NFOGM
NORWEGIAN SOCIETY FOR OIL AND GAS MEASUREMENT

Volumetric allocation

By Erlend Nilsen and Sidsel E. Corneliussen

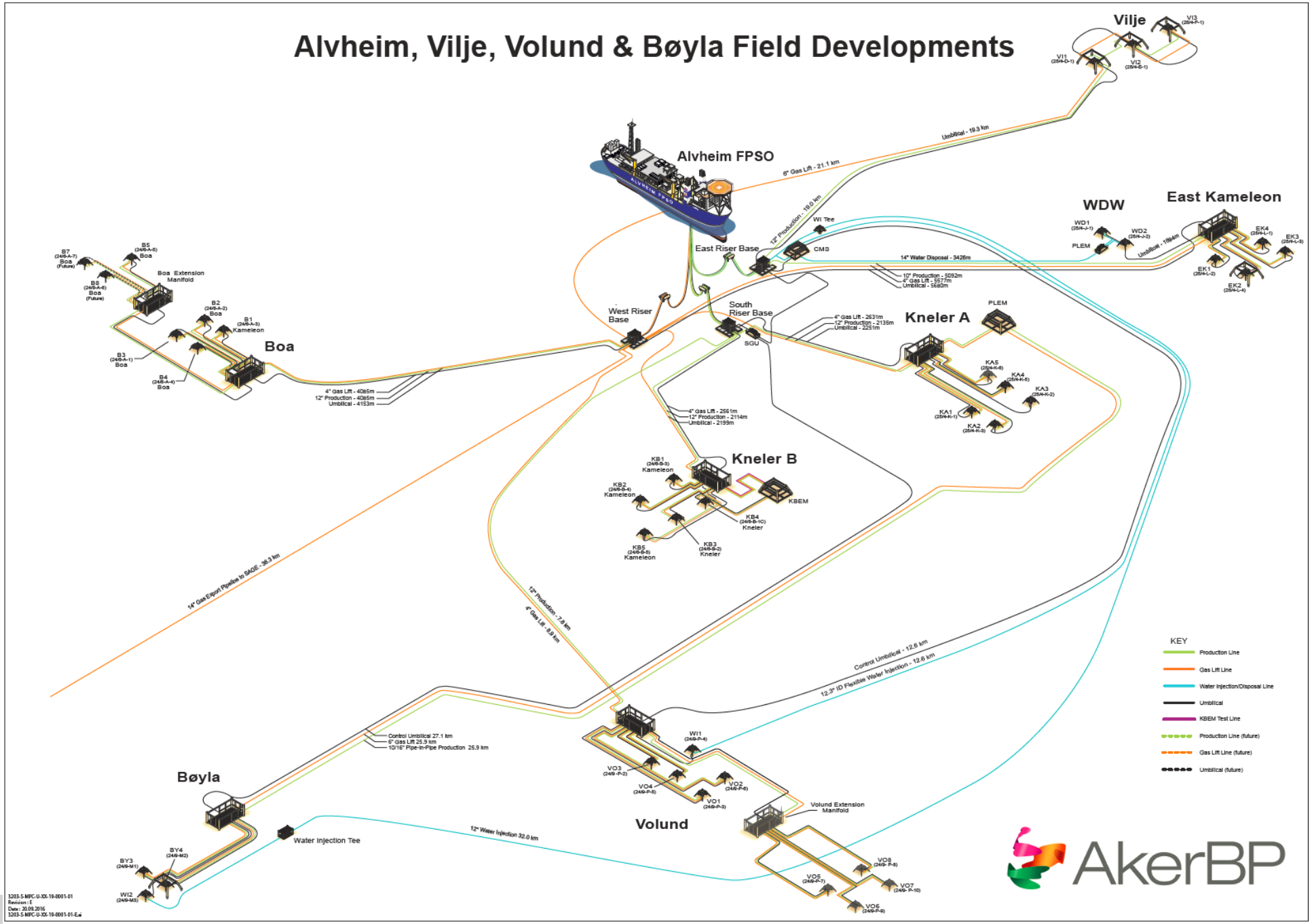
07.06.2018

Alvheim – Allocation of oil, water and gas based on volume

Alvheim FPSO and connected fields

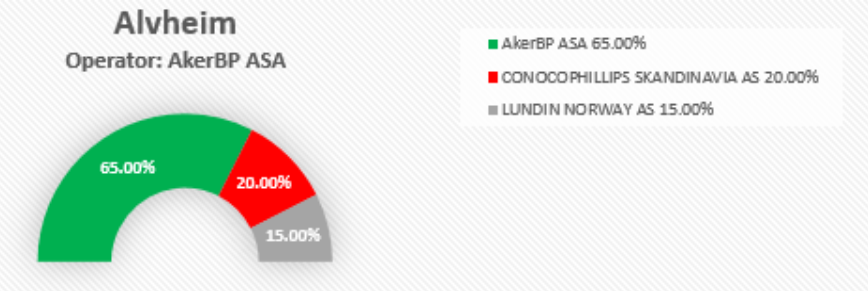
- Located west from Stavanger
- First oil 8th of June 2008
- Sea depth around 130m
- Alvheim fields
- 5 tie-in fields
- 32 oil producer wells
- 2 water injector and 2 water disposal wells
- Oil exported by tanker
- Gas exported with pipeline to SAGE St.Fergus terminal in Scotland

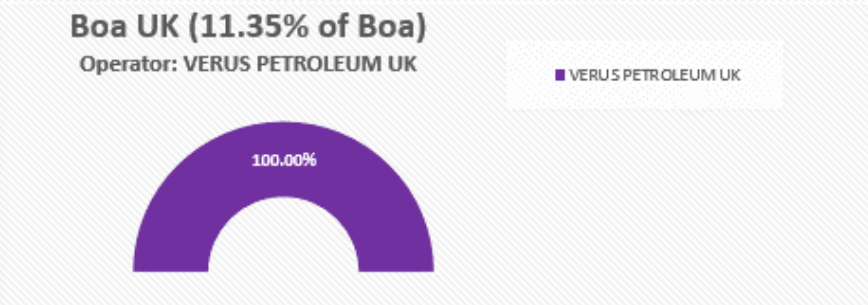
Alvheim, Vilje, Volund & Bøyla Field Developments



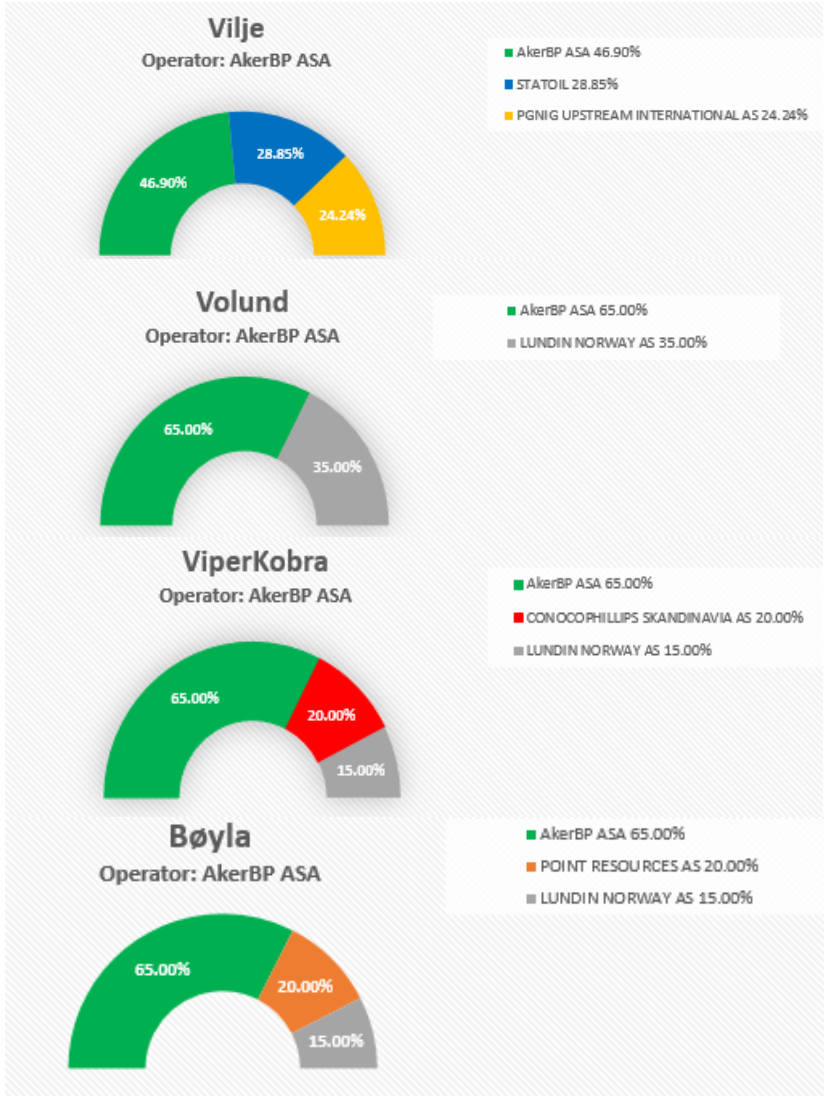
ALVHEIM area. Owner and partner overview

- Alvheim - Kameleon, Kneler and Boa

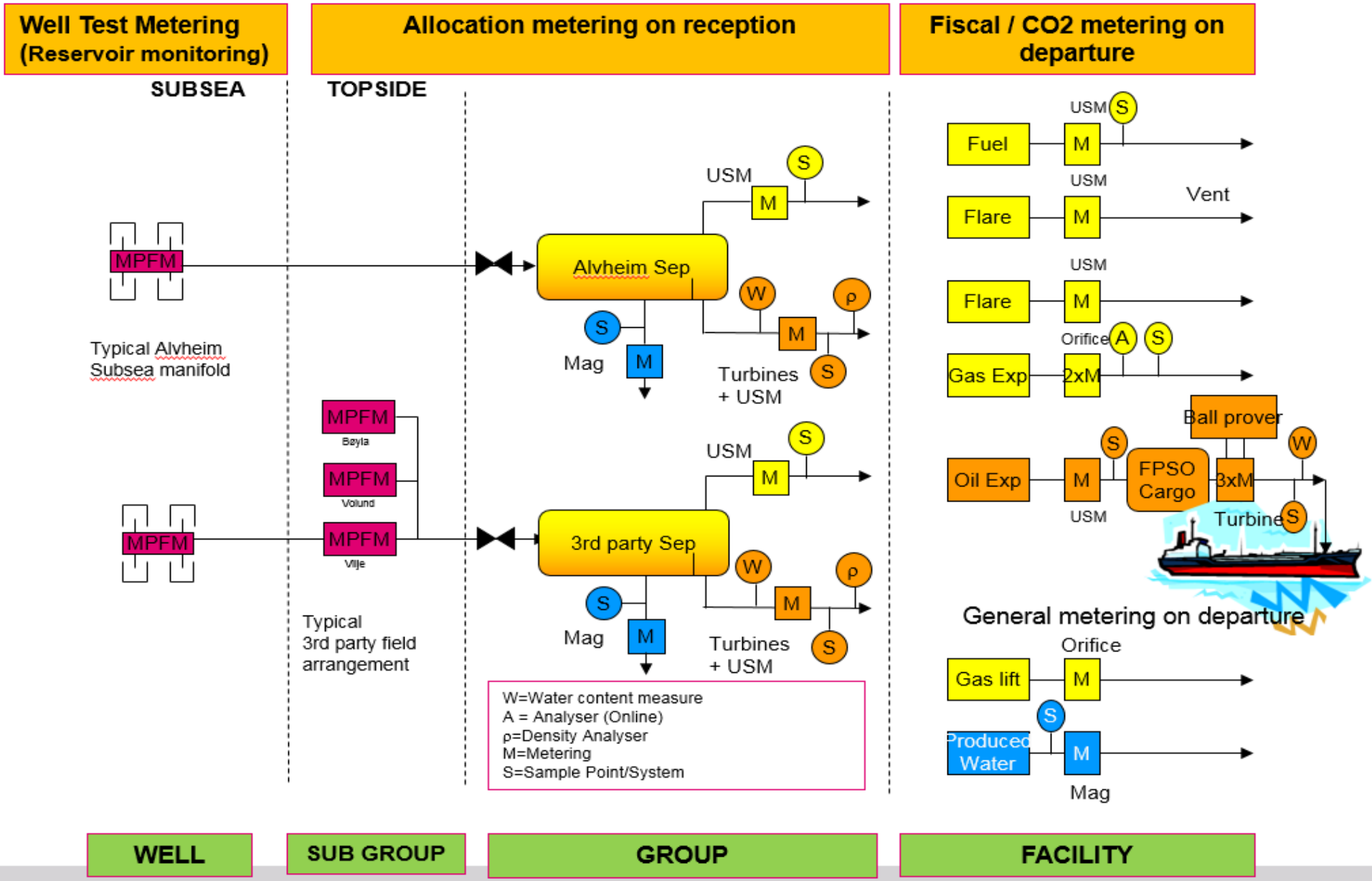




- Tie-in fields Vilje, Volund, Viper/Kobra and Bøyla



ALVHEIM METERING AND ALLOCATION OVERVIEW



Allocation principles:

Asset allocation is divided into following allocation steps:

- Group allocation
- Field (sub-group) allocation
- Well allocation
- Gas export allocation
- Utility gas allocation for duty/tariffs: fuel, flare, vent and lift gas

Allocated field production for oil and water:

- Sum of oil and water production per well for each field.
  - The oil and water production is determined by volume proportional calculations in steps from export numbers back to well
  - Field production share of run-down meter is production added to the lifting account.

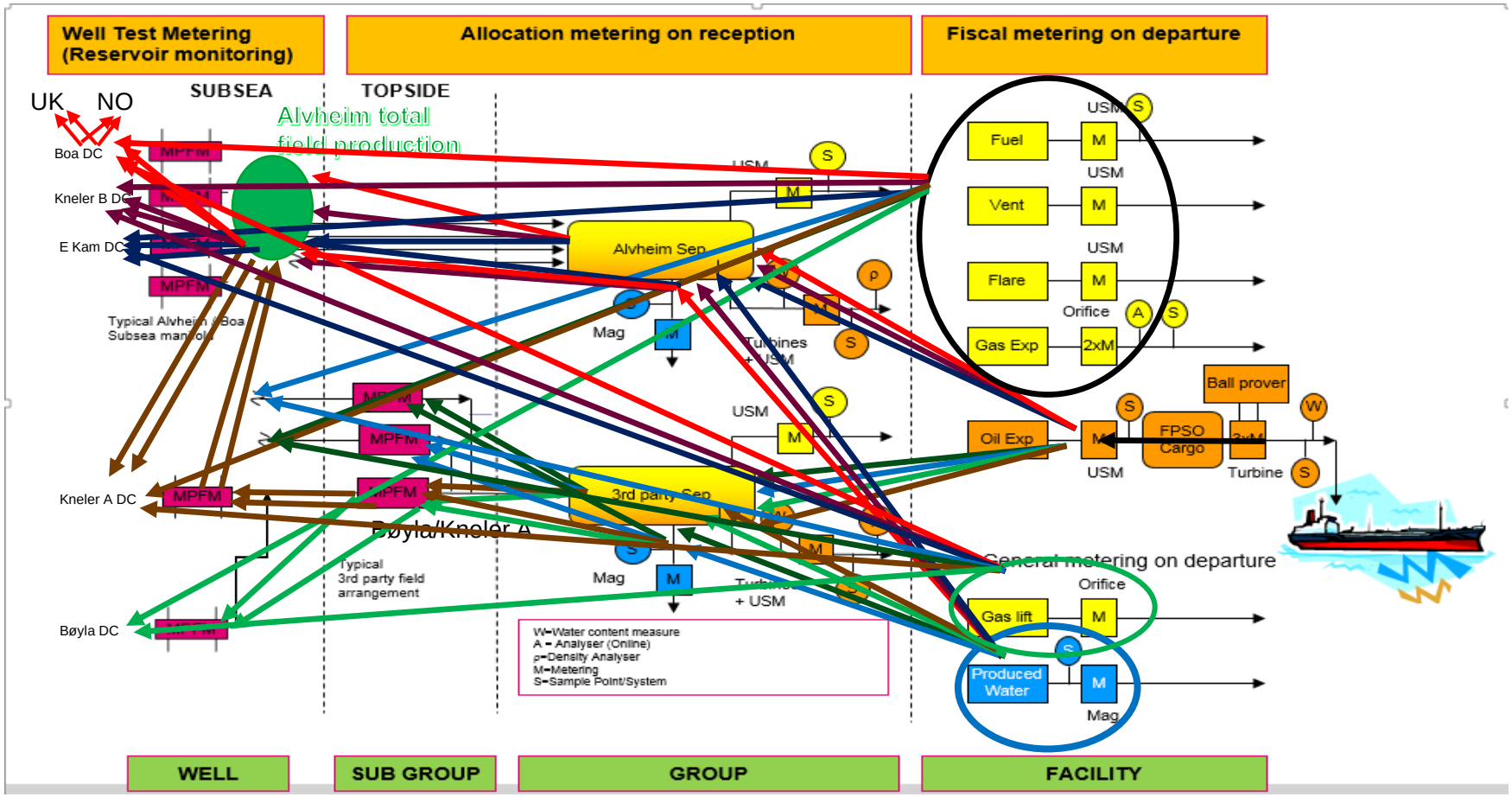
Field gas production:

- Field gas production is the sum of the adjusted theoretical gas production per well for the field.
  - The theoretical gas production is pro-rata adjusted to the total facility gas measurements
  - The Theoretical gas production per well is calculated based on “oil-rate” multiplied with the well’s GOR and well up-time
  - “Oil-rate” is either the theoretical rate or the allocated rate dependent on a fixed or variable GOR per well
  - The total facility gas is the sum of fuel, flare, vent and gas export gas measurements.

Field gas production:

- Field gas export is the pro-rata share of the export measurements.

Allocation process with tie-in fields – pro-rata overview



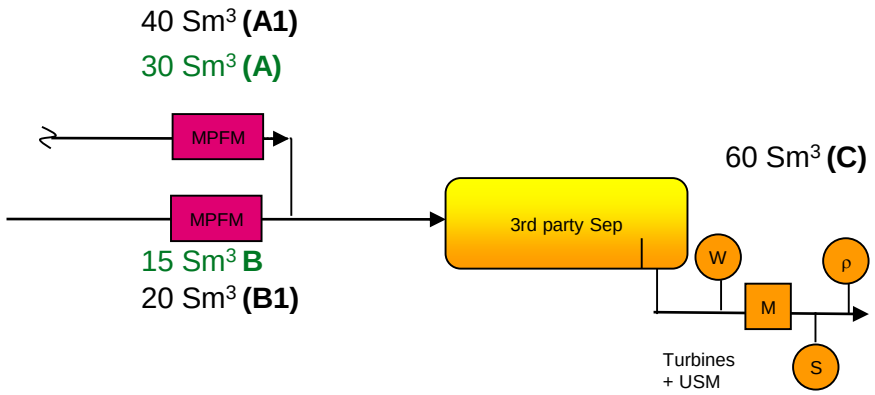
Alvheim Allocation principle – Pro-rata

- Prorating is the overall principle:

> Stated simply, wherever two inputs A and B share an output C then each input shall receive an output (A1 and B1) as follows:
>
> A1 = A*C/(A+B) and B1 = B*C/(A+B).

- Performed on produced volumes normalised to standard conditions (stock tank conditions, 1 atm and 15°C)

- A1=30*60/(30+15)= 40
- B1=15*60/(30+15)= 20

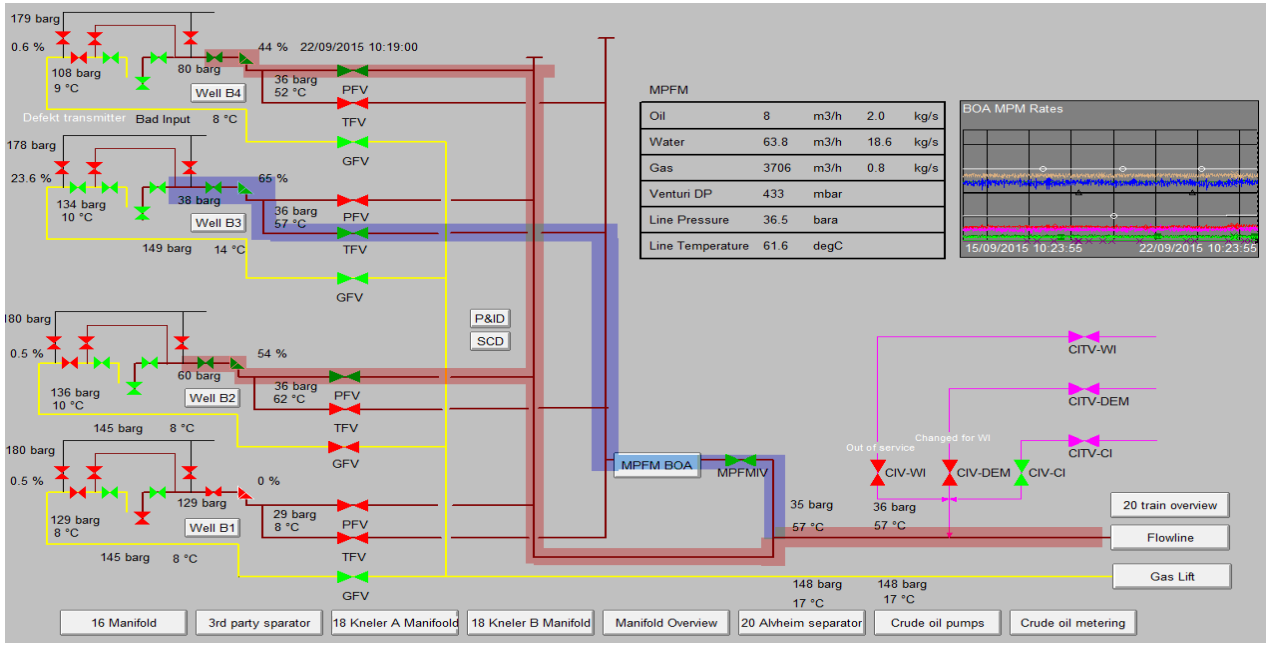


The theoretical production used in the allocation calculation

Theoretical production

Is the prediction of well production based on well pressure, performance curves and well up-time.

- From readings of the BHP for the well the oil, water and gas flow rate are given from the performance curve
- Well up-time is the time, when the well is open and hydrocarbon flowing.
- The well is defined open when all valve openings are set and the fluid temperature is above 8 deg.

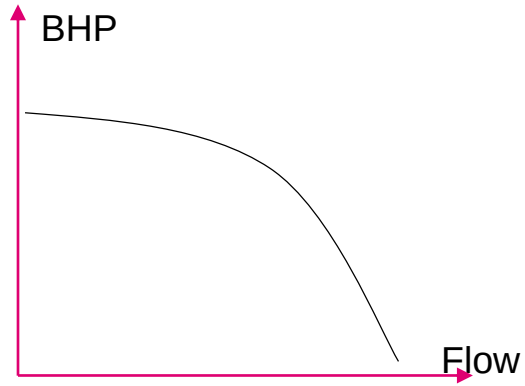


Performance curve:

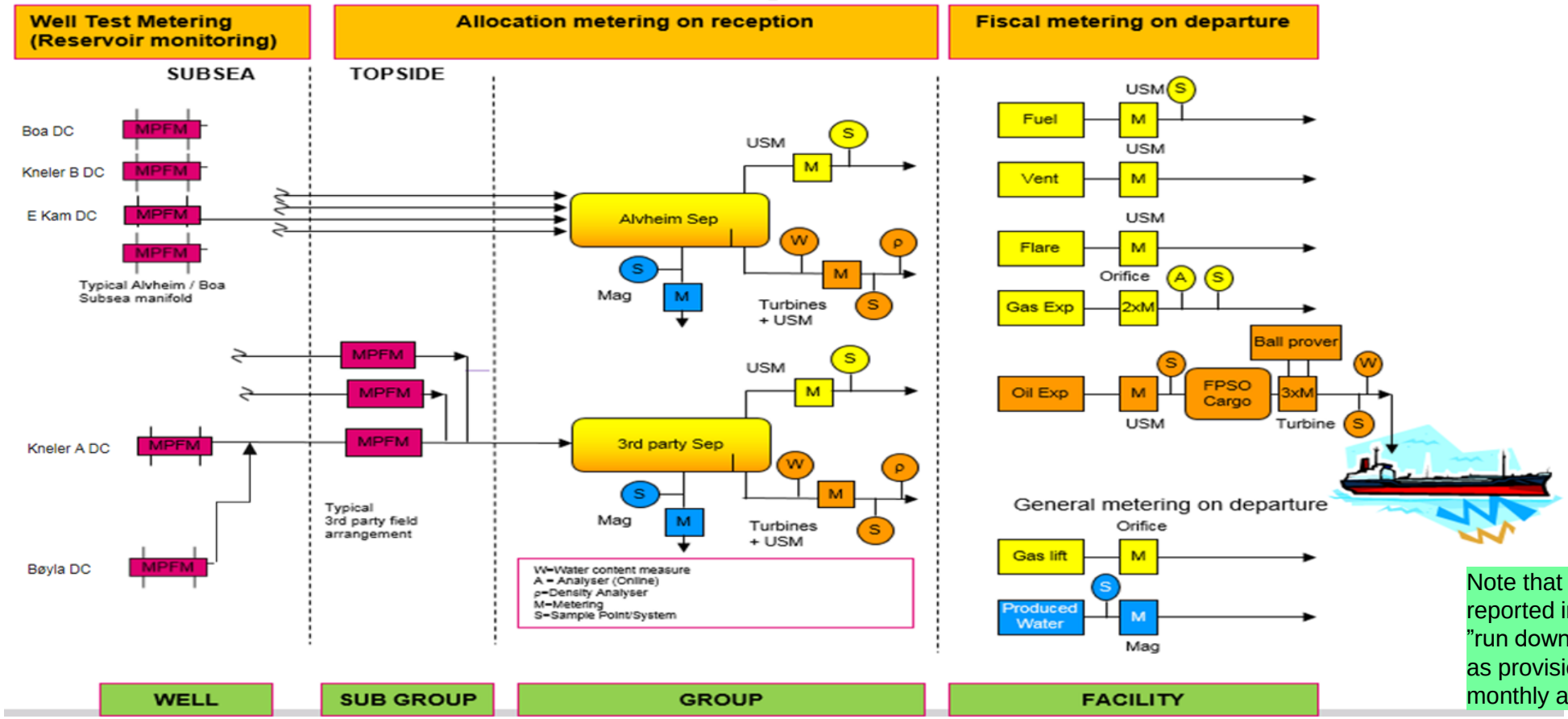
A performance curve is derived from well-tests conducted by the subsea MPFMs related to well pressure, usually the bottom hole pressure (BHP).

Well tests are executed bi-weekly.

Theoretical flow rate is related to the BHP.



Example – NORMAL ALLOCATION MODE



Note that daily allocation as reported in DPR is based on the ”run down meter”, and is regarded as provisional. Corrected as part of monthly allocation.

Example – ALTERNATIVE ALLOCATION MODE – new period starts

Well Test Metering (Reservoir monitoring) | **Allocation metering on reception** | **Fiscal metering on departure**

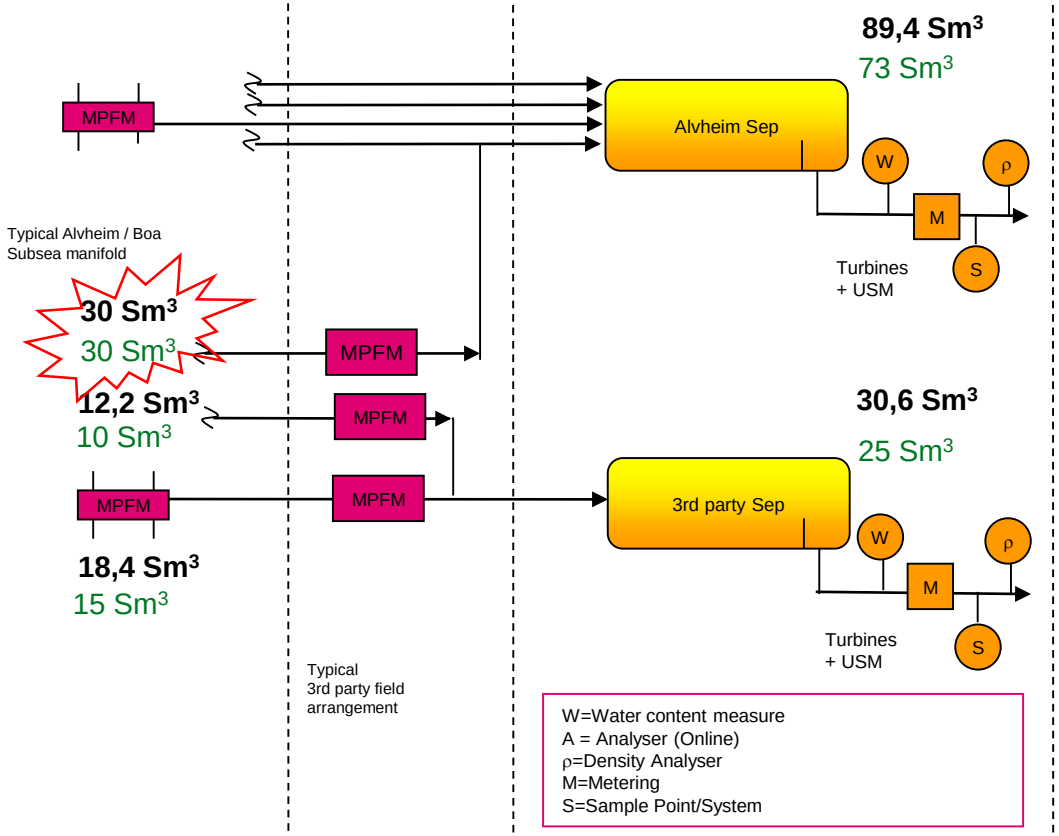
SUBSEA | TOPSIDE

89,4-30= **59,4 Sm³**

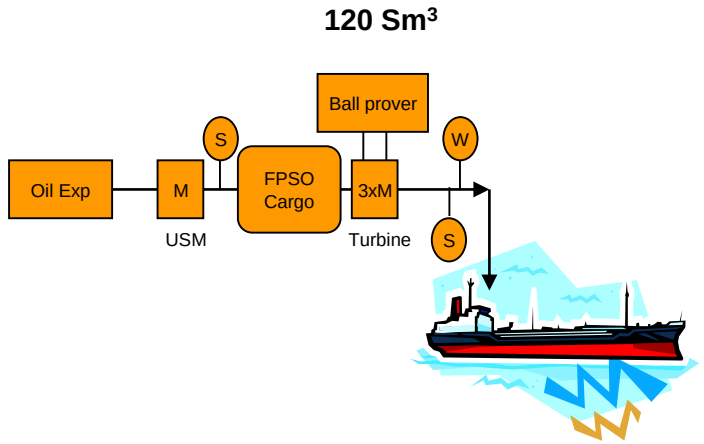
Before 60Sm3

--------- Allocated

--------- Measured (net shrunk)



W=Water content measure
A = Analyser (Online)
ρ=Density Analyser
M=Metering
S=Sample Point/System



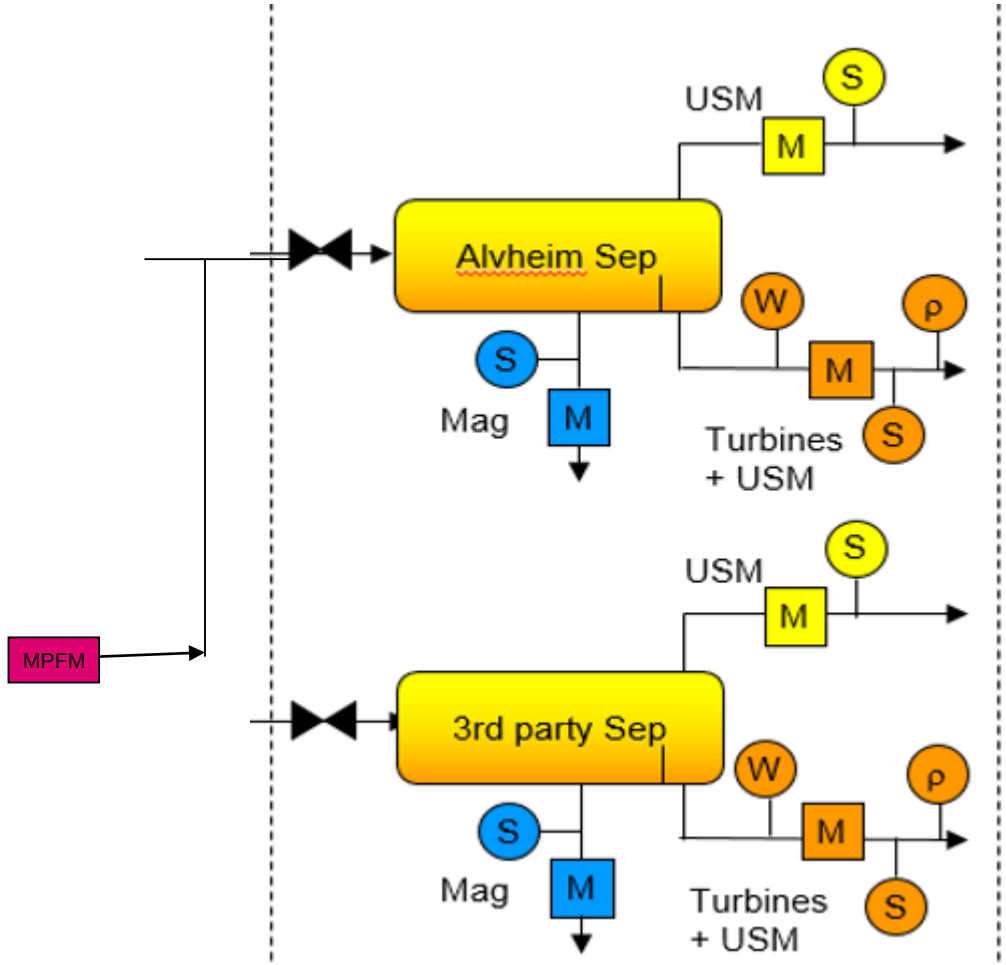
Note that daily allocation as reported in DPR is based on the ”run down meter”, and is regarded as provisional. Corrected as part of monthly allocation.

WELL | **SUB GROUP** | **GROUP** | **FACILITY**

Group (separator) Allocation – flexibility and complexity

Flowlines can be routed freely between the separators.

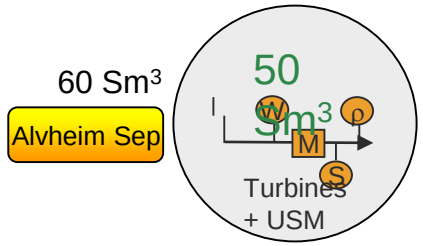
- Flowline configuration
  - Flowline configuration is checked each 5 min by the system.
  - Change in flowline configuration will trigger a new calculation setup for the given combination of fields.
- New parameters:
  - Combined shrinkage factor for separator
  - Shrinkage factors due to change in process pressure and temperature for each field/flowline.
- Calculation change:
  - Actual production related to separators.
  - Field theoretical production related to separators.
  - Allocated production to each field.



What affects and what to monitor…

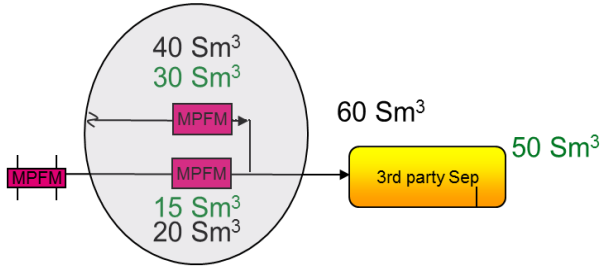
Sources for change/failure:

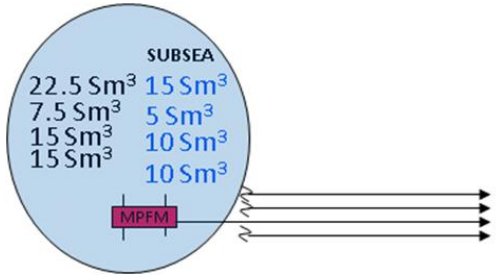
- Instruments and flowmeters
- Calibration, particular calibration/check of the MPFM without a dedicated test separator.
- Conversion to Sm3 performed in the metering computer; applying a meter internal shrinkage factor based on the PVT modelling.
- Sampling and analysis
- Process conditions and flexibility
- Shrinkage factors (P/T table in allocation program)



Monitoring changes or difference:

- “Coro factor” (separator shrunk volume vs volume export meters + delta stock)
- Both separator measurements compared to rundown meter (oil to tank meter)
- Topside MPFM measurements compared to separator measurements
- Comparing topside MPFM to subsea MPFM (theoretical rates)
- Difference between allocated rates and measured production rates
- Allocation Factor (AF)
- Supplier – external monitoring of the MPFM
- Well test evaluations
- Empty Pipe testing
- Flowline test by difference





Experience from Alvheim:

Alvheim is considered as a success:

- Good and steady production. Most wells are producing over reservoir bubble point.
- Allocation amounts are within +- 6% for oil and 8% for gas as the minimum proposed limits.
- Volume allocation is feasible due to oil cargo shipments by volume,
- The gas sale is by energy on blended GCV.
- The produced fluid from the fields are close in composition, quality and sp.gr.

Contribution to the success:

Less investment cost. Multiphase meters require less deck space and weight, rel. separators, valves and piping.

Less sampling and analyzing cost.

Less complexed allocation calculation; no split down to each component, no field GCV calculation etc.

No conversion calculation from mass to volume and hereby no difference between measured volume and calculated volume.

Volume is easy to relate to and is used (directly) in lifting accounts, cargo reports and other reports.

Close follow-up of a lot of data and monitoring parameters gives a good overview of the process from well to sale.

Close follow-up and strict control of well test and well allocation.

Dedicated work forces offshore and onshore.

Close communication/collaboration between P-tek, metering, reservoir and Hydrocarbon Management

No waiting for analysis result and herby final allocation is conducted soon after the month end.

Experience from Alvheim:

Potential for improvement:

- More measurement points. One topside MPFM per flow line would have reduced one allocation step.
- More redundancy in instrumentation and measurements, particular subsea for well testing and well monitoring.
- Wider range in the subsea MPFM for well testing.
- Faster data communication with the subsea monitoring system.
- Dedicated topside test separator to calibrate/check the topside MPFM to improve measurement and sampling.
- Easier configuration for taking CVA and PVT samples.

Reflection/Challenges:

- The Alvheim allocation is a plain, but require a lot of human resources and effort to make it perform properly in operation. (Operation complexity, access to equipment, data and functionality.) Higher risk for errors.
- It is a pressure and temperature dependent system.
- Little or poor information regarding fluid quality per field, due to sampling access.
- One shrinkage factor (oil recovery factor) applied per field per total volume.
- Blended export quality is common for all fields.
- Crude oil value adjustment related to blend, but no adjustment for gas GCV.
- Allocation corrections are complicated and time consuming.
- Could face future sever challenges, if higher differences in the fields fluid properties.
- Allocation uncertainty and bias calculations are complexed.

NFOGM
NORWEGIAN SOCIETY FOR OIL AND GAS MEASUREMENT

Thank you – questions?

Tekna