Kuwait 4th Flow Measurement Technology Conference

3-5 December 2019
Hilton Kuwait Resort

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AMIN AMIN

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Data Validation and Reconciliation (DVR) Technology
Application in Upstream Production Systems

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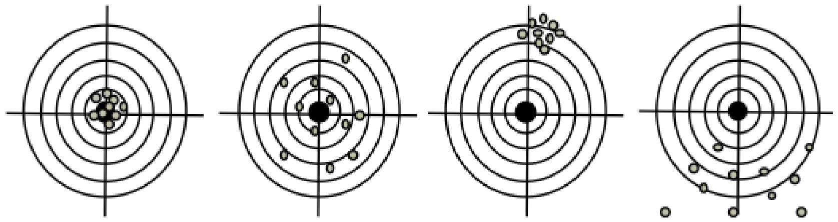
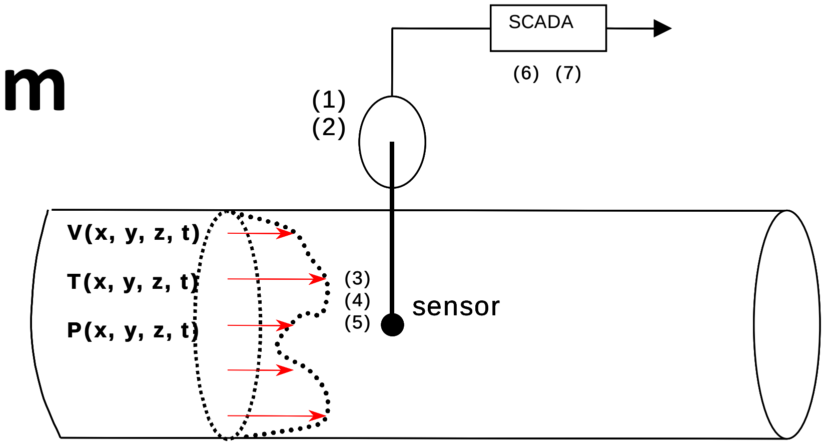
Measurements are never 100% Correct

- Sensor precision
- **Installation** induced **bias**
- Fluctuation of the physical phenomenon
- **Drift** or accuracy bias of the sensor
- **Corrections** (e.g. flow meters)
- Accuracy of the **acquisition system**
- Fluid **sampling** issues
- **Losses and Leaks**

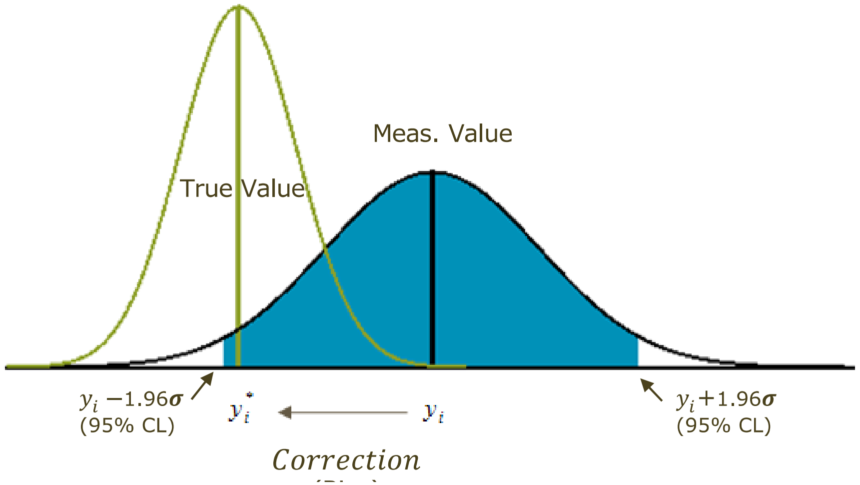




Why Information Redundancy Matters?

- Measurements **Random** and **Systematic** errors are **related**
- Measurements are **guilty** until proven correct – True Value(?)
- **Raw** measurements can lead to **wrong costly decisions**
- Most systems contain **redundancy** - but often **ignored**
- **DVR uses Redundancy** to **unlock**:
  - Accuracy Assurance (remove bias)
  - Precision Improvement (reduce uncertainty)

Make Redundancy Your Friend



tion of Measure Value (Absolute)

Redundancy and Reconciliation

- **3 variables** and **One Equation** A-B-C = 0
- Need 2 measured variables to determine 3rd
- Raw Measurements 35-21-10 = 4 ≠ 0
- 3 measured variables results in <u>1 redundancy</u>

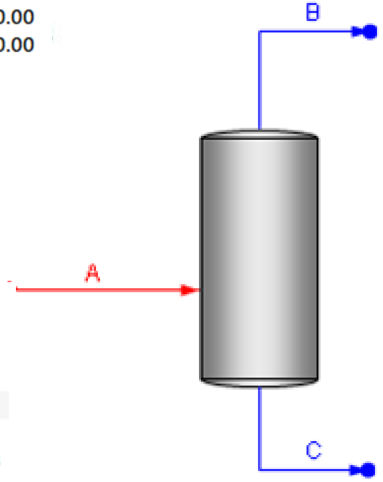
DRY_GAS_CO2	0.75
DRY_GAS_N2	1.00
DRY_GAS_C1	65.97
DRY_GAS_C2	10.16
DRY_GAS_C3	8.32
DRY_GAS_IC4	2.21
DRY_GAS_NC4	6.53
DRY_GAS_IC5	1.90
DRY_GAS_NC5	2.32
DRY_GAS_C6	0.53
DRY_GAS_C7	0.19
DRY_GAS_C8	0.08
DRY_GAS_C9	0.02
DRY_GAS_C10	0.01

Thermodynamic Constraints Increase Redundancy

Tag	Meas. Value	Meas. Unit	Meas. Unc.	Unc. Type
A	**35.00**	t/h	2.10	Abs.

SEP_DRY_GAS_CO2	0.77
SEP_DRY_GAS_N2	1.04
SEP_DRY_GAS_C1	68.32
SEP_DRY_GAS_C2	10.36
SEP_DRY_GAS_C3	8.17
SEP_DRY_GAS_I-C4	2.04
SEP_DRY_GAS_N-C4	5.81
SEP_DRY_GAS_I-C5	1.45
SEP_DRY_GAS_N-C5	1.66
SEP_DRY_GAS_C6	0.29
SEP_DRY_GAS_C7	0.06
SEP_DRY_GAS_C8	0.02
SEP_DRY_GAS_C9	0.00
SEP_DRY_GAS_C10	0.00

Tag	Meas. Value	Meas. Unit	Meas. Unc.	Unc. Type
B	**21.00**	t/h	1.0	Abs.



Constrained Minimization of Non-Linear System

SEP_LIQ_CO2	0.28
SEP_LIQ_N2	0.06
SEP_LIQ_C1	8.70
SEP_LIQ_C2	5.33
SEP_LIQ_C3	11.95
SEP_LIQ_IC4	6.33
SEP_LIQ_NC4	24.18
SEP_LIQ_IC5	12.85
SEP_LIQ_NC5	18.43
SEP_LIQ_C6	6.33
SEP_LIQ_C7	3.13
SEP_LIQ_C8	1.71
SEP_LIQ_C9	0.46
SEP_LIQ_C10	0.24

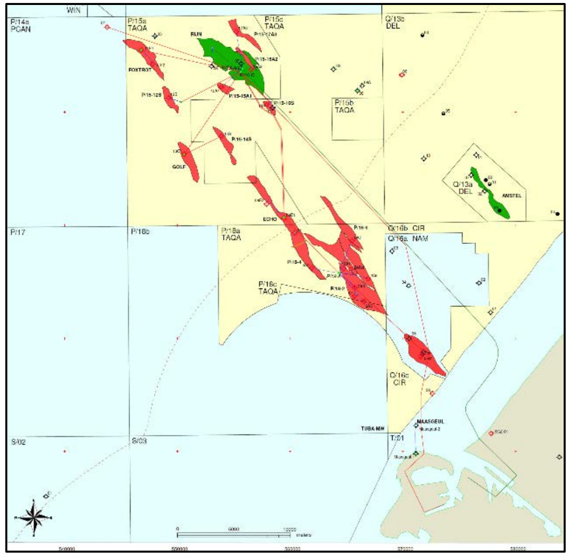
Tag	Meas. Value	Meas. Unit	Meas. Unc.	Unc. Type
C	**10.00**	t/h	0.8	Abs.

<u>**Data Reconciliation to seek True Value**</u>

- build **process model** (1st principles)
- iteratively **correct** measurements
- as **little** as necessary
- using **redundancy** and **uncertainty**
- so that all process **constraints are satisfied**

Produces a *single set of coherent data* representing the most probable process state

Process Data Integration & Surveillance - Field Case



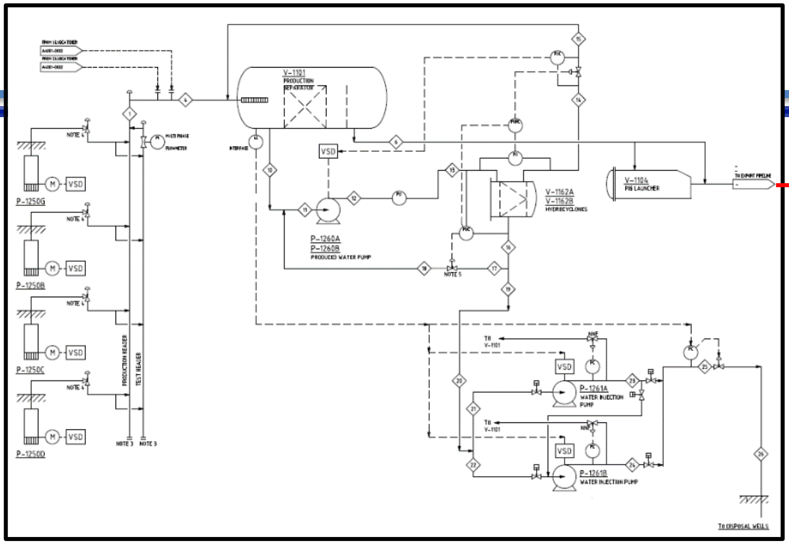
- **Location:** North Sea
- **First oil:** August 2014
- **Gravity** based structure
- **4 oil wells**, 1 water injection well

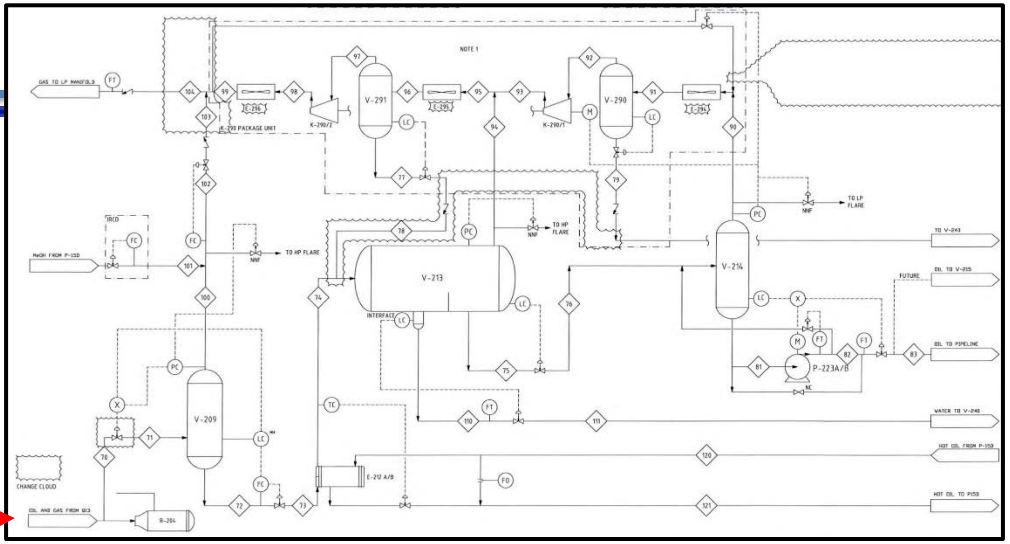
Production Platform – Q13A

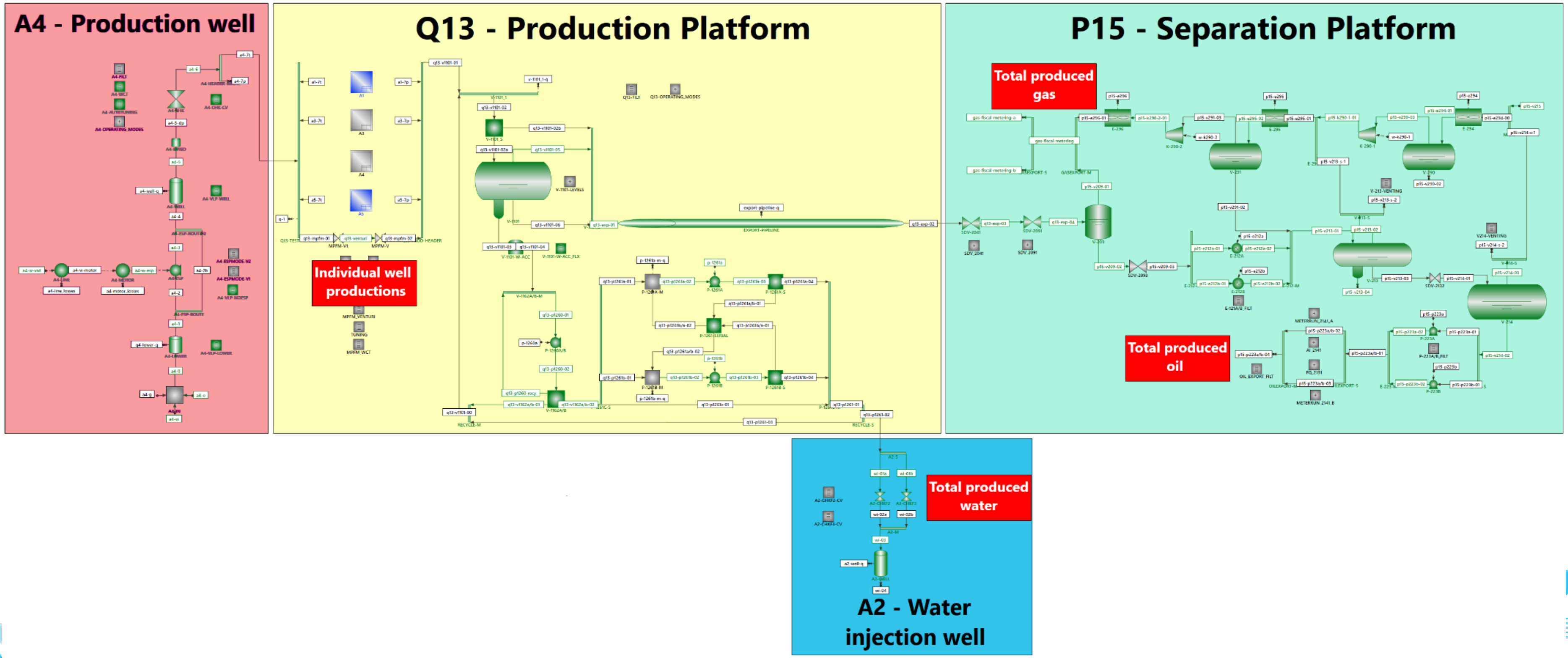
Loading, Testing & Water knock Out

Separation Platform – P15

Processing & Export to Sales







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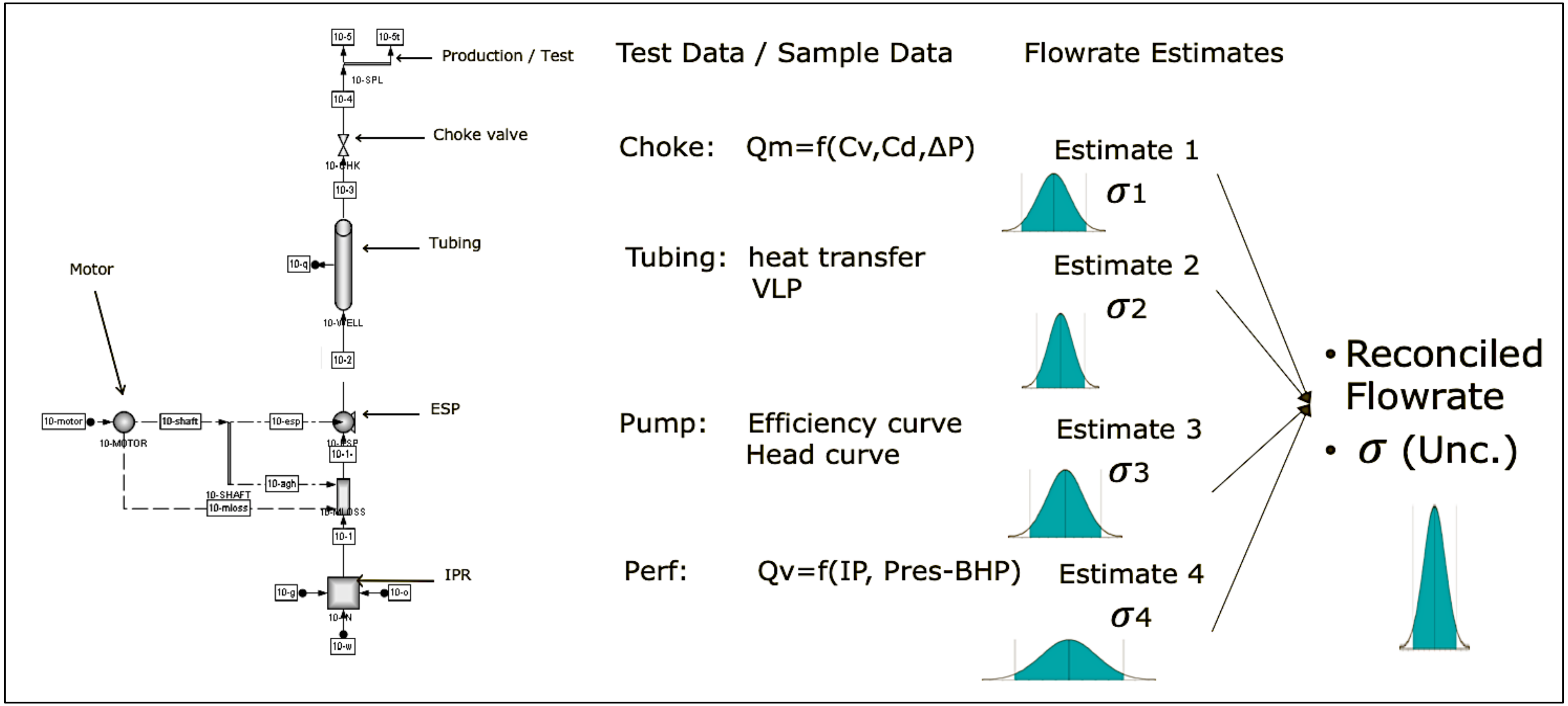
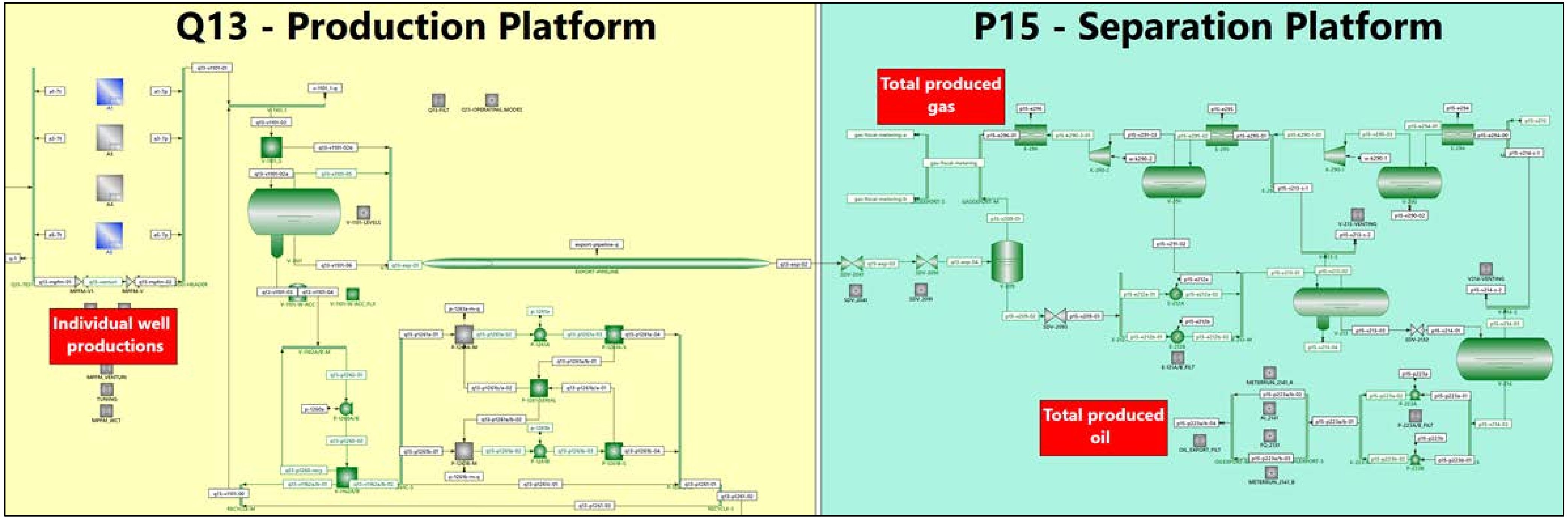
Implementation: Virtual Flow Metering

- Use of downhole measurements and equations to compute **flow rate estimates**
- Reconcile all these estimates into **one single validated flow rate**



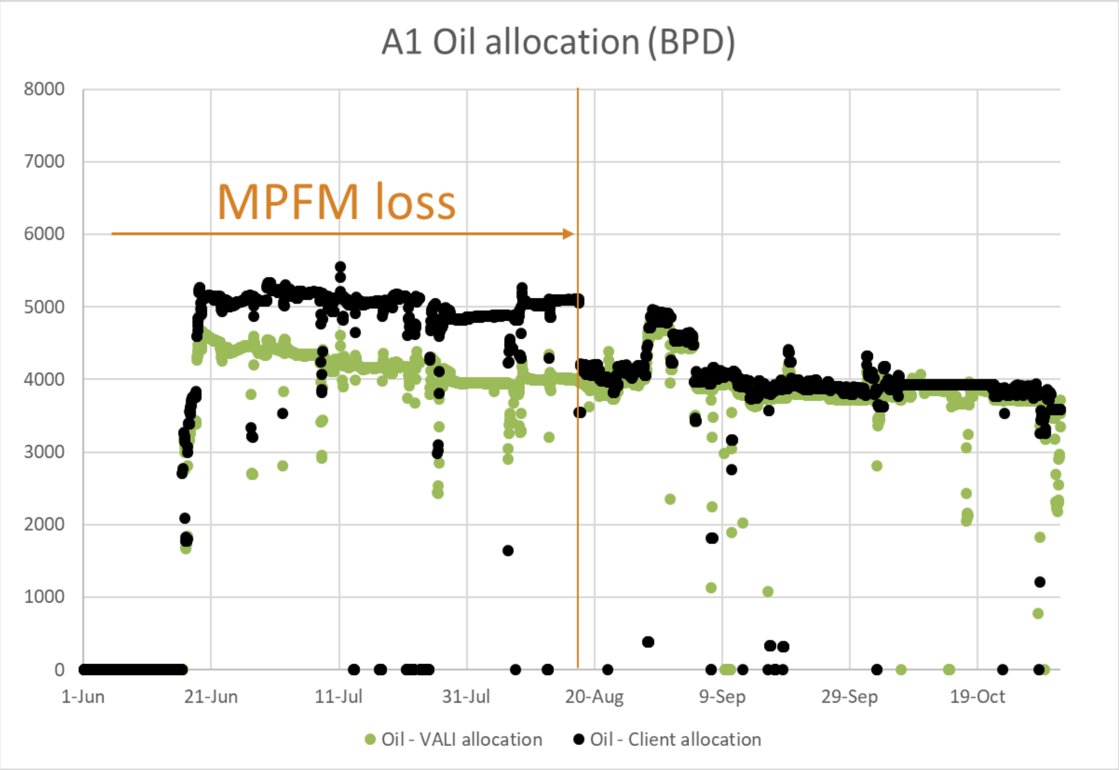
Implementation: Process Modeling

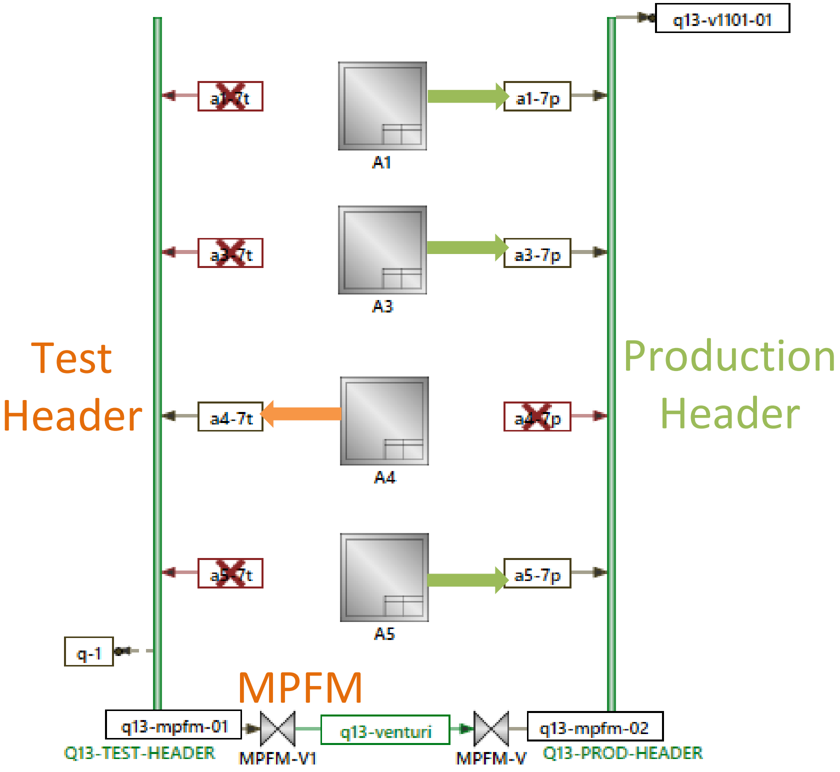
- The **whole process** is modeled, from the production platform to the separation platform
- **Mass** and **energy** and **compounds balances** are maintained through the whole process, therefore linking the well production to process facilities



Virtual Flow Metering Applications

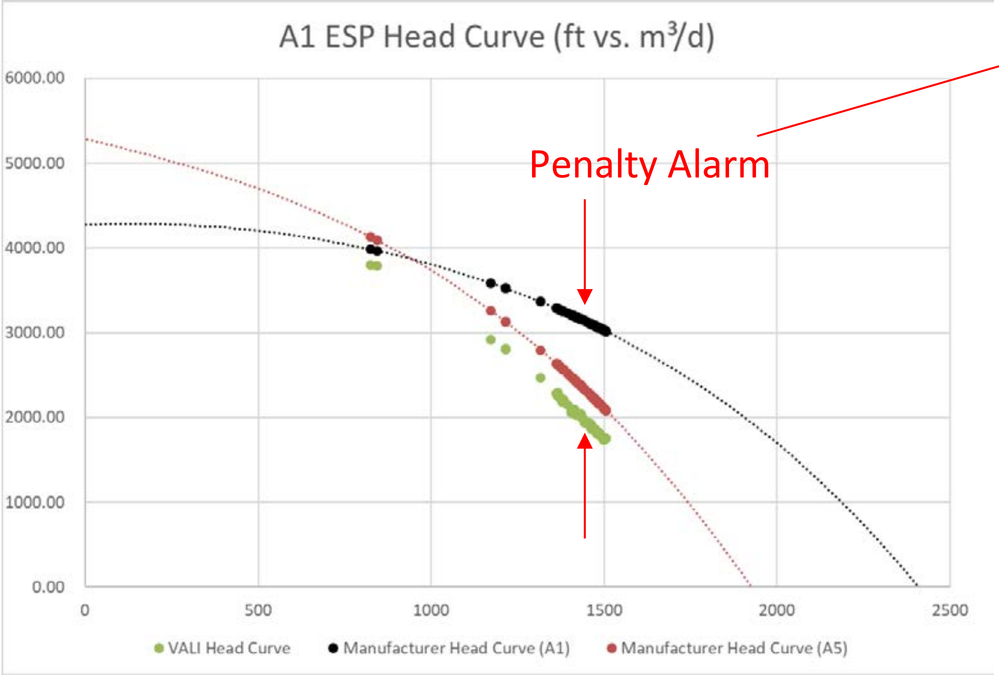
- VALI proved able to fill the gap between the test periods, leading to better allocation of the total production

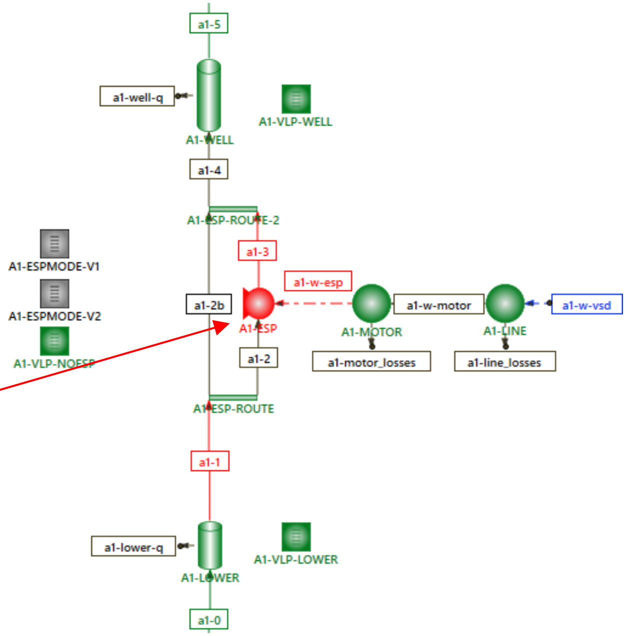


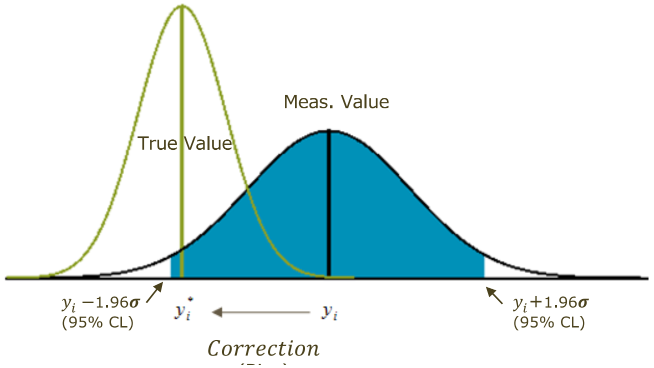


Downhole Surveillance

- Two of the wells presented a lot of **penalty** around their electrical submersible pumps (ESP)







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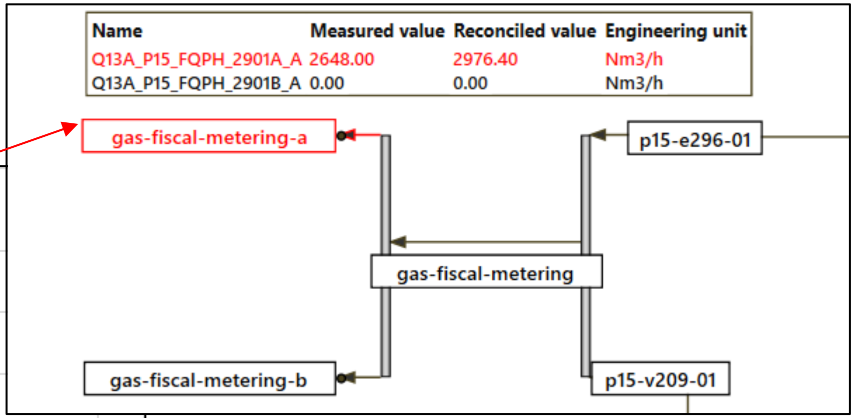
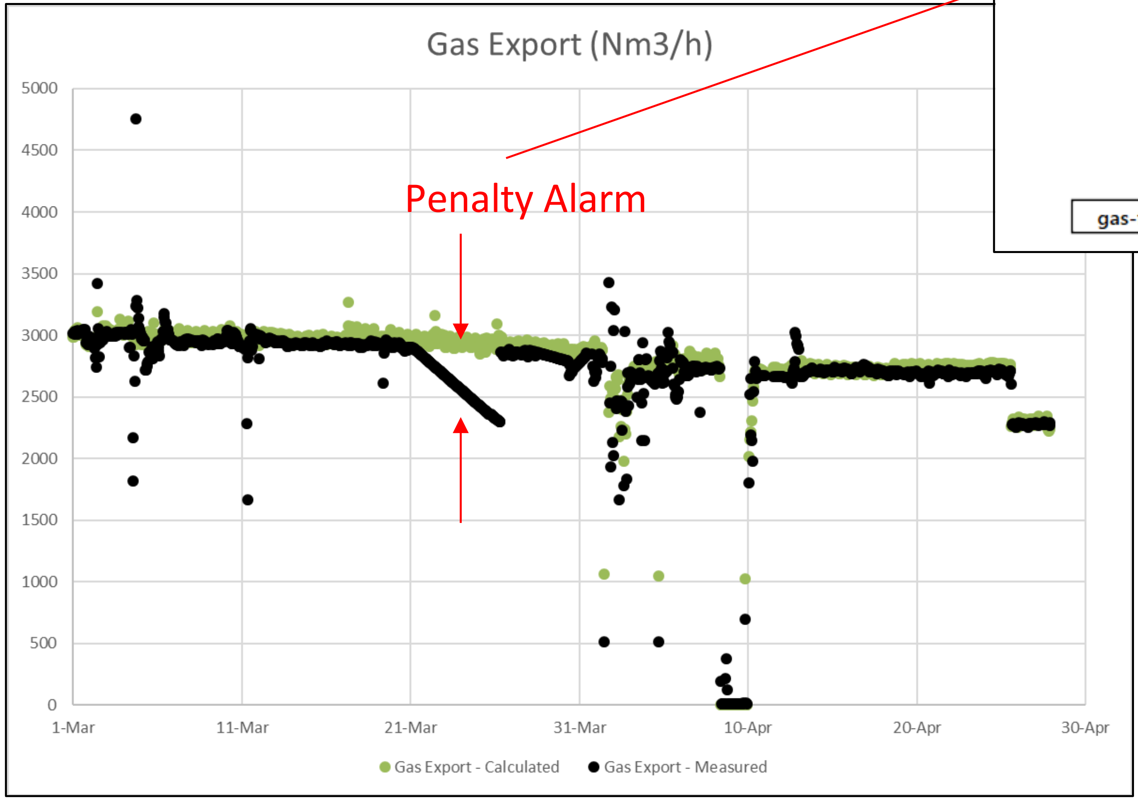
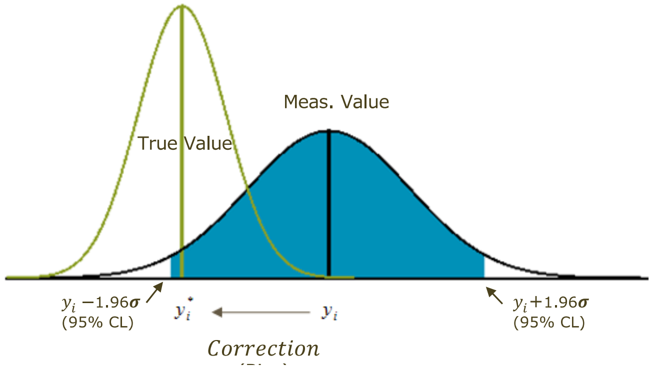
Surface Facility Surveillance

- DVR calculations are able to spot **inconsistent** measurements through their penalty indicator



Name	Measured value	Reconciled value	Engineering unit
Q13A_P15_FQPH_2901A_A	2648.00	2976.40	Nm3/h
Q13A_P15_FQPH_2901B_A	0.00	0.00	Nm3/h





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Summary

- **<u>DVR is Core Modeling Engine</u>** for many upstream applications
- **<u>Examples:</u>** production monitoring, system health check, well-process integration, multiphase validation, allocation, predictive maintenance….
  - Uses **ALL** measurable variables to improve process **accuracy** and **precision** (DP, P&T, flow, phase fractions, composition..)
  - **Integrates ALL data** from VFM, MPFM, Subsea, Surface Process
  - **Integrates thermodynamic models** (fluid properties, constraints)
  - Effective in localizing **bias/leaks** (results resilient to errors)
  - Enables Condition-based Maintenance (**CBM reduces Opex**)
  - Widely used in **downstream**, petrochemical and **power/nuclear** plants
  - Governed by German Engineering **Standard VDI-2048**
- **Enables the use of ALL measurement data with <u>CONFIDENCE</u>**

DVR White Paper

Theory and Case Studies

A FIRST by SPE

SPE Multiphase and Wet Gas Metering in Conventional and Unconventional Data Driven Environment

Workshop - Galveston Texas, 28-29 Jan 2020

THANK YOU