HIGH VAPOR PRESSURE CALCULATIONS

WSCLA

January 14th, 2020

Measurement & Product Validation Department

Introduction

- **Modeling**
  - Samples Analyzed
    - *Composition*
  - Flash Conditions
- **Reproducibility / Auditability**
  - Laboratory Results
  - Software Comparisons
- **GLO Office Example Software**

Modeling

- **Standardization in progress via American Petroleum Institute (API)**
  - Manual of Petroleum Measurement Standards (MPMS)
  - API MPMS is often the reference standard used when auditing
    - *Other standardization groups*
      - **GPA Midstream**

- **Modeling standard is not currently written, but in progress by API 20.4**
  - Standards that exist today that does defend found in API MPMS Chapter 20.
  - Commonly used offshore and now onshore with HVP Oil

Modeling

Required Input for Modeling

- Composition
  - *If large amounts of bulked components are used, get extended characteristics.*
    - **In this case, Molecular Weight and Relative Density**
      - ***Use pseudo components***
- Flashed Conditions
  - *In this case the pressure and temperature.*
  - *Determine from Process Flow Diagram (PFD)*

EOS (Equation of State) Calculation Methodology

- There are many options, but most produce similar results.
- Oil and gas frequently uses Peng-Robinson
  - *My examples will be based upon Peng-Robinson*

Modeling

GPA 2103M

- GPA 2103 revision to better handle HVP oil
  - Composition
  - Heavier component characteristics

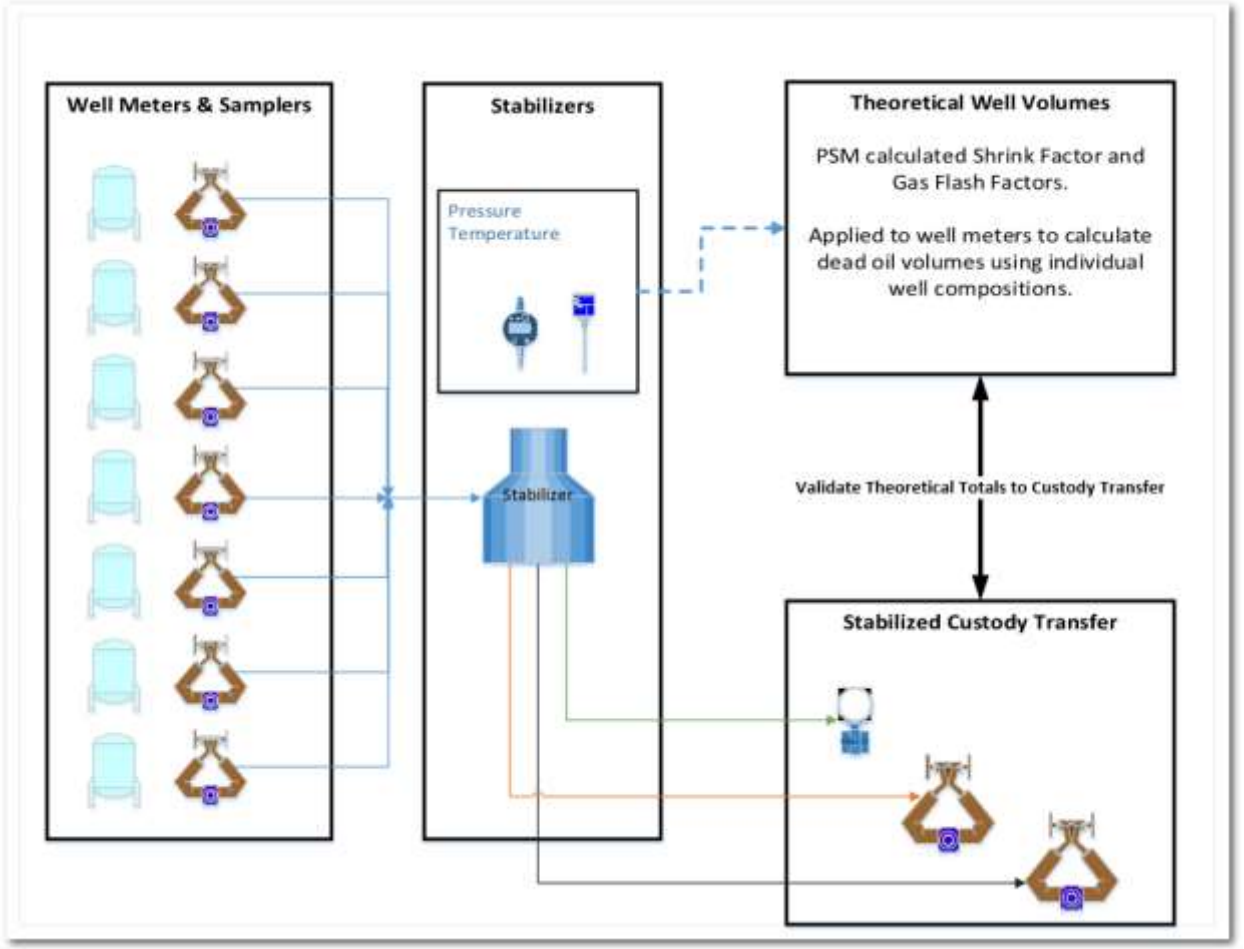
Analytical Data

Components	Mol. %	MW	Wt. %	Sp. Gravity	L.V. %
Nitrogen	0.036	28.013	0.009	0.807	0.008
Methane	0.044	16.043	0.006	0.300	0.015
Carbon Dioxide	0.015	44.010	0.005	0.817	0.005
Ethane	0.816	30.069	0.207	0.356	0.435
Propane	4.138	44.096	1.543	0.507	2.273
Iso-butane	1.957	58.122	0.962	0.563	1.277
n-Butane	7.856	58.122	3.861	0.584	4.938
Iso-pentane	5.166	72.149	3.152	0.625	3.767
n-Pentane	7.778	72.149	4.745	0.631	5.621
Hexanes	11.223	86.175	8.178	0.664	9.201
Heptanes Plus	60.971	150.000	77.332	0.797	72.460
	100.000		100.000		100.000

Calculated Physical Properties	Total	C7+
Specific Gravity at 60°F	0.7472	0.7974
API Gravity at 60°F	57.883	45.952
Molecular Weight	118.264	150.000
Pounds per Gallon (in Vacuum)	6.229	6.648
Pounds per Gallon (in Air)	6.222	6.641
Cu. Ft. Vapor per Gallon @ 14.73 psia	19.942	16.780

Modeling

PFD



Modeling

Flash Conditions

- Based upon a stabilization facility in this example.

Stabilizers	Train 1	Train 2
Flow Rate	20,399	0
Stabilizer Temperatures		
Overhead 1	158	82
Overhead 2	174	85
Temp 1	188	87
Temp 2	190	91
Bottoms	212	85

Flow Time Dependent Averages

- Example
  - *89 Deg. F.*
  - *0 Psig*
-

Reproducibility Auditability

Third Party Performed Modeling Results

Analytical Data

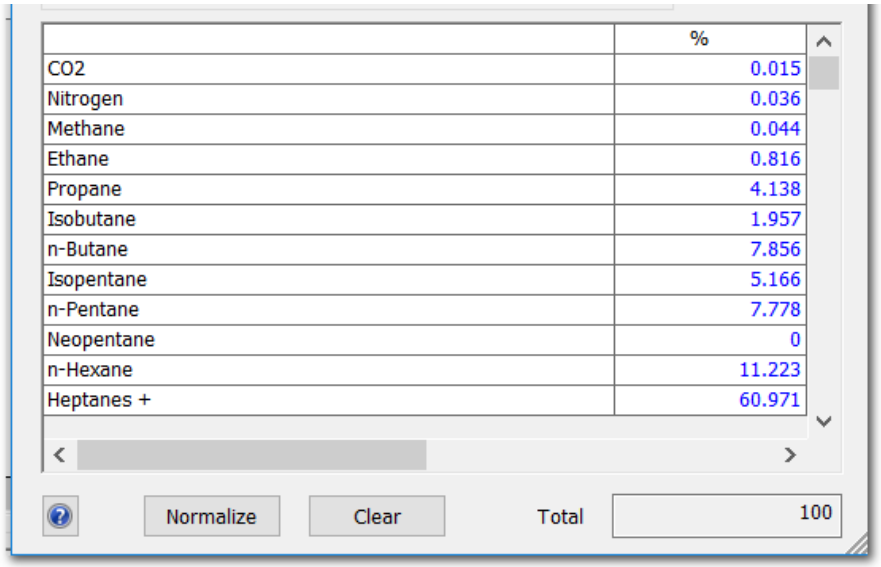
Analyte	Result	Units	Detection Limit
Shrinkage Factor	0.9845		
Flash Factor	22.0370	Cu.Ft./STBbl.	

Comments: Flashed from 24.7 psia @ 89°F to 14.7 psia @ 89°F

Reproducibility Auditability

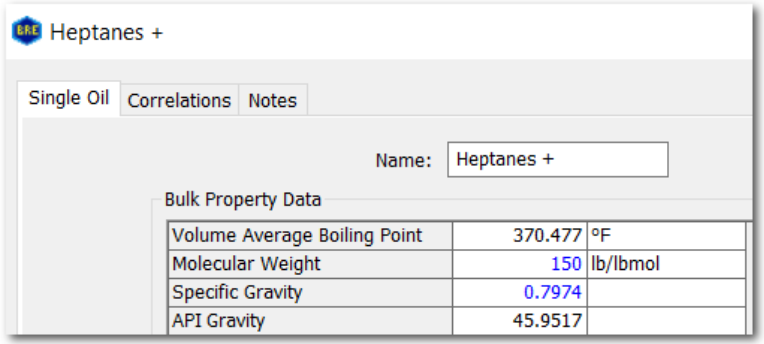
Example 1

- Composition
  - Including Heptanes + Characteristics
- Pressure & Temperature



	%
CO2	0.015
Nitrogen	0.036
Methane	0.044
Ethane	0.816
Propane	4.138
Isobutane	1.957
n-Butane	7.856
Isopentane	5.166
n-Pentane	7.778
Neopentane	0
n-Hexane	11.223
Heptanes +	60.971

Normalize | Clear | Total 100



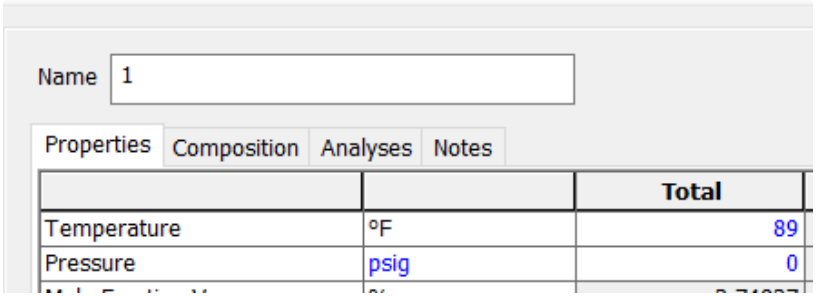
Heptanes +

Single Oil | Correlations | Notes

Name: Heptanes +

Bulk Property Data

Volume Average Boiling Point	370.477	°F
Molecular Weight	150	lb/lbmol
Specific Gravity	0.7974	
API Gravity	45.9517	



Name 1

Properties | Composition | Analyses | Notes

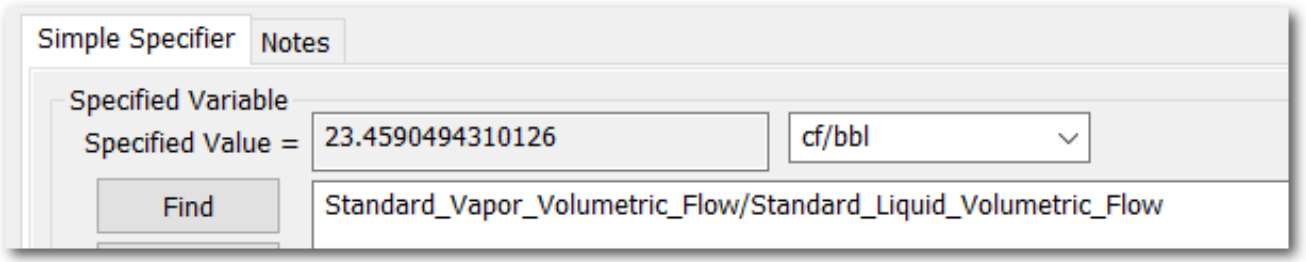
		Total
Temperature	°F	89
Pressure	psig	0

Reproducibility Auditability

Example 1

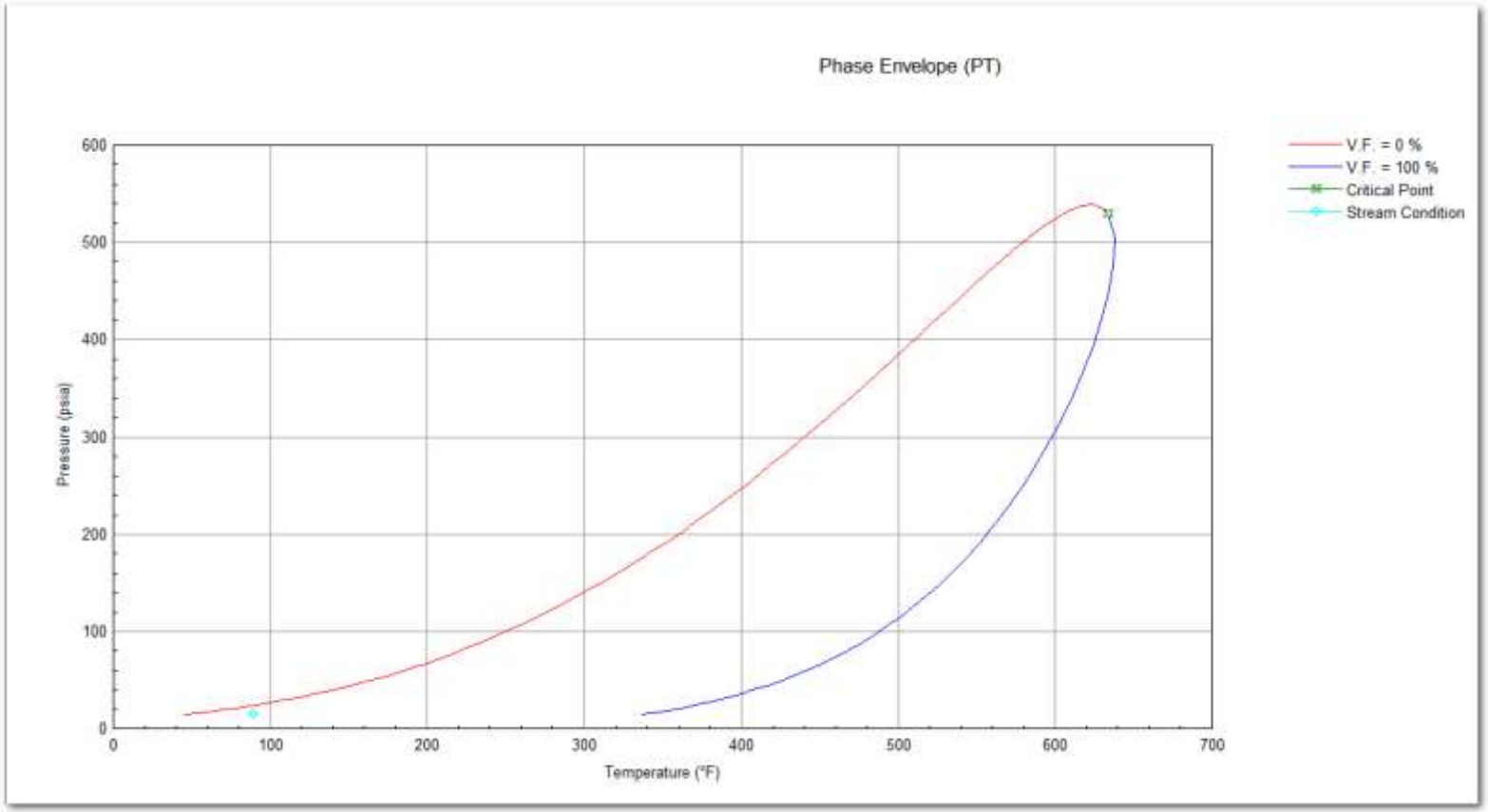
- Results

Std Liquid Volumetric Flow	bbl/d	1	0.0164411	0.983559	



Phase Diagram

- Multiphase Region
  - Some gas and some liquid



Reproducibility Auditability

- **Shrink Factor**
  - 0.9845 Laboratory 0.9836 Software
- **Gas Flash Factor**
  - 22 Laboratory 23 Software
- **Less than 1% difference**
- **Many other software programs have shown reproducible results.**

GLO Office Example Software

Inputs for EOS

Material Stream Details

Status	Active
Name	HVP Oil
Compound Amount Basis	Default

Select the basis to display compound amounts in floating tables, if enabled.

Property Package

Property Package	Peng-Robinson (PR) (
Flash Algorithm	Default

Properties

Flash Specification	Temperature and Pre

Select a pair of properties to specify the thermodynamic state of the stream's mixture.

Temperature (F)	89

Enter the temperature of the stream if the Flash Spec is T/P or T/VF, otherwise it will be calculated.

Pressure (psig)	0.000142253

Enter the pressure of the stream if the Flash Spec is T/P, P/H, P/S or P/VF,

Mixture Composition

Composition changes will only be committed after clicking on the 'Accept' button.

Amount Basis	Molar Fractions
Methane	0.00438256
Ethane	0.00812765
Propane	0.041216
N-butane	0.0782486
Isobutane	0.0194924
N-pentane	0.0774916
Isopentane	0.0514552
hexane	0.111785
heptane	0.538505
Nitrogen	0.000358573
Carbon dioxide	0.000149405
Heptanes + (OIL)_NBP460	0.303646
Heptanes + (OIL)_NBP480	0.303646

Normalize

Equalize

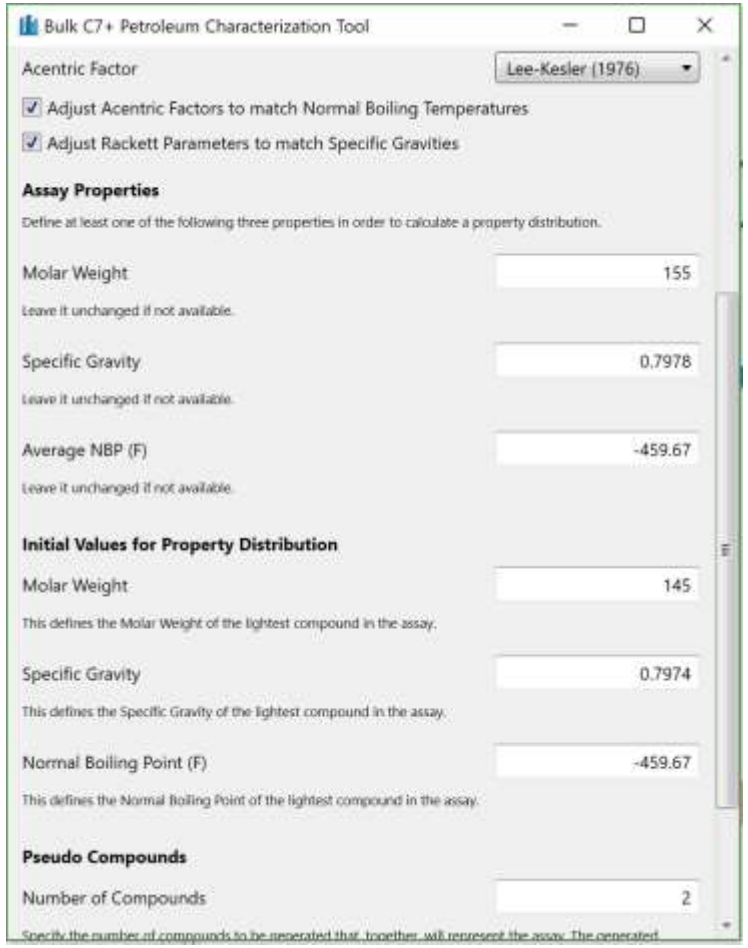
Clear

Accept/Update

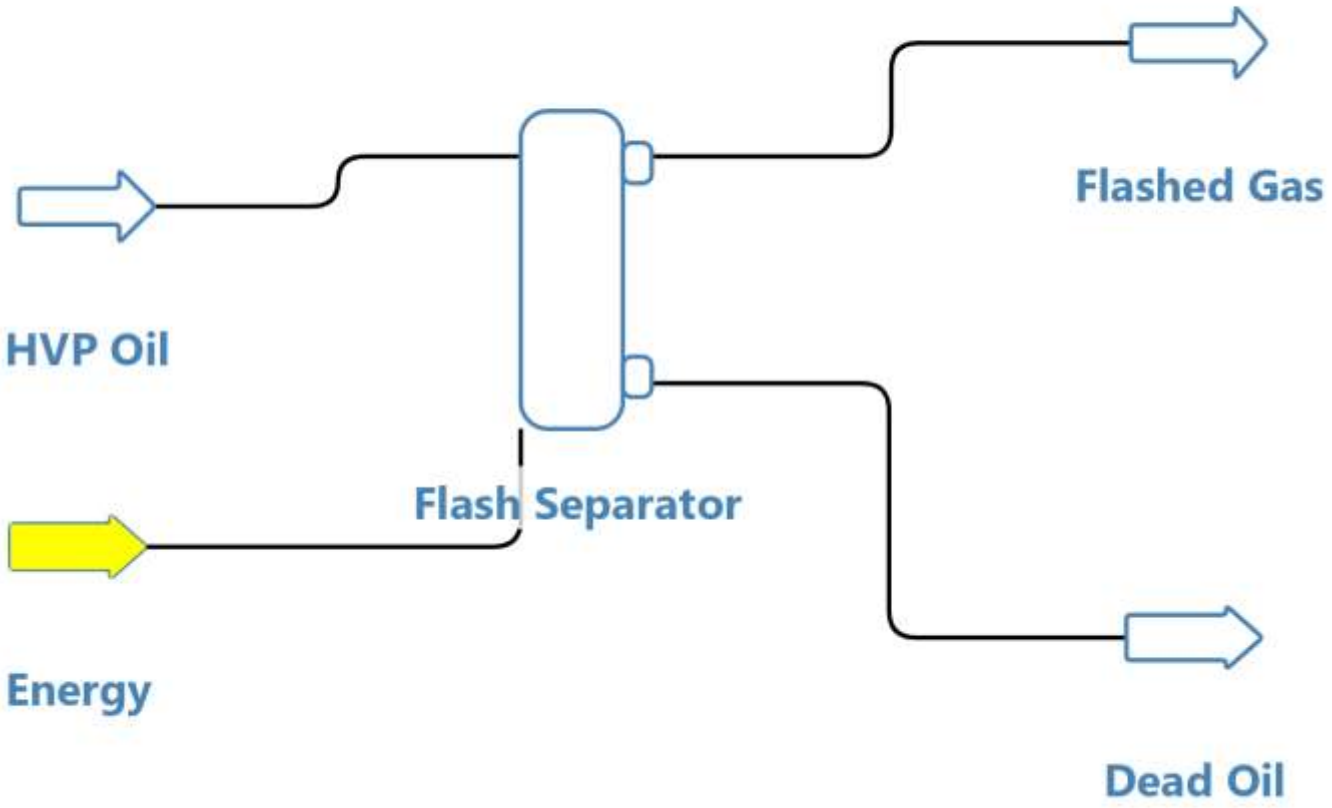
GLO Office Example Software

Heptanes +

- This software uses pseudo components
  - Used similar components to the characterization from the sample results



GLO Office Example Software



Component Level Comparison

Dead Oil
Compound Amounts - Basis: Molar Fracti

Compounds / Phases	Overall
Methane	0.000691769
Ethane	0.00402723
Propane	0.0308749
N-butane	0.0688731
Isobutane	0.0166821
N-pentane	0.0717311
Isopentane	0.0472783
hexane	0.105191
heptane	0.0788133
Nitrogen	2.25347E-05
Carbon dioxide	6.16456E-05
Heptanes + (Oil)_NBP460	0.287871
Heptanes + (Oil)_NBP480	0.287882

Fraction
Total

	Total	Vapor	Light Liquid
	%	%	%
CO2	0.015	0.386691	0.00449588
Nitrogen	0.036	1.24556	0.0018173
Methane	0.044	1.39233	0.00589555
Ethane	0.816	15.3963	0.403954
Propane	4.138	34.47	3.28081
Isobutane	1.957	7.87166	1.78985
n-Butane	7.856	22.2046	7.4505
Isopentane	5.166	6.40893	5.13087
n-Pentane	7.778	7.35335	7.79
Neopentane	0	0	0
n-Hexane	11.223	3.15981	11.4509
Heptanes +	60.971	0.110741	62.6909

GLO Office Example Software

Similar Results

- Shrink Factor was 0.9856

Other Software Provides Similar Results

- If the design was setup similarly.

Alternative Methods

- **More options that just this modeling**
  - Modeling may be done differently
  - Other companies may choose other methods.
    - *API MPMS Chapter 20 outlines several methods*
  - As long as the results are reproducible, accurate, and auditable
    - *End up with accurate Shrink Factor, Gas Flash Factor, and Dead oil Density*

- **Run through similar process as given in the example**

Summary

- **Modeling**
  - Samples Analyzed
    - *Composition*
  - Flash Conditions

- **Reproducibility / Auditability**
  - Laboratory Results
  - Software Comparisons

Questions, Thoughts, Ideas…

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Validation Department