



KUWAIT 3RD FLOW MEASUREMENT TECHNOLOGY CONFERENCE

19 - 21 NOVEMBER 2017
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إحدى شركات مؤسسة البترول الكويتية
A Subsidiary of Kuwait Petroleum Corporation



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EMERSONTM

Remediation of Effects of Gas on Liquid Measurement in Coriolis

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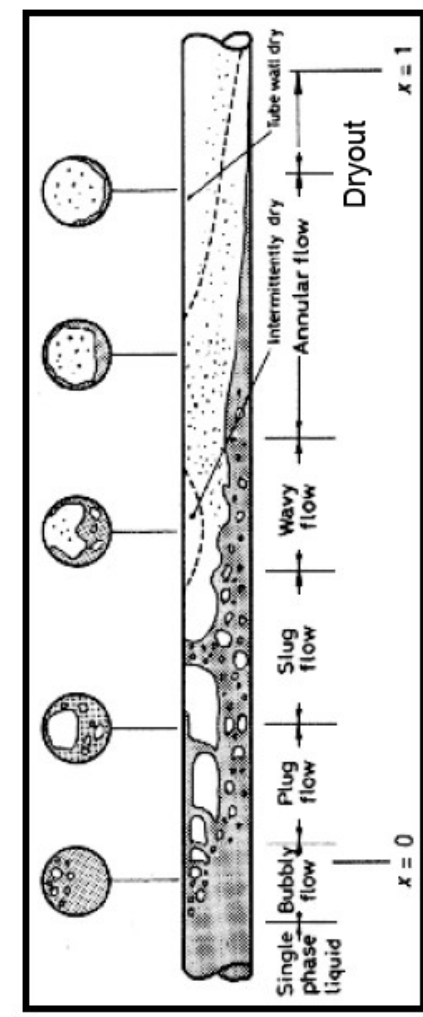
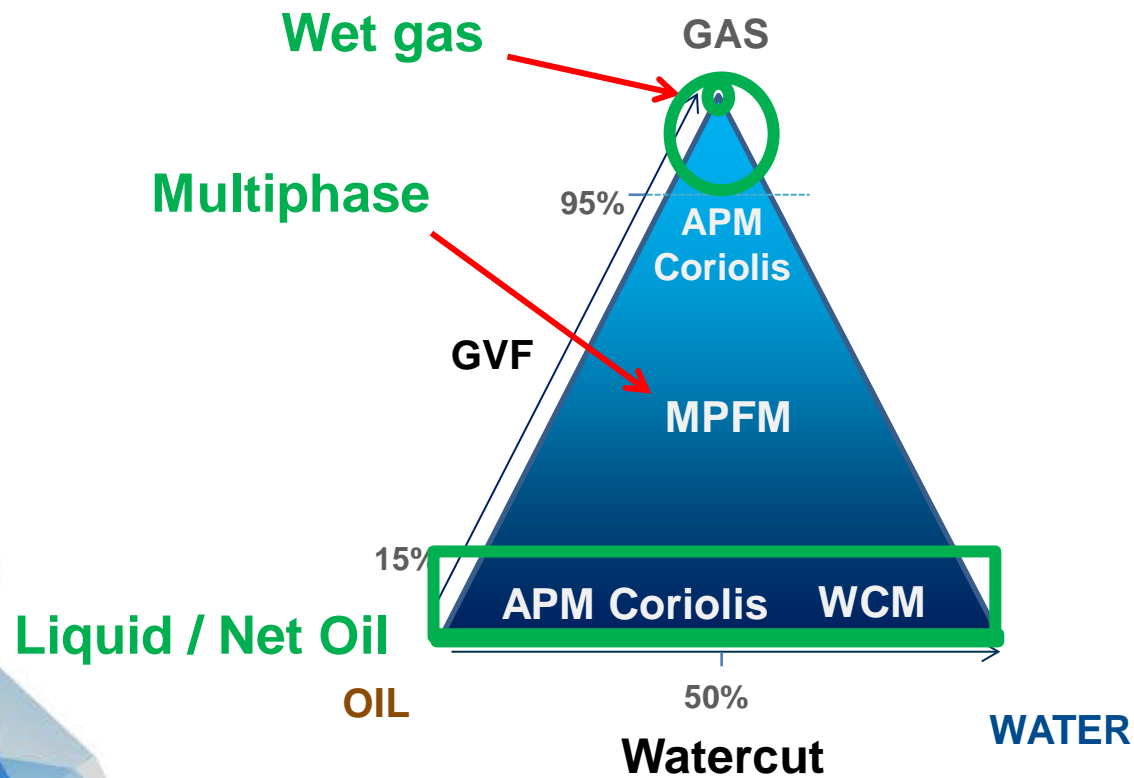


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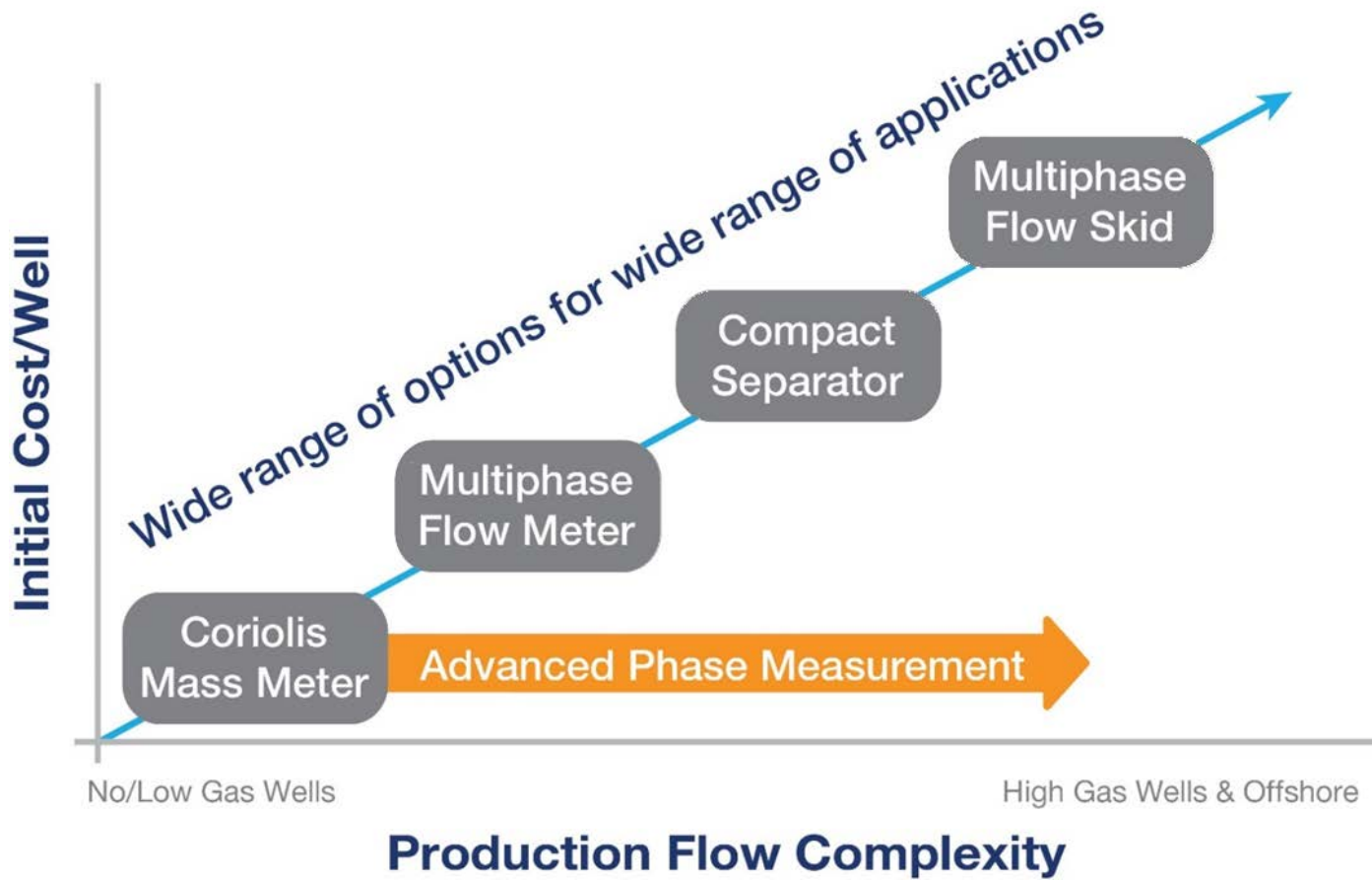
- What do we mean by two-phase and multiphase?
- How can coriolis meter measure 3 phases?
- Detecting multiphase conditions
- Remediation algorithm
- Real-world application examples
- 3rd party lab testing results



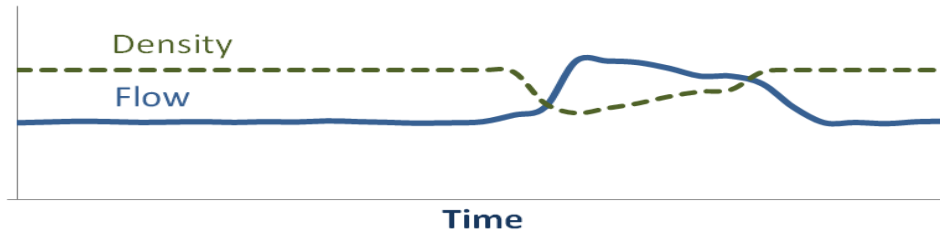
Single Phase Measurement Technology in Multiphase Processes



Coriolis with Advanced Phase Measurement versus Other Multiphase Technologies



Why Coriolis for 2-Phase or Multiphase?



Coriolis provides unprecedented insight

- Access to **mass** and **density** enables insight on remediated liquid flow
- Ability to positively **identify two phases** with drive gain

Other single phase technologies

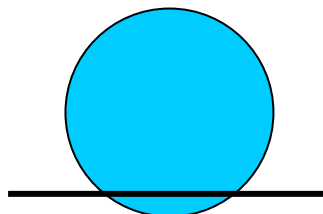
- Single variable with no insight
- Higher maintenance



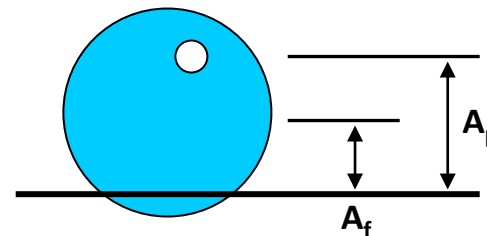
Coriolis Error in 2-Phase: Decoupling Defined by Inverse Stokes Number

**Decoupling of
phases in flow tubes**

Single Phase



Two Phase



**Inverse Stokes
Number**

$$\delta = \sqrt{\frac{2\nu_f}{\omega a^2}}$$

**Kinematic Fluid
Viscosity**

Frequency

Bubble radius

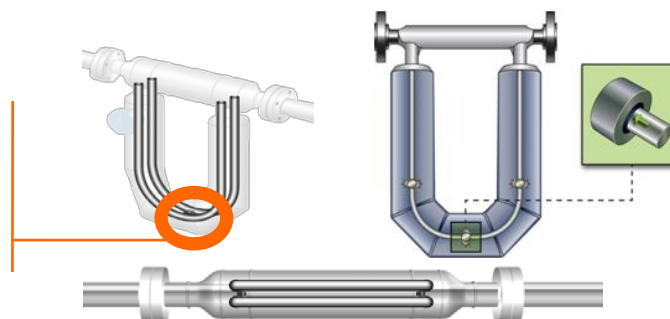


Coriolis Drive and Pickoff Coils

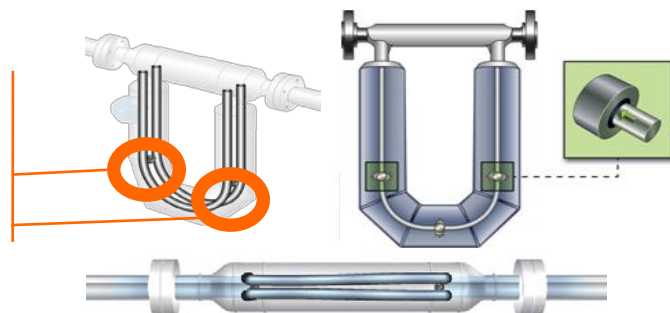
Keep the Sensor Tubes Vibrating

Process fluid enters the sensor and flow is split with half the flow through each tube.

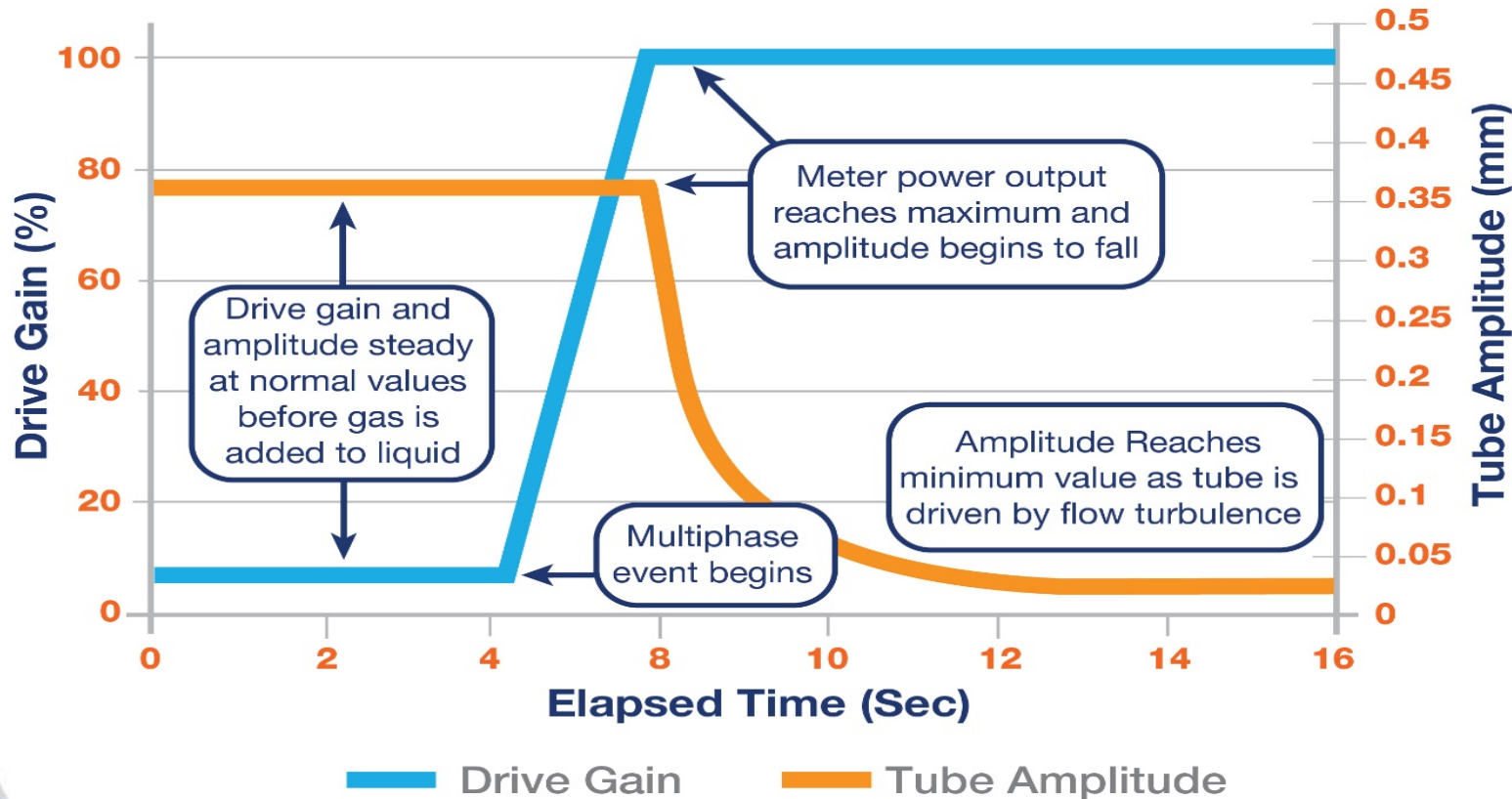
The sensor flow tubes are vibrated in opposition to each other by energizing a drive coil. Tubes are oscillated at their natural frequency.



Magnet and coil assemblies, called pick-offs, are mounted to the flow tubes. As each coil moves through the uniform magnetic field of the adjacent magnet it creates a voltage in the form of a sine wave.



Drive Gain is a Sensitive Indicator of Single-Phase vs Multiphase Conditions



Multi-Variable Outputs and Drive Gain Give Insight to Phase Conditions

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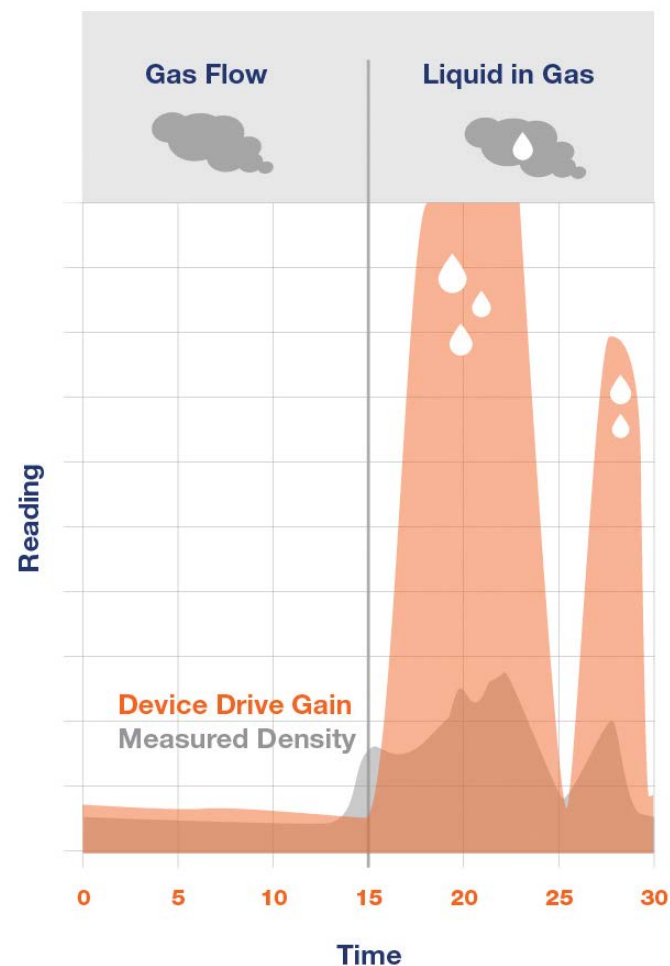


إدارة القياسات والقياسات
Measurement and Instrumentation Department
Kuwait Petroleum Corporation

Independent measurement
of **mass** and **density** yield
insight into multi-fluid and
multi-phase events

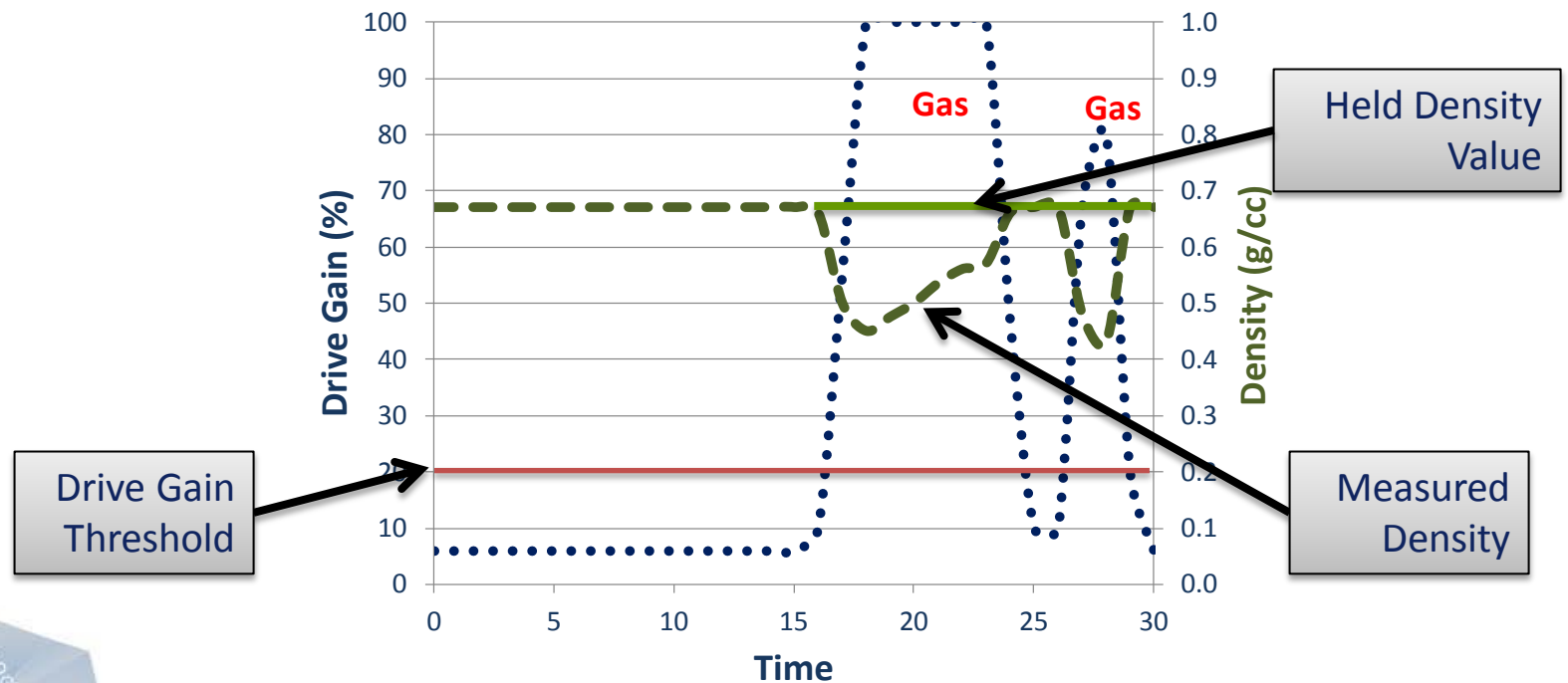
Drive gain indicates
presence of **multiple phases**

Can detect
Liquid composition changes
Gas in liquid
Mist in gas



Multiphase Remediation Algorithm: A Simple Approach

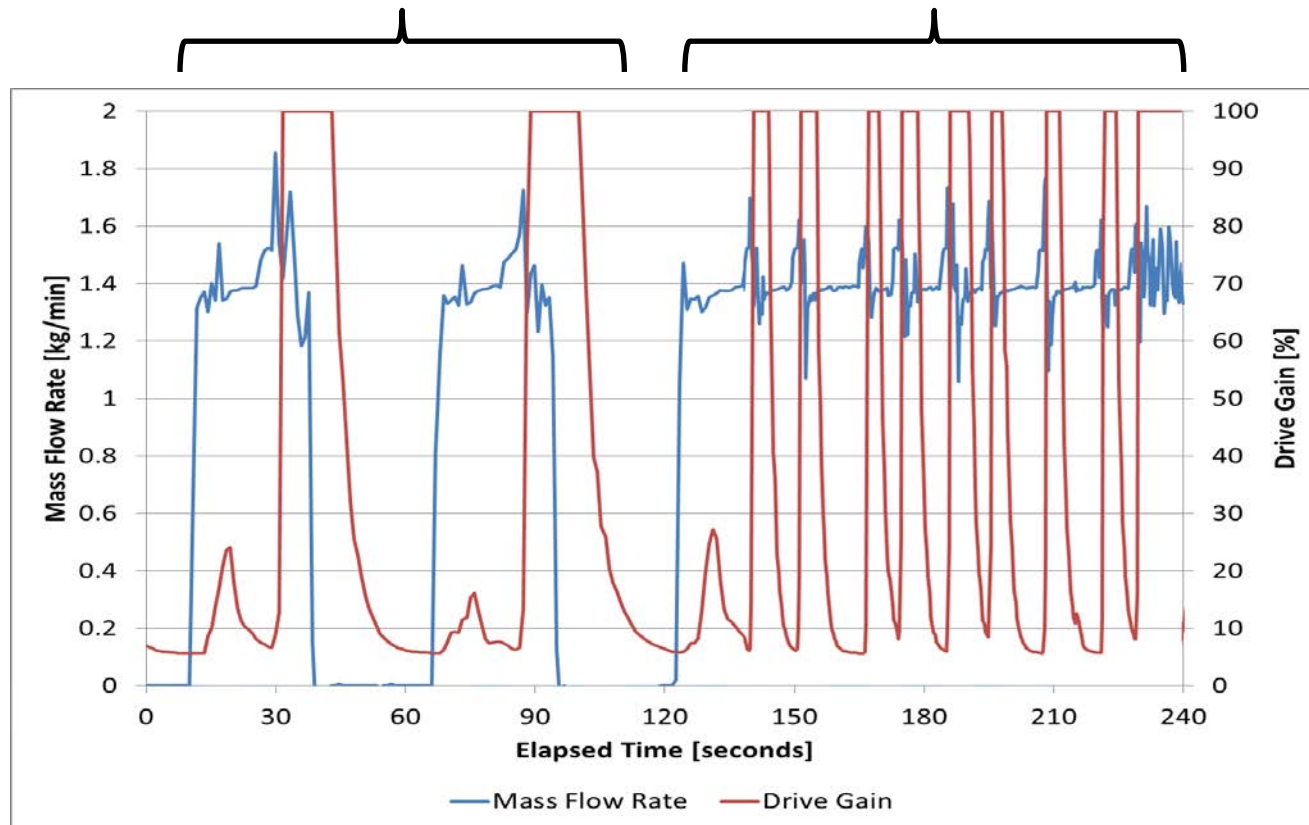
- Drive gain is an excellent indicator of 2-phase conditions
- Data from single phase conditions are used to correct errors during 2-phase conditions



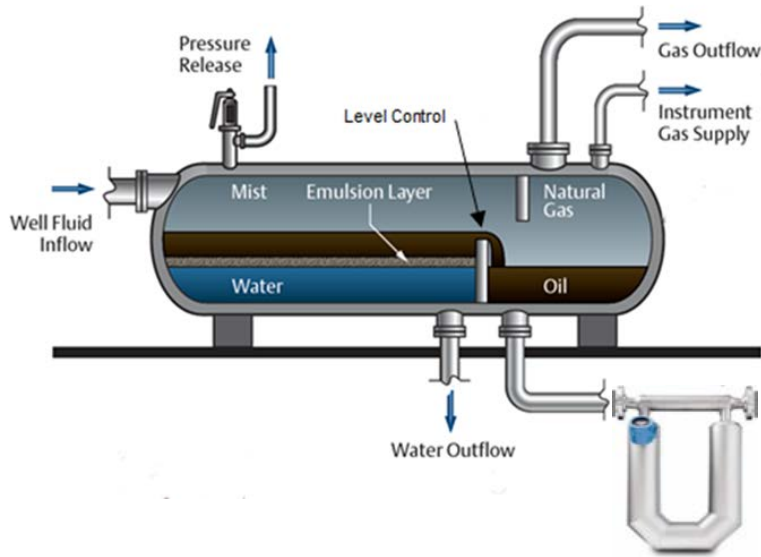
Flow Regimes in the Real World

Separator Dump Valve
or Beam Pump

Natural Slugging



Algorithm Validated in Field Application



$$V_{gross} = \frac{mass}{\rho_{mix}}$$

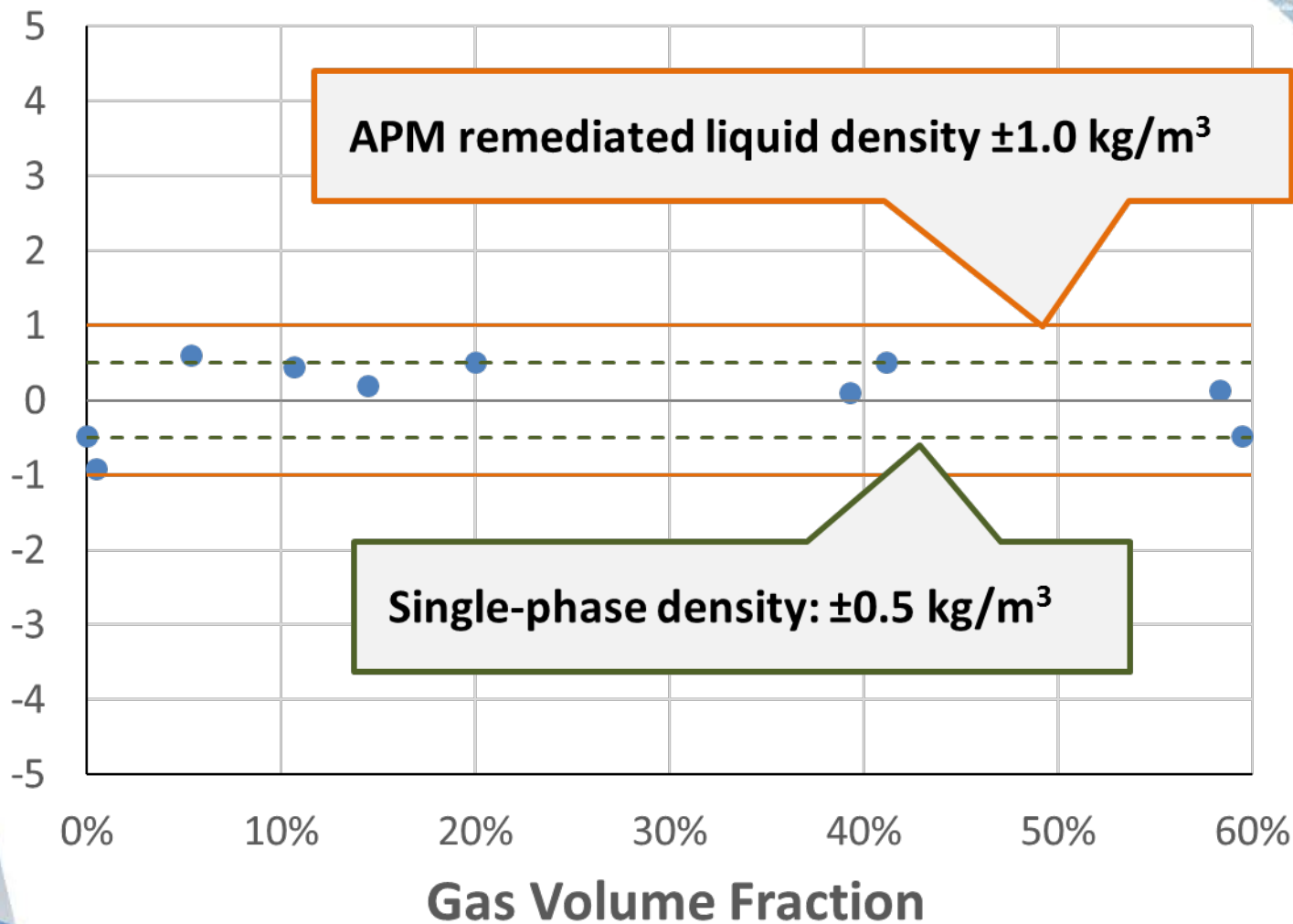
$$watercut = \frac{\rho_{mix} - \rho_{oil}}{\rho_{water} - \rho_{oil}}$$

$$V_{oil} = V_{gross} (1 - watercut)$$

Date	Liquid Total no APM(bbls)	Oil Total with APM (bbls)	Water Total with APM(bbls)	Gas Over- measurement (bbls)
10/1/2015	1753	1746	0.0	
1/5/2016	38705	33114	5.5	17.78%
Total	36952	31368	5.5	5579

Remediated Liquid Density: $\pm 1.0 \text{ kg/m}^3$ up to 60% GVF

Remediated Liquid Density
Error (kg/m³)

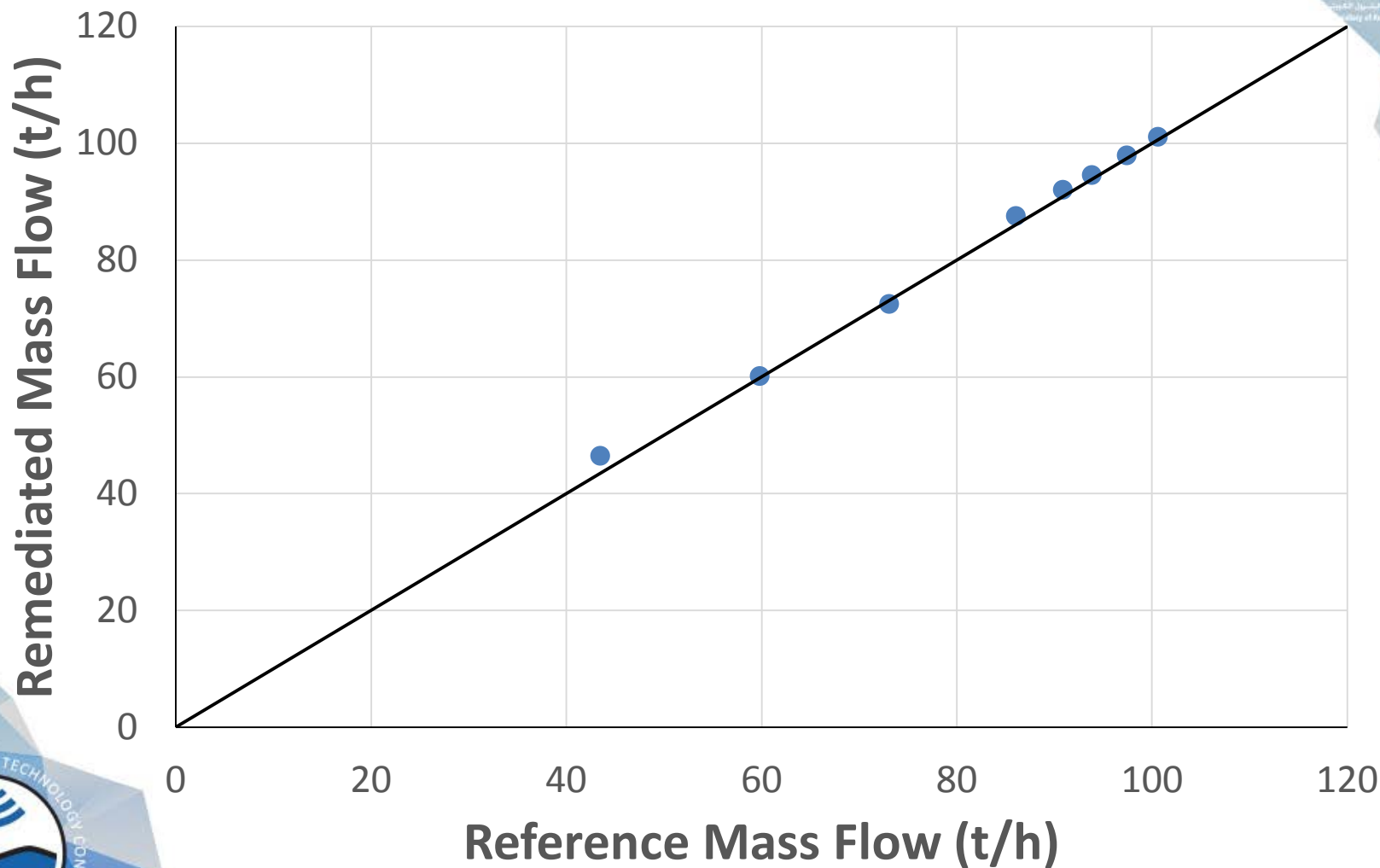


Results from Algorithm Testing at DNV-GL Remediated Mass Flow – up to 40% GVF

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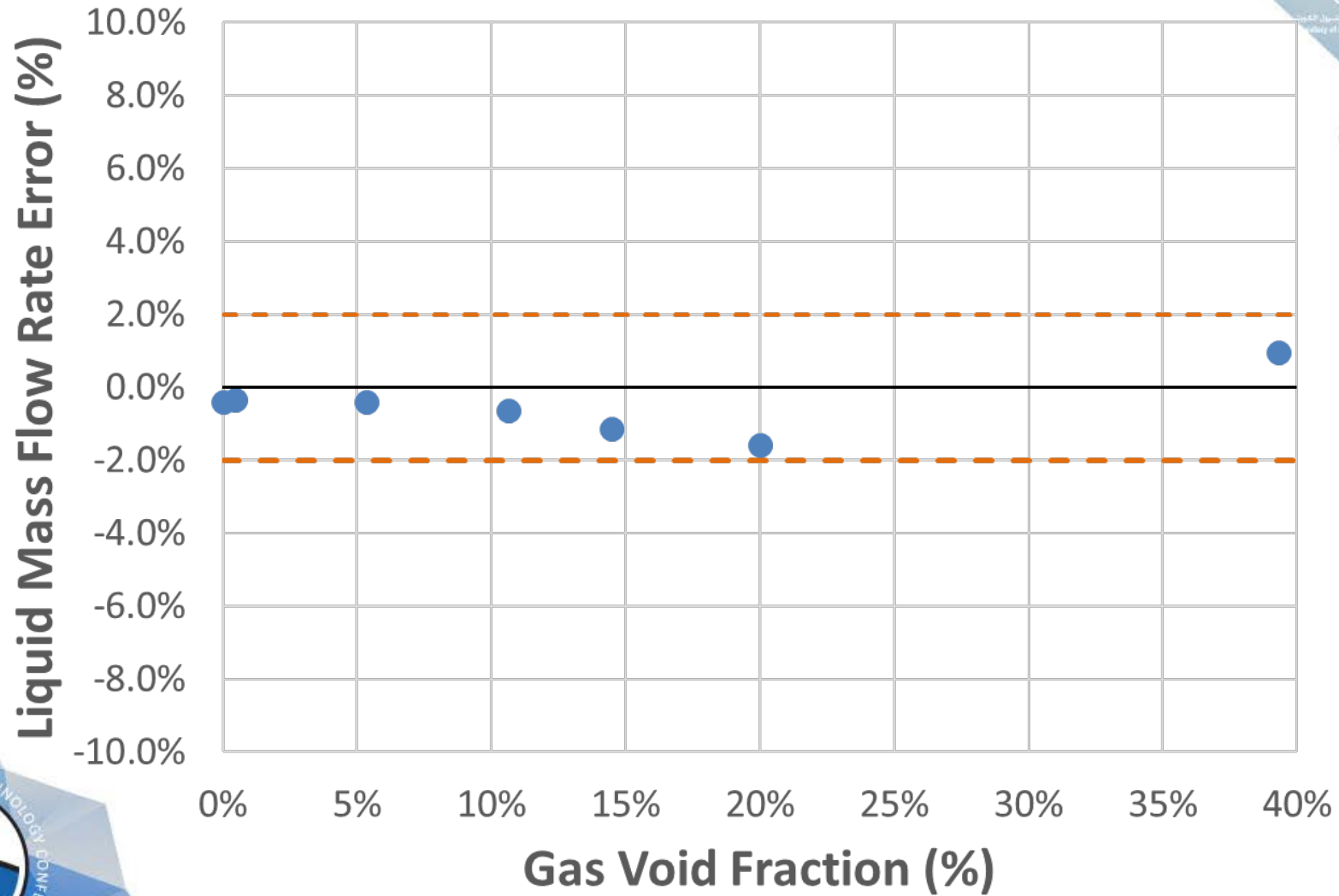


Remediated Mass Flow Rate ± 2% of reading up to 40% GVF

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Summary

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مؤسسو الشركات مؤسستة الامارات
Founding of Kuwait Petroleum Corporation

- Errors due to gas **need to be remediated** for **flow** and **density** measurement
- Errors due to **intermittent gas** can be largely remediated with algorithm
- Results verified in **field trials** and **independent lab test**





Thanks for Attention