Multiphase metering for allocation between Kristin og Tyrihans
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Outline

• MPFM for field allocation, introduced by tie-in of Tyrihans to Kristin
• Original metering philosophy and allocation principle
• Events and challenges
• Remedial actions and changes
• Status metering and allocation
• Future challenges technologies / opportunities
Kristin subsea infrastructure

- Kristin Semi - processing & gas export via ÅGT
- 4 production/templates
- 6 x DEH flowlines, 7km to Kristin
- Åsgard C condensate export
Tyrihans subsea infrastructure

Kristin Semi - processing & gas export via ÅGT

43km DEH flow-line to Kristin

1 SRSWI template (power from Kristin)

Åsgard C condensate export

Gas injection/lift flow-line from Åsgard B

4 production/GI templates
Tyrihans Topside and Subsea MPFM

Topside MPFMs

Subsea MPFM

2005 ... 2009 2010 2011 2012 2013 2014 ...
Main purposes of oil and gas allocation

• Fiscal allocation
  – Ownership allocation, distribution of the income
    • Oil and condensate mass
    • Gas energy
• Production Management
  – Detailed production monitoring and optimization
    • Allocated production and injection volumes for individual wells
• Reservoir Management
  – Reservoir simulation model history matching
    • Allocated production and injection volumes for individual wells
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Original Allocation principle:
Kristin as balance field (Kristin by difference – KBD)

\[ Kristin_{\text{oil,gas}} = Kristin_{\text{total}} - Tyrihans_{\text{oil,gas}} \]

Well tests

- Multiphase meters topside (2 off)
  - Accuracy and performance?
- Multiphase meters subsea (backup)
  - Accuracy and performance?

~80% of total production
Allocation factor = Allocated volume/theoretical volume

Tyrihans start-up
Troubleshooting Allocation System

The original field allocation system does not reproduce the results from field tests. Main issues seem to be:

- Test separator readings high compared to export rates
- Topside MPFM mass correction is not linear as a function of rate under calibration
- Unable to calibrate topside MPMs against the test separator at normal operational conditions
- Problem with gas measurements at high rates
- Allocation principle with Kristin as balance field
Multi phase flow meter calibration principle

CALIBRATION AGAINST TEST SEPARATOR

MULTIPHASE METER

TEST SEPARATOR

CORRECTED MULTIPHASE METER

MULTIPHASE METER AT NORMAL OPERATION

Ko = 1.25
Multi phase flow meter calibration principle

CALIBRATION AGAINST TEST SEPARATOR

5000 Sm3/d

4000 Sm3/d

Ko = 1.25

MULTIPHASE METER AT NORMAL OPERATION

10000 Sm3/d

8600 Sm3/d

5000 Sm3/d

FIELD TEST

NORMAL OPERATION

4000 Sm3/d

8000 Sm3/d

UNCORRECTED MULTIPHASE METER
New allocation principle: Subsea HC mass & ProRata split

Uncorrected mass rate + composition and WC from test separator

Tyrihans theoretical

Sum of subsea MPFMs & performance curves (back-up)

LEVEL 1

Tyrihans allocated

Kristin allocated

LEVEL 2

Kristin theoretical

Sum of well performance curves (control method)

Sum of well performance curves incl. flowline(s) testing

Export measured

Difference

Spilt pro rata
Allocation input and sources

• TYH HC mass
  - TYH total mass (Subsea MPFM and Performance Curves)
  - TYH total water mass fraction (Test separator)
• PVT
  - TYH total HC composition (GOR) (KFC – flowline separator tests)
  - TYH total HC molecular weight pr component (Recombined PVT-samples)
  - Tyrihans gas molecular weight (ISO 6976)
  - Oil recovery factors (ORF) (Hysys)
  - Tyrihans oil density (Hysys)
  - Kristin condensate density (Hysys)
• Well rate estimates
  - Kristin theoretical condensate volume (Performance Curves, KFC – flowline separator tests)
  - Tyrihans theoretical oil volume (Subsea MPFM and Performance Curves)
• Fiscal metering
  - Total export oil and condensate (Fiscal export meters)
  - Total export gas (Fiscal export meters)
Allocation quality control

- Kristin Flowline Campaign (KFC) – Tyrihans by Difference (TBD)
- Allocation factors
- Pro-rata allocation vs TBD result
- Topside MPFM “calibration” (based on TBD)
- Topside MPFM trend
- Subsea MPFM and PC
- PVT-samples
- Single field tests
Allocation workflow

- «Tyrihans by difference» (one production day)
  - Kristin production based on KFC
  - Tyrihans production based on total production and KFC/TFT
  - Tyrihans GOR and WCT determined

- «Pro rata period» (normally 14+ days)
  - Based on latest «Tyrihans by difference»
  - Pro-rata principle to compensate for Tyrihans GOR/WCT development and Kristin depletion effects (not captured by performance curves)
  - Tyrihans GOR (total HC composition) adjusted if necessary (observed trends)

- After next TFT and KFC;
  - Previous «pro rata period» adjusted with new results

- Reallocation is performed when ORF is updated (quarterly)
PVT sampling KRI/TYH
Basis for ORF-calculation and allocation

- Process simulations (ORF update)
- Sampling of TYH mixed well stream + condensate & export gas
  - every three months
  - + as necessary due to fluid changes (new wells)
- Annual sampling of KRI wells / flowlines
Allokeringsfaktor 2011

TYRIHANS OIL ALLOCATION FACTORS FOR THE DIFFERENCE AND PRORATA MODEL

OIL ALLOCATION FACTORS (SMB/SMB)

DATE

01.01.11  20.02.11  11.04.11  31.05.11  20.07.11  08.09.11  28.10.11

AF_TO,EC  AF_TO,prd
Summary:
Challenges in Kristin Tyrihans Allocation

- Tyrihans topside multiphase flow meters (MPFM) disqualified for allocation
  - Cannot be calibrated against test separator at normal operating conditions due to test separator rate limitation
  - Can be adjusted against result for Tyrihans from Kristin Flowline Campaign testing (KFC). Measurement drifting between adjustments.

- Tyrihans subsea multiphase flow meters malfunctioning
  - Only as few as two out of seven subsea MPFM in working order for a long time period (currently 5 of 9 working).

- Extensive use of well performance curves (PC) both on Kristin and Tyrihans.
- QC rely heavily on test separator performance.
- Single field tests that require shut-down of either Kristin or Tyrihans are costly and do not show the mixing effect of the two fields.
Future challenges / concerns

• Replacing existing subsea MPFM (present vendor)
  − Long delivery time, dependent on available choke modules
  − Reliability (will they fail again?)

• Low pressure production (LPP) period from 2014
  − Change in topside process conditions (PVT, ORF-factors, etc.)
  − Change of performance of subsea MPFM under LPP conditions?

• Possible additional 3rd party tie-ins
  − Change in metering philosophy?
  − Change in allocation procedure?
  − Change in topside process conditions (PVT, ORF-factors, etc.)
Future technologies / opportunities

• Install new subsea MPFM(s) (new vendor)
  − Long delivery time, need mechanical fitting
  − Increased subsea power requirement
    (limit max no. of MPFMs in operation per template)
• Connect to existing subsea MPFM by ROV for flow data logging possible?
  − Logging for a short period, move to next well and repeat logging
  − Revise well hydraulic models for allocation input
• Investigate subsea PVT sampling (Mirmorax)
  − Representative fluid sampling per well, input to PVT for MPFM calibration / allocation
  − Need mechanical modifications

Figure: ©Mirmorax
Future technologies / opportunities

• Virtual metering
  - Replace direct measurements by indirect analysis and modelling
  - Replace MPFMs
  - «Model based allocation». Calculations based on online data model of the subsea system, updating based on sensor changes.

Figure: ©FMC
Future technologies / opportunities

• Multi-disciplinary integrated modelling
  − Integration of Reservoir simulation to Topside simulations for historical matching and future forecast of ORF.
  − Integrated possibility to calculate ORF based on
    • Lab sample measurements and
    • Historical production data
  − Both options compliant with the work processes and technical requirement for simulation for field allocation
    • Possibility for more frequent update of ORF calculations by utilizing input from reservoir simulations.
    • Possibility for less frequent update of ORF based on Lab sample measurements due to knowledge of future development.
There’s never been a better time for good ideas

Takk til følgende for bidrag:

- Trygve Kløv
- Kurt Haugnæss
- Even Lillemo
- Yngve H. Belsvik
- Kolbjørn Kyllo
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Multiphase metering for allocation between Kristin og Tyrihans

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