FluidMagic –
PVT consistency in allocation from well test to field level

Hydrocarbon Management Workshop 2023, 01/06/2023

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Topics

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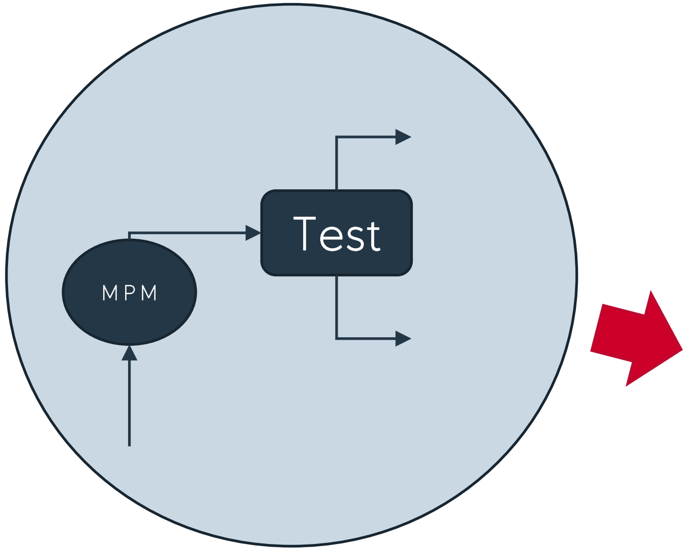
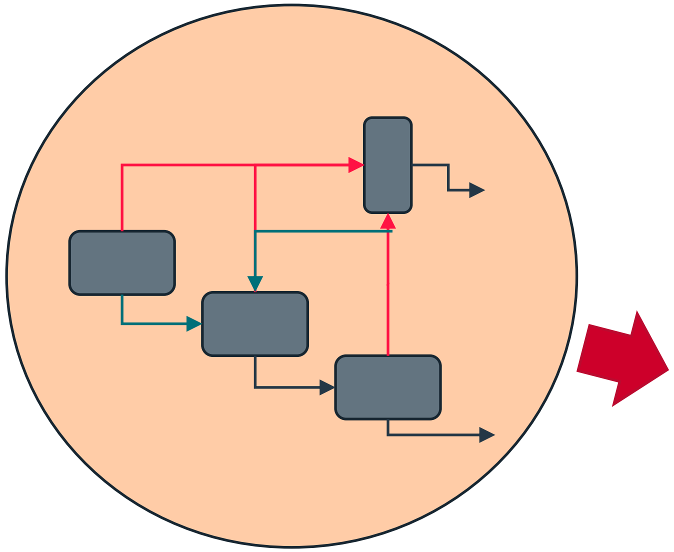
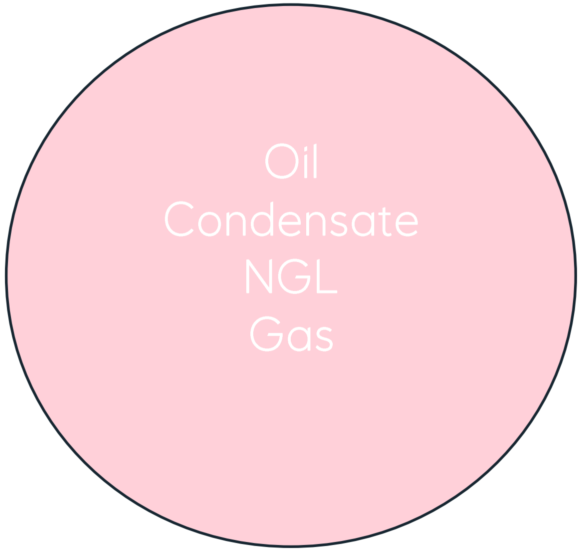
Rate measurements

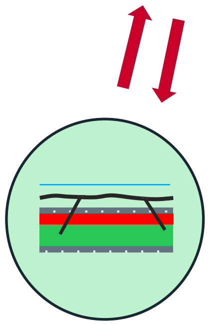


Surface process allocation



Sales products





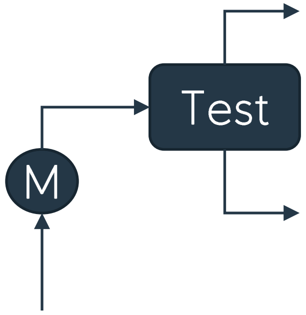
Reservoir allocation

Key elements/problems;

- At metering point:
  - Volume-rate, mass-rate, density, compositions, pressure and temperature
- Resulting Sales products
  - Separation, Shrinkage factors, PT tables, K-factors and ORF-factors

FluidMagic | Ensuring consistent fluids description across all disciplines by using a consistent fluid model for all calculations

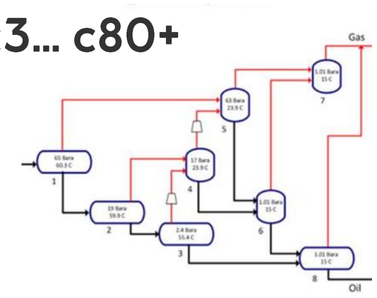
This is what I measure



The production engineer

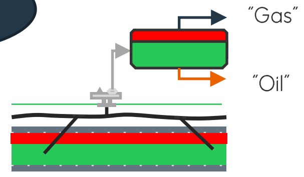
c1, c2, c3… c80+

This is what I need



The production/flow-assurance/process engineers

This is what I simulate



The reservoir engineer

This is what I sell

The economist

Rate Conversions - Problem Definition

(A) *Actual* to *Surface* Product Conversions | Problem statement

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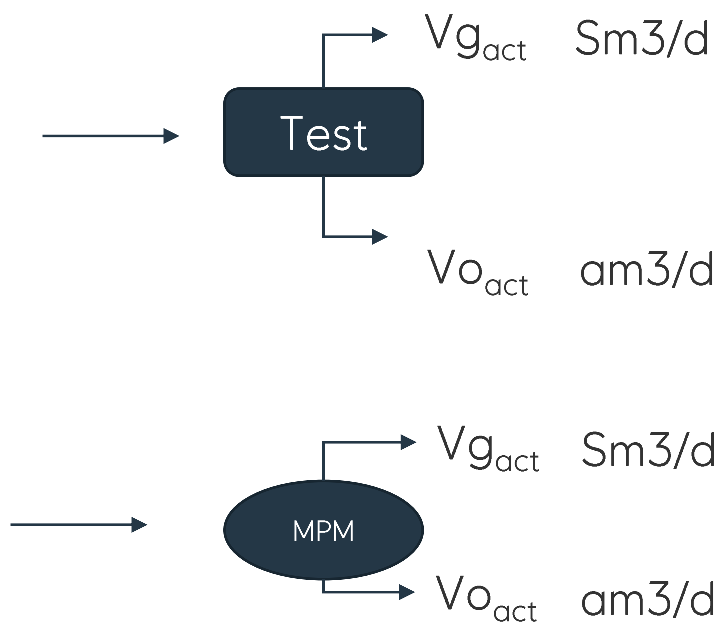
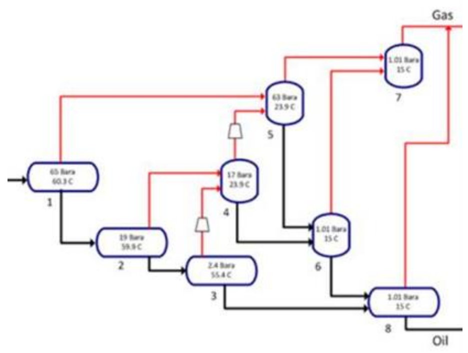
Given measured oil and gas volumes at separator conditions (p_{act} T_{act})...

What do measured volumes at actual conditions correspond to in terms of surface process volumes?



Surface process facility



Vg_{pro} ?

Vo_{pro} ?

Note: act = actual = line measurements = a

(B) *Actual* to *Surface* Product Conversions ***when gas lift is added***

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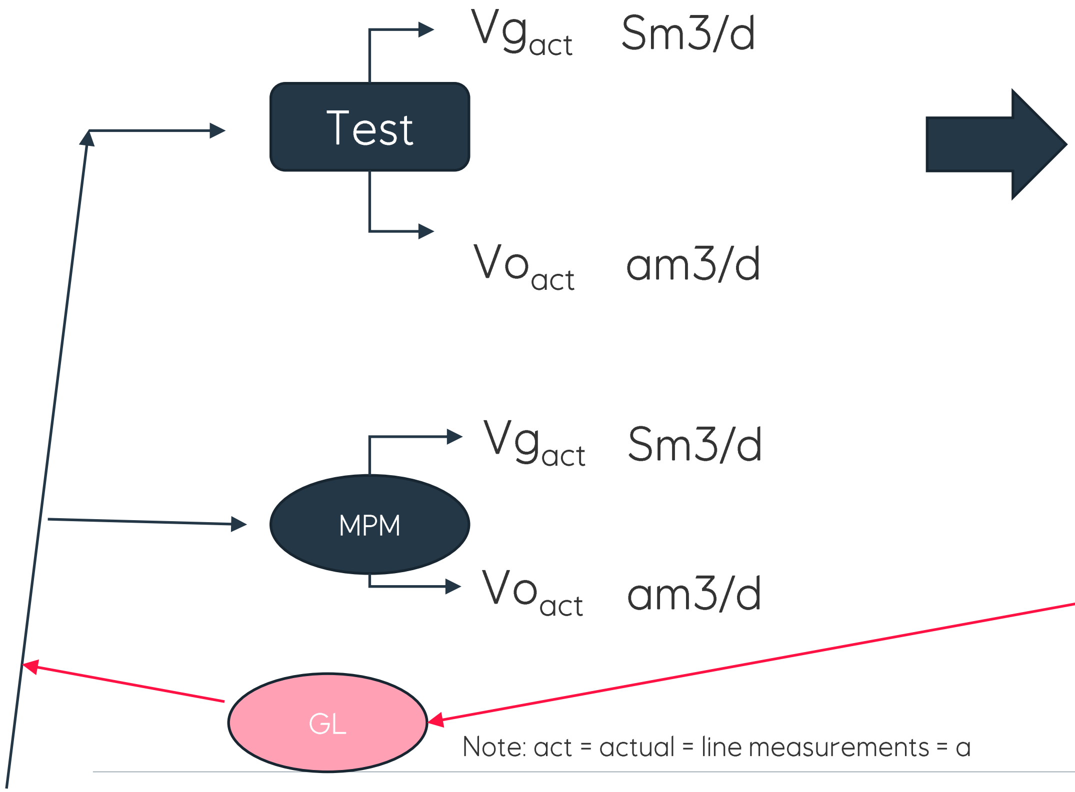
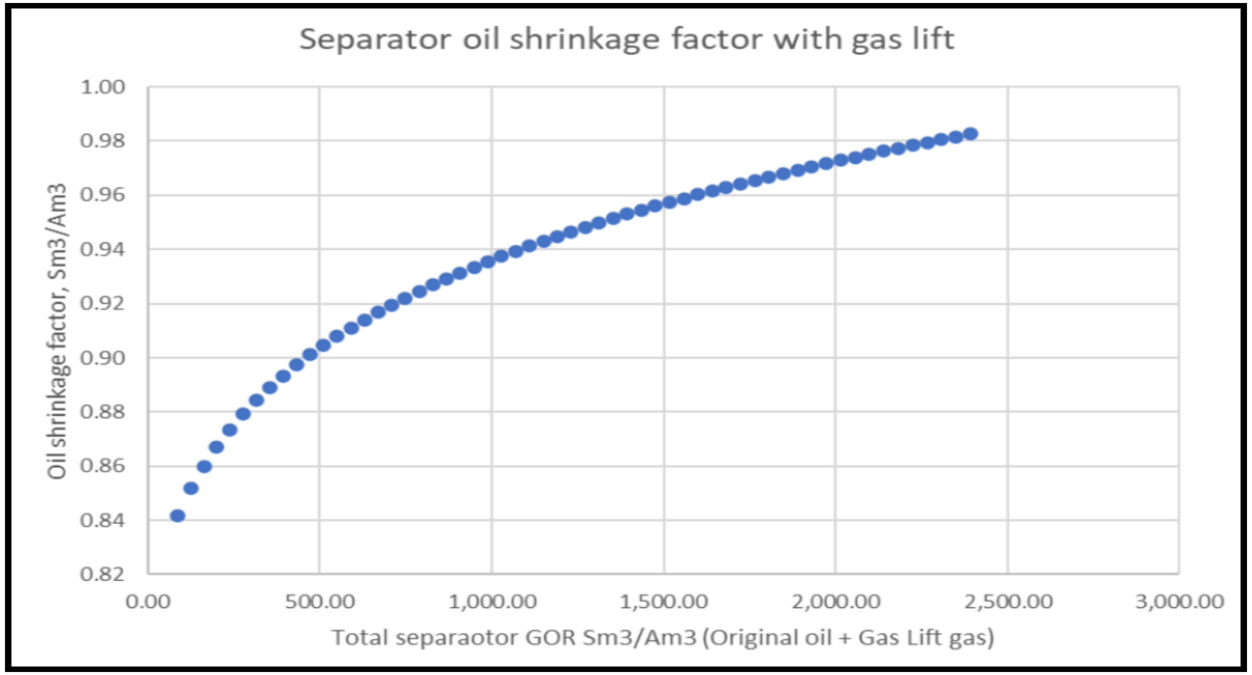
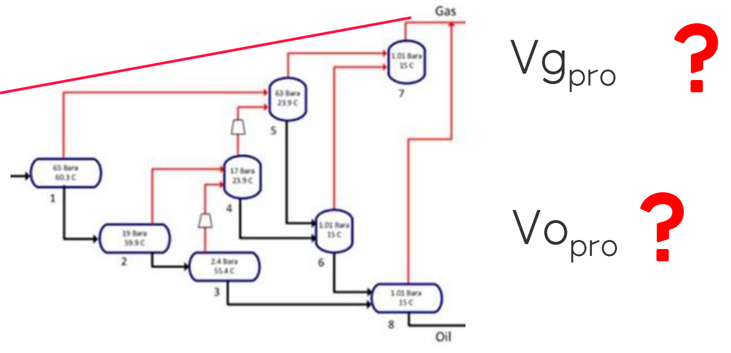




Surface process facility



Note: act = actual = line measurements = a

Rate conversions - Solution Methods

Solution methods: (1) p-T conversion tables, using fixed feed composition

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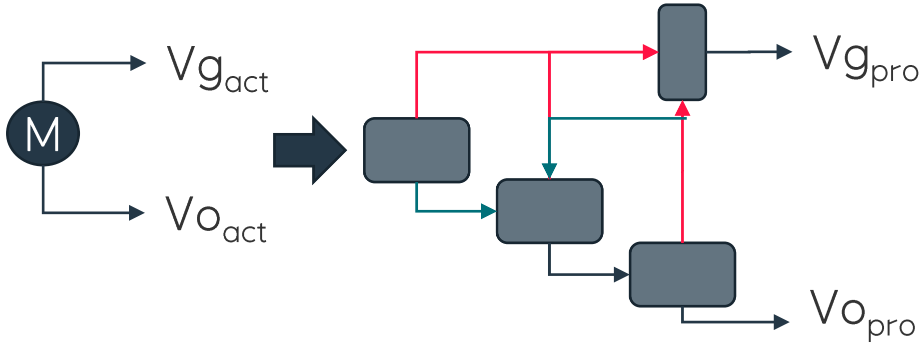
Basis:
- An estimated fluid well stream composition
- A (tuned) equation of state (EOS) model
- A representation of the surface process



Post Inlet Oil shrinkage (1/Bo) [Sm3/m3]

P/T	3	10	12	14	16	18	20	22
10	0.99355105		0.956743823		0.947910237		0.939794274	
20	0.986312392		0.955056221		0.946896381		0.939273676	
30	0.978015448		0.951920963		0.944545251		0.937520722	
40	0.969048738		0.947421725		0.940876289		0.934515336	
45	0.964401021		0.944711584		0.93857806		0.932558305	
50	0.959676617		0.941728443		0.935995405		0.930315236	
55	0.954893822		0.938499551		0.933150224		0.927802911	
60	0.950067029		0.93505209		0.930065774		0.925040294	
65	0.945207648		0.931412235		0.926765674		0.922047684	
70	0.940324836		0.927604561		0.923273127		0.918845937	
75	0.935426033		0.923651677		0.919610341		0.915455739	
80	0.930517403		0.919574022		0.915798124		0.911897159	

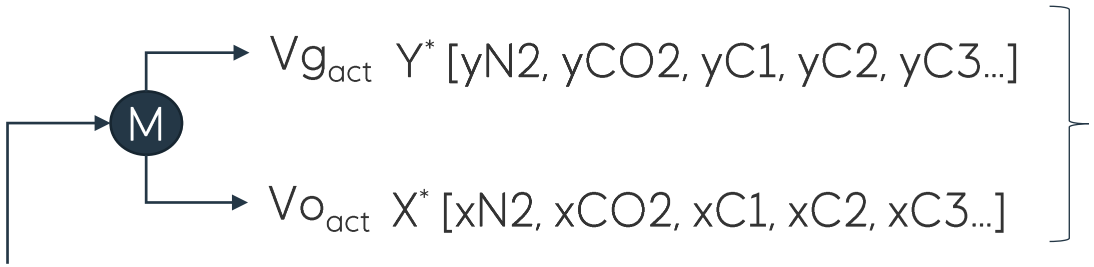
Methodology:
- Calculate process volumes for estimated well-stream composition.
- Calculate corresponding actual oil- and gas volumes at different p_{act}, T_{act}

$$\text{Shrinkage}(p_{act}, T_{act}) = Vo_{pro}/Vo_{act}(p_{act}, T_{act})$$

- This approach cannot handle changing reservoir well stream compositions, nor gas-lift!
- May require frequent update (measurements) of feed composition and generation of new tables.

Solution methods: (2.) Recombine feed composition at actual conditions

Basis:
- An estimated fluid well stream composition
- A (tuned) equation of state (EOS) model
- A representation of the surface process

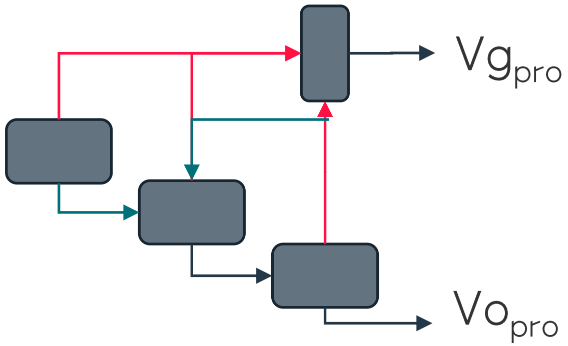


Z^* [N2, CO2, C1, C2, C3…]

Step-1:
- Flash feed composition at actual conditions
- Recombine calculated oil- and gas composition to match measured oil- and gas volumes (GOR)

- Provides updated estimate of well-stream composition

Step-2:
- Use updated feed composition to calculate corresponding surface process volumes



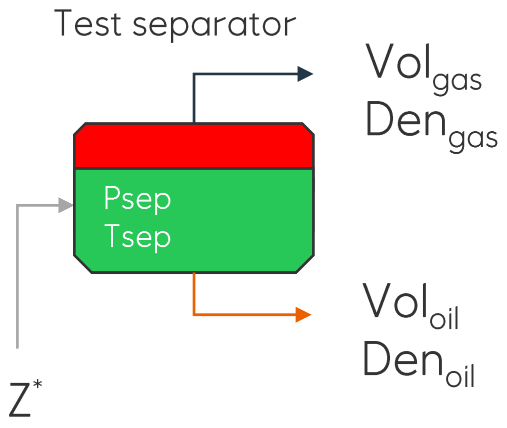
- Guarantees match of actual GOR.
- Does not guarantee match of actual densities.
- Effect of gas lift is (normally) not accounted for
- Does not guarantee accurate process rates!

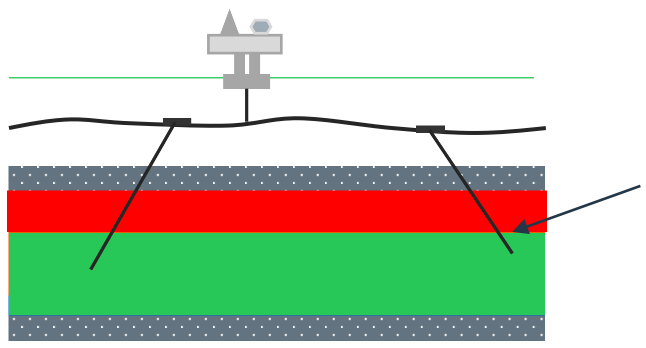
- May require frequent update (measurements) of well-stream composition.

Solution methods: (3.) FluidMagic approach

→ The new solution

Do NOT recombine at the top





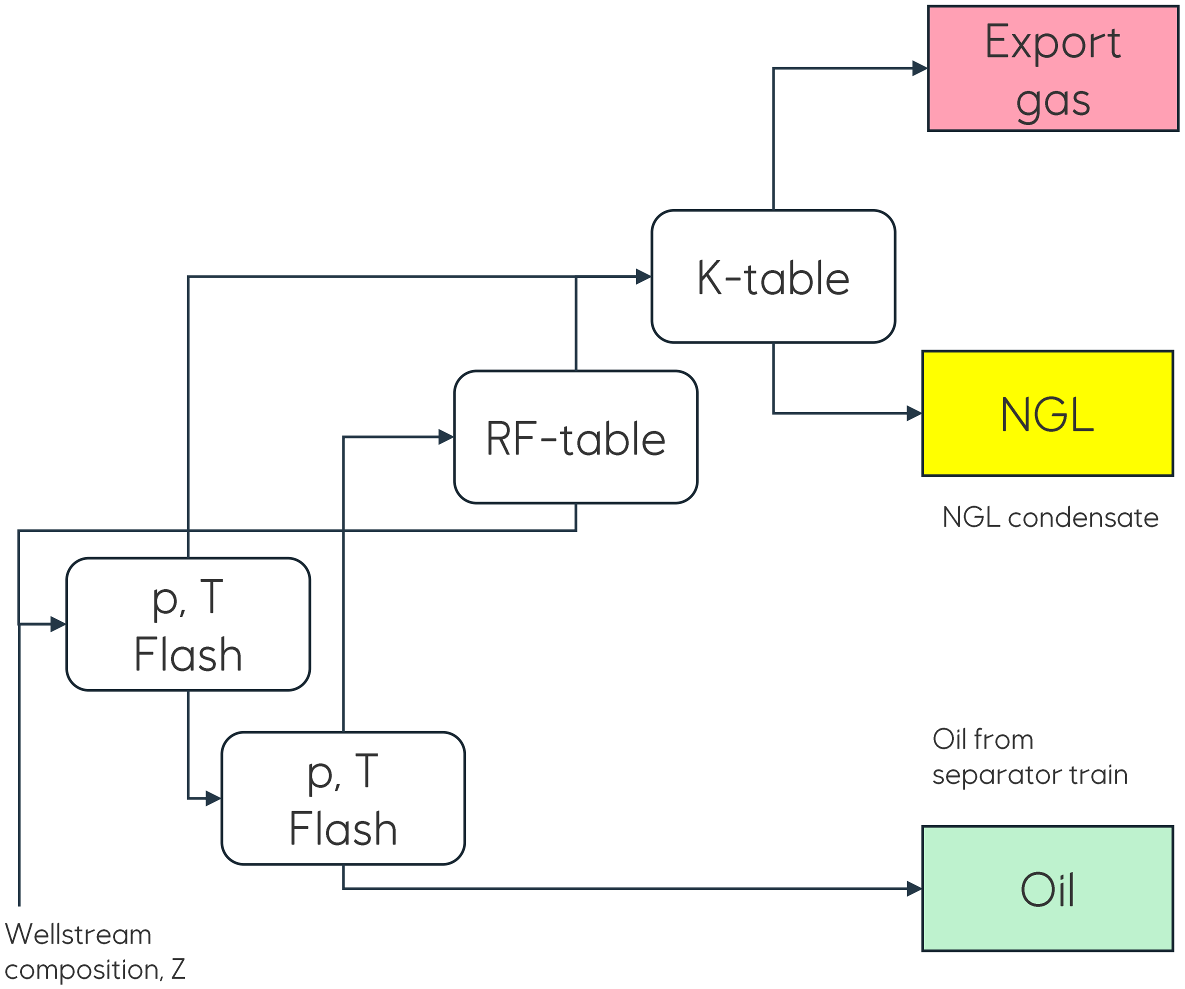
Recombine HERE!

- **Data required:**
  - Measured actual pressure and temperature
  - Measured actual oil and gas volumes/mass
  - Gas-lift rates.
  - Down-hole flowing pressure / reservoir pressure.
  - In-situ original reservoir compositions.
  - Measured actual oil- and gas densities (injection gas option)

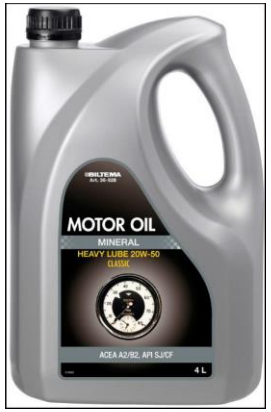
- Do not require frequent update of the estimated well-stream composition (fluid sampling)
- Improved match of actual fluid densities.
- Includes effect of lift gas
- Allocates reservoir fluids produced (free oil-, free reservoir gas and injection gas)

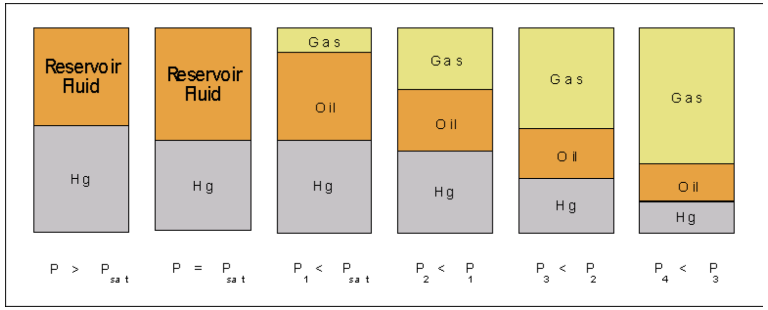
Rate Conversions – Surface process calculations

FluidMagic surface process module



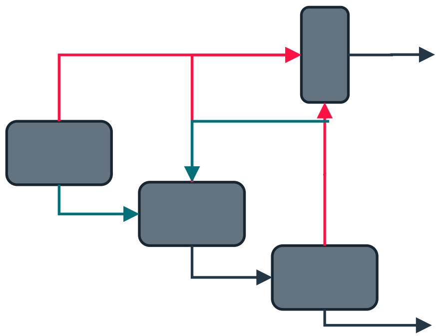
- Calculation of compositions & sales product quality
  - Oil composition, API
  - Condensate, LNG composition
  - Export gas composition and heating value





Representing the surface process using measured production data

By measuring this:



Vg_{pro}
ρg_{pro}
Y^* [yN2, yCO2, yC1, yC2, yC3...]

Vo_{pro}
ρo_{pro}
X^* [xN2, xCO2, xC1, xC2, xC3...]

You can ACCURATELY represent the surface process by calculating this:

Equilibrium K-values:
$K_i = y_i/x_i$

Oil component recovery factors:
$RFO_i = n_o*x_i/(n_o*xi + ng*yi)$

Allows for:
- Accurate surface process calculations without complex surface process simulations.
- Easy update with changing surface process conditions / input feeds.
- Allocation by component mole/mass basis.

Summary

- FluidMagic allows for:
  - Consistent conversions from measured volumes to surface process volumes.
  - More robust methodology in terms of changing well stream compositions.
    - Requires less fluid sampling, or improved methodology when fluid sampling is not feasible.
  - Enabling reservoir fluid allocation.
  - Easy and automated update of p-T conversion tables.
  - Accurate description of the surface process, based on measured surface process compositions.