Virtual Flow Metering

- Characterizing virtual flow metering
- Metering principle
- Maintenance and tuning
- Applications areas

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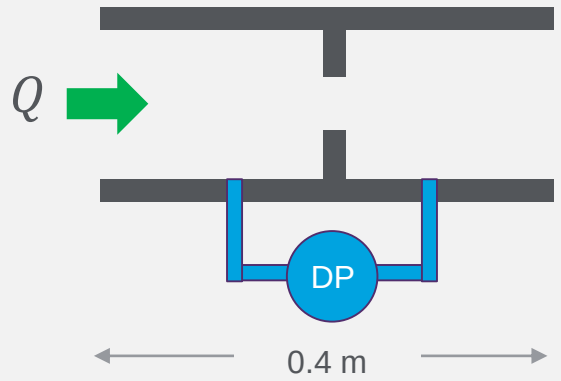
TechnipFMC

Virtual flow metering vs «physical metering»

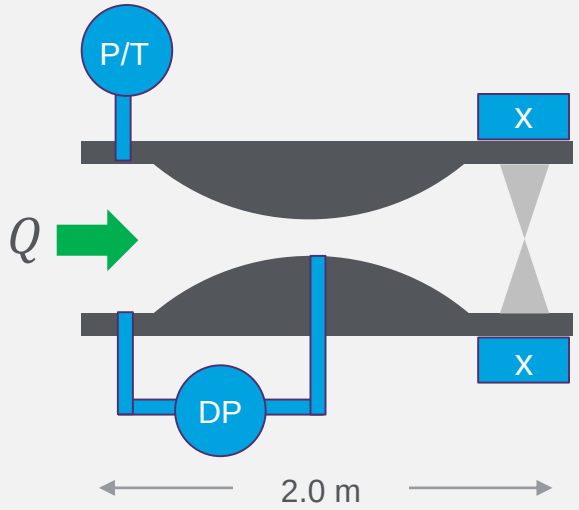
Single phase flow metering



$$Q = f(DP)$$

Compact

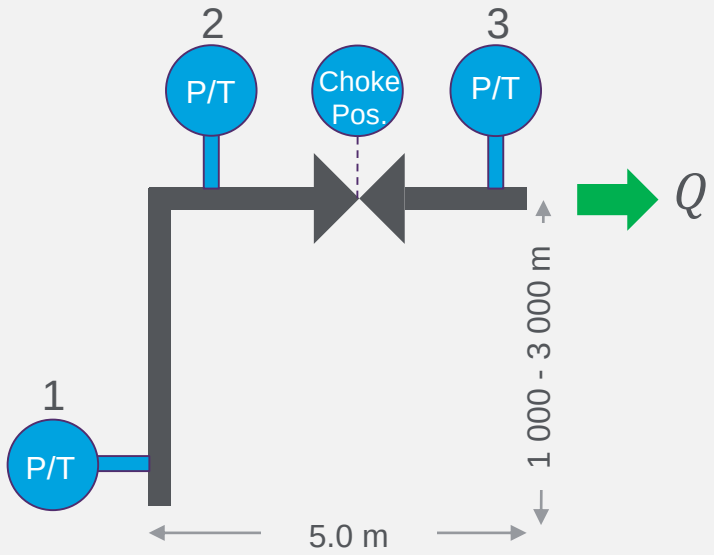
Multiphase flow metering



$$Q = f(DP, P, T, x_i)$$

Compact

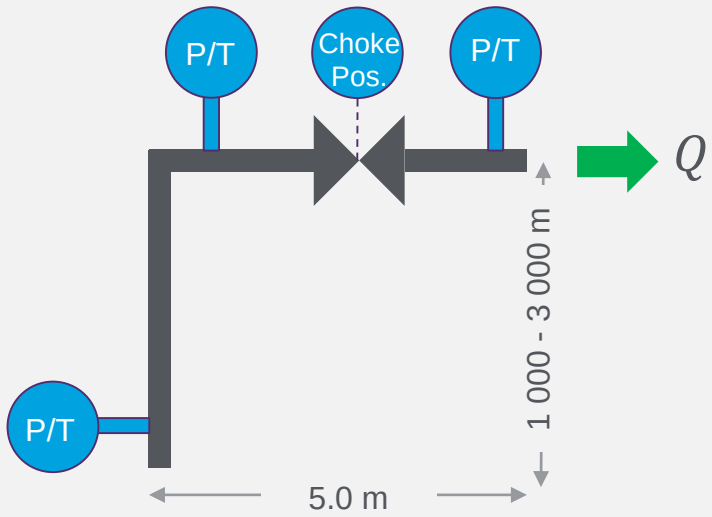
Virtual flow metering



$$Q = f(P_1, T_1, P_2, T_2, P_3, T_3, Chk_{pos}, .. x_i)$$

Distributed

Virtual flow metering – key characteristics



$$Q = f(P_1, T_1, P_2, T_2, P_3, T_3, Chk_{pos}, .. x_i)$$

Distributed

- Distributed instrumentation
- Dependent on instrument and system sensitivity to changes in flow and phase fractions
- Solution range; pure data driven, thermo-hydraulic modelling, or hybrids
- Not boxable, therefore «Factory calibration» not possible
- Dependent on tuning/calibration to extend «calibrated range» and adapt to changing operating conditions

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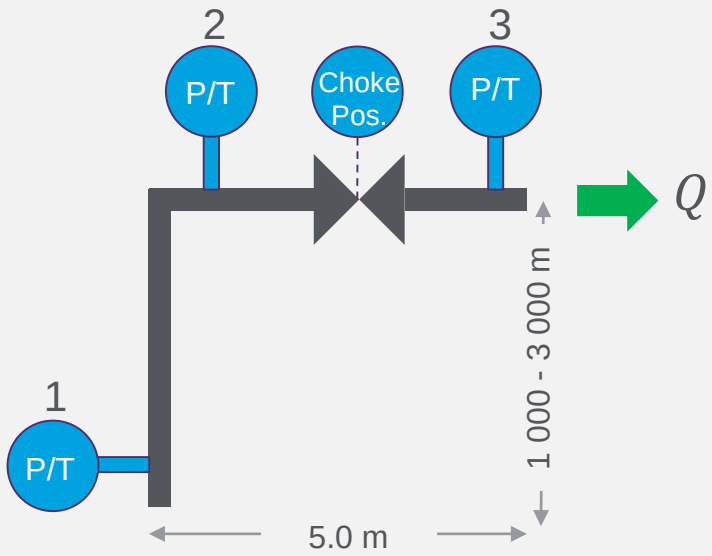
Virtual flow metering – Pressure drop in well



$$Q = f(P_1, T_1, P_2, T_2, P_3, T_3, Chk_{pos}, .. x_i)$$

Distributed

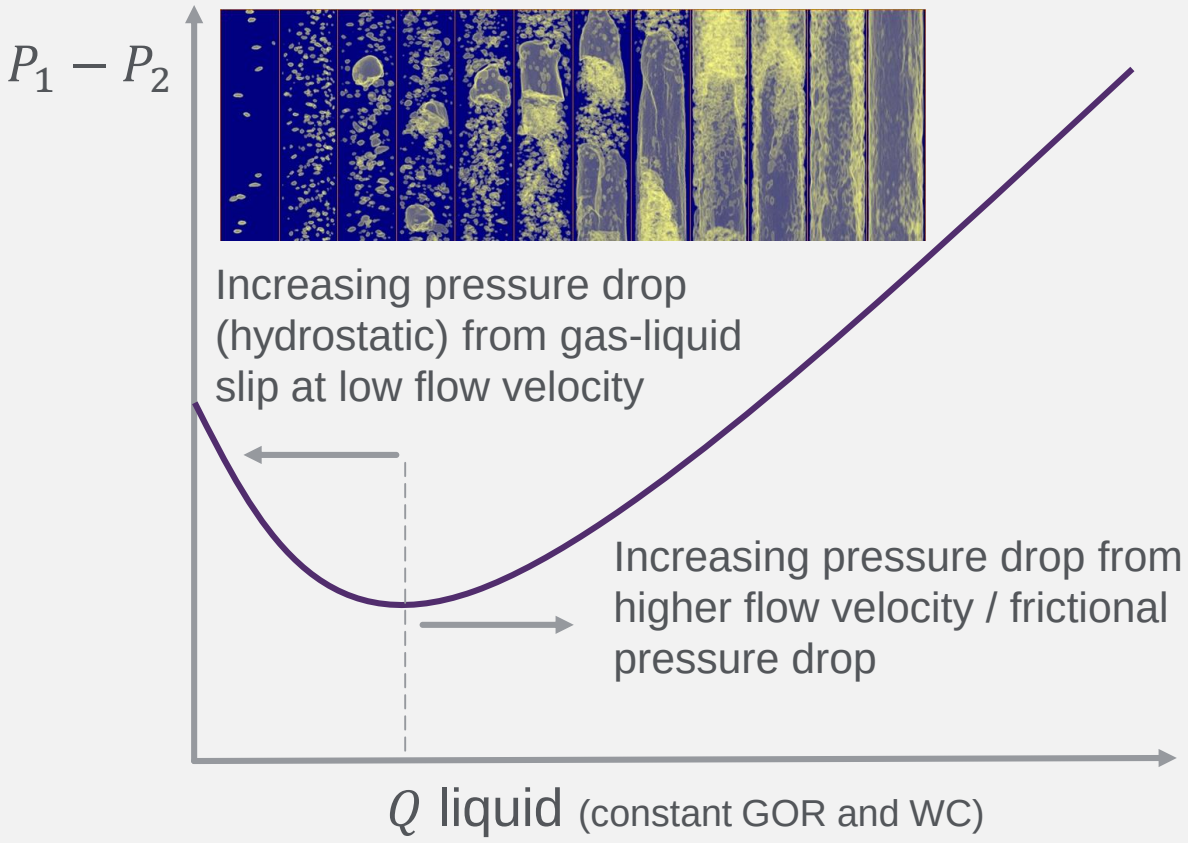
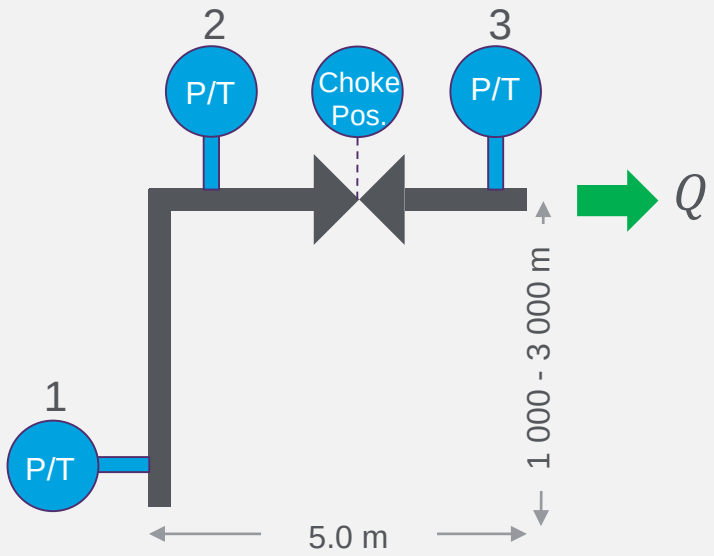


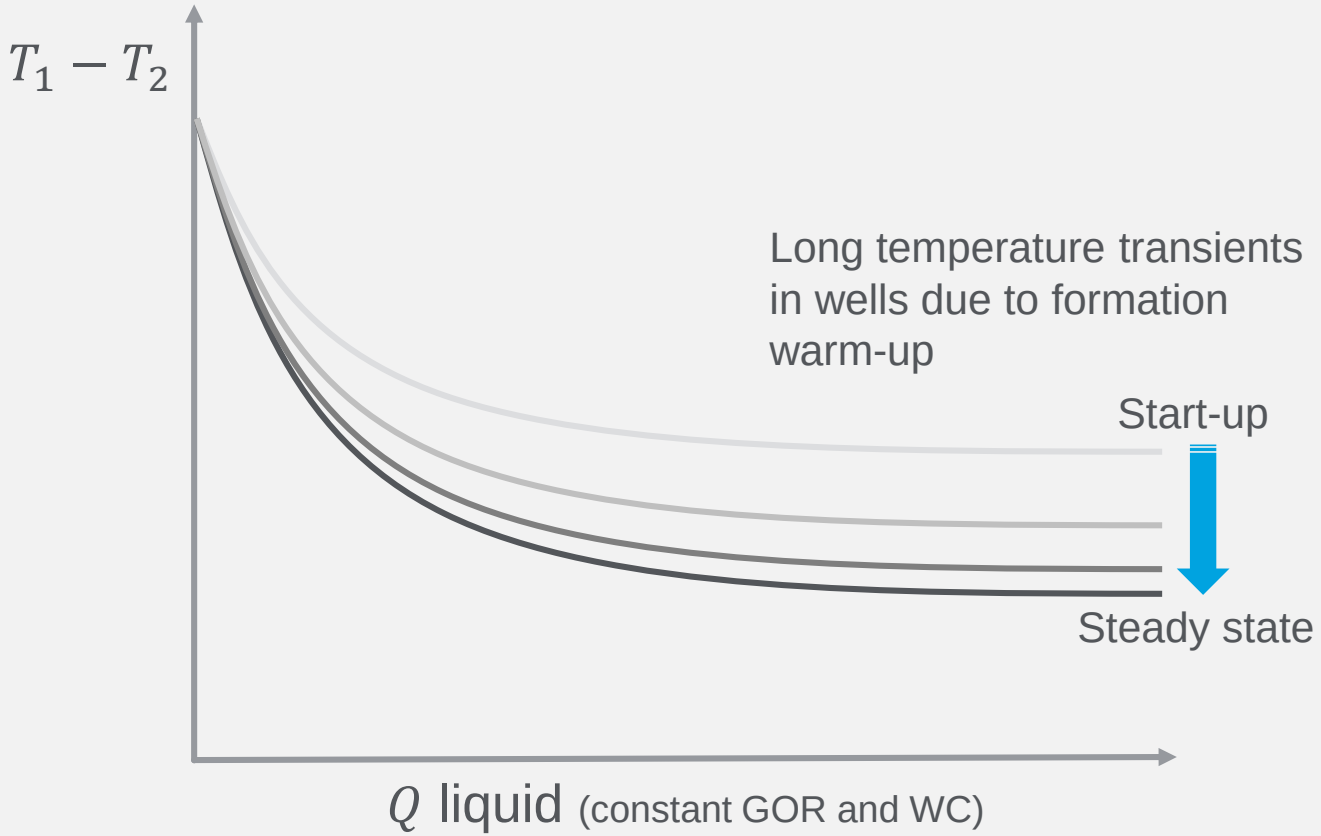
Figure reference:
M. Banowski, Prof. U. Hampel, E. Krepper, M. Beyer, D. Lucas (2018).

Virtual flow metering – Temperature drop in well

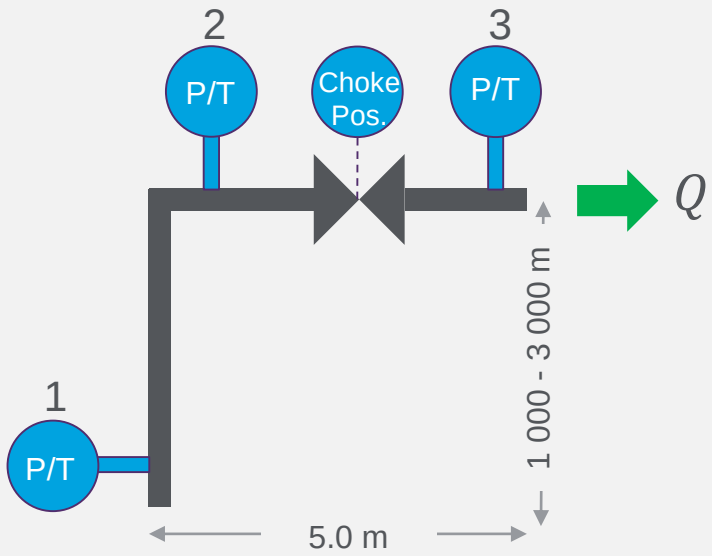


$$Q = f(P_1, T_1, P_2, T_2, P_3, T_3, Chk_{pos}, .. x_i)$$

Distributed



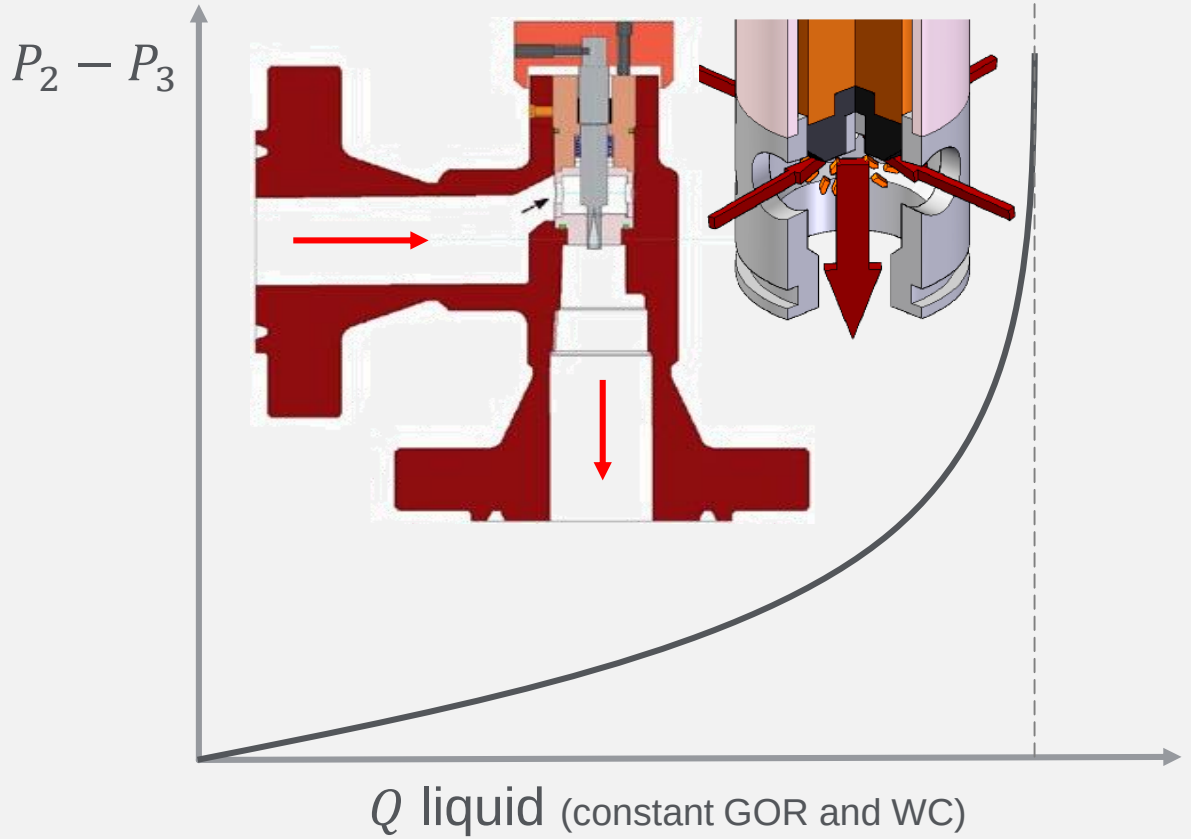
Virtual flow metering – Pressure drop over choke



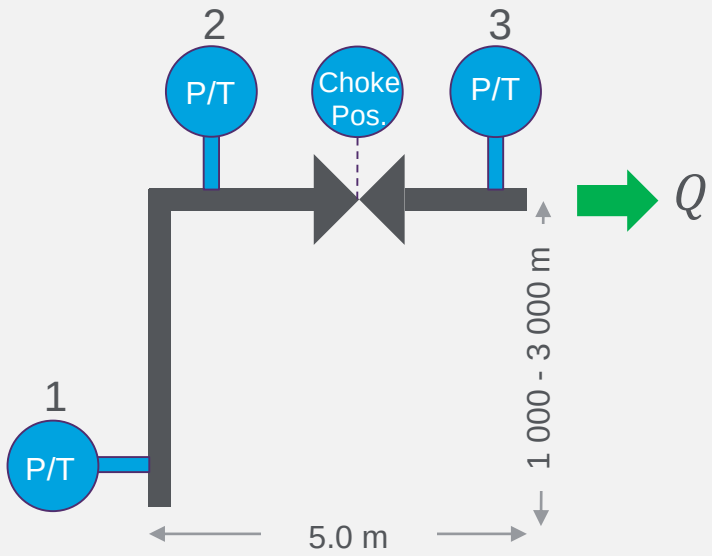
$$Q = f(P_1, T_1, P_2, T_2, P_3, T_3, Chk_{pos}, .. x_i)$$

Distributed

Critical/choked flow:
Flow velocity = velocity of sound

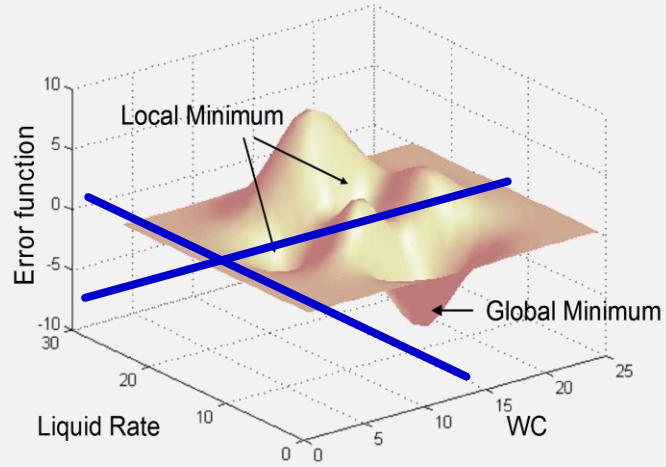


Virtual flow metering – Estimating phase fractions

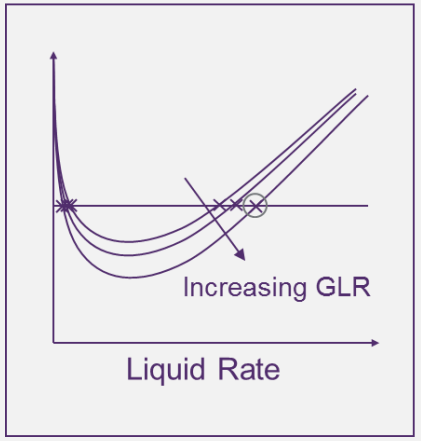


$$Q = f(P_1, T_1, P_2, T_2, P_3, T_3, Chk_{pos}, .. x_i)$$

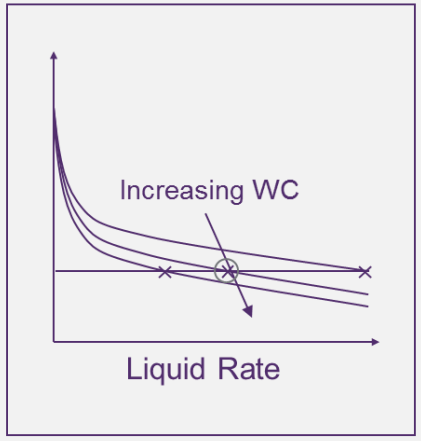
Distributed



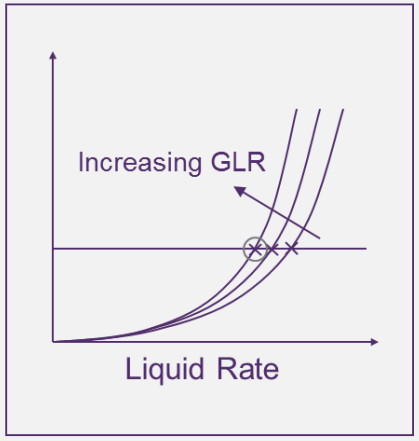
Pressure drop well



Temperature drop well



Pressure drop choke



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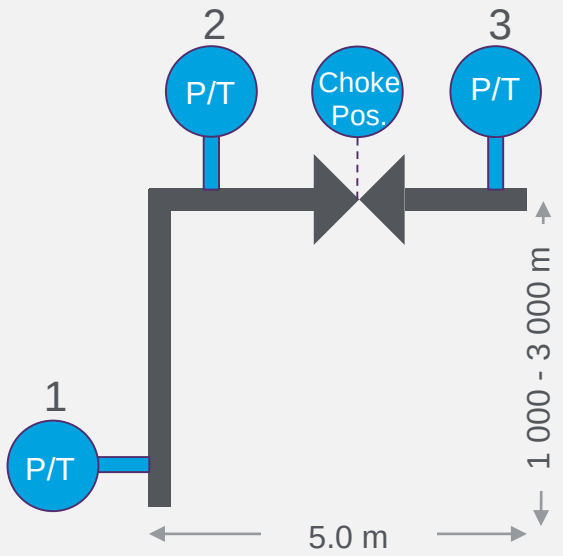
Virtual flow metering – Well testing



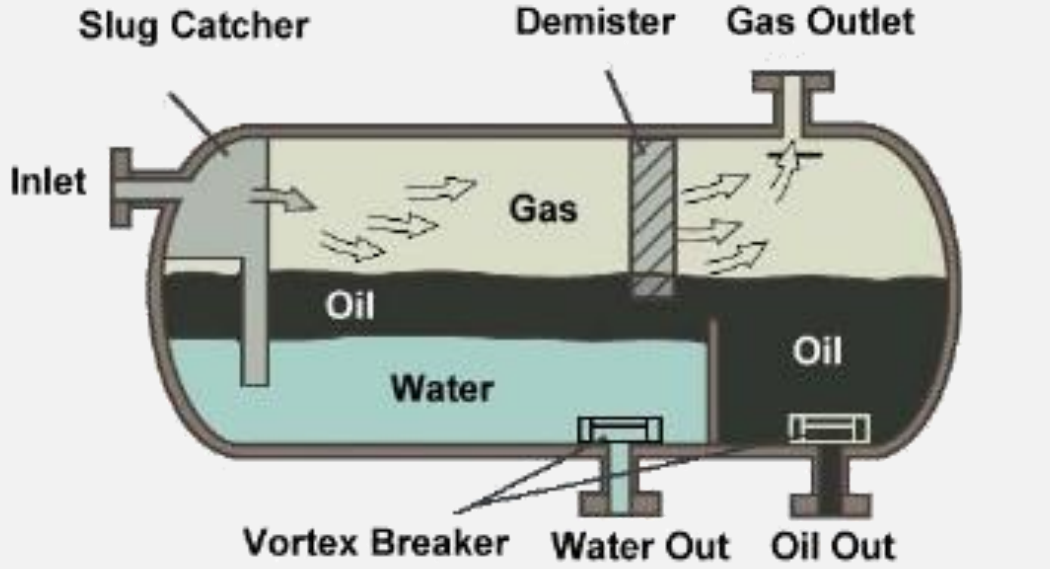
Q

$$Q = f(P_1, T_1, P_2, T_2, P_3, T_3, Chk_{pos}, .. x_i)$$

Distributed

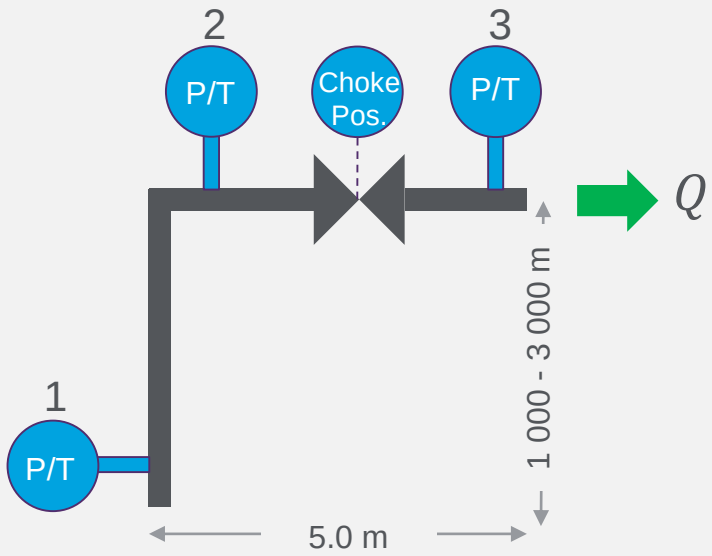
Test alternatives:

A. Test separator test
B. Deduction test



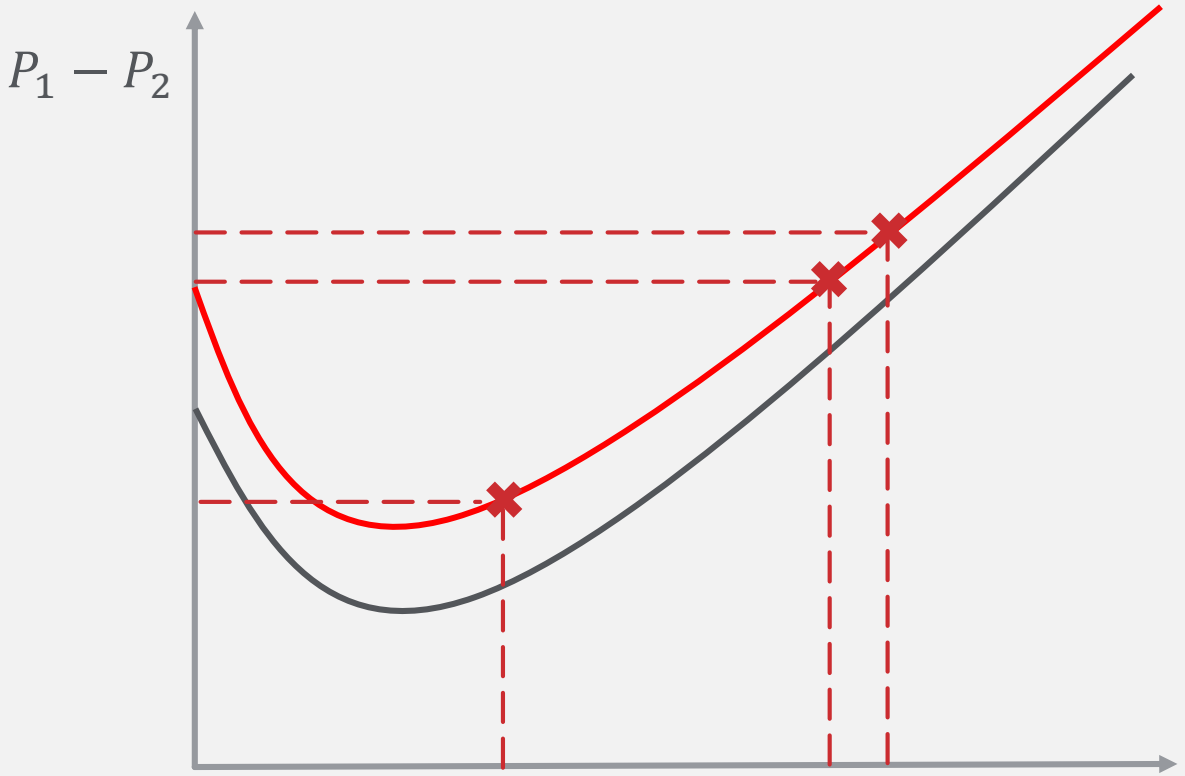
Q liquid

Virtual flow metering - Tuning pressure drop in well

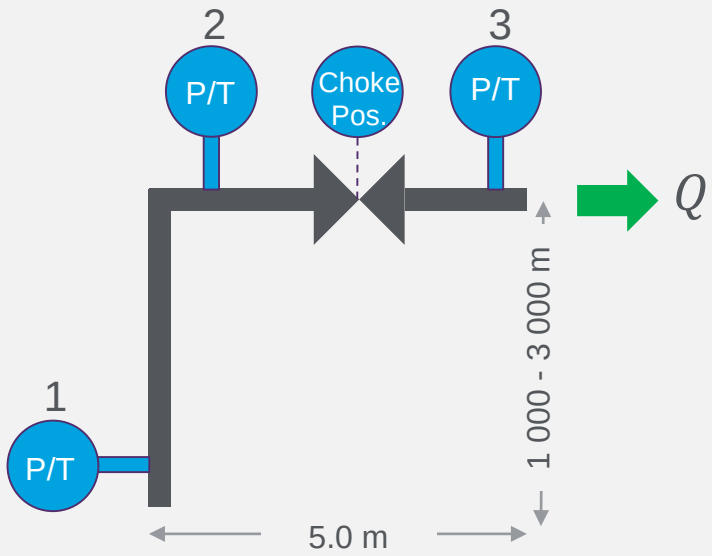


$$Q = f(P_1, T_1, P_2, T_2, P_3, T_3, Chk_{pos}, .. x_i)$$

Distributed

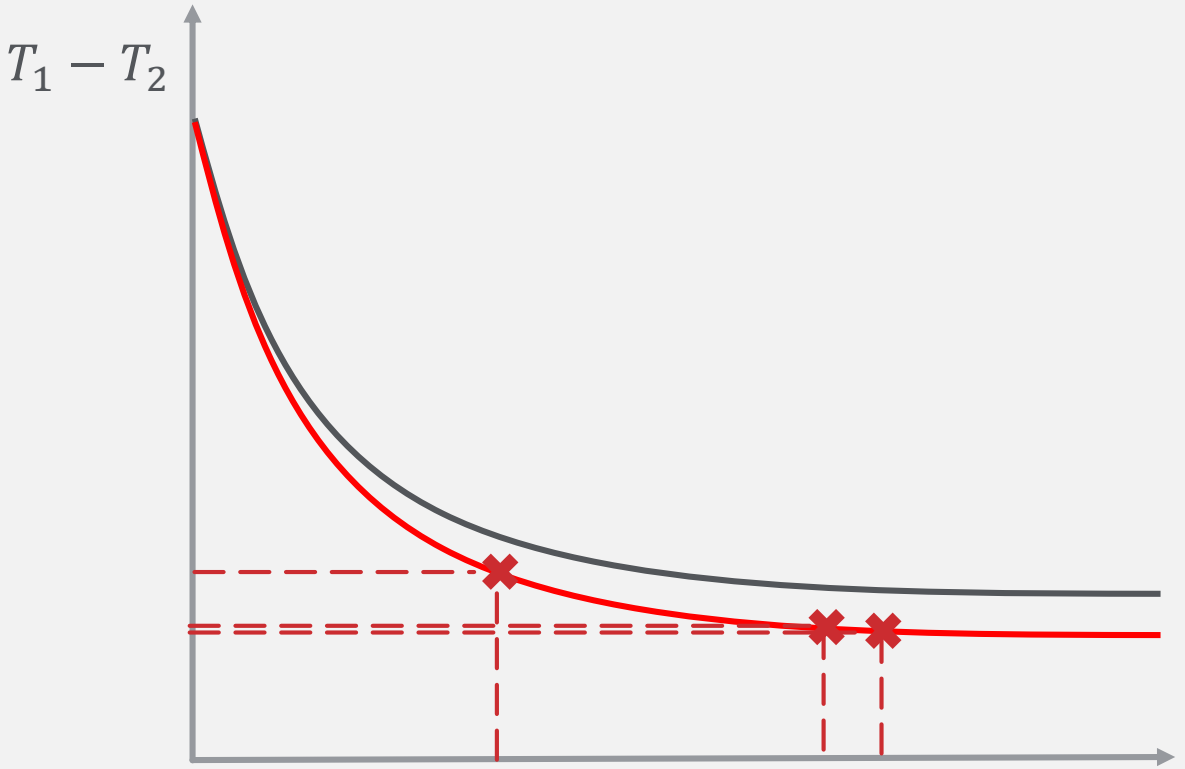


Virtual flow metering - Tuning temperature drop in well



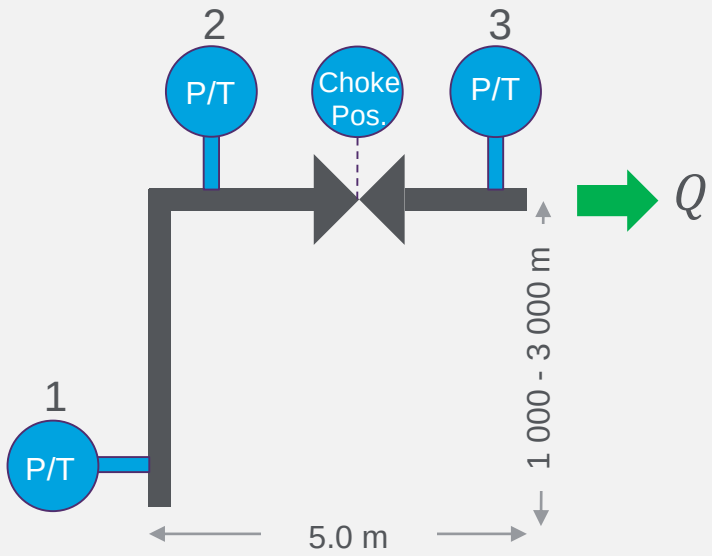
$$Q = f(P_1, T_1, P_2, T_2, P_3, T_3, Chk_{pos}, .. x_i)$$

Distributed



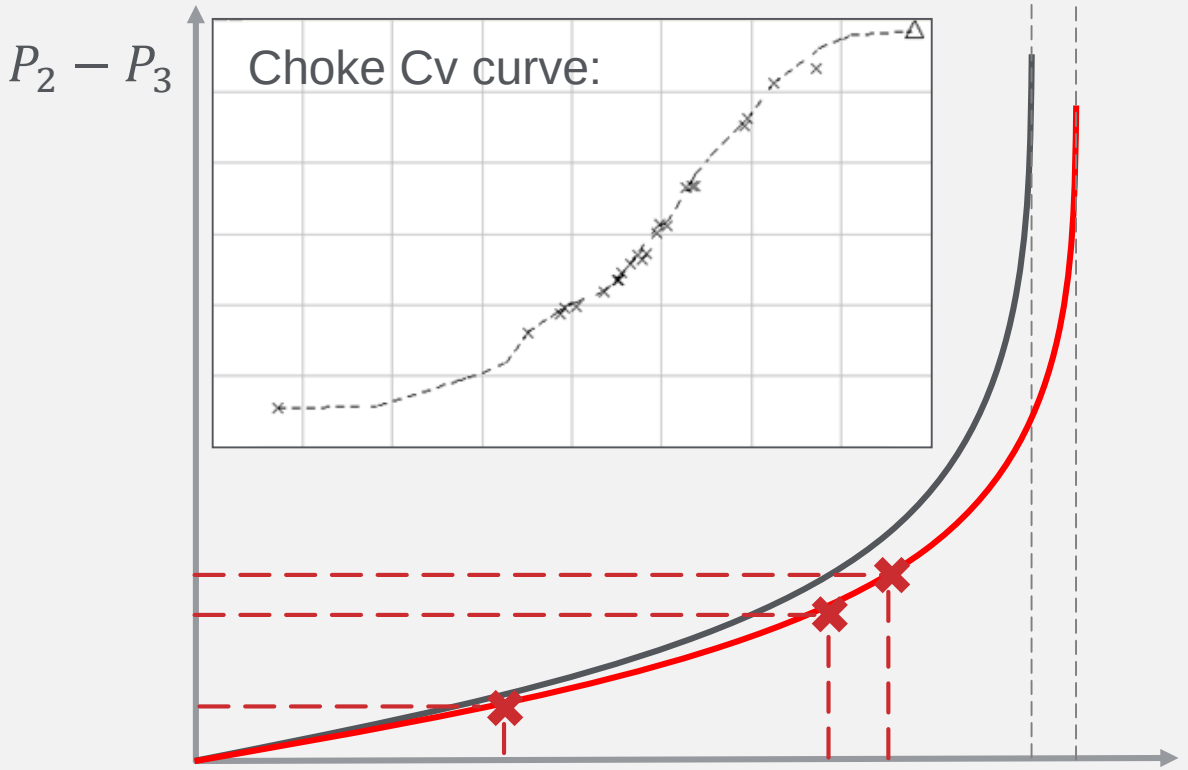
Q liquid (constant GOR and WC)

Virtual flow metering - Tuning pressure drop over choke

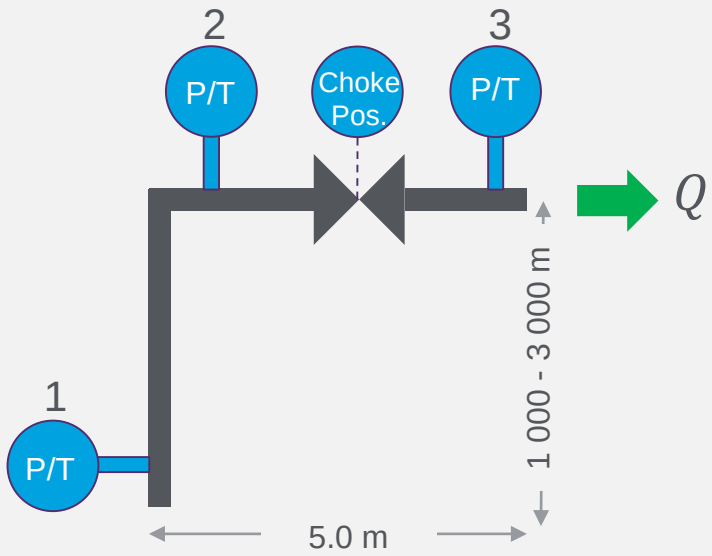


$$Q = f(P_1, T_1, P_2, T_2, P_3, T_3, Chk_{pos}, .. x_i)$$

Distributed



Virtual flow metering – Uncertainty drivers



$$Q = f(P_1, T_1, P_2, T_2, P_3, T_3, Chk_{pos}, .. x_i)$$

Distributed

- Installed instrument uncertainty vs measured value
- Fluid properties / PVT description
- Quality of test / reference data
- Instrument sensitivity to changes in flow and phase fractions
- Outdated assumptions, e.g. WC or GOR

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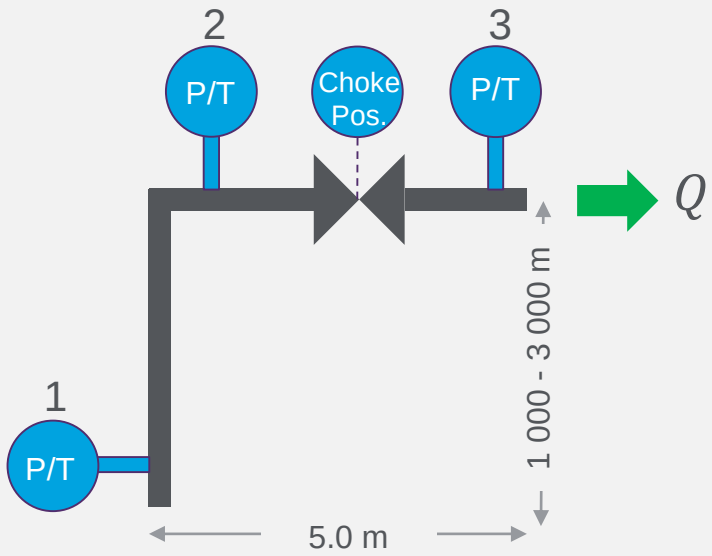
Virtual flow metering – Main application areas

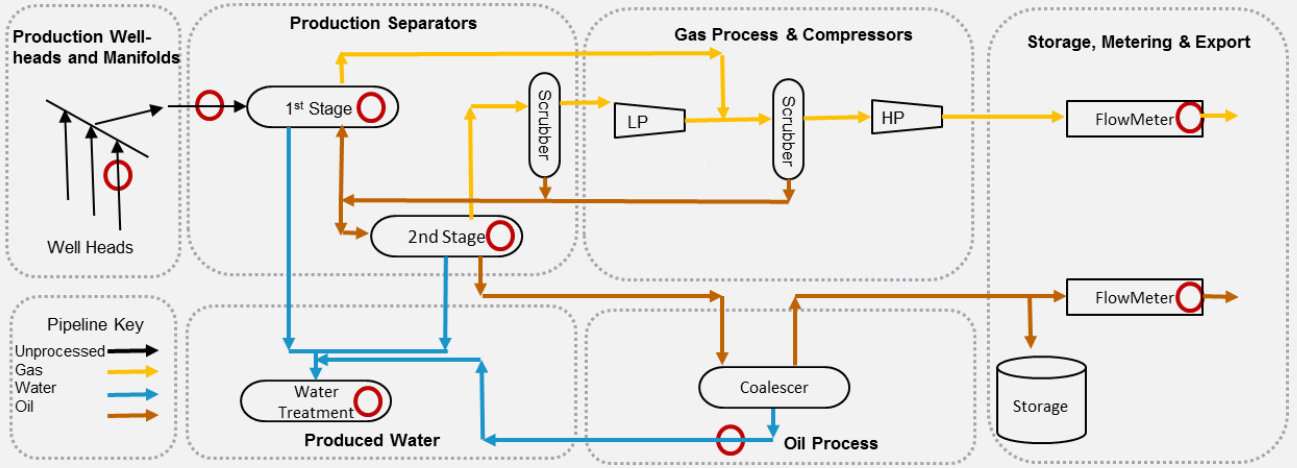


$$Q = f(P_1, T_1, P_2, T_2, P_3, T_3, Chk_{pos}, .. x_i)$$

Distributed

A. Establish flow rates without dedicated physical flow meters

B. Provide back-up for physical flow meters



Virtual Flow Metering

Question?