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Abbreviations, Acronyms, and Symbols

bbl  barrel
bbl/day  barrels per day
C10+  decanes and higher hydrocarbons
cf  cubic foot
CP  constant pressure
CV  constant volume
FGOR  flash gas-to-oil ratio
GC  gas chromatograph
GOR  Gas-to-oil ratio
GPA  Gas Processors Association
HP  high-pressure
IPT  initial pressure test
LP  low-pressure
MB100  mass balance corrected to 100%
ml  milli-liter
mole %  mole percent
MP  mid-pressure
Mscfd  thousand standard cubic feet per day
MW  molecular weight
N2  nitrogen
oz  ounce (ounce per square inch)
P  pressure
PFD  Process Flow Diagram
PHLSA  pressurized hydrocarbon liquid sampling and analysis
psi  pounds per square inch
psia  pounds per square inch absolute
psig  pounds per square inch gauge
PSM/EOS  Process Simulation Model / Equation of State
scf  standard cubic foot
scf/bbl     standard cubic feet per barrel
SG         specific gravity
std        standard
T          temperature
WC         well cycle

$\rho$      density
%
°F         degrees Fahrenheit
# Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bubble point pressure</td>
<td>The bubble point pressure is the pressure (at a given temperature) at which the first bubble of gas comes out of solution in oil. For pressurized hydrocarbon liquid sampling and analysis, the bubble point pressure is typically determined at the pressurized sample collection temperature.</td>
</tr>
<tr>
<td>Down-comer line</td>
<td>A down-comer line is an extension of the separator to tank pipeline installed inside the tank. The line typically ends about a foot from the tank bottom. Introducing separator fluids using a down-comer line, rather than a side-fill configuration, prevents the splatter effect of incoming oil striking the tank liquid surface and reduces the rapid volatilization of light hydrocarbons.</td>
</tr>
<tr>
<td>Flash gas to oil ratio</td>
<td>Flash gas to oil ratio (FGOR) is the volume of flash gas, rapidly generated when a volume of oil undergoes a rapid pressure drop through a dump valve from a separator to an atmospheric oil storage tank, divided by the post-flash oil volume. FGOR can depend on the pressurized oil composition; the separator temperature and pressure; the tank temperature (liquid and headspace gas), pressure, and liquid height; the tank fluid inlet configuration (e.g., down-comer or side-fill); and other parameters. FGOR is reported as scf of flash gas per barrel of post-flash oil.</td>
</tr>
<tr>
<td>Pressurized liquids</td>
<td>“Pressurized Liquids” shall mean hydrocarbon liquids separated from, condensed from, or produced with natural gas while still under pressure and upstream of the Condensate tanks servicing the well.</td>
</tr>
<tr>
<td>Separator</td>
<td>“Separator” shall mean a pressurized vessel used for separating a well stream into gaseous and liquid components.</td>
</tr>
<tr>
<td>Shrinkage</td>
<td>Shrinkage is the reduction in the volume of a pressurized liquid hydrocarbon sample when the sample temperature and pressure change from separator conditions to tank conditions.</td>
</tr>
<tr>
<td>Siphon hole</td>
<td>A small hole near the top of a storage tank down-comer to prevent a siphon effect and backflow of liquid from the tank to the separator.</td>
</tr>
<tr>
<td>Storage tank</td>
<td>An atmospheric storage tank for condensate equipped with a pressure relief valve to maintain the pressure below a design threshold (e.g., 16 oz).</td>
</tr>
</tbody>
</table>
1. Introduction and Background

This appendix presents the results of the Process Simulation Modeling/Equation of State (PSM/EOS) calculations task for the Noble Energy PHSLA study. PSM/EOS calculations used to estimate the flash gas generated when a pressurized hydrocarbon liquid (e.g., condensate) is subjected to pressure and temperature changes as it is transferred from a pressurize vessel (typically a separator) into an atmospheric storage tank. The PHSLA study was conducted at a single production site in the DJ Basin, the Bernhardt J31-32D well, and the results presented in this appendix apply to this production site. PSM/EOS calculations for other sites may produce different results due to differences in parameters such as equipment, operating conditions, process rates and fluid properties.

The primary objectives of the PSM/EOS calculations task were to:

- identify parameters needed to calculate flash gas generation rates in condensate storage tanks using commercially available PSM/EOS programs;
- calculate flash gas generation rate estimates using the pressurized condensate compositions and process conditions for the Winter and Summer three-pressure tests;
- determine the sensitivity of calculated flash gas generation rates to these input parameters;
- estimate the uncertainty of the PSM/EOS calculations; and
- develop recommended “best practices” for PSM/EOS calculation of flash gas generation rates.

Parameters that impact storage tank flash gas generation rates and are required for PSM/EOS calculations of flashing emissions include the pressurized hydrocarbon liquid composition, and the separator and storage tank operating conditions. Pressurized liquid hydrocarbon samples are collected from the last pressurized vessel upstream of the atmospheric pressure storage tank, and analyzed using gas chromatograph (GC) methods to determine the composition (refer to Section 2.3 of the Final Report). The pressures and temperatures of the separator and storage tank used for PSM/EOS calculations should represent the operating conditions at the time of the sample collection and condensate transfer from the separator to the tank.

PSM/EOS calculations are equilibrium calculations and will estimate the volume of flash gas generated when a known volume of condensate is dumped from a separator operating at a known temperature and pressure to a storage tank operating at a known temperature and pressure. The calculations are based on the pressurized condensate sample being in gas/liquid equilibrium at the separator temperature and pressure, and the tank liquids being in gas/liquid
equilibrium at the storage tank temperature and pressure. Flashing emissions from an atmospheric storage tank are not a steady-state process because storage tank headspace gas accumulation/pressure increase and tank-to-burner gas flow are inter-dependent. Further, it has been observed that flash gas that enters a storage tank at the bottom through a down-comer does not migrate to the tank headspace at a steady rate (refer to Section 2.1 of the Final Report). Thus, it is anticipated that the flash gas to oil (FGOR) values estimated by the steady state modeling would be inputs to dynamic models used to design storage tank control systems.

1.1 Siphon Prevention Hole in the Storage Tank Down-comer

A discovery during the testing was that the storage tank down-comer pipe has a 3/8” hole near the top of the tank. This “siphon prevention hole (SPH)” was installed as a safety feature. Absent such a hole, in the event of an upset condition where a negative pressure is applied on the separator, a siphon could form and oil would flow from the tank back to the separator. The siphon prevention hole was drilled to prevent siphon formation and such back-flow. An illustration of the hole location within the tank is shown in Figure 1-1.

![Figure 1-1. Location of the siphon prevention hole on the down-comer pipe.](image)

A consequence of the SPH is that some of the fluids flowing from the separator to the tank pass through the siphon prevention hole into the tank headspace. The tank headspace temperature and pressure differ from the tank bottom conditions where the majority of the separator fluids are expected to flow (refer to Section 2.1 of the Final Report), and this temperature and
pressure difference would impact liquids flashing. The SPH was considered in the PSM/EOS calculations as discussed in the following. The fraction of the separator to tank fluids flow that passes through the SPH could not be directly measured, and was estimated to be 0.06 based on a simple engineering model that is presented in Appendix V.1.

1.2 Appendix V Organization

This section introduces PSM/EOS software programs and provides some background information. Section 2 describes the approach used to conduct this task including the different PSM/EOS models used to simulate the Bernhardt production site processes, and Section 3 presents the results of the PSM/EOS models calculations. Section 4 describes a PSM/EOS calculations sensitivity study (i.e., how much does an incremental change in a PSM/EOS calculation input change the outputs) and Section 5 provides estimations of the uncertainties of the PSM/EOS calculations. Section 6 then summarizes task conclusions and recommendations for conducting PSM/EOS calculations of storage tank flash gas emissions.

Appendix V.1 Estimated Discharge From Siphon Prevention Hole
Appendix V.2 PSM Instructions
Appendix V.3 PSM/EOS Modeling Results
Appendix V.4 PSM/EOS Sensitivity Study Results
Appendix V.5 Monte Carlo Simulation Results
Appendix V.6 – V9 Files with Inputs and Outputs for PSM/EOS Calculations

2. Approach: PSM/EOS Separator Mass Balance, FGOR, and Bubble Point Pressure Calculations

PSM/EOS estimates of FGOR generation rates were calculated using four different commercially available simulation software programs identified as Sim 1, Sim 2, Sim 3, and Sim 4. Unless otherwise noted, a Peng-Robinson equation of state was used for the equilibrium calculations. Three simulation models were conducted using the four simulation programs:

1. Separator balance. For each well cycle from the Winter and Summer three-pressure testing (refer to Final Report Section 3.2.9), measured volumes and compositions of sales gas, oil production, and water production were recombined into a single well output/separator input process stream that was input to each PSM/EOS software program. Separator sales gas, oil, and water outputs were calculated and compared to the measured volumes to check the accuracy of the software programs. Due to the high uncertainty of direct measurement in the Mass Balance (U>20%), the Separator Balance provides a secondary
means of estimating EOS uncertainty since the separator measurement uncertainty is significantly lower (U<5%).

2. **FGOR.** Flash gas to oil ratios and flash gas compositions were calculated for each well cycle from the Winter and Summer three-pressure testing based on the pressurized oil composition, separator pressure ($P_{sep}$), separator liquids temperature ($T_{sep}$), the pressure at the tank bottom at the down-comer exit ($P_{tank}$), and the temperature of the storage tank liquids at the down-comer exit ($T_{tank}$).

3. **Dead oil.** As discussed in Section 4.7 of the Final Report, directly measured storage tank mass balance closures improved as each testing day progressed and tank liquid temperatures increased. It was hypothesized that the tank oil in the vicinity of the tank down-comer had cooled over-night and was under-saturated (i.e., not at gas/liquid equilibrium), and that some of the flash gas was being absorbed by this cold oil rather than migrating to the tank headspace. To evaluate this theory, the FGOR model was modified to add a sufficient volume of dead oil to pressurized oil such that the PSM/EOS calculated FGOR equaled the directly measured FGOR.

These simulation models are discussed in greater detail in the following sub-sections.

2.1 **Separator Mass Balance Model**

Each PSM/EOS software program was evaluated by conducting separator balance calculations using the model shown the Process Flow Diagram (PFD) shown in Figure 2-1. For each well cycle, measured volumes and compositions of sales gas, oil production, and water production (one analysis per season) cycle, the measured volumes of sales gas (Sales_Gas), produced oil (Separator_Oil), and produced water (Separator_Water) and associated measured compositions were recombined in “Mixer 1” to form the “Well Bore Fluid”. PSM/EOS calculations of separator outlet streams volumes and compositions were conducted. The measured volumes were compared to the modeled volumes to better understand the uncertainty of the PSM/EOS equilibrium calculations.

The separator mass balance model was developed using process simulation software 1 (Sim 1) and then mimicked in Sim 2 and 3. Because Sim 4 is not a graphic PSM/EOS model, recreating the separator mass balance model was not practical.
2.2 FGOR Models

Two PSM/EOS models were developed to calculate FGORs. The “Simple” model does not consider the siphon prevention hole discussion above and 100% of the separator to tank fluids flow is assumed to flow through the tank down-comer to the bottom of the storage tank (i.e., into the tank liquids about 1 foot from the tank bottom). Figure 2-2 is the process flow diagram for the simple model. Pressurized oil (Pressurized_Condensate) enters the storage tank and flash gas (Flash_Gas) and post-flash oil (Tank_Condensate) are the outputs.

Figure 2-2. “Simple” PSM/EOS model process flow diagram.
Figure 2-3 presents the process flow for the “complex” model that evolved from the simple model. The change was to consider the impact of the siphon prevention hole in the storage tank down-comer. Pressurized oil (Oil_to_tank) enters the down-comer and splits into two streams:

1. Fluids that pass through the SPH to the storage tank headspace (Oil_to_tank_headspace). This fluid partitions to gas (Flash_Gas_from_HS) and liquid (Oil_from_SPH) in the tank headspace.

2. Fluids that pass through the entire down-comer to the tank bottom (Oil_to_Tank_bottom). This fluid partitions to gas (Flash_Gas_from_tank_bottom) and liquid (Tank_Condensate) in the tank bottom in the vicinity of the down-comer outlet.

Flash_Gas_from_HS and Flash_Gas_from_tank_bottom are mixed to determine the entire volume of flash gas (Flash_Gas). Oil_from_SPH and Tank_Condensate are mixed to determine the entire volume of post-flash tank oil (Tank_Oil).

The simple and complex models were developed using process simulation software 1 (Sim 1) and then mimicked in Sim 2 and 3. Sim 4 is similar to the simple model, with the separator condensate dumping into the tank without the additional PFD objects utilized in the complex model. Because Sim 4 is not a graphic PSM/EOS model, recreating the complex model with the SPH was not practical.

2.3 Dead Oil Model

As discussed in Section 4.7 of the Final Report, measured FGORs and storage tank mass balance closures tended to increase as the test day progressed and tank liquid temperatures increased. A theory to at least partially explain these measurements is that cold morning tank liquids were
not in gas/liquid equilibrium and some flash gas was absorbed by under-saturated “dead oil” in the bottom of the tank. Under these conditions, PSM/EOS equilibrium calculations would not be expected to agree with the storage tank emission measurements. To compensate for these non-equilibrium conditions, a “dead oil” modeling approach was used. The dead oil model added a volume of unsaturated dead oil to the flash gas simulation, and adjusted this volume such that PSM/EOS calculation results matched the Bernhardt site direct measurements of FGOR.

Similar to the models discussed above, the dead oil model was developed using Sim 1 and then mimicked in Sim 2 and 3. Because Sim 4 is not a graphic PSM/EOS model, recreating the dead oil model was not practical.

2.4 PSM/EOS Calculations of Bubble Point Pressure

The Bubble Point is the temperature and pressure where the first bubble begins to form in a liquid mixture. The determination of Bubble Point is performed at a fixed pressure (Bubble Point Pressure) or a fixed pressure (Bubble Point Temperature). It becomes useful information when the determination is done at one of the operating conditions of pressure or temperature. For Bubble Point Pressure (which was used in this study) the vapor pressure is calculated for the fluid composition at a set temperature. In the study, the temperature of the separator (Tsep) was used. The Bubble Point in this case is the pressure at a given temperature that the first gas bubble begins to form in the liquid mixture.

PSM/EOS software programs often feature special property calculations such as Dew Point and Bubble Point. The Bubble Point from EOS is used as an operational performance check to validate sample collection and analysis results. Bubble Points were also run at 72°F to compare to Initial Pressure Tests (IPT) run at that temperature. This step was added to validate the IPT as an operational performance check.

2.5 Inputs for PSM/EOS Calculations

As discussed in Section 3.3 of the Final Report, the Bernhardt test site was instrumented to measure process parameters such as separator and tank pressures and temperatures, and gas and liquid flow rates. These process measurement data (sales gas volume and composition, produced water volume and composition, and produced condensate volume), and the pressurized condensate samples’ analytical results (including the density and molecular weight of the decanes and heavier), were used as inputs for modeling the Winter and Summer three-pressure testing well cycles. Figure 2-4 provides an overview of the data flow.
Table 2-1 lists the average operating conditions during the Winter testing well cycles, and Table 2-2 lists the average operating conditions during the Summer testing well cycles. These values were used for the PSM/EOS calculations of FGOR and sample bubble point pressure at the separator temperature. Table 2-3 lists the engineering units and standard conditions for the PSM/EOS calculations. Table 2-4 lists the pressurized condensate composition used for the PSM/EOS calculations. Review of the analytical results determined that nitrogen in samples above trace levels were a result of air entrainment during sample collection (refer to Section 4.1 of the Final Report). The threshold amount for this study was 0.020 mole %. Nitrogen-free compositions were used when analytical results exceeded this threshold value.
Table 2-1. Average Operating Conditions During Winter 3-Pressure Testing Well Cycles

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Well Cycle&lt;sup&gt;A&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HP1</td>
</tr>
<tr>
<td>Separator Temperature (°F)</td>
<td>84.6</td>
</tr>
<tr>
<td>Separator Pressure (psig)</td>
<td>262.3</td>
</tr>
<tr>
<td>Ambient Pressure (psia)</td>
<td>12.33</td>
</tr>
<tr>
<td>Separator Pressure (psia)</td>
<td>274.6</td>
</tr>
<tr>
<td>Siphon Hole Fraction</td>
<td>0.06</td>
</tr>
<tr>
<td>Tank Headspace Temperature (°F)</td>
<td>65.5</td>
</tr>
<tr>
<td>Tank Headspace Pressure (oz)&lt;sup&gt;B&lt;/sup&gt;</td>
<td>3.5</td>
</tr>
<tr>
<td>Tank Bottom Temperature (°F)</td>
<td>46.0</td>
</tr>
<tr>
<td>Tank Liquids Height (inches)</td>
<td>130.2</td>
</tr>
<tr>
<td>Tank liquids Density (SG)</td>
<td>0.7587</td>
</tr>
<tr>
<td>Tank Bottom Pressure (psia)</td>
<td>15.79</td>
</tr>
</tbody>
</table>

A. Well cycle process data from Appendix IV.
B. Assumed to be the midpoint of 2 - 5 oz (VOC burner off and on pressures)
Table 2-2. Average Operating Conditions During Summer 3-Pressure Testing Well Cycles

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Well Cycle^A</th>
<th>S-HP1</th>
<th>S-HP2</th>
<th>S-HP3</th>
<th>S-MP1</th>
<th>S-MP2</th>
<th>S-MP3</th>
<th>S-MP4</th>
<th>S-MP5</th>
<th>S-LP1</th>
<th>S-LP2</th>
<th>S-LP3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separator Temperature (°F)</td>
<td></td>
<td>62.5</td>
<td>77.9</td>
<td>85.8</td>
<td>65.9</td>
<td>69.7</td>
<td>84.2</td>
<td>62.1</td>
<td>71.7</td>
<td>66.7</td>
<td>69.6</td>
<td>80.3</td>
</tr>
<tr>
<td>Separator Pressure (psig)</td>
<td></td>
<td>267.5</td>
<td>264.1</td>
<td>265.0</td>
<td>229.4</td>
<td>227.7</td>
<td>234.0</td>
<td>229.0</td>
<td>230.5</td>
<td>177.7</td>
<td>175.3</td>
<td>177.9</td>
</tr>
<tr>
<td>Separator Pressure (psia)</td>
<td></td>
<td>279.8</td>
<td>276.5</td>
<td>277.4</td>
<td>241.7</td>
<td>240.0</td>
<td>246.3</td>
<td>241.3</td>
<td>242.9</td>
<td>190.0</td>
<td>187.6</td>
<td>190.2</td>
</tr>
<tr>
<td>Siphon Hole Fraction</td>
<td></td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>Tank Headspace Temperature (°F)</td>
<td></td>
<td>70.1</td>
<td>99.6</td>
<td>99.8</td>
<td>75.0</td>
<td>88.9</td>
<td>89.6</td>
<td>71.4</td>
<td>87.0</td>
<td>71.7</td>
<td>88.8</td>
<td>95.8</td>
</tr>
<tr>
<td>Tank Headspace Pressure (oz)^B</td>
<td></td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Tank Bottom Temperature (°F)</td>
<td></td>
<td>76.7</td>
<td>80.0</td>
<td>82.9</td>
<td>78.2</td>
<td>79.3</td>
<td>80.3</td>
<td>75.0</td>
<td>76.2</td>
<td>75.1</td>
<td>75.8</td>
<td>77.9</td>
</tr>
<tr>
<td>Tank Liquids Height (inches)</td>
<td></td>
<td>156.6</td>
<td>156.8</td>
<td>157.5</td>
<td>157.8</td>
<td>158.1</td>
<td>158.0</td>
<td>158.5</td>
<td>158.7</td>
<td>160.5</td>
<td>160.8</td>
<td>161.2</td>
</tr>
<tr>
<td>Tank liquids Density (SG)</td>
<td></td>
<td>0.7595</td>
<td>0.76</td>
<td>0.7595</td>
<td>0.7595</td>
<td>0.7595</td>
<td>0.7595</td>
<td>0.7595</td>
<td>0.7595</td>
<td>0.7595</td>
<td>0.7595</td>
<td>0.7595</td>
</tr>
</tbody>
</table>

A. Well cycle process data from Appendix IV.
B. Assumed to be the midpoint of 2 - 5 oz (VOC burner off and on pressures)

Table 2-3. PSM/EOS Calculations Input and Output Data Engineering Units and Standard Conditions

<table>
<thead>
<tr>
<th>Measured Value</th>
<th>Units</th>
<th>Standard Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Flow Rates</td>
<td>Std. bbls / day</td>
<td>60°F, 14.73 psia^A</td>
</tr>
<tr>
<td>Gas Flow Rates</td>
<td>Mscfd</td>
<td>60°F, 14.73 psia^A</td>
</tr>
<tr>
<td>Pressure</td>
<td>psia</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>°F</td>
<td></td>
</tr>
</tbody>
</table>

A. Sim 3 used Standard Conditions of 60°F, 14.70 psia. This difference resulted in approximately 0.2% difference in FGOR results.
Table 2-4. Pressurized Condensate Composition Input Data for PSM/EOS Calculations (WC S-MP3)\textsuperscript{A}

<table>
<thead>
<tr>
<th>Component</th>
<th>Pressurized</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>0.401</td>
<td>Mole %</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.003</td>
<td>Mole %</td>
</tr>
<tr>
<td>Methane</td>
<td>5.768</td>
<td>Mole %</td>
</tr>
<tr>
<td>Ethane</td>
<td>6.128</td>
<td>Mole %</td>
</tr>
<tr>
<td>Propane</td>
<td>7.709</td>
<td>Mole %</td>
</tr>
<tr>
<td>Iso-Butane</td>
<td>2.542</td>
<td>Mole %</td>
</tr>
<tr>
<td>n-Butane</td>
<td>7.755</td>
<td>Mole %</td>
</tr>
<tr>
<td>Iso-Pentane</td>
<td>4.988</td>
<td>Mole %</td>
</tr>
<tr>
<td>n-Pentane</td>
<td>6.972</td>
<td>Mole %</td>
</tr>
<tr>
<td>n-Hexane</td>
<td>5.765</td>
<td>Mole %</td>
</tr>
<tr>
<td>Heptanes</td>
<td>13.323</td>
<td>Mole %</td>
</tr>
<tr>
<td>Octanes</td>
<td>10.577</td>
<td>Mole %</td>
</tr>
<tr>
<td>Nonanes</td>
<td>4.780</td>
<td>Mole %</td>
</tr>
<tr>
<td>Decanes Plus</td>
<td>11.490</td>
<td>Mole %</td>
</tr>
<tr>
<td>Benzene</td>
<td>0.773</td>
<td>Mole %</td>
</tr>
<tr>
<td>Toluene</td>
<td>2.760</td>
<td>Mole %</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>0.189</td>
<td>Mole %</td>
</tr>
<tr>
<td>m,p-Xylene (100% meta)</td>
<td>2.205</td>
<td>Mole %</td>
</tr>
<tr>
<td>o-Xylene</td>
<td>0.510</td>
<td>Mole %</td>
</tr>
<tr>
<td>2,2,4-Trimethylpentane</td>
<td>0.046</td>
<td>Mole %</td>
</tr>
<tr>
<td>2,2-Dimethylbutane</td>
<td>0.086</td>
<td>Mole %</td>
</tr>
<tr>
<td>2,3-Dimethylbutane</td>
<td>0.299</td>
<td>Mole %</td>
</tr>
<tr>
<td>Cyclopentane</td>
<td>0.366</td>
<td>Mole %</td>
</tr>
<tr>
<td>2-Methylpentane</td>
<td>2.808</td>
<td>Mole %</td>
</tr>
<tr>
<td>3-Methylpentane</td>
<td>1.757</td>
<td>Mole %</td>
</tr>
<tr>
<td>Water</td>
<td>0.000</td>
<td>Mole %</td>
</tr>
<tr>
<td>Total</td>
<td>100.000</td>
<td>Mole %</td>
</tr>
<tr>
<td>C10+ Molecular Weight</td>
<td>217.111</td>
<td>lb/lb-mol</td>
</tr>
<tr>
<td>C10+ Relative Density at 60°F</td>
<td>0.8237</td>
<td></td>
</tr>
<tr>
<td>C10+ Density at 60°F</td>
<td>51.37</td>
<td>lb/ft\textsuperscript{3}</td>
</tr>
</tbody>
</table>

A. Example composition from Summer medium pressure well cycle 3 (S-HP3) GPA 2103M analysis (N2-free)
2.6 Outputs of PSM/EOS Calculations

Table 2-5 lists the process parameters outputs from PSM/EOS calculations of FGOR and sample bubble point pressure at the separator temperature. Table 2-6 lists the compositions of the outlet process streams from PSM/EOS calculations of FGOR. Appendix B is an example of the PSM Model Output sheet.

Table 2-5. Output Data for PSM/EOS Calculations of FGOR

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Engineering Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Gas Volume Flow</td>
<td>Scf/day</td>
</tr>
<tr>
<td>Temperature</td>
<td>°F</td>
</tr>
<tr>
<td>Pressure</td>
<td>psia</td>
</tr>
<tr>
<td>Density</td>
<td>Lb / Ft³</td>
</tr>
<tr>
<td>Molecular Weight</td>
<td>Lb/Lb-mol</td>
</tr>
<tr>
<td>Standard Post-Flash Liquid Volume Flow</td>
<td>Std. bbls/day</td>
</tr>
<tr>
<td>Standard Pre-Flash Liquid Volume Flow</td>
<td>Std. bbls/day</td>
</tr>
<tr>
<td>Shrinkage Factor¹</td>
<td>(bbl/bbl)</td>
</tr>
<tr>
<td>Standard Dead Oil Liquid Volume Flow</td>
<td>Std. bbls/day</td>
</tr>
<tr>
<td>FGOR</td>
<td>Scf/bbl</td>
</tr>
<tr>
<td>Bubble Point Pressure at Tsep</td>
<td>psia</td>
</tr>
</tbody>
</table>

a. Shrinkage factor is the ratio of the post-flash oil volume at STP to the pre-flash oil volume at STP
Table 2-6. Output Composition Data for PSM/EOS Calculations of FGOR (WC S-MP3)\textsuperscript{A}

<table>
<thead>
<tr>
<th>Component</th>
<th>Flash Gas</th>
<th>Storage Tank Oil</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>1.449</td>
<td>0.024</td>
<td>Mole %</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.011</td>
<td>0.000</td>
<td>Mole %</td>
</tr>
<tr>
<td>Methane</td>
<td>21.435</td>
<td>0.121</td>
<td>Mole %</td>
</tr>
<tr>
<td>Ethane</td>
<td>21.167</td>
<td>0.721</td>
<td>Mole %</td>
</tr>
<tr>
<td>Propane</td>
<td>21.861</td>
<td>2.660</td>
<td>Mole %</td>
</tr>
<tr>
<td>Iso-Butane</td>
<td>5.242</td>
<td>1.594</td>
<td>Mole %</td>
</tr>
<tr>
<td>n-Butane</td>
<td>13.365</td>
<td>5.814</td>
<td>Mole %</td>
</tr>
<tr>
<td>Iso-Pentane</td>
<td>4.659</td>
<td>5.145</td>
<td>Mole %</td>
</tr>
<tr>
<td>n-Pentane</td>
<td>5.355</td>
<td>7.598</td>
<td>Mole %</td>
</tr>
<tr>
<td>n-Hexane</td>
<td>1.489</td>
<td>7.301</td>
<td>Mole %</td>
</tr>
<tr>
<td>Heptanes</td>
<td>1.181</td>
<td>17.642</td>
<td>Mole %</td>
</tr>
<tr>
<td>Octanes</td>
<td>0.314</td>
<td>14.215</td>
<td>Mole %</td>
</tr>
<tr>
<td>Nonanes</td>
<td>0.047</td>
<td>6.456</td>
<td>Mole %</td>
</tr>
<tr>
<td>Decanes Plus</td>
<td>0.000</td>
<td>15.556</td>
<td>Mole %</td>
</tr>
<tr>
<td>Benzene</td>
<td>0.193</td>
<td>0.981</td>
<td>Mole %</td>
</tr>
<tr>
<td>Toluene</td>
<td>0.204</td>
<td>3.668</td>
<td>Mole %</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>0.005</td>
<td>0.254</td>
<td>Mole %</td>
</tr>
<tr>
<td>m-Xylene</td>
<td>0.048</td>
<td>2.970</td>
<td>Mole %</td>
</tr>
<tr>
<td>o-Xylene</td>
<td>0.010</td>
<td>0.687</td>
<td>Mole %</td>
</tr>
<tr>
<td>2,2,4-Trimethylpentane</td>
<td>0.004</td>
<td>0.061</td>
<td>Mole %</td>
</tr>
<tr>
<td>2,2-Dimethylbutane</td>
<td>0.044</td>
<td>0.101</td>
<td>Mole %</td>
</tr>
<tr>
<td>2,3-Dimethylbutane</td>
<td>0.118</td>
<td>0.365</td>
<td>Mole %</td>
</tr>
<tr>
<td>Cyclopentane</td>
<td>0.206</td>
<td>0.425</td>
<td>Mole %</td>
</tr>
<tr>
<td>2-Methylpentane</td>
<td>1.020</td>
<td>3.455</td>
<td>Mole %</td>
</tr>
<tr>
<td>3-Methylpentane</td>
<td>0.574</td>
<td>2.184</td>
<td>Mole %</td>
</tr>
<tr>
<td>Water</td>
<td>0.000</td>
<td>0.000</td>
<td>Mole %</td>
</tr>
</tbody>
</table>

A. Example composition from Summer Medium pressure well cycle 3 (S-MP3) GPA 2103M analysis

3. Results: PSM/EOS Separator Mass Balance, FGOR, and Bubble Point Pressure Calculations

3.1 Separator Mass Balance Calculations

Table 3-1 presents example separator balance results. Note that the results indicate some of the oil and water are absorbed in the gas, and analysis of the oil and gas samples for water was not conducted (i.e., analysis of gas and oil for water content by GC is not routine or practical). Some of this effect would likely be reduced if the trace levels of water present in the gas and oil had been quantified.

The oil and gas volumes listed under “Measured” were measured during the individual well cycles associated with pressurized condensate sample collection. The volume of produced
water was very small and the volume of water produced with each well cycle was often less than the separator water box volume (i.e., there were zero water dumps for some well cycles). Therefore, the volume of water for each well cycle was estimated from the volume of oil production and a water/oil ratio determined from numerous well cycles.

Generally, gas predictions were about + 1% of measured, oil predictions were about - 6% of measured, and water predictions were about - 10% of estimated. As indicated in Table 3-1, Sim1, Sim2 and Sim3 results had excellent agreement. The GOR results calculated from these data are likely overstated, possibly due to volume translation error in the EOS. This was not corrected in the study, although it was discussed. It is likely that FGOR results will have a similar positive bias. Refer to Appendix V.3.

### Table 3-1. Example Separator Mass Balance Results

<table>
<thead>
<tr>
<th></th>
<th>Separator Feed</th>
<th>Outflows</th>
<th></th>
<th>Sim 1</th>
<th>Sim 2</th>
<th>Sim 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Measured</td>
<td></td>
<td>Sim 1</td>
<td>Sim 2</td>
<td>Sim 3</td>
<td></td>
</tr>
<tr>
<td>Gas (Mscf/d)</td>
<td>7.614</td>
<td></td>
<td>7.688</td>
<td>7.692</td>
<td>7.685</td>
<td>Mscf/d</td>
</tr>
<tr>
<td></td>
<td>Sim x / Measured</td>
<td></td>
<td>101.0%</td>
<td>101.0%</td>
<td>100.9%</td>
<td>%</td>
</tr>
<tr>
<td>Oil (Bbl.)</td>
<td>0.522</td>
<td></td>
<td>0.479</td>
<td>0.477</td>
<td>0.485</td>
<td>bbl/d</td>
</tr>
<tr>
<td></td>
<td>Sim x / Measured</td>
<td></td>
<td>91.8%</td>
<td>91.4%</td>
<td>92.9%</td>
<td>%</td>
</tr>
<tr>
<td>Water (Bbl.)</td>
<td>0.026</td>
<td></td>
<td>0.024</td>
<td>0.024</td>
<td>0.023</td>
<td>bbl/d</td>
</tr>
<tr>
<td></td>
<td>Sim x / Measured</td>
<td></td>
<td>90.1%</td>
<td>90.0%</td>
<td>89.1%</td>
<td>%</td>
</tr>
</tbody>
</table>

a. Predicted volumes for Summer, Medium Pressure Group 3, Sim 1, Sim 2, and Sim 3 model results shown in this example

3.1. **FGOR Models Calculations**

The PSM assumes the pressurized condensate is in equilibrium at the separator pressure and temperature, and no gas flashes in the separator. FGOR values were calculated by zeroing the gas and water volumes going to “Mixer 1” in Figure 2.3. If this step is not done, the FGOR value will be affected by the differences between measured and modeled shown in the Separator Balance discussed in Section 3.1. This leaves only the pressurized condensate going into and out from the separator to the storage tank. This value is compared to the Direct Measurement FGOR. Table 3.2 shows an example of the comparison of FGOR from the four simulation packages.
### Table 3.2. Comparison of EOS Calculated FGOR to Direct Measurement FGOR

<table>
<thead>
<tr>
<th>Property</th>
<th>Sim 1</th>
<th>Sim 2</th>
<th>Sim 3</th>
<th>Sim 4</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separator Temperature</td>
<td>84.2</td>
<td>84.2</td>
<td>84.2</td>
<td>84.2</td>
<td>°F</td>
</tr>
<tr>
<td>Separator Pressure</td>
<td>246.33</td>
<td>246.33</td>
<td>246.33</td>
<td>246.33</td>
<td>psia</td>
</tr>
<tr>
<td>Bubble Point P at $T_{\text{Sep}}$</td>
<td>228.3</td>
<td>247.1</td>
<td>236.8</td>
<td>N/A</td>
<td>psia</td>
</tr>
<tr>
<td>Flash Gas to Oil Ratio (FGOR)</td>
<td>311.7</td>
<td>311.5</td>
<td>310.5</td>
<td>257.5</td>
<td>scf/bbl.</td>
</tr>
<tr>
<td>Direct Measurement FGOR (refer to Section 4.7 of the final report)</td>
<td>308.9</td>
<td>308.9</td>
<td>308.9</td>
<td>308.9</td>
<td>scf/bbl.</td>
</tr>
</tbody>
</table>

| Shrinkage $^a$                                | 0.8309| 0.8310| 0.8469| N/A   |         |

a. Shrinkage factor is the ratio of post-flash oil volume to pre-flash oil volume and does not have units (bbl/bbl)
b. Modeling results for Summer, Medium Pressure Group 3 for Sim 1, Sim 2, Sim 3 and Sim 4 results shown in this example

### 3.3. Dead Oil Model Calculations

As previously discussed in Section 2.3, the PSM/EOS model separator fluid enters an empty tank and the resulting FGOR was often significantly higher than what was measured. An analysis of the storage tank oil was used for the composition of the dead oil. The volume of dead oil was varied until the FGOR calculation matched the measured FGOR for the well cycle. These were the additional inputs used for the Dead Oil Model used to approximate direct measurement results in an effort to understand the quenching effect of the dead oil in the storage tank during the testing. An example of the results for Sim1, Simi2, and Sim3 are shown in Table 3.3.

### Table 3.3. Example Mass Balance Results Showing Dead Oil Volume Required to Match Direct Measurement

<table>
<thead>
<tr>
<th>Typical Mass Balance Results</th>
<th>Direct Measurement</th>
<th>Sim 1</th>
<th>Sim 2</th>
<th>Sim 3</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash Gas to Oil Ratio (FGOR) – Standard</td>
<td>309</td>
<td>309</td>
<td>309</td>
<td>309</td>
<td>scf/bbl</td>
</tr>
<tr>
<td>Dead Oil Volume required to match Direct Measurement FGOR$^a$</td>
<td>0.11</td>
<td>0.10</td>
<td>0.10</td>
<td></td>
<td>bbl/d</td>
</tr>
</tbody>
</table>

a. Differences in dead oil volume required mixing with live oil to match direct measurement mass balance FGOR is likely due to subtle differences in the three models.
b. PSM/EOS results for Summer, Medium Pressure Group 3, for Sim 1, Sim 2, and Sim3 model results shown in this example
3.4 Bubble Point Pressure Calculations

Figure 2-6 shows a Phase Envelope for one of the samples for this project. The phase envelope is a graphic representation of the EOS thermodynamic model output. The Y-axis is pressure in psia and the X-axis is temperature in °F. The red line shows the Bubble Point curve and the blue line shows the Dew Point curve. To the left of and above the red line is the Liquid Region, and a mixture in this area is 100% liquid. To the right of and below the red line is the 2-Phase Region, and a mixture in this region is less than 100% liquid. If sample conditions are not within an acceptable tolerance of this red line, then it is likely that the sampling and analysis results are not representative of a fluid at those conditions. The green star shows the sample conditions and proximity to the red line. In this case, the sample conditions are almost centered on the line, indicating that the results are likely representative of a fluid at those conditions. For this study, which had highly controlled operating conditions and accurate temperature and pressure measurement, the results were typically within ±7%. Normally accepted tolerances are around 20-30%.

Also shown is the Vapor Region to the right of and below the blue Dew Point curve. For gas compositions, the same general process applies. Sample conditions should be within an acceptable tolerance of this line. The red dot in Figure 2-6 is the Cricondenbar Point, and represents the highest pressure that a 2-phase mixture can exist. The blue dot is the Cricondentherm Point and represents the highest temperature that a 2-phase mixture can exist. The yellow dot is the Critical Point and mixtures above this temperature and pressure are supercritical fluids.

Separator fluids are assumed to be at equilibrium in the separator. Therefore, when the sample collection process is executed it is imperative to keep pressure and temperature changes minimal. Changes in pressure or temperature can cause phase change. If the pressure drops or the temperature increases, then the sampling conditions enter the 2-Phase region. The sample drops below its Bubble Point, gas bubbles form in the liquid, and the subsequent analysis of this fluid have excess lighter (higher vapor pressure components) and the resulting plot would show the green star in the 2-Phase Region.
Figure 3-1. Phase envelope for a condensate sample tested for the PHLSA study.

Reciprocally, if the sample cylinder leaks, lighter hydrocarbons gasify more rapidly than heavier hydrocarbons and therefore have more losses than the heavier. The subsequent analysis of this fluid will cause the red line to be lower, and the green star further into the Liquid Region. This is why it is important that the sample is collected, handled and analyzed in a manner to prevent phase change from occurring.

4. **PSM/EOS FGOR Calculations Sensitivity Study**

4.1 **Sensitivity Study**

4.1.1 Numerical Approximation Approach

Sensitivity studies were performed to determine the sensitivity of key parameters calculated by varying one PSM/EOS input parameter at a time, keeping all others constant, to evaluate impact of each parameter on the PSM/EOS output. Measurement data was input over normal observed variations, utilizing the uncertainty of each measurement. The sensitivity data was used to create an uncertainty budget for the normal variations and uncertainty of input data. In the case of Storage Tank Pressure, the Pressure at one foot from the bottom of the tank was calculated and sensitivity perturbation values were calculated as shown below in Table 4.1. A similar approach was used for other sensitivity perturbation values. Six well cycles, one from each study phase, were selected which showed the best results in the direct measurement mass balance. Only CP cylinder analyses were used, samples collected at 20 ml per minute,
collected less than 30 minutes after the completion of the well cycle, for both GPA 2103M and GPA 2186M analysis methods.

**Table 4.1. Sensitivity Study for Storage Tank Conditions and Decanes Plus Properties – Numerical Approximation Approach**

<table>
<thead>
<tr>
<th>Tank Headspace temperature</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Minimum - Uncertainty (**F)</td>
<td>86.6</td>
<td>°F</td>
<td>313</td>
<td>0.8300</td>
<td>228.3</td>
</tr>
<tr>
<td>2  (Average + Minimum - Uncertainty)/2</td>
<td>88.1</td>
<td>°F</td>
<td>314</td>
<td>0.8298</td>
<td>228.3</td>
</tr>
<tr>
<td>3  Average (**F)</td>
<td>89.6</td>
<td>°F</td>
<td>314</td>
<td>0.8296</td>
<td>228.3</td>
</tr>
<tr>
<td>4  (Average + Maximum + Uncertainty)/2</td>
<td>91.2</td>
<td>°F</td>
<td>315</td>
<td>0.8293</td>
<td>228.3</td>
</tr>
<tr>
<td>5  Maximum + Uncertainty (**F)</td>
<td>92.7</td>
<td>°F</td>
<td>315</td>
<td>0.8291</td>
<td>228.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tank Headspace pressure</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6  Minimum - Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.38</td>
<td>psia</td>
<td>314</td>
<td>0.8294</td>
<td>228.3</td>
</tr>
<tr>
<td>7  (Average + Minimum - Uncertainty)/2</td>
<td>12.47</td>
<td>psia</td>
<td>314</td>
<td>0.8295</td>
<td>228.3</td>
</tr>
<tr>
<td>8  Average (PIT 2/16 + Pambient) (psi)</td>
<td>12.55</td>
<td>psia</td>
<td>314</td>
<td>0.8295</td>
<td>228.3</td>
</tr>
<tr>
<td>9  (Average + Maximum + Uncertainty)/2</td>
<td>12.63</td>
<td>psia</td>
<td>314</td>
<td>0.8296</td>
<td>228.3</td>
</tr>
<tr>
<td>10 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.72</td>
<td>psia</td>
<td>314</td>
<td>0.8296</td>
<td>228.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tank 1’ from Bottom temperature</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>11  Average - Uncertainty (**F)</td>
<td>78.8</td>
<td>°F</td>
<td>310</td>
<td>0.8321</td>
<td>228.3</td>
</tr>
<tr>
<td>12  Average -1/2 Uncertainty (**F)</td>
<td>79.5</td>
<td>°F</td>
<td>312</td>
<td>0.8309</td>
<td>228.3</td>
</tr>
<tr>
<td>13  Average</td>
<td>80.3</td>
<td>°F</td>
<td>314</td>
<td>0.8296</td>
<td>228.3</td>
</tr>
<tr>
<td>14  Average + 1/2 Uncertainty (**F)</td>
<td>81.0</td>
<td>°F</td>
<td>316</td>
<td>0.8284</td>
<td>228.3</td>
</tr>
<tr>
<td>15  Average + Uncertainty (**F)</td>
<td>81.8</td>
<td>°F</td>
<td>319</td>
<td>0.8270</td>
<td>228.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tank 1’ from Bottom pressure</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>16  Minimum - Uncertainty (psi)</td>
<td>16.39</td>
<td>psia</td>
<td>313</td>
<td>0.8300</td>
<td>228.3</td>
</tr>
<tr>
<td>17  (Average + Minimum - Uncertainty)/2</td>
<td>16.47</td>
<td>psia</td>
<td>313</td>
<td>0.8304</td>
<td>228.3</td>
</tr>
<tr>
<td>18  Average (Pamb + PIT2 + L<em>p</em>Constant) (psi)</td>
<td>16.55</td>
<td>psia</td>
<td>312</td>
<td>0.8309</td>
<td>228.3</td>
</tr>
<tr>
<td>19  (Average + Maximum + Uncertainty)/2</td>
<td>16.64</td>
<td>psia</td>
<td>311</td>
<td>0.8314</td>
<td>228.3</td>
</tr>
<tr>
<td>20 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>16.72</td>
<td>psia</td>
<td>310</td>
<td>0.8318</td>
<td>228.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decanes Plus Molecular Weight</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>21  Minimum - U</td>
<td>208.231</td>
<td>gm/gm-mol</td>
<td>318</td>
<td>0.8280</td>
<td>229.0</td>
</tr>
<tr>
<td>22  (Average + Minimum - U)/2</td>
<td>210.732</td>
<td>gm/gm-mol</td>
<td>317</td>
<td>0.8285</td>
<td>228.8</td>
</tr>
<tr>
<td>23  Average</td>
<td>213.233</td>
<td>gm/gm-mol</td>
<td>316</td>
<td>0.8289</td>
<td>228.6</td>
</tr>
<tr>
<td>24  (Average + Maximum + U)/2</td>
<td>216.004</td>
<td>gm/gm-mol</td>
<td>315</td>
<td>0.8294</td>
<td>228.4</td>
</tr>
<tr>
<td>25  Maximum + U</td>
<td>218.774</td>
<td>gm/gm-mol</td>
<td>314</td>
<td>0.8298</td>
<td>228.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decanes Plus Density</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>26  Minimum - U</td>
<td>0.8169</td>
<td>(H₂O=1)</td>
<td>313</td>
<td>0.8300</td>
<td>227.3</td>
</tr>
<tr>
<td>27  (Average + Minimum - U)/2</td>
<td>0.8195</td>
<td>(H₂O=1)</td>
<td>314</td>
<td>0.8298</td>
<td>227.7</td>
</tr>
<tr>
<td>28  Average</td>
<td>0.8221</td>
<td>(H₂O=1)</td>
<td>314</td>
<td>0.8297</td>
<td>228.1</td>
</tr>
<tr>
<td>29  (Average + Maximum + U)/2</td>
<td>0.8249</td>
<td>(H₂O=1)</td>
<td>314</td>
<td>0.8295</td>
<td>228.5</td>
</tr>
<tr>
<td>30  Maximum + U</td>
<td>0.8278</td>
<td>(H₂O=1)</td>
<td>315</td>
<td>0.8293</td>
<td>229.0</td>
</tr>
</tbody>
</table>
Sensitivity study results for Summer, Medium Pressure Group 3, for Sim 1 model results shown in this example. The complete set of results can be found in Appendix V.4.

A similar approach was used for the effects of separator conditions. Table 4.2 below shows the results for Summer, Medium Pressure Group 3, for Sim 1 model results. The complete set of results can be found in Appendix V.4.

Table 4-2. Sensitivity Study for Separator Conditions and SPH Fraction – Numerical Approximation Approach

<table>
<thead>
<tr>
<th>Psep (psia)</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>236.3</td>
<td>psia</td>
<td>311</td>
<td>0.8310</td>
</tr>
<tr>
<td>32</td>
<td>231.3</td>
<td>psia</td>
<td>307</td>
<td>0.8317</td>
</tr>
<tr>
<td>33</td>
<td>226.3</td>
<td>psia</td>
<td>303</td>
<td>0.8325</td>
</tr>
<tr>
<td>34</td>
<td>221.3</td>
<td>psia</td>
<td>299</td>
<td>0.8332</td>
</tr>
<tr>
<td>35</td>
<td>216.3</td>
<td>psia</td>
<td>295</td>
<td>0.8339</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tsep (°F)</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>92.2</td>
<td>°F</td>
<td>311</td>
<td>0.8310</td>
</tr>
<tr>
<td>37</td>
<td>94.2</td>
<td>°F</td>
<td>309</td>
<td>0.8313</td>
</tr>
<tr>
<td>38</td>
<td>96.2</td>
<td>°F</td>
<td>308</td>
<td>0.8316</td>
</tr>
<tr>
<td>39</td>
<td>98.2</td>
<td>°F</td>
<td>306</td>
<td>0.8319</td>
</tr>
<tr>
<td>40</td>
<td>100.2</td>
<td>°F</td>
<td>304</td>
<td>0.8322</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Siphon Prevention Hole</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>0.00</td>
<td>(0-1)</td>
<td>306</td>
<td>0.8338</td>
</tr>
<tr>
<td>42</td>
<td>0.03</td>
<td>(0-1)</td>
<td>309</td>
<td>0.8323</td>
</tr>
<tr>
<td>43</td>
<td>0.06</td>
<td>(0-1)</td>
<td>312</td>
<td>0.8308</td>
</tr>
<tr>
<td>44</td>
<td>0.12</td>
<td>(0-1)</td>
<td>317</td>
<td>0.8279</td>
</tr>
<tr>
<td>45</td>
<td>0.24</td>
<td>(0-1)</td>
<td>328</td>
<td>0.8219</td>
</tr>
<tr>
<td>46</td>
<td>0.48</td>
<td>(0-1)</td>
<td>351</td>
<td>0.8101</td>
</tr>
<tr>
<td>47</td>
<td>1.00</td>
<td>(0-1)</td>
<td>402</td>
<td>0.7844</td>
</tr>
</tbody>
</table>

Table 4.3 shows the average results obtained in the sensitivity study. One set of sample data was selected from each set of pressure groups (3) for each seasonal test (2) for each analytical method (2) for a total of 12 data sets. Six perturbations were performed on each data set. The particular data sets used were the ones that had the best mass balance results for that pressure group. The complete set of results can be found in Appendix V.4.
Individual results were similar, but showed slightly less sensitivity to temperature and pressure for GPA 2186M and slightly less sensitivity to Decanes Plus properties for GPA 2103M. Note that the “siphon prevention hole” flow was 6% to the tank headspace, with 94% of the flow going to one foot from the tank bottom. This is why the tank headspace conditions show less sensitivity than the tank bottom conditions. The effects will be different as the ratio for the “siphon prevention hole” changes, as with side-spray and 100% flow to the tank headspace.

Bubble Point is insensitive to the “tank” conditions since this value is calculated at the separator conditions.

### Table 4.3. Average Results of Sensitivity Study

<table>
<thead>
<tr>
<th>Perturbation</th>
<th>Parameter</th>
<th>Study Average</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank Headspace Temperature</td>
<td>FGOR</td>
<td>0.08%</td>
<td>per°F</td>
</tr>
<tr>
<td></td>
<td>Shrinkage</td>
<td>-0.01%</td>
<td>per°F</td>
</tr>
<tr>
<td>Tank Headspace Pressure</td>
<td>FGOR</td>
<td>-0.37%</td>
<td>per psi</td>
</tr>
<tr>
<td></td>
<td>Shrinkage</td>
<td>0.06%</td>
<td>per psi</td>
</tr>
<tr>
<td>Tank Bottom Temperature</td>
<td>FGOR</td>
<td>0.97%</td>
<td>per°F</td>
</tr>
<tr>
<td></td>
<td>Shrinkage</td>
<td>-0.16%</td>
<td>per°F</td>
</tr>
<tr>
<td>Tank Bottom Pressure</td>
<td>FGOR</td>
<td>-0.22%</td>
<td>per ounce</td>
</tr>
<tr>
<td></td>
<td>Shrinkage</td>
<td>0.54%</td>
<td>per psi</td>
</tr>
<tr>
<td>Separator Temperature</td>
<td>FGOR</td>
<td>0.33%</td>
<td>per°F</td>
</tr>
<tr>
<td></td>
<td>Shrinkage</td>
<td>-0.01%</td>
<td>per°F</td>
</tr>
<tr>
<td>Separator Pressure</td>
<td>FGOR</td>
<td>-0.30%</td>
<td>per psi</td>
</tr>
<tr>
<td></td>
<td>Shrinkage</td>
<td>0.01%</td>
<td>per psi</td>
</tr>
<tr>
<td>Decanes Plus Mole Weight</td>
<td>FGOR</td>
<td>-0.20%</td>
<td>per gm/gm-mol</td>
</tr>
<tr>
<td></td>
<td>Shrinkage</td>
<td>0.03%</td>
<td>per gm/gm-mol</td>
</tr>
<tr>
<td></td>
<td>B. Point</td>
<td>-0.04%</td>
<td>per gm/gm-mol</td>
</tr>
<tr>
<td>Decanes Plus Density</td>
<td>FGOR</td>
<td>0.03%</td>
<td>per .0010</td>
</tr>
<tr>
<td></td>
<td>Shrinkage</td>
<td>-0.01%</td>
<td>per .0010</td>
</tr>
<tr>
<td></td>
<td>B. Point</td>
<td>0.07%</td>
<td>per .0010</td>
</tr>
<tr>
<td>Siphon Prevention Hole Fraction</td>
<td>FGOR</td>
<td>0.50%</td>
<td>per .01</td>
</tr>
<tr>
<td></td>
<td>Shrinkage</td>
<td>-0.07%</td>
<td>per .01</td>
</tr>
</tbody>
</table>

4.1.2 Monte Carlo Simulation

Similar data tables were used in a Monte Carlo Simulation for each of the 6 well cycles and 2 analytical methods used in the Numerical Approximation approach. Additionally, analytical data was varied within the uncertainty of each compositional value. See Table 4.4-A and 4.4-B.
Approximately 3,000 iterations produced a normal distribution of data and a similar uncertainty budget. The results are discussed in Section 5 of this appendix. Sim 3 was used for the Monte Carlo simulations due to the PSM/EOS design for Excel input/output and the ease of linking it to the Crystal Ball software. The complete set of results can be found in Appendix V.5.

### Table 4-4A. Monte Carlo Simulation Input Data – Process Data

<table>
<thead>
<tr>
<th></th>
<th>STD</th>
<th>Min Value</th>
<th>Max Value</th>
<th>Distribution Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Flow Rate</td>
<td>0.5219 bbl/d</td>
<td><strong>0.00151</strong></td>
<td></td>
<td>Normal</td>
</tr>
<tr>
<td>Separator Temperature</td>
<td>84.2 °F</td>
<td>1.15</td>
<td>82.21</td>
<td>86.19</td>
</tr>
<tr>
<td>Separator Pressure</td>
<td>246.33 psia</td>
<td><strong>2.90</strong></td>
<td>241.31</td>
<td>251.35</td>
</tr>
<tr>
<td>Siphon hole fraction</td>
<td>0.06 (0 - 1)</td>
<td>0.012</td>
<td>0.04</td>
<td>0.08</td>
</tr>
<tr>
<td>Tank HS Temperature</td>
<td>89.6 °F</td>
<td>1.17</td>
<td><strong>87.58</strong></td>
<td>91.62</td>
</tr>
<tr>
<td>Tank HS Pressure</td>
<td>12.55 psia</td>
<td>0.069</td>
<td><strong>12.43</strong></td>
<td>12.67</td>
</tr>
<tr>
<td>Tank Bottom Temperature</td>
<td>80.3 °F</td>
<td>0.87</td>
<td><strong>78.79</strong></td>
<td>81.81</td>
</tr>
<tr>
<td>Tank Bottom Pressure</td>
<td>18.54 psia</td>
<td>0.071</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4-4B. Monte Carlo Simulation Input Data – Analytical Data

<table>
<thead>
<tr>
<th>Components</th>
<th>Avg</th>
<th>STD</th>
<th>Units</th>
<th>Distribution Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>0.401</td>
<td>0.003</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.000</td>
<td>0.000</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Methane</td>
<td>5.770</td>
<td>0.063</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Ethane</td>
<td>6.130</td>
<td>0.048</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Propane</td>
<td>7.710</td>
<td>0.051</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Iso-Butane</td>
<td>2.540</td>
<td>0.012</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>n-Butane</td>
<td>7.760</td>
<td>0.040</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Iso-Pentane</td>
<td>4.990</td>
<td>0.059</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>n-Pentane</td>
<td>6.970</td>
<td>0.029</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>n-Hexane</td>
<td>5.770</td>
<td>0.125</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Heptanes</td>
<td>13.303</td>
<td>0.202</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Octanes</td>
<td>10.577</td>
<td>0.346</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Nonanes</td>
<td>4.780</td>
<td>0.061</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Decanes Plus</td>
<td>11.490</td>
<td>0.148</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Benzene</td>
<td>0.773</td>
<td>0.021</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Toluene</td>
<td>2.760</td>
<td>0.031</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>0.189</td>
<td>0.018</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>m, p-Xylenes</td>
<td>2.210</td>
<td>0.029</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>o-Xylene</td>
<td>0.510</td>
<td>0.007</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>2,2,4-Trimethylpentane</td>
<td>0.046</td>
<td>0.000</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>2,2-Dimethylbutane</td>
<td>0.086</td>
<td>0.000</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>2,3-Dimethylbutane</td>
<td>0.299</td>
<td>0.001</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>Cyclopentane</td>
<td>0.366</td>
<td>0.001</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>2-Methylpentane</td>
<td>2.810</td>
<td>0.007</td>
<td>mol%</td>
<td>Normal</td>
</tr>
<tr>
<td>3-Methylpentane</td>
<td>1.760</td>
<td>0.004</td>
<td>mol%</td>
<td>Normal</td>
</tr>
</tbody>
</table>

100

100

C10+ Properties

| Mol Wt. | 217.11 | 1.95 | lb/lb-mol | Normal | -8.9 |
| Sp. Gravity at 60°F | 0.8237 | 0.0082 | adim. | Normal | -0.0049 |

4.2 Equation of State Models

The Peng-Robinson equation of state was used in the PSM/EOS modeling portion of the study. 22 EOS models with various activity coefficient methods were evaluated and six were selected as fit for purpose to evaluate the effect of EOS selection on calculated results. Three of the tested EOS models more suited for natural gas modeling failed to resolve. Six EOS were selected and tested in the comparison after evaluating...
the performance on two data sets, one from GPA 2186M and one from GPA 2103M results. Table 4.5 shows the results of one data set from the EOS Model Perturbation.

### Table 4-5. EOS Model Selection Results

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FGOR</td>
<td>314</td>
<td>302</td>
<td>341</td>
<td>305</td>
<td>303</td>
<td>306</td>
<td>390</td>
<td>scf/std. bbl.</td>
</tr>
<tr>
<td>MB100</td>
<td>309</td>
<td>309</td>
<td>309</td>
<td>309</td>
<td>309</td>
<td>309</td>
<td>309</td>
<td>scf/std. bbl.</td>
</tr>
<tr>
<td>FGOR/MB100</td>
<td>102%</td>
<td>98%</td>
<td>110%</td>
<td>99%</td>
<td>98%</td>
<td>99%</td>
<td>126%</td>
<td>%</td>
</tr>
<tr>
<td>B. Pt.</td>
<td>228.3</td>
<td>248.8</td>
<td>218.0</td>
<td>209.9</td>
<td>196.8</td>
<td>180.6</td>
<td>250.2</td>
<td>psia</td>
</tr>
<tr>
<td>Psep</td>
<td>240.3</td>
<td>240.3</td>
<td>240.3</td>
<td>240.3</td>
<td>240.3</td>
<td>240.3</td>
<td>240.3</td>
<td>psia</td>
</tr>
<tr>
<td>B.Pt/P&lt;sub&gt;sep&lt;/sub&gt;</td>
<td>95%</td>
<td>104%</td>
<td>91%</td>
<td>87%</td>
<td>82%</td>
<td>75%</td>
<td>104%</td>
<td>%</td>
</tr>
</tbody>
</table>

a. Advanced PR was the EOS model used in this study.
b. MB 100 is the Direct Measurement results corrected to 100% Mass Balance.
c. PSM/EOS results for Summer, Medium Pressure Group 3, for Sim 1, Sim 2, and Sim3 model results shown in this example. The complete set of results can be found in Appendix V.4.

### 5. FGOR Uncertainty Study

Using the sensitivity results of the Monte Carlo Simulation, a relative expanded uncertainty for FGOR calculated using PSM/EOS modeling of pressurized condensate analyses is approximately 3.3% of value at 95% confidence. A slightly higher result was obtained using the results of the Numerical Approximation approach. See Table 5.1 for FGOR uncertainty from both approaches. Table 5.2 lists the uncertainty of Bubble Point Calculations and Table 5.3 lists the uncertainty of Shrinkage Calculations using these two approaches. There is reasonable agreement of these two approaches.
### Table 5-1. FGOR Uncertainty Calculations

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### Table 5-3. Shrinkage Factor Uncertainty Calculations

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6. Conclusions and Recommendations

Suggested considerations for PSM/EOS calculations of bubble point pressures and FGOR:

- Accurately measured the separator tank liquid temperature.
- Accurately measured the separator tank pressure (suggest redundant pressure gauges).
- Accurately measure the tank bottom temperature for tanks with down-comers and the tank headspace temperature for tanks that use side fill.
- To model FGOR to be used to design storage tank emission control systems collect a pressurized condensate sample during high pressure / low temperature separator operation and assume maximum tank temperatures and minimum tank pressures for PSM/EOS calculations.
- To model FGOR to be used for emission inventory estimates, collect a pressurized condensate sample during medium pressure / medium temperature separator operation and assume medium tank temperatures and medium tank pressures for PSM/EOS calculations.
- Analyze the pressurized condensate through decanes plus at a minimum, and accurately determine or calculate the plus fraction density and molecular weight.
Appendix V.1. Estimated Discharge From Siphon Prevention Hole

A discovery during the testing was that the storage tank down-comer pipe has a 3/8” hole near the top of the tank. This “siphon prevention hole” was installed as a safety feature. Absent such a hole, in the event of an upset condition where a negative pressure is applied on the separator, a siphon could form and oil would flow from the tank back to the separator. The siphon prevention hole was drilled to prevent siphon formation and such back-flow. An illustration of the hole location within the tank is shown in Figure V1-1.

![Figure V1.1. Location of the siphon prevention hole on the down-comer pipe.](image)

It is expected that some of the fluids flowing from the separator to the tank pass through the siphon prevention hole into the tank headspace. The tank headspace temperature and pressure differ from the tank bottom conditions where the majority of the separator fluids are expected to flow, and this temperature and pressure difference would impact liquids flashing. The tank headspace gas temperature was usually higher than the tank bottom liquids temperature and the tank headspace gas pressure was lower than the tank bottom pressure, and both of these trends favor higher FGOR for liquids that pass through the siphon prevention hole. The flow from the separator to the tank is two-phase, gas and liquid, and the gas to liquid ratio likely changes over the course of each separator dump. Measuring the rate and composition of the siphon prevention hole flow was beyond the scope of this study, and a simple model assuming incompressible flow was used to estimate the relative flows through the siphon prevention hole and to the tank bottom.
Flow through the siphon prevention hole was estimated using the following equation for incompressible flow through an orifice.

$$Q_{SPH} = C \cdot A_{SPH} \cdot \sqrt{\frac{2 \cdot \Delta P_{SPH}}{\rho}}$$

Where:

- $Q_{SPH}$ = Siphon Prevention Hole (SPH) discharge flow rate (m$^3$/s)
- $C$ = Discharge coefficient, assumed to be 0.6 (unitless)
- $A_{SPH}$ = SPH cross sectional area (m$^2$)
  
  \(D_{SPH} = \text{SPH diameter} = 0.375 \text{ inches} = 0.00953 \text{ meter}\)
- $\rho$ = Density of the separator to tank flow fluid (kg/m$^3$)
- $\Delta P_{SPH}$ = Pressure change across the SPH = 10 psi
  
  - 10 psig was a typical pressure measured in the vicinity of the SPH during well cycles.
  - Typical range was 8 to 12 psig as shown in Figure V1-2.

Flow through the down-comer pipe was estimated using the Darcy-Weisbach equation for incompressible flow through pipe.

$$Q_{DC} = \frac{A_{DC} \cdot \sqrt{2 \cdot D_{DC} \cdot \Delta P_{DC}}}{f \cdot L_{DC} \cdot \rho}$$

Where:

- $Q_{DC}$ = Down-comer (DC) flow rate (m$^3$/s)
- $A_{DC}$ = DC pipe cross sectional area (m$^2$)
- $D_{DC} = \text{DC pipe diameter} = 1.6875 \text{ inches} = 0.0429 \text{ meter}\$
- $L_{DC} = \text{DC pipe length from SPH to discharge} = 13 \text{ feet} = 3.96 \text{ meter}\$
- $f$ = friction factor
- $\rho$ = Density of the separator to tank flow fluid (kg/m$^3$)
- $\Delta P_{DC}$ = Pressure change down the DC pipe = 10 – 4 = 6 psi
  
  - 10 psig was typical pressure measured in the vicinity of the SPH during well cycles and 4 psi is estimated liquid head pressure at the down-comer discharge (12 feet * SG = 0.76 * 0.4331 psi/ft H$_2$O)

The ratio of $Q_{SPH}$ and $Q_{DC}$ is estimated to be:
\[
\frac{Q_{SPH}}{Q_{DC}} = \frac{C \times A_{SPH} \times \sqrt{\frac{2 \times \Delta P_{SPH}}{\rho}}}{A_{DC} \times \sqrt{\frac{2 \times D_{DC} \times \Delta P_{DC}}{f \times L_{DC}}} + \frac{C \times D_{SPH} \times D_{SPH}}{D_{DC} \times D_{DC}} \times \sqrt{\frac{\Delta P_{SPH}}{\Delta P_{DC}}}}
\]

Entering the values listed above into the equation calculates an estimated \(Q_{SPH} / Q_{DC}\) ratio of about 0.06 or 6%. A pseudo-Monte Carlo simulation, conducted by systematically varying the primary input parameters over their estimated uncertainty ranges, estimated a \(Q_{SPH} / Q_{DC}\) ratio uncertainty of 6% +/- 2%.

Figure V1-2. Location of pressure transducers used to estimate the flow through the hole.
Appendix V.2 – PSM Instructions

Sim1 Instructions

Separator Balance

1. Input header data: Study Phase, Study Group, CoA#, Method, Sample Date, Cylinder No. & type, Sample Pressure and Temperature, Sample Rate, Sample Location, and Test Description
2. Input Feed Gas composition (from Sales Gas analysis for this well-cycle) in mol %, temperature, pressure, and flow rate
3. Input Feed Oil composition (from Pressurized Condensate analysis for this well-cycle) in mol %, temperature, pressure, and flow rate
4. Input Feed Oil C10+ MW and SG (in Property Package from Pressurized Condensate analysis for this well-cycle)
5. Input Feed Water composition (from Pressurized Water analysis for this season) in mol %, temperature, pressure and flow rate
6. Input Dead Oil composition (air-free basis from Storage Tank Condensate Analysis for this season) mol % and flow rate
7. Input Dead Oil C10+ MW and SG (in Property Package from Storage Tank Condensate analysis for this season)
8. Input separator temperature and pressure in "Vap/Sales_Gas.In"
9. Allow model to resolve and save as "model ID+Separator Balance"

FGOR

13. Input Feed Gas flow rate as 0
14. Input Feed Water flow rate as 0
15. Input the separator pressure 1 psi above the calculated Bubble Point at Tsep
16. Allow model to resolve and save as "model ID+FGOR"

Mass Balance

17. Change the dead oil flow rate to obtain measured FGOR = Modeled FGOR
18. Allow model to resolve and save as "model ID+Mass Balance"
19. Change the dead oil volume rate to zero
Sim2 / Sim3 Instructions

Separator Balance
1. Input modeling ID number, sample type, sample name, and sample date
2. Input sales gas composition, temperature, pressure and flow rate
3. Input pressurized oil composition (mol%), temperature, pressure and flow rate
4. Input pressurized oil C10+ MW and SG
5. Input pressurized water composition (mol%), temperature, pressure and flow rate
6. Input dead oil composition (air-free basis, mol%)
7. Input dead Oil C10+ MW and SG
8. Input separator temperature and pressure (Table No.1)
9. Solve for the pressurized oil bubble point at sample temperature (Table No.2)
10. Solve for the pressurized oil bubble point at separator temperature (Table No.2)

FGOR
11. Input discharge through siphon hole (Table No.3)
12. Input tank headspace temperature (Table No.3)
13. Input tank headspace pressure (Table No.3)
14. Input tank bottom temperature (Table No.3)
15. Input tank bottom pressure (Table No.3)
16. Make sure the dead oil pressure and temperature are equal to that of the tank bottom
17. Input sales gas composition flow rate as 0
18. Input pressurized water composition flow rate as 0
19. Copy the sales gas composition and flow rate to the "OUTPUT Separator" tab
20. Copy the pressurized oil composition and flow rate to the "OUTPUT Separator" tab
21. Copy the pressurized water composition and flow rate to the "OUTPUT Separator" tab
22. In the simulation file, set the pressurized gas stream to zero flow rate
23. In the simulation file, set the pressurized water stream to zero flow rate
24. Increase the separator pressure to above its bubble point
25. Fill in Table No. 3 using the separator pressure used in step (25)

Mass Balance
26. Change the dead oil volume rate to obtain measured FGOR = Modeled FGOR
27. Fill in Table No. 4
28. Fill the upper table in the "OUTPUT Tank" tab
29. Change the dead oil volume rate to zero
30. Fill in Table No. 5
31. Fill the lower table in the "OUTPUT Tank" tab
32. If desired, fill Tables 6-8 by using different dead oil volume rates
Sim4 Instructions

FGOR

1. Input flowsheet Selection (Tank with Separator or Stable Oil Tank) in Configuration sheet
2. Input Model Selection for W&S Losses (AP-42 or RVP Distillation Column) in Configuration sheet
3. Input Known Separator Stream Information (LP Oil, HP Oil, LP gas, or Geographical Database) in Configuration sheet
4. Input Control Efficiency (use Control Efficiency and Destruction Efficiency) in Configuration sheet
5. Component Group (Select the last Cn+ in Stream) in Configuration sheet
6. Input Oil composition (in mol % from Pressurized Condensate analysis for this well-cycle) in HP Separator sheet
7. Input Oil C10+ MW and SG (from Pressurized Condensate analysis for this well-cycle) in HP Separator sheet
8. Input separator pressure and temperature in HP Separator sheet
9. Input tank pressure and temperature in Flash Valve sheet
10. Input Days, API Gravity, Reid Vapor Pressure and Flow rate in Sales Oil sheet
11. Save model as Model ID#
Appendix V.3 PSM/EOS Modeling Results

The table below links the PSM/EOC calculations presented in this appendix to the Certificate of Analysis number for the condensate sample.

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* Blown Rupture disc on cylinder
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**Winter HP3**

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**Winter MP2**

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**Mass Bal.**

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**Winter MP2 2103 CP**

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**Winter MP2 2186 CP**

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<td>89.0%</td>
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**Mass Bal.**

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<td>2</td>
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**Winter MP2 2103 CV**

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<th>EOS Bubble Point at Tsep (psia)</th>
<th>Volume of Dead Oil Required to match Mass Balance (Bbls.)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>181.0</td>
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<tr>
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<td>243.4</td>
<td>2.47</td>
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<td>4</td>
<td>199.6</td>
<td>231.9</td>
<td>2.80</td>
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<td>1</td>
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**Winter MP2 2186 CV**

<table>
<thead>
<tr>
<th>Sim</th>
<th>Predicted Separator Gas / Measured Separator Gas</th>
<th>Predicted Separator Oil / Measured Separator Oil</th>
<th>Predicted Separator Water / Measured Separator Water</th>
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<td>93.7%</td>
<td>90.0%</td>
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<td>93.5%</td>
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**Mass Bal.**

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<tr>
<th>Sim</th>
<th>Volume of Dead Oil Required to match Mass Balance (Bbls.)</th>
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<tbody>
<tr>
<td>1</td>
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<td>Winter MP3 2103 CV</td>
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<td>----------------</td>
<td>--------------------</td>
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<tr>
<td><strong>Sim</strong></td>
<td><strong>GPA 2103M</strong></td>
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<tr>
<td>FGOR</td>
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</tr>
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<td>Flash Gas to Oil Ratio (FGOR) - Scf/ST Bbl</td>
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<tr>
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<td>Predicted Separator Water / Measured Separator Water</td>
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</tr>
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<td>Mass Bal. Volume of Dead Oil Required to match Mass Balance (Bbls.)</td>
<td>0.75</td>
</tr>
<tr>
<td>Winter LP1</td>
<td>GPA 2103M</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>FGOR</td>
<td>Measured</td>
</tr>
<tr>
<td>Flash Gas to Oil Ratio (FGOR) - Scf/ST Bbl</td>
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</tr>
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<tr>
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<td>0.9154 0.9148 0.9251</td>
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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Predicted Separator Gas / Measured Separator Gas</td>
</tr>
<tr>
<td>Predicted Separator Oil / Measured Separator Oil</td>
</tr>
<tr>
<td>Predicted Separator Water / Measured Separator Water</td>
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<table>
<thead>
<tr>
<th>Mass Bal.</th>
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<tbody>
<tr>
<td>Volume of Dead Oil Required to match Mass Balance (Bbls.)</td>
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<table>
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<tr>
<th>Winter LP1</th>
<th>GPA 2103M</th>
<th>GPA 2186M</th>
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<td>FGOR</td>
<td>Measured</td>
<td>Sim 1 Sim 2 Sim 3 Sim 4</td>
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<td>Flash Gas to Oil Ratio (FGOR) - Scf/ST Bbl</td>
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<td>145.3 146.5 146.9 171.0</td>
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<td>EOS Bubble Point at Tsep (psia)</td>
<td>190.6</td>
<td>174.6 181.7 174.2</td>
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<td>bbl post flash liquids / bbl feed (inlet pressurized liquids)</td>
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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Predicted Separator Gas / Measured Separator Gas</td>
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<tr>
<td>Predicted Separator Oil / Measured Separator Oil</td>
</tr>
<tr>
<td>Predicted Separator Water / Measured Separator Water</td>
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<table>
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<td>Volume of Dead Oil Required to match Mass Balance (Bbls.)</td>
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<td>Winter LP2</td>
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<td>-----------</td>
</tr>
<tr>
<td>Sim 1</td>
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</tr>
<tr>
<td>FGOR</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>EOS Bubble Point at Tsep (psia)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>bbl post flash liquids / bbl feed (inlet pressurized liquids)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Sep. Bal.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Predicted Separator Gas / Measured Separator Gas</td>
</tr>
<tr>
<td></td>
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<tr>
<td>Predicted Separator Oil / Measured Separator Oil</td>
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</tr>
<tr>
<td>Predicted Separator Water / Measured Separator Water</td>
</tr>
<tr>
<td></td>
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<tr>
<td>Mass Bal.</td>
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<tr>
<td></td>
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<tr>
<td>Volume of Dead Oil Required to match Mass Balance (Bbls.)</td>
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</table>

**Sample container not real data**
<table>
<thead>
<tr>
<th>Winter LP3</th>
<th>GPA 2103M</th>
<th>GPA 2186M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sim 1</td>
<td>Sim 2</td>
<td>Sim 3</td>
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<tr>
<td>Flash Gas to Oil Ratio (FGOR) - Scf/ST Bbl</td>
<td>181.9</td>
<td>148.6</td>
</tr>
<tr>
<td>EOS Bubble Point at Tsep (psia)</td>
<td>192.3</td>
<td>182.1</td>
</tr>
<tr>
<td>bbl post flash liquids / bbl feed (inlet pressurized liquids)</td>
<td>0.9173</td>
<td>0.9167</td>
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<tr>
<td>Predicted Separator Gas / Measured Separator Gas</td>
<td>7507</td>
<td>100.9%</td>
</tr>
<tr>
<td>Predicted Separator Oil / Measured Separator Oil</td>
<td>0.4825</td>
<td>92.1%</td>
</tr>
<tr>
<td>Predicted Separator Water / Measured Separator Water</td>
<td>0.0259</td>
<td>87.2%</td>
</tr>
<tr>
<td>Volume of Dead Oil Required to match Mass Balance (Bbls.)</td>
<td>4.64</td>
<td>5.02</td>
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<table>
<thead>
<tr>
<th>Winter LP3</th>
<th>GPA 2103M</th>
<th>GPA 2186M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sim 1</td>
<td>Sim 2</td>
<td>Sim 3</td>
</tr>
<tr>
<td>Flash Gas to Oil Ratio (FGOR) - Scf/ST Bbl</td>
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<td>145.6</td>
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<tr>
<td>EOS Bubble Point at Tsep (psia)</td>
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<td>178.1</td>
</tr>
<tr>
<td>bbl post flash liquids / bbl feed (inlet pressurized liquids)</td>
<td>0.9186</td>
<td>0.9180</td>
</tr>
<tr>
<td>Predicted Separator Gas / Measured Separator Gas</td>
<td>7507</td>
<td>100.9%</td>
</tr>
<tr>
<td>Predicted Separator Oil / Measured Separator Oil</td>
<td>0.4825</td>
<td>92.2%</td>
</tr>
<tr>
<td>Predicted Separator Water / Measured Separator Water</td>
<td>0.0259</td>
<td>87.2%</td>
</tr>
<tr>
<td>Volume of Dead Oil Required to match Mass Balance (Bbls.)</td>
<td>4.37</td>
<td>4.75</td>
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</table>
For the Summer testing results, sample “3” (e.g., Summer HP1-3 CP) was collected from the separator oil box oil level sight glass, and sample 1 and 2 were collected from sample probes.

<table>
<thead>
<tr>
<th></th>
<th>Summer HP1</th>
<th></th>
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<td></td>
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</tr>
<tr>
<td>FGOR</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sim 1</td>
<td>Sim 2</td>
<td>Sim 3</td>
<td>Sim 4</td>
<td>Sim 1</td>
<td>Sim 2</td>
<td>Sim 3</td>
</tr>
<tr>
<td>Flash Gas to Oil Ratio (FGOR) - Scf/ST Bbl</td>
<td>404.6</td>
<td>360.2</td>
<td>360.4</td>
<td>357.8</td>
<td>308.6</td>
<td>332.9</td>
<td>330.6</td>
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<tr>
<td>EOS Bubble Point at Tsep (psia)</td>
<td>279.8</td>
<td>220.4</td>
<td>227.5</td>
<td>218.6</td>
<td>209.6</td>
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<td>bbl post flash liquids / bbl feed (inlet pressurized liquids)</td>
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<td>0.8089</td>
<td>0.8090</td>
<td>0.8258</td>
<td></td>
<td>0.8223</td>
<td>0.8236</td>
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<td></td>
<td></td>
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<td>Predicted Separator Gas / Measured Separator Gas</td>
<td>10896</td>
<td>99.8%</td>
<td>99.9%</td>
<td>99.7%</td>
<td>99.7%</td>
<td>99.7%</td>
<td>99.7%</td>
</tr>
<tr>
<td>Predicted Separator Oil / Measured Separator Oil</td>
<td>0.2540</td>
<td>104.0%</td>
<td>104.1%</td>
<td>107.7%</td>
<td>110.1%</td>
<td>110.7%</td>
<td>112.6%</td>
</tr>
<tr>
<td>Predicted Separator Water / Measured Separator Water</td>
<td>0.0130</td>
<td>87.9%</td>
<td>87.4%</td>
<td>88.0%</td>
<td>87.9%</td>
<td>87.5%</td>
<td>88.0%</td>
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<tr>
<td>Mass Bal.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume of Dead Oil Required to match Mass Balance (Bbls.)</td>
<td>3.66</td>
<td>3.34</td>
<td>3.83</td>
<td></td>
<td>3.37</td>
<td>3.04</td>
<td>3.53</td>
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</table>

|          | Summer HP1-2 CP |          |          |          |          |          |          |
|          | GPA 2103M  |          |          |          |          |          |          |
| FGOR     |            |          |          |          |          |          |          |
|          | Sim 1 | Sim 2 | Sim 3 | Sim 4 | Sim 1 | Sim 2 | Sim 3 | Sim 4 |
| Flash Gas to Oil Ratio (FGOR) - Scf/ST Bbl | 404.6 | 440.5 | 436.5 | 431.7 | 363.3 | 397.3 | 394.0 | 398.5 | 340.4 |
| EOS Bubble Point at Tsep (psia) | 279.8 | 256.8 | 265.4 | 254.8 |          | 243.2 | 251.4 | 241.5 |          |
| bbl post flash liquids / bbl feed (inlet pressurized liquids) |          | 0.7754 | 0.7775 | 0.7960 | 0.7952 | 0.7968 | 0.8112 |          |          |
| Separ. Bal. |          |          |          |          |          |          |          |          |
| Predicted Separator Gas / Measured Separator Gas | 10896 | 100.0% | 100.0% | 99.9% | 99.8% | 99.8% | 99.7% |          |          |
| Predicted Separator Oil / Measured Separator Oil | 0.2540 | 104.0% | 104.1% | 107.7% | 110.1% | 110.7% | 112.6% |          |          |
| Predicted Separator Water / Measured Separator Water | 0.0130 | 87.8% | 87.4% | 88.0% | 87.9% | 87.5% | 88.0% |          |          |
| Mass Bal. |          |          |          |          |          |          |          |          |
| Volume of Dead Oil Required to match Mass Balance (Bbls.) | 4.97 | 4.40 | 5.02 |          | 4.44 | 4.01 | 4.64 |          |          |

<p>|          | Summer HP1-3 CP |          |          |          |          |          |          |
|          | GPA 2103M  |          |          |          |          |          |          |
| FGOR     |            |          |          |          |          |          |          |
|          | Sim 1 | Sim 2 | Sim 3 | Sim 4 | Sim 1 | Sim 2 | Sim 3 | Sim 4 |
| Flash Gas to Oil Ratio (FGOR) - Scf/ST Bbl | 404.6 | 409.4 | 431.1 | 406.3 | 344.4 | 380.4 | 377.7 | 381.2 | 326.4 |
| EOS Bubble Point at Tsep (psia) | 279.8 | 248.0 | 259.3 | 246.5 |          | 234.1 | 244.4 | 233.6 |          |
| bbl post flash liquids / bbl feed (inlet pressurized liquids) |          | 0.7888 | 0.7804 | 0.8067 | 0.8025 | 0.8039 | 0.8185 |          |          |
| Separ. Bal. |          |          |          |          |          |          |          |          |
| Predicted Separator Gas / Measured Separator Gas | 10896 | 99.9% | 99.9% | 99.8% | 99.7% | 99.7% | 99.8% |          |          |
| Predicted Separator Oil / Measured Separator Oil | 0.2540 | 107.5% | 106.9% | 109.3% | 113.2% | 112.0% | 114.0% |          |          |
| Predicted Separator Water / Measured Separator Water | 0.0130 | 88.1% | 87.4% | 88.0% | 88.1% | 87.5% | 88.0% |          |          |
| Mass Bal. |          |          |          |          |          |          |          |          |
| Volume of Dead Oil Required to match Mass Balance (Bbls.) | 4.53 | 4.46 | 4.73 |          | 4.07 | 3.85 | 4.43 |          |          |</p>
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<th></th>
<th><strong>Summer HP2-1 CP</strong></th>
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<th><strong>Summer HP2-2 CV</strong></th>
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<th><strong>Summer HP2-3 CV</strong></th>
<th></th>
<th><strong>Summer HP2-4 CV</strong></th>
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<td>FGOR</td>
<td><strong>Measured</strong></td>
<td></td>
<td><strong>Sim 1</strong></td>
<td><strong>Sim 2</strong></td>
<td><strong>Sim 3</strong></td>
<td><strong>Sim 4</strong></td>
<td><strong>Sim 1</strong></td>
<td><strong>Sim 2</strong></td>
<td><strong>Sim 3</strong></td>
</tr>
<tr>
<td></td>
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<td><strong>GPA 2186M</strong></td>
<td><strong>GPA 2103M</strong></td>
<td><strong>GPA 2186M</strong></td>
<td><strong>GPA 2103M</strong></td>
<td><strong>GPA 2186M</strong></td>
<td><strong>GPA 2103M</strong></td>
<td><strong>GPA 2186M</strong></td>
<td><strong>GPA 2103M</strong></td>
</tr>
<tr>
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<td>421.8</td>
<td>416.9</td>
<td>338.1</td>
<td>379.0</td>
<td>376.4</td>
<td>379.7</td>
<td>314.5</td>
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<tr>
<td>EOS Bubble Point at Tsep (psia)</td>
<td>276.5</td>
<td>273.8</td>
<td>283.7</td>
<td>272.1</td>
<td>256.7</td>
<td>266.2</td>
<td>255.4</td>
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<td>bbl post flash liquids / bbl feed (inlet pressurized liquids)</td>
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<td>0.7852</td>
<td>0.8012</td>
<td>0.8022</td>
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<td>0.8034</td>
<td>0.8181</td>
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<td>101.2%</td>
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<td></td>
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<tr>
<td>Predicted Separator Oil / Measured Separator Oil</td>
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<td>96.9%</td>
<td>93.9%</td>
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<tr>
<td>Predicted Separator Water / Measured Separator Water</td>
<td>0.0320</td>
<td>98.1%</td>
<td>93.1%</td>
<td>98.1%</td>
<td>93.1%</td>
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<th><strong>Summer HP2-1 CP</strong></th>
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<th><strong>Summer HP2-2 CV</strong></th>
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<th><strong>Summer HP2-3 CV</strong></th>
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<td><strong>Measured</strong></td>
<td></td>
<td><strong>Sim 1</strong></td>
<td><strong>Sim 2</strong></td>
<td><strong>Sim 3</strong></td>
<td><strong>Sim 4</strong></td>
<td><strong>Sim 1</strong></td>
<td><strong>Sim 2</strong></td>
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<td></td>
<td><strong>GPA 2103M</strong></td>
<td><strong>GPA 2186M</strong></td>
<td><strong>GPA 2103M</strong></td>
<td><strong>GPA 2186M</strong></td>
<td><strong>GPA 2103M</strong></td>
<td><strong>GPA 2186M</strong></td>
<td><strong>GPA 2103M</strong></td>
<td><strong>GPA 2186M</strong></td>
<td><strong>GPA 2103M</strong></td>
</tr>
<tr>
<td>Flash Gas to Oil Ratio (FGOR) - Scf/ST Bbl</td>
<td>299.9</td>
<td>359.9</td>
<td>360.5</td>
<td>355.9</td>
<td>300.5</td>
<td>376.4</td>
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### Summer MP2

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<td>Sim 2</td>
<td>Sim 3</td>
<td>Sim 4</td>
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<td>Sim 2</td>
<td>Sim 3</td>
<td>Sim 4</td>
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<tr>
<td>Flash Gas to Oil Ratio (FGOR) - Scf/ST Bbl</td>
<td>259.1</td>
<td>234.5</td>
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<td>226.3</td>
<td>230.3</td>
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<td>187.6</td>
<td>161.3</td>
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<td>159.5</td>
<td>165.8</td>
<td>159.8</td>
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<tr>
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<td>0.8661</td>
<td>0.8574</td>
<td>0.8694</td>
<td>0.8700</td>
<td>0.8711</td>
<td>0.8822</td>
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<tr>
<td>Predicted Separator Gas / Measured Separator Gas</td>
<td>7211</td>
<td>100.9%</td>
<td>100.9%</td>
<td>100.9%</td>
<td>100.7%</td>
<td>100.7%</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Predicted Separator Oil / Measured Separator Oil</td>
<td>0.5541</td>
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<td>92.4%</td>
<td>93.5%</td>
<td>95.2%</td>
<td>95.2%</td>
<td>95.5%</td>
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</tr>
<tr>
<td>Predicted Separator Water / Measured Separator Water</td>
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<td>92.9%</td>
<td>93.4%</td>
<td>93.1%</td>
<td>92.9%</td>
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<tr>
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<td>0.54</td>
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<td>0.43</td>
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<td>Sim 1</td>
<td>Sim 2</td>
<td>Sim 3</td>
<td>Sim 4</td>
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<tr>
<td>Flash Gas to Oil Ratio (FGOR) - Scf/ST Bbl</td>
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<td>0.8841</td>
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<tr>
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<td>7237</td>
<td>101.1%</td>
<td>101.2%</td>
<td>101.1%</td>
<td>100.9%</td>
<td>100.9%</td>
<td>100.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted Separator Oil / Measured Separator Oil</td>
<td>0.4489</td>
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<td>88.8%</td>
<td>90.2%</td>
<td>92.3%</td>
<td>92.3%</td>
<td>93.1%</td>
<td></td>
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<tr>
<td>Predicted Separator Water / Measured Separator Water</td>
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<td>87.5%</td>
<td>88.5%</td>
<td>88.1%</td>
<td>87.5%</td>
<td>89.6%</td>
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<tr>
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<table>
<thead>
<tr>
<th>Summer LP3</th>
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<th>GPA 2186M</th>
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</thead>
<tbody>
<tr>
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<td>Summer LP3-1 CV</td>
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<td>Sim 3</td>
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<tr>
<td>Flash Gas to Oil Ratio (FGOR) - Scf/ST Bbl</td>
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<tr>
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<td>88.0%</td>
</tr>
<tr>
<td>Predicted Separator Water / Measured Separator Water</td>
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<td>88.0%</td>
</tr>
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<td>Volume of Dead Oil Required to match Mass Balance (Bbls.)</td>
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## Appendix V.4 – Sensitivity (Numerical Approximation Method) Study Results

### Winter Phase EOS Sensitivity Study HP4 GPA 2103M

<table>
<thead>
<tr>
<th>Tank Headspace temperature</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Minimum - Uncertainty (°F)</td>
<td>64.29</td>
<td>°F</td>
<td>339.543</td>
<td>0.8266</td>
<td>259.57</td>
</tr>
<tr>
<td>2 (Average + Minimum - Uncertainty)/2</td>
<td>67.25</td>
<td>°F</td>
<td>340.367</td>
<td>0.8261</td>
<td>259.57</td>
</tr>
<tr>
<td>3 Average (°F)</td>
<td>70.20</td>
<td>°F</td>
<td>341.207</td>
<td>0.8257</td>
<td>259.57</td>
</tr>
<tr>
<td>4 (Average + Maximum + Uncertainty)/2</td>
<td>73.25</td>
<td>°F</td>
<td>342.094</td>
<td>0.8252</td>
<td>259.57</td>
</tr>
<tr>
<td>5 Maximum + Uncertainty (°F)</td>
<td>76.31</td>
<td>°F</td>
<td>343.003</td>
<td>0.8247</td>
<td>259.57</td>
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### Tank Headspace pressure

<table>
<thead>
<tr>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Minimum - Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.37</td>
<td>psia</td>
<td>341.424</td>
<td>0.8256</td>
</tr>
<tr>
<td>7 (Average + Minimum - Uncertainty)/2</td>
<td>12.46</td>
<td>psia</td>
<td>341.315</td>
<td>0.8256</td>
</tr>
<tr>
<td>8 Average (PIT 2/16 + Pambient) (psi)</td>
<td>12.55</td>
<td>psia</td>
<td>341.207</td>
<td>0.8257</td>
</tr>
<tr>
<td>9 (Average + Maximum + Uncertainty)/2</td>
<td>12.64</td>
<td>psia</td>
<td>341.100</td>
<td>0.8257</td>
</tr>
<tr>
<td>10 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.73</td>
<td>psia</td>
<td>340.994</td>
<td>0.8258</td>
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### Tank 1' from Bottom temperature

<table>
<thead>
<tr>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 Average - Uncertainty (°F)</td>
<td>43.3</td>
<td>°F</td>
<td>334.564</td>
<td>0.829</td>
</tr>
<tr>
<td>12 Average - 1/2 Uncertainty (°F)</td>
<td>44.3</td>
<td>°F</td>
<td>337.864</td>
<td>0.8274</td>
</tr>
<tr>
<td>13 Average</td>
<td>45.3</td>
<td>°F</td>
<td>341.207</td>
<td>0.8257</td>
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<tr>
<td>14 Average + 1/2 Uncertainty (°F)</td>
<td>46.5</td>
<td>°F</td>
<td>345.274</td>
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<tr>
<td>15 Average + Uncertainty (°F)</td>
<td>47.7</td>
<td>°F</td>
<td>349.402</td>
<td>0.8216</td>
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### Tank 1' from Bottom pressure

<table>
<thead>
<tr>
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<th>Shrinkage</th>
<th>B. Pt.</th>
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<tr>
<td>16 Minimum - Uncertainty (psi)</td>
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<td>psia</td>
<td>344.708</td>
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<td>17 (Average + Minimum - Uncertainty)/2</td>
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<td>psia</td>
<td>342.945</td>
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<tr>
<td>18 Average (Pamb + PIT2 + L<em>p</em>Constant) (psi)</td>
<td>15.81</td>
<td>psia</td>
<td>341.207</td>
<td>0.8257</td>
</tr>
<tr>
<td>19 (Average + Maximum + Uncertainty)/2</td>
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<td>339.606</td>
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<tr>
<td>20 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>16.10</td>
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### Decanes Plus Molecular Weight

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</thead>
<tbody>
<tr>
<td>21 Minimum - U</td>
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<td>22 (Average + Minimum - U)/2</td>
<td>215.484</td>
<td>gm/gm-mol</td>
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<tr>
<td>23 Average</td>
<td>217.356</td>
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<td>24 (Average + Maximum + U)/2</td>
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<td>gm/gm-mol</td>
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<tr>
<td>25 Maximum + U</td>
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<td>gm/gm-mol</td>
<td>340.703</td>
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### Decanes Plus Density

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<tbody>
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<td>26 Minimum - U</td>
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<td>(H2O=1)</td>
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<td>29 (Average + Maximum + U)/2</td>
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<td>(H2O=1)</td>
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<td>Psep (psia)</td>
<td>Value</td>
<td>Units</td>
<td>FGOR</td>
<td>Shrinkage</td>
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<tr>
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</table>
### Winter Phase EOS Sensitivity Study HP4 GPA 2186M

#### Tank Headspace temperature

<table>
<thead>
<tr>
<th>Values</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
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<tbody>
<tr>
<td>1 Minimum - Uncertainty (°F)</td>
<td>64.29 °F</td>
<td>333.098</td>
<td>0.8308</td>
<td>268.65</td>
</tr>
<tr>
<td>2 (Average + Minimum - Uncertainty)/2</td>
<td>67.25 °F</td>
<td>333.740</td>
<td>0.8304</td>
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</tr>
<tr>
<td>3 Average (°F)</td>
<td>70.20 °F</td>
<td>334.384</td>
<td>0.8301</td>
<td>268.65</td>
</tr>
<tr>
<td>4 (Average + Maximum + Uncertainty)/2</td>
<td>73.25 °F</td>
<td>335.053</td>
<td>0.8297</td>
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</tr>
<tr>
<td>5 Maximum + Uncertainty (°F)</td>
<td>76.31 °F</td>
<td>335.726</td>
<td>0.8294</td>
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#### Tank Headspace pressure

<table>
<thead>
<tr>
<th>Values</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Minimum - Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.37 psia</td>
<td>334.557</td>
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</tr>
<tr>
<td>7 (Average + Minimum - Uncertainty)/2</td>
<td>12.46 psia</td>
<td>334.470</td>
<td>0.8300</td>
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</tr>
<tr>
<td>8 Average (PIT 2/16 + Pambient) (psi)</td>
<td>12.55 psia</td>
<td>334.384</td>
<td>0.8301</td>
<td>268.65</td>
</tr>
<tr>
<td>9 (Average + Maximum + Uncertainty)/2</td>
<td>12.64 psia</td>
<td>334.298</td>
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<tr>
<td>10 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.73 psia</td>
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#### Tank 1' from Bottom temperature

<table>
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<tr>
<th>Values</th>
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<td>11 Average - Uncertainty (°F)</td>
<td>43.3 °F</td>
<td>328.494</td>
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<td>12 Average -1/2 Uncertainty (°F)</td>
<td>44.3 °F</td>
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<td>0.8316</td>
<td>268.65</td>
</tr>
<tr>
<td>13 Average</td>
<td>45.3 °F</td>
<td>334.384</td>
<td>0.8301</td>
<td>268.65</td>
</tr>
<tr>
<td>14 Average + 1/2 Uncertainty (°F)</td>
<td>46.5 °F</td>
<td>337.969</td>
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<tr>
<td>15 Average + Uncertainty (°F)</td>
<td>47.7 °F</td>
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<td>0.8265</td>
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#### Tank 1' from Bottom pressure

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<tr>
<td>16 Minimum - Uncertainty (psi)</td>
<td>15.51 psia</td>
<td>337.552</td>
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<td>17 (Average + Minimum - Uncertainty)/2</td>
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</tr>
<tr>
<td>18 Average (Pamb + PIT2 + L<em>p</em>Constant) (psi)</td>
<td>15.81 psia</td>
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<tr>
<td>20 Maximum + Uncertainty (PIT 2/16 + Pambient)(psi)</td>
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#### Decanes Plus Molecular Weight

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<tbody>
<tr>
<td>21 Minimum - U</td>
<td>146.231 gm/gm-mol</td>
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<td>22 (Average + Minimum - U)/2</td>
<td>147.220 gm/gm-mol</td>
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<td>23 Average</td>
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<td>24 (Average + Maximum + U)/2</td>
<td>149.199 gm/gm-mol</td>
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</tr>
<tr>
<td>25 Maximum + U</td>
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#### Decanes Plus Density

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<tbody>
<tr>
<td>26 Minimum - U</td>
<td>0.7509 (H₂O=1)</td>
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<td>28 Average</td>
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<td>Shrinkage B. Pt.</td>
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<td>33</td>
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<thead>
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<th>Shrinkage B. Pt.</th>
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<tr>
<td>37</td>
<td>65.3</td>
<td>°F</td>
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</tr>
<tr>
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<td>67.3</td>
<td>°F</td>
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<td>0.8308</td>
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<td>39</td>
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<td>40</td>
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<thead>
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<th>FGOR</th>
<th>Shrinkage B. Pt.</th>
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<tr>
<td>43</td>
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<td>44</td>
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<td>45</td>
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<td>Tank Headspace temperature</td>
<td>Value</td>
<td>Units</td>
<td>FGOR</td>
<td>Shrinkage</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------</td>
<td>-------</td>
<td>------</td>
<td>-----------</td>
</tr>
<tr>
<td>1 Minimum - Uncertainty (°F)</td>
<td>70.9</td>
<td>°F</td>
<td>201.707</td>
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</tr>
<tr>
<td>2 (Average + Minimum - Uncertainty)/2</td>
<td>72.3</td>
<td>°F</td>
<td>201.976</td>
<td>0.8885</td>
</tr>
<tr>
<td>3 Average (°F)</td>
<td>73.7</td>
<td>°F</td>
<td>202.248</td>
<td>0.8883</td>
</tr>
<tr>
<td>4 (Average + Maximum + Uncertainty)/2</td>
<td>75.3</td>
<td>°F</td>
<td>202.564</td>
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<tr>
<td>5 Maximum + Uncertainty (°F)</td>
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<td>°F</td>
<td>202.884</td>
<td>0.8879</td>
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<table>
<thead>
<tr>
<th>Tank Headspace pressure</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
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<tbody>
<tr>
<td>6 Minimum - Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.38</td>
<td>psia</td>
<td>202.403</td>
<td>0.8882</td>
<td>197.63</td>
</tr>
<tr>
<td>7 (Average + Minimum - Uncertainty)/2</td>
<td>12.47</td>
<td>psia</td>
<td>202.325</td>
<td>0.8883</td>
<td>197.63</td>
</tr>
<tr>
<td>8 Average (PIT 2/16 + Pambient) (psi)</td>
<td>12.55</td>
<td>psia</td>
<td>202.257</td>
<td>0.8883</td>
<td>197.63</td>
</tr>
<tr>
<td>9 (Average + Maximum + Uncertainty)/2</td>
<td>12.63</td>
<td>psia</td>
<td>202.189</td>
<td>0.8884</td>
<td>197.63</td>
</tr>
<tr>
<td>10 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.72</td>
<td>psia</td>
<td>202.113</td>
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<td>197.63</td>
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<table>
<thead>
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<th>Tank 1' from Bottom temperature</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 Average -Uncertainty (°F)</td>
<td>43.9</td>
<td>°F</td>
<td>202.042</td>
<td>0.8885</td>
<td>197.63</td>
</tr>
<tr>
<td>12 Average -1/2 Uncertainty (°F)</td>
<td>44.7</td>
<td>°F</td>
<td>203.705</td>
<td>0.8875</td>
<td>197.63</td>
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<tr>
<td>13 Average</td>
<td>45.4</td>
<td>°F</td>
<td>205.174</td>
<td>0.8866</td>
<td>197.63</td>
</tr>
<tr>
<td>14 Average + 1/2 Uncertainty (°F)</td>
<td>46.2</td>
<td>°F</td>
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<td>15 Average + Uncertainty (°F)</td>
<td>46.9</td>
<td>°F</td>
<td>208.368</td>
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<table>
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<th>Tank 1' from Bottom pressure</th>
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<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
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<tbody>
<tr>
<td>16 Minimum -Uncertainty (psi)</td>
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<td>197.63</td>
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<tr>
<td>17 (Average + Minimum - Uncertainty)/2</td>
<td>15.76</td>
<td>psia</td>
<td>200.755</td>
<td>0.8892</td>
<td>197.63</td>
</tr>
<tr>
<td>18 Average (Pamb + PIT2 + L<em>p</em>Constant) (psi)</td>
<td>15.85</td>
<td>psia</td>
<td>200.092</td>
<td>0.8896</td>
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<tr>
<td>19 (Average + Maximum + Uncertainty)/2</td>
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<tr>
<td>20 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
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<td>psia</td>
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<table>
<thead>
<tr>
<th>Decanes Plus Molecular Weight</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
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<tbody>
<tr>
<td>21 Minimum - U</td>
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<td>204.062</td>
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<td>22 (Average + Minimum - U)/2</td>
<td>211.973</td>
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<td>23 Average</td>
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<table>
<thead>
<tr>
<th>Decanes Plus Density</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 Minimum - U</td>
<td>0.8162</td>
<td>(H2O=1)</td>
<td>202.378</td>
<td>0.8885</td>
<td>196.73</td>
</tr>
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<td>0.8190</td>
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<td>202.322</td>
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<td>0.8219</td>
<td>(H2O=1)</td>
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<td>0.8243</td>
<td>(H2O=1)</td>
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### EOS Sensitivity Study - Winter Phase - Medium Pressure #2 - GPA 2103M

<table>
<thead>
<tr>
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<th>Value</th>
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<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
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<th>B. Pt.</th>
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<tbody>
<tr>
<td>41</td>
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### Tank Headspace temperature

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<td>1 Minimum - Uncertainty (°F)</td>
<td>70.9 °F</td>
<td>198.255</td>
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<td>2 (Average + Minimum - Uncertainty)/2</td>
<td>72.3 °F</td>
<td>198.476</td>
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<tr>
<td>3 Average (°F)</td>
<td>73.7 °F</td>
<td>198.699</td>
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<tr>
<td>4 (Average + Maximum + Uncertainty)/2</td>
<td>75.3 °F</td>
<td>198.955</td>
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<td>5 Maximum + Uncertainty (°F)</td>
<td>76.9 °F</td>
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### Tank Headspace pressure

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<td>6 Minimum -Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.38 psia</td>
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<td>7 (Average + Minimum - Uncertainty)/2</td>
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<td>8 Average (PIT 2/16 + Pambient) (psi)</td>
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<td>0.8906</td>
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<tr>
<td>9 (Average + Maximum + Uncertainty)/2</td>
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<td>10 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.72 psia</td>
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### Tank 1' from Bottom temperature

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<td>11 Average -Uncertainty (°F)</td>
<td>43.9 °F</td>
<td>198.509</td>
<td>0.8907</td>
<td>200.12</td>
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<tr>
<td>12 Average -1/2 Uncertainty (°F)</td>
<td>44.7 °F</td>
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<td>13 Average</td>
<td>45.4 °F</td>
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<td>14 Average + 1/2 Uncertainty (°F)</td>
<td>46.2 °F</td>
<td>202.929</td>
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<td>15 Average + Uncertainty (°F)</td>
<td>46.9 °F</td>
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### Tank 1' from Bottom pressure

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<tr>
<td>16 Minimum -Uncertainty (psi)</td>
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<tr>
<td>17 (Average + Minimum - Uncertainty)/2</td>
<td>15.76 psia</td>
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<td>18 Average (Pamb + PIT2 + L<em>p</em>Constant) (psi)</td>
<td>15.85 psia</td>
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<td>19 (Average + Maximum + Uncertainty)/2</td>
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<tr>
<td>20 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
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### Decanes Plus Molecular Weight

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<tbody>
<tr>
<td>21 Minimum - U</td>
<td>145.990 gm/gm-mol</td>
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<td>200.23</td>
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<tr>
<td>22 (Average + Minimum - U)/2</td>
<td>146.574 gm/gm-mol</td>
<td>199.031</td>
<td>0.8904</td>
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<tr>
<td>23 Average</td>
<td>147.158 gm/gm-mol</td>
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<td>0.8906</td>
<td>200.12</td>
</tr>
<tr>
<td>24 (Average + Maximum + U)/2</td>
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<tr>
<td>25 Maximum + U</td>
<td>148.326 gm/gm-mol</td>
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### Decanes Plus Density

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<tr>
<td>26 Minimum - U</td>
<td>0.7535 (H&lt;sub&gt;2&lt;/sub&gt;O=1)</td>
<td>198.354</td>
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<tr>
<td>27 (Average + Minimum - U)/2</td>
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<tr>
<td>28 Average</td>
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<td>30 Maximum + U</td>
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<tr>
<td>Psep (psia)</td>
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<th>B. Pt.</th>
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<th>Siphon Prevention Hole</th>
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<td>Shrinkage</td>
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<tr>
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<td>3 Average (°F)</td>
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<tr>
<td>4 (Average + Maximum + Uncertainty)/2</td>
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<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
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<tbody>
<tr>
<td>6 Minimum -Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.38 psia</td>
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<td>7 (Average + Minimum - Uncertainty)/2</td>
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<td>0.9146</td>
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</tr>
<tr>
<td>8 Average (PIT 2/16 + Pambient) (psi)</td>
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<td>0.9147</td>
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<tr>
<td>9 (Average + Maximum + Uncertainty)/2</td>
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<td>11 Average -Uncertainty (°F)</td>
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<td>13 Average</td>
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<td>214.899 (H₂O=1)</td>
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<td>18 Average</td>
<td>217.216 (H₂O=1)</td>
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<td>219.533 (H₂O=1)</td>
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<td>221.850 (H₂O=1)</td>
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<td>149.965</td>
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<table>
<thead>
<tr>
<th>Decanes Plus Density</th>
<th>Value</th>
<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
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<tbody>
<tr>
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<tr>
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<td>155.32</td>
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<td>Psep (psia)</td>
<td>Value</td>
<td>Units</td>
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<td>Shrinkage B. Pt.</td>
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<tr>
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<tr>
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<th>Value</th>
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<td>41</td>
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## Winter Phase EOS Sensitivity Study  LP1 GPA 2186M

### Tank Headspace temperature

<table>
<thead>
<tr>
<th>Value</th>
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<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
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<tbody>
<tr>
<td>1 Minimum - Uncertainty (°F)</td>
<td>80.9 °F</td>
<td>147.312</td>
<td>0.9177</td>
<td>154.43</td>
</tr>
<tr>
<td>2 (Average + Minimum - Uncertainty)/2</td>
<td>83.2 °F</td>
<td>147.623</td>
<td>0.9175</td>
<td>154.43</td>
</tr>
<tr>
<td>3 Average (°F)</td>
<td>85.5 °F</td>
<td>147.936</td>
<td>0.9173</td>
<td>154.43</td>
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<tr>
<td>4 (Average + Maximum + Uncertainty)/2</td>
<td>87.5 °F</td>
<td>148.211</td>
<td>0.9171</td>
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</tr>
<tr>
<td>5 Maximum + Uncertainty (°F)</td>
<td>89.6 °F</td>
<td>148.503</td>
<td>0.9169</td>
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### Tank Headspace pressure

<table>
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<tr>
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<tr>
<td>6 Minimum - Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.38 psia</td>
<td>148.019</td>
<td>0.9173</td>
<td>154.43</td>
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<tr>
<td>7 (Average + Minimum - Uncertainty)/2</td>
<td>12.47 psia</td>
<td>147.960</td>
<td>0.9173</td>
<td>154.43</td>
</tr>
<tr>
<td>8 Average (PIT 2/16 + Pambient) (psi)</td>
<td>12.55 psia</td>
<td>147.909</td>
<td>0.9173</td>
<td>154.43</td>
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<tr>
<td>9 (Average + Maximum + Uncertainty)/2</td>
<td>12.63 psia</td>
<td>147.857</td>
<td>0.9174</td>
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</tr>
<tr>
<td>10 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.72 psia</td>
<td>147.800</td>
<td>0.9174</td>
<td>154.43</td>
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### Tank 1' from Bottom temperature

<table>
<thead>
<tr>
<th>Value</th>
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<th>B. Pt.</th>
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<tbody>
<tr>
<td>11 Average - Uncertainty (°F)</td>
<td>44.6 °F</td>
<td>147.321</td>
<td>0.9177</td>
<td>154.43</td>
</tr>
<tr>
<td>12 Average -1/2 Uncertainty (°F)</td>
<td>45.4 °F</td>
<td>147.499</td>
<td>0.9170</td>
<td>154.43</td>
</tr>
<tr>
<td>13 Average</td>
<td>46.1 °F</td>
<td>147.538</td>
<td>0.9163</td>
<td>154.43</td>
</tr>
<tr>
<td>14 Average + 1/2 Uncertainty (°F)</td>
<td>46.9 °F</td>
<td>150.736</td>
<td>0.9156</td>
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<tr>
<td>15 Average + Uncertainty (°F)</td>
<td>47.6 °F</td>
<td>151.793</td>
<td>0.9150</td>
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### Tank 1' from Bottom pressure

<table>
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<th>Shrinkage</th>
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<tbody>
<tr>
<td>16 Minimum - Uncertainty (psi)</td>
<td>15.72 psia</td>
<td>147.174</td>
<td>0.9178</td>
<td>154.43</td>
</tr>
<tr>
<td>17 (Average + Minimum - Uncertainty)/2</td>
<td>15.81 psia</td>
<td>146.671</td>
<td>0.9181</td>
<td>154.43</td>
</tr>
<tr>
<td>18 Average (Pamb + PIT2 + L<em>p</em>Constant) (psi)</td>
<td>15.89 psia</td>
<td>146.227</td>
<td>0.9183</td>
<td>154.43</td>
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<tr>
<td>19 (Average + Maximum + Uncertainty)/2</td>
<td>15.97 psia</td>
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<tr>
<td>20 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>16.06 psia</td>
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### Decanes Plus Molecular Weight

<table>
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<th>B. Pt.</th>
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<tbody>
<tr>
<td>21 Minimum - U</td>
<td>145.575 gm/gm-mol</td>
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</tr>
<tr>
<td>22 (Average + Minimum - U)/2</td>
<td>146.229 gm/gm-mol</td>
<td>148.252</td>
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<tr>
<td>23 Average</td>
<td>146.883 gm/gm-mol</td>
<td>147.975</td>
<td>0.9173</td>
<td>154.45</td>
</tr>
<tr>
<td>24 (Average + Maximum + U)/2</td>
<td>147.536 gm/gm-mol</td>
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<tr>
<td>25 Maximum + U</td>
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### Decanes Plus Density

<table>
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<th>Shrinkage</th>
<th>B. Pt.</th>
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<tbody>
<tr>
<td>26 Minimum - U</td>
<td>0.7537 (H2O=1)</td>
<td>147.775</td>
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<td>27 (Average + Minimum - U)/2</td>
<td>0.7557 (H2O=1)</td>
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<td>28 Average</td>
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<td>29 (Average + Maximum + U)/2</td>
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<td>Psep (psia)</td>
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<td>FGOR</td>
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<td>32</td>
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<td>33</td>
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<table>
<thead>
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<tbody>
<tr>
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<td>0.9173</td>
<td>178.7</td>
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<tr>
<td>37</td>
<td>102.4</td>
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<td>0.9175</td>
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<tr>
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<th>Siphon Prevention Hole</th>
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<tr>
<td>44</td>
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### Tank Headspace temperature

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<tbody>
<tr>
<td>1</td>
<td>Minimum - Uncertainty (°F)</td>
<td>95.7°F</td>
<td>376.748</td>
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</tr>
<tr>
<td>2</td>
<td>(Average + Minimum - Uncertainty)/2</td>
<td>97.7°F</td>
<td>377.310</td>
<td>0.8013</td>
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<tr>
<td>3</td>
<td>Average (°F)</td>
<td>99.8°F</td>
<td>377.909</td>
<td>0.8009</td>
</tr>
<tr>
<td>4</td>
<td>(Average + Maximum + Uncertainty)/2</td>
<td>102.2°F</td>
<td>378.603</td>
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</tr>
<tr>
<td>5</td>
<td>Maximum + Uncertainty (°F)</td>
<td>104.6°F</td>
<td>379.310</td>
<td>0.8002</td>
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### Tank Headspace pressure

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<tbody>
<tr>
<td>6</td>
<td>Minimum - Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.41 psia</td>
<td>378.256</td>
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<tr>
<td>7</td>
<td>(Average + Minimum - Uncertainty)/2</td>
<td>12.50 psia</td>
<td>378.144</td>
<td>0.8008</td>
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<tr>
<td>8</td>
<td>Average (PIT 2/16 + Pambient) (psi)</td>
<td>12.58 psia</td>
<td>378.044</td>
<td>0.8009</td>
</tr>
<tr>
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<td>(Average + Maximum + Uncertainty)/2</td>
<td>12.66 psia</td>
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<td>10</td>
<td>Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.75 psia</td>
<td>377.835</td>
<td>0.8010</td>
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### Tank 1' from Bottom temperature

<table>
<thead>
<tr>
<th>Value</th>
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<th>B. Pt.</th>
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<tbody>
<tr>
<td>11</td>
<td>Average - Uncertainty (°F)</td>
<td>81.4°F</td>
<td>372.511</td>
<td>0.8037</td>
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<tr>
<td>12</td>
<td>Average - 1/2 Uncertainty (°F)</td>
<td>82.2°F</td>
<td>375.378</td>
<td>0.8022</td>
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<tr>
<td>13</td>
<td>Average</td>
<td>82.9°F</td>
<td>377.909</td>
<td>0.8009</td>
</tr>
<tr>
<td>14</td>
<td>Average + 1/2 Uncertainty (°F)</td>
<td>83.7°F</td>
<td>380.827</td>
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<tr>
<td>15</td>
<td>Average + Uncertainty (°F)</td>
<td>84.4°F</td>
<td>383.403</td>
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### Tank 1' from Bottom pressure

<table>
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<tr>
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<th>Shrinkage</th>
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<tr>
<td>16</td>
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<td>17</td>
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<td>16.49 psia</td>
<td>375.771</td>
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<td>18</td>
<td>Average (Pamb + PIT2 + L<em>p</em>Constant) (psi)</td>
<td>16.57 psia</td>
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<td>(Average + Maximum + Uncertainty)/2</td>
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<td>20</td>
<td>Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>16.74 psia</td>
<td>372.685</td>
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### Decanes Plus Molecular Weight

<table>
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<tr>
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<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
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<tr>
<td>22</td>
<td>(Average + Minimum - U)/2</td>
<td>209.511 gm/gm-mol</td>
<td>377.136</td>
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<tr>
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<td>Average</td>
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<td>(Average + Maximum + U)/2</td>
<td>216.469 gm/gm-mol</td>
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<td>25</td>
<td>Maximum + U</td>
<td>219.808 gm/gm-mol</td>
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### Decanes Plus Density

<table>
<thead>
<tr>
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<th>Units</th>
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<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Minimum - U</td>
<td>0.8162 (H₂O=1)</td>
<td>377.859</td>
<td>0.8011</td>
</tr>
<tr>
<td>27</td>
<td>(Average + Minimum - U)/2</td>
<td>0.8195 (H₂O=1)</td>
<td>377.899</td>
<td>0.8010</td>
</tr>
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<td>Average</td>
<td>0.8228 (H₂O=1)</td>
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<td>0.8008</td>
</tr>
<tr>
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<td>(Average + Maximum + U)/2</td>
<td>0.8266 (H₂O=1)</td>
<td>377.974</td>
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<td>Maximum + U</td>
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<tr>
<td>Psep (psia)</td>
<td>Value</td>
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<td>FGOR</td>
<td>Shrinkage B. Pt.</td>
</tr>
<tr>
<td>------------</td>
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<td>°F</td>
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<tr>
<td>21 Minimum - U</td>
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<th>B. Pt.</th>
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### Summer Phase EOS Sensitivity Study MP3 GPA 2103M

#### Tank Headspace temperature

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#### Tank Headspace pressure

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#### Tank 1’ from Bottom temperature

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#### Tank 1’ from Bottom pressure

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#### Decanes Plus Molecular Weight

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#### Decanes Plus Density

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<td>Psep (psia)</td>
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<table>
<thead>
<tr>
<th>Tsep (°F)</th>
<th>Value</th>
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<th>B. Pt.</th>
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<tbody>
<tr>
<td>36</td>
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<td><strong>Value</strong></td>
<td><strong>Units</strong></td>
<td><strong>FGOR</strong></td>
<td><strong>Shrinkage</strong></td>
<td><strong>B. Pt.</strong></td>
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<td>-------------------------------</td>
<td>-----------</td>
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<tr>
<td>1 Minimum - Uncertainty (°F)</td>
<td>86.6 °F</td>
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<td>3 Average (°F)</td>
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<td>0.8382</td>
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<td>4 (Average + Maximum + Uncertainty)/2</td>
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<td>5 Maximum + Uncertainty (°F)</td>
<td>92.7 °F</td>
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<td>301.679</td>
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<thead>
<tr>
<th><strong>Tank Headspace pressure</strong></th>
<th><strong>Value</strong></th>
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<th><strong>FGOR</strong></th>
<th><strong>Shrinkage</strong></th>
<th><strong>B. Pt.</strong></th>
</tr>
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<tbody>
<tr>
<td>6 Minimum - Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.38 psia</td>
<td>301.325</td>
<td>0.8381</td>
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<td>7 (Average + Minimum - Uncertainty)/2</td>
<td>12.47 psia</td>
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<td>0.8382</td>
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</tr>
<tr>
<td>8 Average (PIT 2/16 + Pambient) (psi)</td>
<td>12.55 psia</td>
<td>301.181</td>
<td>0.8382</td>
<td>231.34</td>
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<tr>
<td>9 (Average + Maximum + Uncertainty)/2</td>
<td>12.63 psia</td>
<td>301.114</td>
<td>0.8382</td>
<td>231.34</td>
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</tr>
<tr>
<td>10 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.72 psia</td>
<td>301.039</td>
<td>0.8383</td>
<td>231.34</td>
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<table>
<thead>
<tr>
<th><strong>Tank 1’ from Bottom temperature</strong></th>
<th><strong>Value</strong></th>
<th><strong>Units</strong></th>
<th><strong>FGOR</strong></th>
<th><strong>Shrinkage</strong></th>
<th><strong>B. Pt.</strong></th>
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<tbody>
<tr>
<td>11 Average - Uncertainty (°F)</td>
<td>78.8 °F</td>
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<td>297.240</td>
<td>0.8403</td>
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<tr>
<td>12 Average - 1/2 Uncertainty (°F)</td>
<td>79.5 °F</td>
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<tr>
<td>13 Average</td>
<td>80.3 °F</td>
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<tr>
<td>14 Average + 1/2 Uncertainty (°F)</td>
<td>81.0 °F</td>
<td></td>
<td>302.925</td>
<td>0.8373</td>
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<tr>
<td>15 Average + Uncertainty (°F)</td>
<td>81.8 °F</td>
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<table>
<thead>
<tr>
<th><strong>Tank 1’ from Bottom pressure</strong></th>
<th><strong>Value</strong></th>
<th><strong>Units</strong></th>
<th><strong>FGOR</strong></th>
<th><strong>Shrinkage</strong></th>
<th><strong>B. Pt.</strong></th>
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<tbody>
<tr>
<td>16 Minimum - Uncertainty (psi)</td>
<td>16.39 psia</td>
<td>300.441</td>
<td>0.8386</td>
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<tr>
<td>17 (Average + Minimum - Uncertainty)/2</td>
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<td>299.686</td>
<td>0.8390</td>
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<tr>
<td>18 Average (Pamb + PIT2 + L<em>p</em>Constant) (psi)</td>
<td>16.55 psia</td>
<td>298.935</td>
<td>0.8394</td>
<td>231.34</td>
<td></td>
</tr>
<tr>
<td>19 (Average + Maximum + Uncertainty)/2</td>
<td>16.64 psia</td>
<td>298.097</td>
<td>0.8398</td>
<td>231.34</td>
<td></td>
</tr>
<tr>
<td>20 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>16.72 psia</td>
<td>297.356</td>
<td>0.8402</td>
<td>231.34</td>
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<table>
<thead>
<tr>
<th><strong>Decanes Plus Molecular Weight</strong></th>
<th><strong>Value</strong></th>
<th><strong>Units</strong></th>
<th><strong>FGOR</strong></th>
<th><strong>Shrinkage</strong></th>
<th><strong>B. Pt.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>21 Minimum - U</td>
<td>144.652 gm/gm-mol</td>
<td>302.138</td>
<td>0.8378</td>
<td>231.45</td>
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</tr>
<tr>
<td>22 (Average + Minimum - U)/2</td>
<td>146.005 gm/gm-mol</td>
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<td>231.32</td>
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<tr>
<td>23 Average</td>
<td>147.359 gm/gm-mol</td>
<td>299.723</td>
<td>0.8389</td>
<td>231.18</td>
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</tr>
<tr>
<td>24 (Average + Maximum + U)/2</td>
<td>148.443 gm/gm-mol</td>
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<td>0.8393</td>
<td>231.08</td>
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</tr>
<tr>
<td>25 Maximum + U</td>
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<td>0.8397</td>
<td>230.97</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Decanes Plus Density</strong></th>
<th><strong>Value</strong></th>
<th><strong>Units</strong></th>
<th><strong>FGOR</strong></th>
<th><strong>Shrinkage</strong></th>
<th><strong>B. Pt.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>26 Minimum - U</td>
<td>0.7515 (H2O=1)</td>
<td>299.417</td>
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<tr>
<td>27 (Average + Minimum - U)/2</td>
<td>0.7544 (H2O=1)</td>
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</tr>
<tr>
<td>28 Average</td>
<td>0.7573 (H2O=1)</td>
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<td>0.8385</td>
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<td>29 (Average + Maximum + U)/2</td>
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### EOS Sensitivity Study - Summer Phase - Medium Pressure #3 - GPA 2186M

<table>
<thead>
<tr>
<th>Psep (psia)</th>
<th>Value</th>
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<th>FGOR</th>
<th>Shrinkage B. Pt.</th>
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<tbody>
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<td>236.3</td>
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<td>psia</td>
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<td>Value</td>
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<td>FGOR</td>
<td>Shrinkage B. Pt.</td>
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<td>0.8395</td>
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<tr>
<td>37</td>
<td>92.2</td>
<td>°F</td>
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<td>0.8398</td>
</tr>
<tr>
<td>38</td>
<td>94.2</td>
<td>°F</td>
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<tr>
<td>39</td>
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<td>40</td>
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<td>0.8410</td>
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<table>
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<tr>
<th>Siphon Prevention Hole</th>
<th>Value</th>
<th>Units</th>
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<th>Shrinkage B. Pt.</th>
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<td>41</td>
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</tr>
<tr>
<td>42</td>
<td>0.03</td>
<td>(0-1)</td>
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<td>0.8406</td>
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<tr>
<td>43</td>
<td>0.06</td>
<td>(0-1)</td>
<td>299</td>
<td>0.8394</td>
</tr>
<tr>
<td>44</td>
<td>0.12</td>
<td>(0-1)</td>
<td>303</td>
<td>0.8369</td>
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<tr>
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<td>0.24</td>
<td>(0-1)</td>
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<td>46</td>
<td>0.48</td>
<td>(0-1)</td>
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<td>0.8013</td>
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### Tank Headspace temperature

<table>
<thead>
<tr>
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<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
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<tbody>
<tr>
<td>1 Minimum - Uncertainty (°F)</td>
<td>91.1</td>
<td>°F</td>
<td>237.531</td>
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</tr>
<tr>
<td>2 (Average + Minimum - Uncertainty)/2</td>
<td>93.4</td>
<td>°F</td>
<td>238.057</td>
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<tr>
<td>3 Average (°F)</td>
<td>95.8</td>
<td>°F</td>
<td>238.617</td>
<td>0.8645</td>
</tr>
<tr>
<td>4 (Average + Maximum + Uncertainty)/2</td>
<td>98.3</td>
<td>°F</td>
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<tr>
<td>5 Maximum + Uncertainty (°F)</td>
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### Tank Headspace pressure

<table>
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<tr>
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<th>Units</th>
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<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Minimum - Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.38</td>
<td>psia</td>
<td>237.273</td>
<td>0.8653</td>
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<tr>
<td>7 (Average + Minimum - Uncertainty)/2</td>
<td>12.47</td>
<td>psia</td>
<td>237.183</td>
<td>0.8654</td>
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<tr>
<td>8 Average (PIT 2/16 + Pambient) (psi)</td>
<td>12.55</td>
<td>psia</td>
<td>237.104</td>
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</tr>
<tr>
<td>9 (Average + Maximum + Uncertainty)/2</td>
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<td>psia</td>
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<tr>
<td>10 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.72</td>
<td>psia</td>
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</table>

### Tank 1' from Bottom temperature

<table>
<thead>
<tr>
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<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
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<tbody>
<tr>
<td>11 Average - Uncertainty (°F)</td>
<td>76.4</td>
<td>°F</td>
<td>238.636</td>
<td>0.8645</td>
</tr>
<tr>
<td>12 Average -1/2 Uncertainty (°F)</td>
<td>77.1</td>
<td>°F</td>
<td>240.544</td>
<td>0.8634</td>
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<tr>
<td>13 Average</td>
<td>77.9</td>
<td>°F</td>
<td>242.747</td>
<td>0.8621</td>
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<tr>
<td>14 Average + 1/2 Uncertainty (°F)</td>
<td>78.6</td>
<td>°F</td>
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<tr>
<td>15 Average + Uncertainty (°F)</td>
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<td>°F</td>
<td>246.940</td>
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### Tank 1' from Bottom pressure

<table>
<thead>
<tr>
<th>Value</th>
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<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
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<tbody>
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<td>235.388</td>
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<tr>
<td>18 Average (Pamb + PIT2 + L<em>p</em>Constant) (psi)</td>
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<td>psia</td>
<td>234.631</td>
<td>0.8668</td>
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<td>19 (Average + Maximum + Uncertainty)/2</td>
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<td>20 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
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### Decanes Plus Molecular Weight

<table>
<thead>
<tr>
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<th>Units</th>
<th>FGOR</th>
<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 Minimum - U</td>
<td>209.333</td>
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<td>239.054</td>
<td>0.8645</td>
</tr>
<tr>
<td>22 (Average + Minimum - U)/2</td>
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<td>gm/gm-mol</td>
<td>238.397</td>
<td>0.8648</td>
</tr>
<tr>
<td>23 Average</td>
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</tr>
<tr>
<td>24 (Average + Maximum + U)/2</td>
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<td>gm/gm-mol</td>
<td>237.147</td>
<td>0.8654</td>
</tr>
<tr>
<td>25 Maximum + U</td>
<td>218.264</td>
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### Decanes Plus Density

<table>
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<tr>
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<th>B. Pt.</th>
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<tbody>
<tr>
<td>26 Minimum - U</td>
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### EOS Sensitivity Study - Summer Phase - Low Pressure #3 - GPA 2103M

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### Summer Phase EOS Sensitivity Study LP3 GPA 2186M

#### Tank Headspace temperature

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<th>Shrinkage</th>
<th>B. Pt.</th>
</tr>
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<tbody>
<tr>
<td>1 Minimum - Uncertainty (°F)</td>
<td>91.1 °F</td>
<td>231.531</td>
<td>0.8698</td>
<td>181.01</td>
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<tr>
<td>2 (Average + Minimum - Uncertainty)/2</td>
<td>93.4 °F</td>
<td>231.927</td>
<td>0.8695</td>
<td>181.01</td>
</tr>
<tr>
<td>3 Average (°F)</td>
<td>95.8 °F</td>
<td>232.343</td>
<td>0.8693</td>
<td>181.01</td>
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<tr>
<td>4 (Average + Maximum + Uncertainty)/2</td>
<td>98.3 °F</td>
<td>232.780</td>
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<tr>
<td>5 Maximum + Uncertainty (°F)</td>
<td>100.9 °F</td>
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#### Tank Headspace pressure

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<tbody>
<tr>
<td>6 Minimum - Uncertainty (PIT 2/16 + Pambient) (psi)</td>
<td>12.38 psia</td>
<td>231.345</td>
<td>0.8699</td>
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<tr>
<td>7 (Average + Minimum - Uncertainty)/2</td>
<td>12.47 psia</td>
<td>231.273</td>
<td>0.8699</td>
<td>181.01</td>
</tr>
<tr>
<td>8 Average (PIT 2/16 + Pambient) (psi)</td>
<td>12.55 psia</td>
<td>231.209</td>
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<td>9 (Average + Maximum + Uncertainty)/2</td>
<td>12.63 psia</td>
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#### Tank 1' from Bottom temperature

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<tr>
<td>11 Average -Uncertainty (°F)</td>
<td>76.4 °F</td>
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<td>12 Average -1/2 Uncertainty (°F)</td>
<td>77.1 °F</td>
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<td>13 Average</td>
<td>77.9 °F</td>
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<td>14 Average + 1/2 Uncertainty (°F)</td>
<td>78.6 °F</td>
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<td>15 Average + Uncertainty (°F)</td>
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#### Tank 1' from Bottom pressure

<table>
<thead>
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<tr>
<td>16 Minimum -Uncertainty (psi)</td>
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<td>17 (Average + Minimum - Uncertainty)/2</td>
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<tr>
<td>18 Average (Pamb + PIT2 + L<em>p</em>Constant) (psi)</td>
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<td>19 (Average + Maximum + Uncertainty)/2</td>
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<tr>
<td>20 Maximum + Uncertainty (PIT 2/16 + Pambient) (psi)</td>
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#### Decanes Plus Molecular Weight

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<tbody>
<tr>
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<tr>
<td>22 (Average + Minimum - U)/2</td>
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<tr>
<td>23 Average</td>
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<tr>
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#### Decanes Plus Density

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<tbody>
<tr>
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<tr>
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<td>28 Average</td>
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</table>
Appendix V.5 Monte Carlo Simulation Results

Winter PHLSA Study – HP4 – GPA 2103M

Crystal Ball Report - Full
Simulation started on 5/1/2017 at 7:20 PM
Simulation stopped on 5/2/2017 at 1:23 PM

Run preferences:
- Number of trials run: 3,000
- Monte Carlo
- Random seed
- Precision control on
  - Confidence level: 95.00%

Run statistics:
- Total running time (sec): 64972.92
- Trials/second (average): 0
- Random numbers per sec: 1

Crystal Ball data:
- Assumptions: 32
- Correlations: 0
- Correlated groups: 0
- Decision variables: 0
- Forecasts: 4

Forecasts

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl)

Cell: S34

Summary:
- Entire range is from 326.124 to 358.501
- Base case is 341.566
- After 3,000 trials, the std. error of the mean is 0.090
### Statistics:

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Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) (cont'd)  

Percentiles: Forecast values
0% 326.124
10% 335.326
20% 337.442
30% 338.957
40% 340.513
50% 341.769
60% 343.001
70% 344.297
80% 345.957
90% 348.330
100% 358.501

Forecast: Flash MW

Summary:
Entire range is from 37.730 to 38.742
Base case is 38.227
After 3,000 trials, the std. error of the mean is 0.003

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<td>Range Width</td>
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<tr>
<td>Mean Std. Error</td>
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Forecast: Flash MW (cont'd)  
Percentiles: Forecast values
0% 37.730
10% 37.991
20% 38.072
30% 38.125
40% 38.178
50% 38.230
60% 38.279
70% 38.331
80% 38.395
90% 38.466
100% 38.742

Forecast: Sample Bubble Point at Tsep  
Summary:
Entire range is from 247.23 to 266.71
Base case is 257.65
After 3,000 trials, the std. error of the mean is 0.05

Statistics:
Trials 3,000
Base Case 257.65
Mean 257.73
Median 257.70
Mode ---
Standard Deviation 2.92
Variance 8.54
Skewness -0.0185
Kurtosis 2.73
Coeff. of Variability 0.0113
Minimum 247.23
Maximum 266.71
Range Width 19.48
Mean Std. Error 0.05
Forecast: Sample Bubble Point at Tsep (cont'd)  

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Forecast: Shrinkage Factor  

Summary:  
Entire range is from 0.834 to 0.848  
Base case is 0.841  
After 3,000 trials, the std. error of the mean is 0.000

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Forecast: Shrinkage Factor (cont’d)  

Percentiles: Forecast values  

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End of Forecasts

Assumptions

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Assumption: 2,2,4-Trimethylpentane  

Normal distribution with parameters:  
Mean: 0.041  
Std. Dev.: 0.000

Assumption: 2,2-Dimethylbutane  

Normal distribution with parameters:  
Mean: 0.099  
Std. Dev.: 0.000

Assumption: 2,3-Dimethylbutane  

Normal distribution with parameters:  
Mean: 0.339  
Std. Dev.: 0.001
Assumption: 2-Methylpentane

Normal distribution with parameters:
Mean 3.102
Std. Dev. 0.007

Assumption: 3-Methylpentane

Normal distribution with parameters:
Mean 1.899
Std. Dev. 0.004

Assumption: Benzene

Normal distribution with parameters:
Mean 0.783
Std. Dev. 0.021

Assumption: Carbon Dioxide

Normal distribution with parameters:
Mean 0.502
Std. Dev. 0.004
**Assumption: Cyclopentane**  
Cell: F25

Normal distribution with parameters:
- Mean: 0.418
- Std. Dev.: 0.001

![Cyclopentane Distribution](image1)

**Assumption: Decanes Plus**  
Cell: F16

Normal distribution with parameters:
- Mean: 7.697
- Std. Dev.: 0.099

![Decanes Plus Distribution](image2)

**Assumption: Discharge Through Siphon Hole (fraction, 0-1)**  
Cell: S8

Uniform distribution with parameters:
- Minimum: 0.04
- Maximum: 0.08

![Discharge Through Siphon Hole Distribution](image3)

**Assumption: Ethane**  
Cell: F6

Normal distribution with parameters:
- Mean: 7.400
- Std. Dev.: 0.058

![Ethane Distribution](image4)
**Assumption: Ethylbenzene**  
Cell: F19

Normal distribution with parameters:
Mean 0.149
Std. Dev. 0.014

**Assumption: Heptanes**  
Cell: F13

Normal distribution with parameters:
Mean 12.297
Std. Dev. 0.187

**Assumption: Iso-Butane**  
Cell: F8

Normal distribution with parameters:
Mean 2.863
Std. Dev. 0.013

**Assumption: Iso-Pentane**  
Cell: F10

Normal distribution with parameters:
Mean 6.069
Std. Dev. 0.071
Assumption: m,p-Xylene (100% meta)  

Cell: F20

Normal distribution with parameters:
Mean 1.584
Std. Dev. 0.021

Assumption: Methane

Cell: F5

Normal distribution with parameters:
Mean 7.357
Std. Dev. 0.080

Assumption: n-Butane

Cell: F9

Normal distribution with parameters:
Mean 8.915
Std. Dev. 0.046

Assumption: n-Hexane

Cell: F12

Normal distribution with parameters:
Mean 5.888
Std. Dev. 0.128
Assumption: Nonanes  
Cell: F15

Normal distribution with parameters:
- Mean: 3.761
- Std. Dev.: 0.048

Assumption: n-Pentane  
Cell: F11

Normal distribution with parameters:
- Mean: 8.256
- Std. Dev.: 0.034

Assumption: Octanes  
Cell: F14

Normal distribution with parameters:
- Mean: 8.997
- Std. Dev.: 0.294

Assumption: o-Xylene  
Cell: F21

Normal distribution with parameters:
- Mean: 0.390
- Std. Dev.: 0.005
Assumption: Propane

Normal distribution with parameters:
Mean 8.716
Std. Dev. 0.057

Assumption: Separator Pressure

Uniform distribution with parameters:
Minimum 270.03
Maximum 281.23

Assumption: Separator Temperature

Uniform distribution with parameters:
Minimum 56.31
Maximum 60.29

Assumption: Tank Bottom Pressure

Normal distribution with parameters:
Mean 15.81
Std. Dev. 0.07
Assumption: Tank Bottom Temperature

Uniform distribution with parameters:
- Minimum: 43.79
- Maximum: 46.81

Assumption: Tank HS Pressure

Uniform distribution with parameters:
- Minimum: 12.43
- Maximum: 12.67

Assumption: Tank HS Temperature

Uniform distribution with parameters:
- Minimum: 68.18
- Maximum: 72.22

Assumption: Toluene

Normal distribution with parameters:
- Mean: 2.478
- Std. Dev.: 0.027
Assumption: Volume Flow (Std. Bbl)  

Normal distribution with parameters:
- Mean: 0.652
- Std. Dev.: 0.002

End of Assumptions

Winter PHLSA Study – HP4 – GPA 2186M

Crystal Ball Report - Full
Simulation started on 4/30/2017 at 1:09 PM
Simulation stopped on 5/1/2017 at 8:22 AM

Run preferences:
- Number of trials run: 3,000
- Monte Carlo
- Random seed
- Precision control on
  - Confidence level: 95.00%

Run statistics:
- Total running time (sec): 69185.52
- Trials/second (average): 0
- Random numbers per sec: 1

Crystal Ball data:
- Assumptions: 32
- Correlations: 0
- Correlated groups: 0
- Decision variables: 0
- Forecasts: 4

Forecasts

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output
Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl)  

Cell: S34

Summary:
Entire range is from 319.728 to 357.052
Base case is 338.101
After 3,000 trials, the std. error of the mean is 0.099

Statistics:

<table>
<thead>
<tr>
<th></th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>338.101</td>
</tr>
<tr>
<td>Mean</td>
<td>338.005</td>
</tr>
<tr>
<td>Median</td>
<td>337.863</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>5.411</td>
</tr>
<tr>
<td>Variance</td>
<td>29.283</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0863</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.92</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0160</td>
</tr>
<tr>
<td>Minimum</td>
<td>319.728</td>
</tr>
<tr>
<td>Maximum</td>
<td>357.052</td>
</tr>
<tr>
<td>Range Width</td>
<td>37.324</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.099</td>
</tr>
</tbody>
</table>
Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) (cont'd)  

Percentiles:  
- 0%: 319.728  
- 10%: 331.084  
- 20%: 333.419  
- 30%: 335.077  
- 40%: 336.486  
- 50%: 337.861  
- 60%: 339.263  
- 70%: 340.736  
- 80%: 342.620  
- 90%: 345.054  
- 100%: 357.052  

Forecast: Flash MW  

Summary:  
Entire range is from 37.076 to 38.113  
Base case is 37.570  
After 3,000 trials, the std. error of the mean is 0.003
### Statistics:

<table>
<thead>
<tr>
<th></th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>37.570</td>
</tr>
<tr>
<td>Mean</td>
<td>37.574</td>
</tr>
<tr>
<td>Median</td>
<td>37.577</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.175</td>
</tr>
<tr>
<td>Variance</td>
<td>0.031</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.0270</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.59</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0046</td>
</tr>
<tr>
<td>Minimum</td>
<td>37.076</td>
</tr>
<tr>
<td>Maximum</td>
<td>38.113</td>
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<tr>
<td>Range Width</td>
<td>1.037</td>
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<tr>
<td>Mean Std. Error</td>
<td>0.003</td>
</tr>
</tbody>
</table>

### Forecast: Flash MW (cont'd)

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>37.076</td>
</tr>
<tr>
<td>10%</td>
<td>37.343</td>
</tr>
<tr>
<td>20%</td>
<td>37.417</td>
</tr>
<tr>
<td>30%</td>
<td>37.475</td>
</tr>
<tr>
<td>40%</td>
<td>37.531</td>
</tr>
<tr>
<td>50%</td>
<td>37.577</td>
</tr>
<tr>
<td>60%</td>
<td>37.622</td>
</tr>
<tr>
<td>70%</td>
<td>37.673</td>
</tr>
<tr>
<td>80%</td>
<td>37.729</td>
</tr>
<tr>
<td>90%</td>
<td>37.799</td>
</tr>
<tr>
<td>100%</td>
<td>38.113</td>
</tr>
</tbody>
</table>

### Forecast: Sample Bubble Point at Tsep

**Summary:**

- Entire range is from 253.80 to 280.48
- Base case is 267.67
- After 3,000 trials, the std. error of the mean is 0.08
Statistics: | Forecast values
---|---
Trials | 3,000
Base Case | 267.67
Mean | 267.57
Median | 267.48
Mode | ---
Standard Deviation | 4.20
Variance | 17.66
Skewness | 0.0111
Kurtosis | 2.89
Coeff. of Variability | 0.0157
Minimum | 253.80
Maximum | 280.48
Range Width | 26.68
Mean Std. Error | 0.08
Forecast: Sample Bubble Point at Tse p (cont'd)  

Percentiles: Forecast values
0% 253.80
10% 262.24
20% 264.01
30% 265.42
40% 266.46
50% 267.48
60% 268.57
70% 269.80
80% 271.13
90% 273.07
100% 280.48

Forecast: Shrinkage Factor

Summary:
Entire range is from 0.838 to 0.853
Base case is 0.845
After 3,000 trials, the std. error of the mean is 0.000
### Statistics: Forecast values

<table>
<thead>
<tr>
<th>Trial</th>
<th>3,000</th>
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<tbody>
<tr>
<td>Base Case</td>
<td>0.845</td>
</tr>
<tr>
<td>Mean</td>
<td>0.845</td>
</tr>
<tr>
<td>Median</td>
<td>0.846</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.002</td>
</tr>
<tr>
<td>Variance</td>
<td>0.000</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.0718</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.86</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0028</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.838</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.853</td>
</tr>
<tr>
<td>Range Width</td>
<td>0.016</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.000</td>
</tr>
</tbody>
</table>

### Forecast: Shrinkage Factor (cont’d)

**Percentiles:**

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0.838</td>
</tr>
<tr>
<td>10%</td>
<td>0.842</td>
</tr>
<tr>
<td>20%</td>
<td>0.843</td>
</tr>
<tr>
<td>30%</td>
<td>0.844</td>
</tr>
<tr>
<td>40%</td>
<td>0.845</td>
</tr>
<tr>
<td>50%</td>
<td>0.846</td>
</tr>
<tr>
<td>60%</td>
<td>0.846</td>
</tr>
<tr>
<td>70%</td>
<td>0.847</td>
</tr>
<tr>
<td>80%</td>
<td>0.847</td>
</tr>
<tr>
<td>90%</td>
<td>0.848</td>
</tr>
<tr>
<td>100%</td>
<td>0.853</td>
</tr>
</tbody>
</table>

**End of Forecasts**

**Assumptions**

**Worksheet:** [Excel_HYSYS_PHLSA.xlsx]Input & Output
Assumption: 2,2,4-Trimethylpentane

Normal distribution with parameters:
Mean 0.040
Std. Dev. 0.000

Assumption: 2,2-Dimethylbutane

Normal distribution with parameters:
Mean 0.048
Std. Dev. 0.000

Assumption: 2,3-Dimethylbutane

Normal distribution with parameters:
Mean 0.155
Std. Dev. 0.000

Assumption: 2-Methylpentane

Normal distribution with parameters:
Mean 1.089
Std. Dev. 0.002
Assumption: 3-Methylpentane  
Cell: F27

Normal distribution with parameters:
Mean 0.617
Std. Dev. 0.001

Assumption: Benzene  
Cell: F17

Normal distribution with parameters:
Mean 0.251
Std. Dev. 0.005

Assumption: Carbon Dioxide  
Cell: F3

Normal distribution with parameters:
Mean 0.526
Std. Dev. 0.016

Assumption: Cyclopentane  
Cell: F25

Normal distribution with parameters:
Mean 0.190
Std. Dev. 0.000
Assumption: Decanes Plus
Cell: F16

Normal distribution with parameters:
Mean 25.152
Std. Dev. 0.398

Assumption: Discharge Through Siphon Hole (fraction, 0-1)
Cell: S8

Uniform distribution with parameters:
Minimum 0.04
Maximum 0.08

Assumption: Ethane
Cell: F6

Normal distribution with parameters:
Mean 7.593
Std. Dev. 0.054

Assumption: Ethylbenzene
Cell: F19

Normal distribution with parameters:
Mean 0.076
Std. Dev. 0.006
Assumption: Heptanes

Normal distribution with parameters:
Mean 8.967
Std. Dev. 0.051

Assumption: Iso-Butane

Normal distribution with parameters:
Mean 2.887
Std. Dev. 0.015

Assumption: Iso-Pentane

Normal distribution with parameters:
Mean 6.020
Std. Dev. 0.104

Assumption: m,p-Xylene (100% meta)

Normal distribution with parameters:
Mean 0.821
Std. Dev. 0.005
**Assumption: Methane**

Normal distribution with parameters:
- Mean: 7.741
- Std. Dev.: 0.140

**Assumption: n-Butane**

Normal distribution with parameters:
- Mean: 9.197
- Std. Dev.: 0.036

**Assumption: n-Hexane**

Normal distribution with parameters:
- Mean: 1.802
- Std. Dev.: 0.008

**Assumption: Nonanes**

Normal distribution with parameters:
- Mean: 2.167
- Std. Dev.: 0.033
Assumption: n-Pentane

Normal distribution with parameters:
Mean: 8.120
Std. Dev.: 0.030

Assumption: Octanes

Normal distribution with parameters:
Mean: 6.541
Std. Dev.: 0.135

Assumption: o-Xylene

Normal distribution with parameters:
Mean: 0.173
Std. Dev.: 0.001

Assumption: Propane

Normal distribution with parameters:
Mean: 8.830
Std. Dev.: 0.071
Assumption: Separator Pressure

Uniform distribution with parameters:
- Minimum: 270.03
- Maximum: 281.23

Assumption: Separator Temperature

Uniform distribution with parameters:
- Minimum: 56.31
- Maximum: 60.29

Assumption: Tank Bottom Pressure

Normal distribution with parameters:
- Mean: 15.81
- Std. Dev.: 0.07

Assumption: Tank Bottom Temperature

Uniform distribution with parameters:
- Minimum: 43.80
- Maximum: 46.80
Assumption: Tank HS Pressure

Uniform distribution with parameters:
- Minimum: 12.43
- Maximum: 12.67

Assumption: Tank HS Temperature

Uniform distribution with parameters:
- Minimum: 68.18
- Maximum: 72.22

Assumption: Toluene

Normal distribution with parameters:
- Mean: 0.997
- Std. Dev.: 0.006

Assumption: Volume Flow (Std. Bbl)

Normal distribution with parameters:
- Mean: 0.652
- Std. Dev.: 0.002

End of Assumptions
Crystal Ball Report - Full  
Simulation started on 5/4/2017 at 8:06 PM  
Simulation stopped on 5/5/2017 at 3:10 PM

Run preferences:
Number of trials run 3,000  
Monte Carlo  
Random seed  
Precision control on  
Confidence level 95.00%

Run statistics:
Total running time (sec) 68629.66  
Trials/second (average) 0  
Random numbers per sec 1

Crystal Ball data:
Assumptions 32  
Correlations 0  
Correlated groups 0  
Decision variables 0  
Forecasts 4

Forecasts

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl)  
Cell: S34

Summary:
Entire range is from 197.101 to 218.230  
Base case is 207.238  
After 3,000 trials, the std. error of the mean is 0.057
Statistics: Forecast values

<table>
<thead>
<tr>
<th>Trials</th>
<th>3,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>207.238</td>
</tr>
<tr>
<td>Mean</td>
<td>207.220</td>
</tr>
<tr>
<td>Median</td>
<td>207.126</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.123</td>
</tr>
<tr>
<td>Variance</td>
<td>9.752</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0622</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.90</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0151</td>
</tr>
<tr>
<td>Minimum</td>
<td>197.101</td>
</tr>
<tr>
<td>Maximum</td>
<td>218.230</td>
</tr>
<tr>
<td>Range Width</td>
<td>21.129</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.057</td>
</tr>
</tbody>
</table>

Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) (cont’d) Cell: S34

Percentiles: Forecast values

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>197.101</td>
</tr>
<tr>
<td>10%</td>
<td>203.190</td>
</tr>
<tr>
<td>20%</td>
<td>204.579</td>
</tr>
<tr>
<td>30%</td>
<td>205.574</td>
</tr>
<tr>
<td>40%</td>
<td>206.372</td>
</tr>
<tr>
<td>50%</td>
<td>207.126</td>
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<td>209.873</td>
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<tr>
<td>90%</td>
<td>211.255</td>
</tr>
<tr>
<td>100%</td>
<td>218.230</td>
</tr>
</tbody>
</table>

Forecast: Flash MW Cell: S29

Summary:

Entire range is from 36.691 to 37.925
Base case is 37.351
After 3,000 trials, the std. error of the mean is 0.004
Statistics:

Forecast values

<table>
<thead>
<tr>
<th>Trial</th>
<th>3,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>37.351</td>
</tr>
<tr>
<td>Mean</td>
<td>37.351</td>
</tr>
<tr>
<td>Median</td>
<td>37.356</td>
</tr>
<tr>
<td>Mode</td>
<td>37.469</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.202</td>
</tr>
<tr>
<td>Variance</td>
<td>0.041</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.0679</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.63</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0054</td>
</tr>
<tr>
<td>Minimum</td>
<td>36.691</td>
</tr>
<tr>
<td>Maximum</td>
<td>37.925</td>
</tr>
<tr>
<td>Range Width</td>
<td>1.234</td>
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<tr>
<td>Mean Std. Error</td>
<td>0.004</td>
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</table>

Forecast: Flash MW (cont'd)

<table>
<thead>
<tr>
<th>Percentiles</th>
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</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>36.691</td>
</tr>
<tr>
<td>10%</td>
<td>37.084</td>
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<tr>
<td>20%</td>
<td>37.175</td>
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<tr>
<td>30%</td>
<td>37.241</td>
</tr>
<tr>
<td>40%</td>
<td>37.305</td>
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<td>50%</td>
<td>37.356</td>
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<td>37.532</td>
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<tr>
<td>90%</td>
<td>37.612</td>
</tr>
<tr>
<td>100%</td>
<td>37.925</td>
</tr>
</tbody>
</table>
Forecast: Sample Bubble Point at Tsep

Cell: S6

Summary:

Entire range is from 225.20 to 242.75
Base case is 234.11
After 3,000 trials, the std. error of the mean is 0.05

Statistics:

<table>
<thead>
<tr>
<th></th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
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<tr>
<td>Mean</td>
<td>234.18</td>
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<td>Median</td>
<td>234.17</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2.48</td>
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<tr>
<td>Variance</td>
<td>6.13</td>
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<tr>
<td>Skewness</td>
<td>0.0806</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.94</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0106</td>
</tr>
<tr>
<td>Minimum</td>
<td>225.20</td>
</tr>
<tr>
<td>Maximum</td>
<td>242.75</td>
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<tr>
<td>Range Width</td>
<td>17.55</td>
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<td>Mean Std. Error</td>
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</table>
### Forecast: Sample Bubble Point at Tse p (cont'd)

<table>
<thead>
<tr>
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<tbody>
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<td>0%</td>
<td>225.20</td>
</tr>
<tr>
<td>10%</td>
<td>230.96</td>
</tr>
<tr>
<td>20%</td>
<td>232.08</td>
</tr>
<tr>
<td>30%</td>
<td>232.86</td>
</tr>
<tr>
<td>40%</td>
<td>233.56</td>
</tr>
<tr>
<td>50%</td>
<td>234.17</td>
</tr>
<tr>
<td>60%</td>
<td>234.77</td>
</tr>
<tr>
<td>70%</td>
<td>235.41</td>
</tr>
<tr>
<td>80%</td>
<td>236.29</td>
</tr>
<tr>
<td>90%</td>
<td>237.41</td>
</tr>
<tr>
<td>100%</td>
<td>242.75</td>
</tr>
</tbody>
</table>

### Forecast: Shrinkage Factor

**Summary:**

- Entire range is from 0.895 to 0.906
- Base case is 0.900
- After 3,000 trials, the std. error of the mean is 0.000
### Statistics: Forecast values

<table>
<thead>
<tr>
<th>Trials</th>
<th>3,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>0.900</td>
</tr>
<tr>
<td>Mean</td>
<td>0.900</td>
</tr>
<tr>
<td>Median</td>
<td>0.900</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.002</td>
</tr>
<tr>
<td>Variance</td>
<td>0.000</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.0444</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.86</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0018</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.895</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.906</td>
</tr>
<tr>
<td>Range Width</td>
<td>0.011</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.000</td>
</tr>
</tbody>
</table>

#### Forecast: Shrinkage Factor (cont’d) Cell: S37

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0.895</td>
</tr>
<tr>
<td>10%</td>
<td>0.898</td>
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<td>20%</td>
<td>0.899</td>
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<tr>
<td>30%</td>
<td>0.900</td>
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<td>40%</td>
<td>0.900</td>
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<tr>
<td>50%</td>
<td>0.900</td>
</tr>
<tr>
<td>60%</td>
<td>0.901</td>
</tr>
<tr>
<td>70%</td>
<td>0.901</td>
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<tr>
<td>80%</td>
<td>0.902</td>
</tr>
<tr>
<td>90%</td>
<td>0.903</td>
</tr>
<tr>
<td>100%</td>
<td>0.906</td>
</tr>
</tbody>
</table>

End of Forecasts Assumptions

### Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

**Assumption: 2,2,4-Trimethylpentane** Cell: F22

Normal distribution with parameters:

- **Mean**: 0.040
- **Std. Dev.**: 0.000

![Histogram of 2,2,4-Trimethylpentane](image)
Assumption: 2,2-Dimethylbutane

Normal distribution with parameters:
Mean: 0.088
Std. Dev.: 0.000

Assumption: 2,3-Dimethylbutane

Normal distribution with parameters:
Mean: 0.309
Std. Dev.: 0.001

Assumption: 2-Methylpentane

Normal distribution with parameters:
Mean: 2.979
Std. Dev.: 0.007

Assumption: 3-Methylpentane

Normal distribution with parameters:
Mean: 1.881
Std. Dev.: 0.004
Assumption: Benzene

Normal distribution with parameters:
Mean 0.814
Std. Dev. 0.022

Assumption: Carbon Dioxide

Normal distribution with parameters:
Mean 0.368
Std. Dev. 0.003

Assumption: Cyclopentane

Normal distribution with parameters:
Mean 0.381
Std. Dev. 0.001

Assumption: Decanes Plus

Normal distribution with parameters:
Mean 12.427
Std. Dev. 0.160
Assumption: Discharge Through Siphon Hole (fraction, 0-1)  

Cell: S8

Uniform distribution with parameters:
- Minimum: 0.04
- Maximum: 0.08

Assumption: Ethane  

Cell: F6

Normal distribution with parameters:
- Mean: 5.513
- Std. Dev.: 0.043

Assumption: Ethylbenzene  

Cell: F19

Normal distribution with parameters:
- Mean: 0.196
- Std. Dev.: 0.018

Assumption: Heptanes  

Cell: F13

Normal distribution with parameters:
- Mean: 12.142
- Std. Dev.: 0.185
Assumption: Iso-Butane

Normal distribution with parameters:
Mean 2.583
Std. Dev. 0.012

Assumption: Iso-Pentane

Normal distribution with parameters:
Mean 5.667
Std. Dev. 0.067

Assumption: m,p-Xylene (100% meta)

Normal distribution with parameters:
Mean 2.319
Std. Dev. 0.030

Assumption: Methane

Normal distribution with parameters:
Mean 5.541
Std. Dev. 0.060
Assumption: n-Butane

Normal distribution with parameters:
- Mean: 8.174
- Std. Dev.: 0.042

Assumption: n-Hexane

Normal distribution with parameters:
- Mean: 6.090
- Std. Dev.: 0.132

Assumption: Nonanes

Normal distribution with parameters:
- Mean: 4.390
- Std. Dev.: 0.056

Assumption: n-Pentane

Normal distribution with parameters:
- Mean: 7.902
- Std. Dev.: 0.033
Assumption: Octanes

Normal distribution with parameters:
- Mean: 9.578
- Std. Dev.: 0.313

Assumption: o-Xylene

Normal distribution with parameters:
- Mean: 0.520
- Std. Dev.: 0.007

Assumption: Propane

Normal distribution with parameters:
- Mean: 7.282
- Std. Dev.: 0.048

Assumption: Separator Pressure

Uniform distribution with parameters:
- Minimum: 234.64
- Maximum: 244.42
Assumption: Separator Temperature  

Cell: S5

Uniform distribution with parameters:
- Minimum: 90.31
- Maximum: 94.29

Assumption: Tank Bottom Pressure  

Cell: S12

Normal distribution with parameters:
- Mean: 15.85
- Std. Dev.: 0.07

Assumption: Tank Bottom Temperature  

Cell: S11

Uniform distribution with parameters:
- Minimum: 42.49
- Maximum: 45.51

Assumption: Tank HS Pressure  

Cell: S10

Uniform distribution with parameters:
- Minimum: 12.43
- Maximum: 12.67
Assumption: Tank HS Temperature

Uniform distribution with parameters:
- Minimum: 71.68
- Maximum: 75.72

Assumption: Toluene

Normal distribution with parameters:
- Mean: 2.816
- Std. Dev.: 0.031

Assumption: Volume Flow (Std. Bbl)

Normal distribution with parameters:
- Mean: 0.604
- Std. Dev.: 0.002

End of Assumptions
Winter PHLSA Study – MP2 – GPA 2186M

Crystal Ball Report - Full
Simulation started on 5/2/2017 at 8:01 PM
Simulation stopped on 5/3/2017 at 2:19 PM

Run preferences:
- Number of trials run: 3,000
- Monte Carlo
- Random seed
- Precision control on
  - Confidence level: 95.00%

Run statistics:
- Total running time (sec): 65892.80
- Trials/second (average): 0
- Random numbers per sec: 1

Crystal Ball data:
- Assumptions: 32
- Correlations: 0
- Correlated groups: 0
- Decision variables: 0
- Forecasts: 4

Summary:
Entire range is from 193.794 to 218.769
Base case is 206.248
After 3,000 trials, the std. error of the mean is 0.064

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl)  Cell: S34

Summary:
Entire range is from 193.794 to 218.769
Base case is 206.248
After 3,000 trials, the std. error of the mean is 0.064
### Statistics: Forecast values

<table>
<thead>
<tr>
<th>Trials</th>
<th>3,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>206.248</td>
</tr>
<tr>
<td>Mean</td>
<td>205.725</td>
</tr>
<tr>
<td>Median</td>
<td>205.749</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.479</td>
</tr>
<tr>
<td>Variance</td>
<td>12.103</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0216</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.88</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0169</td>
</tr>
<tr>
<td>Minimum</td>
<td>193.794</td>
</tr>
<tr>
<td>Maximum</td>
<td>218.769</td>
</tr>
<tr>
<td>Range Width</td>
<td>24.976</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.064</td>
</tr>
</tbody>
</table>

### Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) (cont'd) Cell: S34

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>193.794</td>
</tr>
<tr>
<td>10%</td>
<td>201.227</td>
</tr>
<tr>
<td>20%</td>
<td>202.727</td>
</tr>
<tr>
<td>30%</td>
<td>203.824</td>
</tr>
<tr>
<td>40%</td>
<td>204.773</td>
</tr>
<tr>
<td>50%</td>
<td>205.744</td>
</tr>
<tr>
<td>60%</td>
<td>206.658</td>
</tr>
<tr>
<td>70%</td>
<td>207.654</td>
</tr>
<tr>
<td>80%</td>
<td>208.695</td>
</tr>
<tr>
<td>90%</td>
<td>210.143</td>
</tr>
<tr>
<td>100%</td>
<td>218.769</td>
</tr>
</tbody>
</table>

### Forecast: Flash MW Cell: S29

Summary:
- Entire range is from 36.147 to 37.344
- Base case is 36.654
- After 3,000 trials, the std. error of the mean is 0.004
Forecast values

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>36.654</td>
</tr>
<tr>
<td>Mean</td>
<td>36.671</td>
</tr>
<tr>
<td>Median</td>
<td>36.673</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.197</td>
</tr>
<tr>
<td>Variance</td>
<td>0.039</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.0089</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.61</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0054</td>
</tr>
<tr>
<td>Minimum</td>
<td>36.147</td>
</tr>
<tr>
<td>Maximum</td>
<td>37.344</td>
</tr>
<tr>
<td>Range Width</td>
<td>1.197</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Forecast: Flash MW (cont'd)

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>36.147</td>
</tr>
<tr>
<td>10%</td>
<td>36.414</td>
</tr>
<tr>
<td>20%</td>
<td>36.499</td>
</tr>
<tr>
<td>30%</td>
<td>36.563</td>
</tr>
<tr>
<td>40%</td>
<td>36.622</td>
</tr>
<tr>
<td>50%</td>
<td>36.673</td>
</tr>
<tr>
<td>60%</td>
<td>36.724</td>
</tr>
<tr>
<td>70%</td>
<td>36.780</td>
</tr>
<tr>
<td>80%</td>
<td>36.847</td>
</tr>
<tr>
<td>90%</td>
<td>36.924</td>
</tr>
<tr>
<td>100%</td>
<td>37.344</td>
</tr>
</tbody>
</table>
Forecast: Sample Bubble Point at Tsep

Cell: S6

Summary:
Entire range is from 224.35 to 247.79
Base case is 236.70
After 3,000 trials, the std. error of the mean is 0.07

Statistics:

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>236.70</td>
</tr>
<tr>
<td>Mean</td>
<td>236.65</td>
</tr>
<tr>
<td>Median</td>
<td>236.64</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.63</td>
</tr>
<tr>
<td>Variance</td>
<td>13.15</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0237</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.79</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0153</td>
</tr>
<tr>
<td>Minimum</td>
<td>224.35</td>
</tr>
<tr>
<td>Maximum</td>
<td>247.79</td>
</tr>
<tr>
<td>Range Width</td>
<td>23.44</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.07</td>
</tr>
</tbody>
</table>
### Forecast: Sample Bubble Point at Tsep (cont'd)

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>224.35</td>
</tr>
<tr>
<td>10%</td>
<td>231.88</td>
</tr>
<tr>
<td>20%</td>
<td>233.46</td>
</tr>
<tr>
<td>30%</td>
<td>234.74</td>
</tr>
<tr>
<td>40%</td>
<td>235.72</td>
</tr>
<tr>
<td>50%</td>
<td>236.64</td>
</tr>
<tr>
<td>60%</td>
<td>237.56</td>
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<td>70%</td>
<td>238.62</td>
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<tr>
<td>80%</td>
<td>239.73</td>
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<tr>
<td>90%</td>
<td>241.46</td>
</tr>
<tr>
<td>100%</td>
<td>247.79</td>
</tr>
</tbody>
</table>

### Forecast: Shrinkage Factor

**Summary:**
- Entire range is from 0.896 to 0.909
- Base case is 0.902
- After 3,000 trials, the std. error of the mean is 0.000
Statistics: Forecast values

Trials: 3,000
Base Case: 0.902
Mean: 0.903
Median: 0.903
Mode: ---
Standard Deviation: 0.002
Variance: 0.000
Skewness: -0.0146
Kurtosis: 2.82
Coeff. of Variability: 0.0019
Minimum: 0.896
Maximum: 0.909
Range Width: 0.012
Mean Std. Error: 0.000

Forecast: Shrinkage Factor (cont’d)

Percentiles: Forecast values
0%: 0.896
10%: 0.900
20%: 0.901
30%: 0.902
40%: 0.902
50%: 0.903
60%: 0.903
70%: 0.904
80%: 0.904
90%: 0.905
100%: 0.909

End of Forecasts

Assumptions

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Assumption: 2,2,4-Trimethylpentane

Normal distribution with parameters:
Mean: 0.046
Std. Dev.: 0.000
Assumption: 2,2-Dimethylbutane

Normal distribution with parameters:
- Mean: 0.048
- Std. Dev.: 0.000

Assumption: 2,3-Dimethylbutane

Normal distribution with parameters:
- Mean: 0.162
- Std. Dev.: 0.000

Assumption: 2-Methylpentane

Normal distribution with parameters:
- Mean: 1.151
- Std. Dev.: 0.002

Assumption: 3-Methylpentane

Normal distribution with parameters:
- Mean: 0.653
- Std. Dev.: 0.001
Assumption: Benzene

Normal distribution with parameters:
Mean 0.274
Std. Dev. 0.005

Assumption: Carbon Dioxide

Normal distribution with parameters:
Mean 0.408
Std. Dev. 0.012

Assumption: Cyclopentane

Normal distribution with parameters:
Mean 0.200
Std. Dev. 0.000

Assumption: Decanes Plus

Normal distribution with parameters:
Mean 28.996
Std. Dev. 0.459
**Assumption: Discharge Through Siphon Hole (fraction, 0-1)**  
**Cell: S8**

Uniform distribution with parameters:
- Minimum: 0.04
- Maximum: 0.08

**Assumption: Ethane**  
**Cell: F6**

Normal distribution with parameters:
- Mean: 5.565
- Std. Dev.: 0.039

**Assumption: Ethylbenzene**  
**Cell: F19**

Normal distribution with parameters:
- Mean: 0.102
- Std. Dev.: 0.008

**Assumption: Heptanes**  
**Cell: F13**

Normal distribution with parameters:
- Mean: 9.875
- Std. Dev.: 0.056
Assumption: Iso-Butane

Normal distribution with parameters:
Mean 2.576
Std. Dev. 0.014

Assumption: Iso-Pentane

Normal distribution with parameters:
Mean 5.606
Std. Dev. 0.096

Assumption: m,p-Xylene (100% meta)

Normal distribution with parameters:
Mean 1.108
Std. Dev. 0.007

Assumption: Methane

Normal distribution with parameters:
Mean 5.725
Std. Dev. 0.103
Assumption: n-Butane  
Cell: F9

Normal distribution with parameters:
Mean  8.326
Std. Dev.  0.033

Assumption: n-Hexane  
Cell: F12

Normal distribution with parameters:
Mean  1.940
Std. Dev.  0.008

Assumption: Nonanes  
Cell: F15

Normal distribution with parameters:
Mean  3.023
Std. Dev.  0.046

Assumption: n-Pentane  
Cell: F11

Normal distribution with parameters:
Mean  7.823
Std. Dev.  0.029
Assumption: Octanes

Normal distribution with parameters:
Mean: 7.763
Std. Dev.: 0.160

Assumption: o-Xylene

Normal distribution with parameters:
Mean: 0.238
Std. Dev.: 0.002

Assumption: Propane

Normal distribution with parameters:
Mean: 7.228
Std. Dev.: 0.058

Assumption: Separator Pressure

Uniform distribution with parameters:
Minimum: 234.64
Maximum: 244.42
Assumption: Separator Temperature

Uniform distribution with parameters:
Minimum 90.31
Maximum 94.29

Assumption: Tank Bottom Pressure

Normal distribution with parameters:
Mean 15.85
Std. Dev. 0.07

Assumption: Tank Bottom Temperature

Uniform distribution with parameters:
Minimum 42.50
Maximum 45.50

Assumption: Tank HS Pressure

Uniform distribution with parameters:
Minimum 12.43
Maximum 12.67
Assumption: Tank HS Temperature  
Cell: S9

Uniform distribution with parameters:
Minimum 71.67
Maximum 75.73

Assumption: Toluene  
Cell: F18

Normal distribution with parameters:
Mean 1.164
Std. Dev. 0.007

Assumption: Volume Flow (Std. Bbl)  
Cell: F40

Normal distribution with parameters:
Mean 0.604
Std. Dev. 0.002

End of Assumptions
Winter PHLSA Study – LP1 – GPA 2103M
Crystal Ball Report - Full
Simulation started on 5/7/2017 at 12:54 PM
Simulation stopped on 5/8/2017 at 8:38 AM

Run preferences:
- Number of trials run: 3,000
- Monte Carlo
- Random seed
- Precision control on
  - Confidence level: 95.00%

Run statistics:
- Total running time (sec): 71062.27
- Trials/second (average): 0
- Random numbers per sec: 1

Crystal Ball data:
- Assumptions: 32
- Correlations: 0
- Correlated groups: 0
- Decision variables: 0
- Forecasts: 4

Forecasts

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl)   Cell: S34

Summary:
- Entire range is from 143.570 to 162.012
- Base case is 152.629
- After 3,000 trials, the std. error of the mean is 0.048
<table>
<thead>
<tr>
<th>Statistics:</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>152.629</td>
</tr>
<tr>
<td>Mean</td>
<td>152.618</td>
</tr>
<tr>
<td>Median</td>
<td>152.620</td>
</tr>
<tr>
<td>Mode</td>
<td>150.102</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2.628</td>
</tr>
<tr>
<td>Variance</td>
<td>6.907</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0208</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.88</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0172</td>
</tr>
<tr>
<td>Minimum</td>
<td>143.570</td>
</tr>
<tr>
<td>Maximum</td>
<td>162.012</td>
</tr>
<tr>
<td>Range Width</td>
<td>18.442</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.048</td>
</tr>
</tbody>
</table>

**Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) (cont'd)**  

<table>
<thead>
<tr>
<th>Percentiles:</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>143.570</td>
</tr>
<tr>
<td>10%</td>
<td>149.215</td>
</tr>
<tr>
<td>20%</td>
<td>150.319</td>
</tr>
<tr>
<td>30%</td>
<td>151.241</td>
</tr>
<tr>
<td>40%</td>
<td>151.929</td>
</tr>
<tr>
<td>50%</td>
<td>152.617</td>
</tr>
<tr>
<td>60%</td>
<td>153.298</td>
</tr>
<tr>
<td>70%</td>
<td>154.024</td>
</tr>
<tr>
<td>80%</td>
<td>154.827</td>
</tr>
<tr>
<td>90%</td>
<td>155.983</td>
</tr>
<tr>
<td>100%</td>
<td>162.012</td>
</tr>
</tbody>
</table>

**Forecast: Flash MW**  

Summary:  
Entire range is from 36.795 to 38.144  
Base case is 37.480  
After 3,000 trials, the std. error of the mean is 0.005
Statistics: Forecast values

Trials 3,000
Base Case 37.480
Mean 37.475
Median 37.477
Mode 37.064
Standard Deviation 0.248
Variance 0.061
Skewness -0.0170
Kurtosis 2.49
Coeff. of Variability 0.0066
Minimum 36.795
Maximum 38.144
Range Width 1.349
Mean Std. Error 0.005

Forecast: Flash MW (cont'd) Cell: S29

Percentiles: Forecast values
0% 36.795
10% 37.140
20% 37.254
30% 37.334
40% 37.410
50% 37.477
60% 37.544
70% 37.615
80% 37.696
90% 37.800
100% 38.144
Forecast: Sample Bubble Point at Tsep  

Cell: S6

Summary:
Entire range is from 174.05 to 187.07
Base case is 180.37
After 3,000 trials, the std. error of the mean is 0.04

Statistics:

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>180.37</td>
</tr>
<tr>
<td>Mean</td>
<td>180.39</td>
</tr>
<tr>
<td>Median</td>
<td>180.35</td>
</tr>
<tr>
<td>Mode</td>
<td>181.59</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.97</td>
</tr>
<tr>
<td>Variance</td>
<td>3.88</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.1081</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.83</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0109</td>
</tr>
<tr>
<td>Minimum</td>
<td>174.05</td>
</tr>
<tr>
<td>Maximum</td>
<td>187.07</td>
</tr>
<tr>
<td>Range Width</td>
<td>13.02</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.04</td>
</tr>
</tbody>
</table>
Forecast: Sample Bubble Point at Tsep (cont'd)  

Percentiles:  
- 0%: 174.05
- 10%: 177.87
- 20%: 178.70
- 30%: 179.30
- 40%: 179.87
- 50%: 180.35
- 60%: 180.85
- 70%: 181.39
- 80%: 182.07
- 90%: 182.95
- 100%: 187.07

Forecast: Shrinkage Factor

Summary:
- Entire range is from 0.920 to 0.930
- Base case is 0.925
- After 3,000 trials, the std. error of the mean is 0.000
Statistics: Forecast values
Trials 3,000
Base Case 0.925
Mean 0.925
Median 0.925
Mode 0.927
Standard Deviation 0.001
Variance 0.000
Skewness -0.0206
Kurtosis 2.83
Coeff. of Variability 0.0016
Minimum 0.920
Maximum 0.930
Range Width 0.010
Mean Std. Error 0.000

Forecast: Shrinkage Factor (cont’d)  
Cell: S37

Percentiles: Forecast values
0% 0.920
10% 0.923
20% 0.924
30% 0.924
40% 0.925
50% 0.925
60% 0.925
70% 0.926
80% 0.926
90% 0.927
100% 0.930

End of Forecasts  
Assumptions

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Assumption: 2,2,4-Trimethylpentane  
Cell: F22

Normal distribution with parameters:
Mean 0.042
Std. Dev. 0.000
Assumption: 2,2-Dimethylbutane

Normal distribution with parameters:
Mean: 0.102
Std. Dev.: 0.000

Assumption: 2,3-Dimethylbutane

Normal distribution with parameters:
Mean: 0.349
Std. Dev.: 0.001

Assumption: 2-Methylpentane

Normal distribution with parameters:
Mean: 3.287
Std. Dev.: 0.008

Assumption: 3-Methylpentane

Normal distribution with parameters:
Mean: 2.049
Std. Dev.: 0.005
Assumption: Benzene

Normal distribution with parameters:
Mean 0.894
Std. Dev. 0.024

Assumption: Carbon Dioxide

Normal distribution with parameters:
Mean 0.290
Std. Dev. 0.002

Assumption: Cyclopentane

Normal distribution with parameters:
Mean 0.429
Std. Dev. 0.001

Assumption: Decanes Plus

Normal distribution with parameters:
Mean 13.699
Std. Dev. 0.176
**Assumption: Discharge Through Siphon Hole (fraction, 0-1)**  
*Cell: S8*

Uniform distribution with parameters:
- Minimum: 0.04
- Maximum: 0.08

**Assumption: Ethane**  
*Cell: F6*

Normal distribution with parameters:
- Mean: 4.620
- Std. Dev.: 0.036

**Assumption: Ethylbenzene**  
*Cell: F19*

Normal distribution with parameters:
- Mean: 0.206
- Std. Dev.: 0.019

**Assumption: Heptanes**  
*Cell: F13*

Normal distribution with parameters:
- Mean: 13.189
- Std. Dev.: 0.201
Assumption: Iso-Butane

Normal distribution with parameters:
Mean 2.382
Std. Dev. 0.011

Assumption: Iso-Pentane

Normal distribution with parameters:
Mean 5.186
Std. Dev. 0.061

Assumption: m,p-Xylene (100% meta)

Normal distribution with parameters:
Mean 2.446
Std. Dev. 0.032

Assumption: Methane

Normal distribution with parameters:
Mean 4.266
Std. Dev. 0.046
**Assumption: n-Butane**  
Cell: F9  
Normal distribution with parameters:  
\[
\begin{align*}
\text{Mean} & : 7.531 \\
\text{Std. Dev.} & : 0.039
\end{align*}
\]

**Assumption: n-Hexane**  
Cell: F12  
Normal distribution with parameters:  
\[
\begin{align*}
\text{Mean} & : 6.587 \\
\text{Std. Dev.} & : 0.143
\end{align*}
\]

**Assumption: Nonanes**  
Cell: F15  
Normal distribution with parameters:  
\[
\begin{align*}
\text{Mean} & : 4.661 \\
\text{Std. Dev.} & : 0.060
\end{align*}
\]

**Assumption: n-Pentane**  
Cell: F11  
Normal distribution with parameters:  
\[
\begin{align*}
\text{Mean} & : 7.331 \\
\text{Std. Dev.} & : 0.030
\end{align*}
\]
Assumption: Octanes

Normal distribution with parameters:
- Mean: 10.222
- Std. Dev.: 0.334

Assumption: o-Xylene

Normal distribution with parameters:
- Mean: 0.548
- Std. Dev.: 0.007

Assumption: Propane

Normal distribution with parameters:
- Mean: 6.614
- Std. Dev.: 0.044

Assumption: Separator Pressure

Uniform distribution with parameters:
- Minimum: 186.69
- Maximum: 194.57
Assumption: Separator Temperature

Uniform distribution with parameters:
- Minimum: 85.41
- Maximum: 89.39

Assumption: Tank Bottom Pressure

Normal distribution with parameters:
- Mean: 15.89
- Std. Dev.: 0.07

Assumption: Tank Bottom Temperature

Uniform distribution with parameters:
- Minimum: 43.49
- Maximum: 46.51

Assumption: Tank HS Pressure

Uniform distribution with parameters:
- Minimum: 12.43
- Maximum: 12.67
Assumption: Tank HS Temperature

Cell: S9

Uniform distribution with parameters:
Minimum 83.48
Maximum 87.52

Assumption: Toluene

Cell: F18

Normal distribution with parameters:
Mean 3.070
Std. Dev. 0.034

Assumption: Volume Flow (Std. Bbl)

Cell: F40

Normal distribution with parameters:
Mean 0.642
Std. Dev. 0.002

End of Assumptions
Winter PHLSA Study – LP1 – GPA 2186M

Crystal Ball Report - Full
Simulation started on 5/6/2017 at 11:34 AM
Simulation stopped on 5/7/2017 at 10:02 AM

Run preferences:
- Number of trials run: 3,000
- Monte Carlo
- Random seed
- Precision control on
  - Confidence level: 95.00%

Run statistics:
- Total running time (sec): 80840.07
- Trials/second (average): 0
- Random numbers per sec: 1

Crystal Ball data:
- Assumptions: 32
- Correlations: 0
- Correlated groups: 0
- Decision variables: 0
- Forecasts: 4

Forecasts

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) Cell: S34

Summary:
- Entire range is from 140.537 to 158.657
- Base case is 149.438
- After 3,000 trials, the std. error of the mean is 0.053
Statistics:  
<table>
<thead>
<tr>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
</tr>
<tr>
<td>Base Case</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>Mode</td>
</tr>
<tr>
<td>Standard Deviation</td>
</tr>
<tr>
<td>Variance</td>
</tr>
<tr>
<td>Skewness</td>
</tr>
<tr>
<td>Kurtosis</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
<tr>
<td>Range Width</td>
</tr>
<tr>
<td>Mean Std. Error</td>
</tr>
</tbody>
</table>

**Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) (cont’d)**  
Cell: S34

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>140.537</td>
</tr>
<tr>
<td>10%</td>
<td>145.665</td>
</tr>
<tr>
<td>20%</td>
<td>146.963</td>
</tr>
<tr>
<td>30%</td>
<td>147.817</td>
</tr>
<tr>
<td>40%</td>
<td>148.579</td>
</tr>
<tr>
<td>50%</td>
<td>149.389</td>
</tr>
<tr>
<td>60%</td>
<td>150.182</td>
</tr>
<tr>
<td>70%</td>
<td>150.974</td>
</tr>
<tr>
<td>80%</td>
<td>151.858</td>
</tr>
<tr>
<td>90%</td>
<td>153.182</td>
</tr>
<tr>
<td>100%</td>
<td>158.657</td>
</tr>
</tbody>
</table>

**Forecast: Flash MW**  
Cell: S29

Summary:
- Entire range is from 36.186 to 37.521
- Base case is 36.843
- After 3,000 trials, the std. error of the mean is 0.004
Statistics:

<table>
<thead>
<tr>
<th>Trials</th>
<th>3,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>36.843</td>
</tr>
<tr>
<td>Mean</td>
<td>36.849</td>
</tr>
<tr>
<td>Median</td>
<td>36.844</td>
</tr>
<tr>
<td>Mode</td>
<td>37.026</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.228</td>
</tr>
<tr>
<td>Variance</td>
<td>0.052</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.0167</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.51</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0062</td>
</tr>
<tr>
<td>Minimum</td>
<td>36.186</td>
</tr>
<tr>
<td>Maximum</td>
<td>37.521</td>
</tr>
<tr>
<td>Range Width</td>
<td>1.336</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Forecast values

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>36.186</td>
</tr>
<tr>
<td>10%</td>
<td>36.548</td>
</tr>
<tr>
<td>20%</td>
<td>36.650</td>
</tr>
<tr>
<td>30%</td>
<td>36.719</td>
</tr>
<tr>
<td>40%</td>
<td>36.782</td>
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<td>50%</td>
<td>36.844</td>
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<td>60%</td>
<td>36.916</td>
</tr>
<tr>
<td>70%</td>
<td>36.985</td>
</tr>
<tr>
<td>80%</td>
<td>37.055</td>
</tr>
<tr>
<td>90%</td>
<td>37.146</td>
</tr>
<tr>
<td>100%</td>
<td>37.521</td>
</tr>
</tbody>
</table>
**Forecast: Sample Bubble Point at Tsep**

**Cell: S6**

**Summary:**
- Entire range is from 169.14 to 187.97
- Base case is 178.43
- After 3,000 trials, the std. error of the mean is 0.05

---

**Statistics:**

<table>
<thead>
<tr>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trials</strong></td>
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<tr>
<td><strong>Base Case</strong></td>
</tr>
<tr>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td><strong>Median</strong></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
</tr>
<tr>
<td><strong>Variance</strong></td>
</tr>
<tr>
<td><strong>Skewness</strong></td>
</tr>
<tr>
<td><strong>Kurtosis</strong></td>
</tr>
<tr>
<td><strong>Coeff. of Variability</strong></td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
</tr>
<tr>
<td><strong>Range Width</strong></td>
</tr>
<tr>
<td><strong>Mean Std. Error</strong></td>
</tr>
</tbody>
</table>
Forecast: Sample Bubble Point at Tsep (cont’d)

Percentiles: Forecast values
0% 169.14
10% 174.82
20% 175.94
30% 176.79
40% 177.60
50% 178.25
60% 179.00
70% 179.78
80% 180.62
90% 181.78
100% 187.97

Forecast: Shrinkage Factor

Summary:
Entire range is from 0.923 to 0.932
Base case is 0.928
After 3,000 trials, the std. error of the mean is 0.000
### Statistics: Forecast values

<table>
<thead>
<tr>
<th>Trials</th>
<th>3,000</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.928</td>
</tr>
<tr>
<td>Mean</td>
<td>0.928</td>
</tr>
<tr>
<td>Median</td>
<td>0.928</td>
</tr>
<tr>
<td>Mode</td>
<td>0.927</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.002</td>
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<tr>
<td>Variance</td>
<td>0.000</td>
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<tr>
<td>Skewness</td>
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<td>Kurtosis</td>
<td>2.79</td>
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<td>Coeff. of Variability</td>
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<tr>
<td>Minimum</td>
<td>0.923</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.932</td>
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<tr>
<td>Range Width</td>
<td>0.009</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.000</td>
</tr>
</tbody>
</table>

### Forecast: Shrinkage Factor (cont'd)

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0.923</td>
</tr>
<tr>
<td>10%</td>
<td>0.926</td>
</tr>
<tr>
<td>20%</td>
<td>0.927</td>
</tr>
<tr>
<td>30%</td>
<td>0.927</td>
</tr>
<tr>
<td>40%</td>
<td>0.927</td>
</tr>
<tr>
<td>50%</td>
<td>0.928</td>
</tr>
<tr>
<td>60%</td>
<td>0.928</td>
</tr>
<tr>
<td>70%</td>
<td>0.929</td>
</tr>
<tr>
<td>80%</td>
<td>0.929</td>
</tr>
<tr>
<td>90%</td>
<td>0.930</td>
</tr>
<tr>
<td>100%</td>
<td>0.932</td>
</tr>
</tbody>
</table>

End of Forecasts

### Assumptions

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

**Assumption: 2,2,4-Trimethylpentane**

Normal distribution with parameters:

- Mean: 0.048
- Std. Dev.: 0.000
Assumption: 2,2-Dimethylbutane

Normal distribution with parameters:
Mean 0.047
Std. Dev. 0.000

Cell: F23

Assumption: 2,3-Dimethylbutane

Normal distribution with parameters:
Mean 0.165
Std. Dev. 0.000

Cell: F24

Assumption: 2-Methylpentane

Normal distribution with parameters:
Mean 1.195
Std. Dev. 0.002

Cell: F26

Assumption: 3-Methylpentane

Normal distribution with parameters:
Mean 0.685
Std. Dev. 0.001

Cell: F27
Assumption: Benzene

Normal distribution with parameters:
Mean 0.297
Std. Dev. 0.005

Assumption: Carbon Dioxide

Normal distribution with parameters:
Mean 0.370
Std. Dev. 0.011

Assumption: Cyclopentane

Normal distribution with parameters:
Mean 0.203
Std. Dev. 0.000

Assumption: Decanes Plus

Normal distribution with parameters:
Mean 32.238
Std. Dev. 0.510
Assumption: Discharge Through Siphon Hole (fraction, 0-1)

Cell: S8

Uniform distribution with parameters:

- Minimum: 0.04
- Maximum: 0.08

Assumption: Ethane

Cell: F6

Normal distribution with parameters:

- Mean: 4.688
- Std. Dev.: 0.033

Assumption: Ethylbenzene

Cell: F19

Normal distribution with parameters:

- Mean: 0.112
- Std. Dev.: 0.008

Assumption: Heptanes

Cell: F13

Normal distribution with parameters:

- Mean: 10.472
- Std. Dev.: 0.059
Assumption: Iso-Butane

Normal distribution with parameters:
Mean 2.397
Std. Dev. 0.013

Assumption: Iso-Pentane

Normal distribution with parameters:
Mean 5.161
Std. Dev. 0.089

Assumption: m,p-Xylene (100% meta)

Normal distribution with parameters:
Mean 1.205
Std. Dev. 0.008

Assumption: Methane

Normal distribution with parameters:
Mean 4.266
Std. Dev. 0.077
Assumption: n-Butane

Normal distribution with parameters:
- Mean: 7.660
- Std. Dev.: 0.030

Assumption: n-Hexane

Normal distribution with parameters:
- Mean: 2.081
- Std. Dev.: 0.009

Assumption: Nonaes

Normal distribution with parameters:
- Mean: 3.092
- Std. Dev.: 0.047

Assumption: n-Pentane

Normal distribution with parameters:
- Mean: 7.270
- Std. Dev.: 0.027
Assumption: Octanes

Normal distribution with parameters:
Mean 8.203
Std. Dev. 0.169

Assumption: o-Xylene

Normal distribution with parameters:
Mean 0.242
Std. Dev. 0.002

Assumption: Propane

Normal distribution with parameters:
Mean 6.586
Std. Dev. 0.053

Assumption: Separator Pressure

Uniform distribution with parameters:
Minimum 186.69
Maximum 194.57
Assumption: Separator Temperature

Cell: S5

Uniform distribution with parameters:
- Minimum 85.41
- Maximum 89.39

Assumption: Tank Bottom Pressure

Cell: S12

Normal distribution with parameters:
- Mean 15.89
- Std. Dev. 0.07

Assumption: Tank Bottom Temperature

Cell: S11

Uniform distribution with parameters:
- Minimum 43.50
- Maximum 46.50

Assumption: Tank HS Pressure

Cell: S10

Uniform distribution with parameters:
- Minimum 12.43
- Maximum 12.67
Assumption: Tank HS Temperature

Cell: S9

Uniform distribution with parameters:
Minimum  83.48
Maximum  87.52

Assumption: Toluene

Cell: F18

Normal distribution with parameters:
Mean  1.317
Std. Dev.  0.008

Assumption: Volume Flow (Std. Bbl)

Cell: F40

Normal distribution with parameters:
Mean  0.642
Std. Dev.  0.002

End of Assumptions
Summer PHLSA Study – HP3 – GPA 2103M

Crystal Ball Report - Full
Simulation started on 5/16/2017 at 8:03 PM
Simulation stopped on 5/17/2017 at 4:57 PM

Run preferences:
- Number of trials run: 3,000
- Monte Carlo
- Random seed
- Precision control on
  - Confidence level: 95.00%

Run statistics:
- Total running time (sec): 75227.02
- Trials/second (average): 0
- Random numbers per sec: 1

Crystal Ball data:
- Assumptions: 32
- Correlations: 0
- Correlated groups: 0
- Decision variables: 0
- Forecasts: 4

Forecasts

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) Cell: S34

Summary:
- Entire range is from 353.763 to 390.451
- Base case is 374.079
- After 3,000 trials, the std. error of the mean is 0.110
## Statistics: Forecast values

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>374.079</td>
</tr>
<tr>
<td>Mean</td>
<td>372.760</td>
</tr>
<tr>
<td>Median</td>
<td>372.607</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>6.046</td>
</tr>
<tr>
<td>Variance</td>
<td>36.550</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0392</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.80</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0162</td>
</tr>
<tr>
<td>Minimum</td>
<td>353.763</td>
</tr>
<tr>
<td>Maximum</td>
<td>390.451</td>
</tr>
<tr>
<td>Range Width</td>
<td>36.688</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.110</td>
</tr>
</tbody>
</table>

### Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) (cont'd)  
**Cell: S34**

<table>
<thead>
<tr>
<th>Percentiles:</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>353.763</td>
</tr>
<tr>
<td>10%</td>
<td>365.027</td>
</tr>
<tr>
<td>20%</td>
<td>367.662</td>
</tr>
<tr>
<td>30%</td>
<td>369.517</td>
</tr>
<tr>
<td>40%</td>
<td>371.098</td>
</tr>
<tr>
<td>50%</td>
<td>372.605</td>
</tr>
<tr>
<td>60%</td>
<td>374.205</td>
</tr>
<tr>
<td>70%</td>
<td>375.985</td>
</tr>
<tr>
<td>80%</td>
<td>378.099</td>
</tr>
<tr>
<td>90%</td>
<td>380.600</td>
</tr>
<tr>
<td>100%</td>
<td>390.451</td>
</tr>
</tbody>
</table>

### Forecast: Flash MW  
**Cell: S29**

**Summary:**
- Entire range is from 42.400 to 43.822
- Base case is 43.028
- After 3,000 trials, the std. error of the mean is 0.004
Statistics: Forecast values

<table>
<thead>
<tr>
<th>Trials</th>
<th>3,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>43.028</td>
</tr>
<tr>
<td>Mean</td>
<td>43.068</td>
</tr>
<tr>
<td>Median</td>
<td>43.069</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.236</td>
</tr>
<tr>
<td>Variance</td>
<td>0.056</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0024</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.50</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0055</td>
</tr>
<tr>
<td>Minimum</td>
<td>42.400</td>
</tr>
<tr>
<td>Maximum</td>
<td>43.822</td>
</tr>
<tr>
<td>Range Width</td>
<td>1.422</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.004</td>
</tr>
</tbody>
</table>

**Forecast: Flash MW (cont'd)**

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>42.400</td>
</tr>
<tr>
<td>10%</td>
<td>42.756</td>
</tr>
<tr>
<td>20%</td>
<td>42.856</td>
</tr>
<tr>
<td>30%</td>
<td>42.929</td>
</tr>
<tr>
<td>40%</td>
<td>43.002</td>
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<tr>
<td>50%</td>
<td>43.068</td>
</tr>
<tr>
<td>60%</td>
<td>43.138</td>
</tr>
<tr>
<td>70%</td>
<td>43.207</td>
</tr>
<tr>
<td>80%</td>
<td>43.279</td>
</tr>
<tr>
<td>90%</td>
<td>43.379</td>
</tr>
<tr>
<td>100%</td>
<td>43.822</td>
</tr>
</tbody>
</table>

Cell: S29
Forecast: Sample Bubble Point at Tsep

Summary:

Entire range is from 263.71 to 289.04
Base case is 277.92
After 3,000 trials, the std. error of the mean is 0.06

Statistics:

<table>
<thead>
<tr>
<th>Forecast values</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>277.92</td>
</tr>
<tr>
<td>Mean</td>
<td>277.96</td>
</tr>
<tr>
<td>Median</td>
<td>277.90</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.31</td>
</tr>
<tr>
<td>Variance</td>
<td>10.94</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0299</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>3.04</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0119</td>
</tr>
<tr>
<td>Minimum</td>
<td>263.71</td>
</tr>
<tr>
<td>Maximum</td>
<td>289.04</td>
</tr>
<tr>
<td>Range Width</td>
<td>25.33</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.06</td>
</tr>
</tbody>
</table>
Forecast: Sample Bubble Point at Tsep (cont'd)  

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>263.71</td>
</tr>
<tr>
<td>10%</td>
<td>273.66</td>
</tr>
<tr>
<td>20%</td>
<td>275.03</td>
</tr>
<tr>
<td>30%</td>
<td>276.25</td>
</tr>
<tr>
<td>40%</td>
<td>277.14</td>
</tr>
<tr>
<td>50%</td>
<td>277.90</td>
</tr>
<tr>
<td>60%</td>
<td>278.81</td>
</tr>
<tr>
<td>70%</td>
<td>279.67</td>
</tr>
<tr>
<td>80%</td>
<td>280.72</td>
</tr>
<tr>
<td>90%</td>
<td>282.21</td>
</tr>
<tr>
<td>100%</td>
<td>289.04</td>
</tr>
</tbody>
</table>

Forecast: Shrinkage Factor  

Summary:

- Entire range is from 0.812 to 0.829
- Base case is 0.820
- After 3,000 trials, the std. error of the mean is 0.000
### Statistics: Forecast values

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
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</tr>
<tr>
<td>Base Case</td>
<td>0.820</td>
</tr>
<tr>
<td>Mean</td>
<td>0.820</td>
</tr>
<tr>
<td>Median</td>
<td>0.820</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.003</td>
</tr>
<tr>
<td>Variance</td>
<td>0.000</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.0373</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.72</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0034</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.812</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.829</td>
</tr>
<tr>
<td>Range Width</td>
<td>0.017</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.000</td>
</tr>
</tbody>
</table>

#### Forecast: Shrinkage Factor (cont'd)

**Cell: S37**

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0.812</td>
</tr>
<tr>
<td>10%</td>
<td>0.817</td>
</tr>
<tr>
<td>20%</td>
<td>0.818</td>
</tr>
<tr>
<td>30%</td>
<td>0.819</td>
</tr>
<tr>
<td>40%</td>
<td>0.820</td>
</tr>
<tr>
<td>50%</td>
<td>0.820</td>
</tr>
<tr>
<td>60%</td>
<td>0.821</td>
</tr>
<tr>
<td>70%</td>
<td>0.822</td>
</tr>
<tr>
<td>80%</td>
<td>0.823</td>
</tr>
<tr>
<td>90%</td>
<td>0.824</td>
</tr>
<tr>
<td>100%</td>
<td>0.829</td>
</tr>
</tbody>
</table>

End of Forecasts

### Assumptions

**Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output**

**Assumption: 2,2,4-Trimethylpentane**

**Cell: F22**

Normal distribution with parameters:

- Mean: 0.043
- Std. Dev.: 0.001
Assumption: 2,2-Dimethylbutane  
Cell: F23

Normal distribution with parameters:
Mean 0.094
Std. Dev. 0.001

Assumption: 2,3-Dimethylbutane  
Cell: F24

Normal distribution with parameters:
Mean 0.311
Std. Dev. 0.004

Assumption: 2-Methylpentane  
Cell: F26

Normal distribution with parameters:
Mean 2.800
Std. Dev. 0.038

Assumption: 3-Methylpentane  
Cell: F27

Normal distribution with parameters:
Mean 1.730
Std. Dev. 0.023
Assumption: Benzene  
Cell: F17

Normal distribution with parameters:
Mean 0.749
Std. Dev. 0.010

Assumption: Carbon Dioxide  
Cell: F3

Normal distribution with parameters:
Mean 0.442
Std. Dev. 0.006

Assumption: Cyclopentane  
Cell: F25

Normal distribution with parameters:
Mean 0.383
Std. Dev. 0.005

Assumption: Decanes Plus  
Cell: F16

Normal distribution with parameters:
Mean 10.981
Std. Dev. 0.148
Assumption: Discharge Through Siphon Hole (fraction, 0-1)  
Cell: S8

Uniform distribution with parameters:
Minimum 0.06  
Maximum 0.06

Assumption: Ethane  
Cell: F6

Normal distribution with parameters:
Mean 6.490  
Std. Dev. 0.088

Assumption: Ethylbenzene  
Cell: F19

Normal distribution with parameters:
Mean 0.188  
Std. Dev. 0.003

Assumption: Heptanes  
Cell: F13

Normal distribution with parameters:
Mean 12.779  
Std. Dev. 0.173
Assumption: Iso-Butane

Normal distribution with parameters:
- Mean: 2.650
- Std. Dev.: 0.036

Assumption: Iso-Pentane

Normal distribution with parameters:
- Mean: 4.990
- Std. Dev.: 0.067

Assumption: m,p-Xylene (100% meta)

Normal distribution with parameters:
- Mean: 2.170
- Std. Dev.: 0.029

Assumption: Methane

Normal distribution with parameters:
- Mean: 6.890
- Std. Dev.: 0.093
Assumption: n-Butane

Normal distribution with parameters:
Mean 7.980
Std. Dev. 0.108

Assumption: n-Hexane

Normal distribution with parameters:
Mean 5.600
Std. Dev. 0.076

Assumption: Nonanes

Normal distribution with parameters:
Mean 4.340
Std. Dev. 0.059

Assumption: n-Pentane

Normal distribution with parameters:
Mean 6.870
Std. Dev. 0.093
Assumption: Octanes

Normal distribution with parameters:
Mean 10.258
Std. Dev. 0.138

Assumption: o-Xylene

Normal distribution with parameters:
Mean 0.492
Std. Dev. 0.007

Assumption: Propane

Normal distribution with parameters:
Mean 7.960
Std. Dev. 0.107

Assumption: Separator Pressure

Uniform distribution with parameters:
Minimum 270.88
Maximum 283.84
**Assumption: Separator Temperature**

Cell: S5

Uniform distribution with parameters:
- Minimum: 83.80
- Maximum: 87.80

**Assumption: Tank Bottom Pressure**

Cell: S12

Normal distribution with parameters:
- Mean: 16.57
- Std. Dev.: 0.22

**Assumption: Tank Bottom Temperature**

Cell: S11

Uniform distribution with parameters:
- Minimum: 80.96
- Maximum: 84.84

**Assumption: Tank HS Pressure**

Cell: S10

Uniform distribution with parameters:
- Minimum: 12.29
- Maximum: 12.87
**Assumption: Tank HS Temperature**  
Cell: S9

Uniform distribution with parameters:
- Minimum: 97.47
- Maximum: 102.13

**Assumption: Toluene**  
Cell: F18

Normal distribution with parameters:
- Mean: 2.810
- Std. Dev.: 0.038

**Assumption: Volume Flow (Std. Bbl)**  
Cell: F40

Normal distribution with parameters:
- Mean: 0.489
- Std. Dev.: 0.007

End of Assumptions
Summer PHLSA Study – HP3 – GPA 2186M

Crystal Ball Report - Full
Simulation started on 4/26/2017 at 10:37 PM
Simulation stopped on 4/27/2017 at 5:50 PM

Run preferences:
Number of trials run 3,000
Monte Carlo
Random seed
Precision control on
Confidence level 95.00%

Run statistics:
Total running time (sec) 69162.20
Trials/second (average) 0
Random numbers per sec 1

Crystal Ball data:
Assumptions 32
Correlations 0
Correlated groups 0
Decision variables 0
Forecasts 4

Forecasts

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) Cell: S34

Summary:
Entire range is from 319.733 to 363.565
Base case is 339.787
After 3,000 trials, the std. error of the mean is 0.092
Statistics: Forecast values

<table>
<thead>
<tr>
<th>Trials</th>
<th>3,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>339.787</td>
</tr>
<tr>
<td>Mean</td>
<td>339.933</td>
</tr>
<tr>
<td>Median</td>
<td>339.918</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>5.056</td>
</tr>
<tr>
<td>Variance</td>
<td>25.563</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.0111</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>3.03</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0149</td>
</tr>
<tr>
<td>Minimum</td>
<td>319.733</td>
</tr>
<tr>
<td>Maximum</td>
<td>363.565</td>
</tr>
<tr>
<td>Range Width</td>
<td>43.832</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.092</td>
</tr>
</tbody>
</table>

Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) (cont’d)  

Percentiles: Forecast values

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Forecast values</th>
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</thead>
<tbody>
<tr>
<td>0%</td>
<td>319.733</td>
</tr>
<tr>
<td>10%</td>
<td>333.442</td>
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<tr>
<td>20%</td>
<td>335.651</td>
</tr>
<tr>
<td>30%</td>
<td>337.181</td>
</tr>
<tr>
<td>40%</td>
<td>338.633</td>
</tr>
<tr>
<td>50%</td>
<td>339.917</td>
</tr>
<tr>
<td>60%</td>
<td>341.327</td>
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<td>342.687</td>
</tr>
<tr>
<td>80%</td>
<td>344.241</td>
</tr>
<tr>
<td>90%</td>
<td>346.384</td>
</tr>
<tr>
<td>100%</td>
<td>363.565</td>
</tr>
</tbody>
</table>
Forecast: Flash MW

Summary:
Entire range is from 41.441 to 42.563
Base case is 42.064
After 3,000 trials, the std. error of the mean is 0.003

Statistics:

<table>
<thead>
<tr>
<th></th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>42.064</td>
</tr>
<tr>
<td>Mean</td>
<td>42.061</td>
</tr>
<tr>
<td>Median</td>
<td>42.063</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.176</td>
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<tr>
<td>Variance</td>
<td>0.031</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.0260</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.57</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
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</tr>
<tr>
<td>Minimum</td>
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</tr>
<tr>
<td>Maximum</td>
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</tr>
<tr>
<td>Range Width</td>
<td>1.122</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.003</td>
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</tbody>
</table>
Forecast: Flash MW (cont'd)  

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Forecast Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>41.441</td>
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<tr>
<td>10%</td>
<td>41.830</td>
</tr>
<tr>
<td>20%</td>
<td>41.904</td>
</tr>
<tr>
<td>30%</td>
<td>41.961</td>
</tr>
<tr>
<td>40%</td>
<td>42.011</td>
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<tr>
<td>50%</td>
<td>42.063</td>
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<td>60%</td>
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<tr>
<td>80%</td>
<td>42.221</td>
</tr>
<tr>
<td>90%</td>
<td>42.288</td>
</tr>
<tr>
<td>100%</td>
<td>42.563</td>
</tr>
</tbody>
</table>

Forecast: Sample Bubble Point at Tsep  

Summary:
- Entire range is from 245.26 to 273.63
- Base case is 258.71
- After 3,000 trials, the std. error of the mean is 0.07
Statistics:  
<table>
<thead>
<tr>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
</tr>
<tr>
<td>Base Case</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>Mode</td>
</tr>
<tr>
<td>Standard Deviation</td>
</tr>
<tr>
<td>Variance</td>
</tr>
<tr>
<td>Skewness</td>
</tr>
<tr>
<td>Kurtosis</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
<tr>
<td>Range Width</td>
</tr>
<tr>
<td>Mean Std. Error</td>
</tr>
</tbody>
</table>

Forecast: Sample Bubble Point at Tsep (cont'd)  

Percentiles:  
<table>
<thead>
<tr>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
</tr>
<tr>
<td>10%</td>
</tr>
<tr>
<td>20%</td>
</tr>
<tr>
<td>30%</td>
</tr>
<tr>
<td>40%</td>
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</tr>
<tr>
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</tr>
<tr>
<td>70%</td>
</tr>
<tr>
<td>80%</td>
</tr>
<tr>
<td>90%</td>
</tr>
<tr>
<td>100%</td>
</tr>
</tbody>
</table>

Forecast: Shrinkage Factor  

Summary:  
- Entire range is from 0.826 to 0.845  
- Base case is 0.836  
- After 3,000 trials, the std. error of the mean is 0.000
Statistics: Forecast values

<table>
<thead>
<tr>
<th>Trials</th>
<th>3,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>0.836</td>
</tr>
<tr>
<td>Mean</td>
<td>0.836</td>
</tr>
<tr>
<td>Median</td>
<td>0.836</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.002</td>
</tr>
<tr>
<td>Variance</td>
<td>0.000</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0249</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.93</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0027</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.826</td>
</tr>
<tr>
<td>Maximum</td>
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<td>Range Width</td>
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<td>Mean Std. Error</td>
<td>0.000</td>
</tr>
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</table>

Forecast: Shrinkage Factor (cont'd)

Percentiles: Forecast values

<table>
<thead>
<tr>
<th>Percentile</th>
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</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
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<tr>
<td>10%</td>
<td>0.833</td>
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<tr>
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</tr>
<tr>
<td>60%</td>
<td>0.837</td>
</tr>
<tr>
<td>70%</td>
<td>0.837</td>
</tr>
<tr>
<td>80%</td>
<td>0.838</td>
</tr>
<tr>
<td>90%</td>
<td>0.839</td>
</tr>
<tr>
<td>100%</td>
<td>0.845</td>
</tr>
</tbody>
</table>

End of Forecasts
Assumptions

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Assumption: 2,2,4-Trimethylpentane

Cell: F22

Normal distribution with parameters:
Mean 0.058
Std. Dev. 0.000

Assumption: 2,2-Dimethylbutane

Cell: F23

Normal distribution with parameters:
Mean 0.050
Std. Dev. 0.000

Assumption: 2,3-Dimethylbutane

Cell: F24

Normal distribution with parameters:
Mean 0.162
Std. Dev. 0.000

Assumption: 2-Methylpentane

Cell: F26

Normal distribution with parameters:
Mean 1.200
Std. Dev. 0.002
**Assumption: 3-Methylpentane**

Cell: F27

Normal distribution with parameters:
- Mean: 0.696
- Std. Dev.: 0.001

**Assumption: Benzene**

Cell: F17

Normal distribution with parameters:
- Mean: 0.304
- Std. Dev.: 0.006

**Assumption: Carbon Dioxide**

Cell: F3

Normal distribution with parameters:
- Mean: 0.423
- Std. Dev.: 0.013

**Assumption: Cyclopentane**

Cell: F25

Normal distribution with parameters:
- Mean: 0.198
- Std. Dev.: 0.000
Assumption: Decanes Plus  

Cell: F16

Normal distribution with parameters:
- Mean: 23.430
- Std. Dev.: 0.371

Assumption: Discharge Through Siphon Hole (fraction, 0-1)  

Cell: S8

Uniform distribution with parameters:
- Minimum: 0.04
- Maximum: 0.08

Assumption: Ethane  

Cell: F6

Normal distribution with parameters:
- Mean: 6.350
- Std. Dev.: 0.045

Assumption: Ethylbenzene  

Cell: F19

Normal distribution with parameters:
- Mean: 0.125
- Std. Dev.: 0.009
**Assumption: Heptanes**  
Cell: F13

Normal distribution with parameters:
- Mean: 11.665
- Std. Dev.: 0.066

**Assumption: Iso-Butane**  
Cell: F8

Normal distribution with parameters:
- Mean: 2.630
- Std. Dev.: 0.014

**Assumption: Iso-Pentane**  
Cell: F10

Normal distribution with parameters:
- Mean: 4.986
- Std. Dev.: 0.086

**Assumption: m,p-Xylene (100% met)***  
Cell: F20

Normal distribution with parameters:
- Mean: 1.370
- Std. Dev.: 0.009
Assumption: Methane  
Cell: F5

Normal distribution with parameters:
- Mean: 6.480
- Std. Dev.: 0.117

Assumption: n-Butane  
Cell: F9

Normal distribution with parameters:
- Mean: 8.190
- Std. Dev.: 0.032

Assumption: n-Hexane  
Cell: F12

Normal distribution with parameters:
- Mean: 2.150
- Std. Dev.: 0.009

Assumption: Nonanes  
Cell: F15

Normal distribution with parameters:
- Mean: 3.520
- Std. Dev.: 0.054
Assumption: n-Pentane

Normal distribution with parameters:
Mean 6.860
Std. Dev. 0.025

Assumption: Octanes

Normal distribution with parameters:
Mean 9.492
Std. Dev. 0.196

Assumption: o-Xylene

Normal distribution with parameters:
Mean 0.291
Std. Dev. 0.002

Assumption: Propane

Normal distribution with parameters:
Mean 7.880
Std. Dev. 0.064
Assumption: Separator Pressure

Cell: S7

Uniform distribution with parameters:
Minimum 271.73
Maximum 282.99

Assumption: Separator Temperature

Cell: S5

Uniform distribution with parameters:
Minimum 83.72
Maximum 87.88

Assumption: Tank Bottom Pressure

Cell: S12

Normal distribution with parameters:
Mean 16.55
Std. Dev. 0.07

Assumption: Tank Bottom Temperature

Cell: S11

Uniform distribution with parameters:
Minimum 81.39
Maximum 84.41
Assumption: Tank HS Pressure

Cell: S10

Uniform distribution with parameters:
Minimum 12.46
Maximum 12.70

Assumption: Tank HS Temperature

Cell: S9

Uniform distribution with parameters:
Minimum 97.78
Maximum 101.82

Assumption: Toluene

Cell: F18

Normal distribution with parameters:
Mean 1.490
Std. Dev. 0.009

Assumption: Volume Flow (Std. Bbl)

Cell: F40

Normal distribution with parameters:
Mean 0.489
Std. Dev. 0.001

End of Assumptions
Crystal Ball Report - Full
Simulation started on 4/27/2017 at 7:39 PM
Simulation stopped on 4/28/2017 at 4:05 PM

Run preferences:
Number of trials run 3,000
Monte Carlo
Random seed
Precision control on
Confidence level 95.00%

Run statistics:
Total running time (sec) 73581.37
Trials/second (average) 0
Random numbers per sec 1

Crystal Ball data:
Assumptions 32
Correlations 0
Correlated groups 0
Decision variables 0
Forecasts 4

Forecasts

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl)  

Cell: S34

Summary:
Entire range is from 294.065 to 324.190
Base case is 310.770
After 3,000 trials, the std. error of the mean is 0.082
Statistics:  

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>310.770</td>
</tr>
<tr>
<td>Mean</td>
<td>311.033</td>
</tr>
<tr>
<td>Median</td>
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<tr>
<td>Mode</td>
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<tr>
<td>Standard Deviation</td>
<td>4.503</td>
</tr>
<tr>
<td>Variance</td>
<td>20.273</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.0245</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.82</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0145</td>
</tr>
<tr>
<td>Minimum</td>
<td>294.065</td>
</tr>
<tr>
<td>Maximum</td>
<td>324.190</td>
</tr>
<tr>
<td>Range Width</td>
<td>30.124</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.082</td>
</tr>
</tbody>
</table>

**Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) (cont'd)**

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>294.065</td>
</tr>
<tr>
<td>10%</td>
<td>305.266</td>
</tr>
<tr>
<td>20%</td>
<td>307.205</td>
</tr>
<tr>
<td>30%</td>
<td>308.591</td>
</tr>
<tr>
<td>40%</td>
<td>309.879</td>
</tr>
<tr>
<td>50%</td>
<td>311.031</td>
</tr>
<tr>
<td>60%</td>
<td>312.195</td>
</tr>
<tr>
<td>70%</td>
<td>313.523</td>
</tr>
<tr>
<td>80%</td>
<td>315.039</td>
</tr>
<tr>
<td>90%</td>
<td>316.821</td>
</tr>
<tr>
<td>100%</td>
<td>324.190</td>
</tr>
</tbody>
</table>
**Forecast: Flash MW**

**Summary:**
- Entire range is from 42.205 to 43.342
- Base case is 42.789
- After 3,000 trials, the std. error of the mean is 0.003

### Statistics:

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
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<tbody>
<tr>
<td>Trials</td>
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<tr>
<td>Base Case</td>
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<tr>
<td>Mean</td>
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<tr>
<td>Median</td>
<td>42.807</td>
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<td>Mode</td>
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<tr>
<td>Standard Deviation</td>
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<td>Variance</td>
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<tr>
<td>Skewness</td>
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</tr>
<tr>
<td>Kurtosis</td>
<td>2.45</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
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<tr>
<td>Minimum</td>
<td>42.205</td>
</tr>
<tr>
<td>Maximum</td>
<td>43.342</td>
</tr>
<tr>
<td>Range Width</td>
<td>1.137</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.003</td>
</tr>
</tbody>
</table>
Forecast: Flash MW (cont'd)  Cell: S29

Percentiles: Forecast values

0% 42.205
10% 42.557
20% 42.635
30% 42.698
40% 42.751
50% 42.807
60% 42.853
70% 42.902
80% 42.956
90% 43.022
100% 43.342

Forecast: Sample Bubble Point at Tsep  Cell: S6

Summary:

Entire range is from 226.59 to 245.79
Base case is 236.56
After 3,000 trials, the std. error of the mean is 0.05
Statistics: Forecast values

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
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<tr>
<td>Base Case</td>
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<tr>
<td>Mean</td>
<td>236.61</td>
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<tr>
<td>Median</td>
<td>236.56</td>
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<td>Mode</td>
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</tr>
<tr>
<td>Standard Deviation</td>
<td>2.62</td>
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<tr>
<td>Variance</td>
<td>6.88</td>
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<tr>
<td>Skewness</td>
<td>-0.0041</td>
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<td>Kurtosis</td>
<td>2.98</td>
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<tr>
<td>Coeff. of Variability</td>
<td>0.0111</td>
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<tr>
<td>Minimum</td>
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</tr>
<tr>
<td>Maximum</td>
<td>245.79</td>
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<td>Range Width</td>
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<tr>
<td>Mean Std. Error</td>
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</table>

Forecast: Sample Bubble Point at Tsep (cont'd)  

Percentiles: Forecast values

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>0%</td>
<td>226.59</td>
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<tr>
<td>10%</td>
<td>233.27</td>
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<td>20%</td>
<td>234.41</td>
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<td>30%</td>
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<td>235.91</td>
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<td>50%</td>
<td>236.56</td>
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<td>60%</td>
<td>237.24</td>
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<tr>
<td>70%</td>
<td>237.99</td>
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<tr>
<td>80%</td>
<td>238.85</td>
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<tr>
<td>90%</td>
<td>239.94</td>
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<tr>
<td>100%</td>
<td>245.79</td>
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</table>

Forecast: Shrinkage Factor  

Summary:

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Entire range is from 0.841 to 0.855</td>
</tr>
<tr>
<td>Base case is 0.847</td>
</tr>
<tr>
<td>After 3,000 trials, the std. error of the mean is 0.000</td>
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</tbody>
</table>
### Statistics:

<table>
<thead>
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<th>Forecast values</th>
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</thead>
<tbody>
<tr>
<td><strong>Trials</strong></td>
<td>3,000</td>
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<tr>
<td><strong>Base Case</strong></td>
<td>0.847</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>0.847</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>0.847</td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td>---</td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td>0.002</td>
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<td><strong>Variance</strong></td>
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<td><strong>Skewness</strong></td>
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<td><strong>Kurtosis</strong></td>
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<td>0.0026</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
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</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>0.855</td>
</tr>
<tr>
<td><strong>Range Width</strong></td>
<td>0.014</td>
</tr>
<tr>
<td><strong>Mean Std. Error</strong></td>
<td>0.000</td>
</tr>
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</table>

### Forecast: Shrinkage Factor (cont’d)

<table>
<thead>
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<th>Percentiles</th>
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<tr>
<td>0%</td>
<td>0.841</td>
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<tr>
<td>10%</td>
<td>0.844</td>
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<tr>
<td>20%</td>
<td>0.845</td>
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<tr>
<td>30%</td>
<td>0.845</td>
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<tr>
<td>40%</td>
<td>0.846</td>
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<tr>
<td>50%</td>
<td>0.847</td>
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<tr>
<td>60%</td>
<td>0.847</td>
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<tr>
<td>70%</td>
<td>0.848</td>
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<tr>
<td>90%</td>
<td>0.849</td>
</tr>
<tr>
<td>100%</td>
<td>0.855</td>
</tr>
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</table>

**Cell: S37**
Assumptions

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Assumption: 2,2,4-Trimethylpentane  
Cell: F22
Normal distribution with parameters:
Mean 0.046  
Std. Dev. 0.000

Assumption: 2,2-Dimethylbutane  
Cell: F23
Normal distribution with parameters:
Mean 0.086  
Std. Dev. 0.000

Assumption: 2,3-Dimethylbutane  
Cell: F24
Normal distribution with parameters:
Mean 0.299  
Std. Dev. 0.001

Assumption: 2-Methylpentane  
Cell: F26
Normal distribution with parameters:
Mean 2.810  
Std. Dev. 0.007
**Assumption: 3-Methylpentane**

Cell: F27

Normal distribution with parameters:
- Mean: 1.760
- Std. Dev.: 0.004

![Graph of 3-Methylpentane](image)

**Assumption: Benzene**

Cell: F17

Normal distribution with parameters:
- Mean: 0.773
- Std. Dev.: 0.021

![Graph of Benzene](image)

**Assumption: Carbon Dioxide**

Cell: F3

Normal distribution with parameters:
- Mean: 0.401
- Std. Dev.: 0.003

![Graph of Carbon Dioxide](image)

**Assumption: Cyclopentane**

Cell: F25

Normal distribution with parameters:
- Mean: 0.366
- Std. Dev.: 0.001

![Graph of Cyclopentane](image)
Assumption: Decanes Plus

Normal distribution with parameters:
Mean 11.490
Std. Dev. 0.148

Assumption: Discharge Through Siphon Hole (fraction, 0-1)

Uniform distribution with parameters:
Minimum 0.04
Maximum 0.08

Assumption: Ethane

Normal distribution with parameters:
Mean 6.130
Std. Dev. 0.048

Assumption: Ethylbenzene

Normal distribution with parameters:
Mean 0.189
Std. Dev. 0.018
Assumption: Heptanes

Normal distribution with parameters:
Mean 13.303
Std. Dev. 0.202

Assumption: Iso-Butane

Normal distribution with parameters:
Mean 2.540
Std. Dev. 0.012

Assumption: Iso-Pentane

Normal distribution with parameters:
Mean 4.990
Std. Dev. 0.059

Assumption: m,p-Xylene (100% meta)

Normal distribution with parameters:
Mean 2.210
Std. Dev. 0.029
Assumption: Methane

Normal distribution with parameters:
Mean 5.770
Std. Dev. 0.063

Assumption: n-Butane

Normal distribution with parameters:
Mean 7.760
Std. Dev. 0.040

Assumption: n-Hexane

Normal distribution with parameters:
Mean 5.770
Std. Dev. 0.125

Assumption: Nonanes

Normal distribution with parameters:
Mean 4.780
Std. Dev. 0.061
Assumption: n-Pentane

Cell: F11

Normal distribution with parameters:
Mean 6.970
Std. Dev. 0.029

Assumption: Octanes

Cell: F14

Normal distribution with parameters:
Mean 10.577
Std. Dev. 0.346

Assumption: o-Xylene

Cell: F21

Normal distribution with parameters:
Mean 0.510
Std. Dev. 0.007

Assumption: Propane

Cell: F7

Normal distribution with parameters:
Mean 7.710
Std. Dev. 0.051
Assumption: Separator Pressure

Cell: S7

Uniform distribution with parameters:
Minimum 241.31
Maximum 251.35

Assumption: Separator Temperature

Cell: S5

Uniform distribution with parameters:
Minimum 82.21
Maximum 86.19

Assumption: Tank Bottom Pressure

Cell: S12

Normal distribution with parameters:
Mean 16.54
Std. Dev. 0.07

Assumption: Tank Bottom Temperature

Cell: S11

Uniform distribution with parameters:
Minimum 78.79
Maximum 81.81
Assumption: Tank HS Pressure

Cell: S10

Uniform distribution with parameters:
Minimum 12.43
Maximum 12.67

Assumption: Tank HS Temperature

Cell: S9

Uniform distribution with parameters:
Minimum 87.58
Maximum 91.62

Assumption: Toluene

Cell: F18

Normal distribution with parameters:
Mean 2.760
Std. Dev. 0.031

Assumption: Volume Flow (Std. Bbl)

Cell: F40

Normal distribution with parameters:
Mean 0.522
Std. Dev. 0.002

End of Assumptions
Crystal Ball Report - Full
Simulation started on 5/9/2017 at 7:00 PM
Simulation stopped on 5/10/2017 at 8:49 PM

Run preferences:
Number of trials run 3,000
Monte Carlo
Random seed
Precision control on
Confidence level 95.00%

Run statistics:
Total running time (sec) 92900.19
Trials/second (average) 0
Random numbers per sec 1

Crystal Ball data:
Assumptions 32
Correlations 0
Correlated groups 0
Decision variables 0
Forecasts 4

Forecasts

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) Cell: S34

Summary:
Entire range is from 286.003 to 315.355
Base case is 300.418
After 3,000 trials, the std. error of the mean is 0.083
Statistics: Forecast values

<table>
<thead>
<tr>
<th>Trials</th>
<th>3,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>300.418</td>
</tr>
<tr>
<td>Mean</td>
<td>300.344</td>
</tr>
<tr>
<td>Median</td>
<td>300.381</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>4.536</td>
</tr>
<tr>
<td>Variance</td>
<td>20.572</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0349</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.93</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0151</td>
</tr>
<tr>
<td>Minimum</td>
<td>286.003</td>
</tr>
<tr>
<td>Maximum</td>
<td>315.355</td>
</tr>
<tr>
<td>Range Width</td>
<td>29.352</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.083</td>
</tr>
</tbody>
</table>

**Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) (cont'd)**

Percentiles: Forecast values

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>286.003</td>
</tr>
<tr>
<td>10%</td>
<td>294.464</td>
</tr>
<tr>
<td>20%</td>
<td>296.532</td>
</tr>
<tr>
<td>30%</td>
<td>297.914</td>
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<tr>
<td>40%</td>
<td>299.125</td>
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<td>301.494</td>
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<tr>
<td>70%</td>
<td>302.659</td>
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<tr>
<td>80%</td>
<td>304.084</td>
</tr>
<tr>
<td>90%</td>
<td>306.244</td>
</tr>
<tr>
<td>100%</td>
<td>315.355</td>
</tr>
</tbody>
</table>
Forecast: Flash MW

Summary:
Entire range is from 40.978 to 42.022
Base case is 41.515
After 3,000 trials, the std. error of the mean is 0.003

Statistics:

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>41.515</td>
</tr>
<tr>
<td>Mean</td>
<td>41.514</td>
</tr>
<tr>
<td>Median</td>
<td>41.508</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.176</td>
</tr>
<tr>
<td>Variance</td>
<td>0.031</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0078</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.55</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0042</td>
</tr>
<tr>
<td>Minimum</td>
<td>40.978</td>
</tr>
<tr>
<td>Maximum</td>
<td>42.022</td>
</tr>
<tr>
<td>Range Width</td>
<td>1.045</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.003</td>
</tr>
</tbody>
</table>
Forecast: Flash MW (cont'd)

Percentiles: Forecast values
0% 40.978
10% 41.288
20% 41.358
30% 41.412
40% 41.462
50% 41.508
60% 41.561
70% 41.613
80% 41.671
90% 41.746
100% 42.022

Forecast: Sample Bubble Point at Tsep

Summary:
Entire range is from 226.73 to 250.68
Base case is 239.57
After 3,000 trials, the std. error of the mean is 0.07
<table>
<thead>
<tr>
<th>Statistics:</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>239.57</td>
</tr>
<tr>
<td>Mean</td>
<td>239.58</td>
</tr>
<tr>
<td>Median</td>
<td>239.55</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.58</td>
</tr>
<tr>
<td>Variance</td>
<td>12.81</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.0251</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.92</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0149</td>
</tr>
<tr>
<td>Minimum</td>
<td>226.73</td>
</tr>
<tr>
<td>Maximum</td>
<td>250.68</td>
</tr>
<tr>
<td>Range Width</td>
<td>23.95</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.07</td>
</tr>
</tbody>
</table>

**Forecast: Sample Bubble Point at Tsep (cont'd)**

**Cell: S6**

<table>
<thead>
<tr>
<th>Percentiles:</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>226.73</td>
</tr>
<tr>
<td>10%</td>
<td>235.07</td>
</tr>
<tr>
<td>20%</td>
<td>236.61</td>
</tr>
<tr>
<td>30%</td>
<td>237.65</td>
</tr>
<tr>
<td>40%</td>
<td>238.59</td>
</tr>
<tr>
<td>50%</td>
<td>239.55</td>
</tr>
<tr>
<td>60%</td>
<td>240.47</td>
</tr>
<tr>
<td>70%</td>
<td>241.42</td>
</tr>
<tr>
<td>80%</td>
<td>242.63</td>
</tr>
<tr>
<td>90%</td>
<td>244.25</td>
</tr>
<tr>
<td>100%</td>
<td>250.68</td>
</tr>
</tbody>
</table>

**Forecast: Shrinkage Factor**

**Cell: S37**

Summary:
- Entire range is from 0.848 to 0.861
- Base case is 0.854
- After 3,000 trials, the std. error of the mean is 0.000
Statistics: Forecast values

Trials: 3,000
Base Case: 0.854
Mean: 0.854
Median: 0.854
Mode: ---
Standard Deviation: 0.002
Variance: 0.000
Skewness: -0.0490
Kurtosis: 2.85
Coeff. of Variability: 0.0025
Minimum: 0.848
Maximum: 0.861
Range Width: 0.013
Mean Std. Error: 0.000

Forecast: Shrinkage Factor (cont'd)  Cell: S37

Percentiles: Forecast values
0%: 0.848
10%: 0.852
20%: 0.853
30%: 0.853
40%: 0.854
50%: 0.854
60%: 0.855
70%: 0.856
80%: 0.856
90%: 0.857
100%: 0.861

End of Forecasts
Assumptions

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Assumption: 2,2,4-Trimethylpentane

Normal distribution with parameters:
Mean: 0.056
Std. Dev.: 0.000

Assumption: 2,2-Dimethylbutane

Normal distribution with parameters:
Mean: 0.048
Std. Dev.: 0.000

Assumption: 2,3-Dimethylbutane

Normal distribution with parameters:
Mean: 0.161
Std. Dev.: 0.000

Assumption: 2-Methylpentane

Normal distribution with parameters:
Mean: 1.203
Std. Dev.: 0.002
**Assumption: 3-Methylpentane**

Cell: F27

Normal distribution with parameters:
- Mean: 0.698
- Std. Dev.: 0.001

**Assumption: Benzene**

Cell: F17

Normal distribution with parameters:
- Mean: 0.305
- Std. Dev.: 0.006

**Assumption: Carbon Dioxide**

Cell: F3

Normal distribution with parameters:
- Mean: 0.626
- Std. Dev.: 0.019

**Assumption: Cyclopentane**

Cell: F25

Normal distribution with parameters:
- Mean: 0.196
- Std. Dev.: 0.000
Assumption: Decanes Plus

Normal distribution with parameters:
Mean: 25.162
Std. Dev.: 0.398

Assumption: Discharge Through Siphon Hole (fraction, 0-1)

Uniform distribution with parameters:
Minimum: 0.04
Maximum: 0.08

Assumption: Ethane

Normal distribution with parameters:
Mean: 6.058
Std. Dev.: 0.043

Assumption: Ethylbenzene

Normal distribution with parameters:
Mean: 0.116
Std. Dev.: 0.009
Assumption: Heptanes

Normal distribution with parameters:
- Mean: 11.908
- Std. Dev.: 0.067

Assumption: Iso-Butane

Normal distribution with parameters:
- Mean: 2.509
- Std. Dev.: 0.013

Assumption: Iso-Pentane

Normal distribution with parameters:
- Mean: 4.910
- Std. Dev.: 0.085

Assumption: m,p-Xylene (100% meta)

Normal distribution with parameters:
- Mean: 1.258
- Std. Dev.: 0.008
**Assumption: Methane**  
Cell: F5

Normal distribution with parameters:
- Mean: 5.919
- Std. Dev.: 0.107

**Assumption: n-Butane**  
Cell: F9

Normal distribution with parameters:
- Mean: 7.802
- Std. Dev.: 0.031

**Assumption: n-Hexane**  
Cell: F12

Normal distribution with parameters:
- Mean: 2.153
- Std. Dev.: 0.009

**Assumption: Nonanes**  
Cell: F15

Normal distribution with parameters:
- Mean: 3.521
- Std. Dev.: 0.054
Assumption: n-Pentane

Normal distribution with parameters:
- Mean: 6.868
- Std. Dev.: 0.025

Assumption: Octanes

Normal distribution with parameters:
- Mean: 9.397
- Std. Dev.: 0.194

Assumption: o-Xylene

Normal distribution with parameters:
- Mean: 0.253
- Std. Dev.: 0.002

Assumption: Propane

Normal distribution with parameters:
- Mean: 7.483
- Std. Dev.: 0.060
Assumption: Separator Pressure

Cell: S7

Uniform distribution with parameters:
Minimum 241.31
Maximum 251.35

Assumption: Separator Temperature

Cell: S5

Uniform distribution with parameters:
Minimum 82.21
Maximum 86.19

Assumption: Tank Bottom Pressure

Cell: S12

Normal distribution with parameters:
Mean 16.54
Std. Dev. 0.07

Assumption: Tank Bottom Temperature

Cell: S11

Uniform distribution with parameters:
Minimum 78.79
Maximum 81.81
Assumption: Tank HS Pressure

Cell: S10

Uniform distribution with parameters:
- Minimum: 12.43
- Maximum: 12.67

Assumption: Tank HS Temperature

Cell: S9

Uniform distribution with parameters:
- Minimum: 87.58
- Maximum: 91.62

Assumption: Toluene

Cell: F18

Normal distribution with parameters:
- Mean: 1.390
- Std. Dev.: 0.008

Assumption: Volume Flow (Std. Bbl)

Cell: F40

Normal distribution with parameters:
- Mean: 0.522
- Std. Dev.: 0.002

End of Assumptions
Crystal Ball Report - Full
Simulation started on 4/28/2017 at 6:25 PM
Simulation stopped on 4/29/2017 at 3:39 PM

Run preferences:
Number of trials run 3,000
Monte Carlo
Random seed
Precision control on
   Confidence level 95.00%

Run statistics:
Total running time (sec) 76401.72
Trials/second (average) 0
Random numbers per sec 1

Crystal Ball data:
Assumptions 32
Correlations 0
Correlated groups 0
Decision variables 0
Forecasts 4

Forecasts

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) Cell: S34

Summary:
 Entire range is from 231.047 to 255.399
 Base case is 244.111
 After 3,000 trials, the std. error of the mean is 0.067
Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) (cont'd)

Percentiles:                  Forecast values
0%       231.047
10%      239.281
20%      240.773
30%      242.040
40%      242.959
50%      243.933
60%      244.948
70%      246.015
80%      247.244
90%      248.886
100%     255.399
Forecast: Flash MW

Summary:
Entire range is from 42.709 to 43.868
Base case is 43.292
After 3,000 trials, the std. error of the mean is 0.004

Statistics:

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Forecast values</th>
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</thead>
<tbody>
<tr>
<td>Trials</td>
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</tr>
<tr>
<td>Base Case</td>
<td>43.292</td>
</tr>
<tr>
<td>Mean</td>
<td>43.300</td>
</tr>
<tr>
<td>Median</td>
<td>43.300</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.198</td>
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<tr>
<td>Variance</td>
<td>0.039</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.0040</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.55</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0046</td>
</tr>
<tr>
<td>Minimum</td>
<td>42.709</td>
</tr>
<tr>
<td>Maximum</td>
<td>43.868</td>
</tr>
<tr>
<td>Range Width</td>
<td>1.159</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.004</td>
</tr>
</tbody>
</table>
Forecast: Flash MW (cont’d)  

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
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<tbody>
<tr>
<td>0%</td>
<td>42.709</td>
</tr>
<tr>
<td>10%</td>
<td>43.044</td>
</tr>
<tr>
<td>20%</td>
<td>43.122</td>
</tr>
<tr>
<td>30%</td>
<td>43.188</td>
</tr>
<tr>
<td>40%</td>
<td>43.249</td>
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<td>50%</td>
<td>43.300</td>
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<tr>
<td>60%</td>
<td>43.352</td>
</tr>
<tr>
<td>70%</td>
<td>43.413</td>
</tr>
<tr>
<td>80%</td>
<td>43.478</td>
</tr>
<tr>
<td>90%</td>
<td>43.562</td>
</tr>
<tr>
<td>100%</td>
<td>43.868</td>
</tr>
</tbody>
</table>

Forecast: Sample Bubble Point at Tsep  

Summary:  
Entire range is from 179.01 to 192.63  
Base case is 186.44  
After 3,000 trials, the std. error of the mean is 0.04
Statistics: Forecast values

Trials 3,000
Base Case 186.44
Mean 186.40
Median 186.44
Mode ---
Standard Deviation 2.06
Variance 4.23
Skewness -0.0348
Kurtosis 2.80
Coeff. of Variability 0.0110
Minimum 179.01
Maximum 192.63
Range Width 13.62
Mean Std. Error 0.04

Forecast: Sample Bubble Point at Tsep (cont'd) Cell: S6

Percentiles: Forecast values
0% 179.01
10% 183.69
20% 184.65
30% 185.29
40% 185.86
50% 186.44
60% 186.93
70% 187.48
80% 188.14
90% 189.05
100% 192.63

Forecast: Shrinkage Factor Cell: S37

Summary:
Entire range is from 0.869 to 0.882
Base case is 0.875
After 3,000 trials, the std. error of the mean is 0.000
Statistics:

<table>
<thead>
<tr>
<th></th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
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</tr>
<tr>
<td>Base Case</td>
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<tr>
<td>Mean</td>
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<tr>
<td>Median</td>
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<tr>
<td>Mode</td>
<td>0.876</td>
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<tr>
<td>Standard Deviation</td>
<td>0.002</td>
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<tr>
<td>Variance</td>
<td>0.000</td>
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<tr>
<td>Skewness</td>
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<tr>
<td>Kurtosis</td>
<td>2.71</td>
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<tr>
<td>Coeff. of Variability</td>
<td>0.0022</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.869</td>
</tr>
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<td>Maximum</td>
<td>0.882</td>
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<tr>
<td>Range Width</td>
<td>0.013</td>
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<tr>
<td>Mean Std. Error</td>
<td>0.000</td>
</tr>
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</table>

Forecast: Shrinkage Factor (cont’d)

Percentiles:

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<tbody>
<tr>
<td>0%</td>
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<tr>
<td>10%</td>
<td>0.872</td>
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<td>0.873</td>
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<td>40%</td>
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<tr>
<td>90%</td>
<td>0.877</td>
</tr>
<tr>
<td>100%</td>
<td>0.882</td>
</tr>
</tbody>
</table>

End of Forecasts
Assumptions

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Assumption: 2,2,4-Trimethylpentane

Cell: F22

Normal distribution with parameters:
Mean 0.045
Std. Dev. 0.000

Assumption: 2,2-Dimethylbutane

Cell: F23

Normal distribution with parameters:
Mean 0.091
Std. Dev. 0.000

Assumption: 2,3-Dimethylbutane

Cell: F24

Normal distribution with parameters:
Mean 0.325
Std. Dev. 0.001

Assumption: 2-Methylpentane

Cell: F26

Normal distribution with parameters:
Mean 3.130
Std. Dev. 0.007
Assumption: 3-Methylpentane  
Cell: F27
Normal distribution with parameters:
Mean 1.960
Std. Dev. 0.005

Assumption: Benzene  
Cell: F17
Normal distribution with parameters:
Mean 0.851
Std. Dev. 0.023

Assumption: Carbon Dioxide  
Cell: F3
Normal distribution with parameters:
Mean 0.321
Std. Dev. 0.002

Assumption: Cyclopentane  
Cell: F25
Normal distribution with parameters:
Mean 0.399
Std. Dev. 0.001
**Assumption: Decanes Plus**

Normal distribution with parameters:
- Mean: 12.362
- Std. Dev.: 0.159

**Cell: F16**

**Assumption: Discharge Through Siphon Hole (fraction, 0-1)**

Uniform distribution with parameters:
- Minimum: 0.04
- Maximum: 0.08

**Cell: S8**

**Assumption: Ethane**

Normal distribution with parameters:
- Mean: 5.070
- Std. Dev.: 0.040

**Cell: F6**

**Assumption: Ethylbenzene**

Normal distribution with parameters:
- Mean: 0.197
- Std. Dev.: 0.018

**Cell: F19**
Assumption: Heptanes

Normal distribution with parameters:
Mean 13.420
Std. Dev. 0.204

Assumption: Iso-Butane

Normal distribution with parameters:
Mean 2.510
Std. Dev. 0.012

Assumption: Iso-Pentane

Normal distribution with parameters:
Mean 5.310
Std. Dev. 0.062

Assumption: m,p-Xylene (100% meta)

Normal distribution with parameters:
Mean 2.310
Std. Dev. 0.030
Assumption: Methane  
Cell: F5

Normal distribution with parameters:
Mean 4.570
Std. Dev. 0.050

Assumption: n-Butane  
Cell: F9

Normal distribution with parameters:
Mean 7.910
Std. Dev. 0.041

Assumption: n-Hexane  
Cell: F12

Normal distribution with parameters:
Mean 6.370
Std. Dev. 0.138

Assumption: Nonanes  
Cell: F15

Normal distribution with parameters:
Mean 4.540
Std. Dev. 0.058
Assumption: n-Pentane

Normal distribution with parameters:
Mean 7.415
Std. Dev. 0.031

Assumption: Octanes

Normal distribution with parameters:
Mean 10.339
Std. Dev. 0.338

Assumption: o-Xylene

Normal distribution with parameters:
Mean 0.525
Std. Dev. 0.007

Assumption: Propane

Normal distribution with parameters:
Mean 7.080
Std. Dev. 0.047
Assumption: Separator Pressure

Cell: S7

Uniform distribution with parameters:
Minimum 186.30
Maximum 194.16

Assumption: Separator Temperature

Cell: S5

Uniform distribution with parameters:
Minimum 78.31
Maximum 82.29

Assumption: Tank Bottom Pressure

Cell: S12

Normal distribution with parameters:
Mean 16.63
Std. Dev. 0.07

Assumption: Tank Bottom Temperature

Cell: S11

Uniform distribution with parameters:
Minimum 76.39
Maximum 79.41
Assumption: Tank HS Pressure

Cell: S10

Uniform distribution with parameters:
Minimum 12.43
Maximum 12.67

Assumption: Tank HS Temperature

Cell: S9

Uniform distribution with parameters:
Minimum 93.78
Maximum 97.82

Assumption: Toluene

Cell: F18

Normal distribution with parameters:
Mean 2.950
Std. Dev. 0.033

Assumption: Volume Flow (Std. Bbl)

Cell: F40

Normal distribution with parameters:
Mean 0.449
Std. Dev. 0.001

End of Assumptions
**Crystal Ball Report - Full**
Simulation started on 5/14/2017 at 7:26 PM
Simulation stopped on 5/15/2017 at 5:35 PM

**Run preferences:**
- Number of trials run: 3,000
- Monte Carlo
- Random seed
- Precision control on
  - Confidence level: 95.00%

**Run statistics:**
- Total running time (sec): 79694.70
- Trials/second (average): 0
- Random numbers per sec: 1

**Crystal Ball data:**
- Assumptions: 32
- Correlations: 0
- Correlated groups: 0
- Decision variables: 0
- Forecasts: 4

**Forecasts**

**Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output**

**Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) Cell: S34**

**Summary:**
- Entire range is from 220.464 to 246.461
- Base case is 233.455
- After 3,000 trials, the std. error of the mean is 0.072

---

236
Statistics:

Forecast values

<table>
<thead>
<tr>
<th>Trials</th>
<th>3,000</th>
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<tbody>
<tr>
<td>Base Case</td>
<td>233.455</td>
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<tr>
<td>Mean</td>
<td>233.564</td>
</tr>
<tr>
<td>Median</td>
<td>233.474</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.924</td>
</tr>
<tr>
<td>Variance</td>
<td>15.396</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0743</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.77</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0168</td>
</tr>
<tr>
<td>Minimum</td>
<td>220.464</td>
</tr>
<tr>
<td>Maximum</td>
<td>246.461</td>
</tr>
<tr>
<td>Range Width</td>
<td>25.997</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.072</td>
</tr>
</tbody>
</table>

Forecast: Flash Gas to Oil Ratio (FGOR) - Standard (scf/bbl) (cont'd)  

Percentiles:

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>220.464</td>
</tr>
<tr>
<td>10%</td>
<td>228.547</td>
</tr>
<tr>
<td>20%</td>
<td>230.319</td>
</tr>
<tr>
<td>30%</td>
<td>231.429</td>
</tr>
<tr>
<td>40%</td>
<td>232.432</td>
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<tr>
<td>50%</td>
<td>233.473</td>
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<td>60%</td>
<td>234.445</td>
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<tr>
<td>70%</td>
<td>235.646</td>
</tr>
<tr>
<td>80%</td>
<td>236.918</td>
</tr>
<tr>
<td>90%</td>
<td>238.843</td>
</tr>
<tr>
<td>100%</td>
<td>246.461</td>
</tr>
</tbody>
</table>
Forecast: Flash MW

Summary:
Entire range is from 41.627 to 42.768
Base case is 42.180
After 3,000 trials, the std. error of the mean is 0.003

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>42.180</td>
</tr>
<tr>
<td>Mean</td>
<td>42.183</td>
</tr>
<tr>
<td>Median</td>
<td>42.185</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.187</td>
</tr>
<tr>
<td>Variance</td>
<td>0.035</td>
</tr>
<tr>
<td>Skewness</td>
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</tr>
<tr>
<td>Kurtosis</td>
<td>2.64</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0044</td>
</tr>
<tr>
<td>Minimum</td>
<td>41.627</td>
</tr>
<tr>
<td>Maximum</td>
<td>42.768</td>
</tr>
<tr>
<td>Range Width</td>
<td>1.141</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.003</td>
</tr>
</tbody>
</table>
Forecast: Flash MW (cont’d)

Percentiles: Forecast values
0% 41.627
10% 41.932
20% 42.018
30% 42.083
40% 42.141
50% 42.184
60% 42.234
70% 42.285
80% 42.349
90% 42.430
100% 42.768

Forecast: Sample Bubble Point at Tsep

Summary:
- Entire range is from 174.48 to 193.63
- Base case is 182.99
- After 3,000 trials, the std. error of the mean is 0.05
Statistics: Forecast values

<table>
<thead>
<tr>
<th>Trials</th>
<th>3,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>182.99</td>
</tr>
<tr>
<td>Mean</td>
<td>183.07</td>
</tr>
<tr>
<td>Median</td>
<td>183.05</td>
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<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2.70</td>
</tr>
<tr>
<td>Variance</td>
<td>7.30</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0785</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.97</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0148</td>
</tr>
<tr>
<td>Minimum</td>
<td>174.48</td>
</tr>
<tr>
<td>Maximum</td>
<td>193.63</td>
</tr>
<tr>
<td>Range Width</td>
<td>19.15</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.05</td>
</tr>
</tbody>
</table>

**Forecast: Sample Bubble Point at Tsep (cont'd)**

Percentiles: Forecast values

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>174.48</td>
</tr>
<tr>
<td>10%</td>
<td>179.57</td>
</tr>
<tr>
<td>20%</td>
<td>180.78</td>
</tr>
<tr>
<td>30%</td>
<td>181.60</td>
</tr>
<tr>
<td>40%</td>
<td>182.38</td>
</tr>
<tr>
<td>50%</td>
<td>183.05</td>
</tr>
<tr>
<td>60%</td>
<td>183.73</td>
</tr>
<tr>
<td>70%</td>
<td>184.48</td>
</tr>
<tr>
<td>80%</td>
<td>185.31</td>
</tr>
<tr>
<td>90%</td>
<td>186.49</td>
</tr>
<tr>
<td>100%</td>
<td>193.63</td>
</tr>
</tbody>
</table>

**Forecast: Shrinkage Factor**

Summary:
- Entire range is from 0.875 to 0.888
- Base case is 0.882
- After 3,000 trials, the std. error of the mean is 0.000
Statistics:

<table>
<thead>
<tr>
<th></th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>3,000</td>
</tr>
<tr>
<td>Base Case</td>
<td>0.882</td>
</tr>
<tr>
<td>Mean</td>
<td>0.882</td>
</tr>
<tr>
<td>Median</td>
<td>0.882</td>
</tr>
<tr>
<td>Mode</td>
<td>---</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.002</td>
</tr>
<tr>
<td>Variance</td>
<td>0.000</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.0567</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.73</td>
</tr>
<tr>
<td>Coeff. of Variability</td>
<td>0.0023</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.875</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.888</td>
</tr>
<tr>
<td>Range Width</td>
<td>0.013</td>
</tr>
<tr>
<td>Mean Std. Error</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Forecast: Shrinkage Factor (cont'd)

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Forecast values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0.875</td>
</tr>
<tr>
<td>10%</td>
<td>0.879</td>
</tr>
<tr>
<td>20%</td>
<td>0.880</td>
</tr>
<tr>
<td>30%</td>
<td>0.881</td>
</tr>
<tr>
<td>40%</td>
<td>0.881</td>
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<tr>
<td>50%</td>
<td>0.882</td>
</tr>
<tr>
<td>60%</td>
<td>0.882</td>
</tr>
<tr>
<td>70%</td>
<td>0.883</td>
</tr>
<tr>
<td>80%</td>
<td>0.883</td>
</tr>
<tr>
<td>90%</td>
<td>0.884</td>
</tr>
<tr>
<td>100%</td>
<td>0.888</td>
</tr>
</tbody>
</table>

End of Forecasts
Assumptions

Worksheet: [Excel_HYSYS_PHLSA.xlsx]Input & Output

Assumption: 2,2,4-Trimethylpentane

Cell: F22

Normal distribution with parameters:
Mean 0.055
Std. Dev. 0.000

Assumption: 2,2-Dimethylbutane

Cell: F23

Normal distribution with parameters:
Mean 0.051
Std. Dev. 0.000

Assumption: 2,3-Dimethylbutane

Cell: F24

Normal distribution with parameters:
Mean 0.180
Std. Dev. 0.000

Assumption: 2-Methylpentane

Cell: F26

Normal distribution with parameters:
Mean 1.330
Std. Dev. 0.002
**Assumption: 3-Methylpentane**

Cell: F27

Normal distribution with parameters:
- Mean: 0.768
- Std. Dev.: 0.001

---

**Assumption: Benzene**

Cell: F17

Normal distribution with parameters:
- Mean: 0.328
- Std. Dev.: 0.006

---

**Assumption: Carbon Dioxide**

Cell: F3

Normal distribution with parameters:
- Mean: 0.337
- Std. Dev.: 0.010

---

**Assumption: Cyclopentane**

Cell: F25

Normal distribution with parameters:
- Mean: 0.218
- Std. Dev.: 0.000
Assumption: Decanes Plus  
Cell: F16

Normal distribution with parameters:
Mean  27.409  
Std. Dev.  0.434

Assumption: Discharge Through Siphon Hole (fraction, 0-1)  
Cell: S8

Uniform distribution with parameters:
Minimum  0.04  
Maximum  0.08

Assumption: Ethane  
Cell: F6

Normal distribution with parameters:
Mean  5.090  
Std. Dev.  0.036

Assumption: Ethylbenzene  
Cell: F19

Normal distribution with parameters:
Mean  0.120  
Std. Dev.  0.009
Assumption: Heptanes

Normal distribution with parameters:
Mean: 11.692
Std. Dev.: 0.066

Assumption: Iso-Butane

Normal distribution with parameters:
Mean: 2.530
Std. Dev.: 0.013

Assumption: Iso-Pentane

Normal distribution with parameters:
Mean: 5.270
Std. Dev.: 0.091

Assumption: m,p-Xylene (100% meta)

Normal distribution with parameters:
Mean: 1.330
Std. Dev.: 0.009
**Assumption: Methane**

Normal distribution with parameters:
- Mean: 4.550
- Std. Dev.: 0.082

**Cell: F5**

![Methane Distribution](image1)

**Assumption: n-Butane**

Normal distribution with parameters:
- Mean: 8.110
- Std. Dev.: 0.032

**Cell: F9**

![n-Butane Distribution](image2)

**Assumption: n-Hexane**

Normal distribution with parameters:
- Mean: 2.350
- Std. Dev.: 0.010

**Cell: F12**

![n-Hexane Distribution](image3)

**Assumption: Nonanes**

Normal distribution with parameters:
- Mean: 3.220
- Std. Dev.: 0.049

**Cell: F15**

![Nonanes Distribution](image4)
Assumption: n-Pentane

Normal distribution with parameters:
Mean 7.340
Std. Dev. 0.027

Assumption: Octanes

Normal distribution with parameters:
Mean 8.960
Std. Dev. 0.185

Assumption: o-Xylene

Normal distribution with parameters:
Mean 0.257
Std. Dev. 0.002

Assumption: Propane

Normal distribution with parameters:
Mean 7.055
Std. Dev. 0.057
**Assumption: Separator Pressure**

Cell: S7

Uniform distribution with parameters:
- Minimum: 186.30
- Maximum: 194.16

**Assumption: Separator Temperature**

Cell: S5

Uniform distribution with parameters:
- Minimum: 78.31
- Maximum: 82.29

**Assumption: Tank Bottom Pressure**

Cell: S12

Normal distribution with parameters:
- Mean: 16.63
- Std. Dev.: 0.07

**Assumption: Tank Bottom Temperature**

Cell: S11

Uniform distribution with parameters:
- Minimum: 76.39
- Maximum: 79.41
Assumption: Tank HS Pressure

Cell: S10

Uniform distribution with parameters:
- Minimum: 12.43
- Maximum: 12.67

Assumption: Tank HS Temperature

Cell: S9

Uniform distribution with parameters:
- Minimum: 93.78
- Maximum: 97.82

Assumption: Toluene

Cell: F18

Normal distribution with parameters:
- Mean: 1.450
- Std. Dev.: 0.009

Assumption: Volume Flow (Std. Bbl)

Cell: F40

Normal distribution with parameters:
- Mean: 0.449
- Std. Dev.: 0.001

End of Assumptions