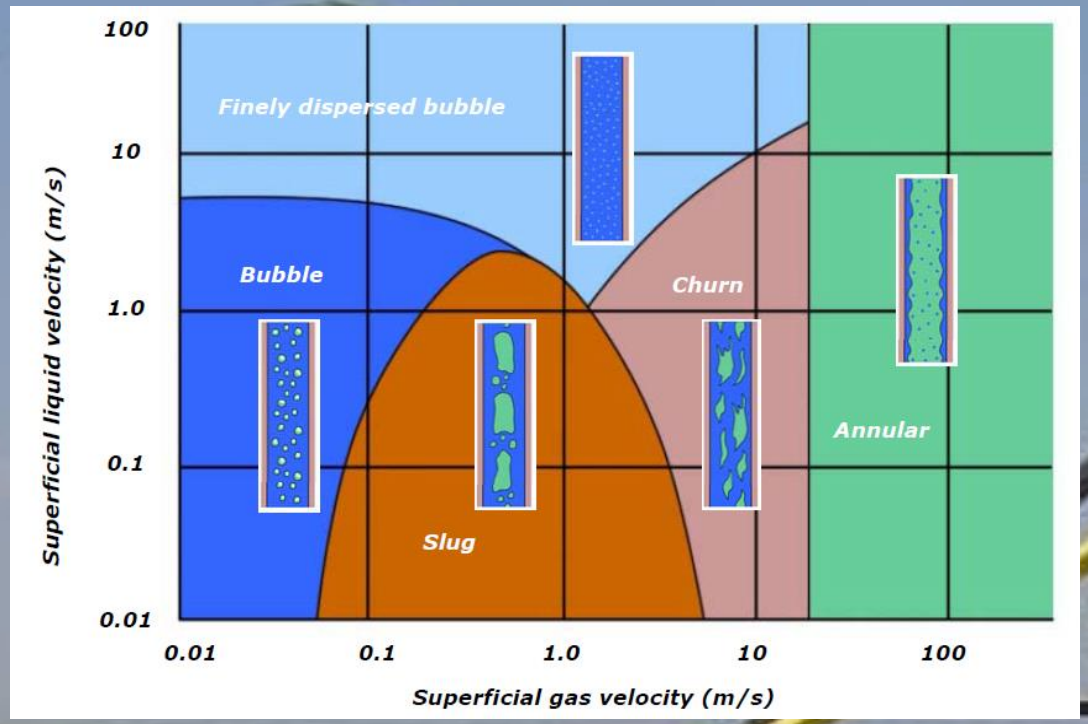
API RP17S – Recommended Practice for the Design & Operation of Subsea Multiphase Flow Meters

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.

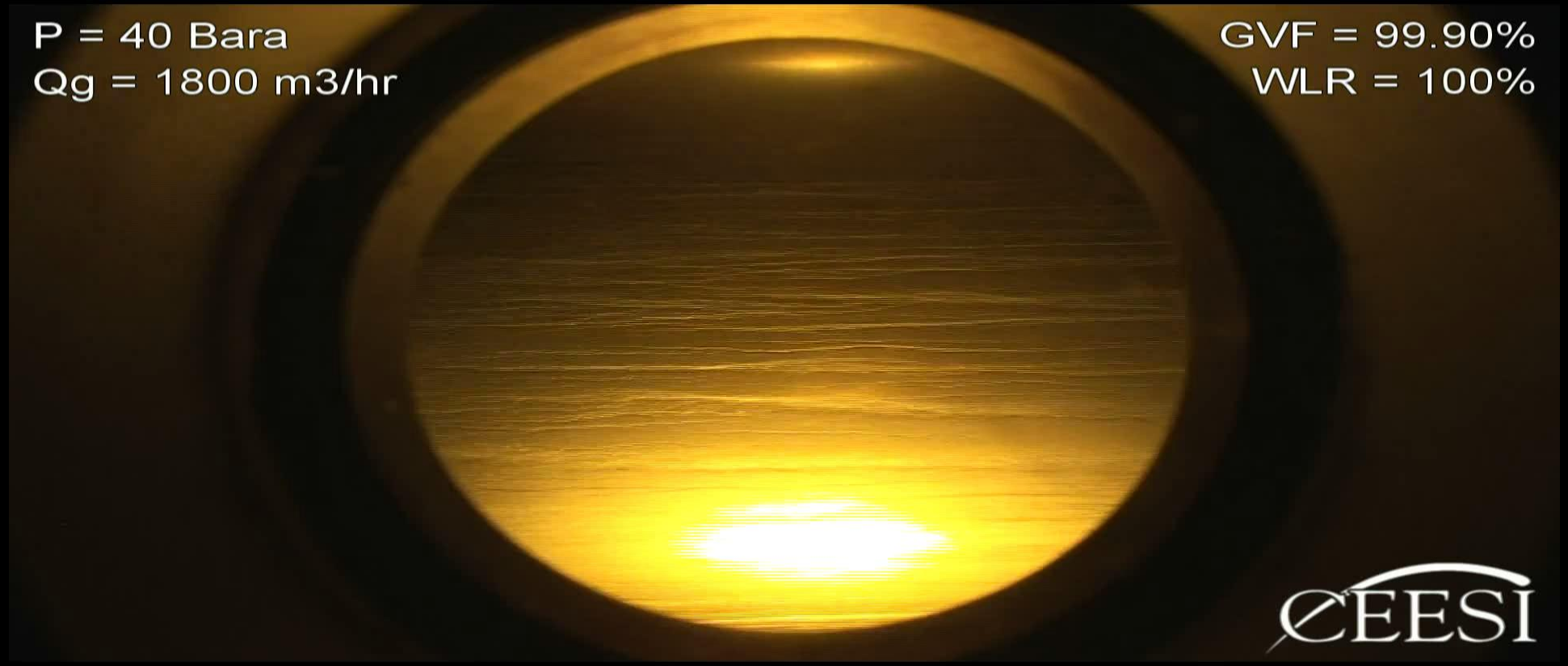
Flow Map - Horizontal



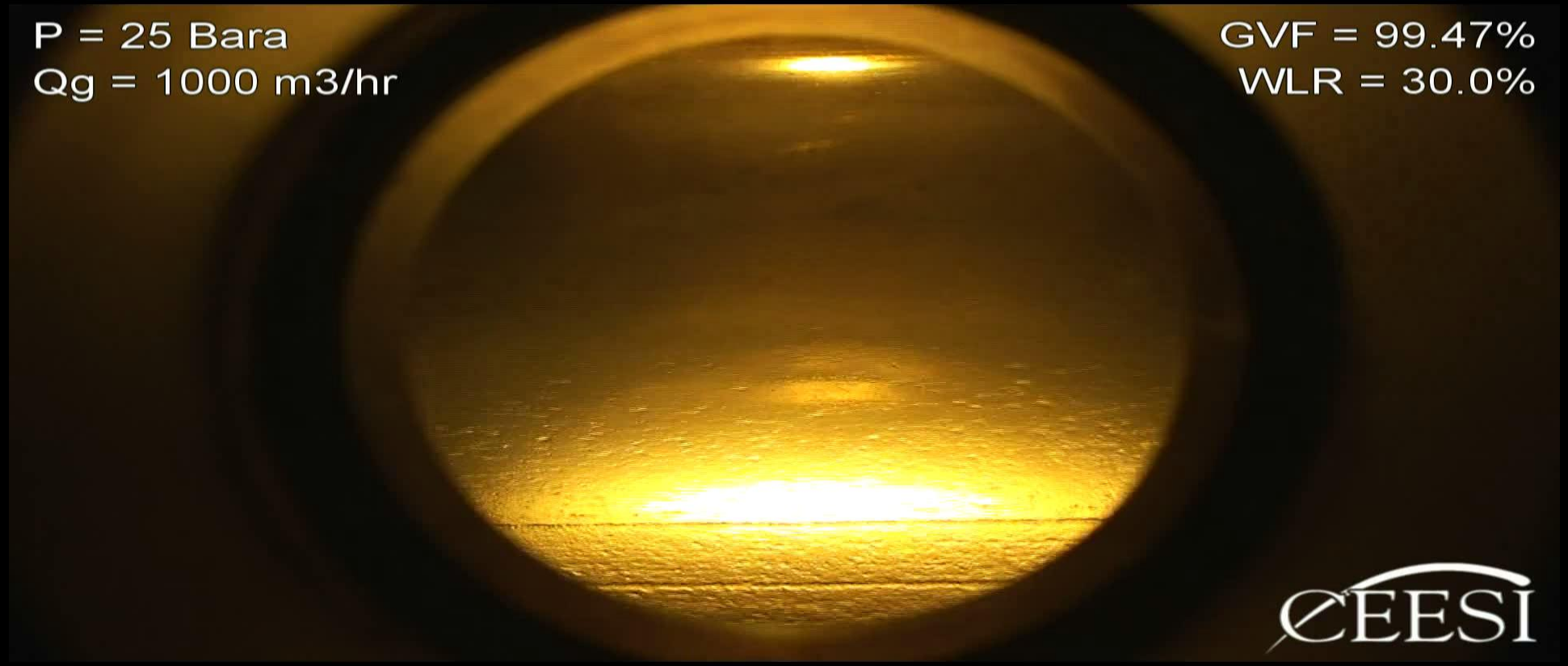
Flow Map - Vertical



99.9% GVF



99.5% GVF



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?

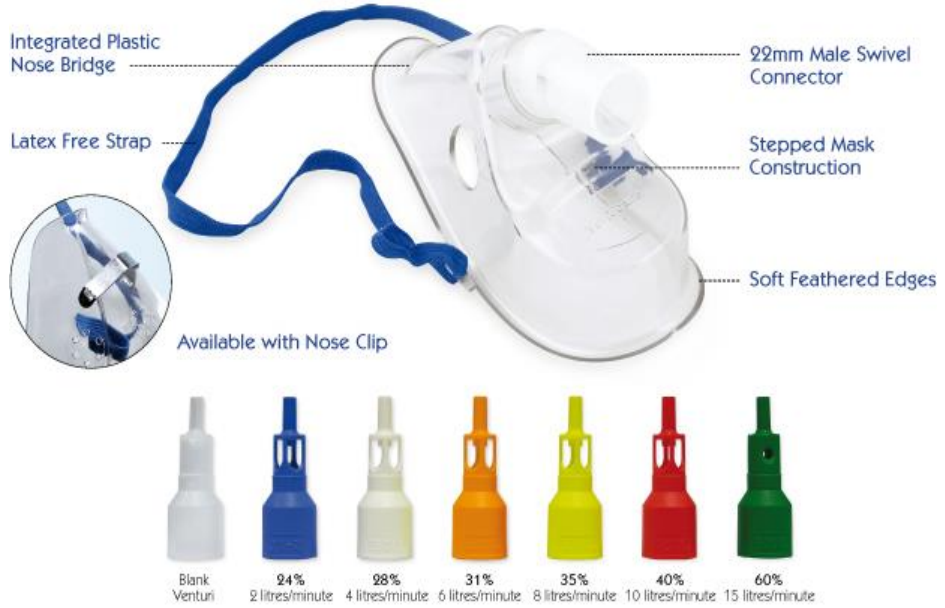
Bernoulli

Venturi

Reynolds

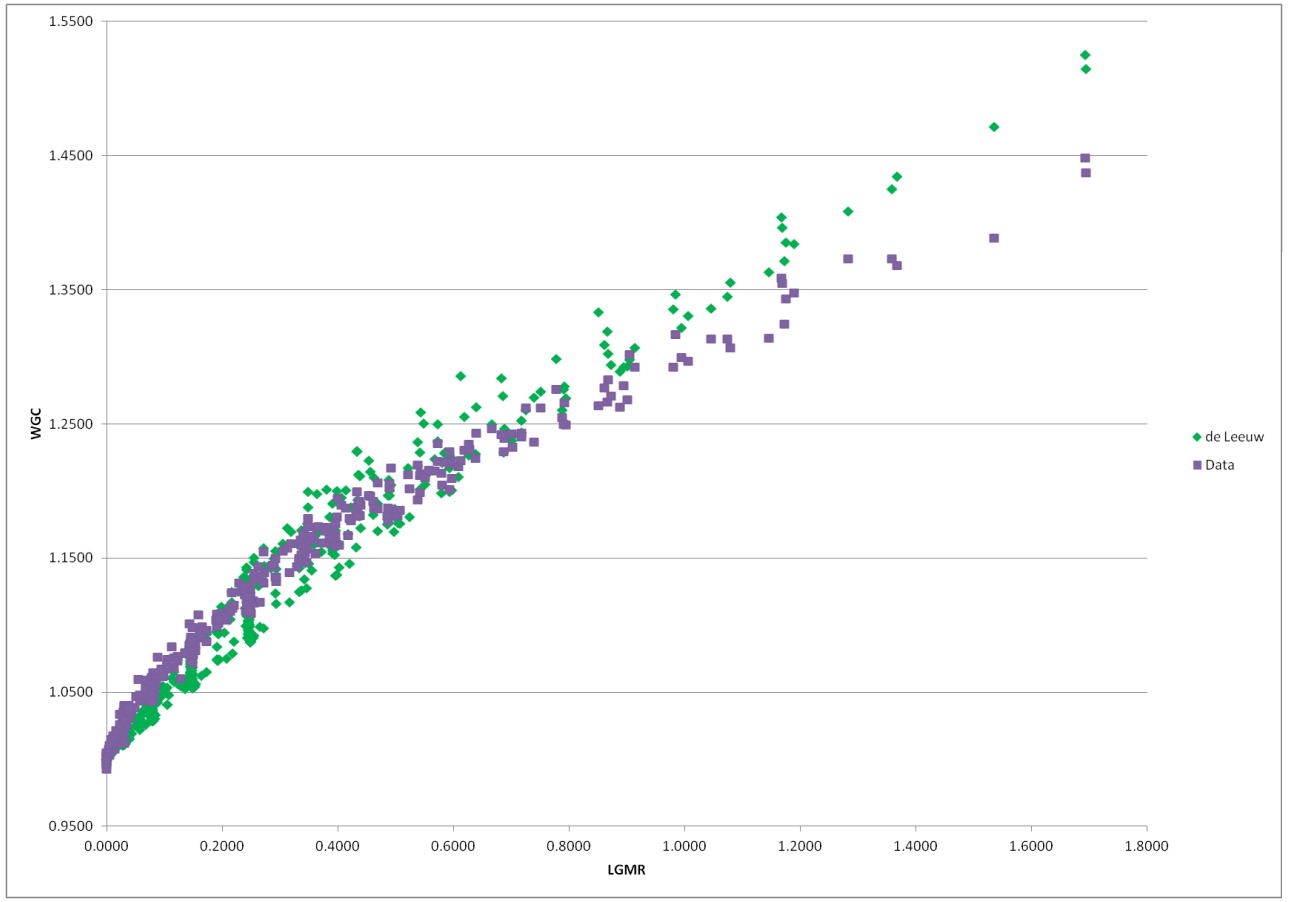
From ISO 5167:

$$Q_m = \frac{C}{\sqrt{1-\beta^4}} \varepsilon \frac{\pi d^2}{4} \sqrt{2\rho\Delta P}$$



Wet Gas Correction:

$$Q_{gm} = \frac{Q_{gi}}{WGC} \quad \text{(for wet gas)}$$



EVALUATING AND IMPROVING WET GAS CORRECTIONS FOR HORIZONTAL VENTURI METERS

Alistair Collins, Mark Tudge, Carol Wade (Solartron ISA)

	2δ relative wet gas correction uncertainty		
	All Data Points	X ≤ 0.3	X ≤ 0.1
CONVENTIONAL / ORIFICE WET GAS CORRECTIONS			
Homogeneous	6.036%	5.583%	3.570%
Murdock (M = 1.26)	10.061%	9.990%	8.720%
Murdock (M = 1.50)	7.774%	7.739%	7.305%
Chisholm	10.464%	10.362%	8.772%
James	14.676%	14.215%	10.309%
Lin	17.481%	16.602%	11.323%
Smith and Leang	19.158%	18.825%	16.598%
VENTURI SPECIFIC CORRECTIONS			
de Leeuw	4.011%	3.829%	3.311%
Steven	4.719%	4.458%	4.208%
ISO TR 11583:2012	2.584%	2.502%	2.338%
He and Bai	4.186%	4.010%	3.198%
EXAMPLE OF MANUFACTURER-SPECIFIC WET GAS CORRECTION			
Solartron ISA	1.579%	1.497%	1.217%

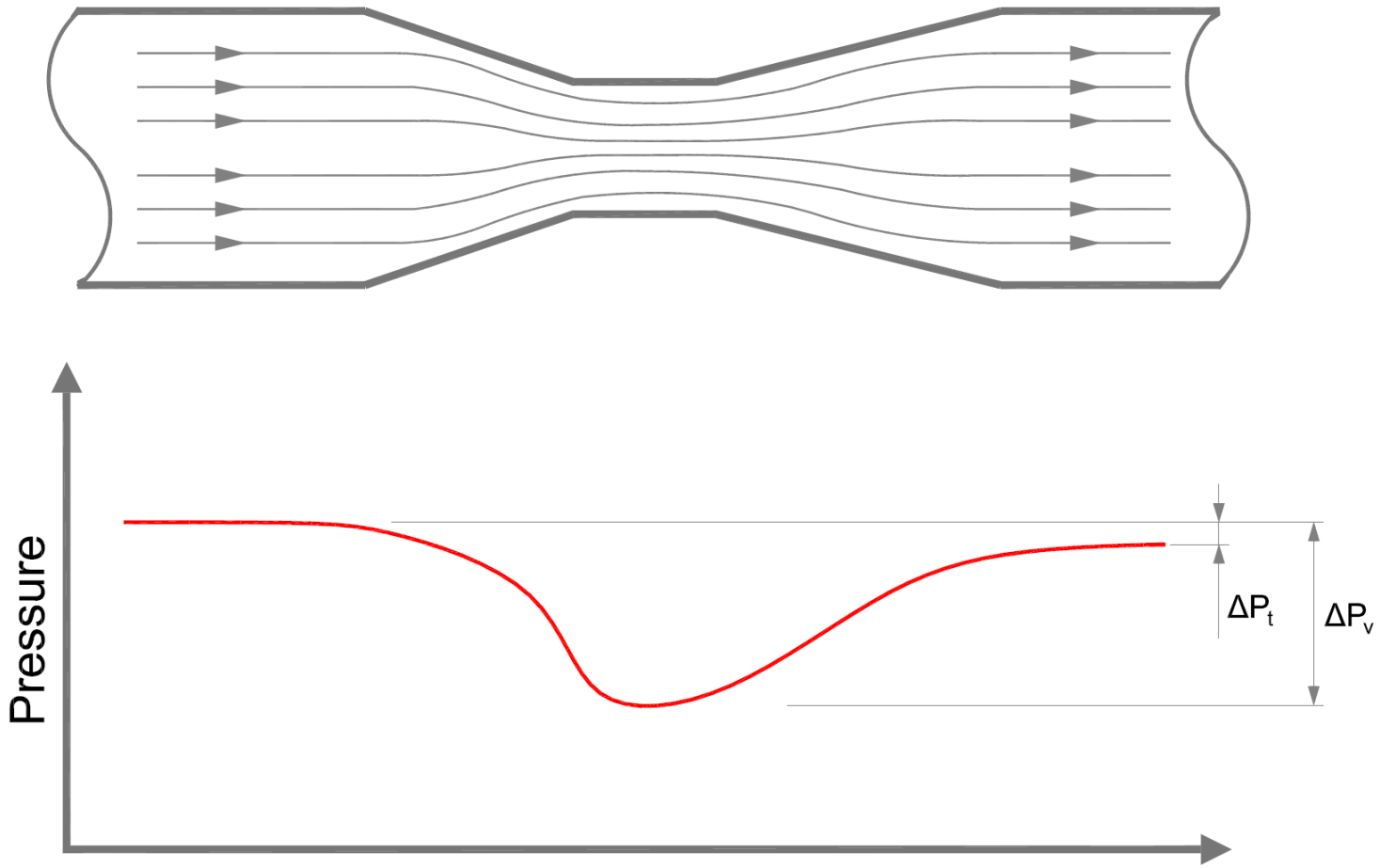
Table 2 – Performance of the Wet Gas Corrections

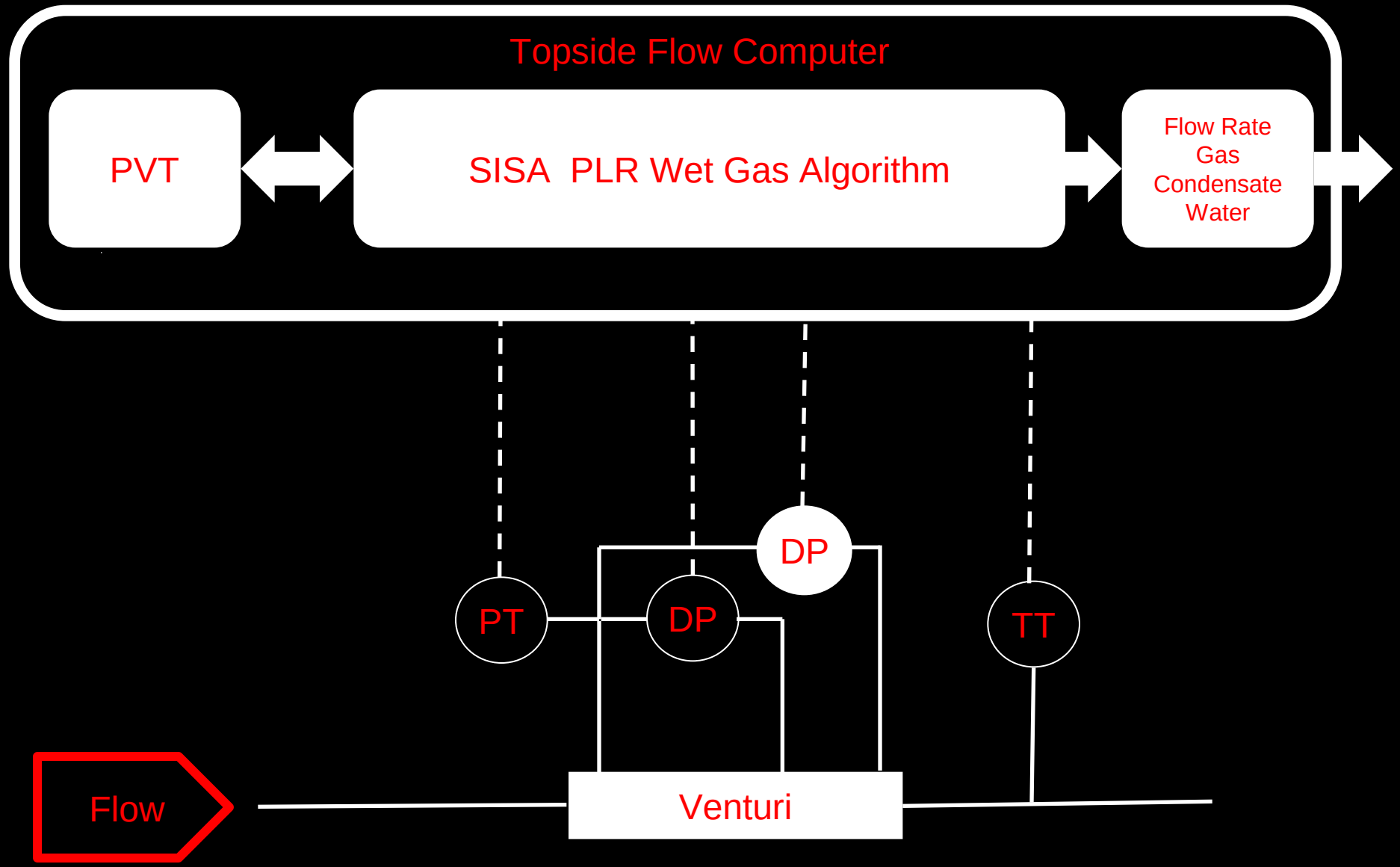
COST EFFECTIVE INTELLIGENCE

DUALSTREAM 1 (ADVANCED)

- ✓High Accuracy
- ✓ Low CAPEX
- ✓ Low OPEX
- ✓ Low Power

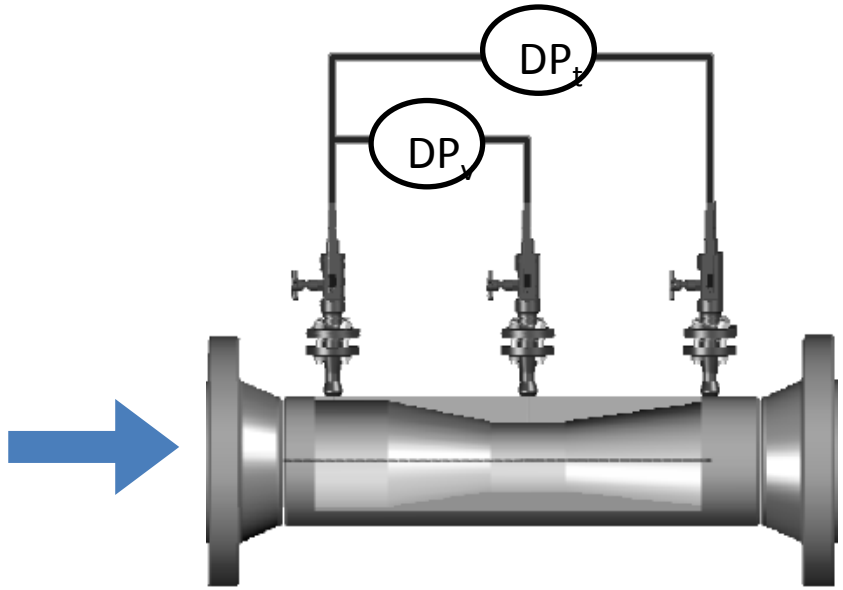
Pressure Profile

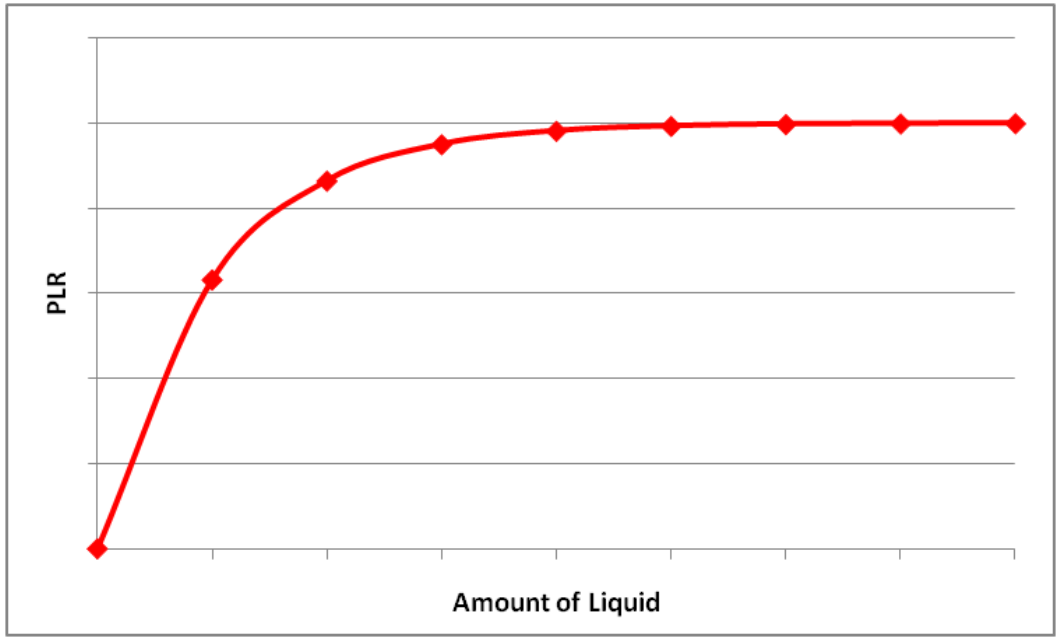



Topside Flow Computer
PVT
SISA PLR Wet Gas Algorithm
Flow Rate
Gas
Condensate
Water
DP
PT
DP
TT
Flow
Venturi

Pressure Loss Ratio

The ratio of the total differential pressure (DPt) across the Venturi to the standard Venturi differential pressure (DPv)

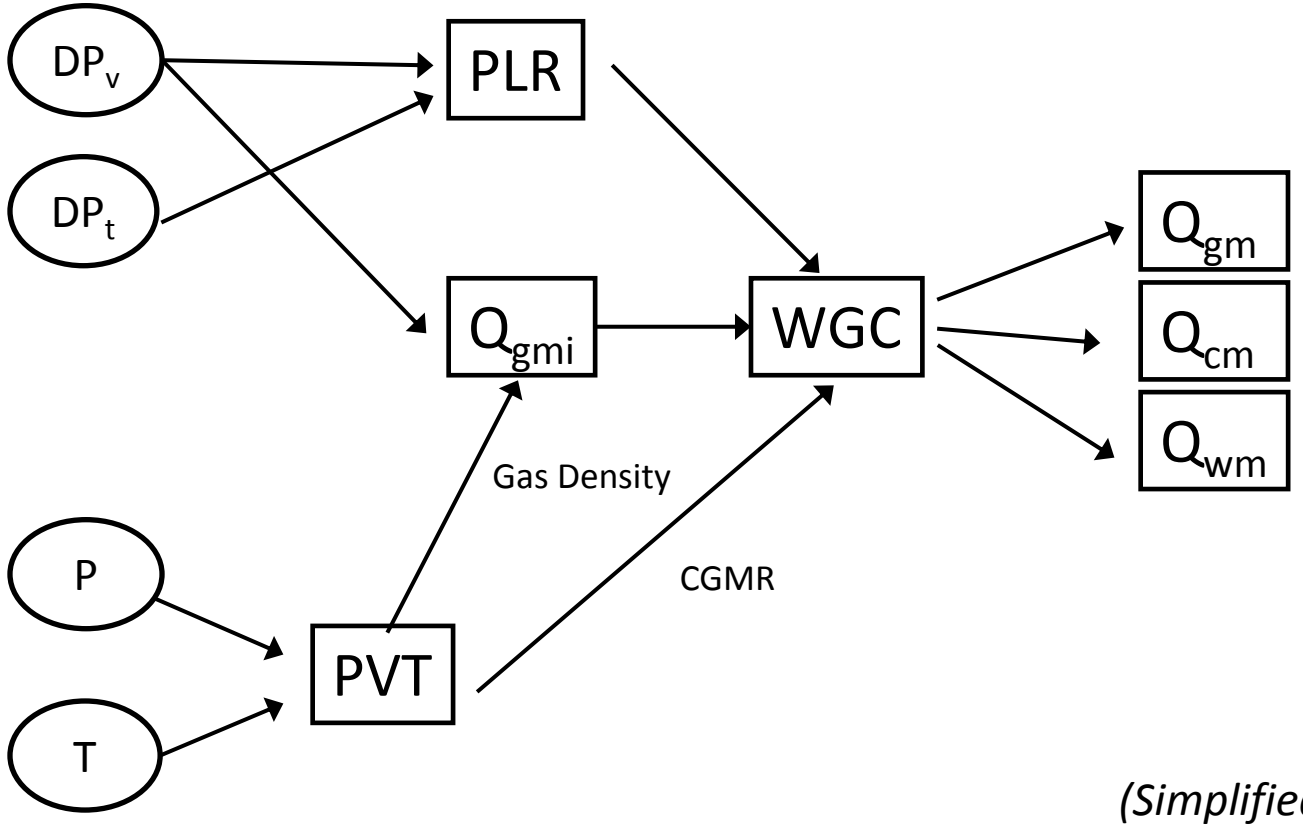




$$PLR = \frac{DP_t}{DP_v}$$

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

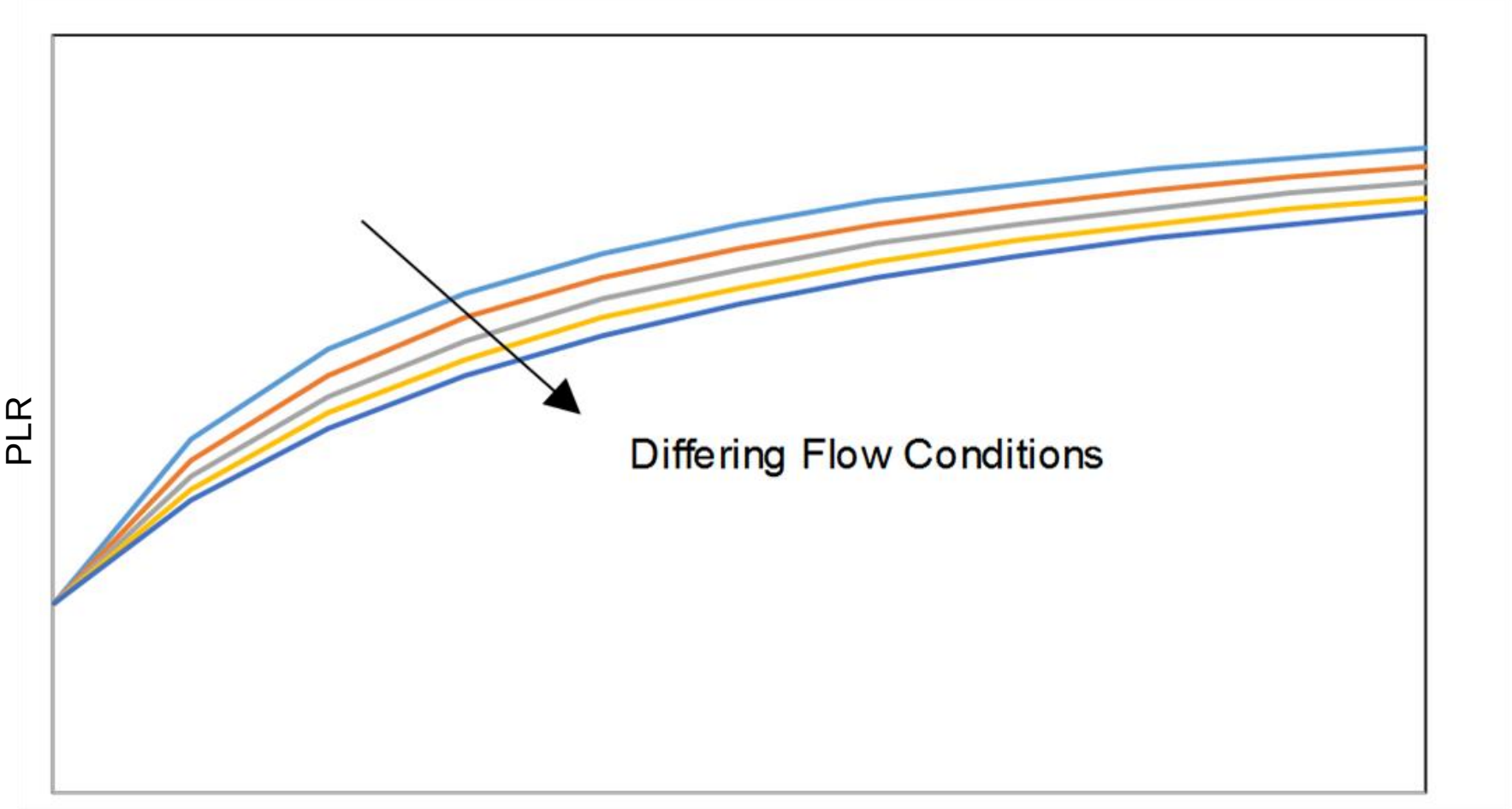
Section 6.5.2 Differential pressure meter classical DP/permanent pressure loss wet gas meters

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

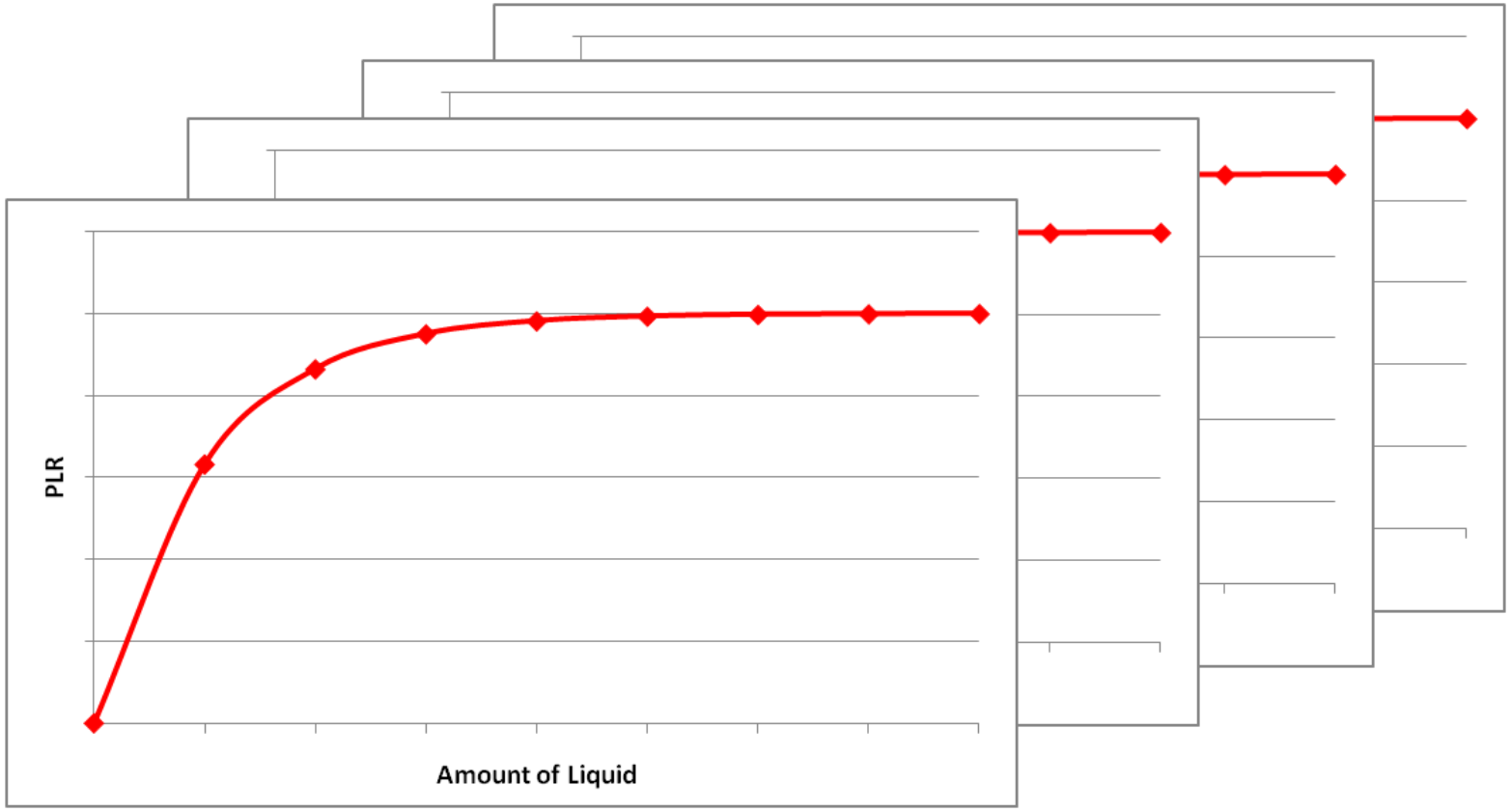
Wet Gas Calibration

Wet Gas Calibration – PLR

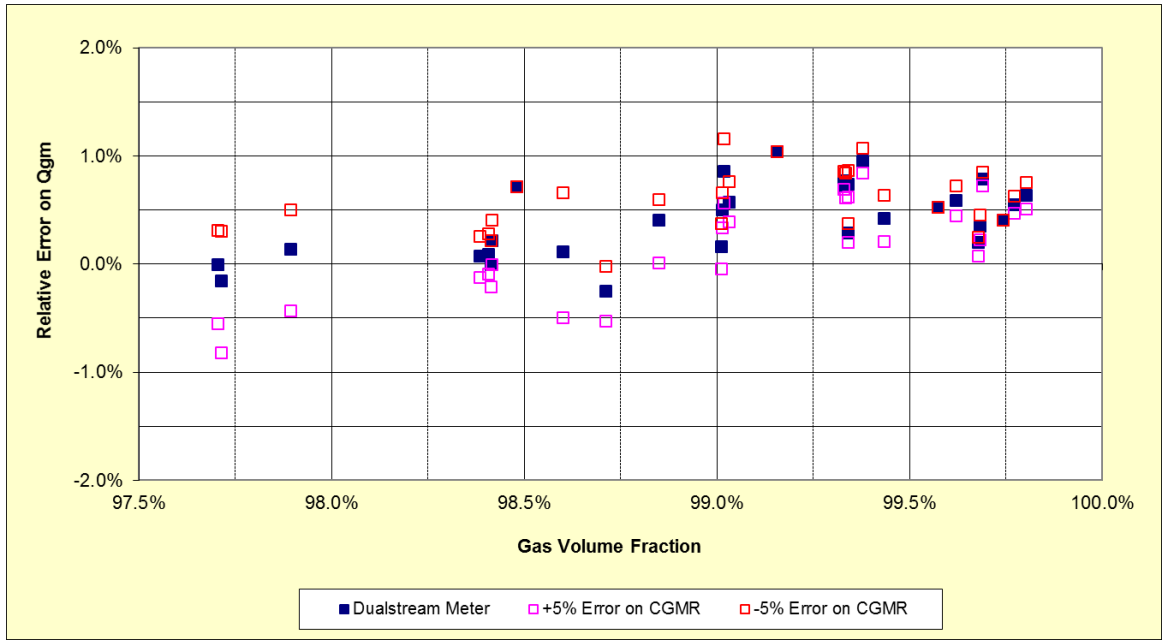


Wet Gas Calibration – PLR

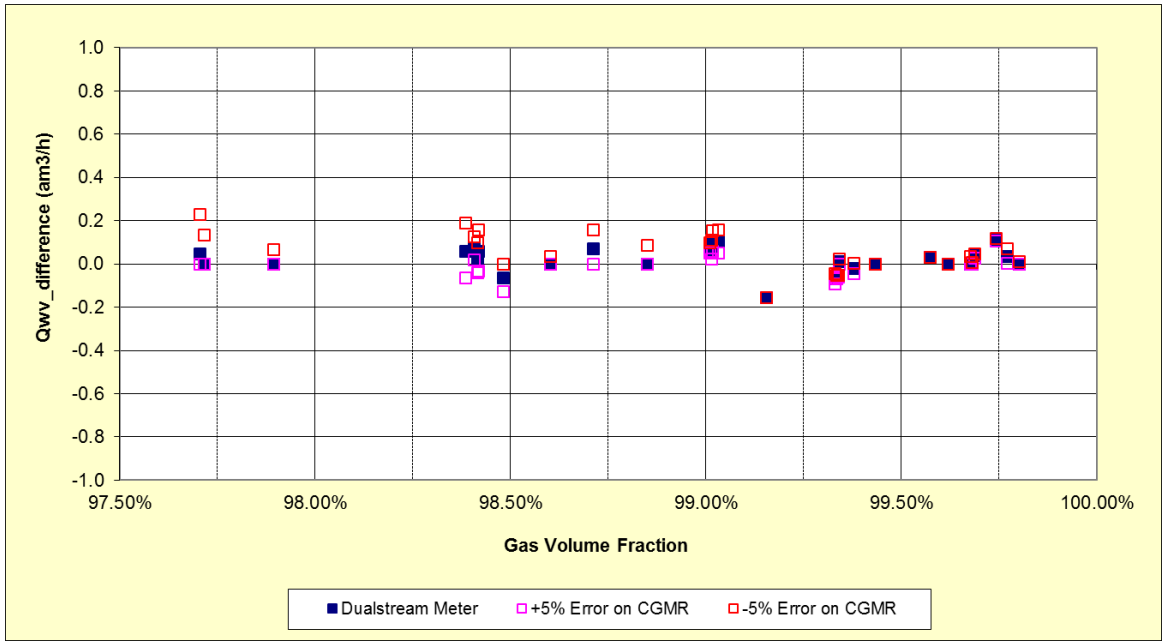
Suite of curves are used to form algorithm – calibration optimises for specific field conditions



Performance:



Gas Rate ± 2%

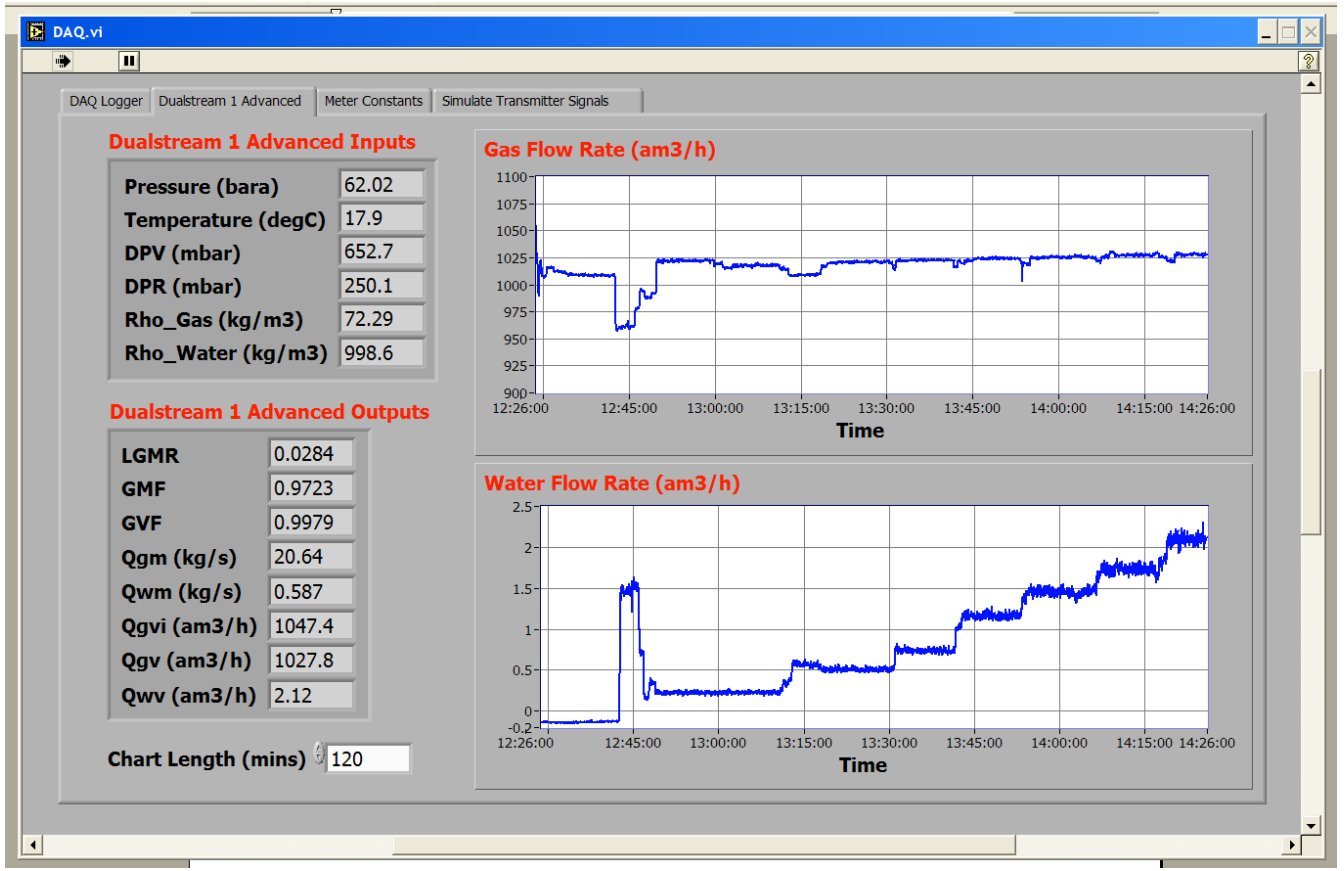


Water Rate ± 1 am3/h

Recent Third Party Testing

Water Sensitivity ± 0.2 am3/h

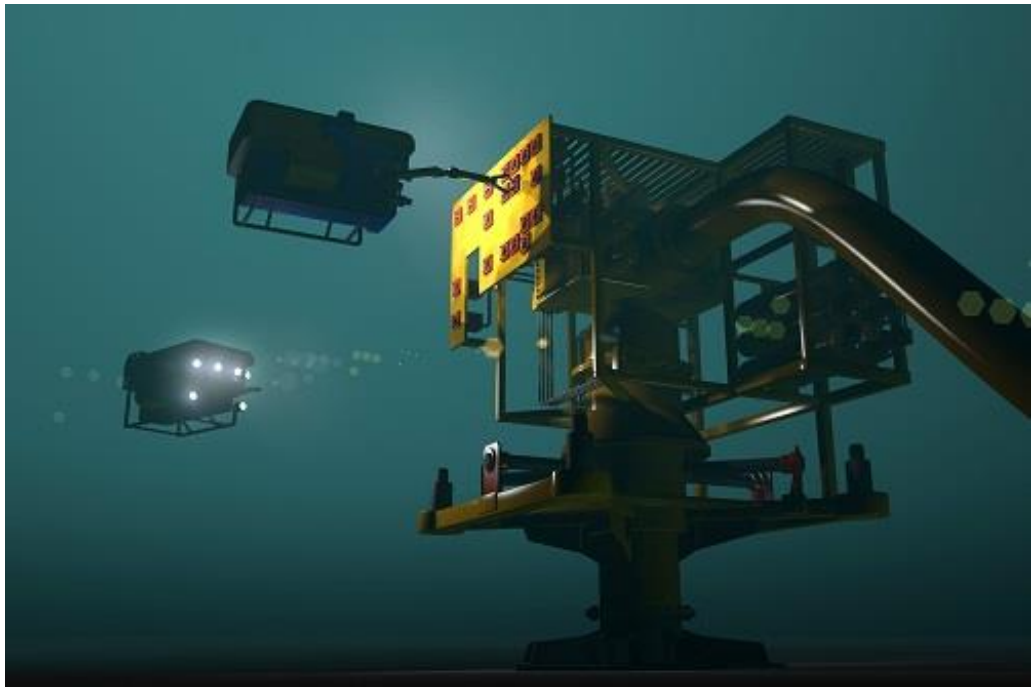
’Well management / flow assurance applications are defined by the need to track changes…Tracking the difference between measurements over a period of time, rather than the validity of an individual measurement, is of greatest concern.’ *API RP 17S*



Subsea interventions…

"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



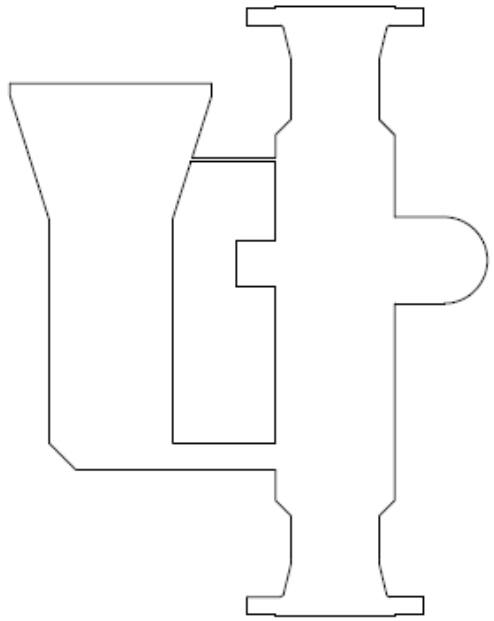
Redundancy vs Replacement

REDUNDANT INSTRUMENTS

- Redundant instruments online
- Ready to swap
- Multiple communications paths

REPLACEABLE INSTRUMENTS

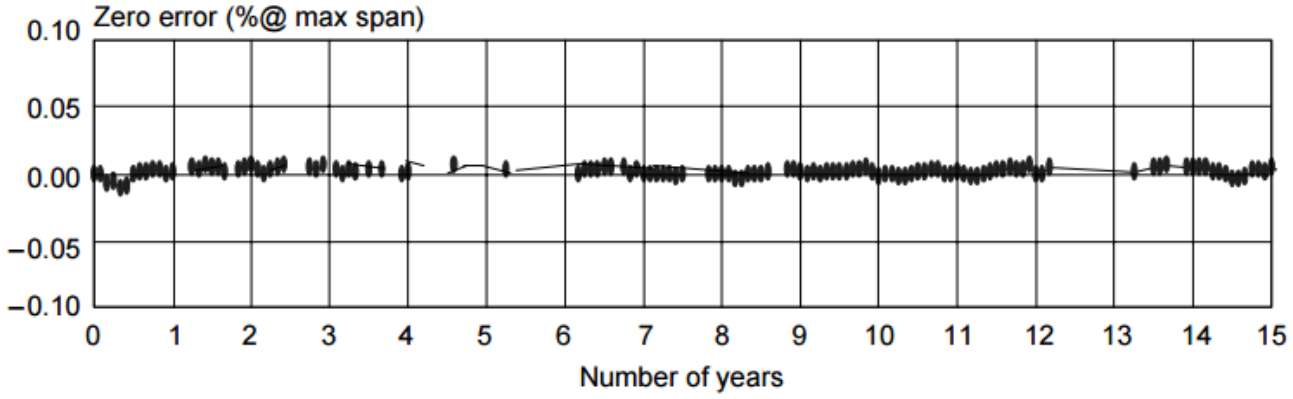
- Replace electronics or pull tree?
- How much?!
- How long before it’s fully working again?



Long term stability

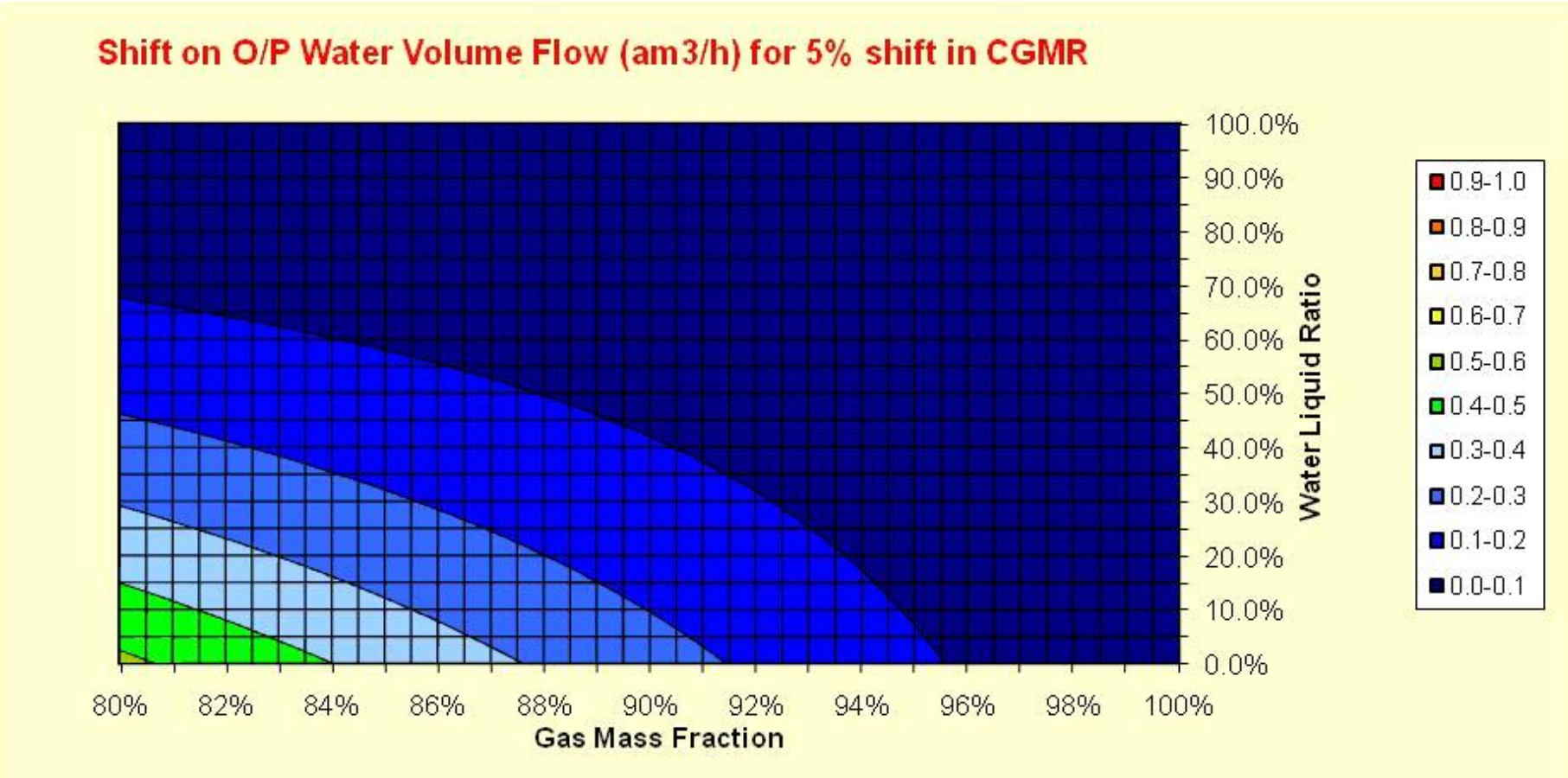
SST3010DP

- Based on Yokogawa DP Cells
- Full welded construction
- Accurate and Stable

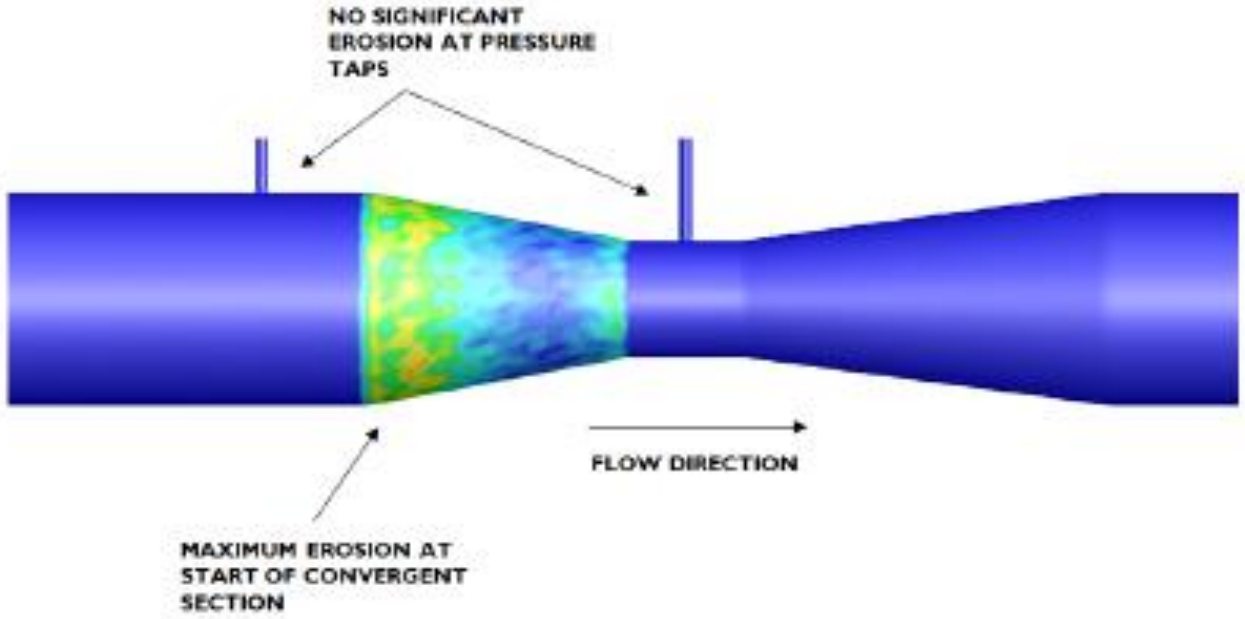


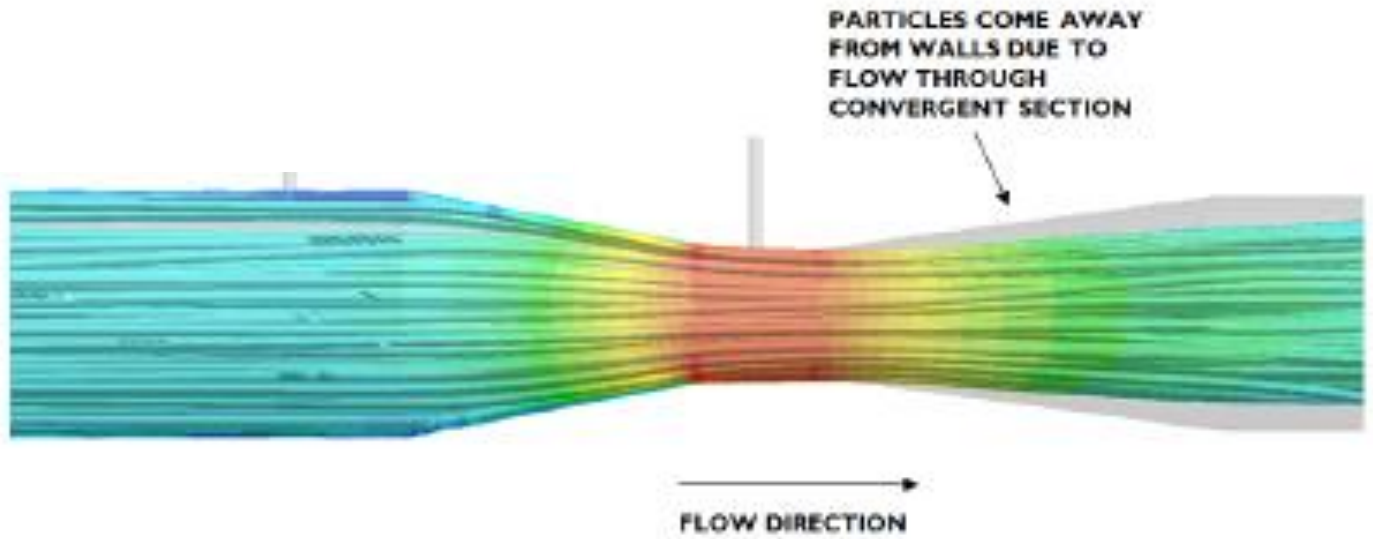
Data from long term stability test

Water Accuracy vs. PVT Sensitivity

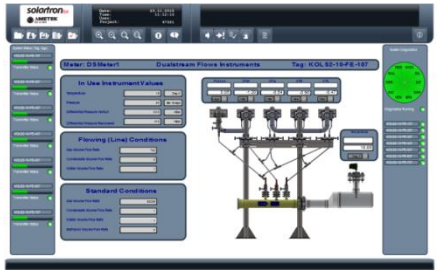


Venturi – Resilience to Erosion



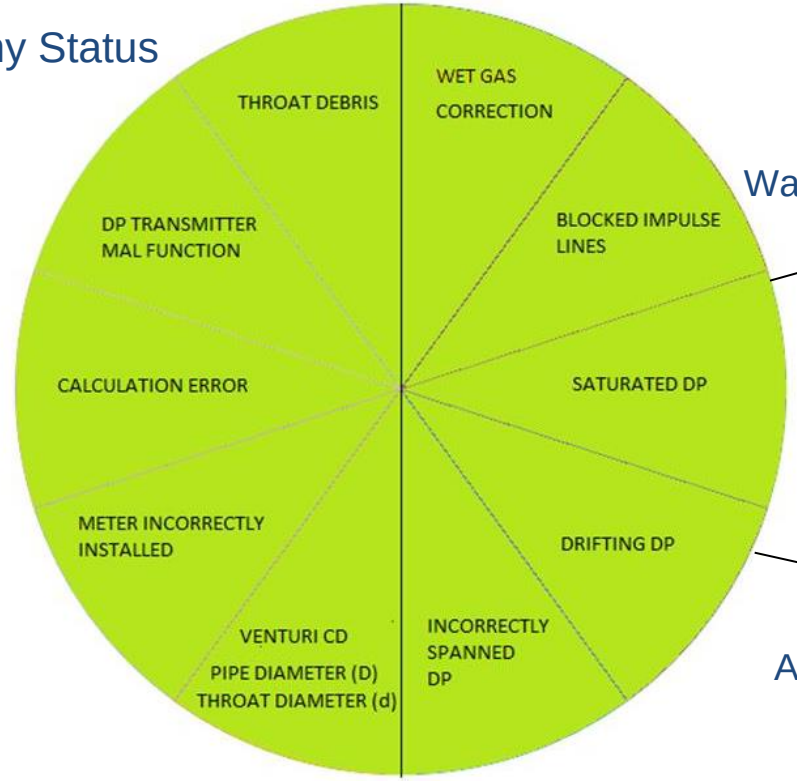


Dualstream Diagnostics

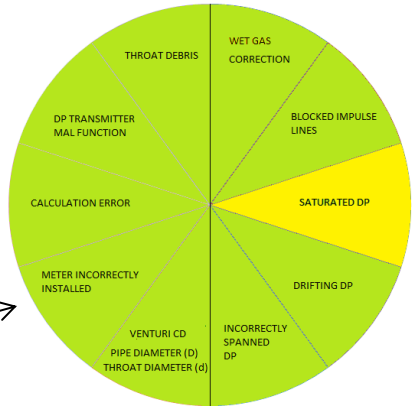


The Diagnostic Pi (π)

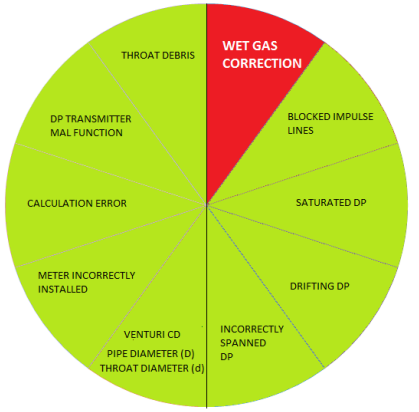
Healthy Status



Warning Status



Alarm Status



Summary

Even in a low cost environment you can get valuable multiphase data for wet gas wells

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THANK YOU – Any questions?

Subsea Controls Down Under
Perth, October 2016

Alan Downing
alan.downing@ametek.com