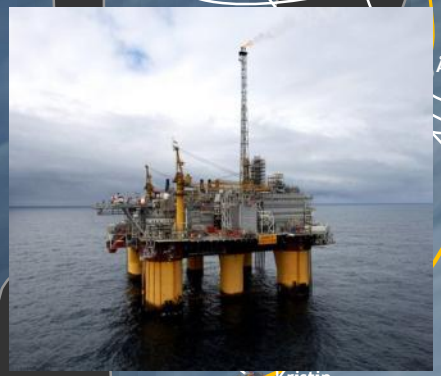
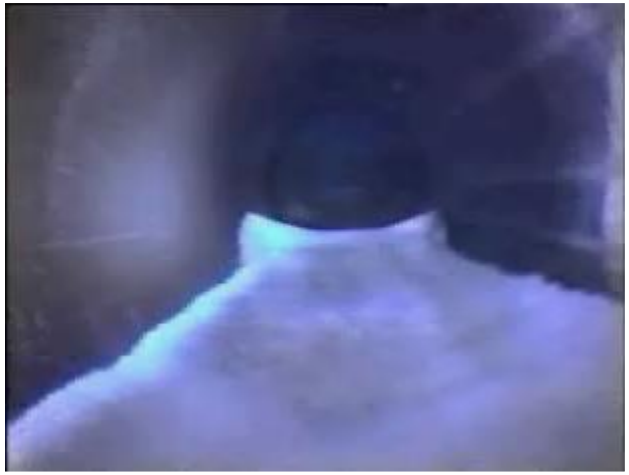
Flow assurance for Åsgard subsea compression



Magnus Nordsveen, Statoil
NTNU, Trondheim, Norway: 26th Feb 2018

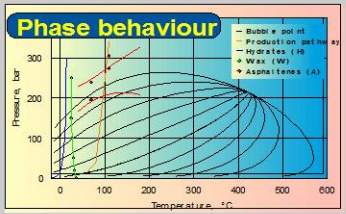
Content

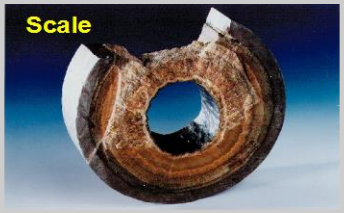
- What is Flow Assurance?
- How do we get multiphase flow – compositions?
- Multiphase flow challenges
- Åsgard subsea compression – surge waves and hydrate incident

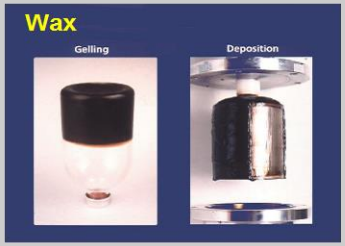


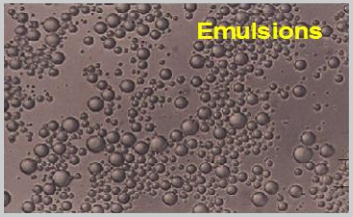
Flow Assurance: **Secure** and **optimize** transport of oil and gas in multiphase pipeline systems

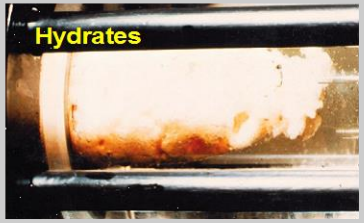
Fluid behaviour and control



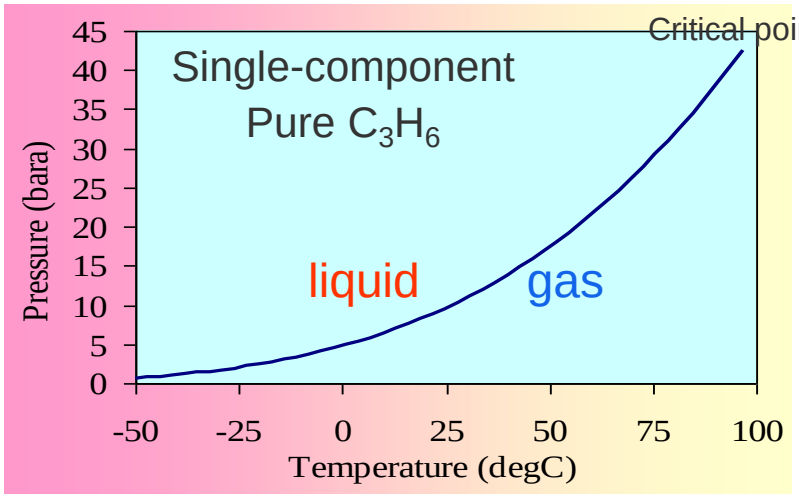


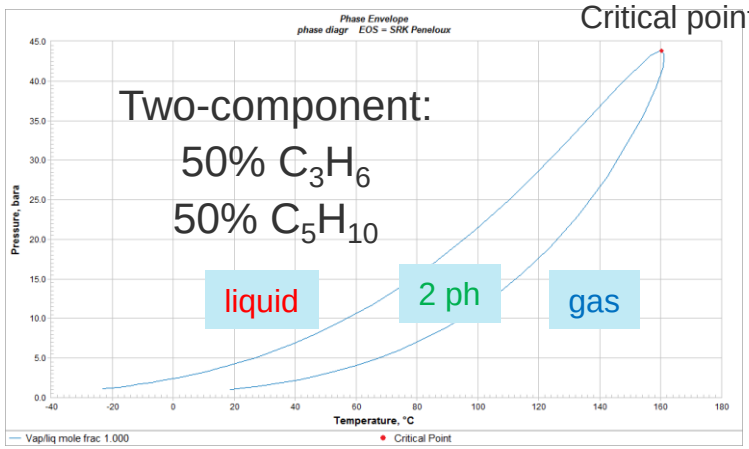


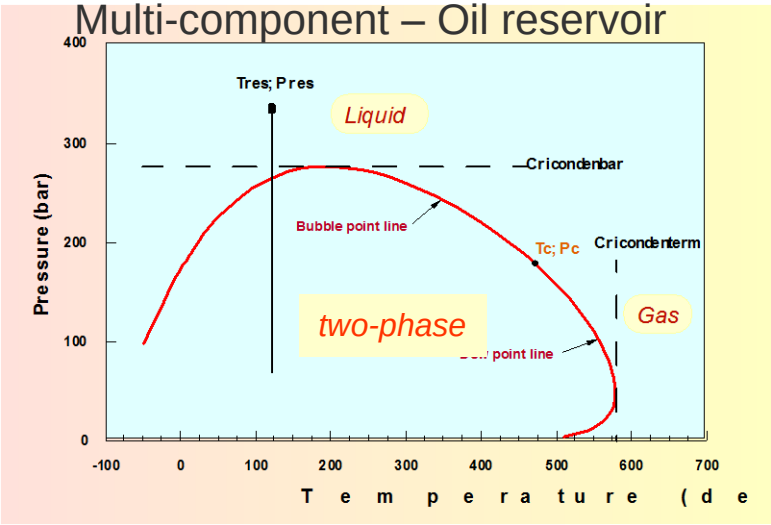


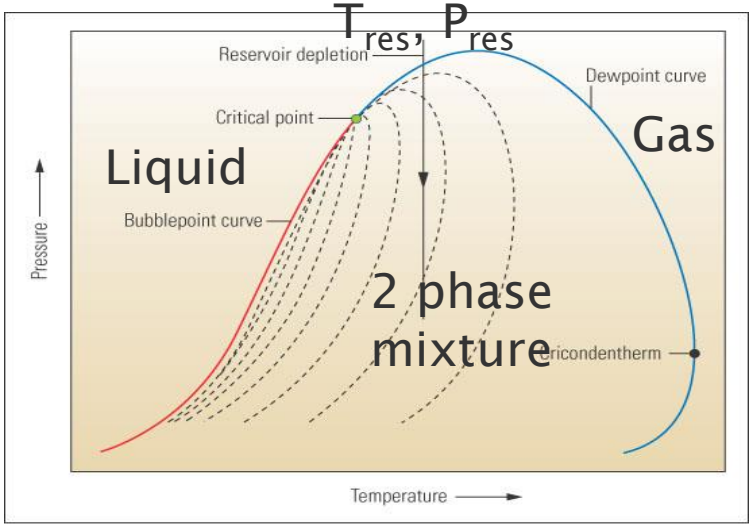


Why multiphase flow?



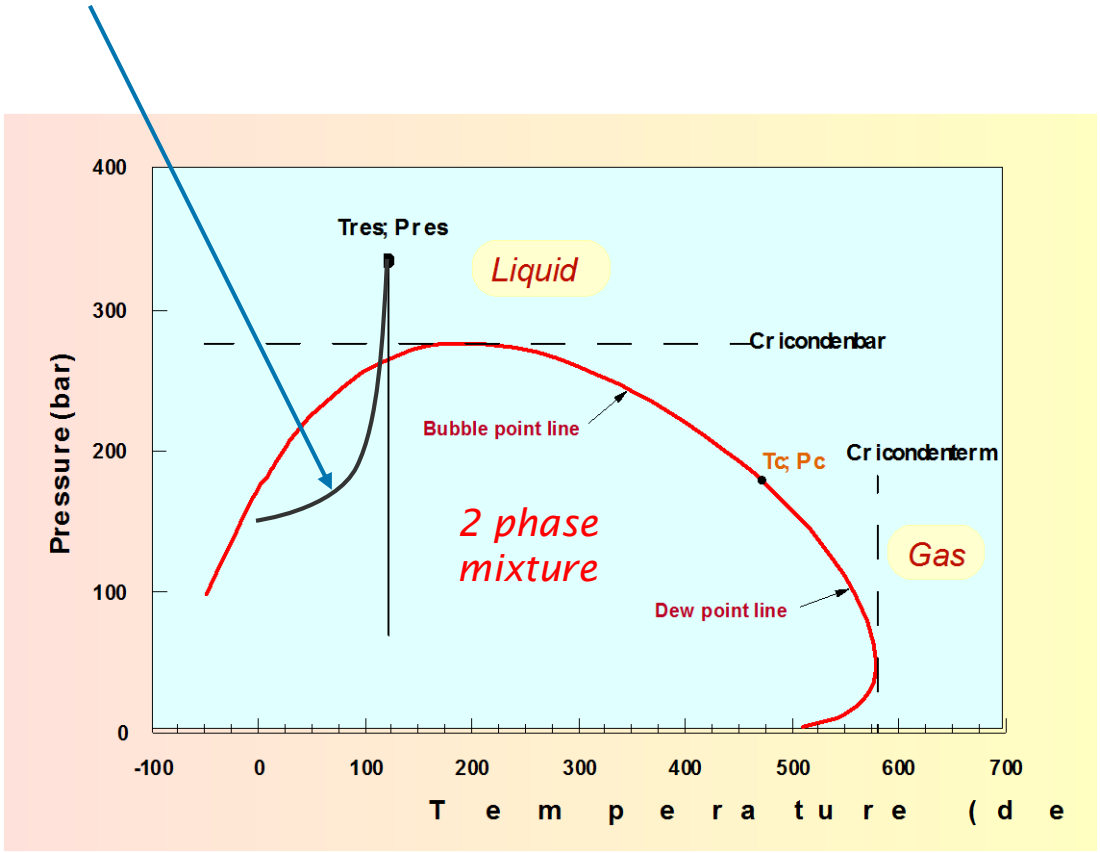


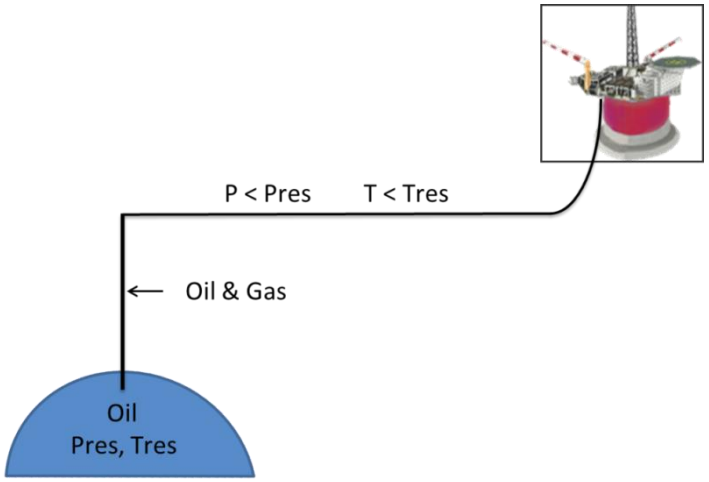




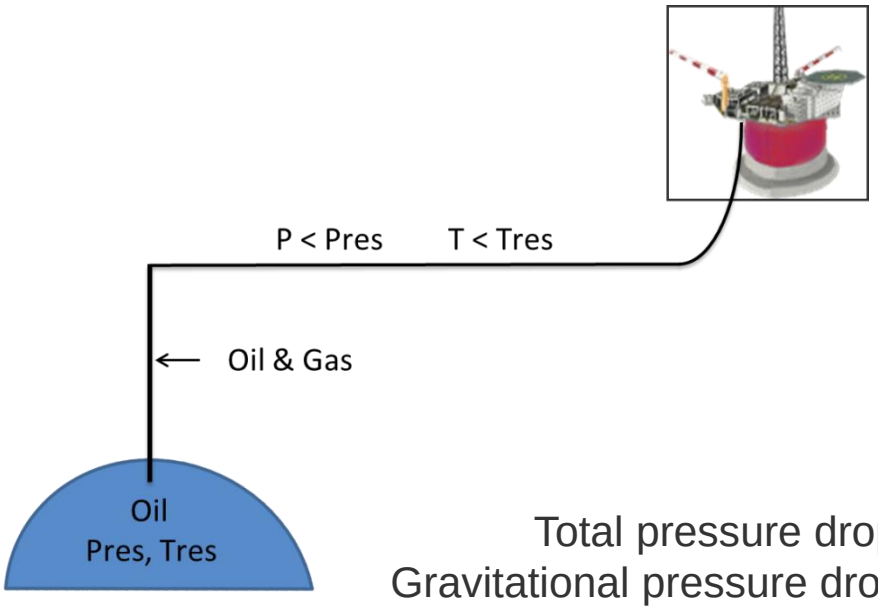
Statoil

Phase envelope and P, T conditions from reservoir to platform (oil field)





Pressure drop from reservoir to platform



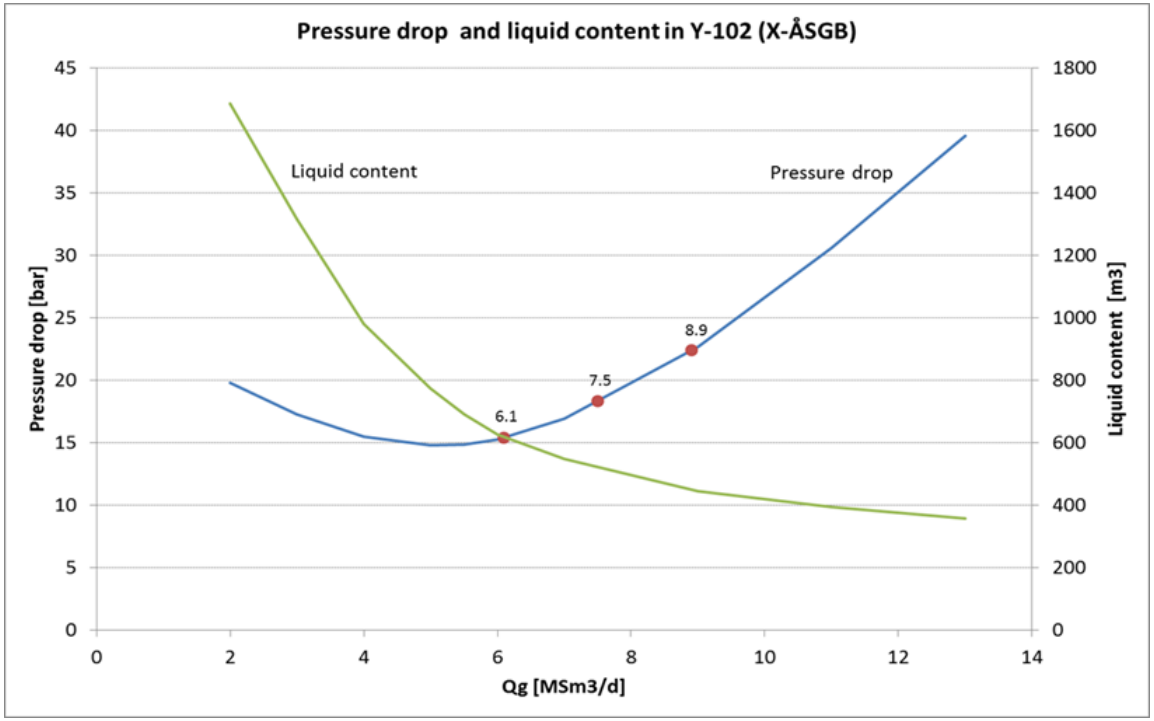
Total pressure drop: $dP = dP_{grav} + dP_{fric}$

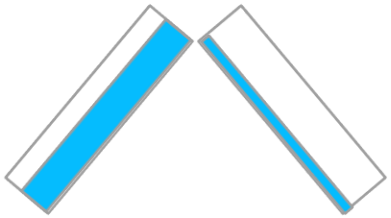
Gravitational pressure drop: $dP_{grav} = \rho_{eff} gH$

Fluid	Effective density [kg/m3]	Heigth [m]	Dpgrav [bar]
Gas	80	2000	16
50% gas, 50% oil	440	2000	86
Oil	800	2000	157

Multiphase flow challenges (1)

- Pressure drop: How much do we get out of the reservoir?
- Liquid accumulation in Gas Condensate flowlines



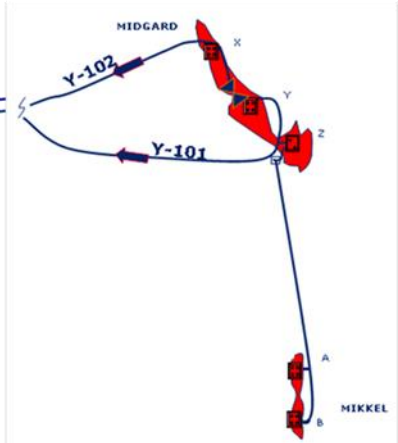


Multiphase flow challenges (2)

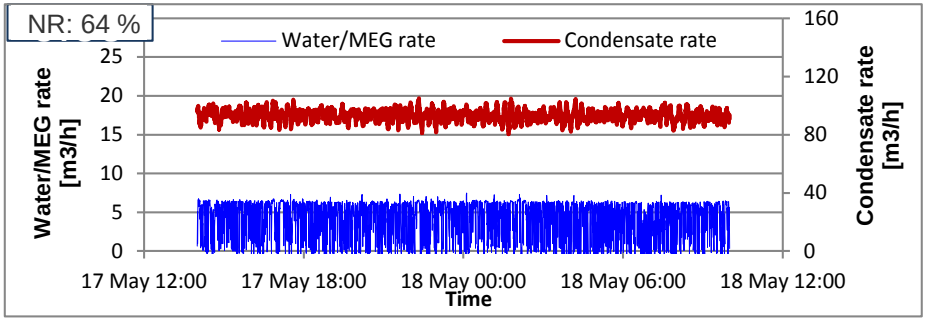
- Surge and slug flow
  - Flooding of separators
  - Slugcatchers

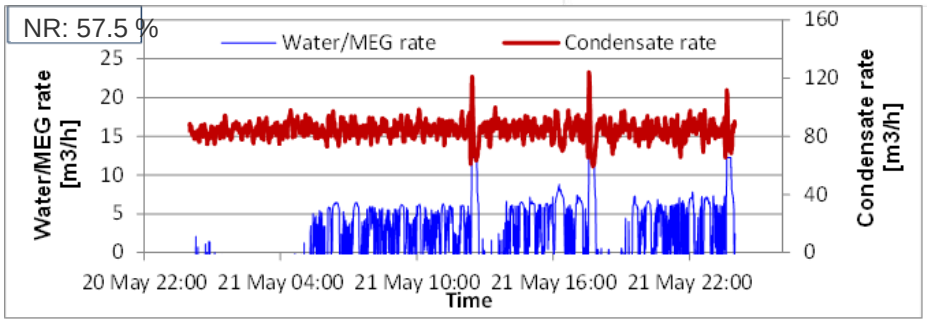
Troll slugcatcher

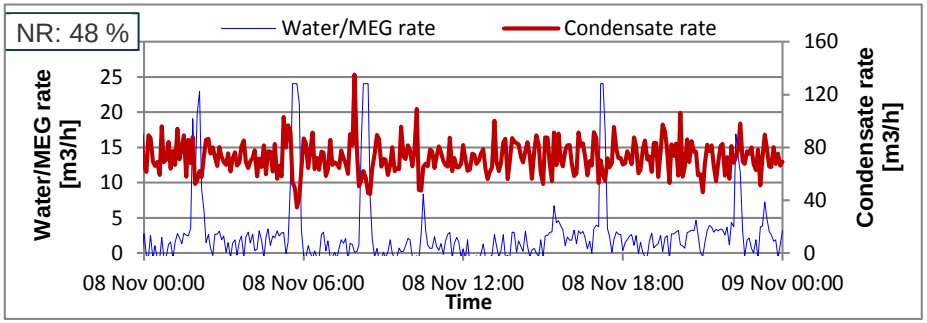
3 phase surge waves arriving at ÅSGB from 20“, 46 km long Y-102 flowline

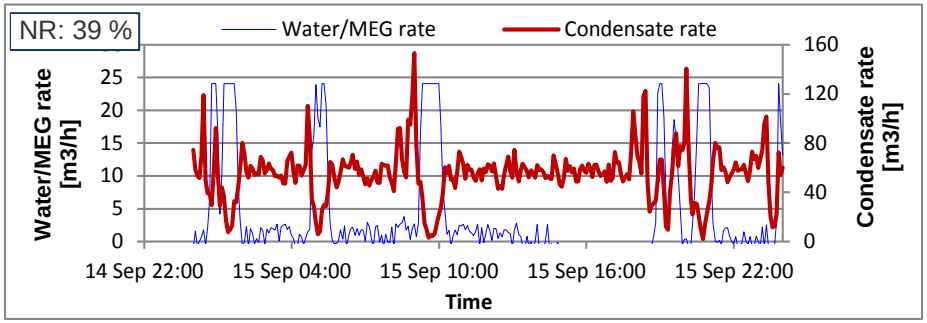


Measured surge wave instabilities

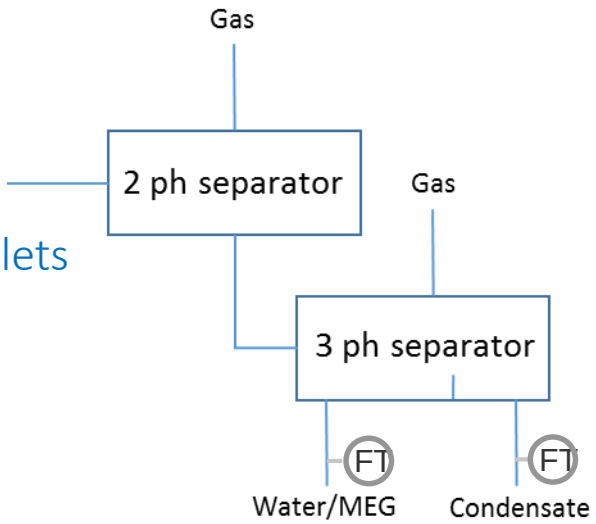




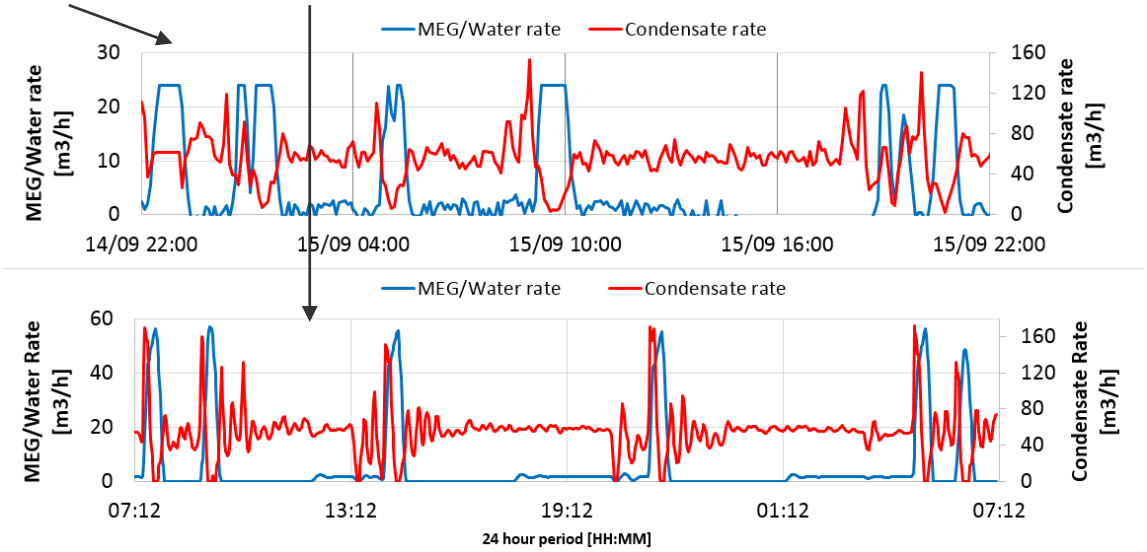




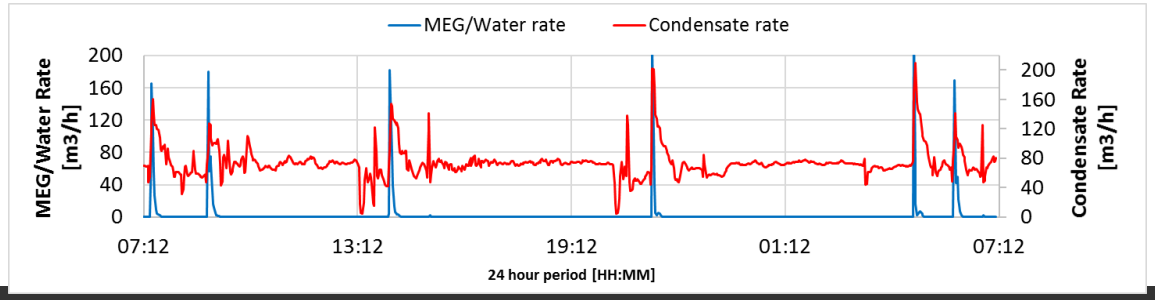
1D Model (FM) vs data



Measured and predicted liquid rates at 3 phase separator outlets



Predicted liquid rates at 2 phase separator inlet

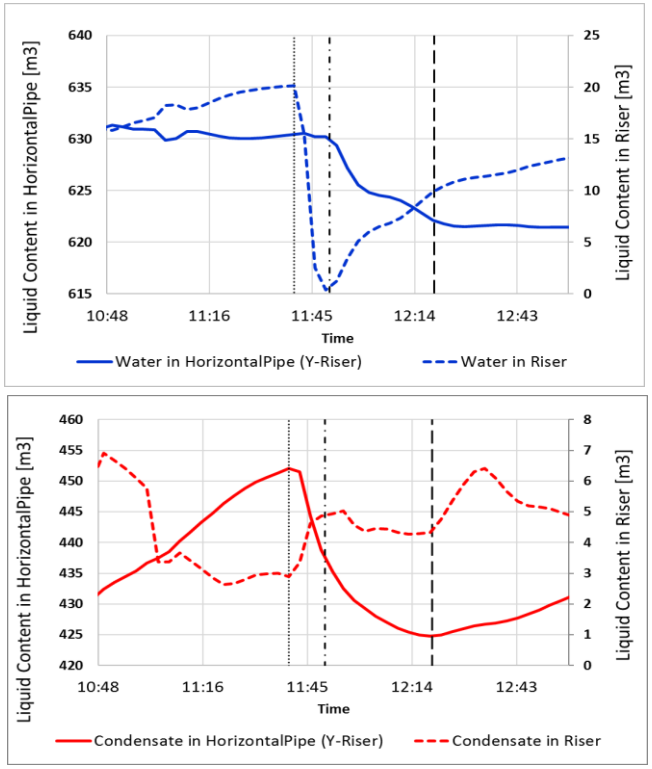


Damping of surges by liquid level control

Prediction of surge origin and liquid re-distribution during surging

Liquid content in riser/flowline

1 2 3



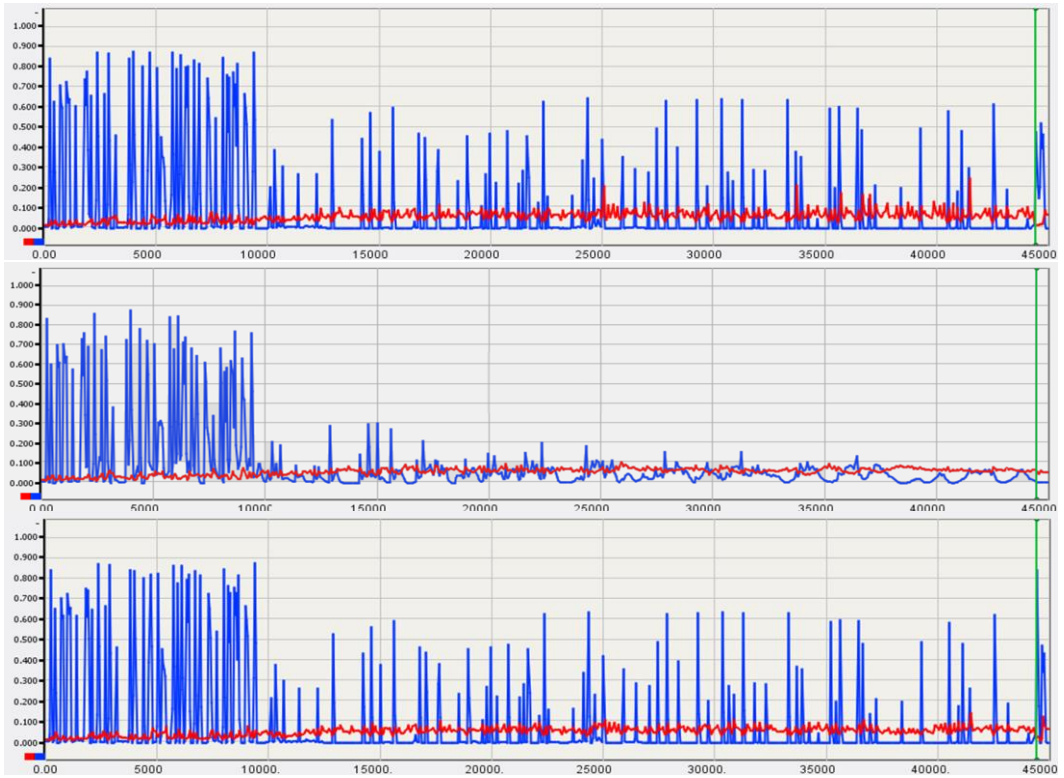
Time-trends

Holdup in flowline/riser

Y - 9 km -X

- 37 km -

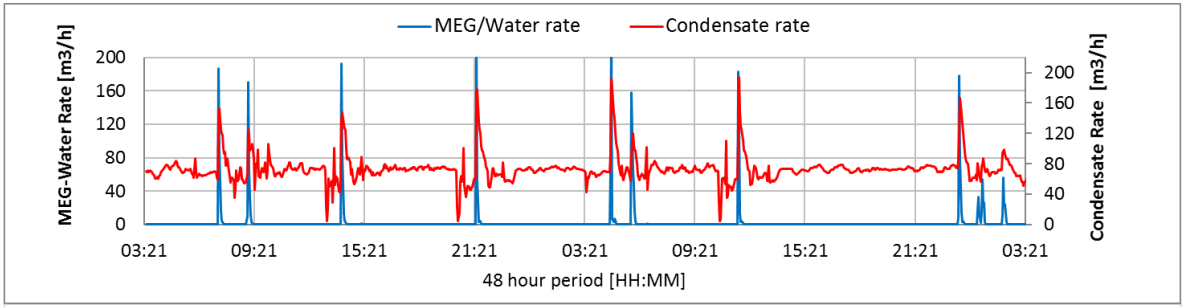
Lazy-S Riser



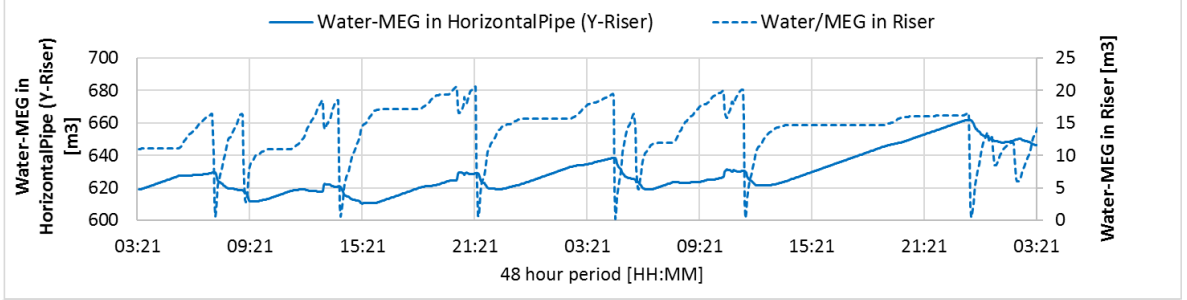
Profiles - plots

Surging details

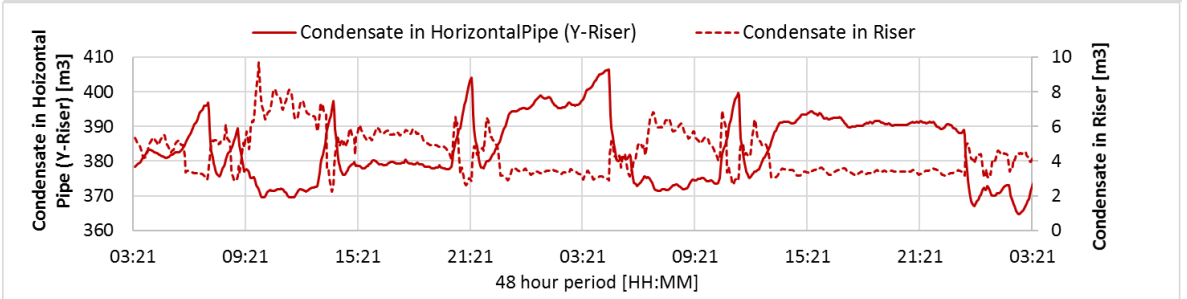
Surge rates at ÅSGB



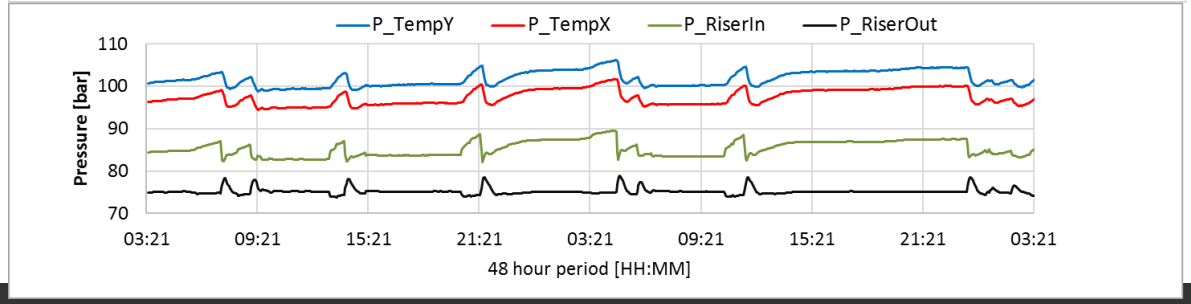
Water/MEG content



Condensate content



Pressure



Statoil

Summary - Surge wave instabilities

- FlowManager reproduce surge waves instabilities:
  - Water surges are predicted to come from the riser
  - Condensate surges are predicted to come from the flowline

- Field data shows:
  - No blockage at riser base
  - Gas and condensate arrives continuously topside
  - Water accumulates and releases
  - This is not a “riser slugging” phenomena

- This phenomenon occurs also in inclined flowlines
  - ref: Landsverk et al. Multiphase flow behavior at Snøhvit, Cannes 2009

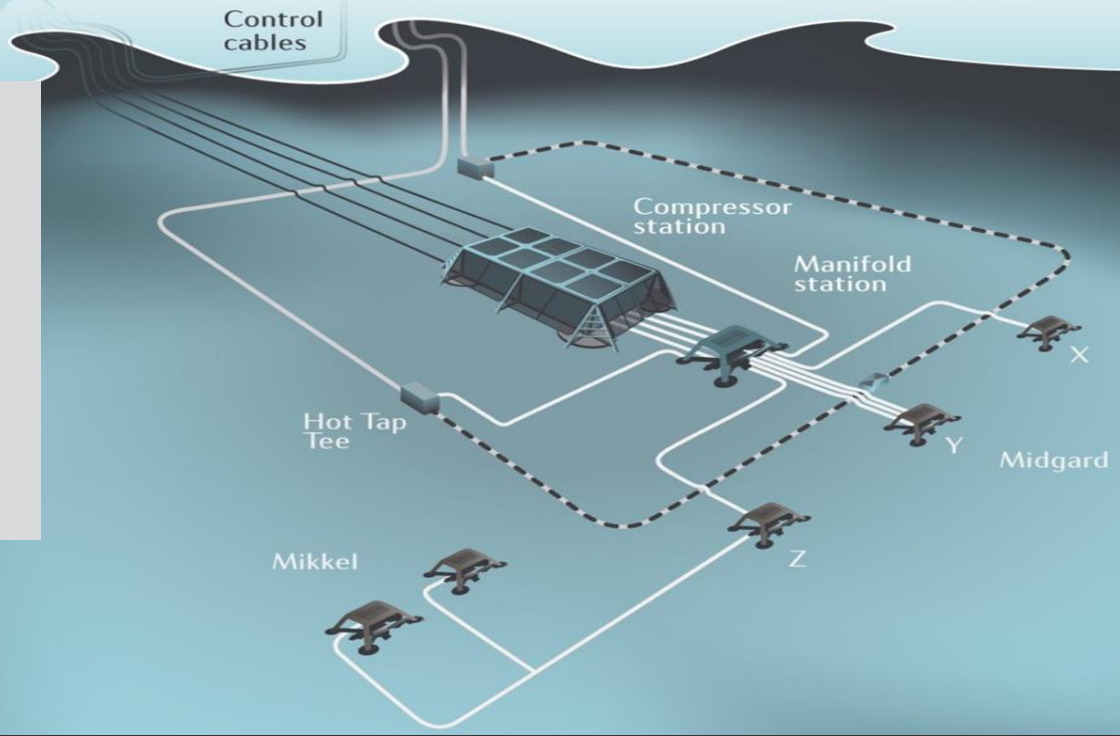
Åsgard Flow Assurance Simulator (FAS)

Pipeline Management System

Liquid Surges/Slugs	Hydrate formation	Subsea compressor station
• Liquid accumulation • Ramp-up surges • Water surging	• Hydrate detection alerts • MEG injection advice	• Monitoring • Advise

Dynamic simulator scope

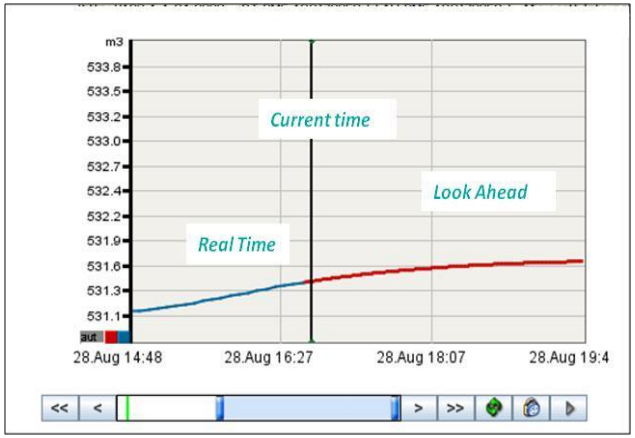
- Wells
- Flowlines
- Subsea compressor station
- Topside separators
- MEG injection



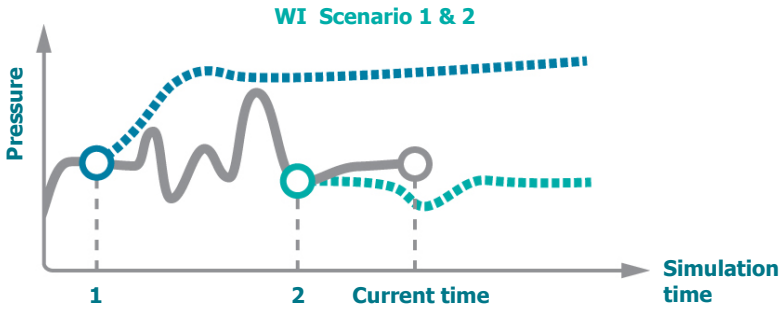
Statoil

Discover potential problems applying different FAS execution modes

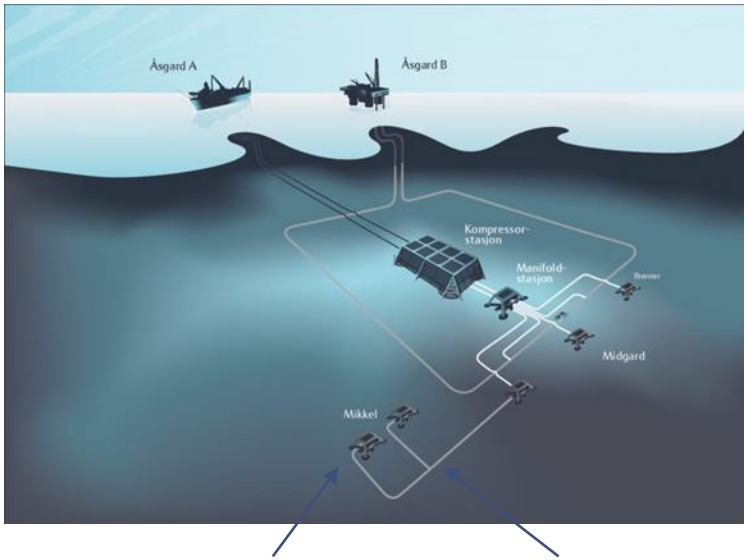
- Real Time for online monitoring
  - Current state of the production system
- Look-Ahead early warning system
  - Predictions into near future



- What-If simulator
  - Operation and dynamic process understanding
  - Planning
  - Analyzes

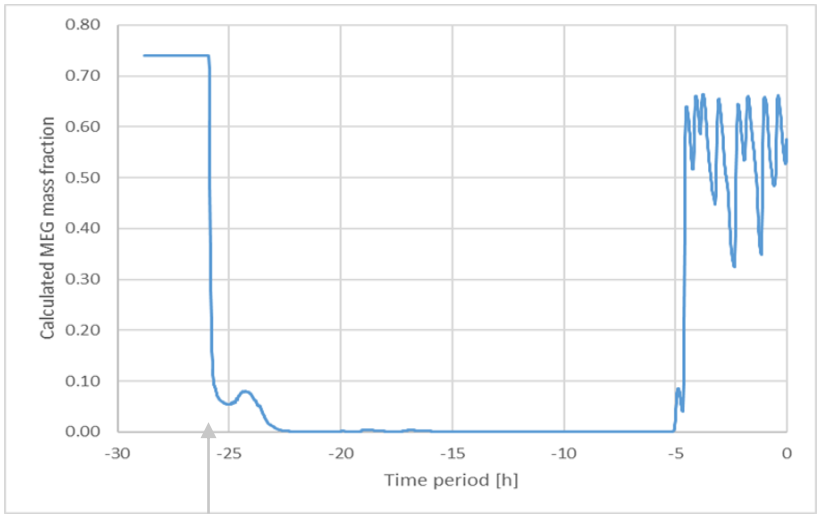


Minor hydrate incident – slurry at Inlet cooler (1)



B-template A-template

Predicted MEG mass fraction at A



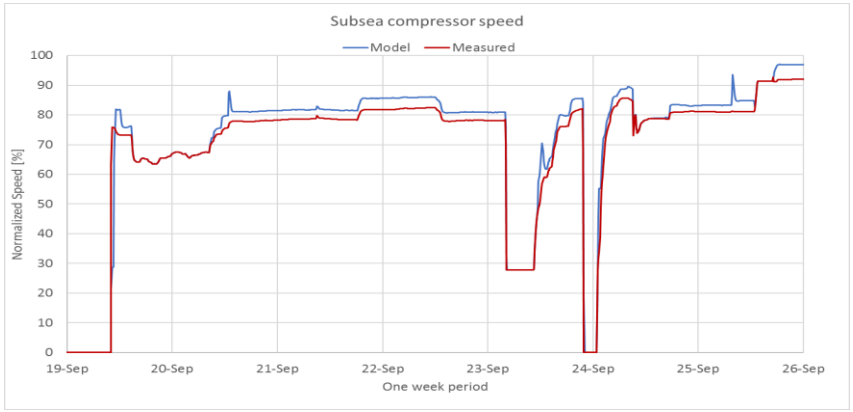
Switch MEG injection from A to B

- Mikkel B well was restarted after a long shutin period
- MEG injection moved from A-template to B-template
- Next day, a sudden pressure increase over the inlet cooler was experienced
- Handled by reduced compressor speed and MEG injection at the Inlet cooler
- After this incident an alarm based on the FAS prediction of MEG mass fraction has been implemented

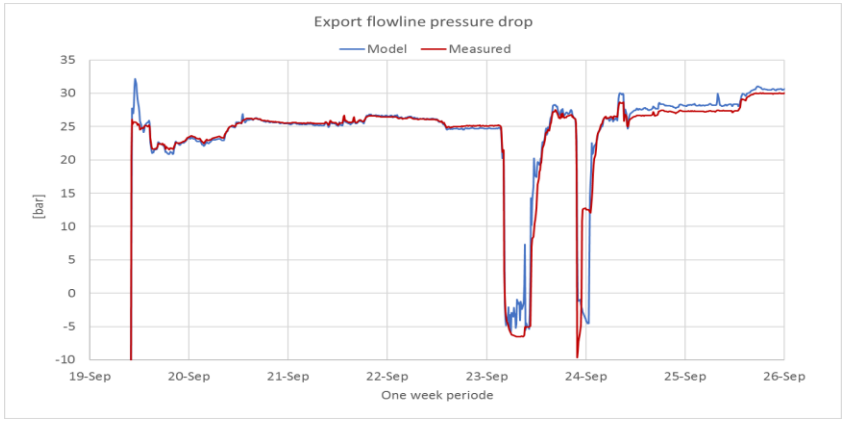
FAS predictions vs field meas. during a system restart

- FAS - Measured

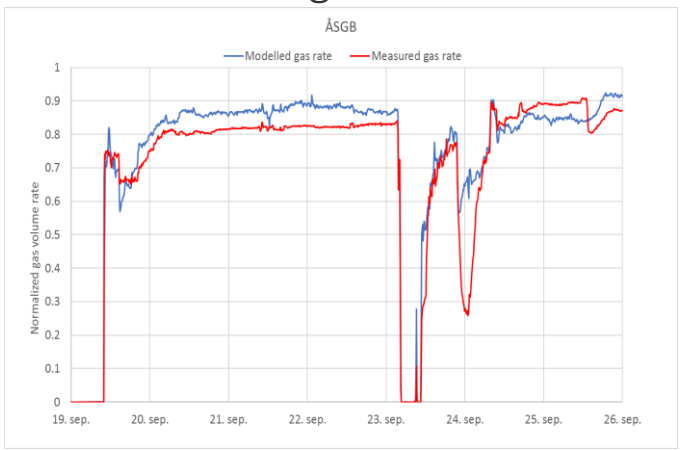
Compressor speed



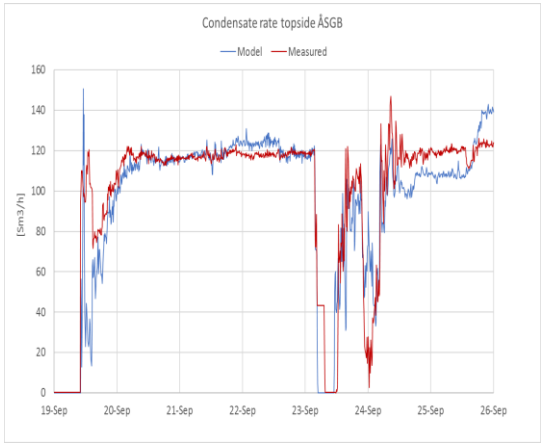
Pressure drop: ÅSC-ÅSGB



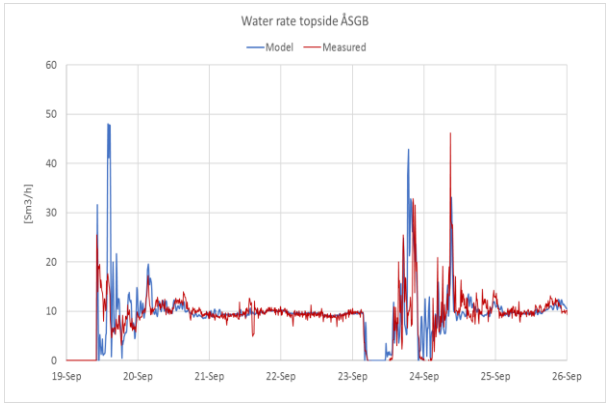
ÅSGB gas rate



ÅSGB condensate rate



ÅSGB water/MEG rate



Summary – FAS for ÅSC

- FAS used for operational planning and online monitoring
- Alarm at ÅSGB on predicted MEG fraction in flowline is implemented
- Good agreement between FAS and measurements are seen for pressure drop in flow lines and for start-up surges

Content

- ✓What is Flow Assurance?
- ✓How do we get multiphase flow – compositions?
- ✓Multiphase flow challenges
- ✓Åsgard subsea compression – surge waves and hydrate control

Thank you!