Kuwait 4th Flow Measurement Technology Conference

3-5 December 2019
Hilton Kuwait Resort

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HALUK TORAL

Petroleum Software Ltd

Project Experience in Large Scale Implementation of MPFMs in an Entire Oil Field

Haluk Toral Petroleum Software Ltd & Arman Ilyassov Gazprom

BADRA OIL FIELD

Wassit Province in Eastern Iraq	9 billion barrels in place
Lead operator Gazprom	2 billion $ investment
Production rates of 22 wells	1000 bbl/d -13000 bbl/d.

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TENDER REQUIREMENTS

Requirement

17 off wellhead MPFMs (6” – 8”)
3 off production line MPFMs (14” - 20”)

Uncertainty

Liquid : ± 5 % Gas : ± 10 %

Materials

- NACE compliance
- Composition of steel (strict limits on Phosphor, Sulfur)
- Hydrogen induced cracking (HIC)
- Sulphide stress cracking (SSC)
- CVN tests (impact testing)

PROCESS & PVT DATA

Process Data

– Wellhead:
- 26 bar / 105 C
- Oil: 600 – 15,000 bpd
- Gas 0.1- 13 mmscfd

– Production Line:
- 16bar/40C
- Oil: 17,000 – 73,000 bpd
- Gas: 11-61 mmscfd

PVT Data

- Composition of reservoir fluid (lab analysis provided)
- Saturation pressure at reservoir temperature (eg 214 bara)
- Molecular weight of reservoir fluid (eg 94 g/mole)
- Multistage separation test results (eg GOR=162; API Oil: 35)

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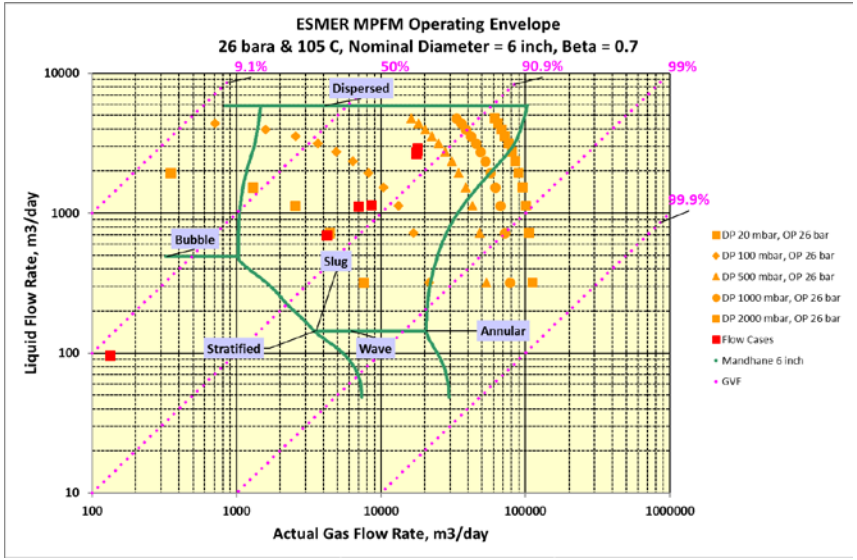
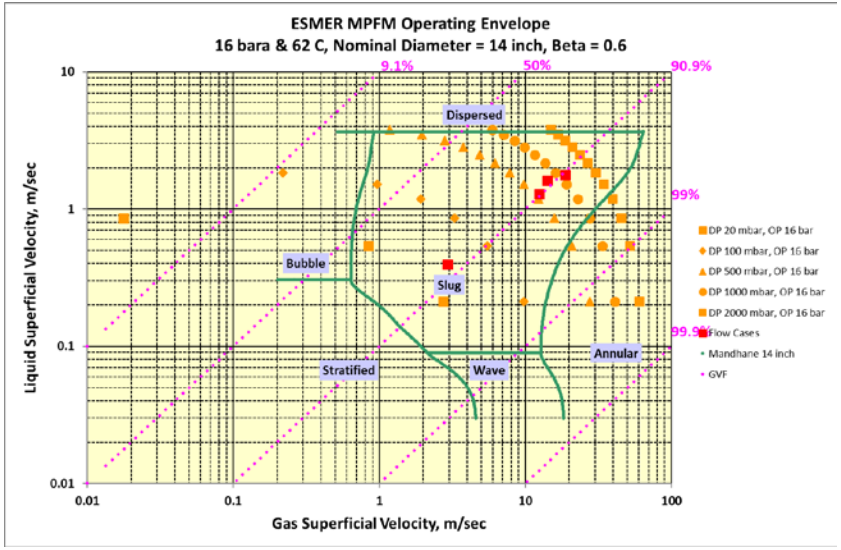
SIZING BY PSL





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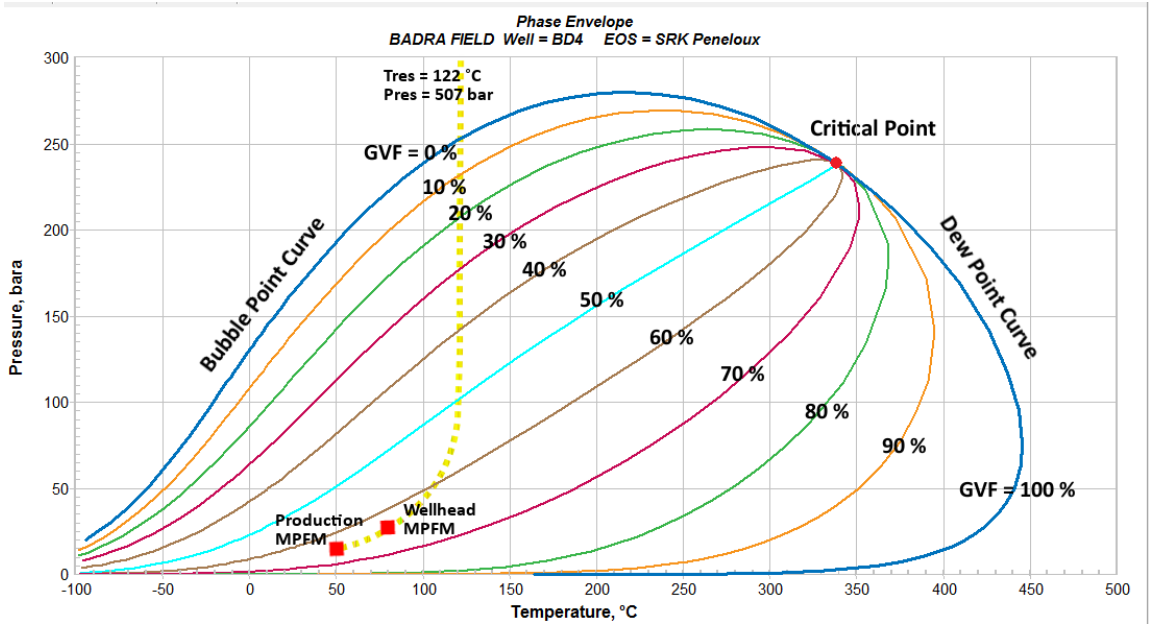
PHASE ENVELOPE BY PSL



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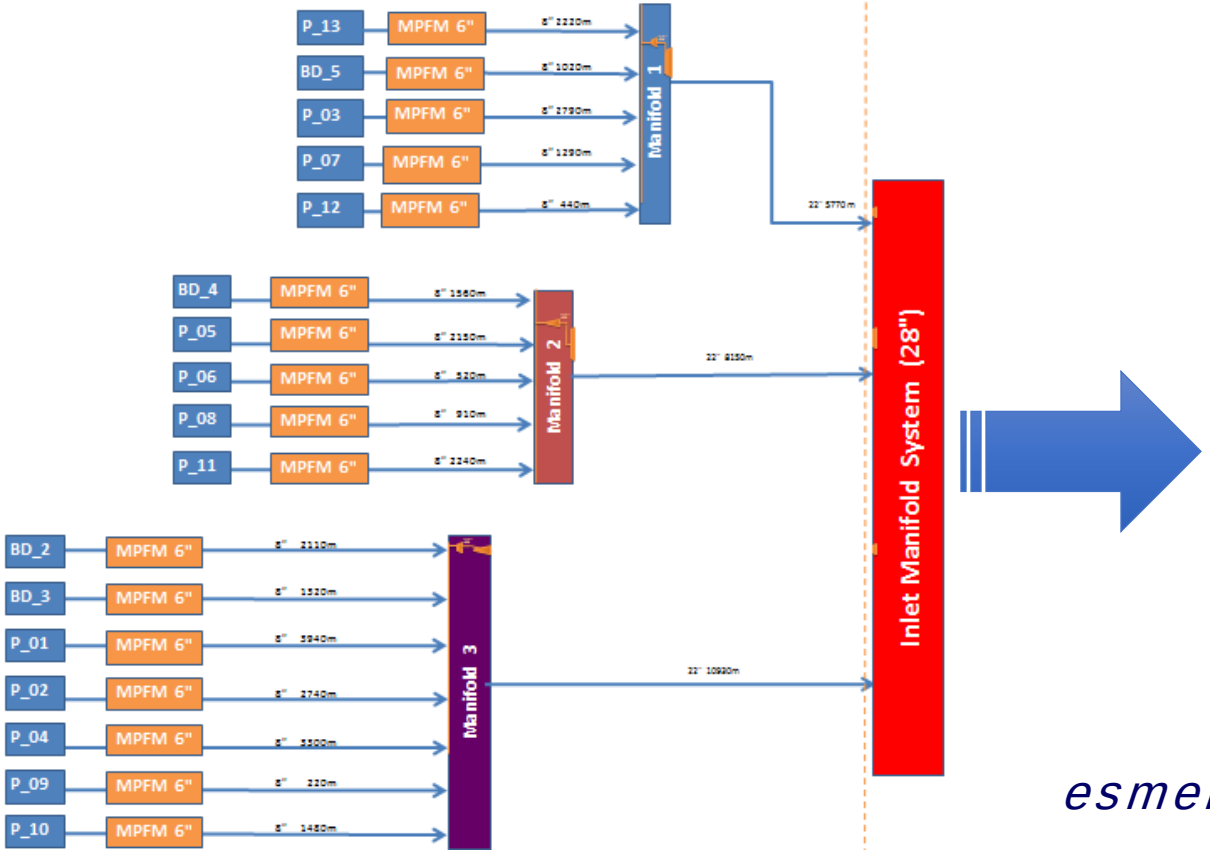
WELL HEAD MPFMs



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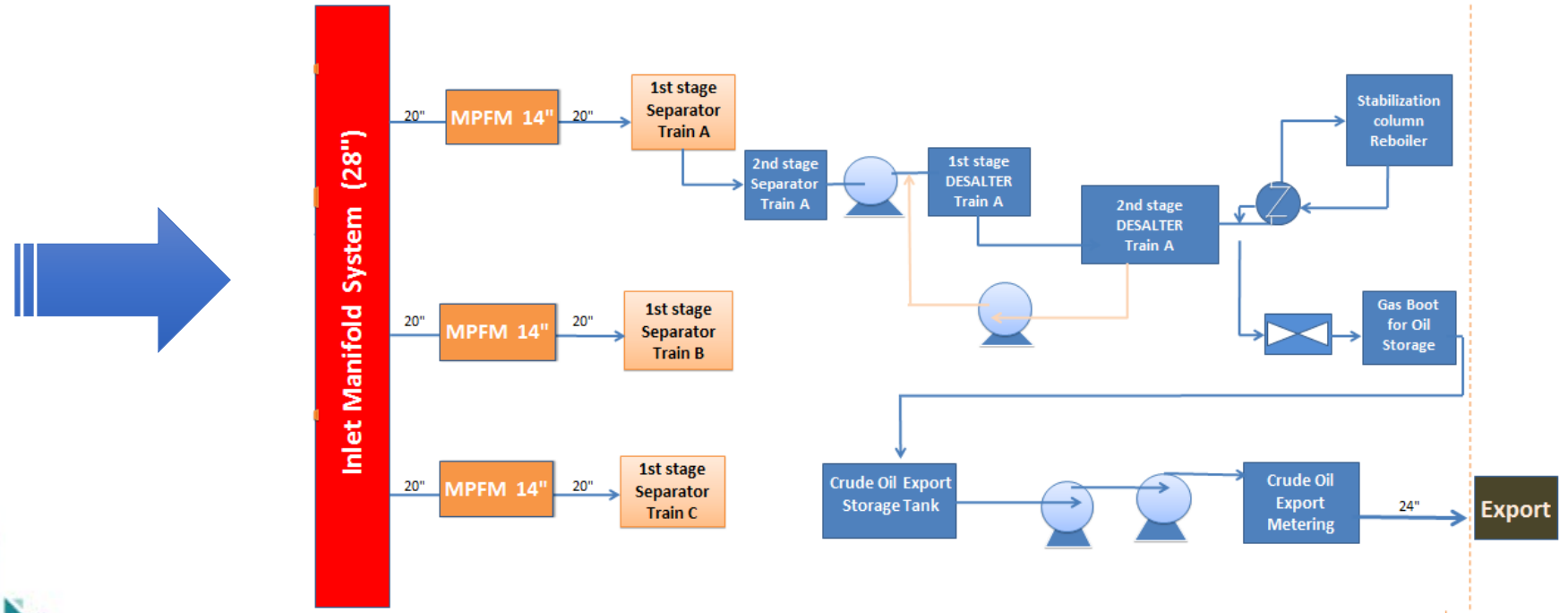
PRODUCTION LINE MPFMs



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AERIAL VIEW

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BUT; HOW TO WIN THE TENDER – STOP & THINK!

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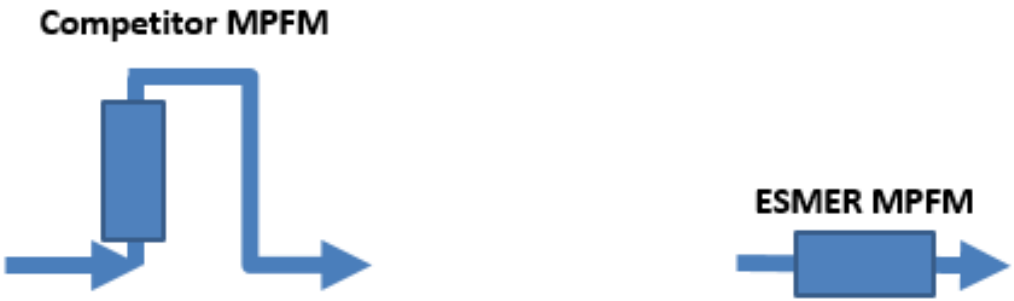
Things Not To Do

THINGS NOT TO DO 1 – AVOID VERTICAL FLOW

Systems based on vertical flow suffer from the following disadvantages:

- The meter may choke due to elbows.
- Pipe structure may be subjected to strong vibrations under certain flow regimes (as liquid gathers at the riser elbow and gets flushed out).
- Extra pressure drop of about 2 bar due to 4 elbows.
- 14” system even less suitable for vertical orientation than 6”



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Things Not To Do

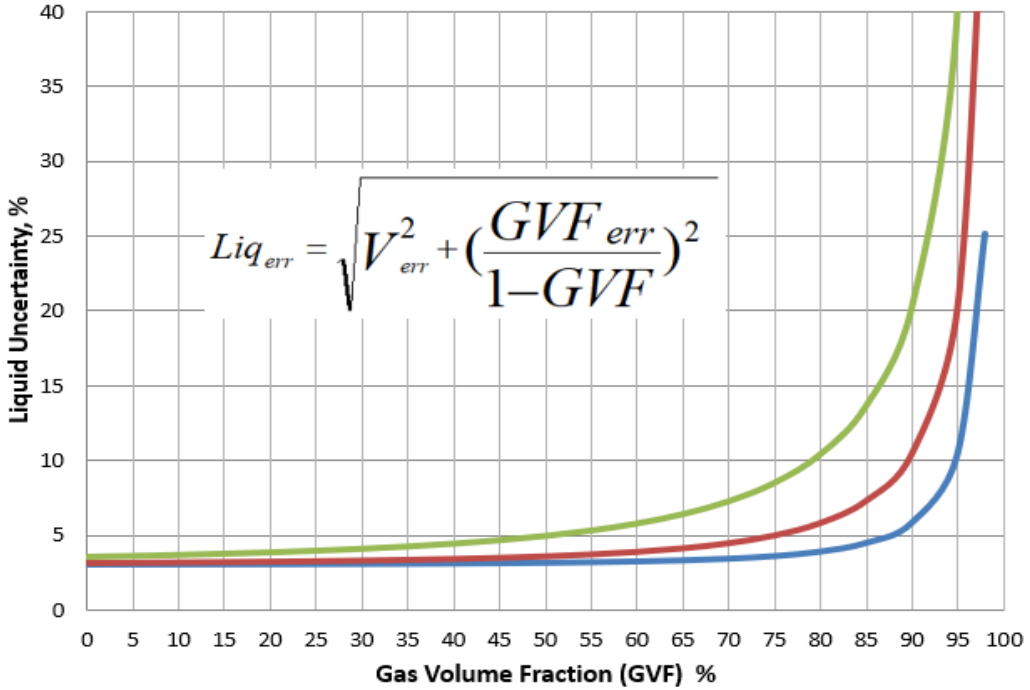
THINGS NOT TO DO 2 – AVOID COMPLEX FIELD ELECTRONICS

It does not make sense to subject electronics to 80^{o}C sunlight !

- ESMER needs 4-20 mAmp twisted wire cable running from field unit to control room.
- All customised electronics will be in the control room.

Things Not To Do

THINGS NOT TO DO 3 – DO NOT WASTE YOUR MONEY CHASING AFTER HIGH ACCURACY



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Things Not To Do

THINGS NOT TO DO 4 – AVOID RADIOACTIVE TRANSMITTER

- Go for Equation Of State Modelling

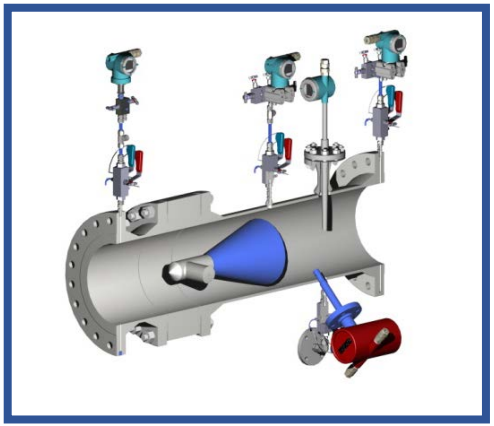
Things Not To Do

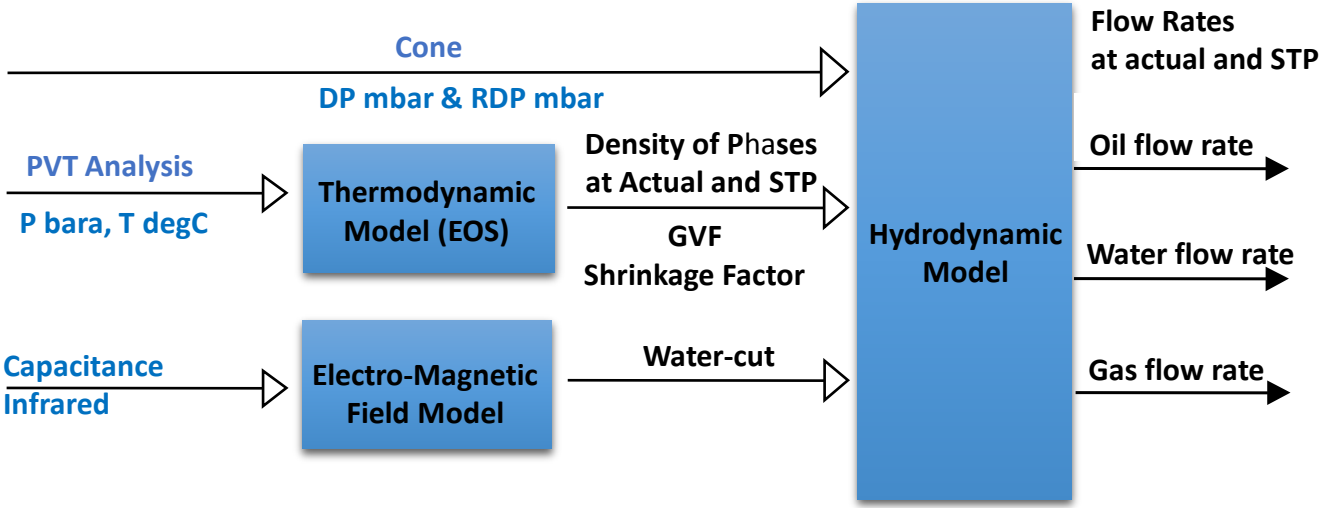
THINGS NOT TO DO 5 – DO NOT RELY ON FLOW LOOP CALIBRATION /TEST.

- In-line MPM calibrations must be tuned-up in the field as per API 2566 recommendations
- Forget the FAT / Loop Test go for the SAT Test.
- PSL will take full responsibility for field calibration and validation.

- In fact, we'll throw in a mobile separator free of charge included in the package.

EsmerMPFM – How Does It Work?





- **Thermodynamic Model** (Cubic EOS based on the reservoir fluid composition) predicts the fluid property parameters by performing a flash calculation at actual conditions and STP assuming thermodynamic equilibrium.
- **Hydrodynamic Model** (Bernoulli equation) predicts total mass rate assuming homogeneous flow.

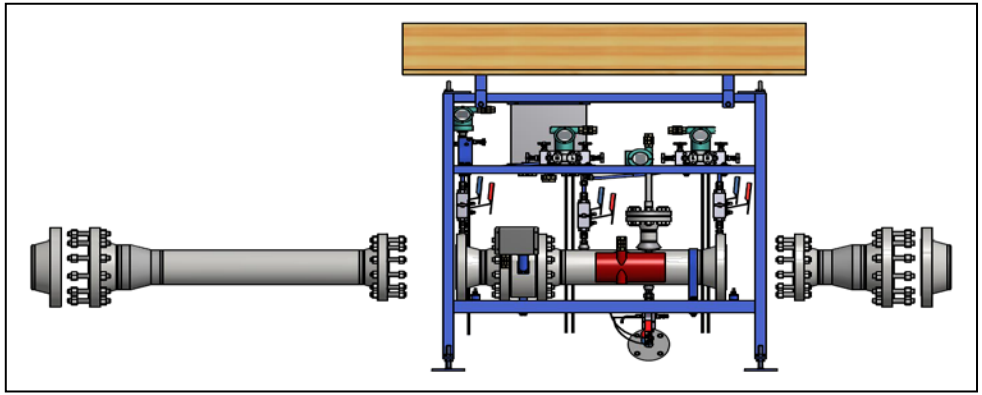
EsmerMPFM – How are you going to calibrate?

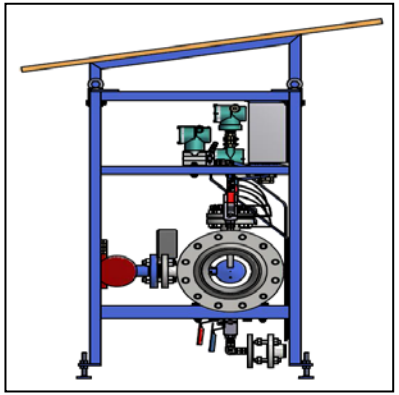
Three stages of calibration of (any) flowmeter

- Theoretical calibration
- Flow loop calibration
- Field calibration (tune up)

BADRA OIL FIELD

MPFM DESIGN & ENGINEERING





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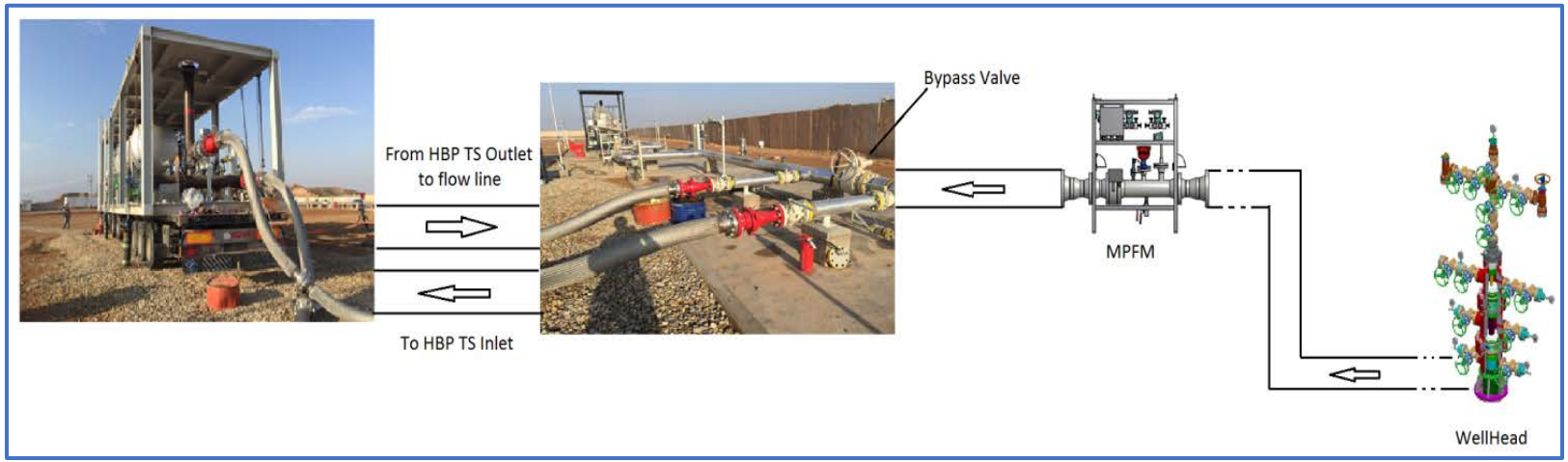
esmerMPFM C14+ Installed at the Production Line Badra Gazprom


KOGEL


Gas outlet line
KÖGEL


KÖGEL

FIELD CALIBRATION
MPFM and Mobile Separator In-line



FIELD IMPLEMENTATION
Tune Up Cycle

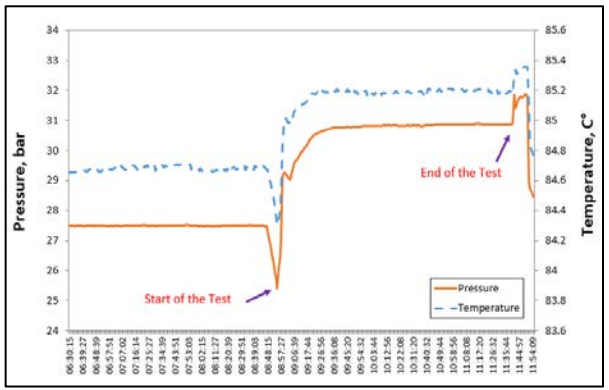
- ***Tune Up:*** Data is logged simultaneously from the MPFM and the Separator on a minute by minute basis for the duration of two hours. Liquid and gas samples drawn from the test separator are subjected to PVT analysis.

- ***Calibration Update:*** Vendor runs Tune Up (MPFM) Simulator which outputs an updated calibration file. The file is transmitted by e-mail and installed on the MPFM by the operator.

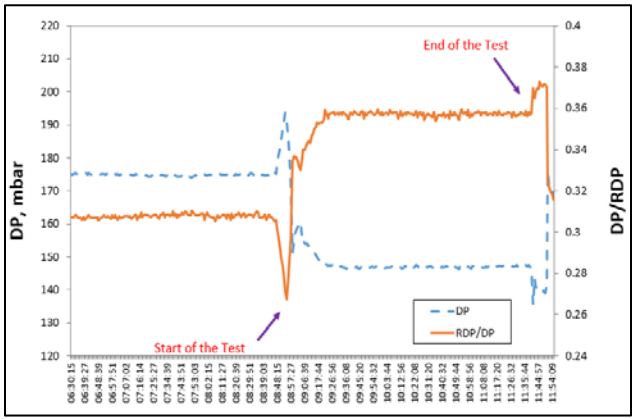
- ***Validation:*** Operator repeats the well test to validate the updated calibration.

FIELD IMPLEMENTATION
Back pressure effect of the Test Separator

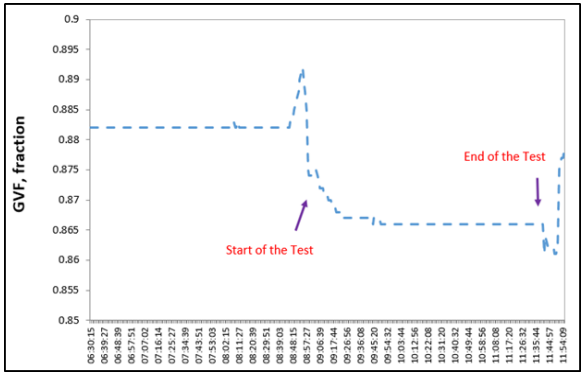
Pressure



DP



GVF



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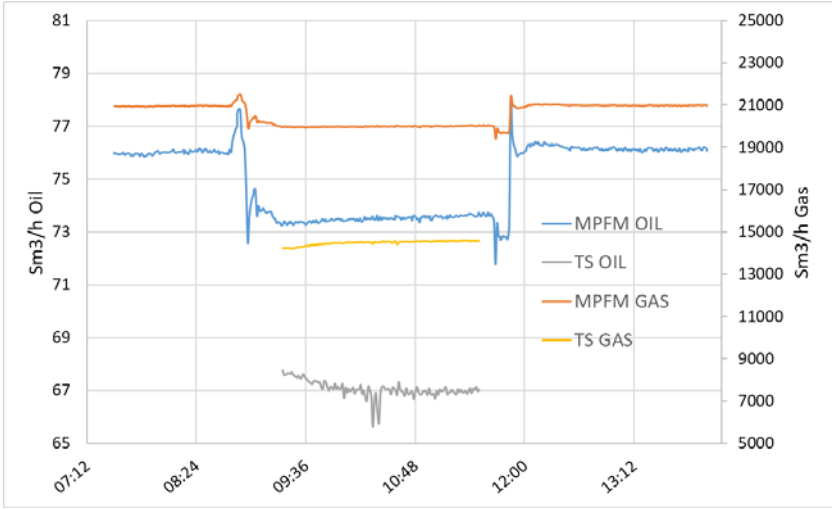
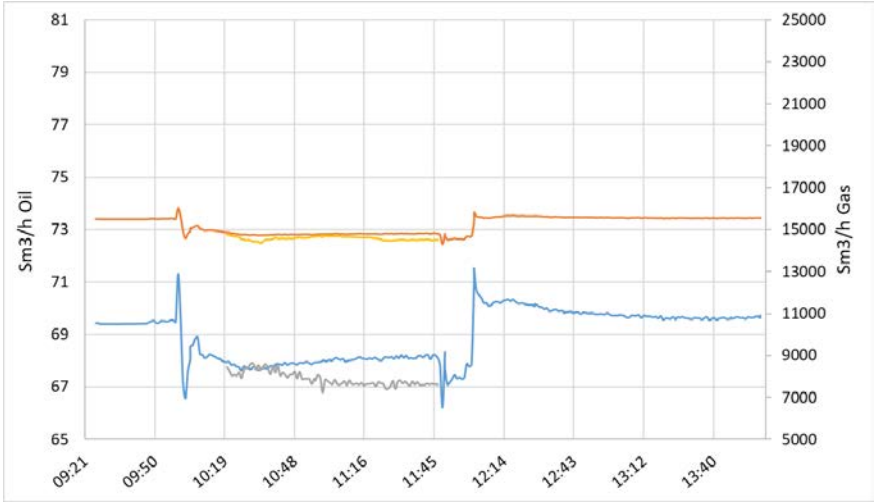
FIELD IMPLEMENTATION
Example Match between MPFM & Separator



Validation Test (Pre-Tune Up) 28/05



Post-Tune Up Test 30/5

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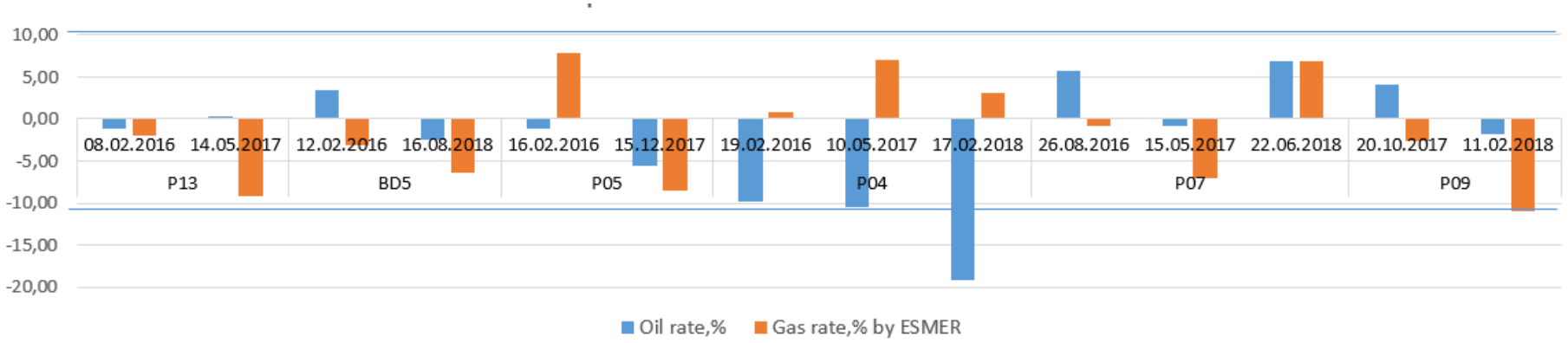
FIELD IMPLEMENTATION
Further Example of Match Between MPFM & Separator



	P13		BD5		P05		P04			P07			P09	
	02/08/2016	05/04/2017	02/12/2016	16/8/2018	16/02/2016	15/12/2017	19/02/2016	10/05/2017	17/02/2018	26/08/2016	15/05/2017	22/06/2018	20/10/2017	02/11/2018
Oil rate,% Offset	-1.15	0.37	3.43	-2.39	-1.10	-5.57	-9.76	-10.45	-19.24	5.65	-0.79	6.95	4.09	-1.82
Gas rate,% Offset	-1.95	-9.22	-3.13	-6.36	7.94	-8.53	0.84	7.03	3.15	-0.90	-7.05	6.86	-2.57	-10.92

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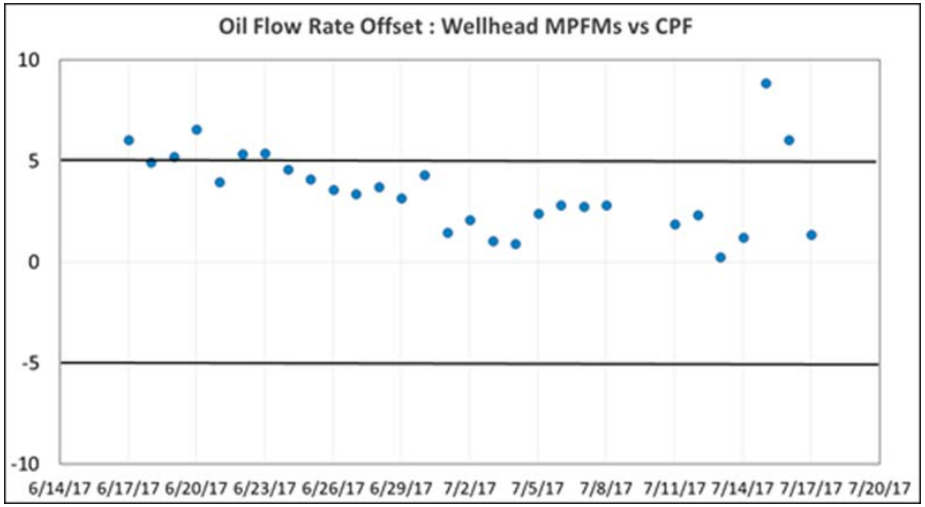
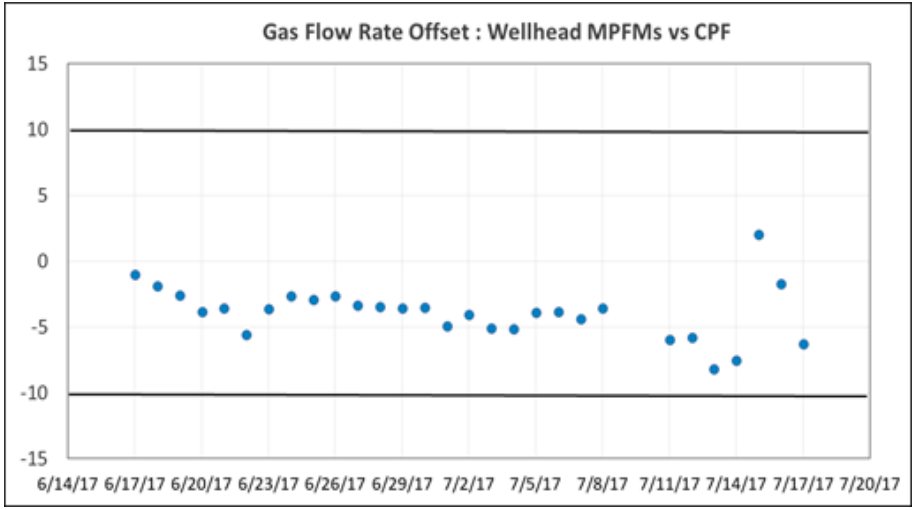
FIELD IMPLEMENTATION
Well Head MPFMs (Cumulative) vs CPF





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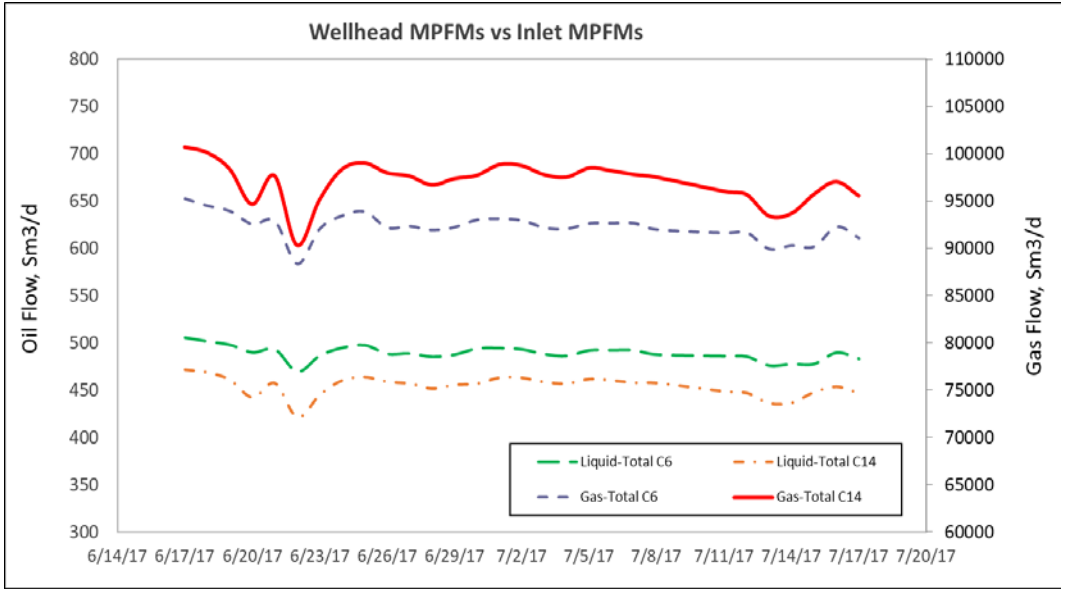
FIELD IMPLEMENTATION
Well Head MPFMs vs Production MPFMs



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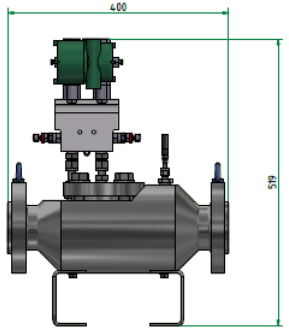
CONCLUSIONS

- MPFMs deploying conventional transmitters can deliver a robust performance and a “reasonable” level of accuracy
- MPFMs can only be effectively validated in-field and their calibration tuned up by means of a test separator.



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THANK YOU