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# PVT - EOS Modelling in Multiphase Flow Metering

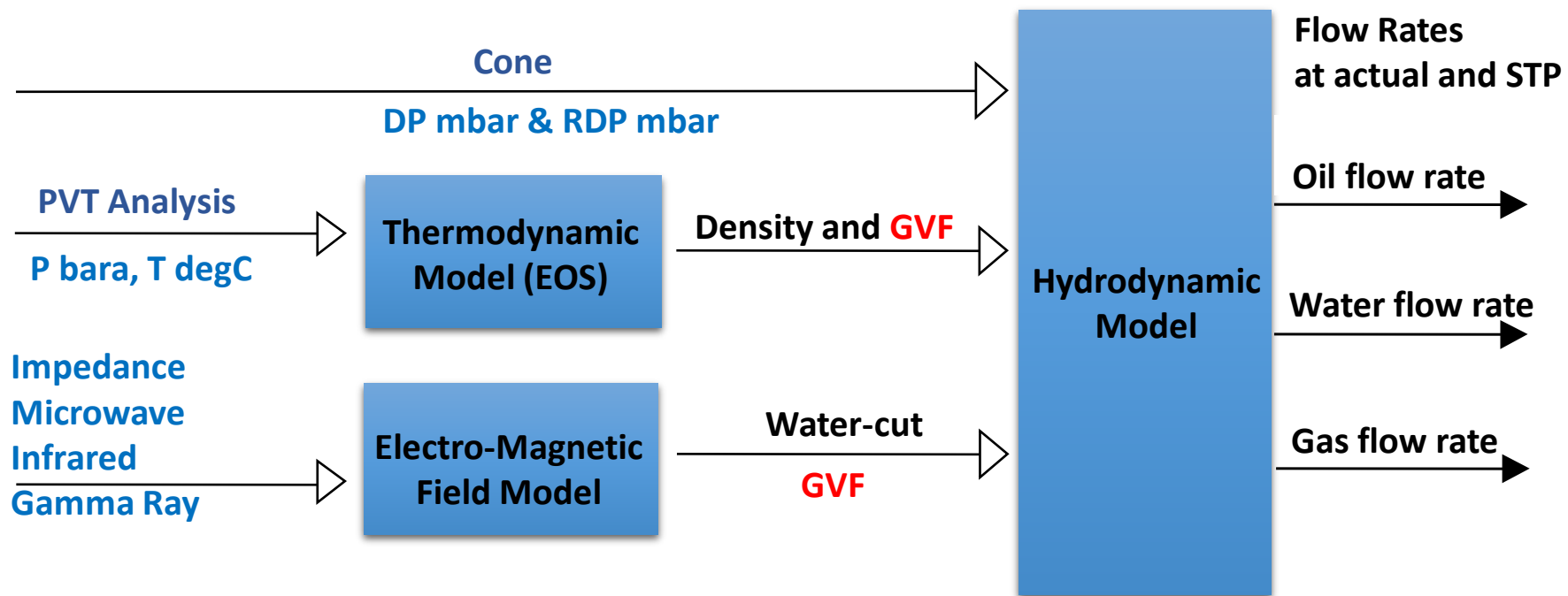
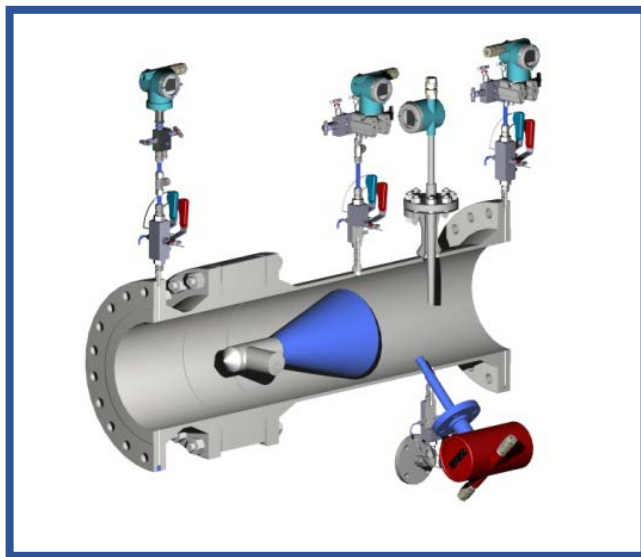
Haluk Toral & Bahar Hosgor Petroleum Software Ltd



# PVT - EOS Modelling in Multiphase Flow Metering

1. Why EOS ?
2. Background
  1. Phase Equilibrium Basics
  2. EOS Theory & Practice
  3. PVT Laboratory Process Simulation and Measurement
3. Foreground
  1. Field PID
  2. Fluid From Reservoir to MPFM and Stock Tank
  3. PSL EOS Model/Concept
  4. PSL Software
4. Uncertainty

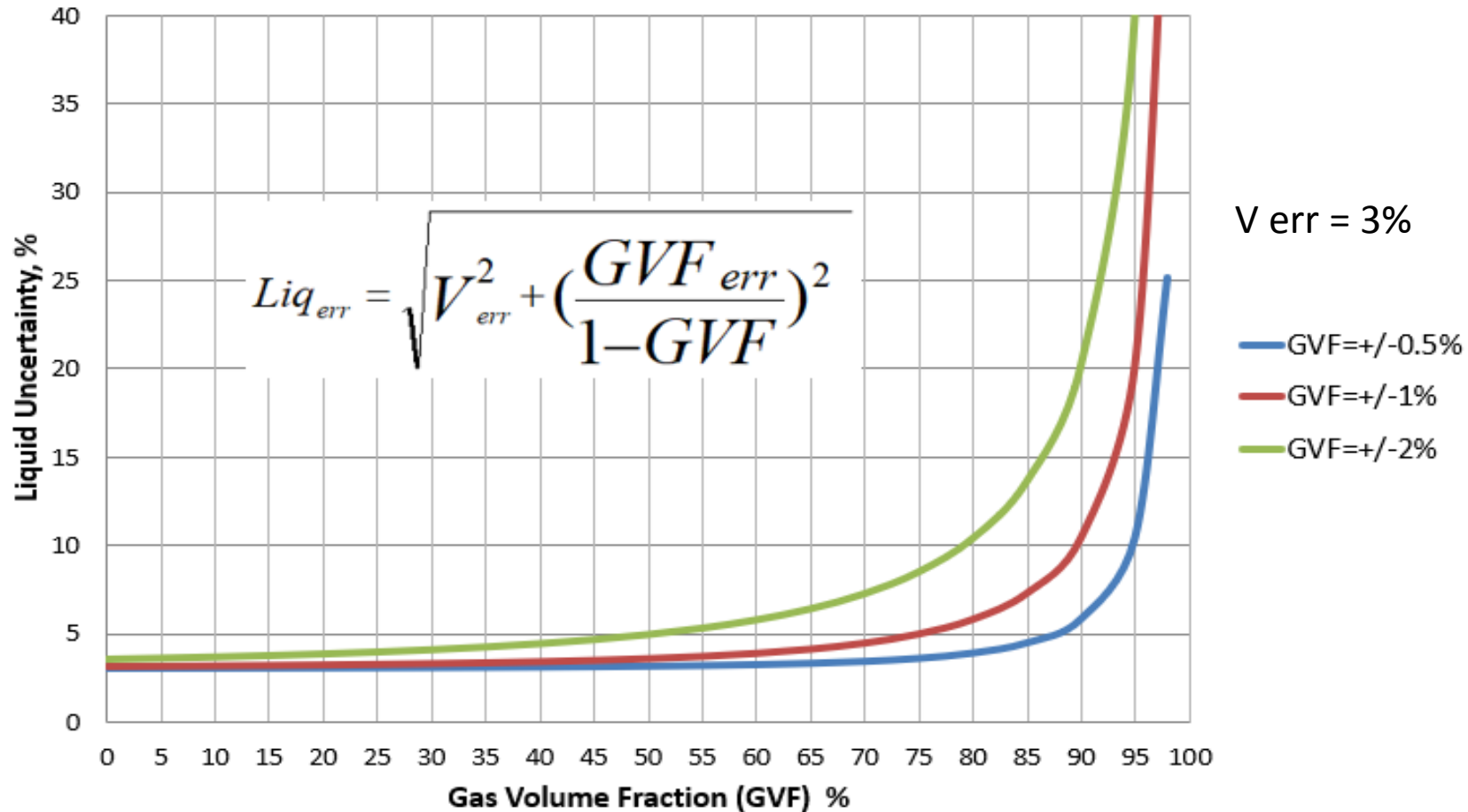
# Why EOS ?





# Sensitivity to GVF

## Liquid Rate Uncertainty



## Why EOS ?

- MPFM accuracy depends strongly on GVF.
  - GVF can be measured directly (only) by means of gamma absorption
  - Indirect derivations are likely to be unreliable / inaccurate. Example of indirect derivation (Bernoulli standing on its head!) :
    - density  $\sim V^2 \rightarrow$  error in density = 2 x error in V
    - gvf  $\sim$  density of phases  $\rightarrow$  error in gvf = 2 error in V + error in liquid and gas densities
  - So, we need EOS for phase density predictions in any case
  - A whole science of thermodynamics and PVT lab practice is dedicated to prediction of GVF and phase densities by EOS.
- 
- Why not EOS ?
  - No better way !





# BACKGROUND





# Phase Equilibrium - 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  $f_n(T_c, P_c)$
- Soave Redlich Kwong [1973] → correction terms as  $f_n(T_c, P_c, \text{acentric factor})$  and binary interaction coefficients



# EOS State of the Art Literature Review

Tune Up of EOS [1973] → Regression of binary interaction coefficients/ C7+ characterisation / Psat / GOR stp to match CCE experiment.



IPTC-18334-MS.pdf

PETSOC-99-13-59.pdf

SPE-68745-MS.pdf

SPE-114702-MS.pdf

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## A Robust Workflow for Reliably Describing Reservoir Fluid PVT Properties Using Equation of State Models

Shu Pan, Asok Kumar Tharanivasan, Jlabao Jack Zhu, Kurt Schmidt, John Ratulowski, and Robert Fisher, Schlumberger

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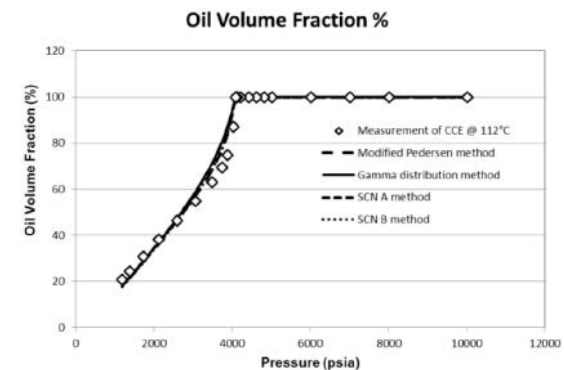
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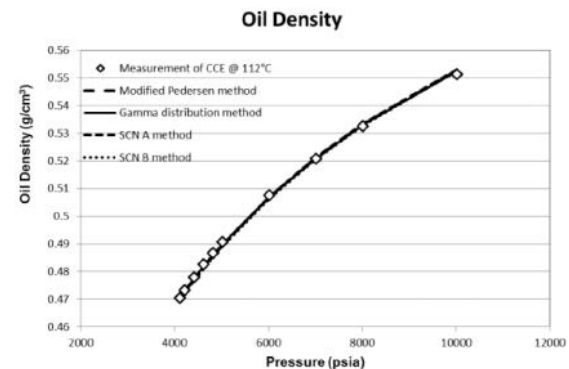
### Abstract

One of the key elements in modern reservoir exploration and management is describing reservoir fluid phase behavior and physical properties commonly referred to as pressure-volume-temperature, or PVT data. Typically, PVT data come from laboratory tests, empirical correlations, and Equation of State (EOS) models. It is common practice to describe the phase behavior or PVT data through EOS models tuned to laboratory measurements on reservoir fluid samples. After a sample is received at a laboratory, a portfolio of PVT laboratory tests are performed. The results are quality checked and the appropriate data are selected to tune an EOS model to obtain an accurate EOS description of the reservoir fluid. Each step in this process requires judgment and decisions from the corresponding domain experts to achieve physically sound PVT relations and calculate the required properties. Such EOS based modelling processes are time consuming, expensive and exposed to various risks due to multiple human interventions.

In the work presented in this paper, a study was conducted to explore the feasibility of a defined step EOS based modelling workflow using a limited, but defined, laboratory data set as the basis for characterizing and tuning the EOS model. In the development of a standardized workflow, a variety of EOS characterization and tuning methods were established to accommodate the diverse and complex nature of reservoir fluids. The methods considered include a modified Pedersen's method, a gamma distribution based method, and two methods based on single carbon number (SCN) composition and aromaticity factors. Despite their differences, the methods follow the principal objectives to be operator independent, robust, thermodynamically consistent, and numerically simple. Apart from the fluid composition, the only PVT data required for the proposed workflow were the saturation pressure, densities and the volumetric data obtained from constant composition expansion (CCE) measurements. The CCE test is advantageous because it is non-destructive to the sample being tested and can be performed quickly and reliably either in the laboratory or at a well-site. An optimized EOS model utilizing appropriate fluid characterization and tuning method is then selected based on a pre-defined Key Performance Indicator (KPI) derived from the deviation of the model predictions with the experimental data. With this optimal model defined, all other PVT data, such as those from sample destructive differential liberation (DL) or constant volume depletion (CVD) tests, can be reliably predicted.



(a)



(c)

Figure 7—Simulation of





# PVT Laboratory Process Simulation and Measurement

- Process
  - CCE
  - CVD
  - Differential Liberation
  - Flash
- Measurement
  - GOR
  - Saturation pressure
  - Phase densities & molecular weights
  - Compositions (lumping of heavy ends)

# Phase Equilibrium Basics

- Gibbs: Free Energy  $G=H-TS$ : “For a closed system  $G$  is At Minimum under Equilibrium Conditions at constant  $P,T$ ”

- $\rightarrow G$  of Liquid  $j = G$  of Vapor  $j$

- $\rightarrow$  Liquid Chemical Potential  $j =$  Gas Chemical Potentia

- $\rightarrow$  Liquid Fugacity  $j =$  Gas Fugacity  $j$

- $\rightarrow$  Fugacity =  $f_n(P,T,V)$ .

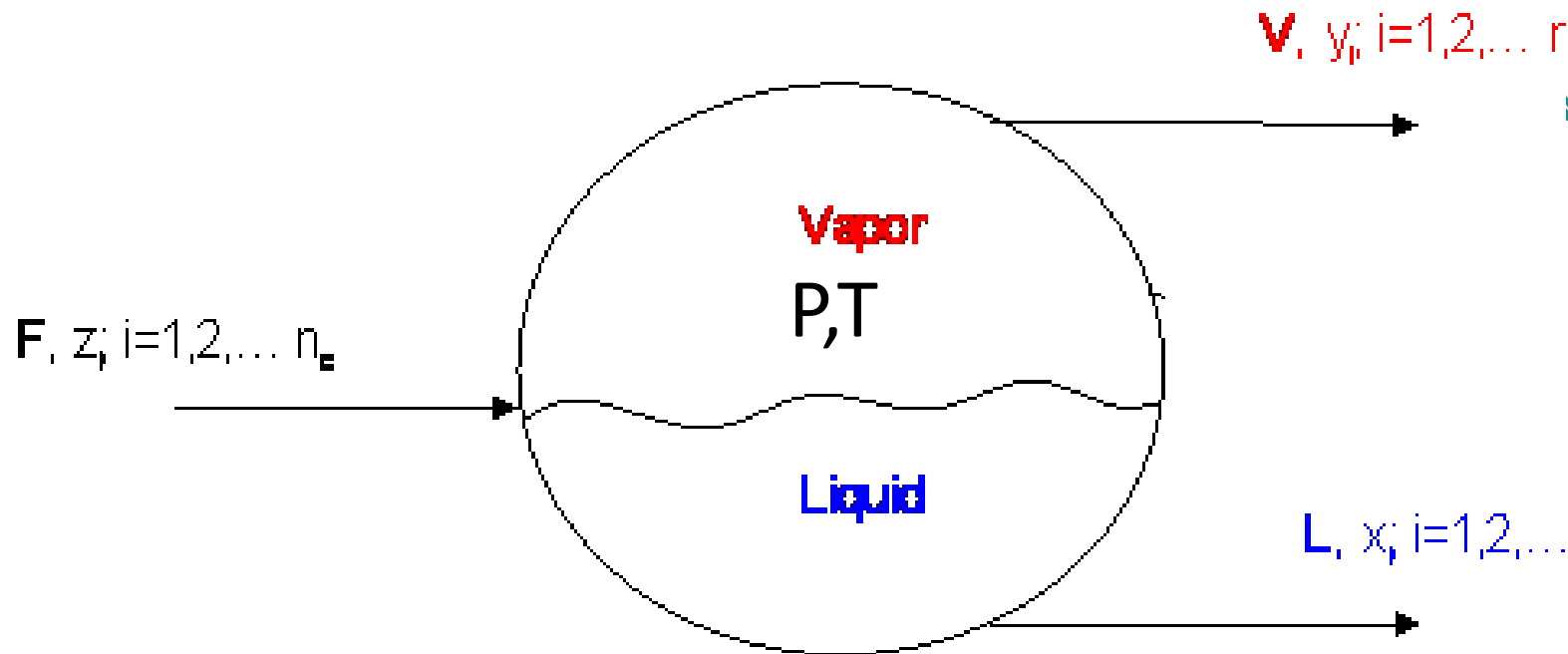
$\rightarrow f_n(P,T,V) = 0$  is named EOS

$$\mu_i = \left( \frac{\partial G}{\partial n_i} \right)_{P,T,n_i \neq n_1} = \bar{G}_i$$

$$\mu_i^{(l)} = \mu_i^{(v)} \text{ for all } i=1,2, \dots n_c$$

$$d\bar{G}_i = RT d \ln f_i \text{ @ constant } T$$

# EOS - Flash Vaporisation



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

• Gibbs: Free Energy  $G=H-TS$ : "For a closed system  $G$  is At Minimum under Equilibrium Conditions at constant  $P,T$ "

•  $\rightarrow G$  of Liquid  $j = G$  of Vapor  $j$

•  $\rightarrow$  Liquid Chemical Potential  $j =$  Gas Chemical Potentia

•  $\rightarrow$  Liquid Fugacity  $j =$  Gas Fugacity  $j$  [Lewis 1905]

•  $\rightarrow$  Fugacity = fn( $P,T,V$ ).

$\rightarrow$  fn( $P,T,V$ ) = 0 is named EOS

$$\mu_i = \left( \frac{\partial G}{\partial n_i} \right)_{P,T,n_i \neq n_i} = \bar{G}_i$$

$$\mu_i^{(l)} = \mu_i^{(v)} \text{ for all } i=1,2, \dots, n_c$$

$$d\bar{G}_i = RT d \ln f_i \text{ @ constant } T$$

$$p = \frac{RT}{V_m - b} - \frac{a \alpha}{V_m (V_m + b)}$$

$$a = \frac{0.427 R^2 T_c^2}{P_c}$$

$$b = \frac{0.08664 RT_c}{P_c}$$

$$\alpha = \left( 1 + (0.48508 + 1.55171 \omega - 0.15613 \omega^2) (1 - T_r^{0.5}) \right)^2$$

$$T_r = \frac{T}{T_c}$$

Where  $\omega$  is the **acentric factor** for the species.

This formulation for  $\alpha$  is due to Graboski and Daubert. The original formulation from Soave is:

$$\alpha = \left( 1 + (0.48 + 1.574 \omega - 0.176 \omega^2) (1 - T_r^{0.5}) \right)^2$$

for hydrogen:

$$\alpha = 1.202 \exp(-0.30288 T_r)$$

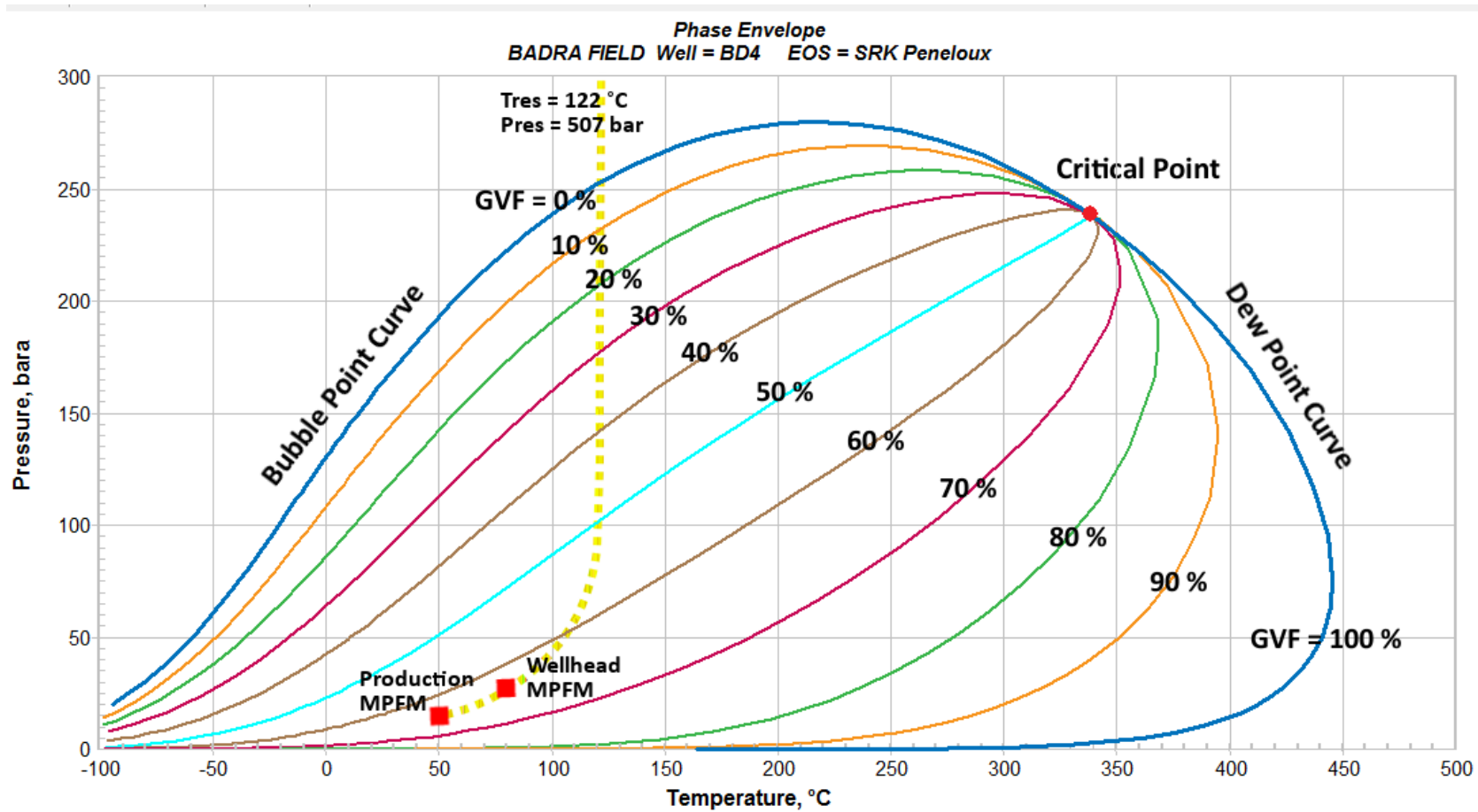
We can also write it in the polynomial form, with:

$$A = \frac{a \alpha P}{R^2 T^2}$$

$$B = \frac{b P}{RT}$$



# Phase Envelope





# FOREGROUND





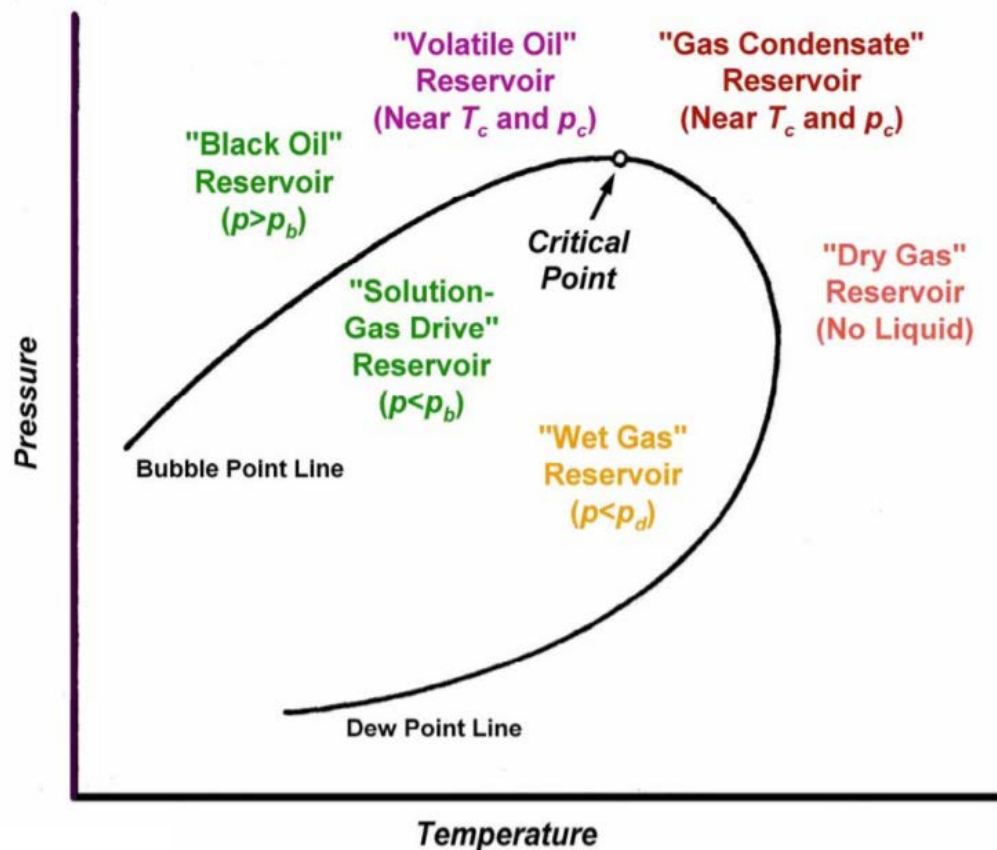


# Ramping up the EOS starting from no PVT

- Text Book (“**Small**”): Use text book fluid properties of typical reservoir fluids to set up the foundation model as best guess.
- Basic PVT Lab (“**Medium**”):  $P_{sat}$ , GOR, API
- Compositional PVT Lab (“**Large**”): Compositional PVT lab analysis of various samples across the field.
- Separator Measurements (“**X Large**”): Tune up (one of above) against GOR, liquid and gas density (mobile separator at the well head or production separator).



# More about "Small" (Text Book Fluid Types)



Component	Dry Gas	Wet Gas	Gas Condensate	Near-Critical Oil	Volatile Oil	Black Oil
CO2	0.1	1.41	2.37	1.3	0.93	0.02
N2	2.07	0.25	0.31	0.56	0.21	0.34
C1	86.12	92.46	73.19	69.44	58.77	34.62
C2	5.91	3.18	7.8	7.88	7.57	4.11
C3	3.58	1.01	3.55	4.26	4.09	1.01
i-C4	1.72	0.28	0.71	0.89	0.91	0.76
n-C4		0.24	1.45	2.14	2.09	0.49
i-C5	0.5	0.13	0.64	0.9	0.77	0.43
n-C5		0.08	0.68	1.13	1.15	0.21
C6		0.14	1.09	1.46	1.75	1.61
C7+		0.82	8.21	10.04	21.76	56.4
Total	100	100	100	100	100	100
M C7+		130	184	219	228	274
$\gamma$ C7+		0.763	0.816	0.839	0.858	0.92
GOR, scf/bbl		105000	5450	3650	1490	300
GOR, m3/m3		18616	966	647	264	53
$\gamma_{oil}$		0.751	0.784	0.802	0.835	0.910
$\gamma_{API}$		57	49	45	38	24
$\gamma_{gas}$		0.61	0.7	0.71	0.7	0.63
Psat, psia		3430	6560	7015	5420	2810
Psat, bar		236	452	484	374	194

[Cronquist, 1979 and Whitson 1983]



# More About “Medium” (Initial PVT)

Gazprom NEFTI		Doc. No. GB164-SD01-100-PR-DS-002 PROCESS DATA SHEET FOR MPFM (OIL PRODUCTION WELLS AND CPF INLET MANIFOLD)	Rev : 0 Date: 19.12.12 Page: 8 / 10	CPP	
Annex-3: Fluid Composition and Properties:					
Component	% mole				
N <sub>2</sub>	0.28				
CO <sub>2</sub>	3.5				
H <sub>2</sub> S	3.07				
C <sub>1</sub>	35.17				
C <sub>2</sub>	9.36				
C <sub>3</sub>	6.11				
iC <sub>4</sub>	1.06				
nC <sub>4</sub>	3.32				
iC <sub>5</sub>	1.49				
nC <sub>5</sub>	2.07				
C <sub>6</sub>	3.19				
C <sub>7</sub>	3.1				
C <sub>8</sub>	3.25				
C <sub>9</sub>	2.93				
C <sub>10</sub>	2.56				
C <sub>11</sub>	2.02				
C <sub>12+</sub>	17.54				
Sum	100				
Molar mass reservoir oil, [g/mol]	93.87				
Reservoir pressure, [bara]	495.88				
Reservoir temperature, [°C]	118.56				
Saturation Pressure @ tRes, bar	214				
Dynamic Viscosity, [cP]					
at Pres	0.43				
at Ps	0.32				
Results of Multistage Separation:					
Formation Volume Factor (FVF), [m <sup>3</sup> /st.m <sup>3</sup> ]	1.500855				
solution gas-oil ratio, [Sm <sup>3</sup> /Sm <sup>3</sup> ]	162.995				
solution gas-oil ratio, [Sm <sup>3</sup> /ton]	190.145				
stock-tank oil density, [kg/m <sup>3</sup> ]	854.5				

Note: 1. Maximum H<sub>2</sub>S Content: 3.8 mol %; Maximum CO<sub>2</sub> Content: 3.7 mol %;  
Water content up to 20% should be considered.  
2. For sour service conditions, the materials shall comply with NACE MR0175 / ISO 15156.

- TUNE UP PARAMETERS:
- C7+Mw adjusted to match Psat at 119C and Mw of Reservoir Oil
- C7+ density adjusted to match STO density.

Result a modified composition →

Component	mol%
N2	0.286
CO2	3.572
H2S	3.133
C1	35.896
C2	9.553
C3	6.236
iC4	1.082
nC4	3.389
iC5	1.521
nC5	2.113
C6	3.256
C7	3.164
C8	3.317
C9	2.99
C10	2.613
C11	2.062
C12+	15.818





# More about “Large” (Updated PVT)

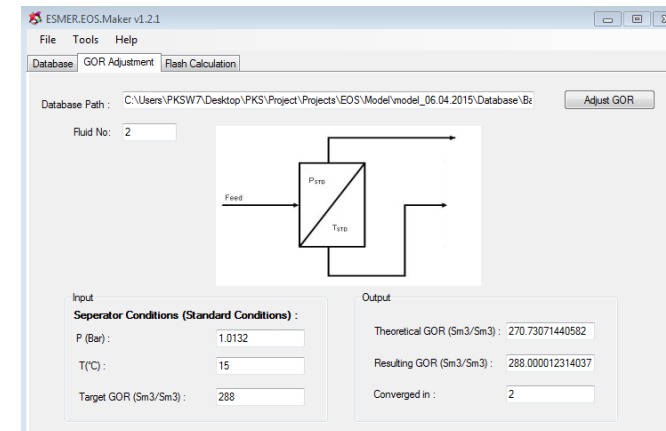
Components	Composition, % mol.				
	Mauddud D, E, G	Mauddud F, G	Mauddud B, D, E	Mauddud Average over Bd-4	Mauddud Average
	Bd-5	Bd-4	Bd-4	Bd-4	Bd-4, Bd-5
N <sub>2</sub>	0,585	0,449	0,369	0,376	0,481
H <sub>2</sub> S	1,324	3,714	3,868	3,855	2,589
CO <sub>2</sub>	4,183	3,583	3,789	3,771	3,977
CH <sub>4</sub>	44,099	37,575	43,422	42,902	43,500
C <sub>2</sub> H <sub>6</sub>	10,434	9,751	10,532	10,462	10,448
C <sub>3</sub> H <sub>8</sub>	5,916	6,048	5,998	6,002	5,959
iC <sub>4</sub> H <sub>10</sub>	1,077	1,000	1,071	1,065	1,071
nC <sub>4</sub> H <sub>10</sub>	3,181	3,242	3,202	3,206	3,193
neo-C <sub>5</sub> H <sub>12</sub>	0,020	0,009	0,011	0,011	0,015
iC <sub>5</sub> H <sub>12</sub>	1,356	1,361	1,346	1,347	1,352
nC <sub>5</sub> H <sub>12</sub>	1,816	1,903	1,807	1,816	1,816
C <sub>6</sub>	2,567	2,827	2,552	2,576	2,572
Benzene	0,095	0,141	0,099	0,102	0,098
C <sub>7</sub>	2,386	2,646	2,289	2,321	2,354
Toluene	0,340	0,396	0,342	0,346	0,343
C <sub>8</sub>	2,152	2,424	2,068	2,100	2,126
Ethylbenzene	0,107	0,138	0,101	0,104	0,105
M- and P- Xylenes	0,325	0,351	0,357	0,356	0,341
O- Xylene	0,181	0,189	0,173	0,175	0,178
C <sub>9</sub>	1,659	1,881	1,592	1,617	1,638
C <sub>10</sub>	1,888	2,149	1,826	1,854	1,871
C <sub>11</sub>	1,520	1,737	1,444	1,470	1,495
C <sub>12</sub>	1,241	1,444	1,166	1,190	1,215
C <sub>13</sub>	1,113	1,291	1,036	1,059	1,086
C <sub>14</sub>	0,978	1,139	0,902	0,923	0,950
C <sub>35</sub>	0,121	0,169	0,108	0,113	0,117
C <sub>36+</sub>	1,777	3,387	1,890	2,023	1,900
Total	100,000	100,000	100,000	100,000	100,000
MC <sub>36+</sub>	635	697	663	666.0	650.5

Parameter	Average over B, D, E units
Saturation pressure, MPa	26.66
<i>Single stage:</i>	
- FVF	1.832
- Gas-oil ratio, m <sup>3</sup> /m <sup>3</sup>	288
- Gas-oil ratio, m <sup>3</sup> /ton	336
- STO density, g/sm <sup>3</sup>	0.856
- Gas gravity (by air)	0.966
<i>Multistage separation (BHS-1):</i>	
- FVF	1.746
- Gas-oil ratio, m <sup>3</sup> /m <sup>3</sup>	269
- Gas-oil ratio, m <sup>3</sup> /ton	319
- STO density, g/sm <sup>3</sup>	0.842
<i>Differential liberation (BHS-1):</i>	
- FVF	1.792
- Gas-oil ratio, m <sup>3</sup> /m <sup>3</sup>	281
- Gas-oil ratio, m <sup>3</sup> /ton	332
- STO density, g/sm <sup>3</sup>	0.846
Density at reservoir condition, g/sm <sup>3</sup>	0.652
Dynamic viscosity, mPa*s:	
- at reservoir condition	0.36

- TUNE UP PARAMETERS:
  - C7+Mw adjusted to match Psat at 19C and Mw of Reservoir
  - C7+ density adjusted to match STO density.
  - **Single stage separation GOR**
- Result a modified composition →

# More about “XLarge” (In-line Separator)

1. Determine Feedz (Reservoir Fluid Composition) from PVT
2. Measure: Separator.GOR in-line with MPFM
3. Perform flash at Feedz, Separator.P, Separator.T to determine:EOS.GOR, EOS.x and EOS.y
4. Update Feedz by recombining Separator.GOR, EOS.x, EOS.y
5. Go back to 2 and repeat until EOS.GOR=Separator.GOR
6. **We now have synthetic fluid which matches Separator**
7. Flash at MPFM.T, MPFM.P to obtain FluidDensity
8.  $Cd = \frac{f_n}{\text{Separator.Mass, DP, FluidDensity}}$



# UNCERTAINTY



# Hydrodynamic Model Uncertainty

## Bottom Up Analysis of Venturi – Single Phase Flow

	Standard Uncertainty u	Sensitivity Coefficient s	S×u	100×(S×u) <sup>2</sup>	Contribution [%]
Orifice Bore Measurement Variance	0.04	2.14	0.086	0.733	4.0
Orifice Bore Micrometer Calibration	0.02	2.14	0.043	0.183	1.0
Meter Tube Measurement Variance	0.14	-0.19	-0.027	0.071	0.4
Meter Tube Micrometer Calibration	0.01	-0.19	-0.002	0.000	0.0
Discharge Coefficient	0.25	1.00	0.250	6.250	33.9
Expansion Factor	0.04	1.00	0.040	0.160	0.9
Densitometer Measurement Variance	0.10	0.50	0.050	0.250	1.4
Densitometer Calibration	0.58	0.50	0.290	8.410	45.7
ΔP Transmitter Measurement Variance	0.10	0.50	0.050	0.250	1.4
ΔP Transmitter Calibration	0.29	0.50	0.145	2.103	11.4

Total error as square root of sum of column 4/100 = 0.43%

From Kegel see References

# MPFM Uncertainty

Total Flow Rate:

- $Q_t = \text{Constant} * C_d * (DP / \text{Density})^{0.5}$  (1.a)

- $\text{Density} = \text{DensityLiquid} * (1 - \text{GVF}) + \text{DensityGas} * \text{GVF}$  (1.b)

Liquid Rate:

- $Q_l = Q_t * (1 - \text{GVF})$  (2)

Uncertainty:

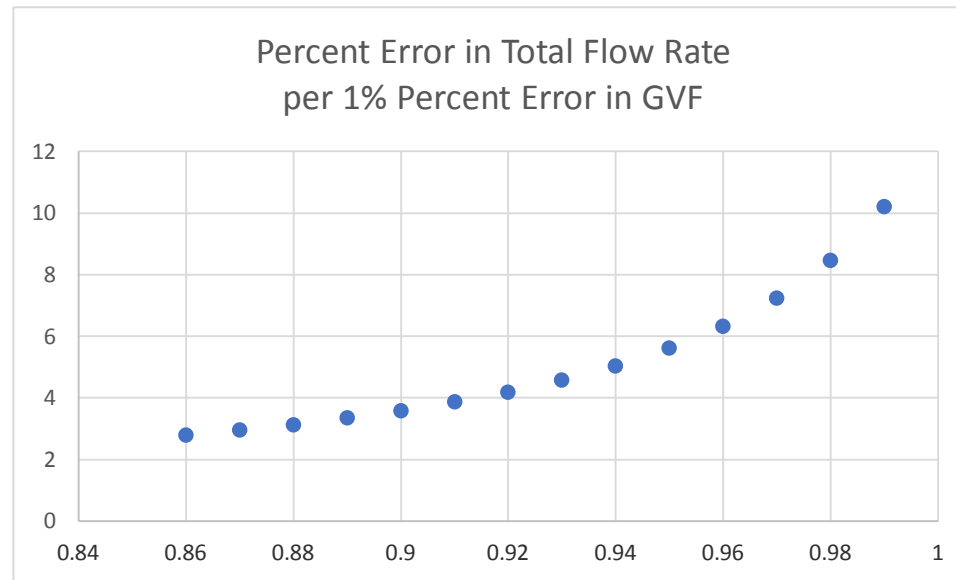
- $\text{Error}Q_t = \text{ErrorGVF} * 0.5 / (1 - \text{GVF})$  (3.a)

- $\text{Error}Q_l = [\text{Error}Q_t^2 + \{\text{ErrorGVF} / (1 - \text{GVF})\}^2]^{0.5}$  (3.b)



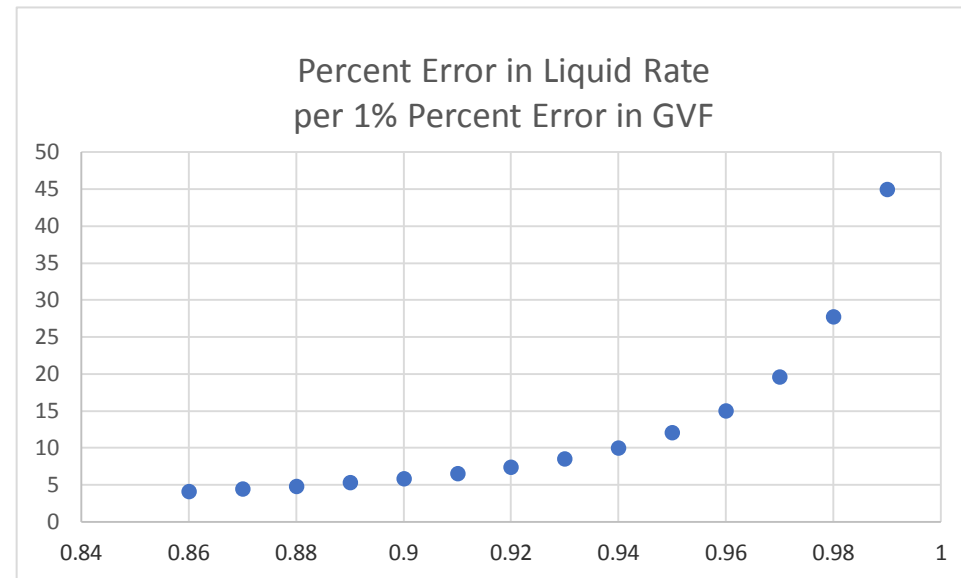
# MPFM Uncertainty

## Total Flow Rate Error / GVF Error



# MPFM Uncertainty

## Liquid Flow Rate Error / GVF Error





## “Densitometer Error”

### *Thermodynamic Model Uncertainty - Sources of Error in EOS*

- There are three separate sources of error.
- 
- **Mis-match “text book” fluid type** eg we try to match a reservoir to one of known – typical fluid compositions as best as we can; what is the error arising from mis-match.
- **Mis-match fluid analysis:** eg we have PVT lab analysis of reservoir sample and we also have PVT data from the Separator; there is a difference between these; what is the error arising from mis-match.
- **Mis-match EOS.** Ie How good is the science of phase equilibrium anyway? What is the error arising from mis-match of theory to experiment (PVT data of a specific fluid)?



# Summary of EOS Models (Example from the present study)

PT Flash at 20 bara and 50 °C												
	Small			Medium			Large			X-Large		
	VolatileOil			Initial PVT Data			Updated PVT Data			Tune Up Against Separator		
	Total	Vapor	Liquid	Total	Vapor	Liquid	Total	Vapor	Liquid	Total	Vapor	Liquid
Mole%	100	69.29	30.71	100	49.8	50.2	100	64.07	35.93	100	59.48	40.52
Weight%	100	20.66	79.34	100	12.76	87.24	100	21.28	78.72	100	17.71	82.29
Volume cm <sup>3</sup> /mol	957.47	1285.19	218.12	729.62	1266.02	197.58	881.12	1264.38	197.68	834.89	1266.87	200.83
GVF	1.0000	0.9300	0.0700	1.0000	0.8640	0.1360	1.0000	0.9194	0.0806	1.0000	0.9025	0.0975
Density kg/cm <sup>3</sup>	71.3	15.8	808.1	128.4	19	823.8	82.5	19.1	805.5	95.8	18.8	809
Z Factor	0.7127	0.9566	0.1624	0.5431	0.9424	0.1471	0.6559	0.9411	0.1471	0.6215	0.943	0.1495
Molecular Weight	68.23	20.34	176.25	93.66	23.99	162.76	72.67	24.13	159.23	80.01	23.83	162.47

# Effect of EOS Models – Worst Case

- Predict / estimate:
- Fluid Density & GVF = EOSFlash(VaryingComposition, SameP, SameT)
- $Q_t = \text{Bernoulli}(\text{SamePipe}, \text{SameBeta}, \text{SameCd}, \text{SameDP}^{0.5}, \text{VaryingDensity}^{-0.5})$
- $Q_l = Q_t * (1 - \text{VaryingGVF})$

	EOS			MIX LAW	BERNOULLI	DECOMPOSE		%Difference vs XLARGE		
	RhoL	RhoG	GVF	RhoF	TOTAL FLOW RATE	LIQUID RATE	GAS RATE	TOTAL	LIQUID	GAS
<b>XLARGE (tune up against separator GOR &amp; density)</b>	809	18.8	0.9025	95.8	0.1021	0.0100	0.0922	0.0	0.0	0.0
<b>LARGE (tune up against compositional PVT)</b>	805.5	19.1	0.9194	82.5	0.1101	0.0089	0.1012	7.8	-10.9	9.8
<b>MEDIUM (tune up against simple PVT)</b>	823.8	19	0.864	128.5	0.0882	0.0120	0.0762	-13.6	20.5	-17.3
<b>SMALL (text book volatile oil composition)</b>	808	15.8	0.93	71.3	0.1185	0.0083	0.1102	16.0	-16.7	19.5
<b>AVG</b>	811.5750	18.1750	0.9040	94.5088	0.1047	0.0098	0.0950			
<b>STD</b>	8.2819	1.5882	0.0290	24.7613	0.0129	0.0016	0.0145			
<b>STD/AVG*100</b>	1.0205	8.7386	3.2032	26.2000	12.2822	16.6849	15.2515			



# Conclusions

- Accuracy of in-line MPFM is highly sensitive to GVF
- GVF can be measured by a gamma ray densitometer (only known direct measurement of GVF)
- Density prediction is essential in *any case* ie for Gamma also
- Prediction is a viable / reasonable alternative to measurement
- GVF, Liquid Density, Gas Density= EOS (P,T,z,tune up parameters)
- z and tune up parameters can be deduced from Stock Tank API → actual fluid PVT → in-line separator in increasing order of effectiveness.
- Prediction and tune up can be automated / implemented in the flow computer of the MPFM
- MPFM can be software based and independent of (manufacturer bound) hardware



# References

- [https://www.e-education.psu.edu/png520/m13\\_p4.html](https://www.e-education.psu.edu/png520/m13_p4.html)
- Thomas Kegel Basic Measurement Uncertainty 71st International School of Hydrocarbon Measurement, April 9-11, 1996, Oklahoma City, OK

- IPTC-18334-MS.pdf
- PETSOC-99-13-59.pdf
- SPE-68745-MS.pdf
- SPE-114702-MS.pdf
- SPE-131046-MS.pdf
- SPE-144025-MS.pdf



**THANK YOU**

