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IPTC-19775: Quantifying Separator Oil Shrinkage

Mathias Carlsen | Curtis Hays Whitson

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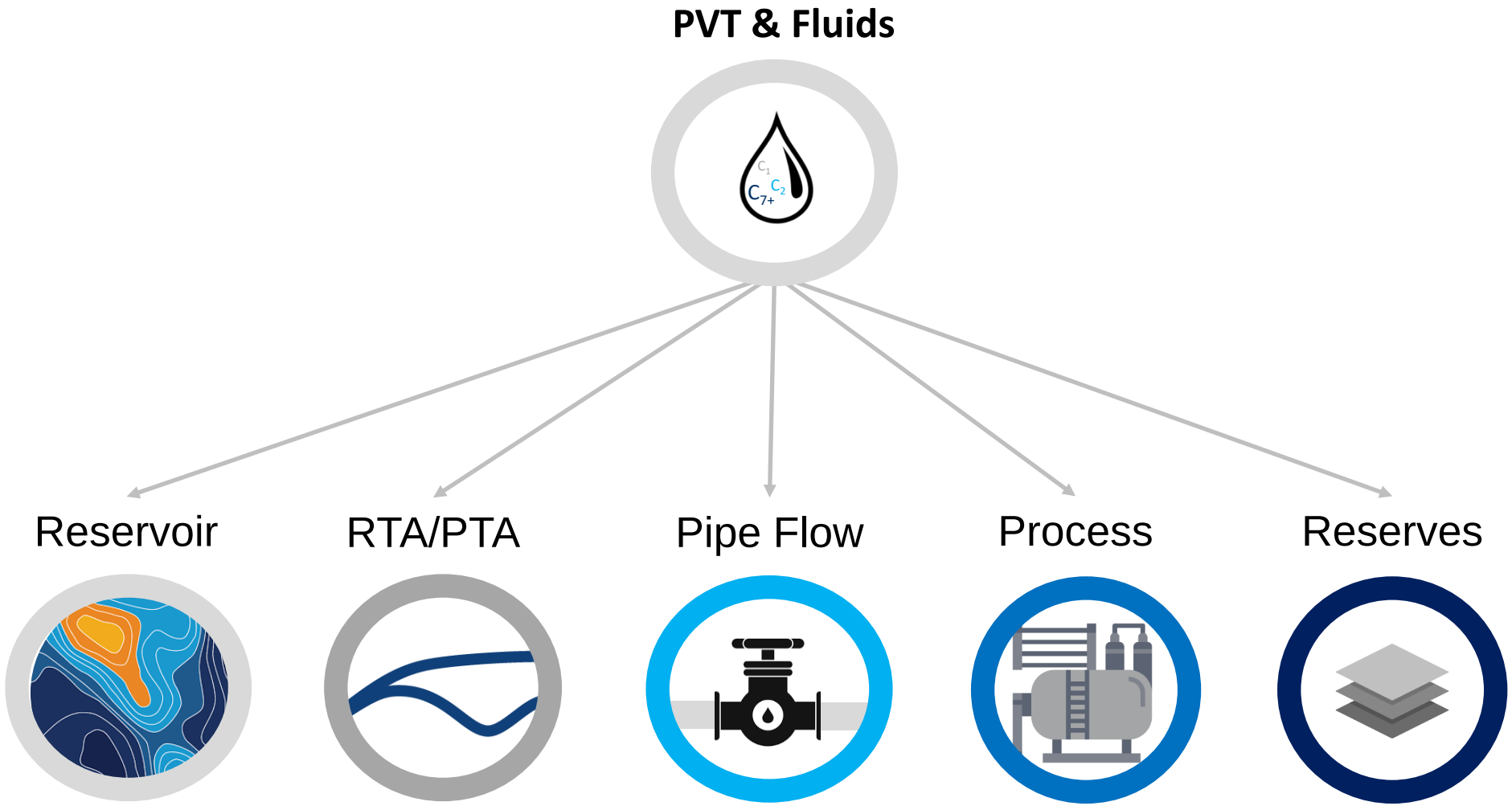
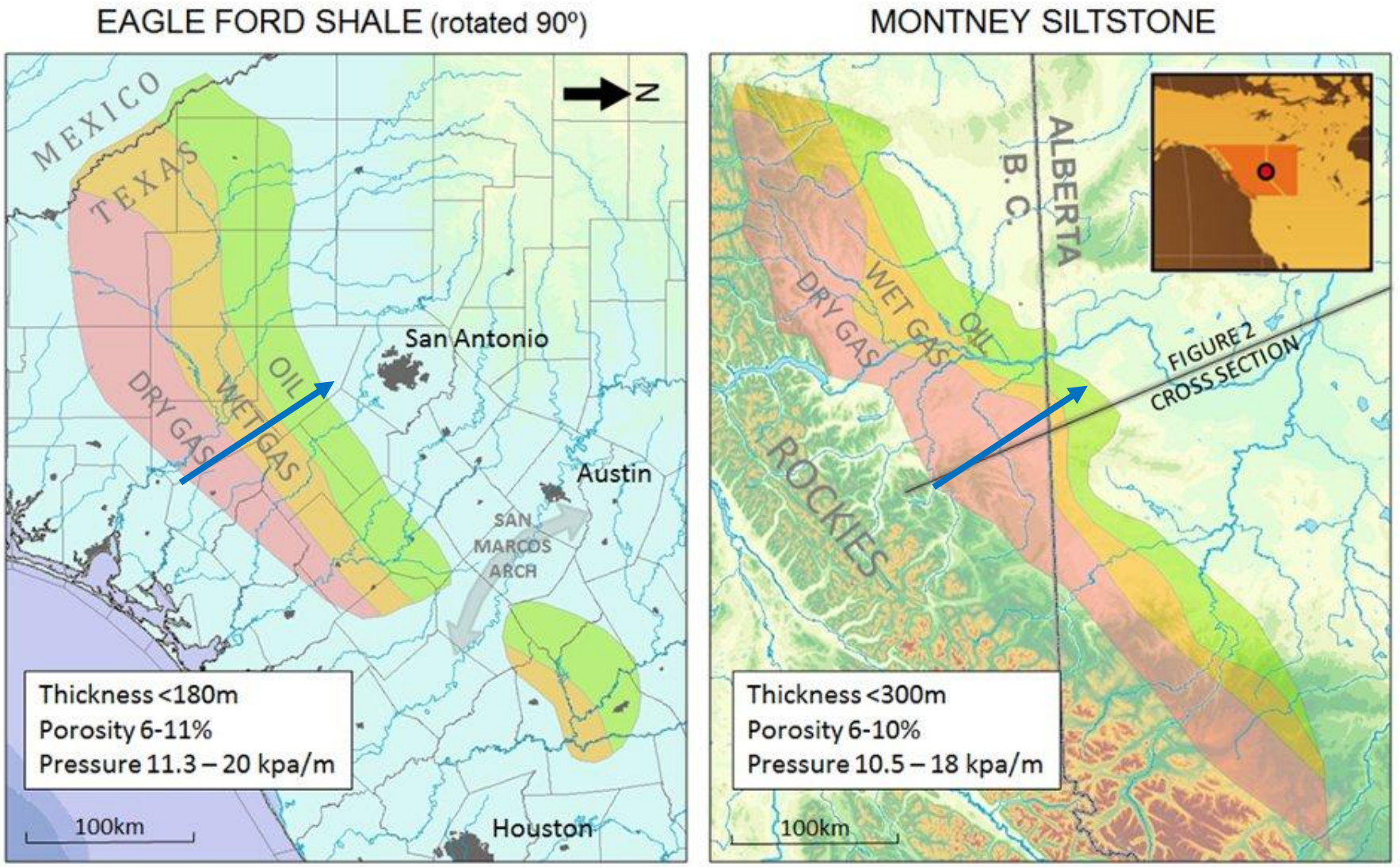
PVT has an Impact on Every Discipline in the Petroleum Domain!



“Shale” Basins Span a Wide Range of Fluids



Work is based on studying 100s of PVT reports in “shale”

Eagle Ford – 60+ PVT samples (2017)

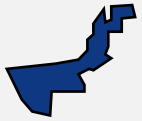
Bakken – 20+ PVT samples (2018)

Montney – 60+ PVT samples (2018)

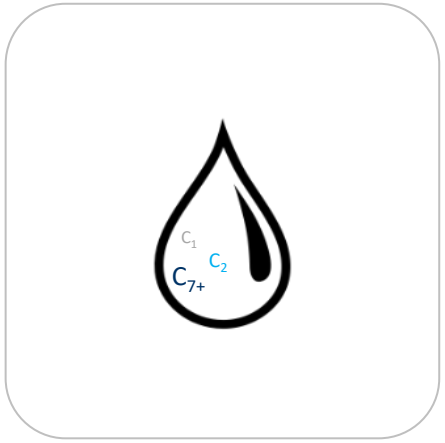
SCOOP/STACK – 40+ PVT samples (2019)

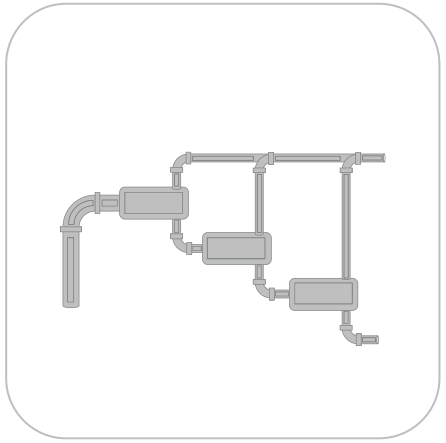
Permian – 120+ PVT samples (2019)

Unconventionals Contain "Complex Fluids"

Basin	Near Critical Fluids	Saturation Pressure (psia)
 Eagle Ford	✓	2000 - 7000
 Bakken	–	1500 – 3500
 Montney	✓	2000 - 7000
 SCOOP/STACK	✓	2000 - 7000
 Permian	✓	1000 – 7000

Narrow Discussion to … Separator Oil Shrinkage





FLUIDS

SHRINKAGE
of
Separator Oil

Relevant for a Wide Range of Disciplines …

Practical Observations made in "Shale"

Rates are measured at separator conditions and seldom reach "stock tank" conditions on a single well basis

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- Albeit not correct, **separator measured rates** are frequently used directly in well analysis

  → overestimate the profitability

Practical Observations made in "Shale"

Rates are measured at separator conditions and seldom reach "stock tank" conditions on a single well basis

- Albeit not correct, **separator measured rates** are frequently used directly in well analysis

  → overestimate the profitability

- If separator shrinkage is accounted for, common to apply one **constant** shrinkage factor for well and/or region

  → shrinkage factors change with time

Topics to Investigate …

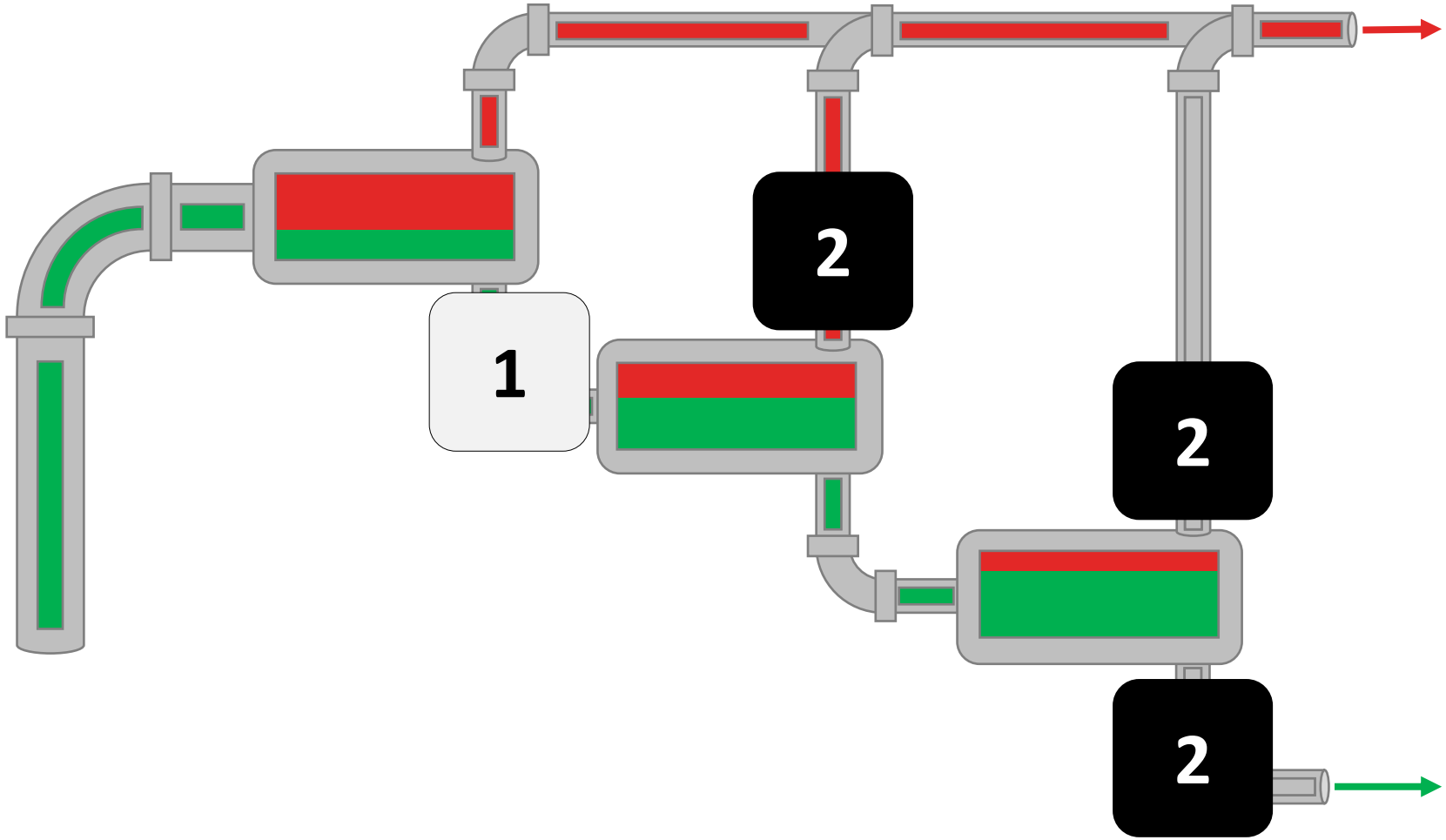
- **Under what circumstances is …**
  … separator oil shrinkage important?
  … expected to change considerably with time?

- **How use an EOS model to estimate daily**
  … separator oil shrinkage factors (STB/sep.bbl)
  … separator oil flash factors (scf/STB)

Separator Oil Shrinkage

A Recap

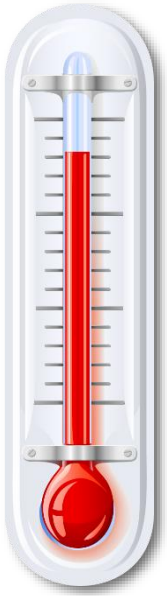
Separator Oil Shrinkage … A Recap



*This is a cartoon not to scale

Separator Oil

PRESSURE

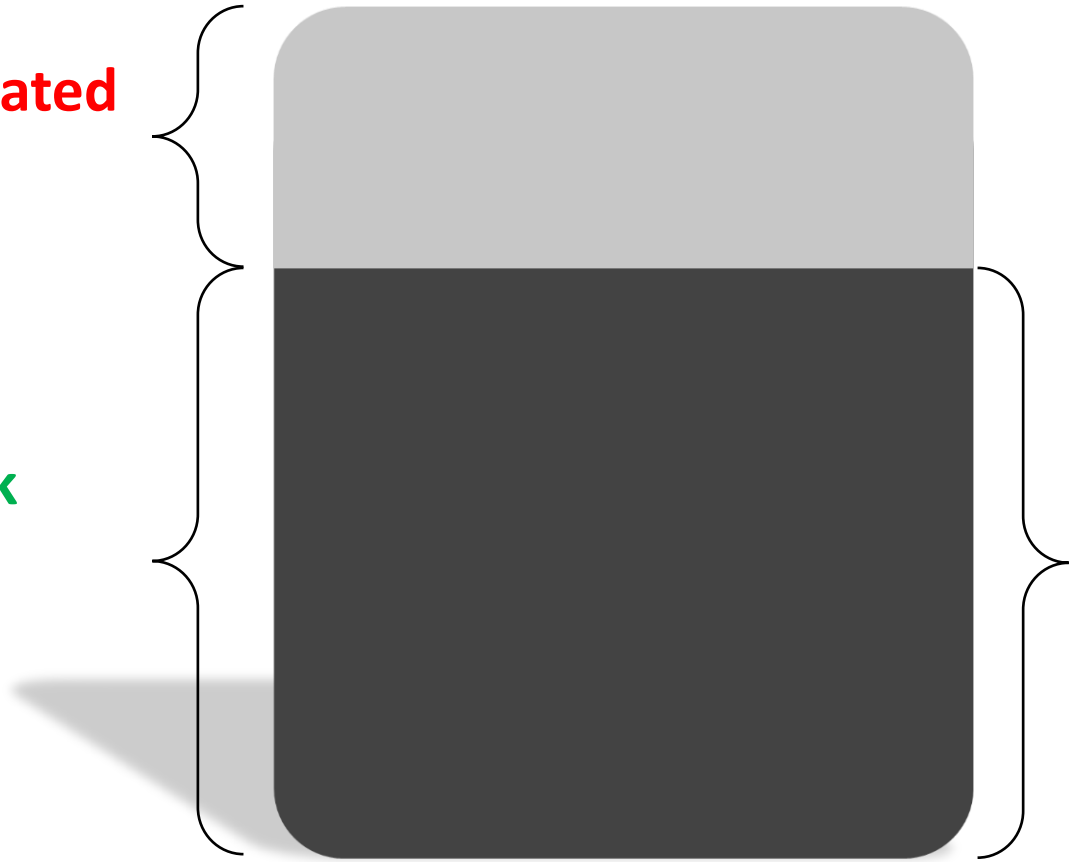


TEMPERATURE

Shrinkage of Oil and Additional Gas “Flashed Off”

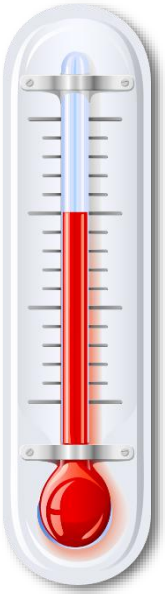
Liberated Gas

Stock Tank Oil



e.g. 80%

PRESSURE



TEMPERATURE

Separator Oil Shrinkage Factor (SF)

$$SF\left(\frac{STB}{sep.bbl}\right)$$

<0.6 - 1

Separator Oil Flash Factor (FF)

$$FF\ \left(\frac{scf}{STB}\right)$$

Essentially solution GOR of separator oil

Total GOR

$$GOR_{tot} = \frac{GOR_{sep}}{SF} + FF$$

Units of scf/STB

1. Under what circumstances is …

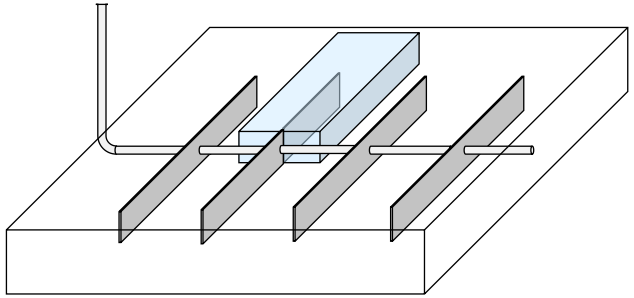
…separator oil shrinkage important?

…expected to change with time?

To Understand When It is Important, we …

… a wide range of in-situ fluids (reservoir oils | reservoir gas)

… with a **compositional** reservoir simulator

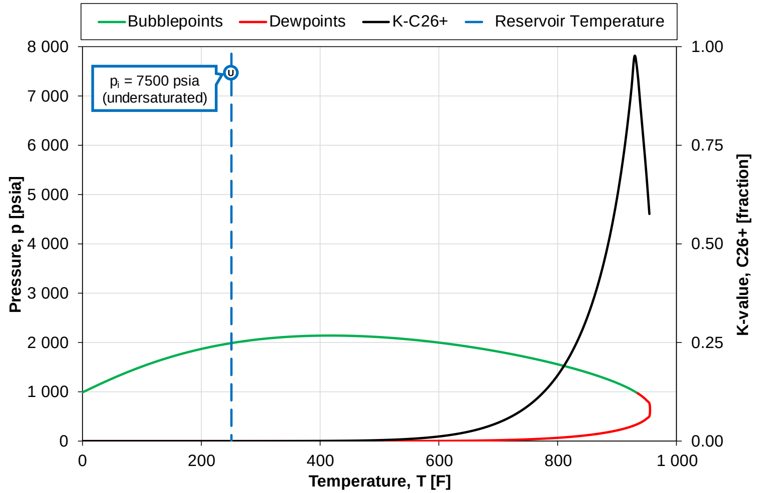


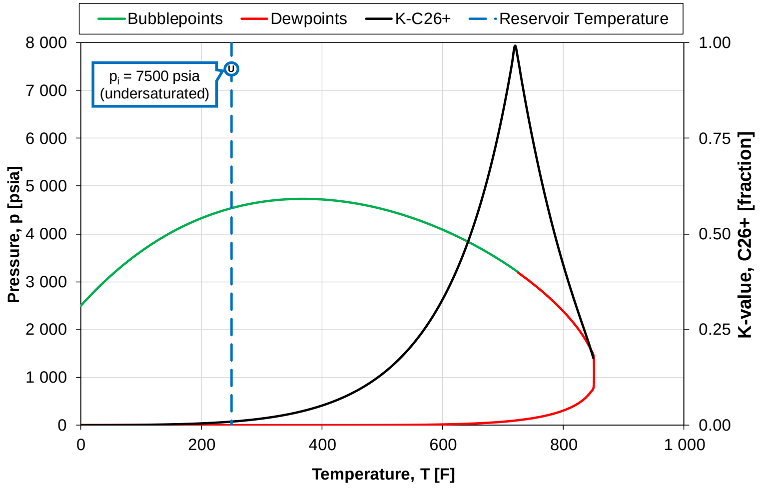
… controlled on a **constant BHP** profile

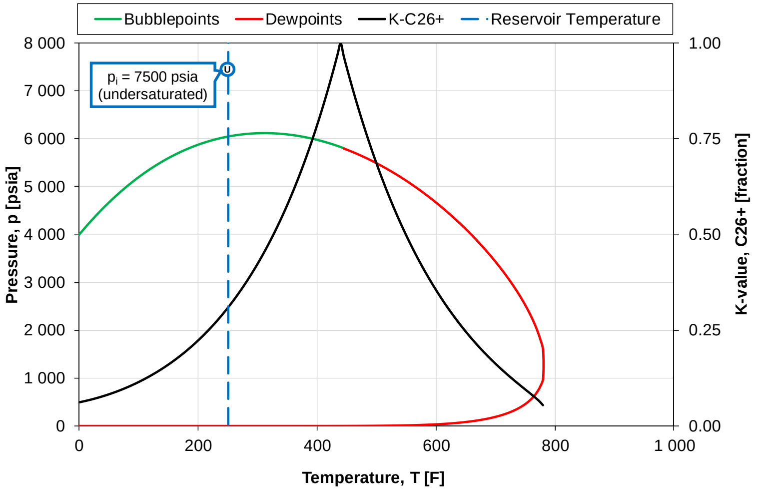
… i) fluids produced at **constant** separator conditions

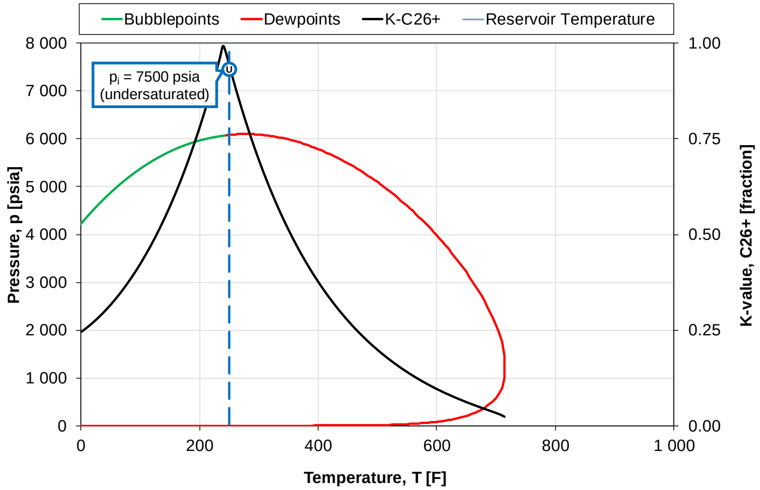
… ii) fluids produced at **changing** separator conditions

A Wide Range of Fluid Systems Studied (p_{Ri} = 7500 psia)









A Wide Range of Fluid Systems Studied (p_{Ri} = 7500 psia)

Black Oil

Volatile Oil

Near Critical Volatile Oil

Near Critical Gas Condensate

What is Separator Oil Shrinkage a Function of?

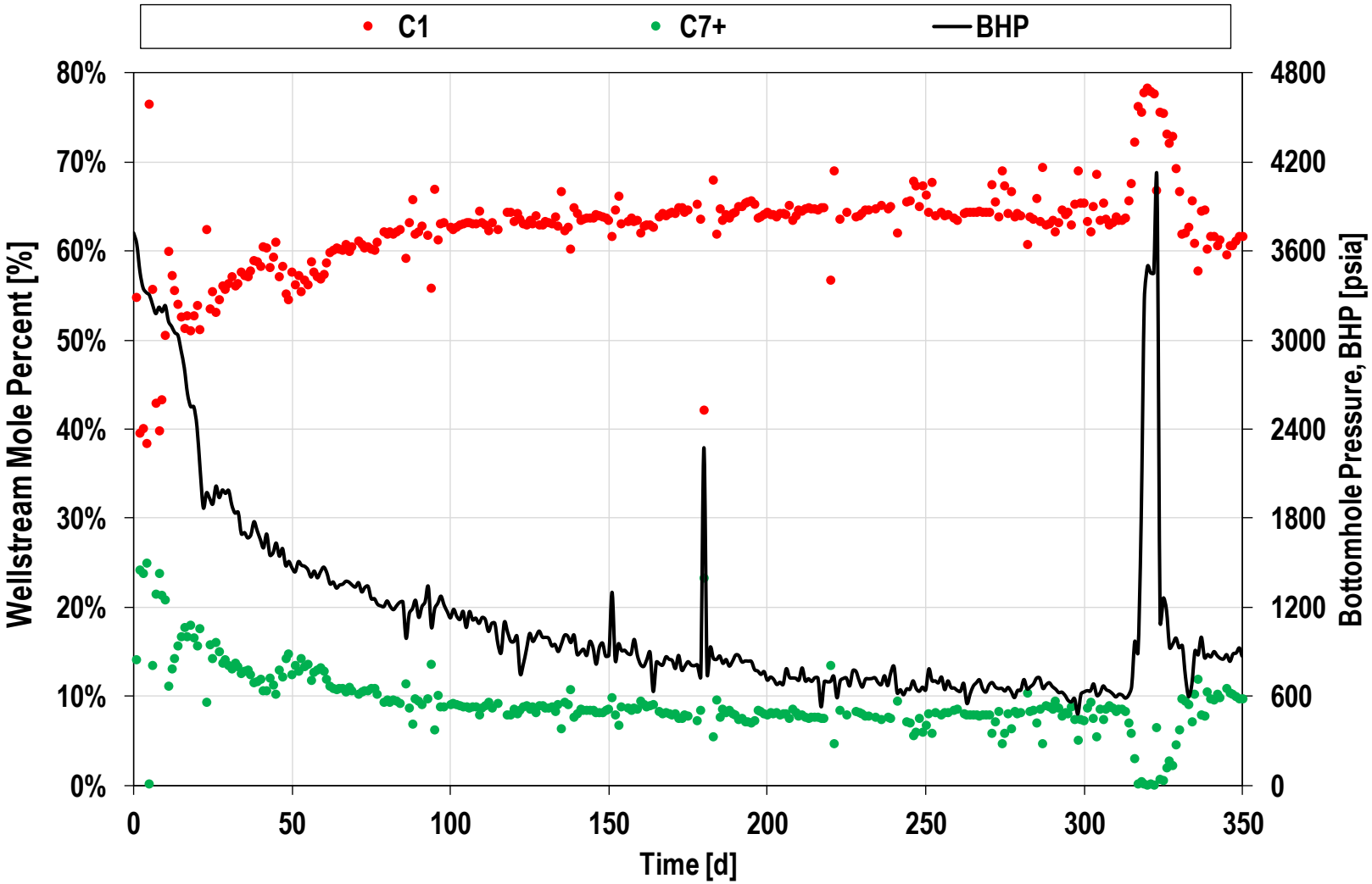
Surface Process

- Separator Stages - fixed
- Separator Pressure (p_{sep}) – f(time)
- Separator Temperature (T_{sep}) – f(time)

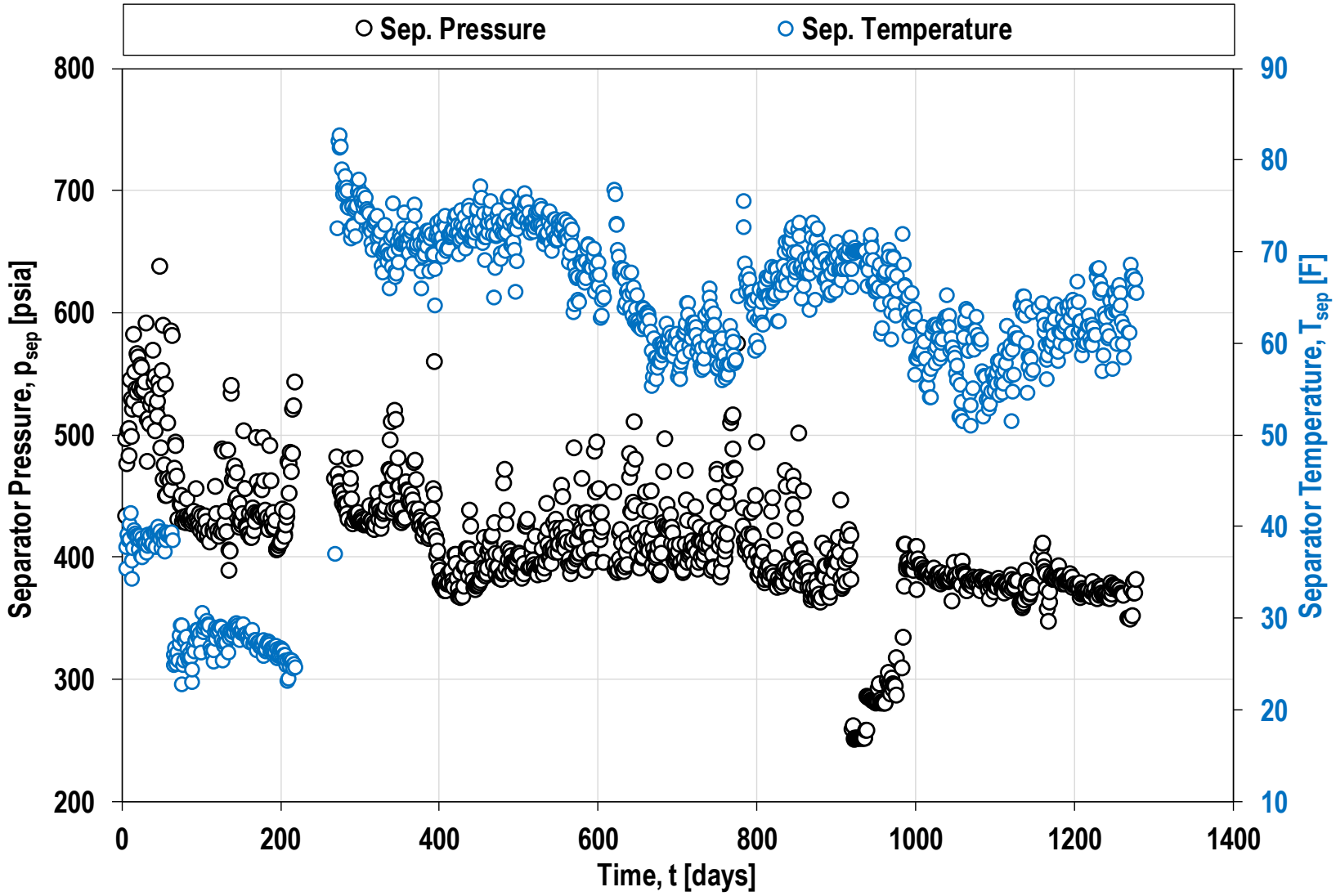
Wellstream composition (z_i) – f(time)

- Amount of different components (C_1 | C_{7+})

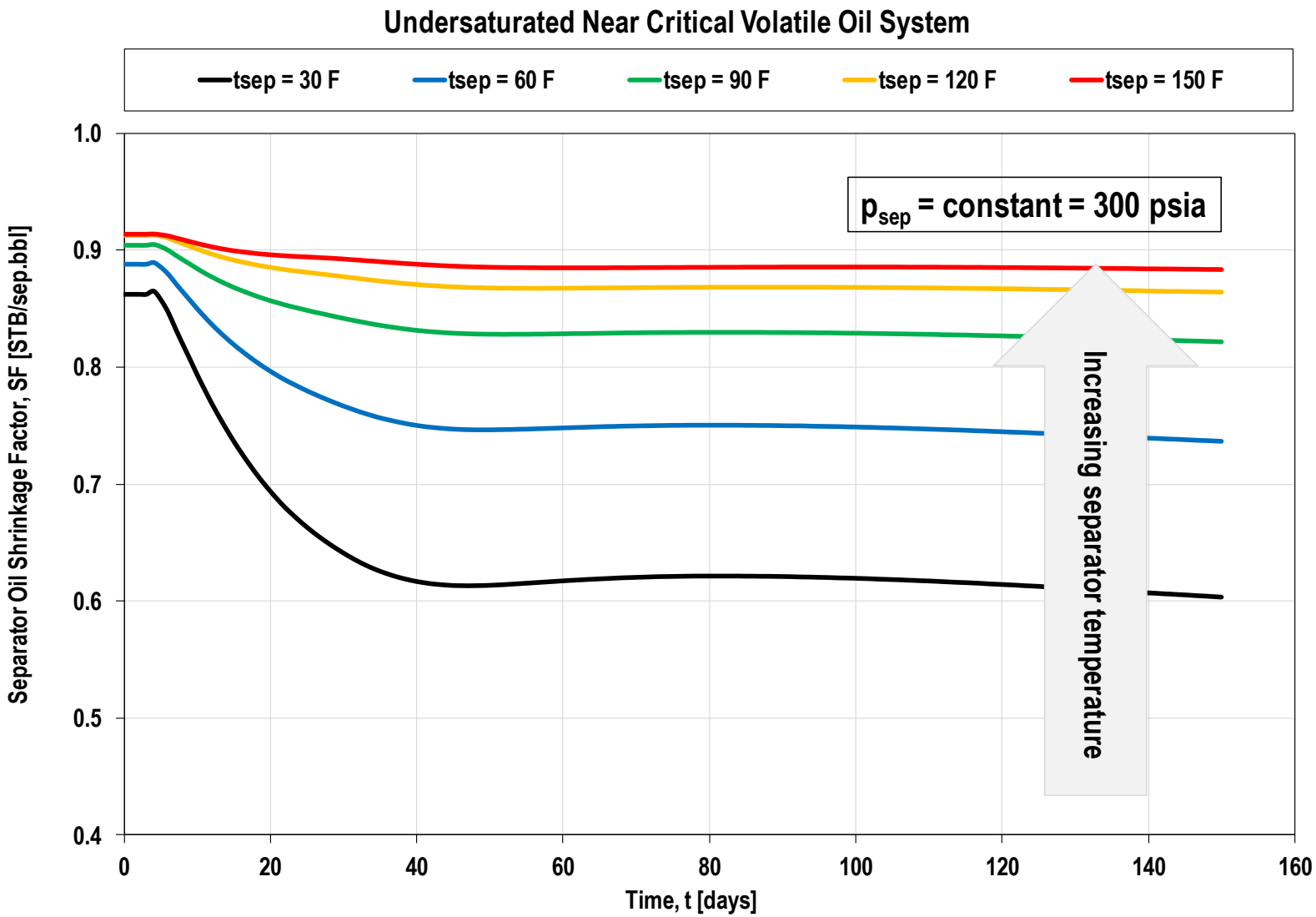
Wellstream Compositions Change Substantially with Time



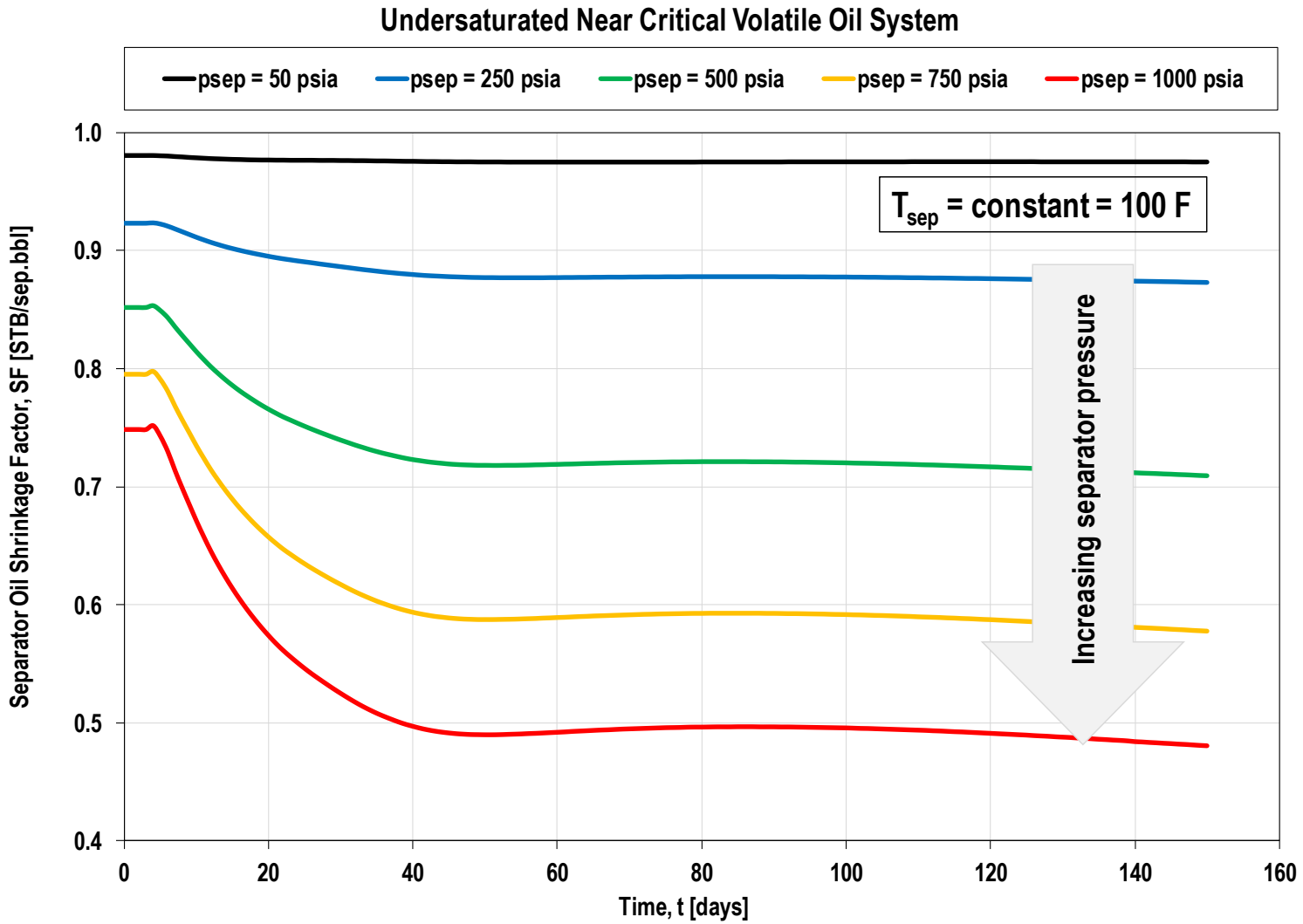
Separator Conditions Changes Substantially with Time



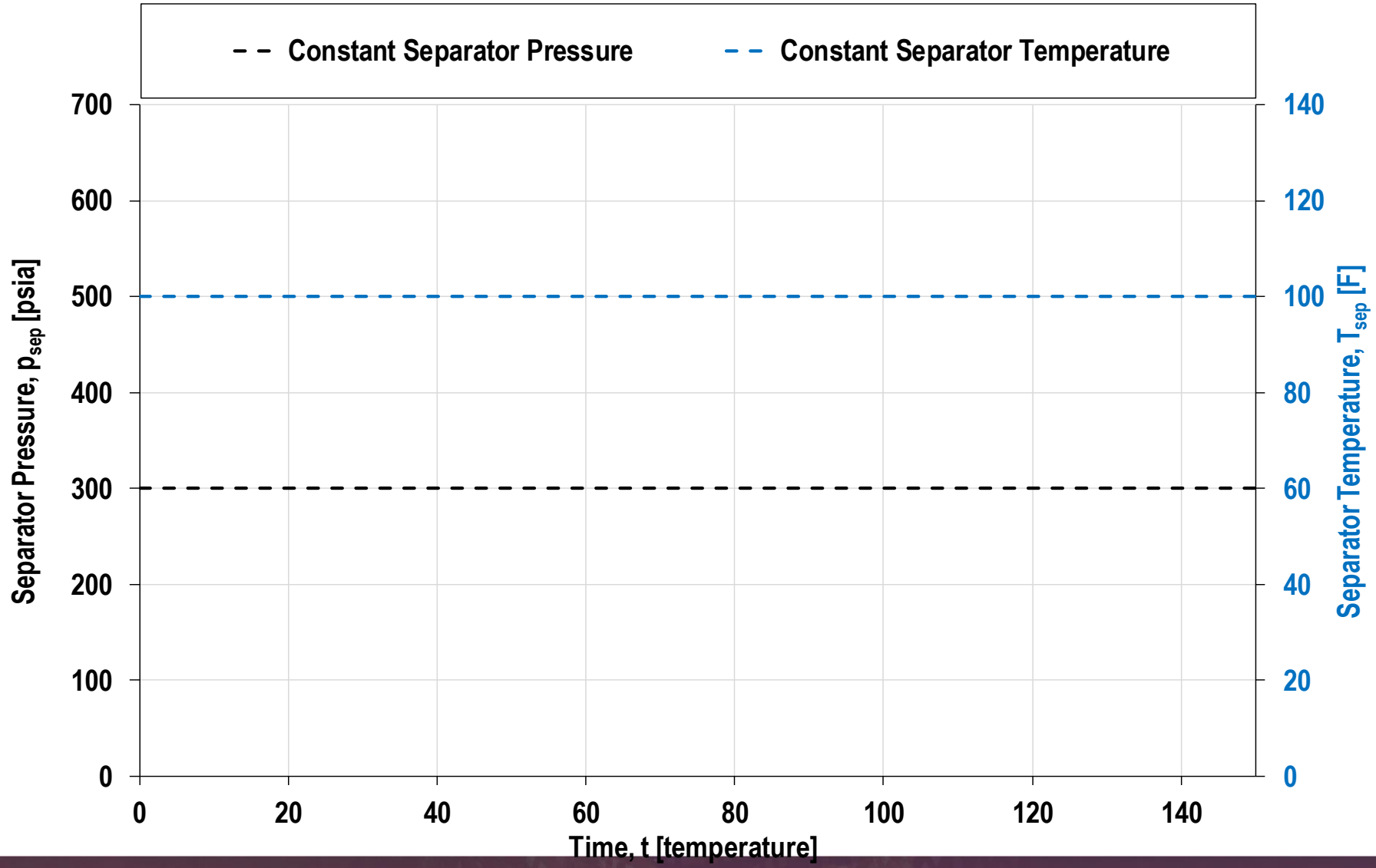
Lower Sep. Temperature, Lower Shrinkage Factor!



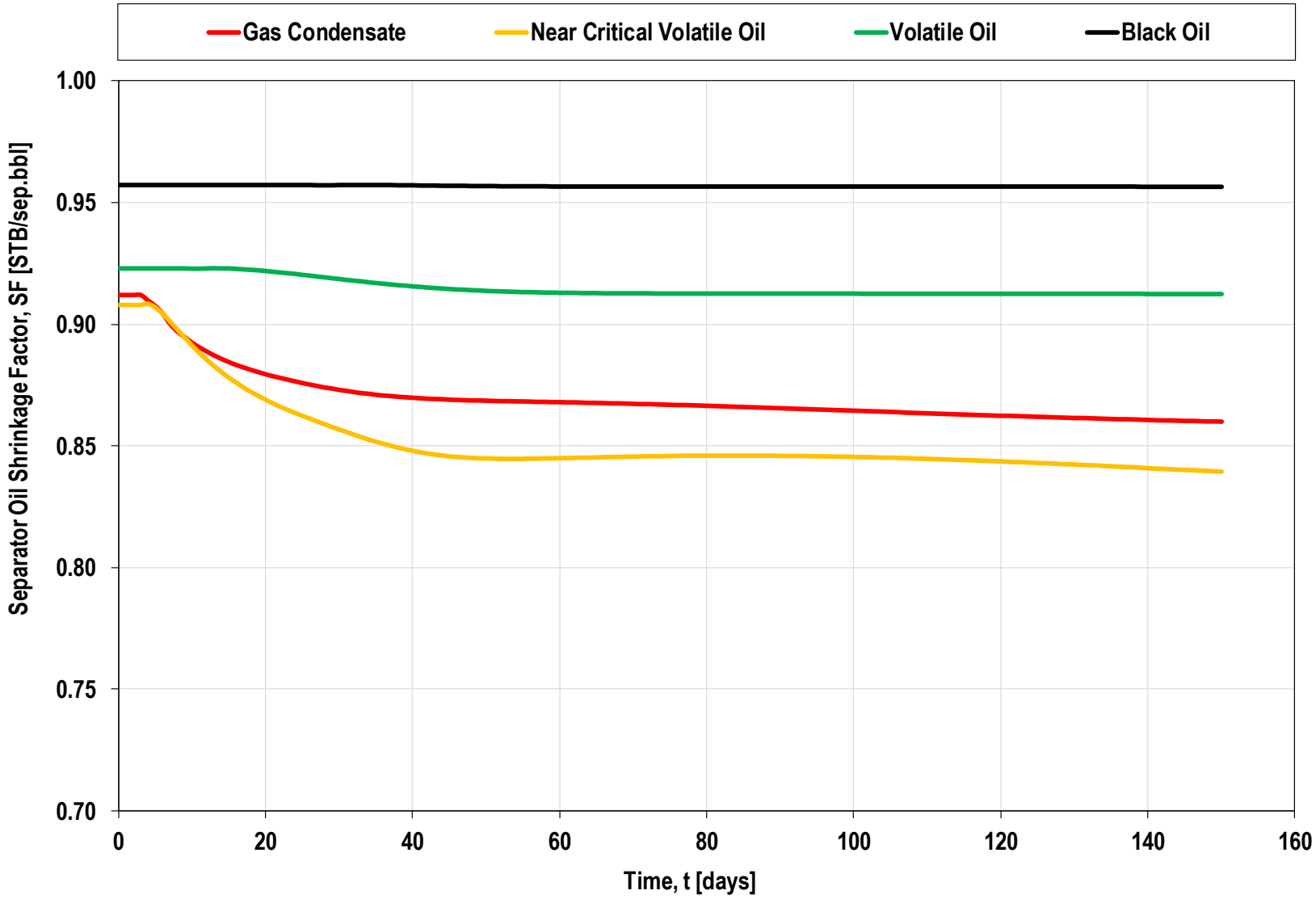
Higher Sep. Pressure, Lower Shrinkage Factor!



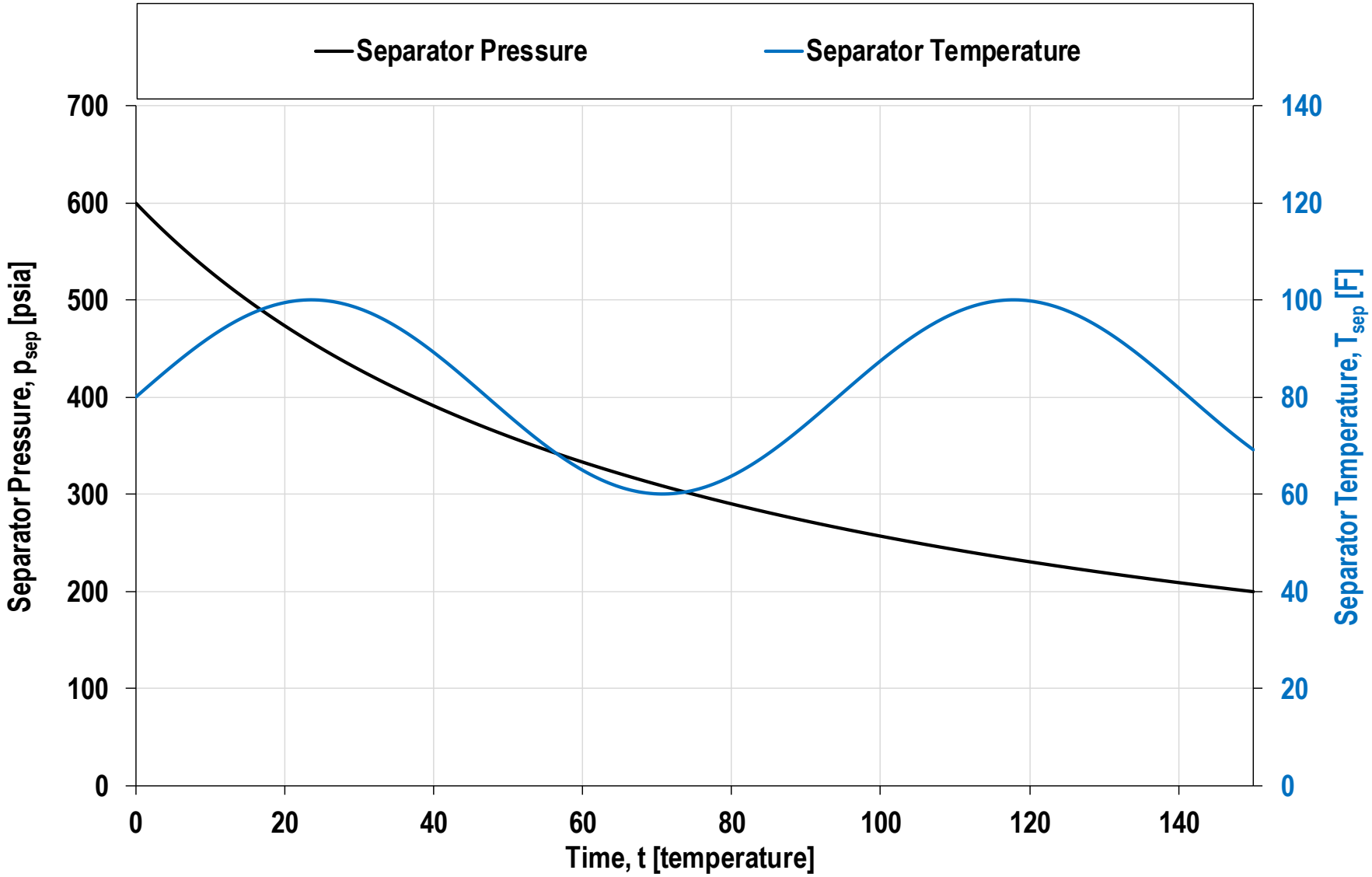
Constant Separator Conditions



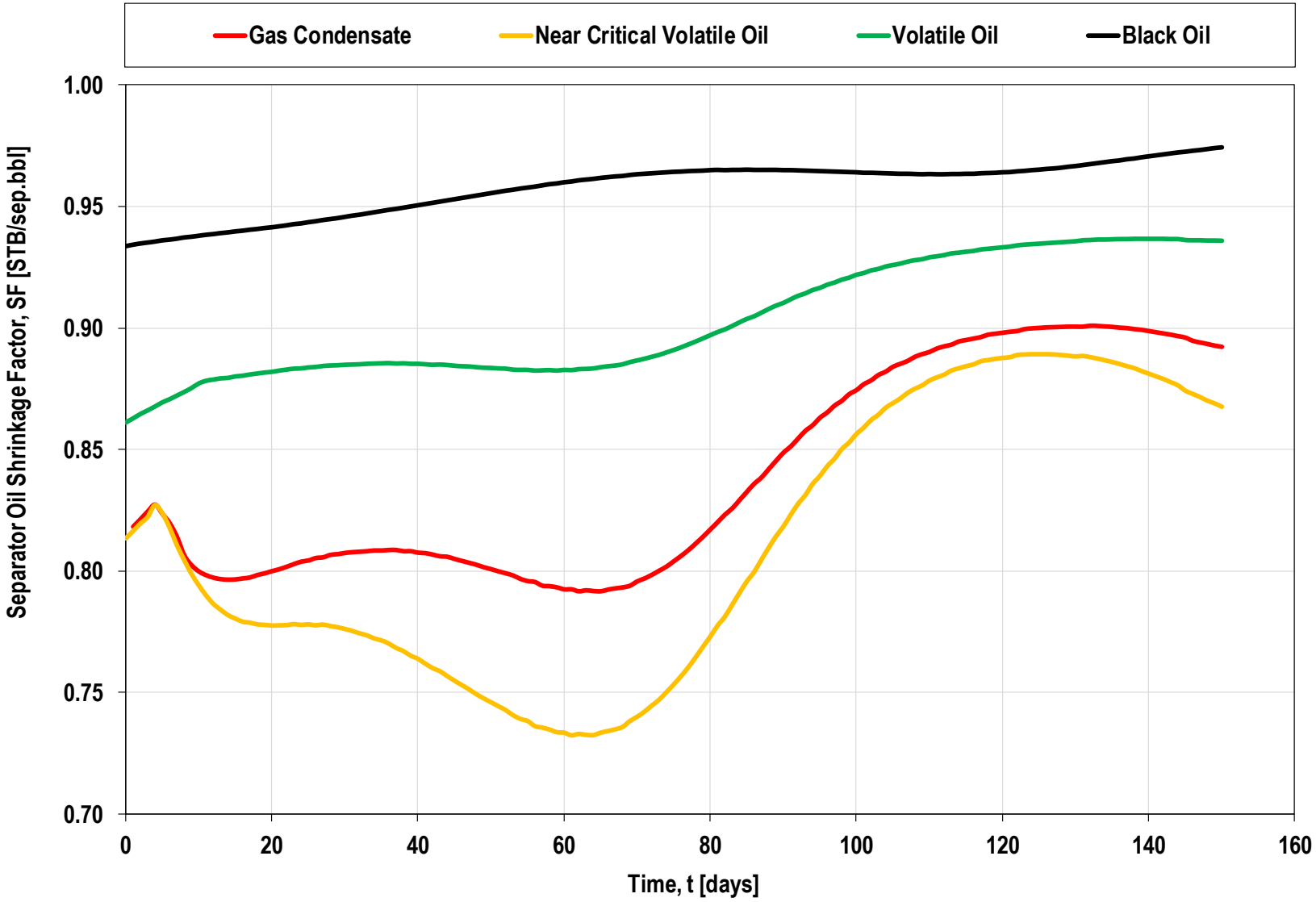
Lower Shrinkage Factors at Higher GORs



Changing Separator Conditions



Changing Separator Conditions has a Big Impact!



Summary

Shrinkage factors **and flash factors should be updated daily if one or more of these criteria are met:**

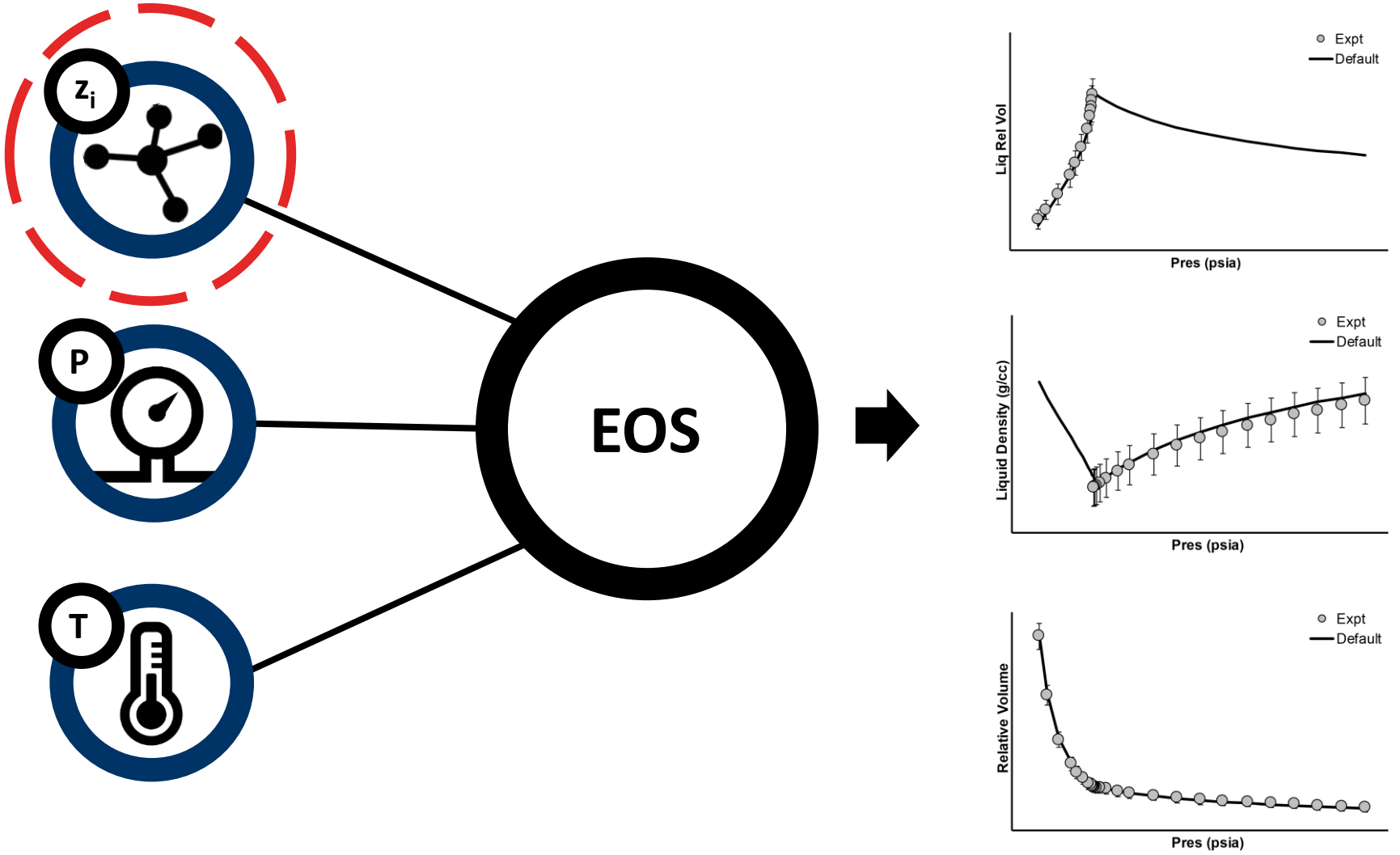
- In-situ solution GOR (R_s) > 1000 scf/STB
- Separator conditions changing with time
- Wellstream compositions changing with time
  - … Large changes in producing GOR with time
  - … Rapid decline in bottomhole pressure
  - … Frequent shut-ins (“CGR kicks”)
  - … Wells subject to gas EOR

2. EOS model to estimate daily

… separator oil shrinkage factors

… separator oil flash factors

What is an EOS Model a function of?



Field Example … A Pragmatic Approach

Requirements to Estimate Wellstream Compositions …

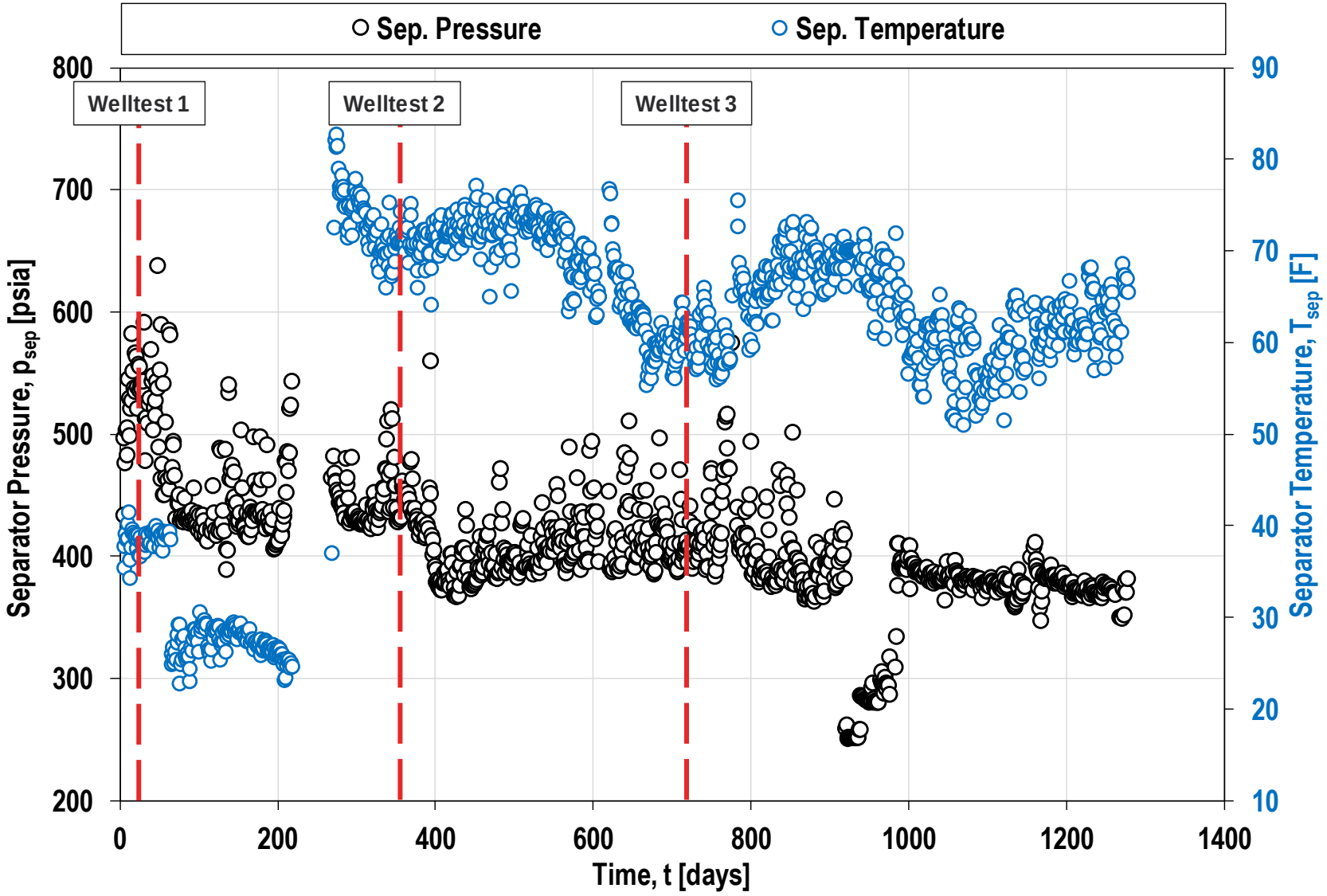
- A properly tuned EOS model
- An estimate of a wellstream comp – "seed feed"
- Separator volumetric rates (GOR)
- Separator conditions (T_{sep}, p_{sep})

Calculate Shrinkage Factor and Flash Factor Daily …

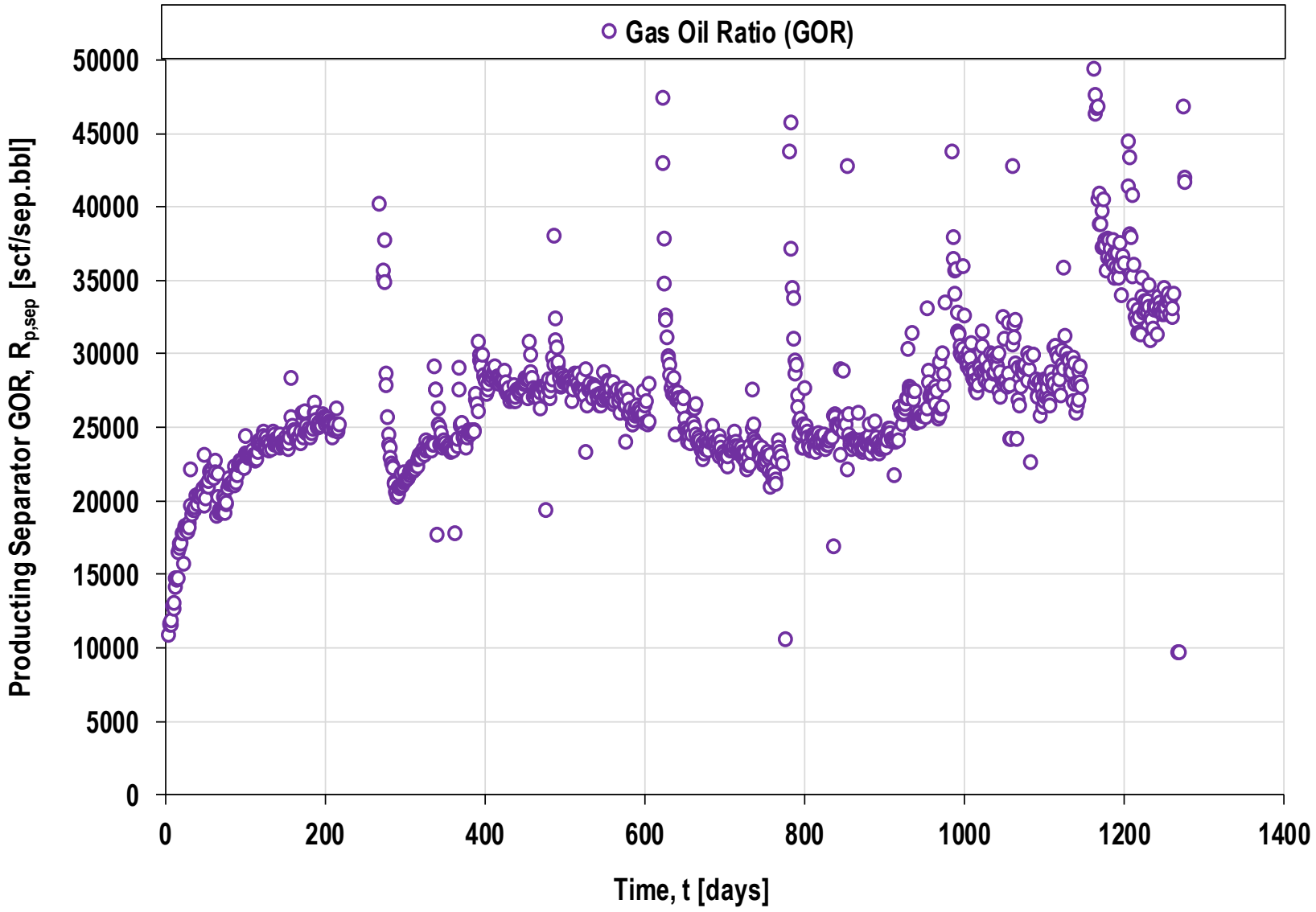
- Consistent fluid description
- Fundamental physical and thermodynamic principles

Sources: SPE-185988-MS, SPE-164334-MS, SPE-155499-MS, IPTC-19596-MS

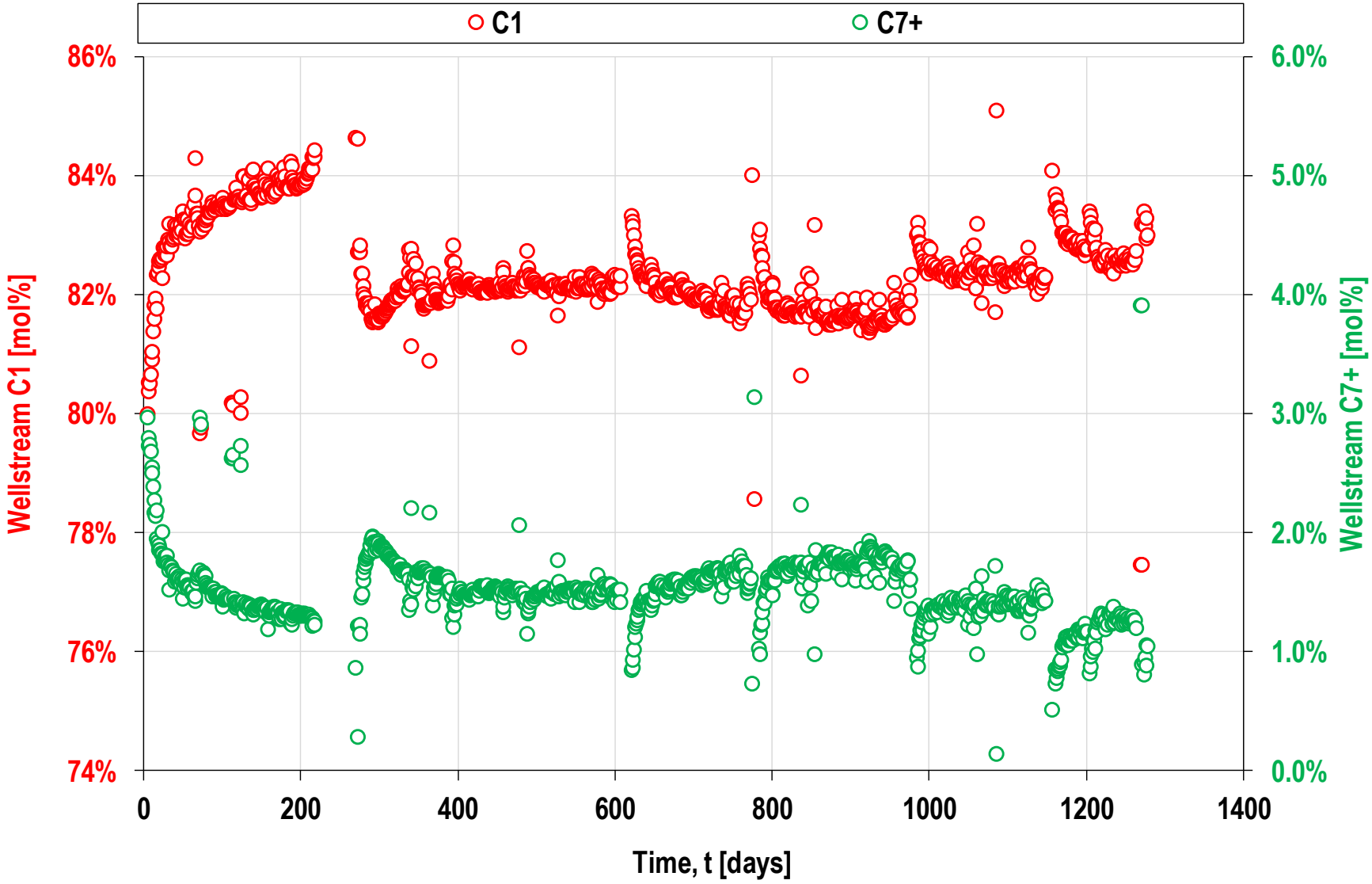
… Daily Separator Conditions



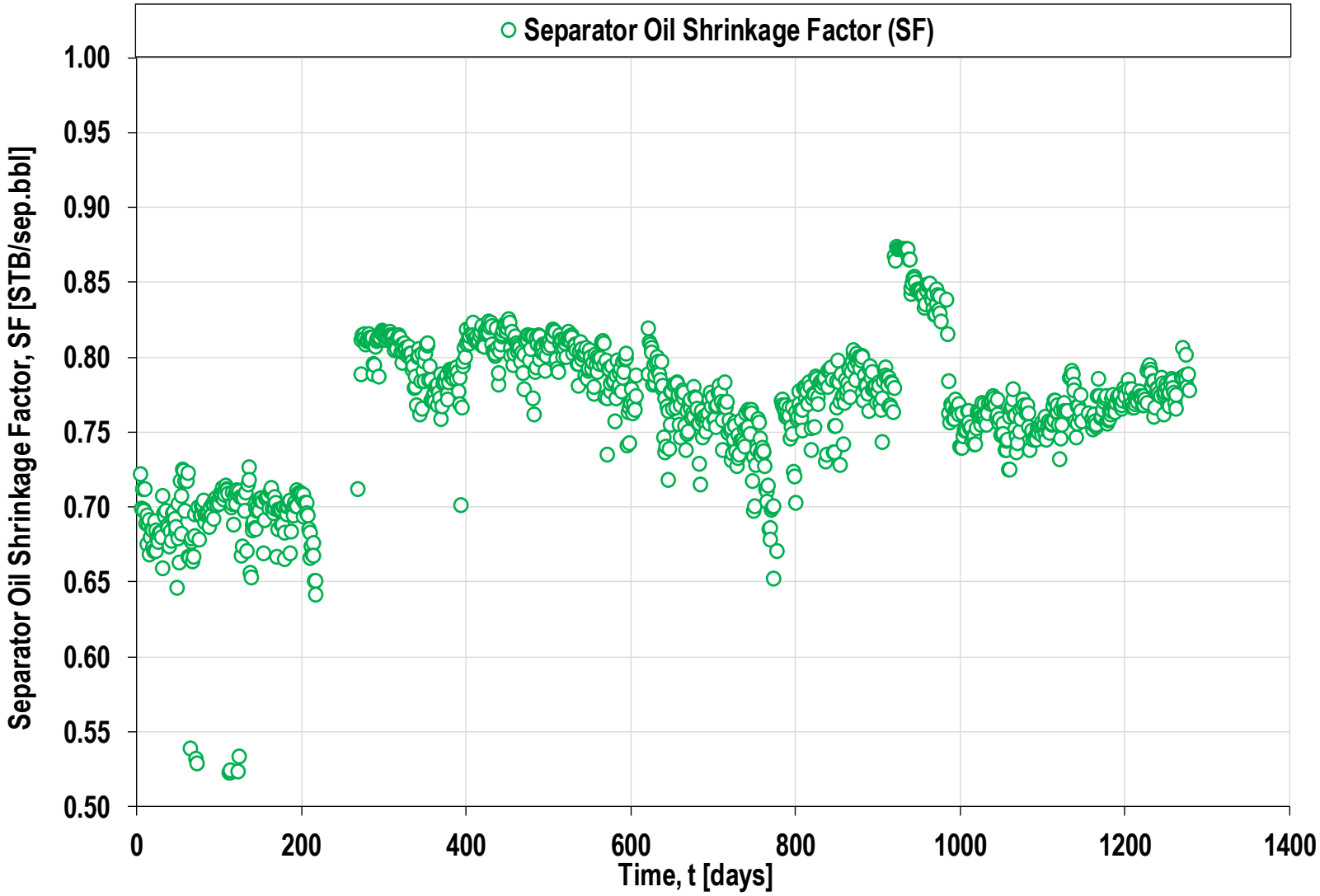
… plus Daily Separator Volumetric Rates …



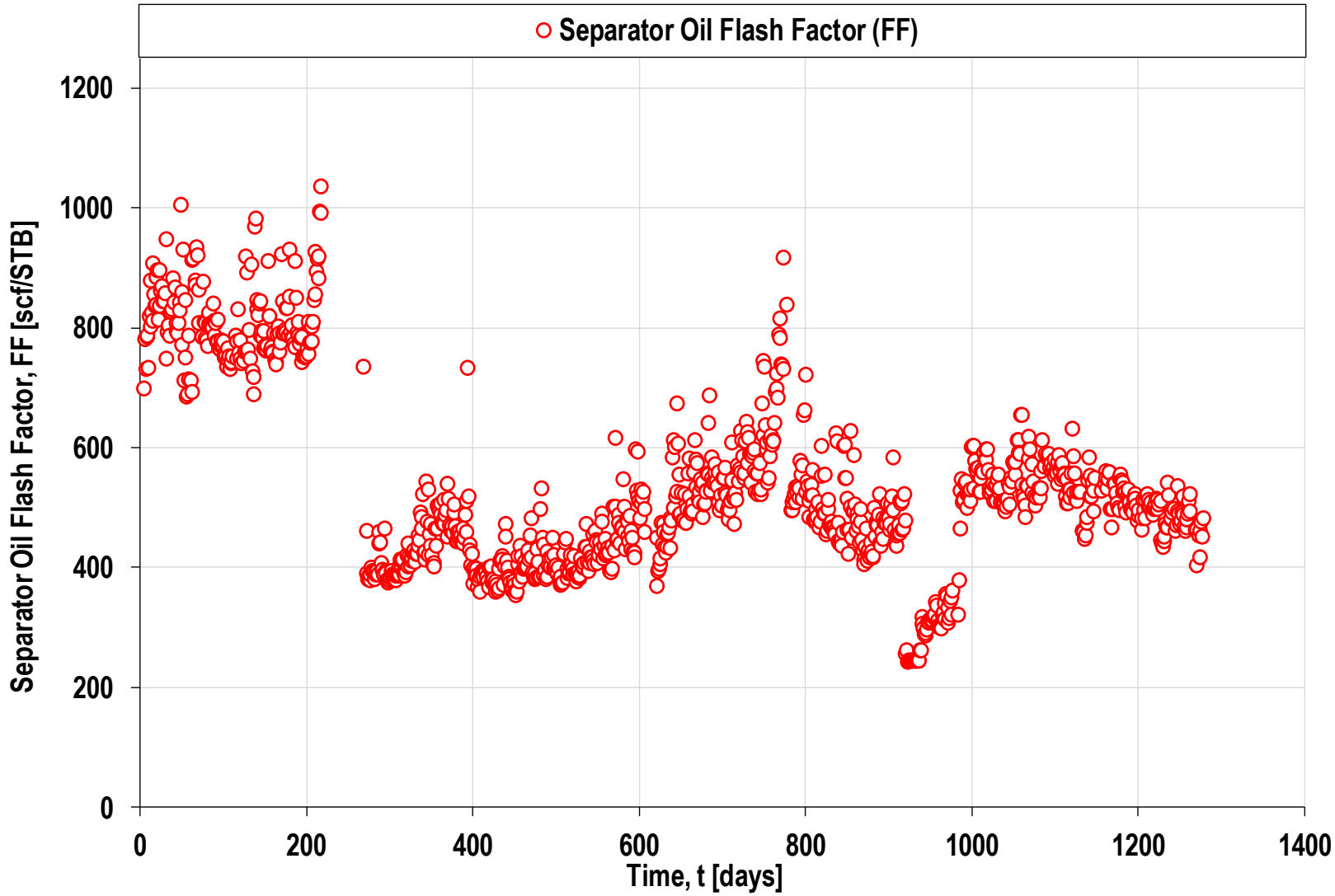
… used to Estimate Daily Wellstream Composition



… that's used to Calculate Daily Shrinkage Factors



… and the Associated Daily Flash Factor



Thank You

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