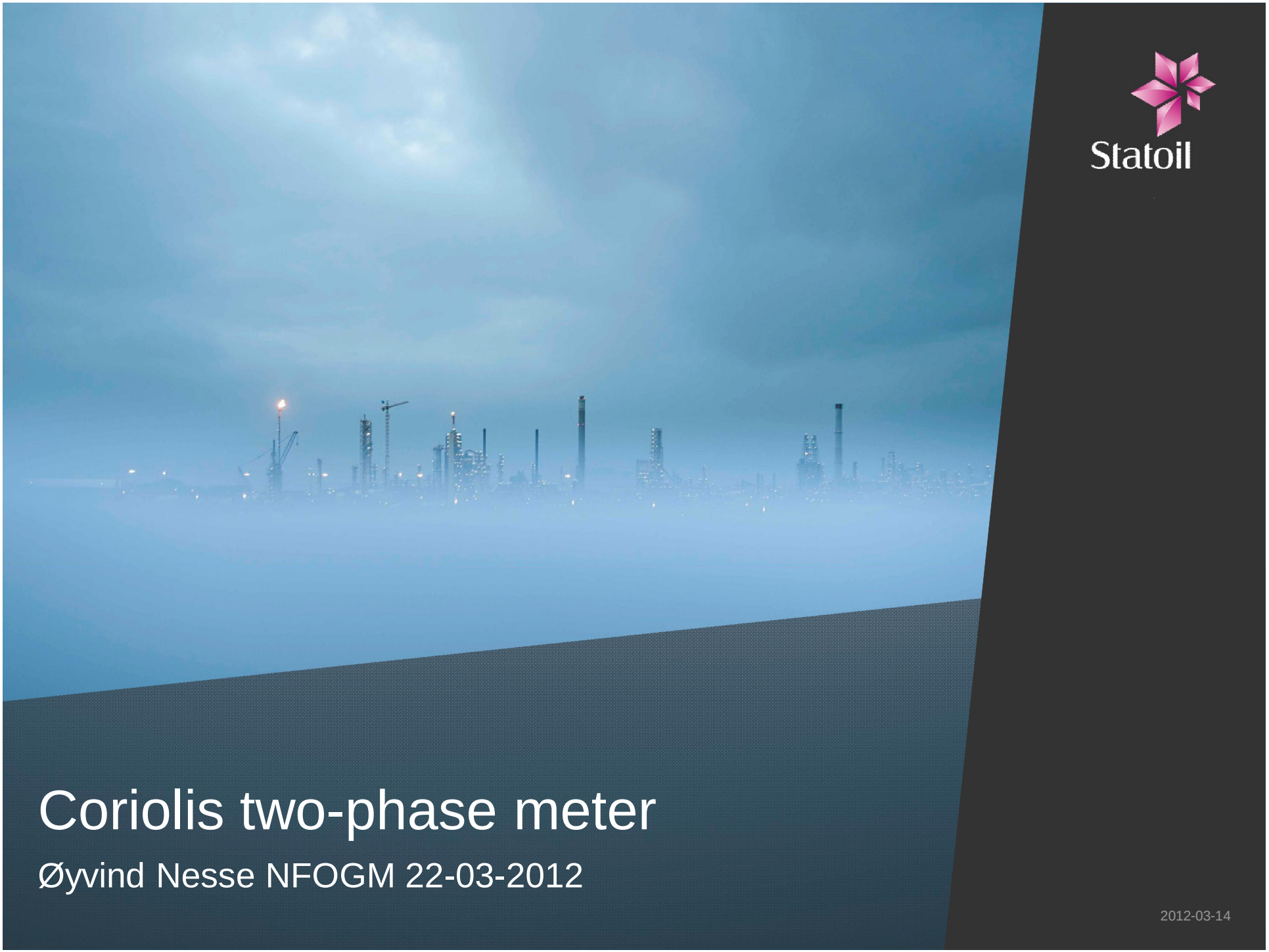


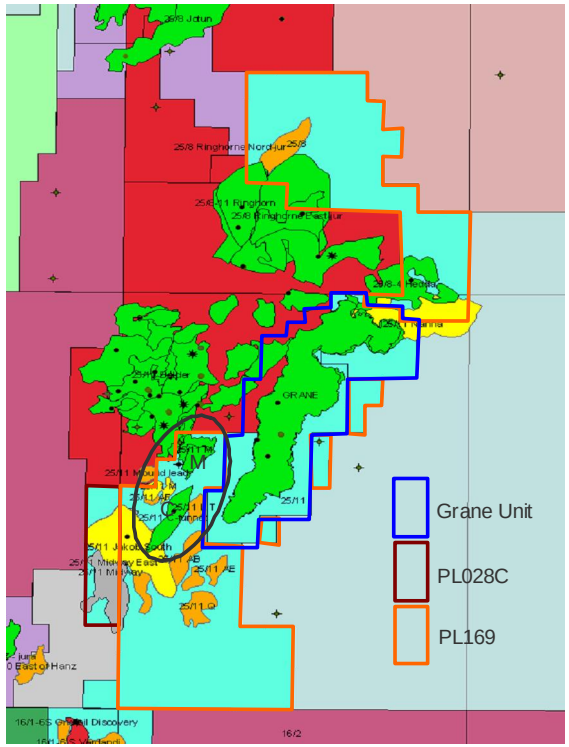
Coriolis two-phase meter

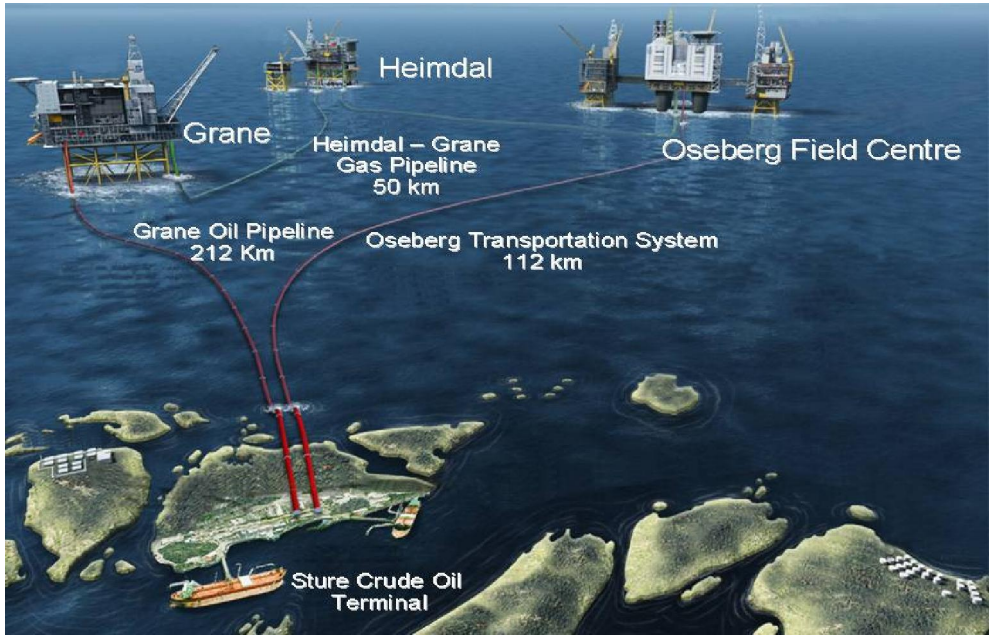
Øyvind Nesse NFOGM 22-03-2012

Agenda

- Project
- Allocation Metering Concept
- Coriolis Test Results
  - Endress & Hauser
    - Mass Flow
    - Density
  - MicroMotion
    - Mass Flow
    - Density
- Conclusions

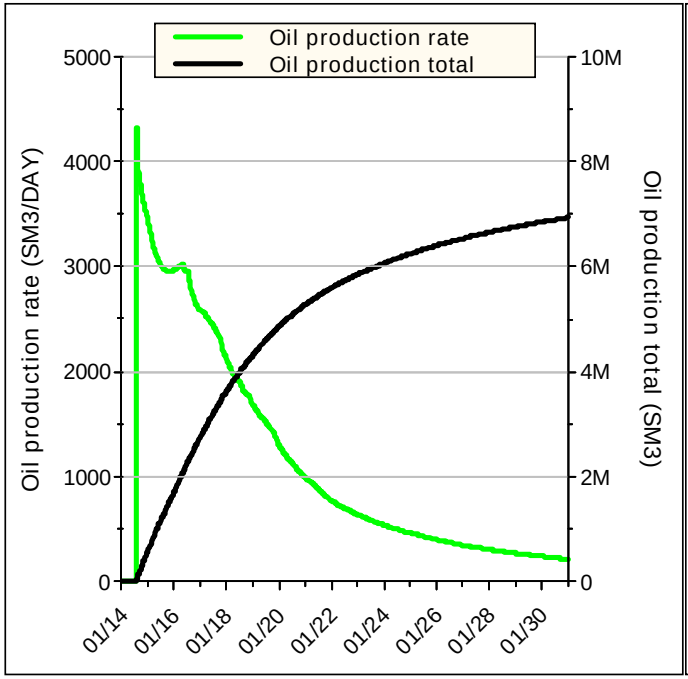
The Svalin Field PL169 tie-in host Grane

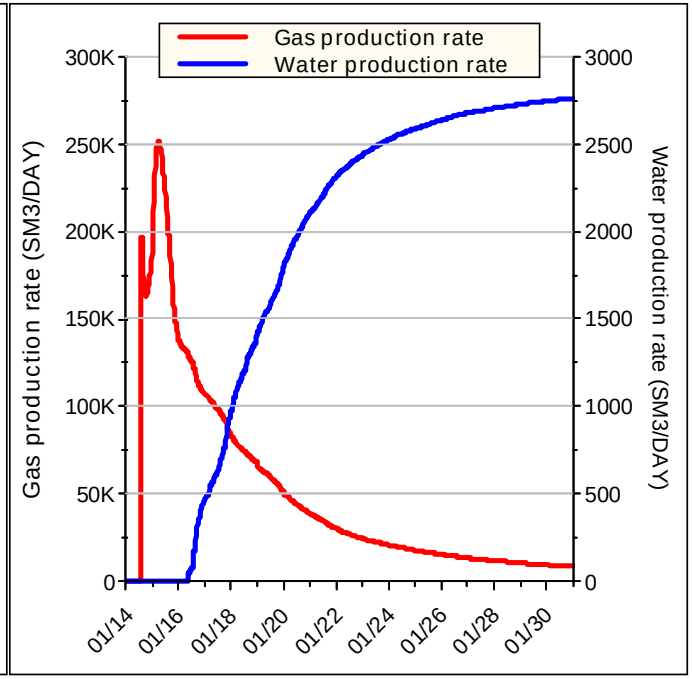




In-place (MSm^3)	P90	Mean	P10	Reserves (MSm^3)
Svalin C	7.3	11.2	15.4	6.4
Svalin M north	6.4	11.9	17.3	6.9

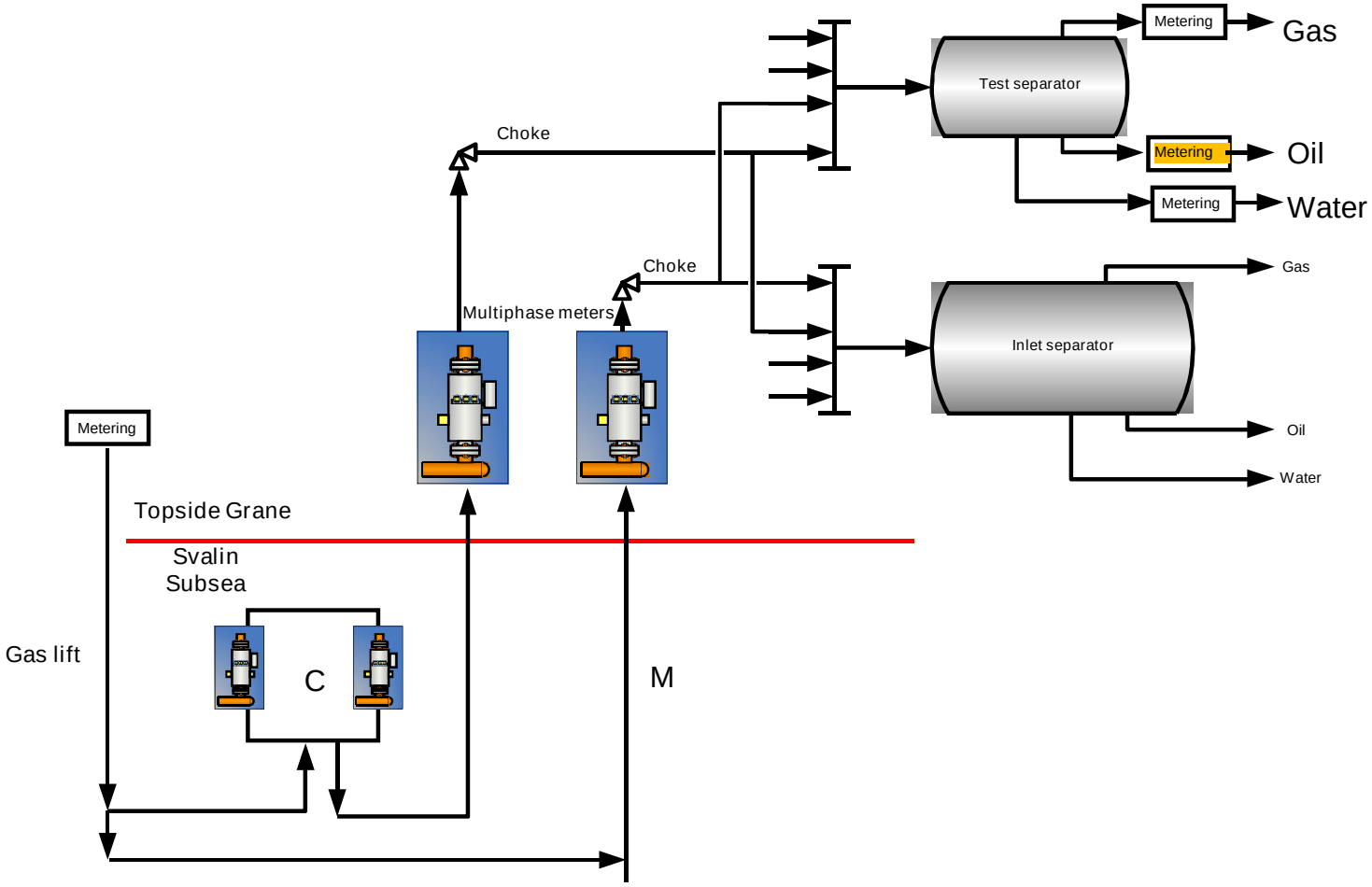
Svalin M production profiles





Field rate limitations (design rates)	M structure
Oil (Sm^3/sd)	5 000
Liquid (Sm^3/sd)	5 000
Water (Sm^3/sd)	3 000
Gas (Sm^3/sd)	400 000
Lift gas (Sm^3/sd)	250 000

Svalin Metering Concept
Challenge: GVF Oil Outlet < 1%



Deviations from ”Forskrift om måling av petroleum for fiskale formål og for beregning av CO2 –avgift”

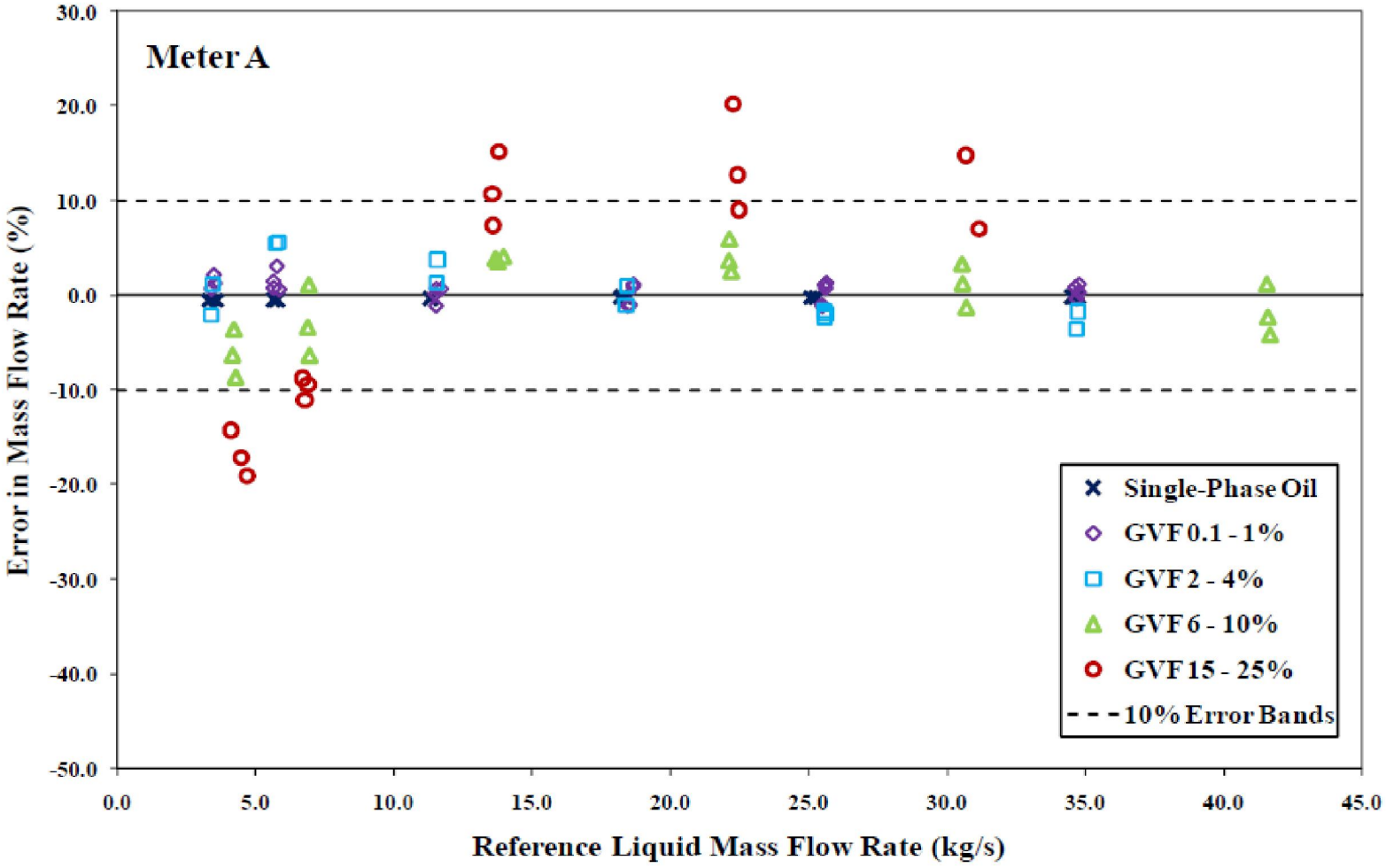
- Simplified metering of oil
  - NPD: “Salg og allokeringsmåling av olje ± 0,30% av standard volum ”
  - Svalin specification: ± 5% of oil mass rate (multiphase meter)

- Justification
  - 1st stage separator (test separator)
  - Small field
  - Cost Benefit Analysis (NPD §4):
    - 8 MNOK may be invested for a 1% reduction in measurement uncertainty for oil

Concept Study, Test Separator Metering upgrade

- Gas
  - Double Ultrasonic flow meters in parallel (two metering runs)
  - Gas analyzer (double gas chromatograph)
  - Redundant P&T
- Oil
  - Automatic condensate sampler for daily/monthly samples, and water cut meter
  - Double Coriolis flow meters in series for condition based maintenance/calibration
  - Master Coriolis flow meter on normally bypass (double block/bleed valves for removal during operation)
  - Redundant P&T
- Water ???

Amy Ross, NSFMW 2011
3’’ Coriolis Vertical Oil-Gas Flow



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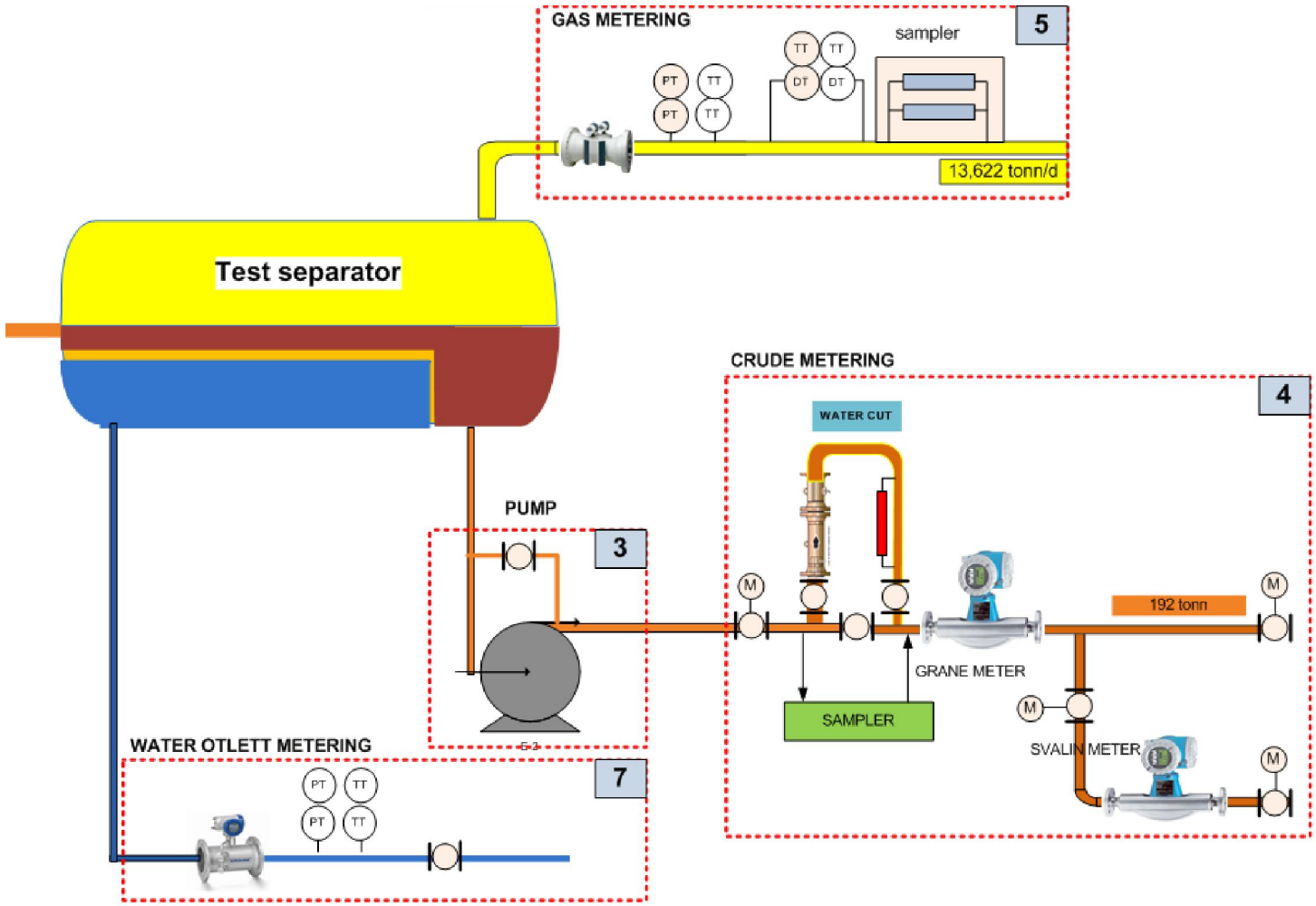
Fiscal metering test separator



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Technology Qualification Program for Coriolis two-phase meter (Technology Readiness Level 4)

Level	Development stage	Description
TRL 0	Unproven Idea	Paper Concept. No analysis or testing has been performed
TRL 1	Analytically Proven Concept	Functionality proven by analysis , reference to common features of existing technology or testing on individual subcomponents /subsystems. The concept may not meet all of the technical requirements at this level, but demonstrates the basic functionality with promise to meet all the requirements with additional testing.
TRL 2	Physically Proven Concept	Concept design or novel features of design validated by model or small scale testing in laboratory environment. The system validates that it can function in a "realistic" environment with the key environmental parameters simulated.
TRL 3	Prototype Tested	Full scale prototype built and put through product qualification test program. The prototype is tested in a robust designed development test program over a limited range of operating conditions to demonstrate is functionality
TRL 4	Environment Tested	Full scale prototype (or production unit) built and put through a qualification test program in (simulated or actual) intended environment
TRL 5	System Integration Tested	Full scale prototype (or production unit) built and integrated into intended operating system with full interface and functionality tests
TRL 6	System Installed	Full scale prototype (or production unit) built and integrated into intended operating system with full interface and functionality test program in intended environment. The technology has successfully operated < 10% of its expected life.
TRL 7	Proven Technology	Production unit integrated into intended operating system. The technology has successfully operated with acceptable performance and reliability for > 10% of its specified life.

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Qualification Activity TRL 4

Qualification Activity (QA)	Acceptance Criteria (AC)	
Carry out horizontal flow tests of Coriolis 4” meters at a recognized laboratory. Test matrix shall be based on Svalin design parameters.	Identify working range and flow conditions: • Absolute mass flow uncertainty < 2%	
Test minimum two different Coriolis designs, i.e. two different vendors.	Verify and rank the performance of the meters	

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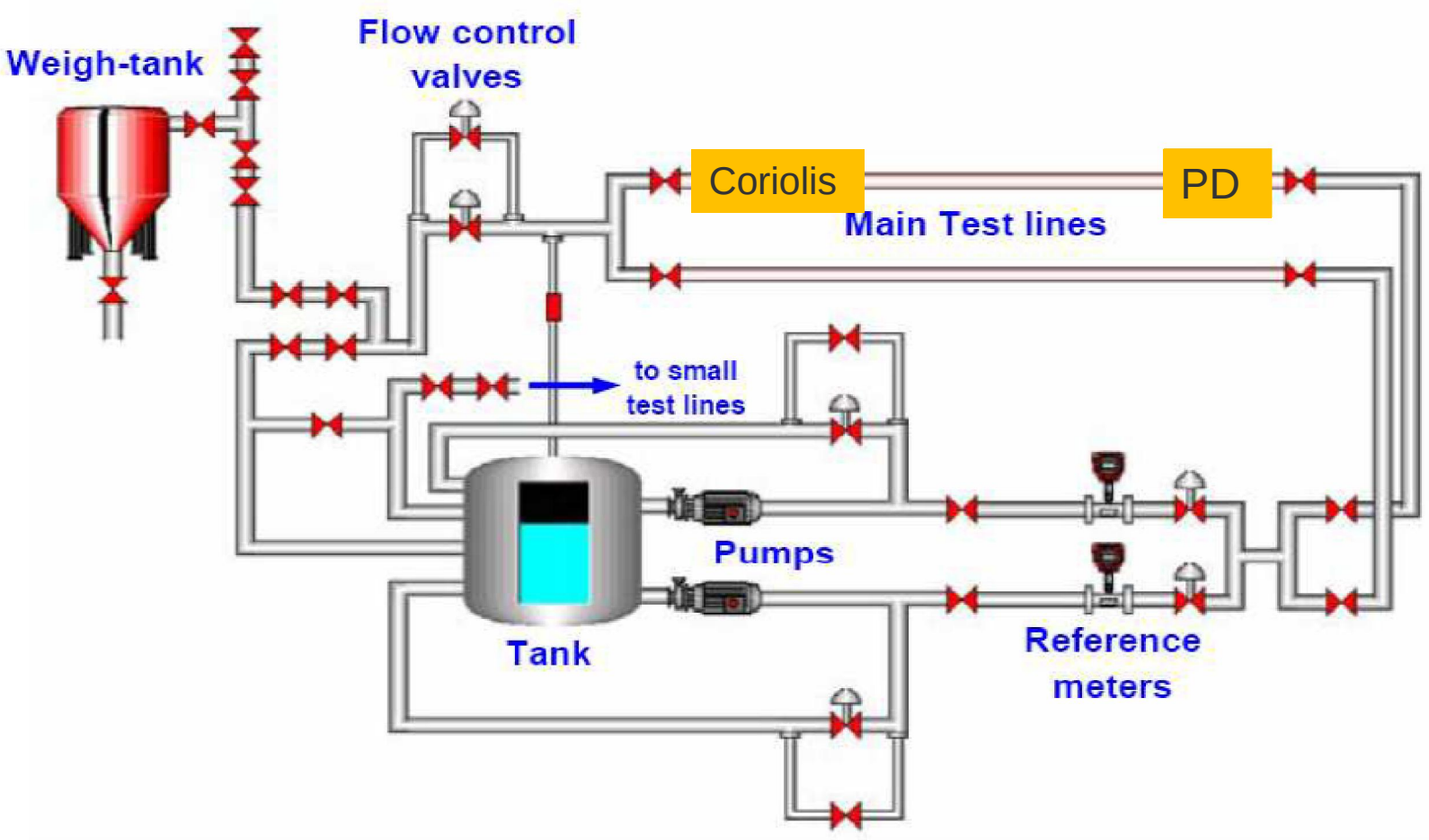
Test matrix

Flow m^3/hr	Gas Volume Fraction %							Flow kg/hr
	0	0.5	1	1.5	2	3	4	
25	X	x	x	x	x	x	x	20000
63	x	x	x	x	x	x	x	50000
125	x	x	x	x	x	x	x	100000
163	x	x	x	x	x	x	x	130000
219	x	x	x	x	x	x	x	175000
240	x	x	x	x	x	x	x	192000

Kinematic viscosity	14 cSt
Temperature	37 ^oC
Density	833 kg/m^3

NEL Oil Flow Test Facility (± 0.08% at k=2)

Traceable to National Standards and is accredited to ISO 17025 by UKAS



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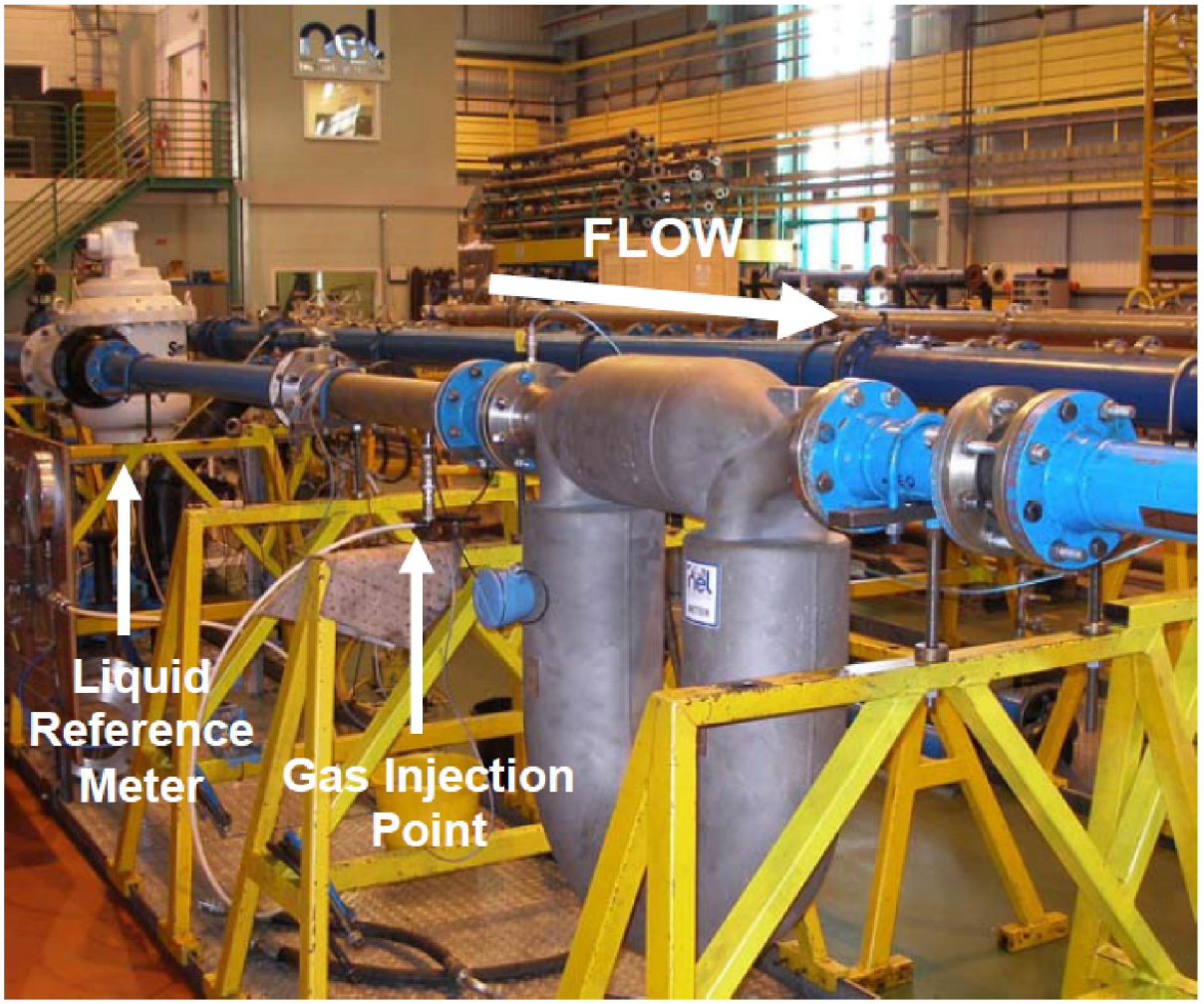
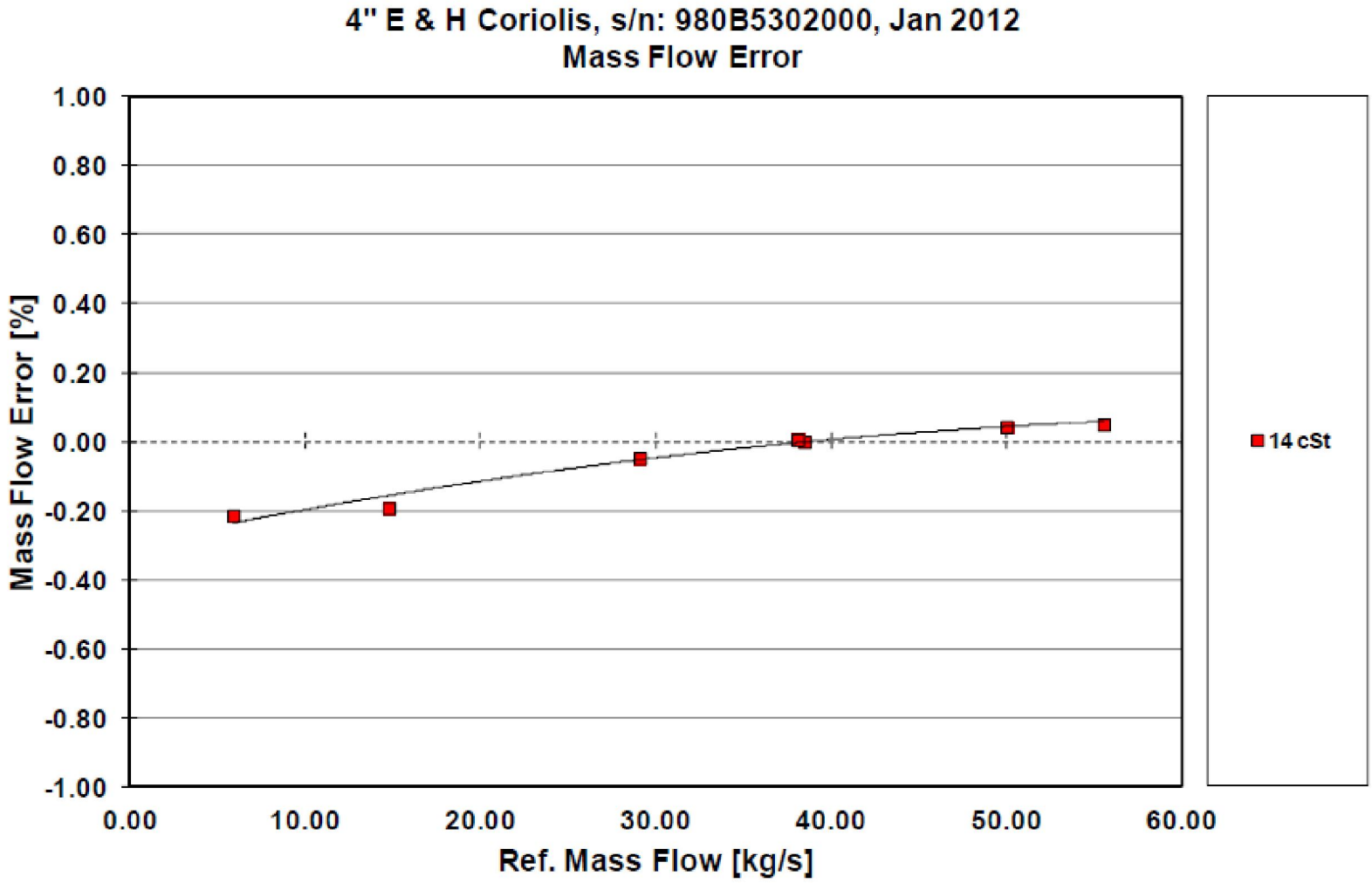
4’’ MicroMotion Coriolis Installed at NEL



Baseline Calibration of 4’’ Endress & Hauser



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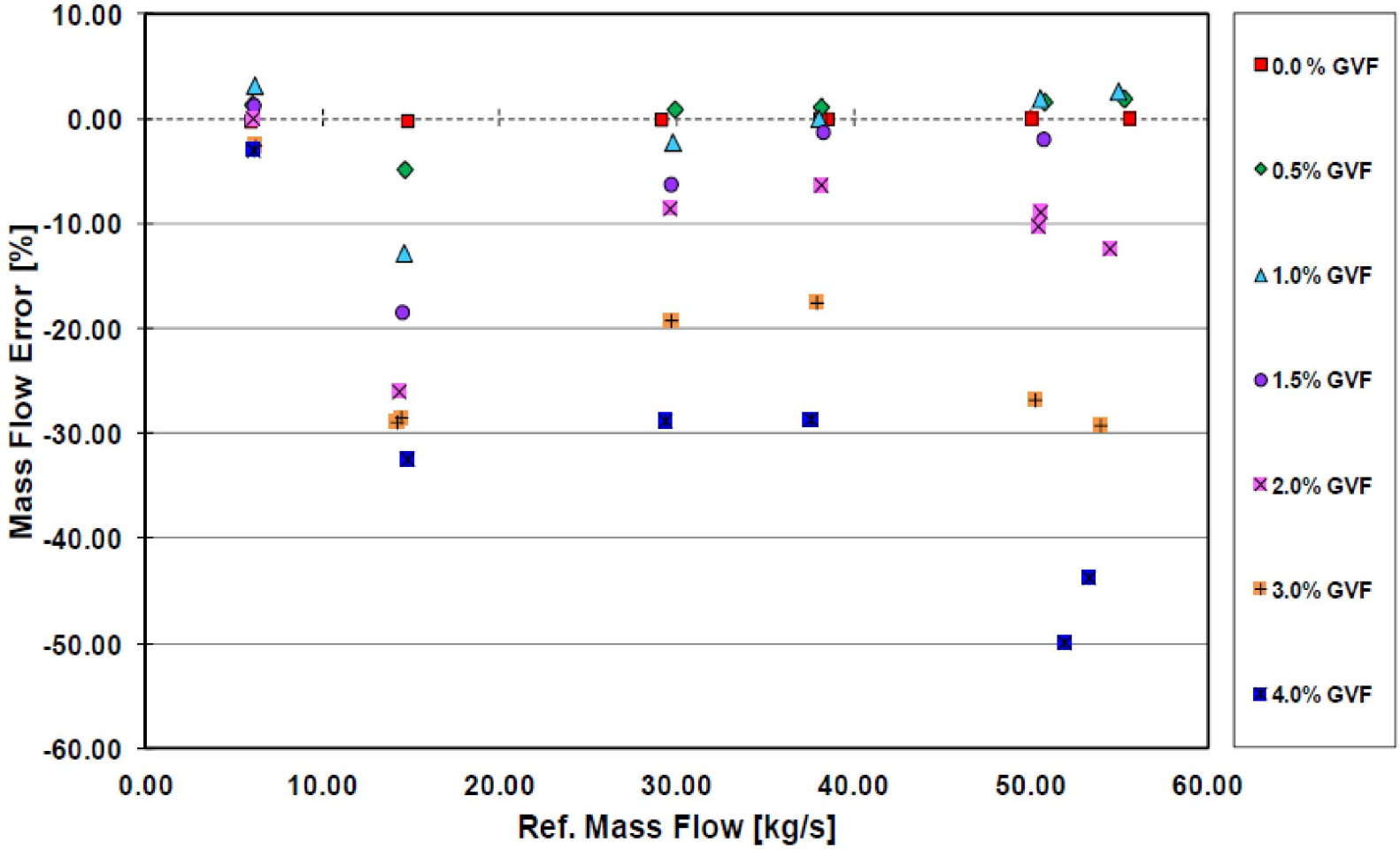
4’’ E & H: Two Phase Oil & Gas Tests

Deviation in Mass Flow Error



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4’’ E & H: Two Phase Oil & Gas Tests

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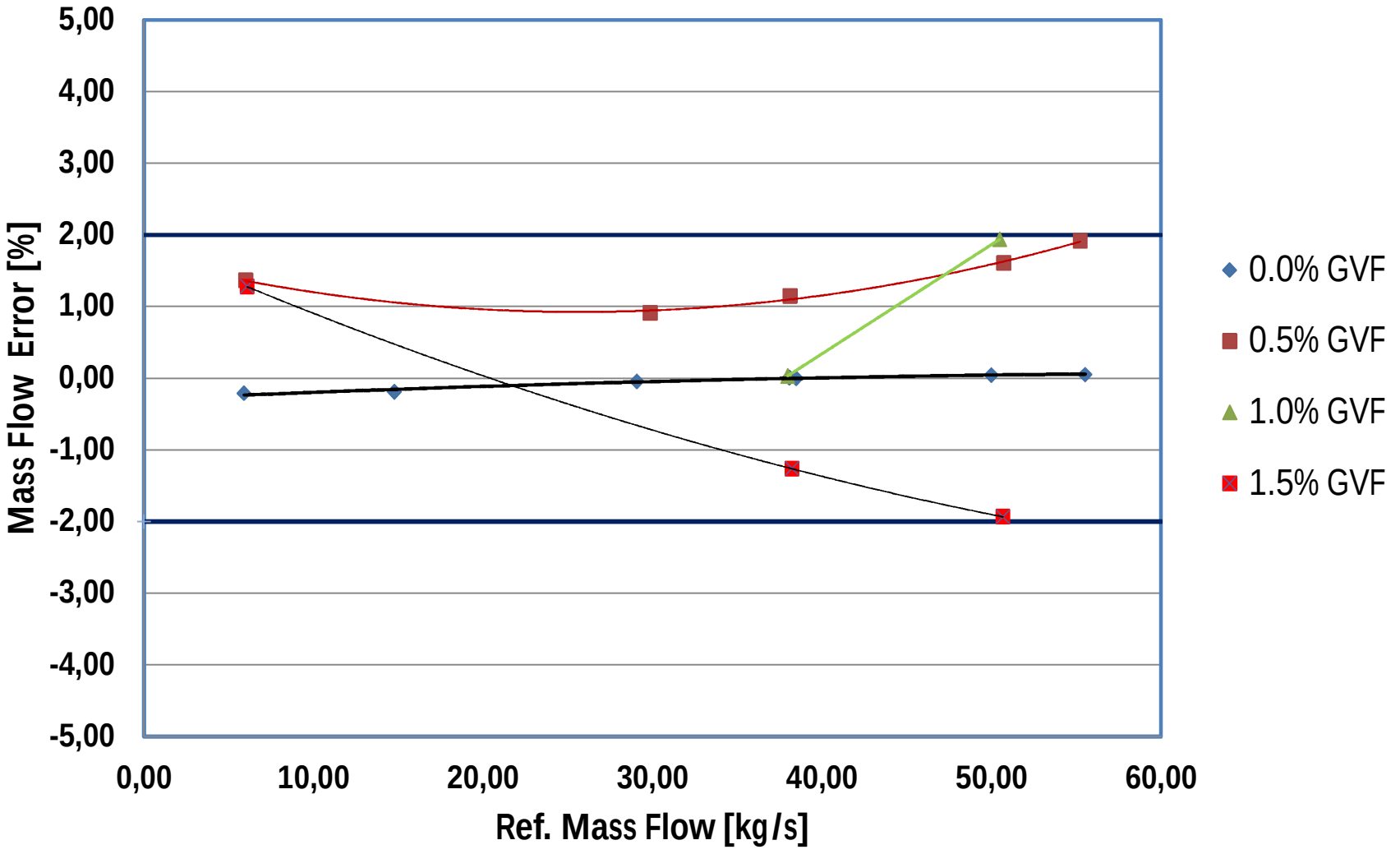

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4’’ E & H: Two Phase Oil & Gas Tests

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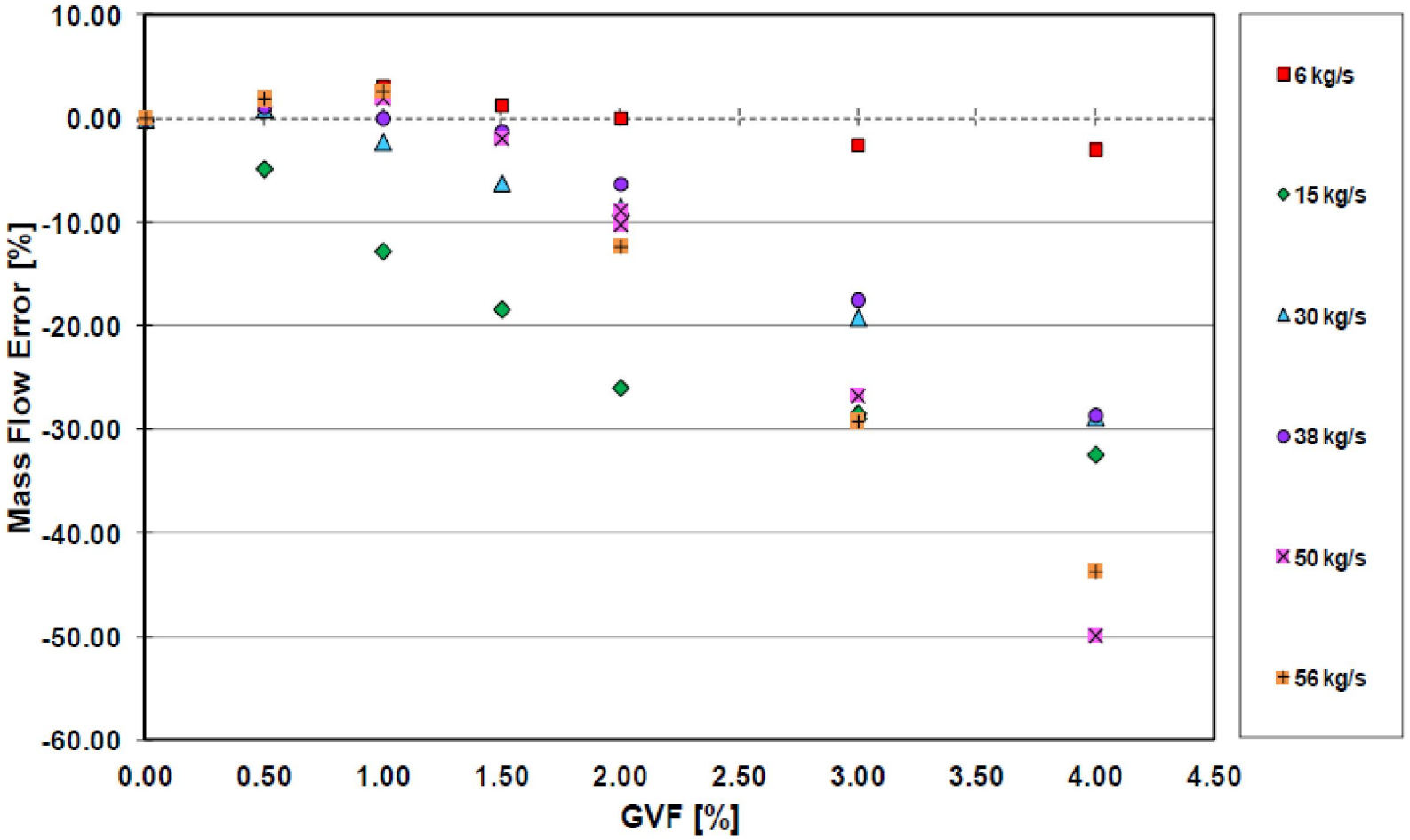

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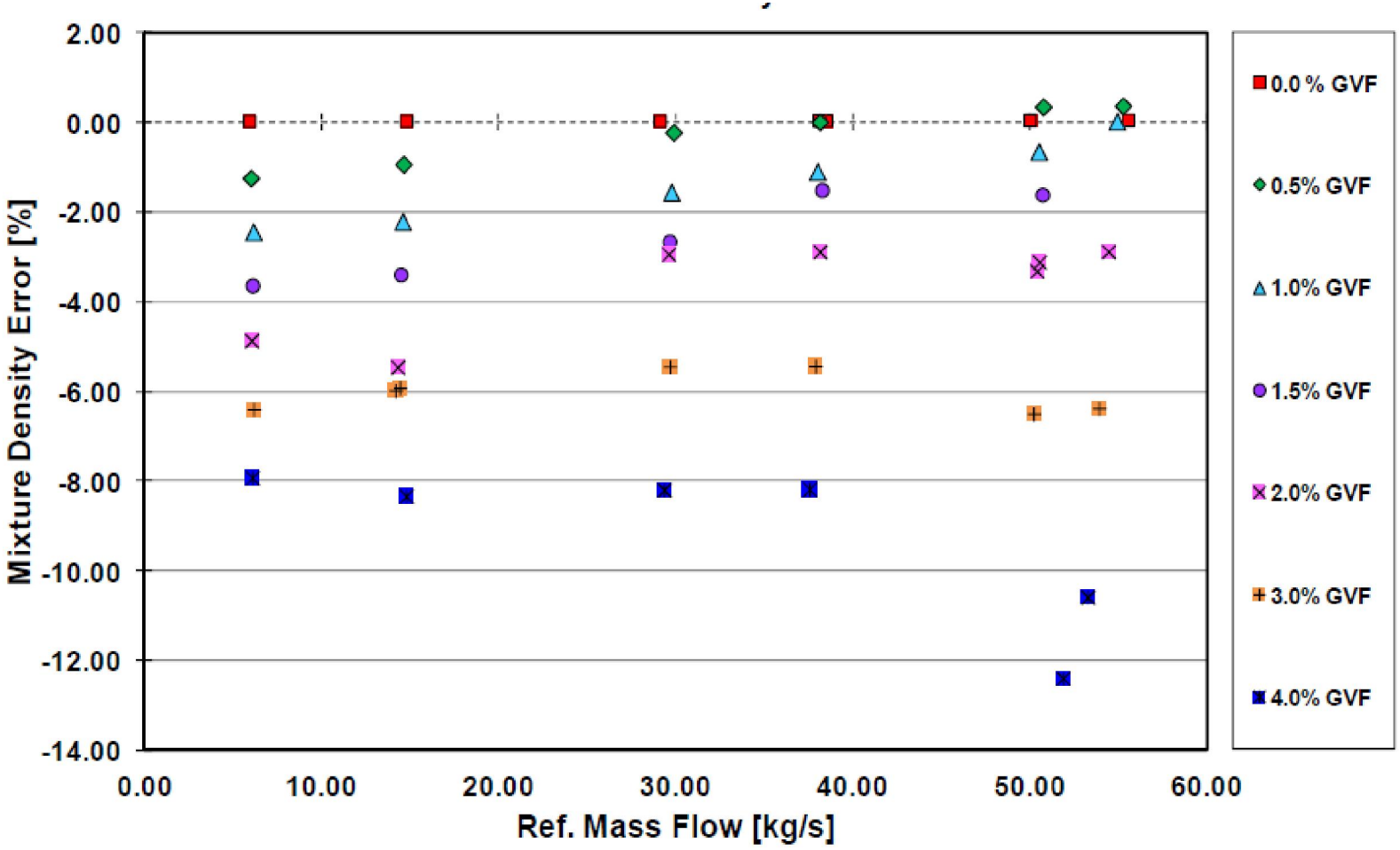
4” E & H: Two Phase Oil & Gas Tests

Mixture Density Error



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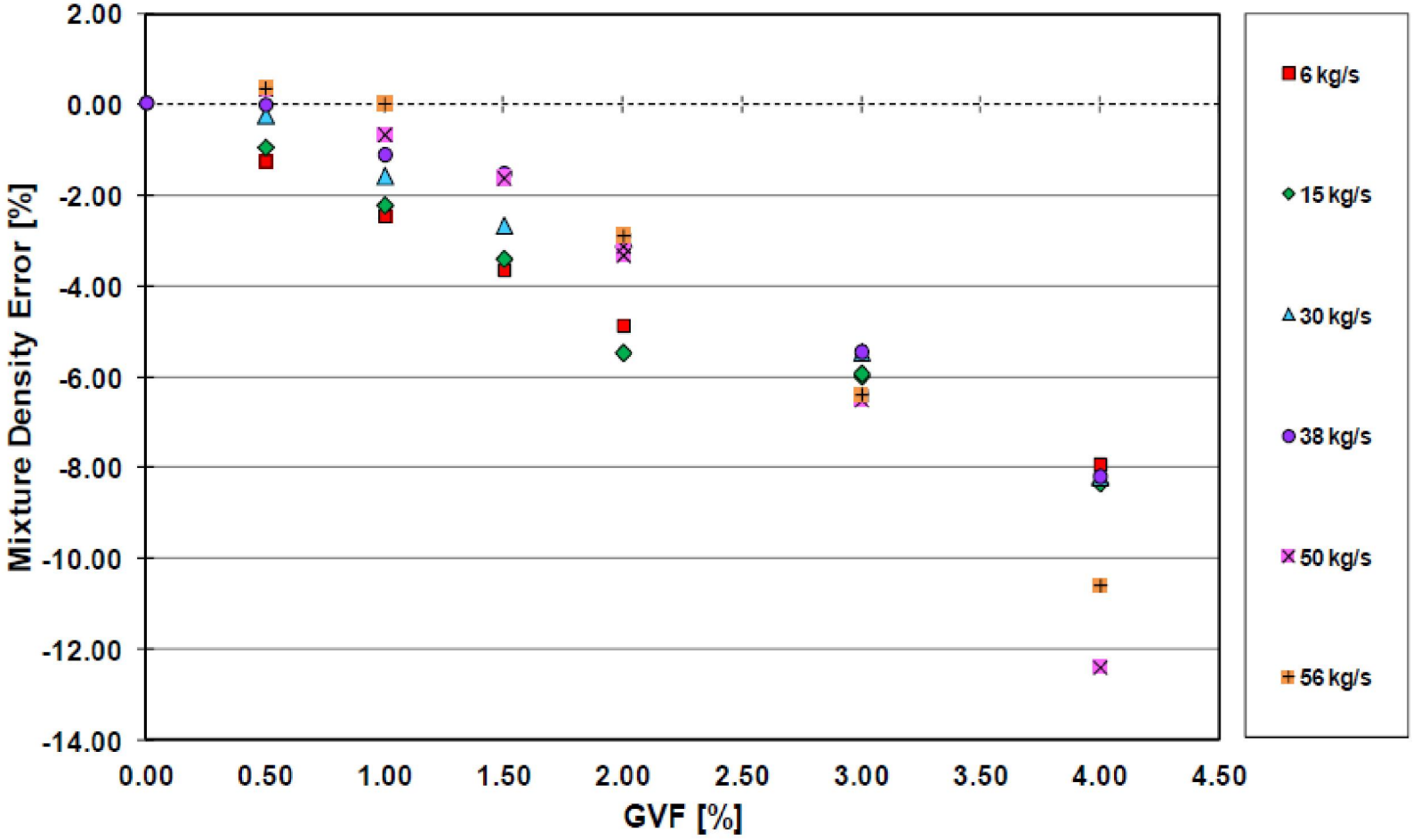
4” E & H: Two Phase Oil & Gas Tests

Mixture Density Error



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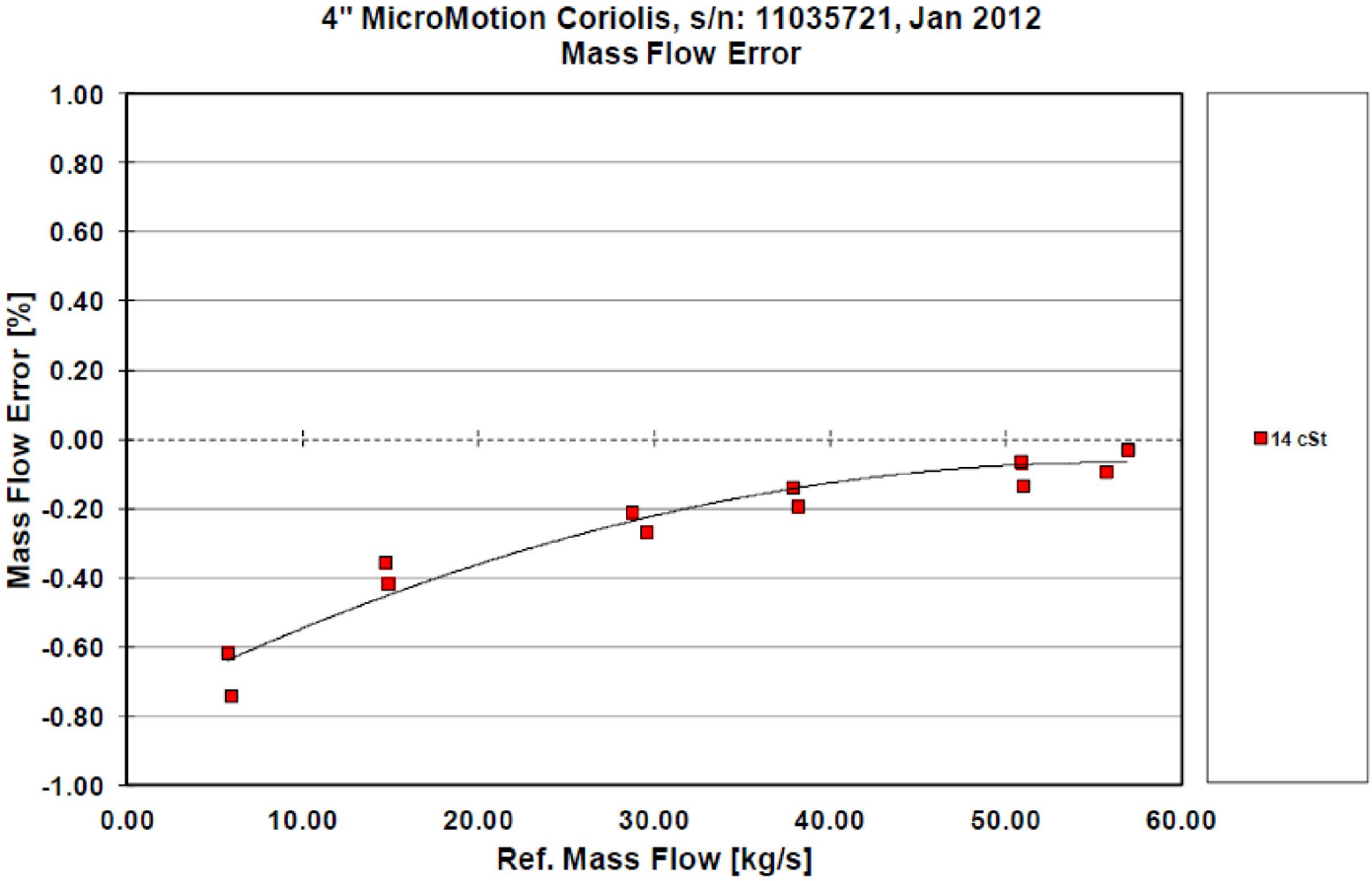
Baseline Calibration of 4’’ MicroMotion



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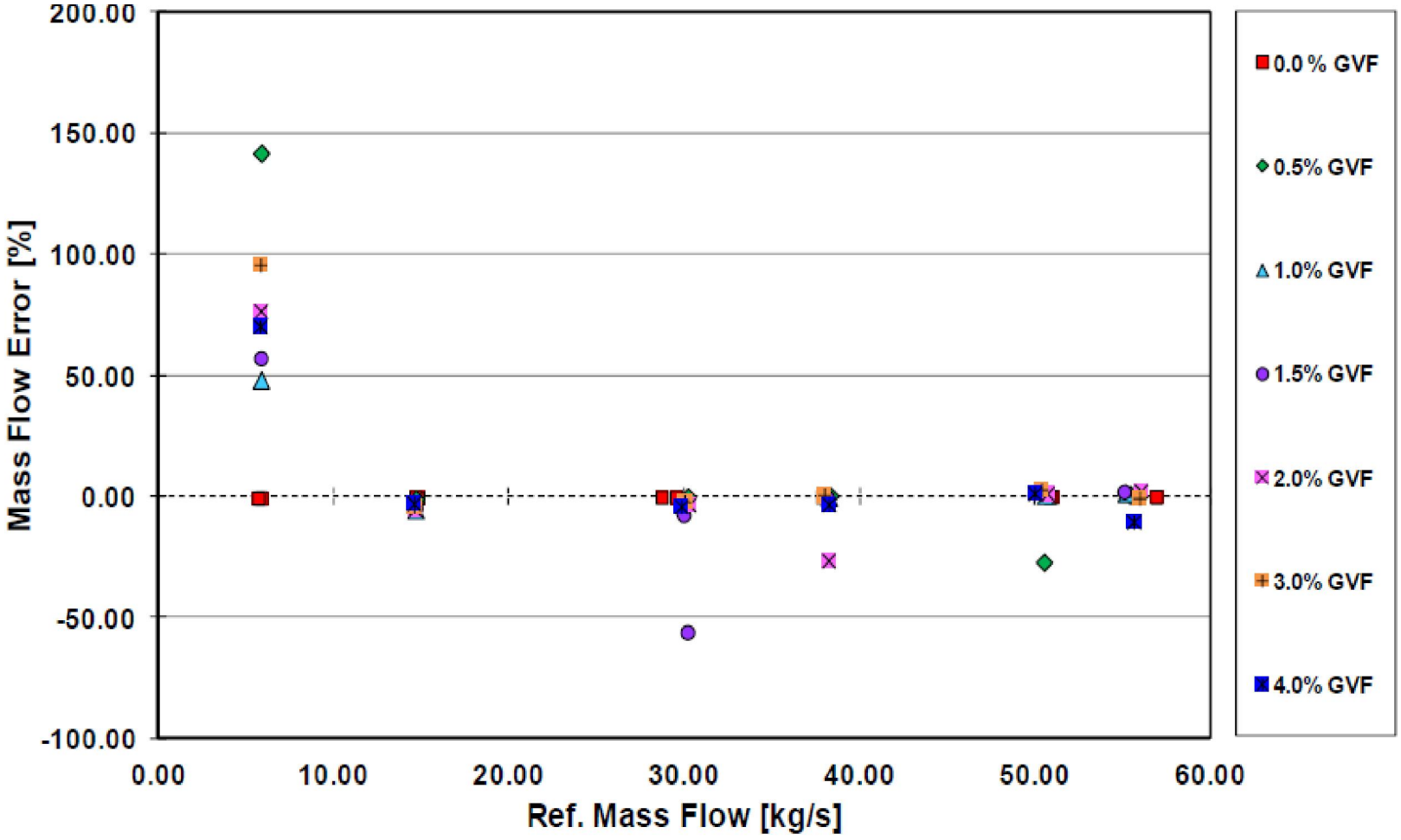
4’’ MicroMotion: Two Phase Oil & Gas Tests

Deviation in Mass Flow Error



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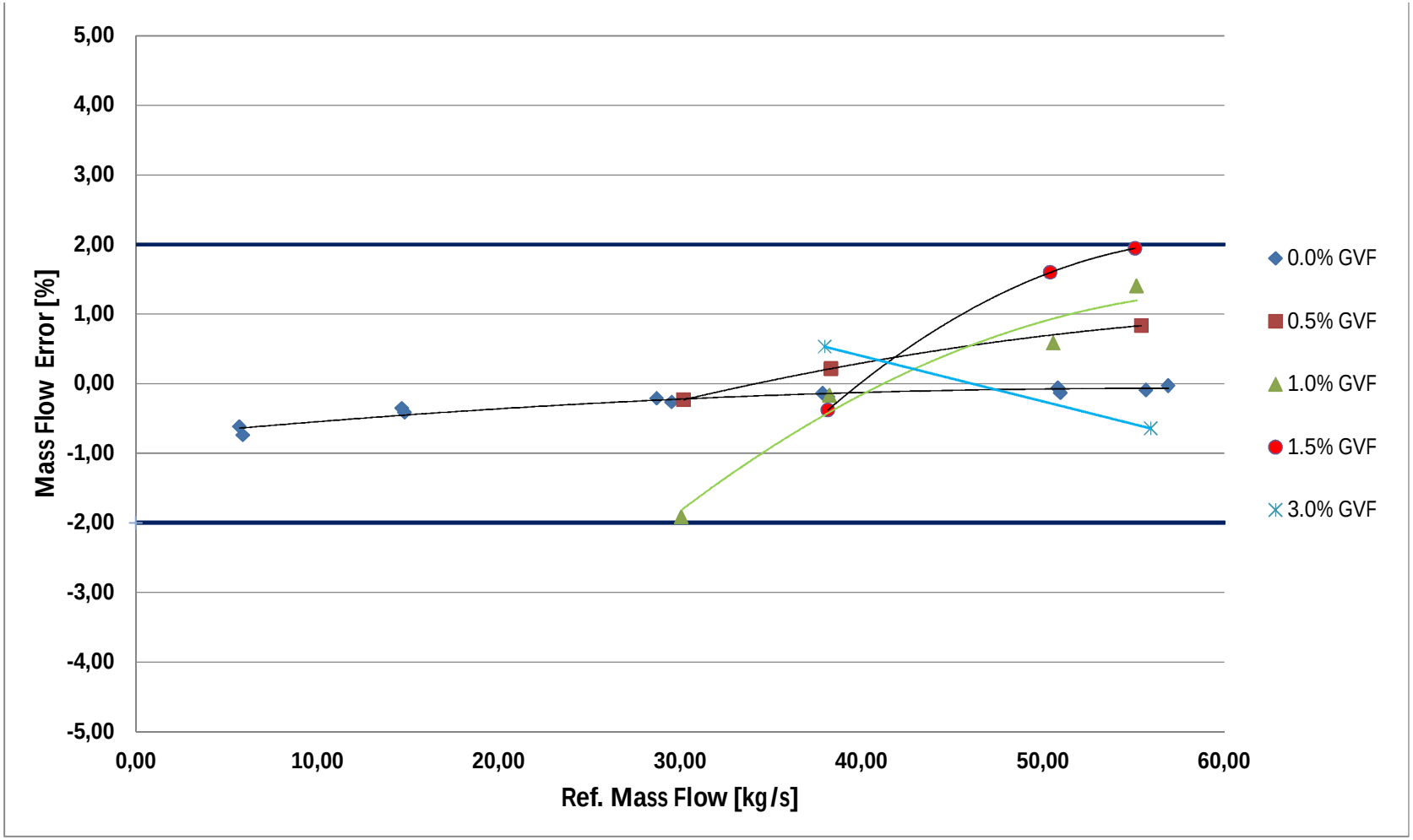
4’’ MicroMotion: Two Phase Oil & Gas Tests

Deviation in Mass Flow Error



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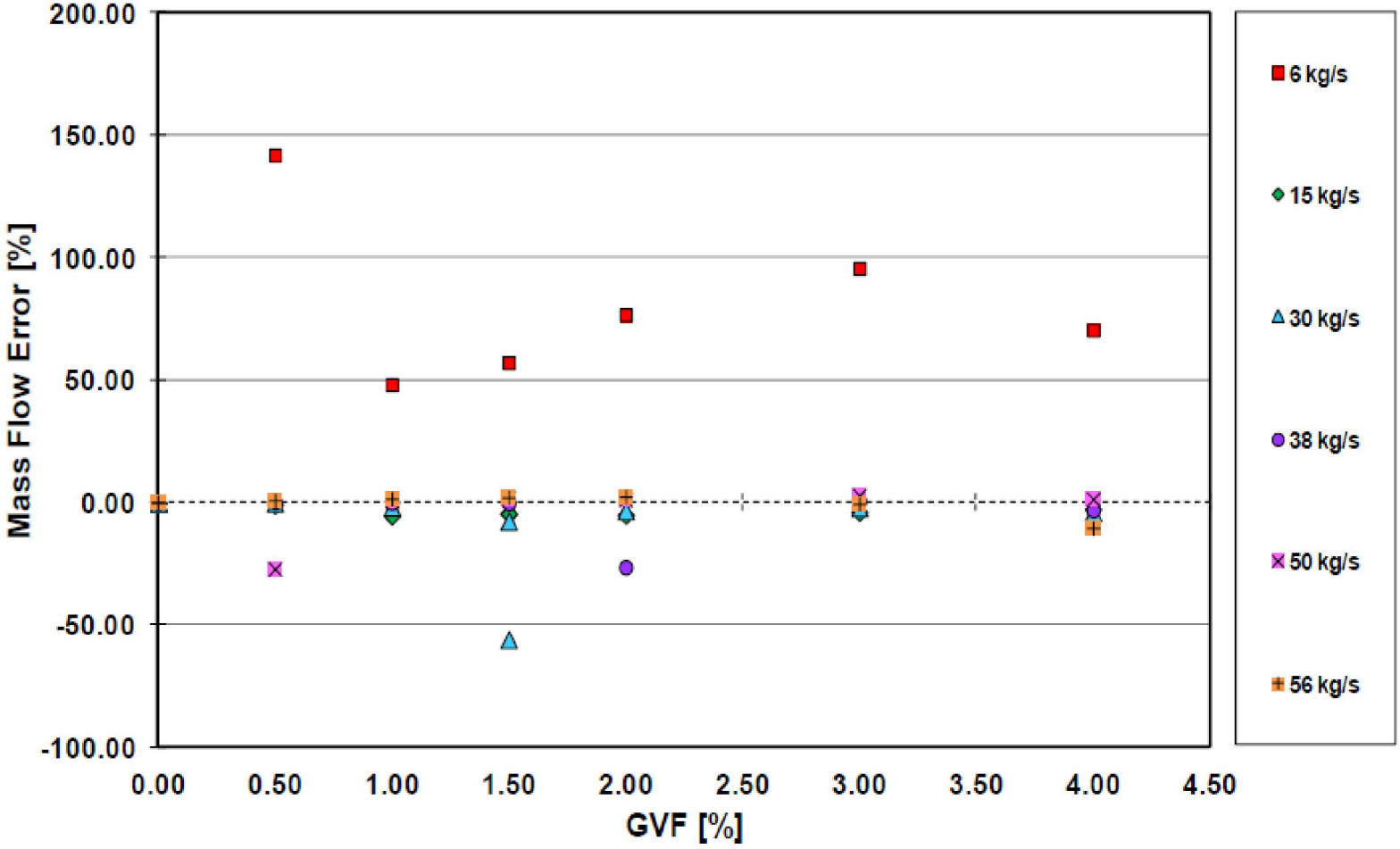
4’’ MicroMotion: Two Phase Oil & Gas Tests

Deviation in Mass Flow Error



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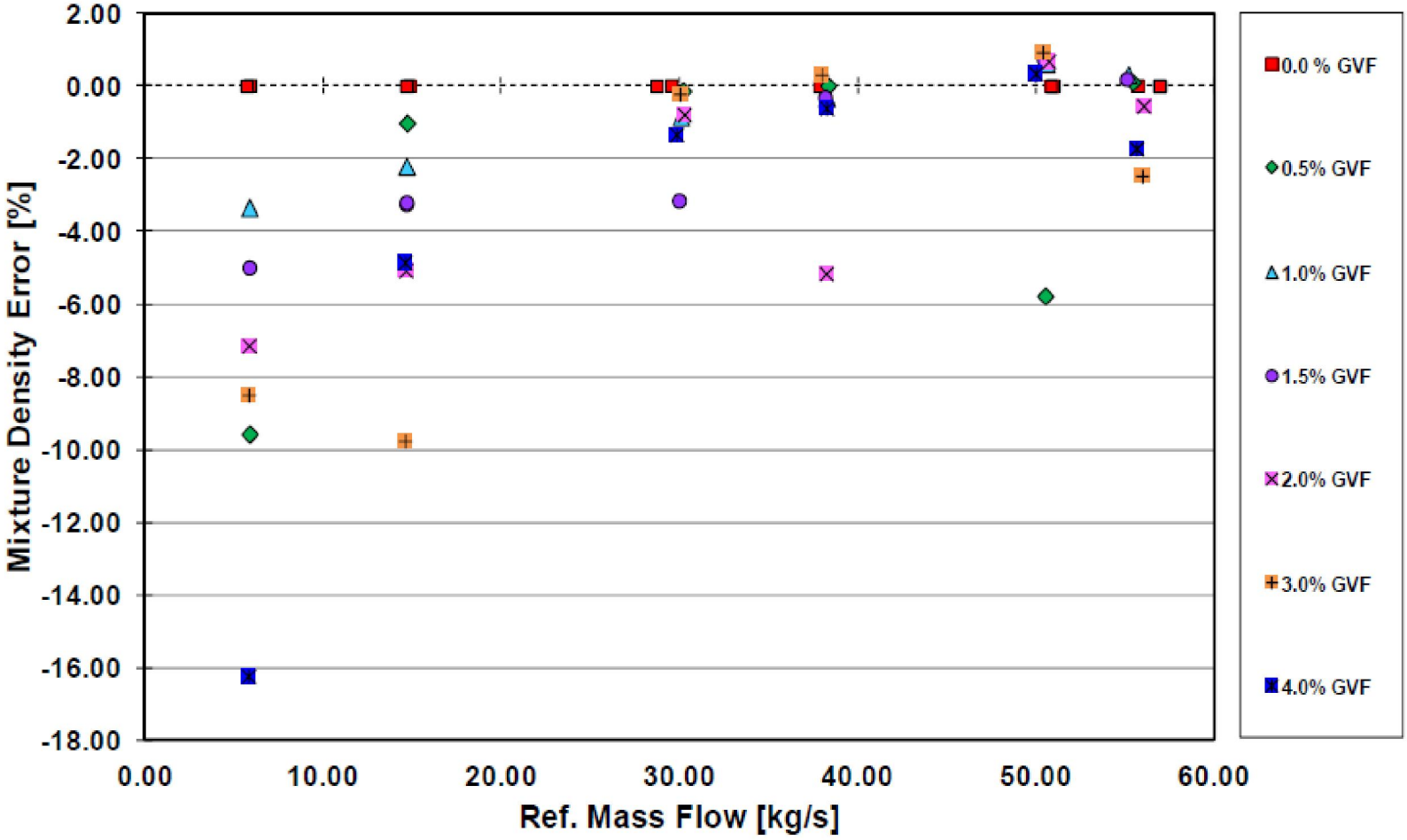
4’’ MicroMotion: Two Phase Oil & Gas Tests

Mixture Density Error



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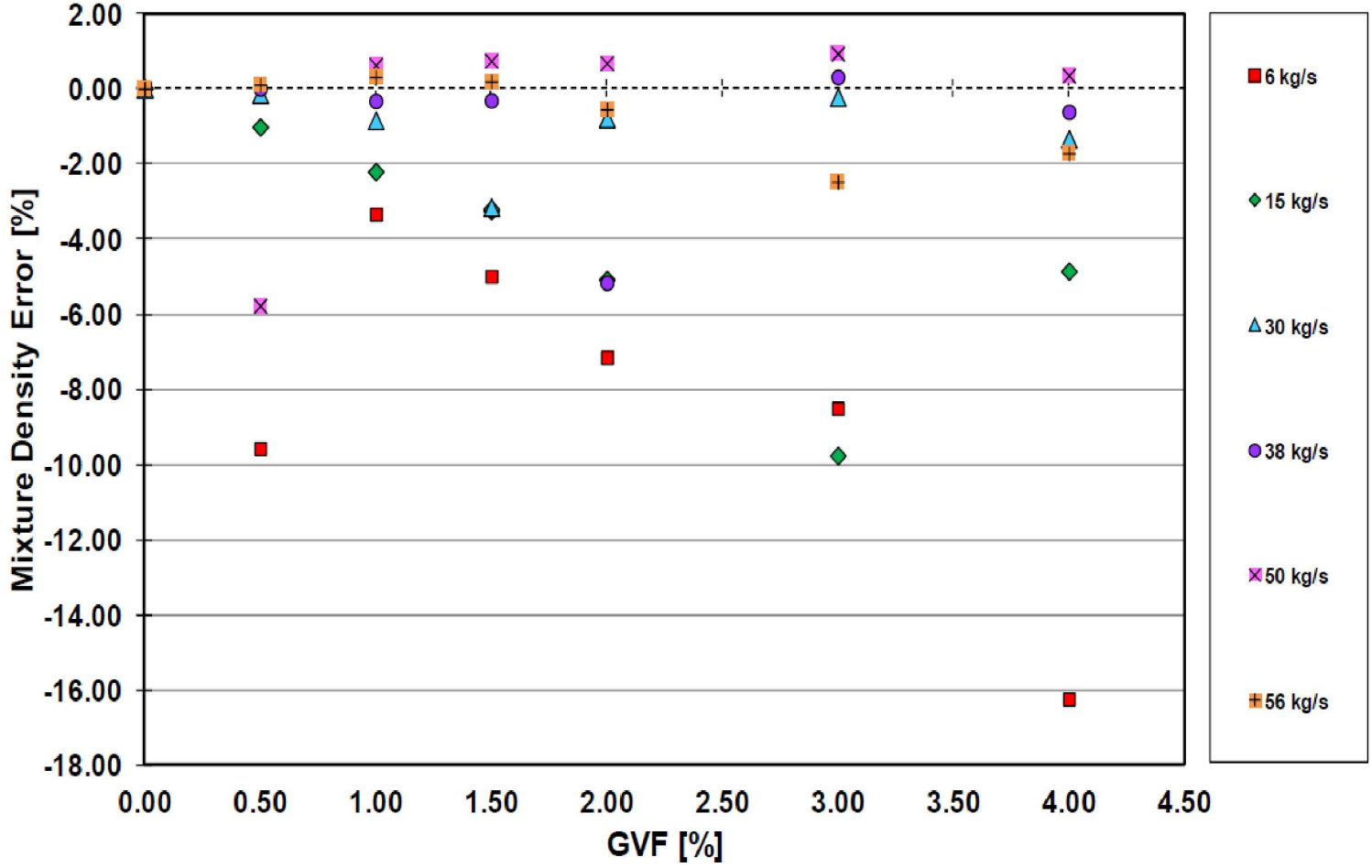
4’’ MicroMotion: Two Phase Oil & Gas Tests

Mixture Density Error



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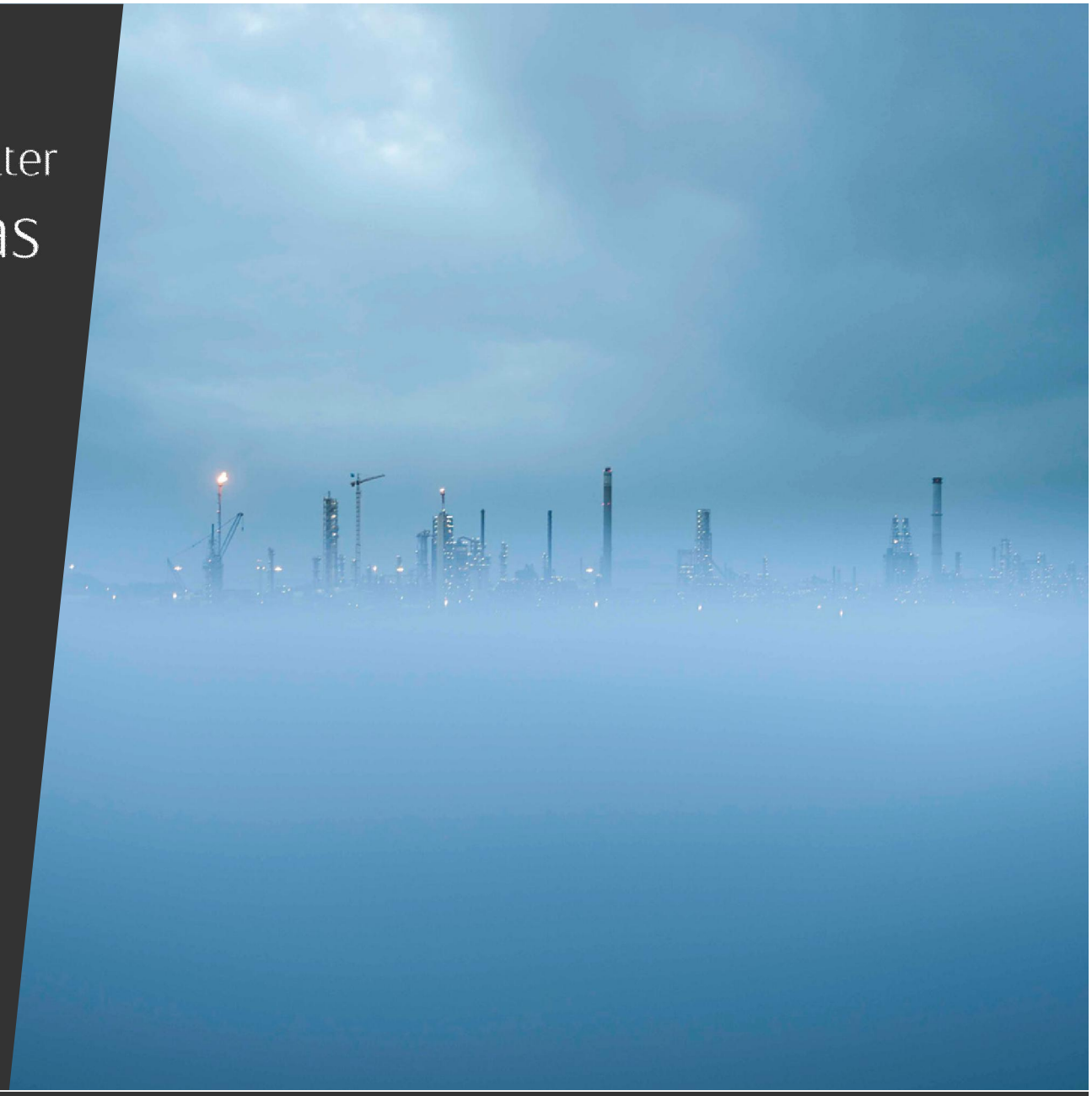
Conclusions

- New application or product
  - Test flow meter at intended environment !!!!
- A robust two-phase flow meter has yet to be found/developed.
- Coriolis:
  - The presence of small levels of gas results in significant mis-measurement of the oil flow.
  - At low GVF the mass flow respons improved sligthly with increased oil flow.
  - The under-reading of the mass flow and density increases with increasing GVF (over-reading at low GVF may occur)
    - MicroMotion over-reading of 142% at 0.5% GVF at 6kg/s.
    - E&H under-reading of 50% at 4% GVF at 50kg/s.
- Simplified metering is a challenge !

There's never been a better time for good ideas



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