Kuwait 4th Flow Measurement Technology Conference

3-5 December 2019
Hilton Kuwait Resort

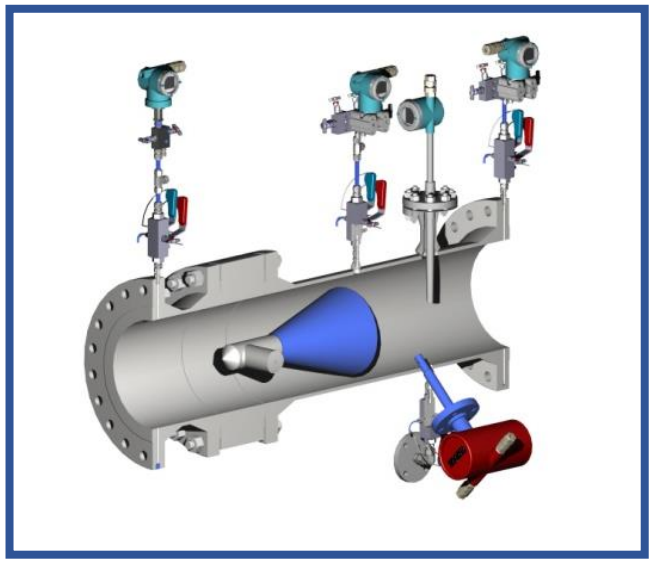
OFFICIAL SPONSOR

الراعـي الرسمـي

HALUK TORAL

Petroleum Software Ltd - Chief Executive Officer

How Do MPFMs Work ?



Cone / Venturi

DP mbar & RDP mbar

PVT Analysis

P bara, T degC

Thermodynamic Model (EOS)

Density and GVF

Impedance
Microwave
Infrared
Gamma Ray

Electro-Magnetic Field Model

Water-cut

GVF

Hydrodynamic Model

Flow Rates at actual and STP

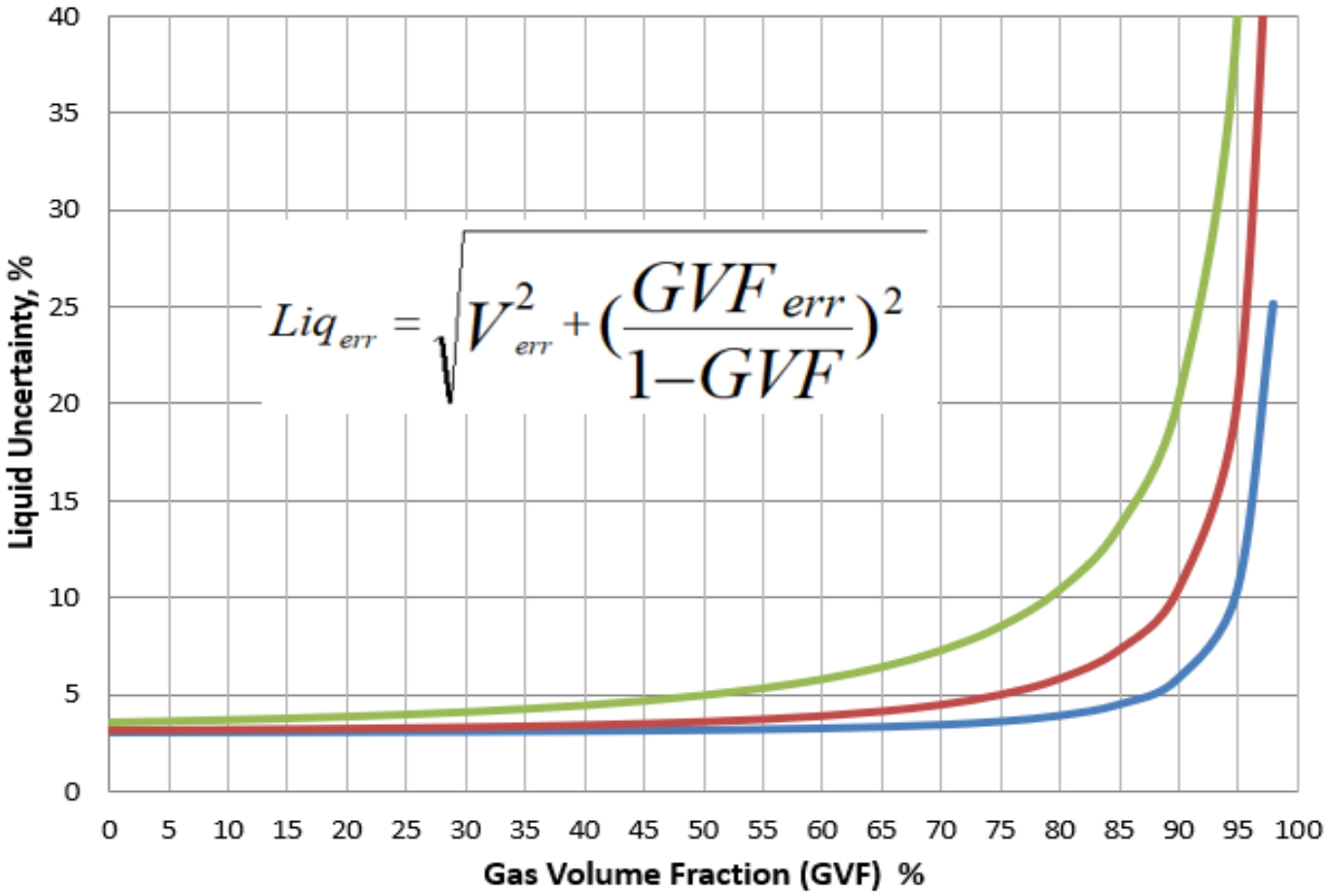
Oil flow rate

Water flow rate

Gas flow rate

esmerGL PSL

Sensitivity of Liquid Flow Rate Measurement to GVF



Gamma ray vs Equation Of State (EOS)

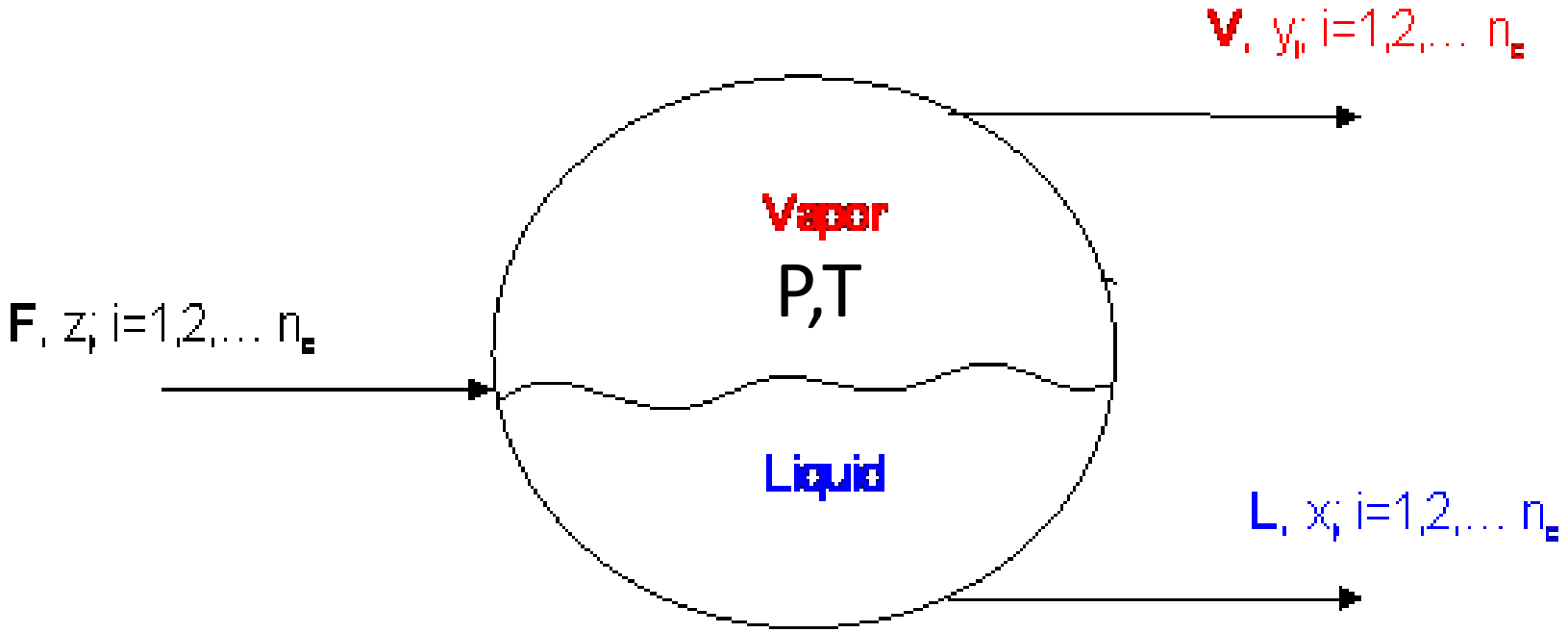
- MPFM accuracy depends strongly on GVF.
- Only known direct measurement of GVF is by gamma ray technique
- Gamma calibration requires phase densities – predicted by EOS
- Gamma accuracy is not going to be better than 2 % (optimistic estimate!)
- EOS can achieve the same!
- So, why not just use EOS directly to predict GVF ?

esmerGL PSL

EOS History

- Robert Boyle [1662]→ Ideal Gas → P.V = m.R.T
- Van derWaal[1873] → correction terms for real gas
- J Willard Gibbs [1876] → Free Energy G = H-TS → "For a closed system G is At Minimum under Equilibrium Conditions at constant P,T"
- Gilbert Lewis [1905] → Fugacity
- Otto Redlich - JNS Kwong [1949] → correction terms as fn(Tc,Pc)
- Soave Redlich Kwong [1973] → correction terms as fn(Tc,Pc,acentric factor) and binary interaction coefficients

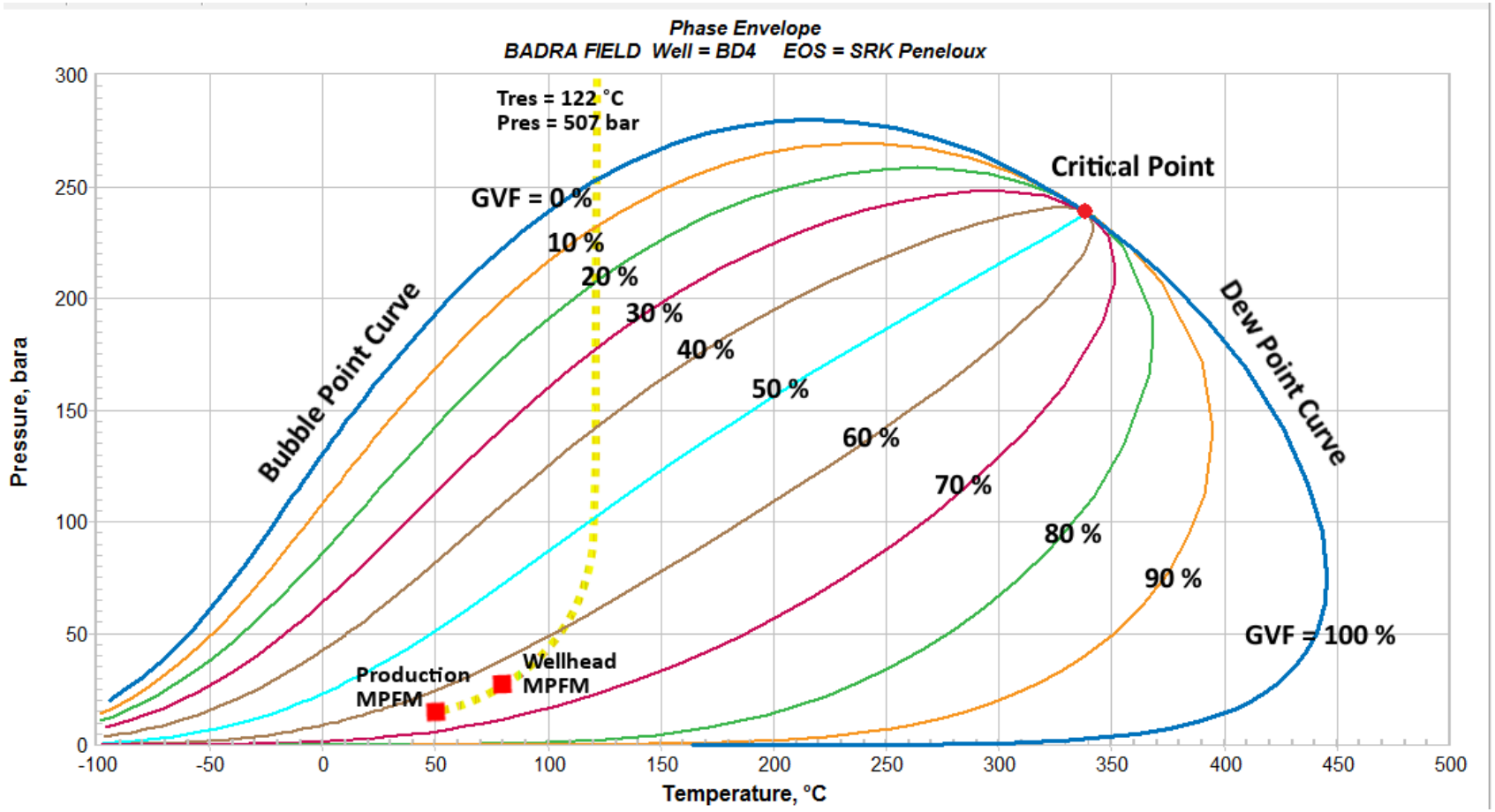
EOS - Flash Vaporisation



GVF, Liquid Density, Gas Density = fn(z, P, T)

esmerGL PSL

Predicting the Phase Envelope by EOS



esmerGL PSL

Ramping up the EOS from Text Book to Separator TuneUp

- Text Book: Use text book fluid properties of typical reservoir fluids to set up the foundation model.
- Tune up by Basic PVT Lab : Matching Psat,GOR, API
- Tune up by Compositional PVT Lab: Matching compositional PVT lab analysis of various samples across the field.
- Tune up against Separator Measurements: Matching measured GOR and phase densities under actual and standard conditions.

Conclusions

- Accuracy of in-line MPFM is highly sensitive to GVF
- GVF can be measured by means of the gamma densitometer
- Gamma requires phase densities for field calibration.
- Density of phases are predicted from an EOS
- This means that gamma depends on EOS based prediction also !
- EOS is the Key:

  EOS no good → Gamma no good !

  EOS good → no need for Gamma !
- EOS GVF prediction can be plugged in directly into the MPFM flow dynamic model – as done in esmerGL

esmerGL PSL