Multiport Profile Proving (MPP) for Automatic Pipeline Sampling

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Content

Introduction to Quantity / Quality Measurement

- Custody Transfer

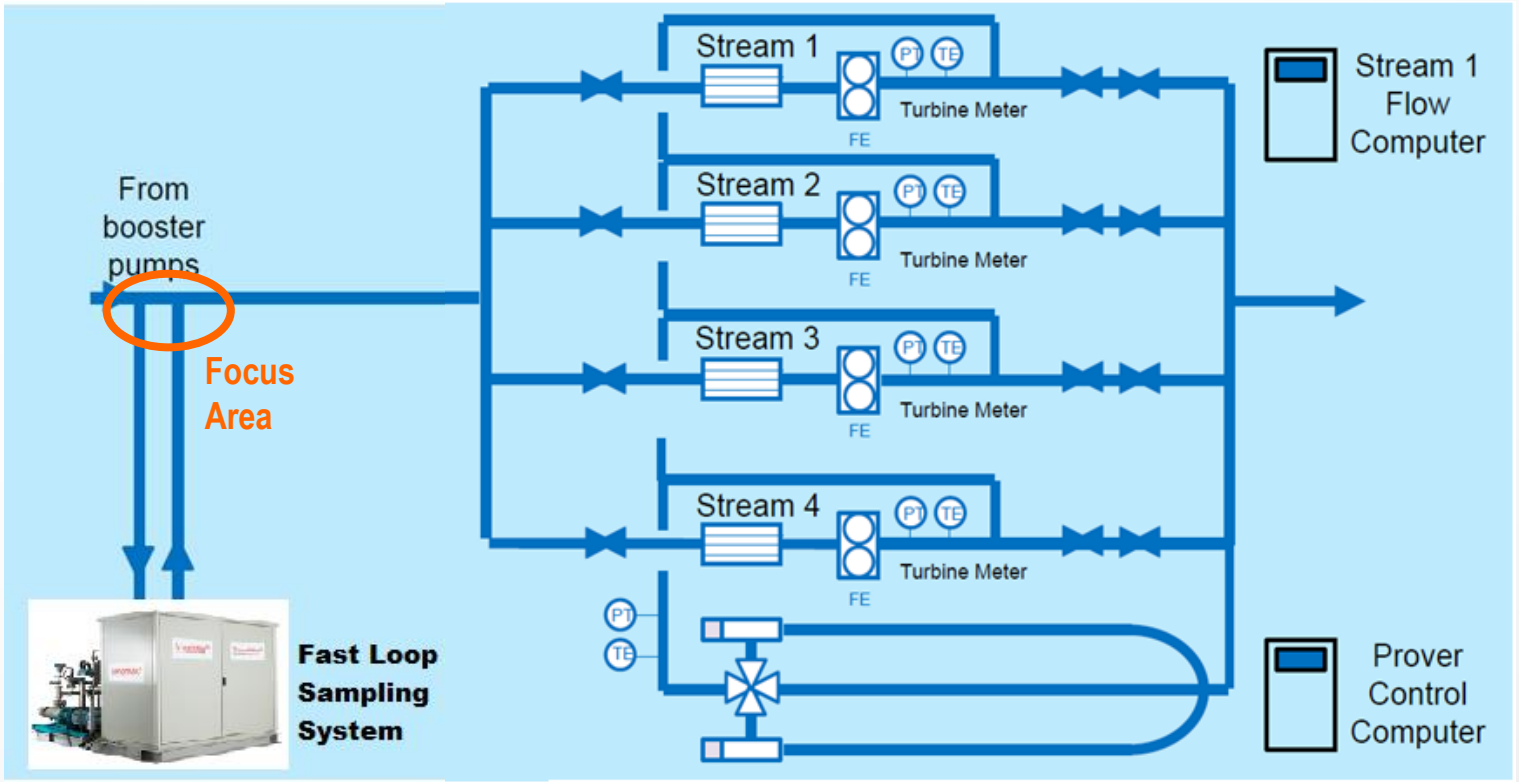
1. **Quantity Measurement**

2. **Quality Measurement**

Quality Measurement

Sampling

Metering



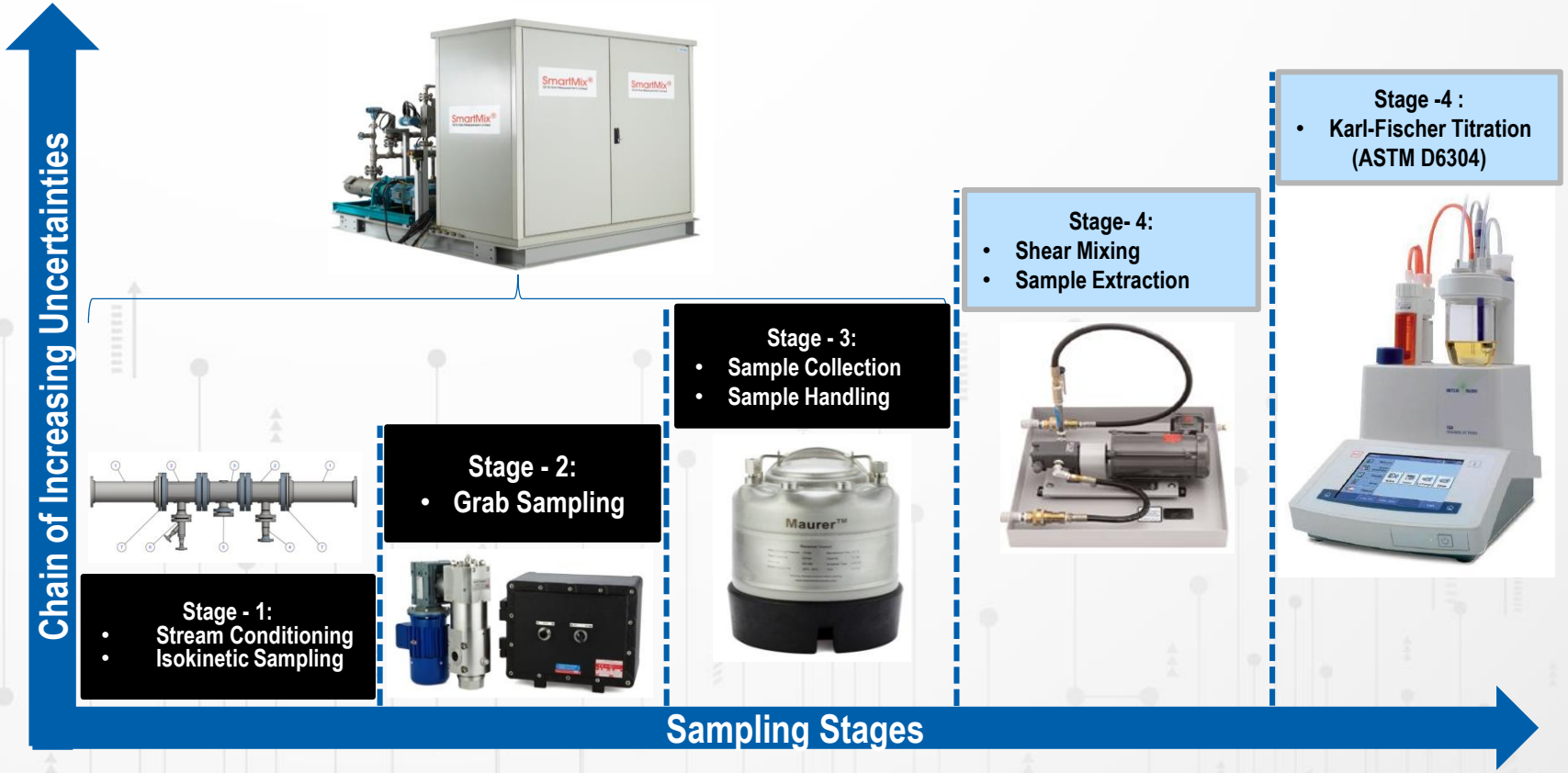
Quantity Measurement

- Quantifies the composition of the liquid
- Combined measurement uncertainty of +/-0.25% (UK)

- Quantifies the total amount of liquid
- Meter Linearity as low as +/-0.15%

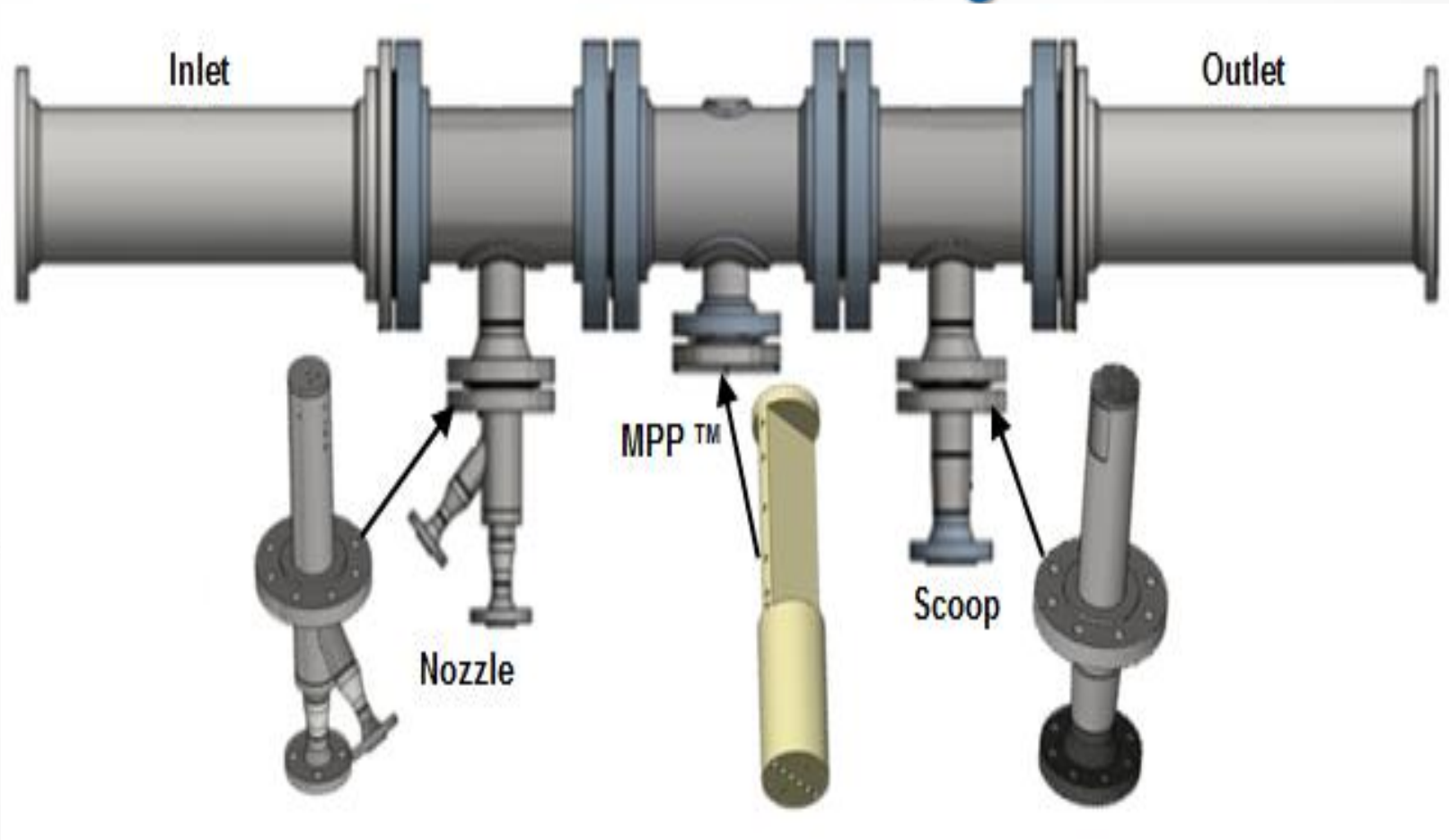
The 5-Stages of Automatic Pipeline Sampling

- All Stages are Equally Important …..
- **Stream Conditioning – Mixing is KEY**
- **This is a laborious and expensive approach with chains of increasing uncertainty.**
- **Can we do better?**



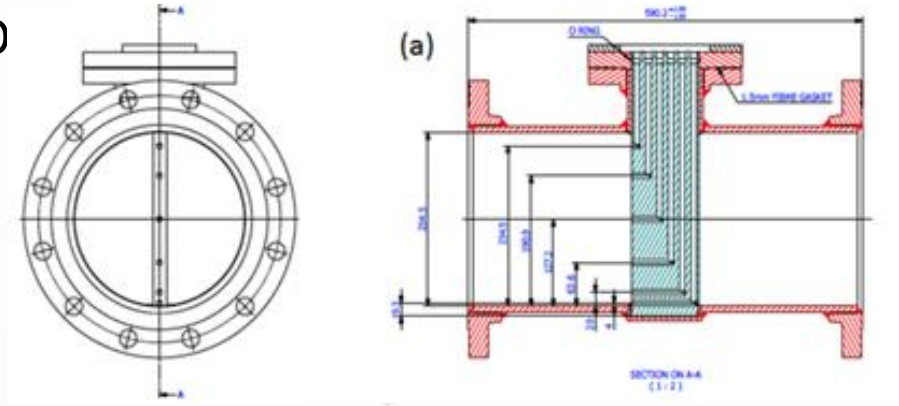
Multi-Port Profiling Proving (MPP)

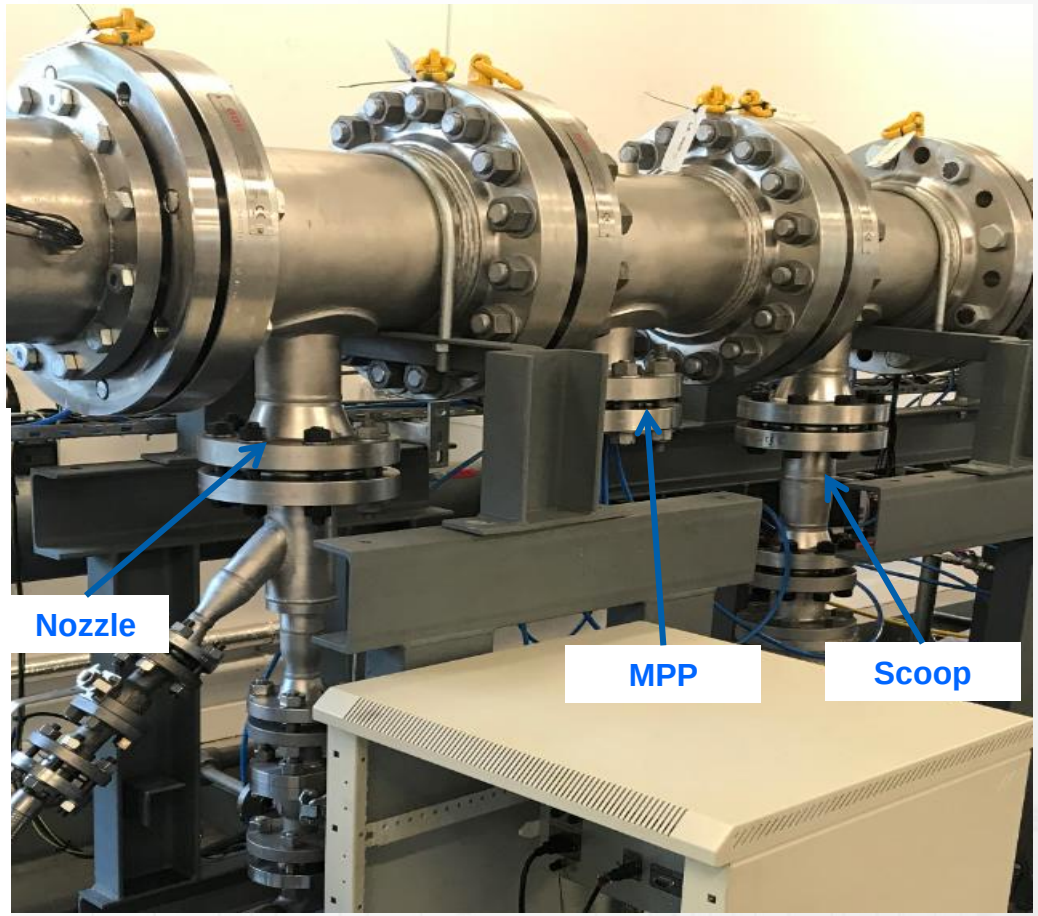
- Part of Fast Loop System
  - Flow take off via Scoop
  - Flow re-injection via Nozzle
  - Region between Nozzle and Scoop is homogenously mixed
- The Six-Probe MPP Device is the focus of this talk.



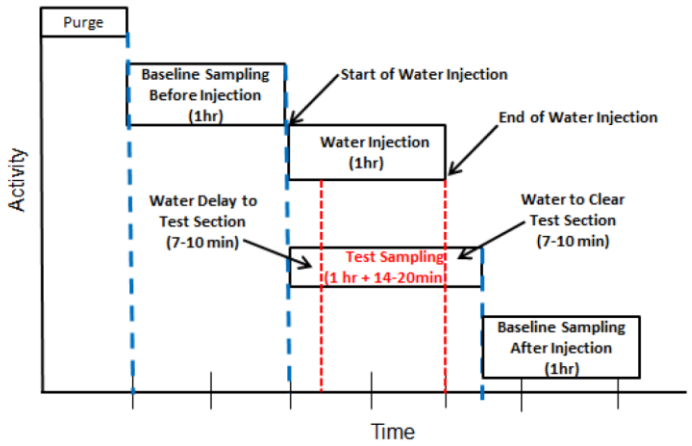
Multi-Port Profiling Proving (MPP)

- Designed compliant to
  - ISO 3171
  - API 8.2
- Six Probes each
  - Connected with mini-Coriolis meters
  - Control Valves
- Measured Parameters
  - **DENSITY**
  - Flow Rates
  - Pressure
  - Temperature





Design of Experiment for MPP

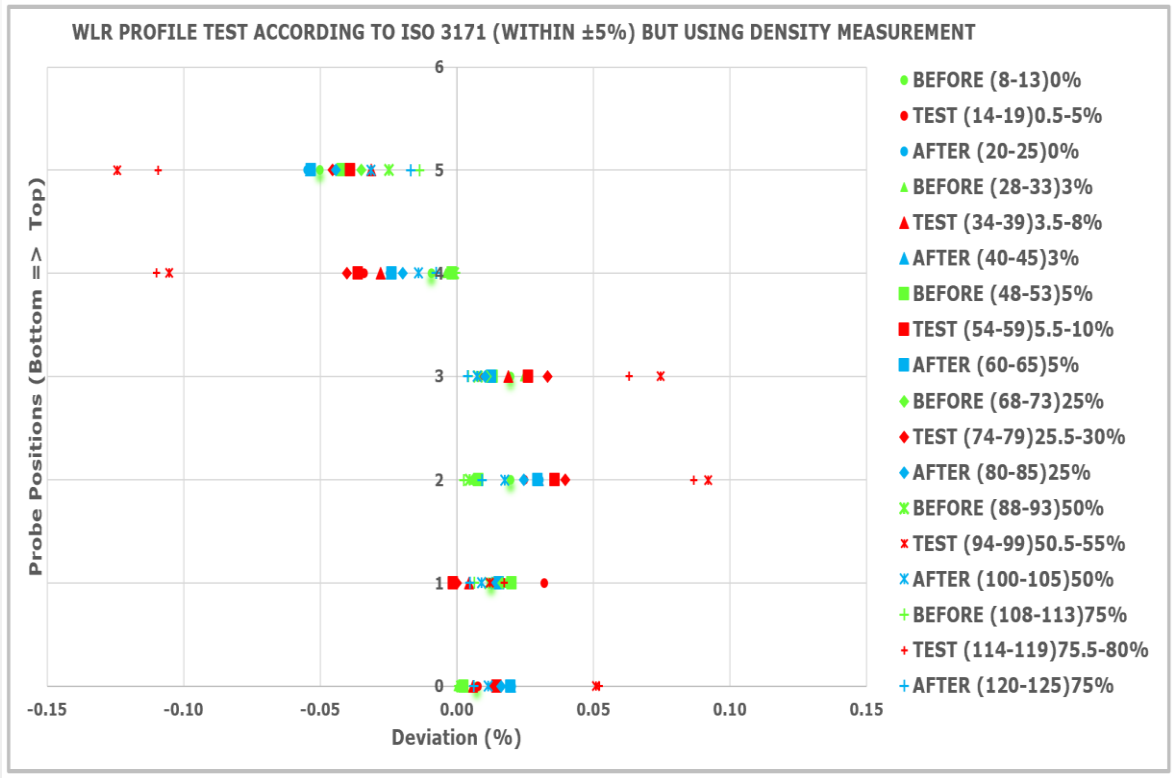


- Combined Profile Testing and Water Injection Testing
  - Before/After: **WLR**(0%, 3%, 5%, 25%, 50%, 75%)
  - Test **WLR**(1%, 1%, 2%, 4%, 4%, 5%) Table Below
  - Test **WLR**(0.5%, 1.5%, 2.5%, 3.5%, 3.5%, 4.5%, 5%)

0% Baseline	BEFORE								TEST								AFTER							
WLR_{INJ}	0%	0%	0%	0%	0%	0%			1.05%	1.08%	2.10%	4.03%	4.04%	5.08%	$WLR_{INJ(14-19)}$		0%	0%	0%	0%	0%	0%		
DoE No	8	9	10	11	12	13			14	15	16	17	18	19			20	21	22	23	24	25		
Probe	R2M5	R3M6	R5M5	R7M7	R8M5	R9M3	$PA_{Tests\ (8-13)}$ Point Average	% Deviation from Mean	R2M5	R3M6	R5M5	R7M7	R8M5	R9M3	$PA_{Tests\ (14-19)}$ Point Average	% Deviation from Mean	R2M5	R3M6	R5M5	R7M7	R8M5	R9M4	$PA_{Tests\ (20-25)}$ Point Average	% Deviation from Mean
5	809.5755	810.2353	809.7001	810.3513	809.7115	809.6115	809.8642	-0.0421	812.1757	811.6525	813.2189	817.4045	816.8558	818.7166	815.0040	-0.0389	809.8576	809.6765	809.3700	810.5351	809.5712	809.5712	809.7636	-0.0549
4	809.4996	810.3622	810.4777	809.5456	810.3755	810.4376	810.1164	-0.0110	811.5045	812.2662	814.0564	816.9193	816.8375	818.6814	815.0442	-0.0340	810.3500	810.4362	810.4378	809.5246	809.6525	809.6525	810.0089	-0.0246
3	810.3248	810.2355	810.3003	810.3755	810.3421	810.5342	810.3521	0.0181	812.2754	812.3886	814.1377	816.5969	817.5522	819.3833	815.3890	0.0083	810.4325	810.4235	810.5300	809.4245	810.5342	810.5342	810.3132	0.0129
2	810.4311	810.2256	810.2877	810.3522	810.4698	810.3470	810.3522	0.0182	812.1942	812.3292	814.1365	817.3888	817.5842	819.5029	815.5226	0.0247	810.5431	810.5226	810.6288	810.3452	810.3470	810.3470	810.4556	0.0305
1	810.2408	810.3775	810.2226	810.2108	810.3478	810.3678	810.2946	0.0110	812.3741	812.3807	814.2288	817.5703	817.5234	819.4192	815.5828	0.0321	810.3241	810.6377	810.3223	810.2708	810.2348	810.2348	810.3374	0.0159
0	810.3301	810.2393	810.3051	809.6578	810.4311	810.5431	810.2511	0.0057	812.0819	812.2435	813.5839	817.5831	817.4144	819.3968	815.3839	0.0077	810.4330	810.4239	810.3751	810.3142	810.3431	810.3431	810.3721	0.0202
$ProfAv_{\_DENSITY}$ (kg/m^3)	810.0670	810.2792	810.2156	810.0822	810.2796	810.3069	810.2051		812.1010	812.2101	813.8937	817.2438	817.2946	819.1834	815.3211		810.3234	810.3534	810.2773	810.0691	810.1138	810.1138	810.2085	
$WLR_{DENSITY(14-19)}$	0.04%	0.16%	0.12%	0.05%	0.16%	0.17%	0.00	BEFORE (8-13)0%	1.19%	1.25%	2.20%	4.08%	4.11%	5.16%	0.03	ST (14-19)0.5-5%	0.18%	0.20%	0.16%	0.04%	0.06%	0.06%	0.00	FTER (20-25)0%
$WLR_{KF(BEFORE)}$	0.05%	0.07%	0.05%	0.07%	0.09%	0.09%		$WLR_{KF(TEST)}$	1.07%	1.05%	2.05%	4.09%	4.10%	5.14%		$WLR_{KF(AFTER)}$	0.06%	0.06%	0.05%	0.08%	0.06%	0.06%		
								$WLR_{KF(DIFF)}$	0.01%	0.01%	0.01%	0.01%	0.03%	0.03%										
								WLR_{DEV}	-0.04%	-0.09%	-0.10%	-0.02%	-0.01%	-0.01%										
								WLR_{BASE}	0.053%	0.063%	0.047%	0.072%	0.072%	0.071%										
								Rating	0.052	0.064	0.023	0.018	0.018	0.014										

Results and Discussions

MPP Test for baseline WLR form 0%-75%



Key/Promising Achievements

- Deviations in WLR between those computed from Density Profile Measurements and those representative samples analyzed using KF-method is less than ±0.15%.
- The MPP shows significant potential when the mixture is homogeneous.
- There is evidence the deviation increasing with WLR values

Results and Discussions

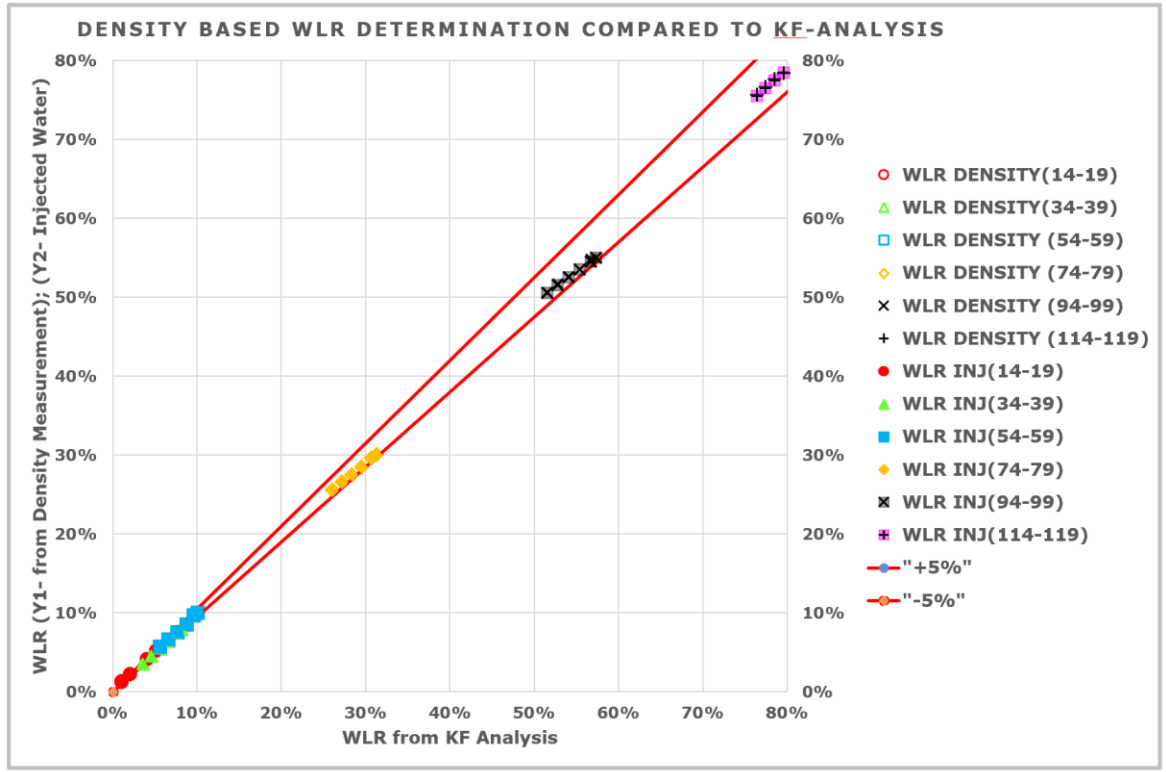
WLR quantified using Three Different Methods

- Y1-Axis: WLR from Density Profile Test
- Y2-Axis: WLR from Water Injections
- X-Axis: WLR from KF-Analysis of Representative Samples

- MPP Shows excellent linearity

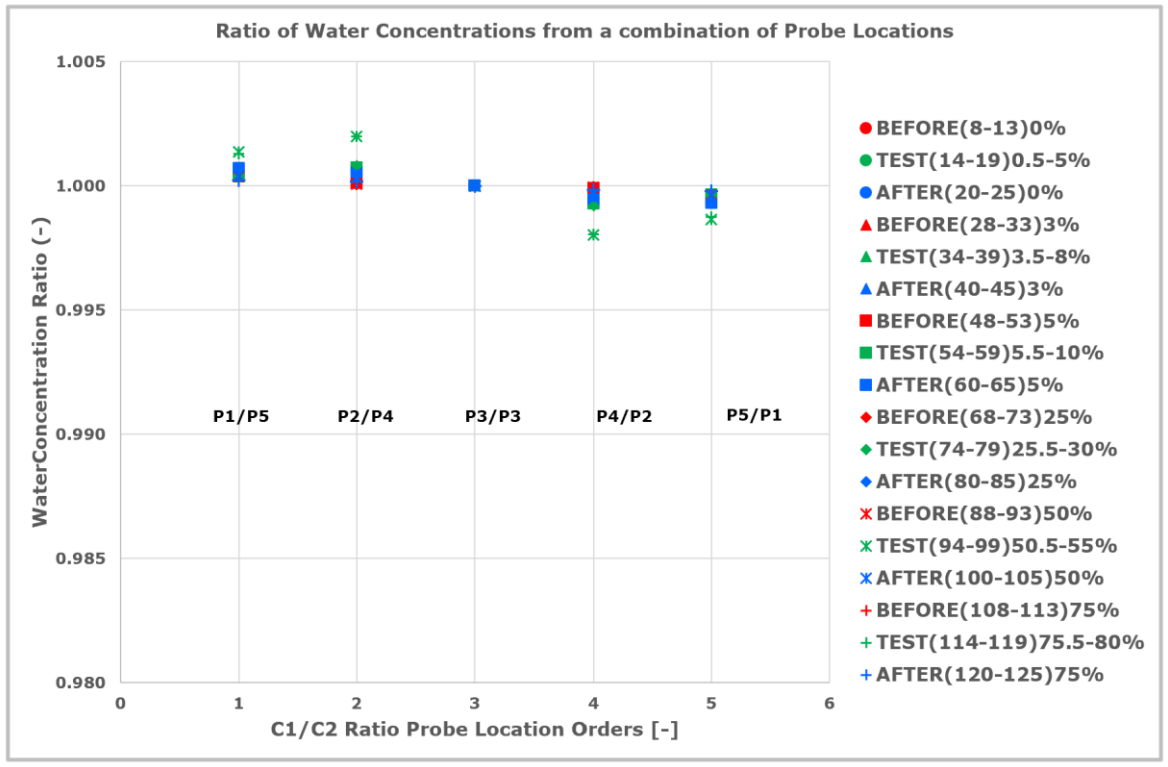
- Possible evidence of departure at transition of Phase Inversion

MPP Test for baseline WLR form 0%-75%

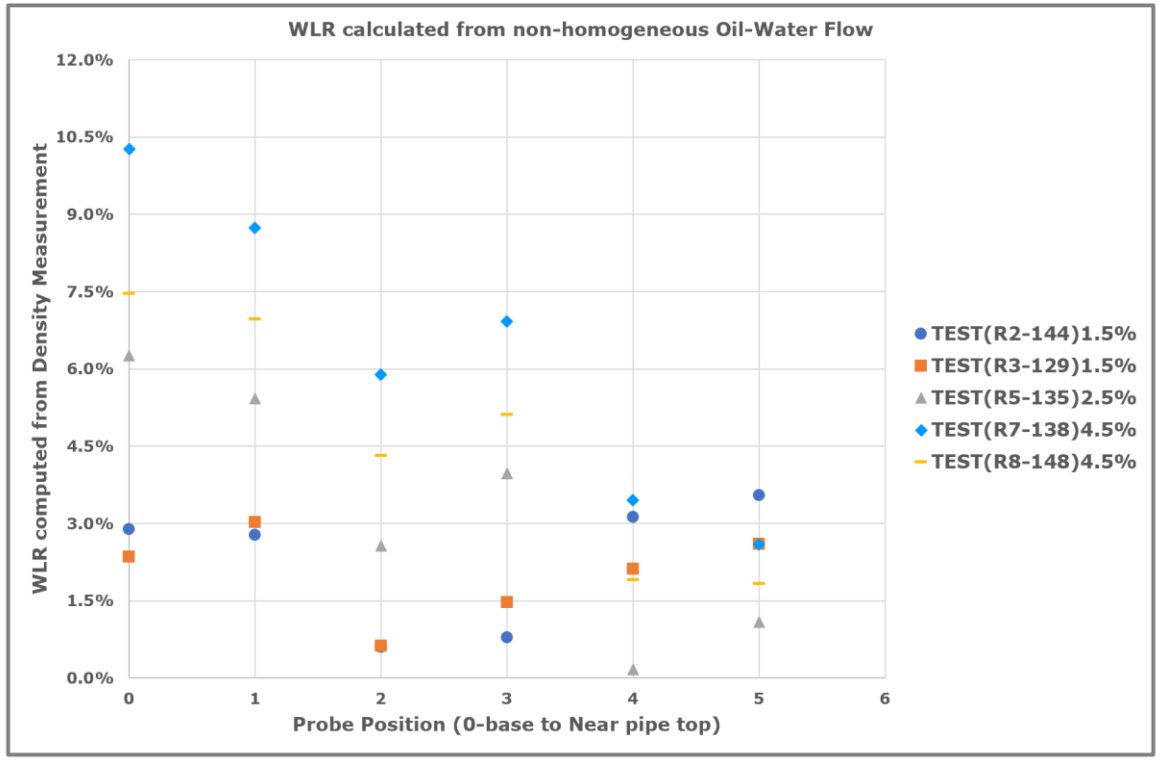


Results and Discussions

C1/C2 or C2/C1 Ratio ➔ Mixing Efficiency



Density measurement deteriorates when mixture is non-homogeneous – a serious shortcoming



Conclusions and Recommendations

- The MPP based Two-Stage “Mix and Measure” approach produced very encouraging results
- The combined Profile Tests and Water Injection Tests are in good agreement with KF-Analysis
  - Further work is required to improve the suitability of the MPP method for various field applications
  - Additional sensor technologies should be investigated – such as electromagnetic techniques
- The MPP device could be placed in the process pipeline either permanently or only as a periodic proving tool
- When the flow is low and the oil-water flow is not homogeneous, the results from the MPP method may not be reliable.

NORTH SEA FLOW MEASUREMENT WORKSHOP

measuring for the energy transition

OGM

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