Seafloor Metering: the Need for Dedicated Research & Test Facilities

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after Bello, O., Falcone, G., Teodoriu, C., *"Experimental Validation of Multiphase Flow Models and Testing of Multiphase Flow Meters: a Critical Review of Flow Loops Worldwide"*, to be presented at the Multiphase Flow 2007, 4th International Conference on Computational and Experimental Methods in Multiphase and Complex Flow.

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Subsea wells

- According to Statoil, Hydro & the NPD (2004), the Recovery Factor from subsea wells is 15-20% lower than for other wells.
- For subsea wells, optimising reservoir management through monitoring (including metering) is essential.

Research & Test Facilities

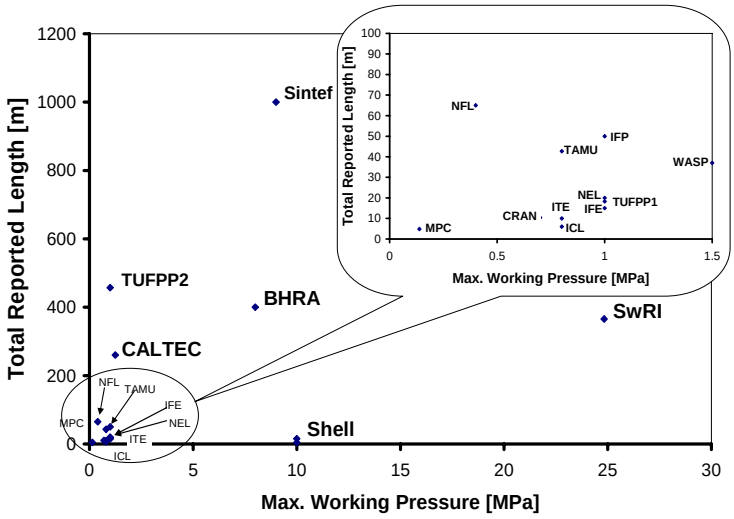
- There exist numerous multiphase flow varieties due to differences in P & T, fluids, flow regimes, pipe geometry, inclination & diameter.
- One flow loop cannot represent all possible situations.
- Even when experiments in a given flow loop are believed to be sufficiently exhaustive for a specific study area, the real conditions encountered in the field can be very different from those recreated in the research facility.

Properties of different test rigs -1

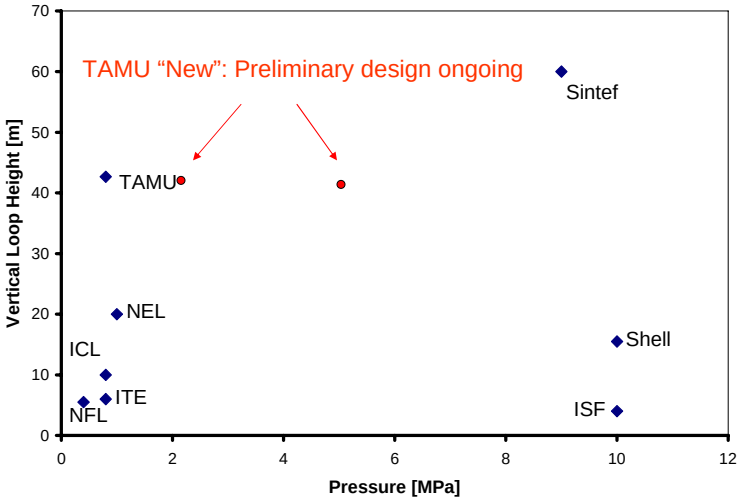
Location	Diameter (inch)	Length (m)	Maximum flow rates	Max. pres. (bar)	Comments
SINTEF, Norway	4, 8 and 12	1000	U_{sg}: 12 m/s U_{so}: 3.5m/s (8" pipe)	90	Not in operation
IFE, Norway	4	20	U_{sg}: 10 m/s U_{so}: 2 m/s U_{sw}: 2 m/s	8	Dense gas SF_6, water, exxol/diesel
Shell Bacton, UK	8	280	U_{sg}: 12 m/s U_{so}: 2.5m/s	75	HC gas and condensate Not in operation
Texaco, US	3 and 6	520	U_{sg}: 11 m/s U_{so}: 2 m/s U_{sw}: 2 m/s	10	HC gas, crude oil and water
Boussens, France	6	120	U_{sg}: 7 m/s U_{so}: 3 m/s	50	HC gas and crude oil Not in operation
Imperial College, UK	3	42	U_{sg}: 14 m/s U_{so}: 1.5m/s U_{sw}: 1.5m/s	25	Air, lube oil and water
Norsk Hydro, Norway	3	120	U_{sg}: 12 m/s U_{so}: 2.5m/s U_{sw}:2.5m/s	110	HC gas, crude oil and water

(Valle, 1998)

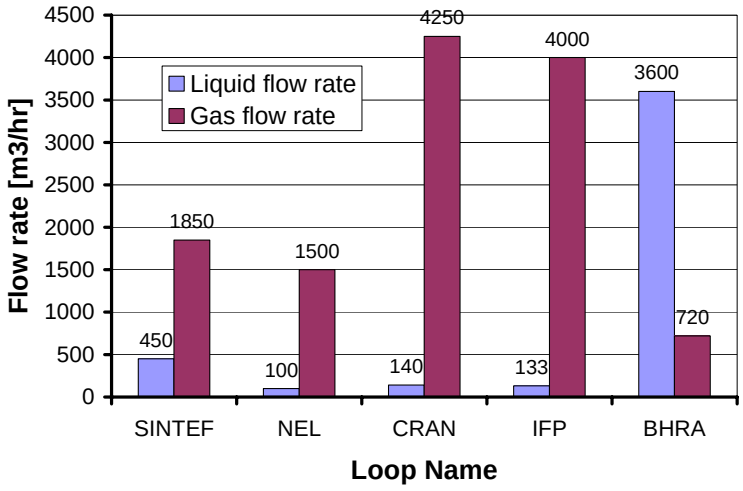
Properties of different test rigs -2



Properties of different test rigs -3



Properties of different test rigs -4



Main techniques for measuring reference phase flow rates, phase hold-up & for identifying flow patterns

Gas flow rate	**Liquid flow rate**	**Phase velocity**	**Phase volumetric fraction or mixture density**	**Flow pattern visualization**
Thermal wave flow meter	Electro-magnetic meter	X-correlation techniques	Gamma ray densitometry	High speed video system (visible spectrum)
Hot wire flow meter	Ultrasonic flow meter	Laser Doppler Anemometer	Capacitance/conductivity probes	
Coriolis flow meter	Coriolis flow meter	Particle Image Velocimetry	X-ray or gamma-ray tomography	
Vortex flow meter				

Flow loops for flow assurance studies

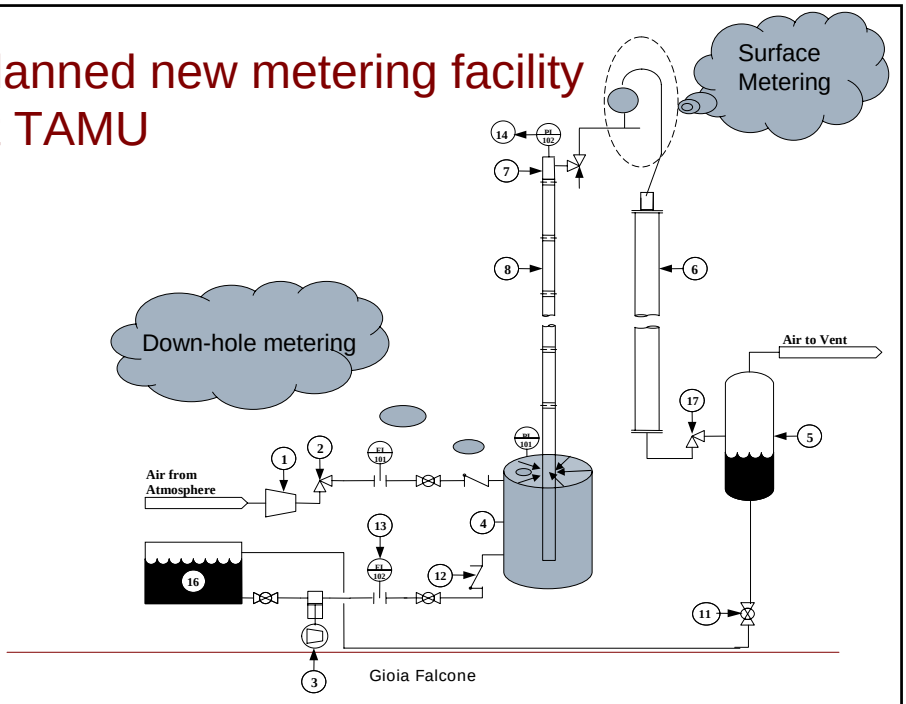
Some examples:

- The Cold-Oil-Water Flow Assurance Loop, the Single- & Multi-Phase Paraffin Deposition Flow Loop & the Marathon Hydrate Assurance Loop at Tulsa University,
- The Multiphase Corrosion Flow Loop at the Ohio University
- CEESI Hydrates flow loop.

Seafloor metering: future needs

- Transient flow metering
- Downhole flow metering
- Multiphase pumping + metering
- Downhole & wellhead metering (e.g. for liquid loading in gas wells)

Planned new metering facility at TAMU



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