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# APPENDICES

# APPENDIX A

## A-1) Reservoir model

The reservoir model is generated by input the required data in Eclipse simulator. The geological model composes of number of cells or blocks in X, Y and Z directions and in this study, the number of block is 35 x 35 x 8.

Reservoir

- Grid option
  - Grid type: Cartesian
- Geometry option
  - Geometry type: Block Centred

PVT

- Oil-Gas-Water Options: Water, Gas Condensate (ISGAS)
- Simulation Types: Number of Components 10

Misc/Sched

Pressure Saturation Options

- Solution Type: AIM

General Option

- Max rate of Pc change: 0.01
- Number of cells in domain: 500
- Size of vector property table: 1000
- Number of Iterations to Update
  - Well Flow Targets: 3

Parallel Option

- Type of run: Distributed

## A-2) Reservoir properties

Grid

| | | | | | |
|---|---|---|---|---|---|
| Properties: | Active grid blocks | X (35) | = | 1 | |
| | | Y (35) | = | 1 | |
| | | Z (8) | = | 1 | |
| | Porosity | | = | 0.165 | |
| | Permeability | k-x | = | 10.85 | mD |
| | | k-y | = | 10.85 | mD |
| | | k-z | = | 1.27 | mD |
| | Net thickness | 100 | feet ( 12.5 x 8 ) | | |

PVT [Gas Condensate]: PVT Table

| | | | |
|---|---|---|---|
| Water PVT Properties | Reference pressure(Pref) | 3000 | Psia |
| | Water FVF at Pref | 1.060897 | Rb/stb |
| | Water viscosity at Pref | 0.1892652 | cp |
| | Water viscosibility | 5.376165E-6 | /psi |
| Fluid Densities at Surface Conditions | Oil density | 49.99914 | $Lb/ft^3$ |
| | Water density | 62.42797 | $Lb/ft^3$ |
| | Gas density | 0.04947417 | $Lb/ft^3$ |
| Rock Properties | Reference Pressure | 3000 | Psia |
| | Rock Compressibility | 2.403571E-6 | /psi |

**A-3) Miscellaneous**

| | | | |
|---|---|---|---|
| Number of Component | Number of Component | 10 | |
| Standard Condition | Standard Temperature | 60 | F |
| | Standard Pressure | 14.7 | Psia |
| Component Names Case: 1 | Component 1 | $C_1$ | |
| | Component 2 | $C_2$ | |
| | Component 3 | $C_3$ | |
| | Component 4 | i-$C_4$ | |
| | Component 5 | n-$C_4$ | |
| | Component 6 | i-$C_5$ | |
| | Component 7 | n-$C_5$ | |
| | Component 8 | $C_6$ | |
| | Component 9 | $C_{7+}$ | |
| | Component 10 | $CO_2$ | |
| Component Names Case: 2 | Component 1 | $C_1$ | |
| | Component 2 | $C_2$ | |
| | Component 3 | $C_3$ | |
| | Component 4 | i-$C_4$ | |
| | Component 5 | n-$C_4$ | |
| | Component 6 | i-$C_5$ | |
| | Component 7 | n-$C_5$ | |
| | Component 8 | $C_6$ | |
| | Component 9 | $C_{7+}$ | |
| | Component 10 | $CO_2$ | |
| | Component 11 | $N_2$ | |
| Component Names Case: 3 | Component 1 | $C_1$ | |
| | Component 2 | $C_2$ | |
| | Component 3 | $C_3$ | |
| | Component 4 | i-$C_4$ | |
| | Component 5 | n-$C_4$ | |
| | Component 6 | i-$C_5$ | |
| | Component 7 | n-$C_5$ | |
| | Component 8 | $C_6$ | |
| | Component 9 | $C_{7+}$ | |
| | Component 10 | $CO_2$ | |
| | Component 11 | $N_2$ | |
| Component Names Case: 4 | Component 1 | $C_1$ | |
| | Component 2 | $C_2$ | |
| | Component 3 | $C_3$ | |
| | Component 4 | i-$C_4$ | |
| | Component 5 | n-$C_4$ | |
| | Component 6 | i-$C_5$ | |
| | Component 7 | n-$C_5$ | |
| | Component 8 | $C_6$ | |
| | Component 9 | $C_7$ | |
| | Component 10 | $C_8$ | |
| | Component 11 | $C_9$ | |
| | Component 12 | $C_{10+}$ | |
| | Component 13 | $CO_2$ | |
| | Component 14 | $N_2$ | |

| | | | |
|---|---|---|---|
| Component Names Case: 5 | Component 1 | $C_1$ | |
| | Component 2 | $C_2$ | |
| | Component 3 | $C_3$ | |
| | Component 4 | i-$C_4$ | |
| | Component 5 | n-$C_4$ | |
| | Component 6 | i-$C_5$ | |
| | Component 7 | n-$C_5$ | |
| | Component 8 | $C_6$ | |
| | Component 9 | $C_7$ | |
| | Component 10 | $C_8$ | |
| | Component 11 | $C_9$ | |
| | Component 12 | $C_{10}$ | |
| | Component 13 | $C_{11+}$ | |
| | Component 14 | $CO_2$ | |
| | Component 15 | $N_2$ | |
| Component Names Case: 6 | Component 1 | $C_1$ | |
| | Component 2 | $C_2$ | |
| | Component 3 | $C_3$ | |
| | Component 4 | i-$C_4$ | |
| | Component 5 | n-$C_4$ | |
| | Component 6 | i-$C_5$ | |
| | Component 7 | n-$C_5$ | |
| | Component 8 | $C_6$ | |
| | Component 9 | $C_7$ | |
| | Component 10 | $C_8$ | |
| | Component 11 | $C_9$ | |
| | Component 12 | $C_{10}$ | |
| | Component 13 | $C_{11+}$ | |
| | Component 14 | $CO_2$ | |
| | Component 15 | $N_2$ | |
| Component Names Case: 7 | Component 1 | $C_1$ | |
| | Component 2 | $C_2$ | |
| | Component 3 | $C_3$ | |
| | Component 4 | i-$C_4$ | |
| | Component 5 | n-$C_4$ | |
| | Component 6 | i-$C_5$ | |
| | Component 7 | n-$C_5$ | |
| | Component 8 | $C_6$ | |
| | Component 9 | $C_7$ | |
| | Component 10 | $C_8$ | |
| | Component 11 | $C_9$ | |
| | Component 12 | $C_{10}$ | |
| | Component 13 | $C_{11+}$ | |
| | Component 14 | $CO_2$ | |
| | Component 15 | $N_2$ | |

| | | | |
|---|---|---|---|
| Component Names Case: 8 | Component 1 | $C_1$ | |
| | Component 2 | $C_2$ | |
| | Component 3 | $C_3$ | |
| | Component 4 | i-$C_4$ | |
| | Component 5 | n-$C_4$ | |
| | Component 6 | i-$C_5$ | |
| | Component 7 | n-$C_5$ | |
| | Component 8 | $C_6$ | |
| | Component 9 | $C_7$ | |
| | Component 10 | $C_8$ | |
| | Component 11 | $C_9$ | |
| | Component 12 | $C_{10}$ | |
| | Component 13 | $C_{11}$ | |
| | Component 14 | $C_{12+}$ | |
| | Component 15 | $CO_2$ | |
| | Component 16 | $N_2$ | |
| Component Names Case: 9 | Component 1 | $C_1$ | |
| | Component 2 | $C_2$ | |
| | Component 3 | $C_3$ | |
| | Component 4 | i-$C_4$ | |
| | Component 5 | n-$C_4$ | |
| | Component 6 | i-$C_5$ | |
| | Component 7 | n-$C_5$ | |
| | Component 8 | $C_6$ | |
| | Component 9 | $C_{7+}$ | |
| | Component 10 | $CO_2$ | |
| | Component 11 | $N_2$ | |
| Component Names Case: 10 | Component 1 | $C_1$ | |
| | Component 2 | $C_2$ | |
| | Component 3 | $C_3$ | |
| | Component 4 | i-$C_4$ | |
| | Component 5 | n-$C_4$ | |
| | Component 6 | i-$C_5$ | |
| | Component 7 | n-$C_5$ | |
| | Component 8 | $C_6$ | |
| | Component 9 | $C_{7+}$ | |
| | Component 10 | $CO_2$ | |
| | Component 11 | $N_2$ | |
| PROPS Reporting Options | Oil PVT Tables | No output | |
| | Gas PVT Tables | No output | |
| | Water PVT Tables | No output | |

EoS Res Tables

| | | | |
|---|---|---|---|
| Pure Component Boiling Points (Reservoir EoS) | Component $C_1$ | 200.94 | R |
| | Component $C_2$ | 332.18 | R |
| | Component $C_3$ | 415.92 | R |
| | Component $IC_4$ | 470.45 | R |
| | Component $NC_4$ | 490.75 | R |
| | Component $IC_5$ | 521.79 | R |
| | Component $NC_5$ | 556.59 | R |
| | Component $C_6$ | 615.39 | R |
| | Component $C_7$ | 734.08 | R |
| | Component $C_8$ | 669.16 | R |
| | Component $C_9$ | 718.21 | R |
| | Component $C_{10}$ | 763.47 | R |
| | Component $C_{11}$ | 805.48 | R |
| | Component $C_{12+}$ | 844.36 | R |
| | Component $CO_2$ | 350.413 | R |
| | Component $N_2$ | 139.22 | R |
| Critical Temperature (Reservoir EoS) | Component $C_1$ | 343 | R |
| | Component $C_2$ | 549.59 | R |
| | Component $C_3$ | 665.73 | R |
| | Component $IC_4$ | 734.13 | R |
| | Component $NC_4$ | 765.29 | R |
| | Component $IC_5$ | 828.77 | R |
| | Component $NC_5$ | 845.47 | R |
| | Component $C_6$ | 913.27 | R |
| | Component $C_7$ | 972.70 | R |
| | Component $C_8$ | 1024.22 | R |
| | Component $C_9$ | 1070.68 | R |
| | Component $C_{10}$ | 1112.00 | R |
| | Component $C_{11}$ | 1154.00 | R |
| | Component $C_{12+}$ | 1182.60 | R |
| | Component $CO_2$ | 547.58 | R |
| | Component $N_2$ | 227.16 | R |
| Constant Reservoir Temperature | Initial Reservoir Temperature | 293 | F |
| Critical Volume (Reservoir EoS) | Component $C_1$ | 0.0988 | $ft^3$/lb-mole |
| | Component $C_2$ | 0.0783 | $ft^3$/lb-mole |
| | Component $C_3$ | 0.0727 | $ft^3$/lb-mole |
| | Component $IC_4$ | 0.0714 | $ft^3$/lb-mole |
| | Component $NC_4$ | 0.0703 | $ft^3$/lb-mole |
| | Component $IC_5$ | 0.0679 | $ft^3$/lb-mole |
| | Component $NC_5$ | 0.0675 | $ft^3$/lb-mole |
| | Component $C_6$ | 0.0688 | $ft^3$/lb-mole |
| | Component $C_7$ | 7.509 | $ft^3$/lb-mole |
| | Component $C_8$ | 0.0691 | $ft^3$/lb-mole |
| | Component $C_9$ | 0.069 | $ft^3$/lb-mole |
| | Component $C_{10}$ | 0.0684 | $ft^3$/lb-mole |
| | Component $C_{11}$ | 0.0679 | $ft^3$/lb-mole |
| | Component $C_{12+}$ | 0.0703 | $ft^3$/lb-mole |
| | Component $CO_2$ | 0.0344 | $ft^3$/lb-mole |
| | Component $N_2$ | 0.0510 | $ft^3$/lb-mole |

| | | | |
|---|---|---|---|
| Overall Composition Case: 1 | Component $C_1$ | 59.991 | % |
| | Component $C_2$ | 8.4326 | % |
| | Component $C_3$ | 6.3988 | % |
| | Component $IC_4$ | 3.4127 | % |
| | Component $NC_4$ | 3.8989 | % |
| | Component $IC_5$ | 1.4286 | % |
| | Component $NC_5$ | 1.3988 | % |
| | Component $C_6$ | 7.2718 | % |
| | Component $C_{7+}$ | 6.54 | % |
| | Component $CO_2$ | 1.23 | % |
| Overall Composition Case: 2 | Component $C_1$ | 64.81 | % |
| | Component $C_2$ | 5.27 | % |
| | Component $C_3$ | 6.23 | % |
| | Component $IC_4$ | 1.67 | % |
| | Component $NC_4$ | 3.09 | % |
| | Component $IC_5$ | 1.37 | % |
| | Component $NC_5$ | 1.31 | % |
| | Component $C_6$ | 1.59 | % |
| | Component $C_{7+}$ | 13.39 | % |
| | Component $CO_2$ | 1.06 | % |
| | Component $N_2$ | 0.21 | % |
| Overall Composition Case: 3 | Component $C_1$ | 74.26 | % |
| | Component $C_2$ | 8.18 | % |
| | Component $C_3$ | 3.95 | % |
| | Component $IC_4$ | 1.04 | % |
| | Component $NC_4$ | 1.58 | % |
| | Component $IC_5$ | 0.74 | % |
| | Component $NC_5$ | 0.87 | % |
| | Component $C_6$ | 0.98 | % |
| | Component $C_{7+}$ | 6.56 | % |
| | Component $CO_2$ | 0.4 | % |
| | Component $N_2$ | 1.44 | % |
| Overall Composition Case: 4 | Component $C_1$ | 83.58 | % |
| | Component $C_2$ | 5.95 | % |
| | Component $C_3$ | 2.91 | % |
| | Component $IC_4$ | 0.45 | % |
| | Component $NC_4$ | 1.11 | % |
| | Component $IC_5$ | 0.36 | % |
| | Component $NC_5$ | 0.48 | % |
| | Component $C_6$ | 0.6 | % |
| | Component $C_7$ | 0.8 | % |
| | Component $C_8$ | 0.76 | % |
| | Component $C_9$ | 0.47 | % |
| | Component $C_{10+}$ | 1.03 | % |
| | Component $CO_2$ | 0.65 | % |
| | Component $N_2$ | 0.85 | % |

| | | | |
|---|---|---|---|
| Overall Composition Case: 5 | Component $C_1$ | 83.2 | % |
| | Component $C_2$ | 7.4 | % |
| | Component $C_3$ | 2.8 | % |
| | Component $IC_4$ | 0.63 | % |
| | Component $NC_4$ | 0.94 | % |
| | Component $IC_5$ | 0.48 | % |
| | Component $NC_5$ | 0.4 | % |
| | Component $C_6$ | 0.64 | % |
| | Component $C_7$ | 0.74 | % |
| | Component $C_8$ | 0.48 | % |
| | Component $C_9$ | 0.36 | % |
| | Component $C_{10}$ | 0.26 | % |
| | Component $C_{11+}$ | 0.99 | % |
| | Component $CO_2$ | 0.2 | % |
| | Component $N_2$ | 0.48 | % |
| Overall Composition Case: 6 | Component $C_1$ | 83.4 | % |
| | Component $C_2$ | 7.2 | % |
| | Component $C_3$ | 2.74 | % |
| | Component $IC_4$ | 0.54 | % |
| | Component $NC_4$ | 0.9 | % |
| | Component $IC_5$ | 0.42 | % |
| | Component $NC_5$ | 0.3 | % |
| | Component $C_6$ | 0.58 | % |
| | Component $C_7$ | 0.49 | % |
| | Component $C_8$ | 0.54 | % |
| | Component $C_9$ | 0.43 | % |
| | Component $C_{10}$ | 0.33 | % |
| | Component $C_{11+}$ | 1.47 | % |
| | Component $CO_2$ | 0.19 | % |
| | Component $N_2$ | 0.47 | % |
| Overall Composition Case: 7 | Component $C_1$ | 73.51 | % |
| | Component $C_2$ | 6.23 | % |
| | Component $C_3$ | 3.01 | % |
| | Component $IC_4$ | 2.89 | % |
| | Component $NC_4$ | 3.65 | % |
| | Component $IC_5$ | 2.4 | % |
| | Component $NC_5$ | 1.11 | % |
| | Component $C_6$ | 1.74 | % |
| | Component $C_7$ | 1.38 | % |
| | Component $C_8$ | 0.97 | % |
| | Component $C_9$ | 0.77 | % |
| | Component $C_{10}$ | 0.48 | % |
| | Component $C_{11+}$ | 1.43 | % |
| | Component $CO_2$ | 0.21 | % |
| | Component $N_2$ | 0.22 | % |

| | | | |
|---|---|---|---|
| Component Names Case: 8 | Component $C_1$ | 71.04 | % |
| | Component $C_2$ | 7.57 | % |
| | Component $C_3$ | 3.48 | % |
| | Component $IC_4$ | 0.64 | % |
| | Component $NC_4$ | 1.43 | % |
| | Component $IC_5$ | 0.5 | % |
| | Component $NC_5$ | 0.56 | % |
| | Component $C_6$ | 0.75 | % |
| | Component $C_7$ | 1.07 | % |
| | Component $C_8$ | 1.36 | % |
| | Component $C_9$ | 0.86 | % |
| | Component $C_{10}$ | 0.61 | % |
| | Component $C_{11}$ | 0.41 | % |
| | Component $C_{12+}$ | 2.02 | % |
| | Component $CO_2$ | 7.08 | % |
| | Component $N_2$ | 0.62 | % |
| Component Names Case: 9 | Component $C_1$ | 60.72 | % |
| | Component $C_2$ | 8.1 | % |
| | Component $C_3$ | 6.37 | % |
| | Component $IC_4$ | 3.98 | % |
| | Component $NC_4$ | 4.45 | % |
| | Component $IC_5$ | 2.91 | % |
| | Component $NC_5$ | 2.52 | % |
| | Component $C_6$ | 1.79 | % |
| | Component $C_7$+ | 8.85 | % |
| | Component $CO_2$ | 0.18 | % |
| | Component $N_2$ | 0.13 | % |
| Component Names Case: 10 | Component $C_1$ | 63.72 | % |
| | Component $C_2$ | 5.75 | % |
| | Component $C_3$ | 4.37 | % |
| | Component $IC_4$ | 4.98 | % |
| | Component $NC_4$ | 3.15 | % |
| | Component $IC_5$ | 3.41 | % |
| | Component $NC_5$ | 3.02 | % |
| | Component $C_6$ | 1.09 | % |
| | Component $C_7$+ | 10.4 | % |
| | Component $CO_2$ | 0.08 | % |
| | Component $N_2$ | 0.03 | % |

| | | | |
|---|---|---|---|
| Critical Pressure (Reservoir EoS) | Component $C_1$ | 666.4 | Psia |
| | Component $C_2$ | 706.5 | Psia |
| | Component $C_3$ | 616 | Psia |
| | Component $IC_4$ | 527.9 | Psia |
| | Component $NC_4$ | 550.6 | Psia |
| | Component $IC_5$ | 490.4 | Psia |
| | Component $NC_5$ | 488.6 | Psia |
| | Component $C_6$ | 436.9 | Psia |
| | Component $C_7$ | 403.29 | Psia |
| | Component $C_8$ | 396.8 | Psia |
| | Component $C_9$ | 360.7 | Psia |
| | Component $C_{10}$ | 331.8 | Psia |
| | Component $C_{11}$ | 305.2 | Psia |
| | Component $C_{12+}$ | 282.0 | Psia |
| | Component $CO_2$ | 1071 | Psia |
| | Component $N_2$ | 493.1 | Psia |
| Equation of State (Reservoir EoS) | Equation of State Method | PR (Peng-Robinson) | |

| | | | |
|---|---|---|---|
| Molecular Weights (Reservoir EoS) | Component $C_1$ | 16.043 | |
| | Component $C_2$ | 30.07 | |
| | Component $C_3$ | 44.097 | |
| | Component $IC_4$ | 58.123 | |
| | Component $NC_4$ | 58.123 | |
| | Component $IC_5$ | 72.15 | |
| | Component $NC_5$ | 72.15 | |
| | Component $C_6$ | 86.177 | |
| | Component $C_7$ | 100.204 | |
| | Component $C_8$ | 114.231 | |
| | Component $C_9$ | 128.258 | |
| | Component $C_{10}$ | 142.285 | |
| | Component $C_{11}$ | 156.31 | |
| | Component $C_{12+}$ | 232 | |
| | Component $CO_2$ | 44.01 | |
| | Component $N_2$ | 28.013 | |
| Binary Interaction Coefficients (Reservoir EoS) | $BIC_1$ to $BIC_9$ | | |

| | | | |
|---|---|---|---|
| Acentric Factor (Reservoir EoS) | Component $C_1$ | 0.0104 | |
| | Component $C_2$ | 0.0979 | |
| | Component $C_3$ | 0.1522 | |
| | Component $IC_4$ | 0.1852 | |
| | Component $NC_4$ | 0.1995 | |
| | Component $IC_5$ | 0.228 | |
| | Component $NC_5$ | 0.2514 | |
| | Component $C_6$ | 0.2994 | |
| | Component $C_7$ | 0.3494 | |
| | Component $C_8$ | 0.3977 | |
| | Component $C_9$ | 0.4445 | |
| | Component $C_{10}$ | 0.4898 | |
| | Component $C_{11}$ | 0.535 | |
| | Component $C_{12+}$ | 0.575 | |
| | Component $CO_2$ | 0.2667 | |
| | Component $N_2$ | 0.0372 | |

**A-4) SCAL**

Saturation Function

| Oil Saturation Functions | Row | So | Krow | Krowg |
|---|---|---|---|---|
| | 1 | 0 | 0 | 0 |
| | 2 | 0.2 | 0 | 0 |
| | 3 | 0.32 | 0.00463 | 0.015625 |
| | 4 | 0.44 | 0.037037 | 0.125 |
| | 5 | 0.56 | 0.125 | 0.421875 |
| | 6 | 0.68 | 0.296296 | 1 |
| | 7 | 0.95 | 1 | 1 |

| Water Saturation Function | Row | Sw | Krw | Pc (psia) |
|---|---|---|---|---|
| | 1 | 0.11 | 0 | 250 |
| | 2 | 0.157 | 0 | 53 |
| | 3 | 0.216 | 0 | 13 |
| | 4 | 0.313 | 0.02 | 1 |
| | 5 | 0.44 | 0.06 | 0 |
| | 6 | 0.56 | 0.10 | 0 |
| | 7 | 0.68 | 0.15 | 0 |
| | 8 | 0.80 | 0.30 | 0 |
| | 9 | 0.90 | 0.65 | 0 |
| Gas Saturation Function | Row | Sg | Krg | Pc (psia) |
| | 1 | 0 | 0 | |
| | 2 | 0.1 | 0 | |
| | 3 | 0.2 | 0 | |
| | 4 | 0.3 | 0.2 | |
| | 5 | 0.4 | 0.4 | |
| | 6 | 0.6 | 0.85 | |
| | 7 | 0.7 | 0.90 | |
| | 8 | 0.8 | 0.92 | |
| | 9 | 0.9 | 0.95 | |
| | 10 | 0.95 | 0.95 | |

**A-5) Initialization Equilibration**

| Equilibration Region | Keywords | NEI (Non-Equilibrium Initialisation) | |
|---|---|---|---|
| EquilReg 1<br>Case: 1 | Non-Equilibrium<br>Initialisation | Row | Fractions |
| | | 1 | 0.59991 |
| | | 2 | 0.084326 |
| | | 3 | 0.063988 |
| | | 4 | 0.034127 |
| | | 5 | 0.038989 |
| | | 6 | 0.014286 |
| | | 7 | 0.013988 |
| | | 8 | 0.072718 |
| | | 9 | 0.065366 |
| | | 10 | 0.012302 |
| EquilReg 1<br>Case: 2 | Non-Equilibrium<br>Initialisation | 1 | 0.6481 |
| | | 2 | 0.0527 |
| | | 3 | 0.0623 |
| | | 4 | 0.0167 |
| | | 5 | 0.0309 |
| | | 6 | 0.0137 |
| | | 7 | 0.0131 |
| | | 8 | 0.0159 |
| | | 9 | 0.1339 |
| | | 10 | 0.0106 |
| | | 11 | 0.0021 |
| EquilReg 1<br>Case: 3 | Non-Equilibrium<br>Initialisation | 1 | 0.7426 |
| | | 2 | 0.0818 |
| | | 3 | 0.0395 |
| | | 4 | 0.0104 |
| | | 5 | 0.0158 |
| | | 6 | 0.0074 |
| | | 7 | 0.0087 |
| | | 8 | 0.0098 |
| | | 9 | 0.0656 |
| | | 10 | 0.004 |
| | | 11 | 0.0144 |
| EquilReg 1<br>Case: 4 | Non-Equilibrium<br>Initialisation | 1 | 0.8358 |
| | | 2 | 0.0595 |
| | | 3 | 0.0291 |
| | | 4 | 0.0045 |
| | | 5 | 0.0111 |
| | | 6 | 0.0036 |
| | | 7 | 0.0048 |
| | | 8 | 0.006 |
| | | 9 | 0.008 |
| | | 10 | 0.0076 |
| | | 12 | 0.0047 |
| | | 13 | 0.0103 |
| | | 14 | 0.0065 |

| Equilibration Region | Keywords | NEI (Non-Equilibrium Initialisation) | |
|---|---|---|---|
| EquilReg 1<br>Case: 5 | Non-Equilibrium<br>Initialisation | Row | Fractions |
| | | 1 | 0.832 |
| | | 2 | 0.074 |
| | | 3 | 0.028 |
| | | 4 | 0.0063 |
| | | 5 | 0.0094 |
| | | 6 | 0.0048 |
| | | 7 | 0.004 |
| | | 8 | 0.0064 |
| | | 9 | 0.0074 |
| | | 10 | 0.0048 |
| | | 11 | 0.0036 |
| | | 12 | 0.0026 |
| | | 13 | 0.0099 |
| | | 14 | 0.002 |
| | | 15 | 0.0048 |
| EquilReg 1<br>Case: 6 | Non-Equilibrium<br>Initialisation | 1 | 0.8340 |
| | | 2 | 0.0720 |
| | | 3 | 0.0274 |
| | | 4 | 0.0054 |
| | | 5 | 0.0090 |
| | | 6 | 0.0042 |
| | | 7 | 0.0030 |
| | | 8 | 0.0058 |
| | | 9 | 0.0049 |
| | | 10 | 0.0054 |
| | | 11 | 0.0043 |
| | | 12 | 0.0033 |
| | | 13 | 0.0147 |
| | | 14 | 0.0019 |
| | | 15 | 0.0047 |
| EquilReg 1<br>Case: 7 | Non-Equilibrium<br>Initialisation | 1 | 0.7351 |
| | | 2 | 0.0623 |
| | | 3 | 0.0301 |
| | | 4 | 0.0289 |
| | | 5 | 0.0365 |
| | | 6 | 0.0240 |
| | | 7 | 0.0111 |
| | | 8 | 0.0174 |
| | | 9 | 0.0138 |
| | | 10 | 0.0097 |
| | | 11 | 0.0077 |
| | | 12 | 0.0048 |
| | | 13 | 0.0143 |
| | | 14 | 0.0021 |
| | | 15 | 0.0022 |

| Equilibration Region | Keywords | NEI (Non-Equilibrium Initialisation) | |
|---|---|---|---|
| EquilReg 1<br>Case: 8 | Non-Equilibrium<br>Initialisation | Row | Fractions |
| | | 1 | 0.7104 |
| | | 2 | 0.0757 |
| | | 3 | 0.0348 |
| | | 4 | 0.0064 |
| | | 5 | 0.0143 |
| | | 6 | 0.0050 |
| | | 7 | 0.0056 |
| | | 8 | 0.0075 |
| | | 9 | 0.0107 |
| | | 10 | 0.0136 |
| | | 11 | 0.0086 |
| | | 12 | 0.0061 |
| | | 13 | 0.0041 |
| | | 14 | 0.0202 |
| | | 15 | 0.0708 |
| | | 16 | 0.0062 |
| EquilReg 1<br>Case: 9 | Non-Equilibrium<br>Initialisation | 1 | 0.6072 |
| | | 2 | 0.081 |
| | | 3 | 0.0637 |
| | | 4 | 0.0398 |
| | | 5 | 0.0445 |
| | | 6 | 0.0291 |
| | | 7 | 0.0252 |
| | | 8 | 0.0179 |
| | | 9 | 0.0885 |
| | | 10 | 0.0018 |
| | | 11 | 0.0013 |
| EquilReg 1<br>Case: 10 | Non-Equilibrium<br>Initialisation | 1 | 0.6372 |
| | | 2 | 0.0575 |
| | | 3 | 0.0437 |
| | | 4 | 0.0498 |
| | | 5 | 0.0315 |
| | | 6 | 0.0341 |
| | | 7 | 0.0302 |
| | | 8 | 0.0109 |
| | | 9 | 0.104 |
| | | 10 | 0.0008 |
| | | 11 | 0.0003 |

Region/Array

| | | | |
|---|---|---|---|
| Initial Water Saturation (SWAT) | : | 0.11 | |
| Initial Gas Saturation (SGAS) | : | 0.89 | |
| Initial Pressure | : | 3000 | psia |
| Dew Point Pressure | : | 2150 | psia |

**A-6) Region** N/A

## A-7) Schedule

***Production***

*Well Specification (Prod1) [WELSPECS]*

| Well | Prod1 |
|---|---|
| Group | 1 |
| I Location | 1 |
| J Location | 1 |
| Preferred Phase | Gas |
| Inflow Equation | STD |
| Automatic Shut-In instruction | Shut |
| Cross Flow | Yes |
| Density calculation | SEG |
| Type of Well Model | STD |

*Well Connection Data (Prod1) [COMPDAT]*

| Well | Prod1 |
|---|---|
| K Upper | 1 |
| K Lower | 8 |
| Open/Shut Flag | Open |
| Well bore ID | 0.625 ft. |
| Direction | Z |

*Production Well Control (Prod1) [WCONPROD]*

| Well | Prod1 |
|---|---|
| Open/Shut Flag | Open |
| Control | GRAT |
| Gas rate | 1000 MSCF/D |
| BHP target | 500 psia |

*Production Well Economics Limit [WECON]*

| Well | Prod1 |
|---|---|
| Minimum oil rate | 3 STB/D |
| Minimum gas rate | 100 MSCF/D |
| Workover procedure | None |
| End run | YES |

*Print File Output Control [RPTSCHED]*

Grid block pressure
Grid block oil saturation
Grid block water saturation
Grid block gas saturation
Liquid component mole fraction

*Restart File Output Control [RPTRST]*

Grid block pressure
Grid block oil saturation
Grid block water saturation
Grid block gas saturation
Restart No Output

***Injection***

*Well Specification (Inj1) [WELSPECS]*

| | |
|---|---|
| Well | Inj1 |
| Group | - |
| I Location | 35 |
| J Location | 35 |
| Preferred Phase | Gas |
| Inflow Equation | STD |
| Automatic Shut-In instruction | Shut |
| Cross Flow | Yes |
| Density calculation | SEG |
| Type of Well Model | STD |

*Well Connection Data (Inj1) [COMPDAT]*

| | |
|---|---|
| Well | Inj1 |
| K Upper | 1 |
| K Lower | 8 |
| Open/Shut Flag | Open |
| Well bore ID | 0.625 ft |
| Direction | Z |

*Injection Well Control (Inj1) [WCONINJE]*

| | |
|---|---|
| Well | Inj1 |
| Injector type | Gas |
| Open/Shut Flag | Open |
| Control Mode | Rate |
| Gas Surface Rate | 1000 MSCF/D |

*Nature of Injection Gas (Inj1) [WINJGAS]*

| | |
|---|---|
| Well | Inj1 |
| Injection fluid | Gas |
| Well stream | 1 |

*Injection Gas Composition [WELLSTRE] (Case: 1)*

| Well Stream | 1 |
|---|---|
| Comp1 | 0.664797 |
| Comp2 | 0.09311 |
| Comp3 | 0.06988 |
| Comp4 | 0.035849 |
| Comp5 | 0.040957 |
| Comp6 | 0.013396 |
| Comp7 | 0.013116 |
| Comp8 | 0.048668 |
| Comp9 | 0.006679 |
| Comp10 | 0.013548 |

*Injection Gas Composition [WELLSTRE] (Case: 2)*

| Well Stream | 1 |
|---|---|
| Comp1 | 0.855239 |
| Comp2 | 0.059479 |
| Comp3 | 0.049945 |
| Comp4 | 0.006794 |
| Comp5 | 0.01257 |
| Comp6 | 0.00227 |
| Comp7 | 0.002171 |
| Comp8 | 0.00086 |
| Comp9 | 0.000001 |
| Comp10 | 0.002428 |
| Comp11 | 0.008242 |

*Injection Gas Composition [WELLSTRE] (Case: 3)*

| Well Stream | 1 |
|---|---|
| Comp1 | 0.835798 |
| Comp2 | 0.086274 |
| Comp3 | 0.035372 |
| Comp4 | 0.006202 |
| Comp5 | 0.009423 |
| Comp6 | 0.002224 |
| Comp7 | 0.002615 |
| Comp8 | 0.00108 |
| Comp9 | 0.002134 |
| Comp10 | 0.01535 |
| Comp11 | 0.003527 |

*Injection Gas Composition [WELLSTRE] (Case: 4)*

| Well Stream | 1 |
|---|---|
| Comp1 | 0.878262 |
| Comp2 | 0.06088 |
| Comp3 | 0.02771 |
| Comp4 | 0.003473 |
| Comp5 | 0.008567 |
| Comp6 | 0.00178 |
| Comp7 | 0.002373 |
| Comp8 | 0.001313 |
| Comp9 | 0.000562 |
| Comp10 | 0.000168 |
| Comp11 | 0.000033 |
| Comp12 | 6.7846E-7 |
| Comp13 | 0.008735 |
| Comp14 | 0.006143 |

*Injection Gas Composition [WELLSTRE] (Case: 5)*

| Well Stream | 1 |
|---|---|
| Comp1 | 0.871904 |
| Comp2 | 0.075622 |
| Comp3 | 0.026729 |
| Comp4 | 0.004923 |
| Comp5 | 0.007345 |
| Comp6 | 0.002441 |
| Comp7 | 0.002034 |
| Comp8 | 0.001463 |
| Comp9 | 0.000547 |
| Comp10 | 0.000112 |
| Comp11 | 0.000027 |
| Comp12 | 0.000026 |
| Comp13 | 0.000006 |
| Comp14 | 0.004925 |
| Comp15 | 0.001896 |

*Injection Gas Composition [WELLSTRE] (Case: 6)*

| Well Stream | 1 |
|---|---|
| Comp1 | 0.877267 |
| Comp2 | 0.073708 |
| Comp3 | 0.02607 |
| Comp4 | 0.004149 |
| Comp5 | 0.006915 |
| Comp6 | 0.002055 |
| Comp7 | 0.001468 |
| Comp8 | 0.001248 |
| Comp9 | 0.000337 |
| Comp10 | 0.000116 |
| Comp11 | 0.000029 |
| Comp12 | 0.000007 |
| Comp13 | 0.000004 |
| Comp14 | 0.004833 |
| Comp15 | 0.001794 |

*Injection Gas Composition [WELLSTRE] (Case: 7)*

| Well Stream | 1 |
|---|---|
| Comp1 | 0.856949 |
| Comp2 | 0.066712 |
| Comp3 | 0.026215 |
| Comp4 | 0.01551 |
| Comp5 | 0.019589 |
| Comp6 | 0.006048 |
| Comp7 | 0.002797 |
| Comp8 | 0.001542 |
| Comp9 | 0.000356 |
| Comp10 | 0.000077 |
| Comp11 | 0.000019 |
| Comp12 | 0.000004 |
| Comp13 | 1.76E-7 |
| Comp14 | 0.002388 |
| Comp15 | 0.001793 |

*Injection Gas Composition [WELLSTRE] (Case: 8)*

| Well Stream | 1 |
|---|---|
| Comp1 | 0.803012 |
| Comp2 | 0.080045 |
| Comp3 | 0.031165 |
| Comp4 | 0.003796 |
| Comp5 | 0.008481 |
| Comp6 | 0.001489 |
| Comp7 | 0.001668 |
| Comp8 | 0.00082 |
| Comp9 | 0.000347 |
| Comp10 | 0.000136 |
| Comp11 | 0.000027 |
| Comp12 | 0.000006 |
| Comp13 | 0.000001 |
| Comp14 | 7.82E-9 |
| Comp15 | 0.006626 |
| Comp16 | 0.062378 |

*Injection Gas Composition [WELLSTRE] (Case: 9)*

| Well Stream | 1 |
|---|---|
| Comp1 | 0.811311 |
| Comp2 | 0.091757 |
| Comp3 | 0.05055 |
| Comp4 | 0.0158973 |
| Comp5 | 0.017774 |
| Comp6 | 0.004727 |
| Comp7 | 0.004094 |
| Comp8 | 0.000952 |
| Comp9 | 0.000039 |
| Comp10 | 0.001512 |
| Comp11 | 0.001387 |

*Injection Gas Composition [WELLSTRE] (Case: 10)*

| Well Stream | 1 |
|---|---|
| Comp1 | 0.856538 |
| Comp2 | 0.065321 |
| Comp3 | 0.034556 |
| Comp4 | 0.01954 |
| Comp5 | 0.01236 |
| Comp6 | 0.005385 |
| Comp7 | 0.004769 |
| Comp8 | 0.000559 |
| Comp9 | 0.00001 |
| Comp10 | 0.00035 |
| Comp11 | 0.000613 |

# APPENDIX B

Flash calculation and standard condition

**CASE 1:**

Expt FLASH1 : Flash Calculation

Peng-Robinson (3-Parm) on ZI with PR corr.
Lohrenz-Bray-Clark Viscosity Correlation
Two phase state

| | | |
|---|---|---|
| Specified temperature | Deg F | 60.0000 |
| Specified pressure | PSIA | 14.7000 |
| Mole Percentage in vapour | | 90.1970 |
| Calculated GOR | MSCF/BBL | 8.9307 |

| Fluid properties | Liquid | Vapour |
|---|---|---|
| | Calculated | Calculated |
| Mole Weight | 101.0560 | 28.4821 |
| Z-factor | 0.0058 | 0.9942 |
| Viscosity | 0.4636 | 0.0113 |
| Density LB/FT3 | 46.0377 | 0.0755 |
| Molar Vol CF/LB-ML | 2.1951 | 377.1522 |

| Molar Distributions Components | | Total, Z | Liquid,X | Vapour,Y | K-Values |
|---|---|---|---|---|---|
| Mnemonic | Number | Measured | Calculated | Calculated | Calculated |
| $CO_2$ | 1 | 1.2302 | 0.0840 | 1.3548 | 16.1223 |
| $C_1$ | 2 | 59.9910 | 0.2890 | 66.4797 | 230.0125 |
| $C_2$ | 3 | 8.4326 | 0.3501 | 9.3110 | 26.5967 |
| $C_3$ | 4 | 6.3988 | 0.9774 | 6.9880 | 7.1494 |
| I-$C_4$ | 5 | 3.4127 | 1.8282 | 3.5849 | 1.9609 |
| N-$C_4$ | 6 | 3.8989 | 2.0886 | 4.0957 | 1.9609 |
| I-$C_5$ | 7 | 1.4286 | 2.2477 | 1.3396 | 0.5960 |
| N-$C_5$ | 8 | 1.3988 | 2.2008 | 1.3116 | 0.5960 |
| $C_6$ | 9 | 7.2718 | 29.4002 | 4.8668 | 0.1655 |
| $C_{7+}$ | 10 | 6.5366 | 60.5339 | 0.6679 | 0.0110 |
| Composition Total | | 100.0000 | 100.0000 | 100.0000 | |

**CASE 2:**

Expt FLASH1 : Flash Calculation

Peng-Robinson (3-Parm) on ZI with PR corr.
Lohrenz-Bray-Clark Viscosity Correlation
Two phase state

| | | |
|---|---|---|
| Specified temperature | Deg F | 60.0000 |
| Specified pressure | PSIA | 250.0000 |
| Mole Percentage in vapour | | 73.8991 |
| Calculated GOR | MSCF/BBL | 2.3839 |

| Fluid properties | Liquid Calculated | Vapour Calculated |
|---|---|---|
| Mole Weight | 121.8316 | 19.6625 |
| Z-factor | 0.1134 | 0.9562 |
| Viscosity | 0.7732 | 0.0131 |
| Density LB/FT3 | 48.1471 | 0.9219 |
| Molar Vol CF/LB-ML | 2.5304 | 21.3291 |

| Molar Distributions Components | | Total, Z | | Liquid,X | Vapour,Y | K-Values |
|---|---|---|---|---|---|---|
| Mnemonic | Number | Measured | Calculated | Calculated | Calculated | |
| N2 | 1 | 0.2100 | 0.1170 | 0.2428 | 2.0751 | |
| CO2 | 2 | 1.0600 | 1.7276 | 0.8242 | 0.4771 | |
| C1 | 3 | 64.8100 | 6.1633 | 85.5239 | 13.8763 | |
| C2 | 4 | 5.2700 | 3.3506 | 5.9479 | 1.7752 | |
| C3 | 5 | 6.2300 | 9.7280 | 4.9945 | 0.5134 | |
| I-C4 | 6 | 1.6700 | 4.4747 | 0.6794 | 0.1518 | |
| N-C4 | 7 | 3.0900 | 8.2796 | 1.2570 | 0.1518 | |
| I-C5 | 8 | 1.3700 | 4.6060 | 0.2270 | 0.0493 | |
| N-C5 | 9 | 1.3100 | 4.4043 | 0.2171 | 0.0493 | |
| C6 | 10 | 1.5900 | 5.8484 | 0.0860 | 0.0147 | |
| C7+ | 11 | 13.3900 | 51.3004 | 0.0001 | 2.5569E-06 | |
| Composition Total | | 100.0000 | 100.0000 | 100.0000 | | |

**CASE 3:**

Expt FLASH1 : Flash Calculation

Peng-Robinson (3-Parm) on ZI with PR corr.
Lohrenz-Bray-Clark Viscosity Correlation
Two phase state

| | | |
|---|---|---|
| Specified temperature | Deg F | 60.0000 |
| Specified pressure | PSIA | 250.0000 |
| Mole Percentage in vapour | | 87.9498 |
| Calculated GOR | MSCF/BBL | 8.6063 |

| Fluid properties | Liquid | Vapour |
|---|---|---|
| | Calculated | Calculated |
| Mole Weight | 78.5045 | 19.7121 |
| Z-factor | 0.0810 | 0.9555 |
| Viscosity | 0.3234 | 0.0131 |
| Density LB/FT3 | 43.4480 | 0.9248 |
| Molar Vol CF/LB-ML | 1.8069 | 21.3142 |

| Molar Distributions Components | | Total, Z | Liquid,X | Vapour,Y | K-Values |
|---|---|---|---|---|---|
| Mnemonic | Number | Measured | Calculated | Calculated | Calculated |
| N2 | 1 | 1.4400 | 0.7464 | 1.5350 | 2.0565 |
| CO2 | 2 | 0.4000 | 0.7450 | 0.3527 | 0.4735 |
| C1 | 3 | 74.2600 | 6.2386 | 83.5798 | 13.3971 |
| C2 | 4 | 8.1800 | 4.9145 | 8.6274 | 1.7555 |
| C3 | 5 | 3.9500 | 6.9631 | 3.5372 | 0.5080 |
| I-C4 | 6 | 1.0400 | 4.1036 | 0.6202 | 0.1511 |
| N-C4 | 7 | 1.5800 | 6.2343 | 0.9423 | 0.1511 |
| I-C5 | 8 | 0.7400 | 4.5175 | 0.2224 | 0.0492 |
| N-C5 | 9 | 0.8700 | 5.3112 | 0.2615 | 0.0492 |
| C6 | 10 | 0.9800 | 7.3444 | 0.1080 | 0.0147 |
| C7+ | 11 | 6.5600 | 52.8812 | 0.2134 | 0.0040 |
| Composition Total | | 100.0000 | 100.0000 | 100.0000 | |

**CASE 4:**

Expt FLASH1 : Flash Calculation

Peng-Robinson (3-Parm) on ZI with PR corr.
Lohrenz-Bray-Clark Viscosity Correlation
Two phase state

| | | |
|---|---|---|
| Specified temperature | Deg F | 60.0000 |
| Specified pressure | PSIA | 250.0000 |
| Mole Percentage in vapour | | 94.7894 |
| Calculated GOR | MSCF/BBL | 17.5902 |

| Fluid properties | Liquid | Vapour |
|---|---|---|
| | Calculated | Calculated |
| Mole Weight | 102.1912 | 18.8500 |
| Z-factor | 0.0988 | 0.9621 |
| Viscosity | 0.5352 | 0.0133 |
| Density LB/FT3 | 46.3777 | 0.8783 |
| Molar Vol CF/LB-ML | 2.2035 | 21.4612 |

| Molar Distributions Components | | Total, Z | Liquid,X | Vapour,Y | K-Values |
|---|---|---|---|---|---|
| Mnemonic | Number | Measured | Calculated | Calculated | Calculated |
| N2 | 1 | 0.8500 | 0.4225 | 0.8735 | 2.0674 |
| CO2 | 2 | 0.6500 | 1.3003 | 0.6143 | 0.4724 |
| C1 | 3 | 83.5800 | 6.3340 | 87.8262 | 13.8659 |
| C2 | 4 | 5.9500 | 3.4404 | 6.0880 | 1.7695 |
| C3 | 5 | 2.9100 | 5.4385 | 2.7710 | 0.5095 |
| I-C4 | 6 | 0.4500 | 2.3180 | 0.3473 | 0.1498 |
| N-C4 | 7 | 1.1100 | 5.7177 | 0.8567 | 0.1498 |
| I-C5 | 8 | 0.3600 | 3.6708 | 0.1780 | 0.0485 |
| N-C5 | 9 | 0.4800 | 4.8943 | 0.2373 | 0.0485 |
| C6 | 10 | 0.6000 | 9.1261 | 0.1313 | 0.0144 |
| C7 | 11 | 0.8000 | 14.3305 | 0.0562 | 0.0039 |
| C8 | 12 | 0.7600 | 14.2803 | 0.0168 | 0.0012 |
| C9 | 13 | 0.4700 | 8.9605 | 0.0033 | 0.0004 |
| C10+ | 14 | 1.0300 | 19.7661 | 6.7846E-05 | 3.4324E-06 |
| Composition Total | | 100.0000 | 100.0000 | 100.0000 | |

**CASE 5:**

Expt FLASH1 : Flash Calculation

Peng-Robinson (3-Parm) on ZI with PR corr.
Lohrenz-Bray-Clark Viscosity Correlation
Two phase state

| | | |
|---|---|---|
| Specified temperature | Deg F | 60.0000 |
| Specified pressure | PSIA | 250.0000 |
| Mole Percentage in vapour | | 95.0668 |
| Calculated GOR | MSCF/BBL | 19.7569 |

| Fluid properties | Liquid | Vapour |
|---|---|---|
| | Calculated | Calculated |
| Mole Weight | 94.8550 | 18.8994 |
| Z-factor | 0.0932 | 0.9601 |
| Viscosity | 0.4626 | 0.0133 |
| Density LB/FT3 | 45.6430 | 0.8825 |
| Molar Vol CF/LB-ML | 2.0782 | 21.4160 |

| Molar Distributions Components | | Total, Z | Liquid,X | Vapour,Y | K-Values |
|---|---|---|---|---|---|
| Mnemonic | Number | Measured | Calculated | Calculated | Calculated |
| N2 | 1 | 0.4800 | 0.2382 | 0.4925 | 2.0679 |
| CO2 | 2 | 0.2000 | 0.4012 | 0.1896 | 0.4724 |
| C1 | 3 | 83.2000 | 6.3005 | 87.1904 | 13.8385 |
| C2 | 4 | 7.4000 | 4.2747 | 7.5622 | 1.7691 |
| C3 | 5 | 2.8000 | 5.2488 | 2.6729 | 0.5092 |
| I-C4 | 6 | 0.6300 | 3.2836 | 0.4923 | 0.1499 |
| N-C4 | 7 | 0.9400 | 4.8993 | 0.7345 | 0.1499 |
| I-C5 | 8 | 0.4800 | 5.0266 | 0.2441 | 0.0486 |
| N-C5 | 9 | 0.4000 | 4.1888 | 0.2034 | 0.0486 |
| C6 | 10 | 0.6400 | 10.1543 | 0.1463 | 0.0144 |
| C7 | 11 | 0.7400 | 13.9457 | 0.0547 | 0.0039 |
| C8 | 12 | 0.4800 | 9.5143 | 0.0112 | 0.0012 |
| C9 | 13 | 0.3600 | 7.2464 | 0.0027 | 0.0004 |
| C11+ | 14 | 0.9900 | 20.0187 | 0.0026 | 0.0001 |
| C10 | 15 | 0.2600 | 5.2587 | 0.0006 | 0.0001 |
| Composition Total | | 100.0000 | 100.0000 | 100.0000 | |

**CASE 6:**

Expt FLASH1 : Flash Calculation

Peng-Robinson (3-Parm) on ZI with PR corr.
Lohrenz-Bray-Clark Viscosity Correlation
Two phase state

Specified temperature Deg F 60.0000
Specified pressure PSIA 250.0000
Mole Percentage in vapour 94.6879
Calculated GOR MSCF/BBL 16.6156

| Fluid properties | Liquid Calculated | Vapour Calculated |
|---|---|---|
| Mole Weight | 107.1308 | 18.7115 |
| Z-factor | 0.1025 | 0.9624 |
| Viscosity | 0.5797 | 0.0133 |
| Density LB/FT3 | 46.8704 | 0.8716 |
| Molar Vol CF/LB-ML | 2.2857 | 21.4684 |

| Molar Distributions Components Mnemonic | Number | Total, Z Measured | Liquid,X Calculated | Vapour,Y Calculated | K-Values Calculated |
|---|---|---|---|---|---|
| N2 | 1 | 0.4700 | 0.2333 | 0.4833 | 2.0718 |
| CO2 | 2 | 0.1900 | 0.3794 | 0.1794 | 0.4727 |
| C1 | 3 | 83.4000 | 6.2768 | 87.7267 | 13.9763 |
| C2 | 4 | 7.2000 | 4.1560 | 7.3708 | 1.7735 |
| C3 | 5 | 2.7400 | 5.1106 | 2.6070 | 0.5101 |
| I-C4 | 6 | 0.5400 | 2.7698 | 0.4149 | 0.1498 |
| N-C4 | 7 | 0.9000 | 4.6164 | 0.6915 | 0.1498 |
| I-C5 | 8 | 0.4200 | 4.2431 | 0.2055 | 0.0484 |
| N-C5 | 9 | 0.3000 | 3.0308 | 0.1468 | 0.0484 |
| C6 | 10 | 0.5800 | 8.6940 | 0.1248 | 0.0144 |
| C7 | 11 | 0.4900 | 8.6236 | 0.0337 | 0.0039 |
| C8 | 12 | 0.5400 | 9.9579 | 0.0116 | 0.0012 |
| C9 | 13 | 0.4300 | 8.0427 | 0.0029 | 0.0004 |
| C10 | 14 | 0.3300 | 6.1996 | 0.0007 | 0.0001 |
| C11+ | 15 | 1.4700 | 27.6659 | 0.0004 | 1.3863E-05 |
| Composition Total | | 100.0000 | 100.0000 | 100.0000 | |

**CASE 7:**

Expt FLASH1 : Flash Calculation

Peng-Robinson (3-Parm) on ZI with PR corr.
Lohrenz-Bray-Clark Viscosity Correlation
Two phase state

| | | |
|---|---|---|
| Specified temperature | Deg F | 60.0000 |
| Specified pressure | PSIA | 250.0000 |
| Mole Percentage in vapour | | 84.6281 |
| Calculated GOR | MSCF/BBL | 6.1396 |

| Fluid properties | Liquid Calculated | Vapour Calculated |
|---|---|---|
| Mole Weight | 84.6570 | 19.9144 |
| Z-factor | 0.0856 | 0.9568 |
| Viscosity | 0.3883 | 0.0131 |
| Density LB/FT3 | 44.3111 | 0.9330 |
| Molar Vol CF/LB-ML | 1.9105 | 21.3440 |

| Molar Distributions Components Mnemonic | Number | Total, Z Measured | Liquid,X Calculated | Vapour,Y Calculated | K-Values Calculated |
|---|---|---|---|---|---|
| N2 | 1 | 0.2200 | 0.1164 | 0.2388 | 2.0514 |
| CO2 | 2 | 0.2100 | 0.3789 | 0.1793 | 0.4733 |
| C1 | 3 | 73.5100 | 6.4276 | 85.6949 | 13.3324 |
| C2 | 4 | 6.2300 | 3.8008 | 6.6712 | 1.7552 |
| C3 | 5 | 3.0100 | 5.1490 | 2.6215 | 0.5091 |
| I-C4 | 6 | 2.8900 | 10.2618 | 1.5510 | 0.1511 |
| N-C4 | 7 | 3.6500 | 12.9604 | 1.9589 | 0.1511 |
| I-C5 | 8 | 2.4000 | 12.2831 | 0.6048 | 0.0492 |
| N-C5 | 9 | 1.1100 | 5.6810 | 0.2797 | 0.0492 |
| C6 | 10 | 1.7400 | 10.4702 | 0.1542 | 0.0147 |
| C7 | 11 | 1.3800 | 8.7814 | 0.0356 | 0.0041 |
| C8 | 12 | 0.9700 | 6.2680 | 0.0077 | 0.0012 |
| C9 | 13 | 0.7700 | 4.9986 | 0.0019 | 0.0004 |
| C10 | 14 | 0.4800 | 3.1205 | 0.0004 | 0.0001 |
| C11+ | 15 | 1.4300 | 9.3026 | 1.7569E-05 | 1.8886E-06 |
| Composition Total | | 100.0000 | 100.0000 | 100.0000 | |

**CASE 8:**

Expt FLASH1 : Flash Calculation

Peng-Robinson (3-Parm) on ZI with PR corr.
Lohrenz-Bray-Clark Viscosity Correlation
Two phase state

| | | |
|---|---|---|
| Specified temperature | Deg F | 60.0000 |
| Specified pressure | PSIA | 250.0000 |
| Mole Percentage in vapour | | 87.5521 |
| Calculated GOR | MSCF/BBL | 6.7249 |

| Fluid properties | Liquid Calculated | Vapour Calculated |
|---|---|---|
| Mole Weight | 103.9993 | 20.6618 |
| Z-factor | 0.0999 | 0.9512 |
| Viscosity | 0.5923 | 0.0129 |
| Density LB/FT3 | 46.6704 | 0.9737 |
| Molar Vol CF/LB-ML | 2.2284 | 21.2189 |

| Molar Distributions Components | | Total, Z | Liquid,X | Vapour,Y | K-Values |
|---|---|---|---|---|---|
| Mnemonic | Number | Measured | Calculated | Calculated | Calculated |
| N2 | 1 | 0.6200 | 0.3200 | 0.6626 | 2.0706 |
| CO2 | 2 | 7.0800 | 13.0034 | 6.2378 | 0.4797 |
| C1 | 3 | 71.0400 | 5.9014 | 80.3012 | 13.6072 |
| C2 | 4 | 7.5700 | 4.5137 | 8.0045 | 1.7734 |
| C3 | 5 | 3.4800 | 6.0368 | 3.1165 | 0.5163 |
| I-C4 | 6 | 0.6400 | 2.4716 | 0.3796 | 0.1536 |
| N-C4 | 7 | 1.4300 | 5.5225 | 0.8481 | 0.1536 |
| I-C5 | 8 | 0.5000 | 2.9692 | 0.1489 | 0.0502 |
| N-C5 | 9 | 0.5600 | 3.3255 | 0.1668 | 0.0502 |
| C6 | 10 | 0.7500 | 5.4483 | 0.0820 | 0.0151 |
| C7 | 11 | 1.0700 | 8.3515 | 0.0347 | 0.0042 |
| C8 | 12 | 1.3600 | 10.8296 | 0.0136 | 0.0013 |
| C9 | 13 | 0.8600 | 6.8897 | 0.0027 | 0.0004 |
| C10 | 14 | 0.6100 | 4.8961 | 0.0006 | 0.0001 |
| C11 | 15 | 0.4100 | 3.2928 | 0.0001 | 3.8337E-05 |
| C12+ | 16 | 2.0200 | 16.2277 | 7.8176E-07 | 4.8174E-08 |
| Composition Total | | 100.0000 | 100.0000 | 100.0000 | |

**CASE 9:**

Expt FLASH1 : Flash Calculation

Peng-Robinson (3-Parm) on ZI with PR corr.
Lohrenz-Bray-Clark Viscosity Correlation
Two phase state

| | | |
|---|---|---|
| Specified temperature | Deg F | 60.0000 |
| Specified pressure | PSIA | 250.0000 |
| Mole Percentage in vapour | | 72.7990 |
| Calculated GOR | MSCF/BBL | 2.9952 |

| Fluid properties | Liquid Calculated | Vapour Calculated |
|---|---|---|
| Mole Weight | 84.4942 | 20.7885 |
| Z-factor | 0.0853 | 0.9496 |
| Viscosity | 0.3909 | 0.0129 |
| Density LB/FT3 | 44.3820 | 0.9814 |
| Molar Vol CF/LB-ML | 1.9038 | 21.1830 |

| Molar Distributions Components | | Total, Z | Liquid,X | Vapour,Y | K-Values |
|---|---|---|---|---|---|
| Mnemonic | Number | Measured | Calculated | Calculated | Calculated |
| N2 | 1 | 0.1300 | 0.0734 | 0.1512 | 2.0604 |
| CO2 | 2 | 0.1800 | 0.2904 | 0.1387 | 0.4777 |
| C1 | 3 | 60.7200 | 6.0929 | 81.1311 | 13.3156 |
| C2 | 4 | 8.1000 | 5.2211 | 9.1757 | 1.7574 |
| C3 | 5 | 6.3700 | 9.8893 | 5.0550 | 0.5112 |
| I-C4 | 6 | 3.9800 | 10.3773 | 1.5897 | 0.1532 |
| N-C4 | 7 | 4.4500 | 11.6028 | 1.7774 | 0.1532 |
| I-C5 | 8 | 2.9100 | 9.4330 | 0.4727 | 0.0501 |
| N-C5 | 9 | 2.5200 | 8.1688 | 0.4094 | 0.0501 |
| C6 | 10 | 1.7900 | 6.3258 | 0.0952 | 0.0151 |
| C7+ | 11 | 8.8500 | 32.5252 | 0.0039 | 0.0001 |
| Composition Total | | 100.0000 | 100.0000 | 100.0000 | |

**CASE 10:**

Expt FLASH1 : Flash Calculation

Peng-Robinson (3-Parm) on ZI with PR corr.
Lohrenz-Bray-Clark Viscosity Correlation
Two phase state

| | | |
|---|---|---|
| Specified temperature | Deg F | 60.0000 |
| Specified pressure | PSIA | 250.0000 |
| Mole Percentage in vapour | | 72.3529 |
| Calculated GOR | MSCF/BBL | 2.6602 |

| Fluid properties | Liquid | Vapour |
|---|---|---|
| | Calculated | Calculated |
| Mole Weight | 95.7280 | 19.9026 |
| Z-factor | 0.0940 | 0.9552 |
| Viscosity | 0.4916 | 0.0131 |
| Density LB/FT3 | 45.6722 | 0.9341 |
| Molar Vol CF/LB-ML | 2.0960 | 21.3077 |

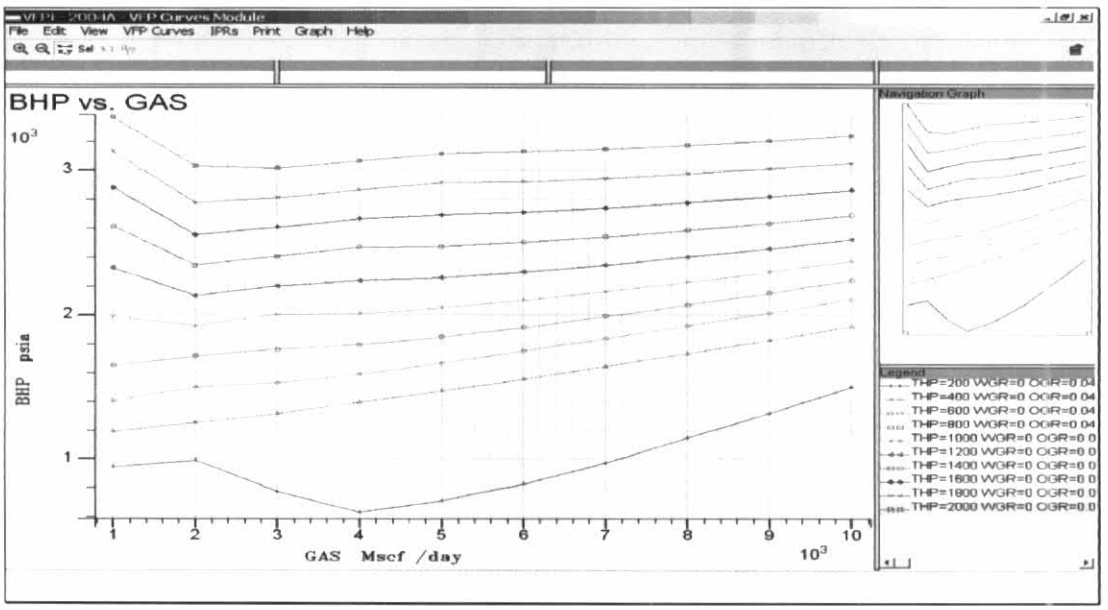
| Molar Distributions | | Total, Z | Liquid,X | Vapour,Y | K-Values |
|---|---|---|---|---|---|
| Components | | | | | |
| Mnemonic | Number | Measured | Calculated | Calculated | Calculated |
| N2 | 1 | 0.0300 | 0.0170 | 0.0350 | 2.0620 |
| CO2 | 2 | 0.0800 | 0.1290 | 0.0613 | 0.4750 |
| C1 | 3 | 63.7200 | 6.3190 | 85.6538 | 13.5550 |
| C2 | 4 | 5.7500 | 3.7032 | 6.5321 | 1.7639 |
| C3 | 5 | 4.3700 | 6.7630 | 3.4556 | 0.5110 |
| I-C4 | 6 | 4.9800 | 12.8990 | 1.9540 | 0.1515 |
| N-C4 | 7 | 3.1500 | 8.1590 | 1.2360 | 0.1515 |
| I-C5 | 8 | 3.4100 | 10.9248 | 0.5385 | 0.0493 |
| N-C5 | 9 | 3.0200 | 9.6753 | 0.4769 | 0.0493 |
| C6 | 10 | 1.0900 | 3.7963 | 0.0559 | 0.0147 |
| C7+ | 11 | 10.4000 | 37.6143 | 0.0010 | 2.6890E-05 |
| Composition Total | | 100.0000 | 100.0000 | 100.0000 | |

# APPENDIX C

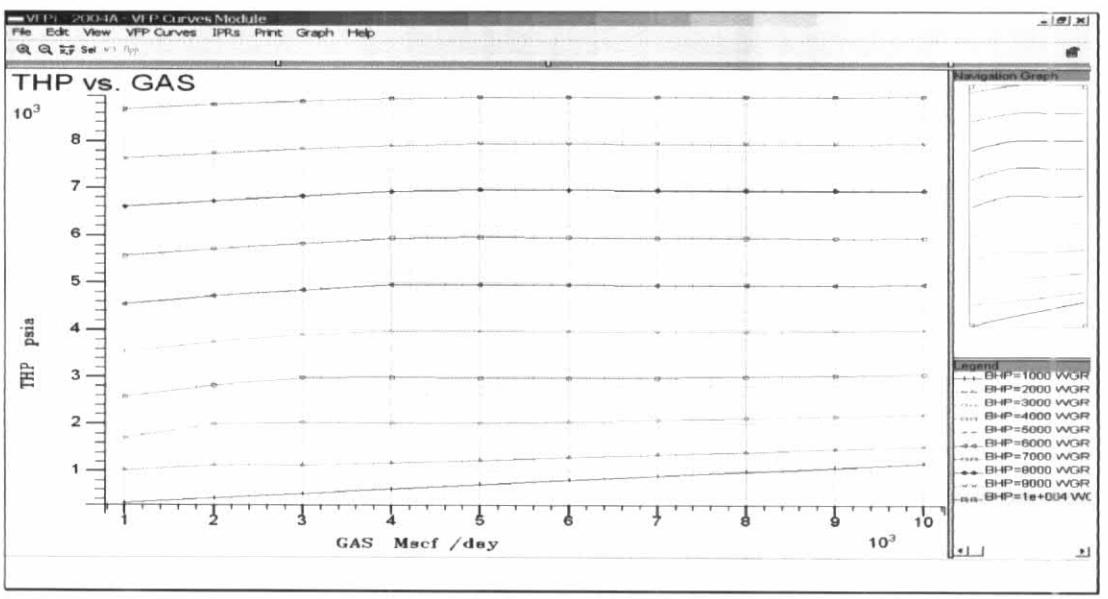
## C-1) Vertical Flow Performance (VFPi)

Vertical Flow Performance or VFPi is used in study the aspects of pressure traverse calculations along wells of production and injection. The VFP table can be generated and examine production and injection. The pressure loss from wells is examined.

1) Vertical flow performance for production well




2) Vertical flow performance for injection well



# APPENDIX D

**D-1) Compressor specification and Cost**

Compressor Spec

| | | |
|---|---|---|
| Make | : | |
| Type | : | Reciprocating |
| Design capacity | : | 14.0 MMSCFD |
| **Operating capacity** | **:** | **12.5 MMSCFD** |
| Operating suction pressure | : | 275 psig |
| Operating discharge pressure | : | 1,350 psig ( $\Delta p$ = 1,075 psig) |
| Operating temperature | : | 50 C |
| Estimated required power | : | 1,400 HP |
| Driver | : | |

Table D-1 Cost estimate

| **Items** | **Cost[1] (1000 US$)** | **Cost (MTHB)** |
|---|---|---|
| **PDS Tariff** | | |
| - Detailed design | 25.0 | 1.0 |
| - Construction | 30.0 | 1.2 |
| - Project management | 25.0 | 1.0 |
| **Materials**<br>- Compressor package<br>- Compressor frame and cylinders<br>- F&G lube system<br>- Pulsation dampener and separator<br>- Air cooler<br>- Gas engine driver<br>- Skid<br>- Water cooling system<br>- PLC control unit<br>- Drawings | 1,760 | 70.4 |
| - Transportation and insurance for major equipment | 137.5 | 5.5 |
| - Foundation and grouting work | 100.0 | 4.0 |
| - Mechanical modification | 50.0 | 2.0 |
| - Instrumentation (replace the aging facility) | 25.0 | 1.0 |
| - Electrical modification (hook-up to power supply from the existing facility)[2]<br>- Soft starter panel, 110 kW, IP55 for fan motor<br>- Cables<br>- RCU<br>- Small distribution board<br>- Lightings<br>- Splice box<br>- Accessories | 112.5 | 4.5 |
| - Modification of fire and gas detection system<br>- New sensor units (5 sets)<br>- Modification of existing fire and gas alarm panel<br>- Software | 30.0 | 1.2 |
| - Commissioning spare parts[3] | 0.0 | 0.0 |
| - Other bulks | 25.0 | 1.0 |

| | | |
|---|---|---|
| Construction and Commissioning Cost | | |
| - Civil work | 20.0 | 0.8 |
| - Mechanical work | 37.5 | 1.5 |
| - Electrical work4 | 20.0 | 0.8 |
| - Instrument work | 5.0 | 0.2 |
| - Third party inspection of K-3850 at the factory | 15.0 | 0.6 |
| - Installation, commissioning, and training (vendor) | 60.0 | 2.4 |
| - Contingency (10%) | 247.75 | 9.91 |
| **Total** | **2,725.25** | **109.01** |

The above costs form part of BI 5DXX

Notes:

1. Assumed currency exchange rate = 40 Baht/USD
2. Cost for electrical facility has been based on the estimated electrical consumption (by the air cooler fan) of 90-110 kW.

**D-2) Electrical/Power consumption calculation**

*Pumping power* is defined as the time-rate of pumping work. It is related to pumping rate and pressure by

$$power = \frac{work}{time} = q\Delta p$$

The customary unit of power for combustion engines is horsepower (HP) and for electrical motors is the kilowatt (kw). The power units are related by

1 HP = 0.746kw.

The approximate compressor power

$$P = 0.23 q_g \left[ \left( \frac{p_2}{p_1} \right)^{0.2} - 1 \right]$$

where

$q_g$ is gas compression rate, mscf/D
$p_1$ is compressor suction pressure, psia
$p_2$ is compressor discharge pressure, psia
P is compression power, HP

| Production / Injection Rate: (MSCF/D) | Power (HP) | Power (kw) | Consumption Total Power Cost(USD/Year) EGAT Power | Consumption TPC(US$/Day) EGAT Power |
|---|---|---|---|---|
| 5000 | 417.89 | 299.21 | 117,697.23 | 322.46 |

**D-3) Calculation of Btu for produced gas**

**CASE 1:**

| Component | Mole Fraction $y_j$ | Gross Heating value, (Btu/scf) $L_{cj}$ | $y_j * L_{cj}$ | Compressibility Factor at Standard Conditions | |
|---|---|---|---|---|---|
| | | | | $z_j$ | $y_j(1-z_j)^{0.5}$ |
| C1 | 0.67018 | 1010.0 | 676.8818 | 0.9980 | 0.0299714 |
| C2 | 0.09385 | 1769.6 | 166.077 | 0.9919 | 0.0084465 |
| C3 | 0.07031 | 2516.1 | 176.907 | 0.9825 | 0.0093011 |
| i-C4 | 0.03648 | 3251.9 | 118.6293 | 0.9711 | 0.0062016 |
| n-C4 | 0.04082 | 3262.3 | 133.1671 | 0.9667 | 0.007449 |
| i-C5 | 0.01354 | 4000.9 | 54.17219 | 0.9480 | 0.0030876 |
| n-C5 | 0.01256 | 4008.9 | 50.35178 | 0.9420 | 0.0030248 |
| C6 | 0.04387 | 4755.9 | 208.6413 | 0.9100 | 0.013161 |
| C7+ | 0.00469 | 5502.5 | 25.80673 | 0.8520 | 0.0018043 |
| CO2 | 0.0137 | 0.0 | 0 | 0.9943 | 0.0010343 |
| | **1.0000** | | **1610.634** | | **0.0834816** |

$$Z = 1 - (\sum y_j (1-z_j)^{0.5})^2$$

$$Z = 1 - (0.0834816)^2$$

$$= 0.993031$$

$$L_c = L_{c\ ideal} \ / \ z$$

$$L_c = (1610.634 \text{ Btu/scf}) / 0.993031$$

**Btu / scf = 1621.938**

**CASE 2:**

| Component | Mole Fraction $y_j$ | Gross Heating value, (Btu/scf) $L_{cj}$ | $y_j * L_{cj}$ | Compressibility Factor at Standard Conditions | |
|---|---|---|---|---|---|
| | | | | $z_j$ | $y_j(1-z_j)^{0.5}$ |
| C1 | 0.6481 | 1010 | 654.581 | 0.9980 | 0.028984 |
| C2 | 0.0527 | 1769.6 | 93.258 | 0.9919 | 0.004743 |
| C3 | 0.0623 | 2516.1 | 156.753 | 0.9825 | 0.008242 |
| i-C4 | 0.0167 | 3251.9 | 54.307 | 0.9711 | 0.002839 |
| n-C4 | 0.0309 | 3262.3 | 100.805 | 0.9667 | 0.005639 |
| i-C5 | 0.0137 | 4000.9 | 54.812 | 0.9480 | 0.003124 |
| n-C5 | 0.0131 | 4008.9 | 52.517 | 0.9420 | 0.003155 |
| C6 | 0.0159 | 4755.9 | 75.619 | 0.9100 | 0.004770 |
| C7+ | 0.1339 | 5502.5 | 736.785 | 0.8520 | 0.051512 |
| N2 | 0.0106 | 0 | 0 | 0.9875 | 0.001185 |
| CO2 | 0.0021 | 0 | 0 | 0.9943 | 0.000159 |
| | **1.0000** | | **1979.436** | | **0.114351** |

$$Z = 1 - (\sum y_j (1-z_j)^{0.5})^2$$

$$Z = 1 - (0.114351)^2$$

$$= 0.986924$$

$$L_c = L_{c\ ideal} \ / \ z$$

$$L_c = (1979.436 \text{ Btu/scf}) / 0.986924$$

**Btu / scf = 2005.6626**

**CASE 3:**

| Component | Mole Fraction $y_j$ | Gross Heating value, (Btu/scf) $L_{cj}$ | $y_j * L_{cj}$ | Compressibility Factor at Standard Conditions | |
|---|---|---|---|---|---|
| | | | | $z_j$ | $y_j(1-z_j)^{0.5}$ |
| C1 | 0.7426 | 1010 | 750.026 | 0.998 | 0.033210 |
| C2 | 0.0818 | 1769.6 | 144.753 | 0.9919 | 0.007362 |
| C3 | 0.0395 | 2516.1 | 99.386 | 0.9825 | 0.005225 |
| i-C4 | 0.0104 | 3251.9 | 33.820 | 0.9711 | 0.001768 |
| n-C4 | 0.0158 | 3262.3 | 51.544 | 0.9667 | 0.002883 |
| i-C5 | 0.0074 | 4000.9 | 29.607 | 0.948 | 0.001687 |
| n-C5 | 0.0087 | 4008.9 | 34.877 | 0.942 | 0.002095 |
| C6 | 0.0098 | 4755.9 | 46.608 | 0.91 | 0.002940 |
| C7+ | 0.0656 | 5502.5 | 360.964 | 0.852 | 0.025237 |
| N2 | 0.0144 | 0 | 0 | 0.9875 | 0.001610 |
| CO2 | 0.004 | 0 | 0 | 0.9943 | 0.000302 |
| | **1.000** | | **1551.585** | | **0.084320** |

$$Z = 1 - (\sum y_j (1-z_j)^{0.5})^2$$

$$Z = 1 - (0.0834816)^2$$

$$= 0.992890$$

$$L_c = L_{c\ ideal} \ / \ z$$

$$L_c = (1610.634 \text{ Btu/scf}) / 0.992890$$

**Btu / scf = 1562.6958**

**CASE 4:**

| Component | Mole Fraction $y_j$ | Gross Heating value, (Btu/scf) $L_{cj}$ | $y_j * L_{cj}$ | Compressibility Factor at Standard Conditions | |
|---|---|---|---|---|---|
| | | | | $z_j$ | $y_j(1-z_j)^{0.5}$ |
| C1 | 0.8358 | 1010 | 844.158 | 0.998 | 0.037378 |
| C2 | 0.0595 | 1769.6 | 105.291 | 0.9919 | 0.005355 |
| C3 | 0.0291 | 2516.1 | 73.219 | 0.9825 | 0.003850 |
| i-C4 | 0.0045 | 3251.9 | 14.634 | 0.9711 | 0.000765 |
| n-C4 | 0.0111 | 3262.3 | 36.212 | 0.9667 | 0.002026 |
| i-C5 | 0.0036 | 4000.9 | 14.403 | 0.948 | 0.000821 |
| n-C5 | 0.0048 | 4008.9 | 19.243 | 0.942 | 0.001156 |
| C6 | 0.006 | 4755.9 | 28.535 | 0.91 | 0.001800 |
| C7+ | 0.0306 | 5502.5 | 168.377 | 0.852 | 0.011772 |
| N2 | 0.0085 | 0 | 0 | 0.9875 | 0.000950 |
| CO2 | 0.0065 | 0 | 0 | 0.9943 | 0.000491 |
| | **1.000** | | **1304.071** | | **0.066363** |

$$Z = 1 - (\sum y_j (1-z_j)^{0.5})^2$$

$$Z = 1 - (0.0834816)^2$$

$$= 0.995596$$

$$L_c = L_{c\ ideal} \ / \ z$$

$$L_c = (1610.634 \text{ Btu/scf}) / 0.995596$$

**Btu / scf = 1309.8393**

**CASE 5:**

| Component | Mole Fraction $y_j$ | Gross Heating value, (Btu/scf) $L_{cj}$ | $y_j * L_{cj}$ | Compressibility Factor at Standard Conditions | |
|---|---|---|---|---|---|
| | | | | $z_j$ | $y_j(1-z_j)^{0.5}$ |
| C1 | 0.832 | 1010 | 840.320 | 0.998 | 0.037208 |
| C2 | 0.074 | 1769.6 | 130.950 | 0.9919 | 0.006660 |
| C3 | 0.028 | 2516.1 | 70.451 | 0.9825 | 0.003704 |
| i-C4 | 0.0063 | 3251.9 | 20.487 | 0.9711 | 0.001071 |
| n-C4 | 0.0094 | 3262.3 | 30.666 | 0.9667 | 0.001715 |
| i-C5 | 0.0048 | 4000.9 | 19.204 | 0.948 | 0.001095 |
| n-C5 | 0.004 | 4008.9 | 16.036 | 0.942 | 0.000963 |
| C6 | 0.0064 | 4755.9 | 30.438 | 0.91 | 0.001920 |
| C7+ | 0.0283 | 5502.5 | 155.721 | 0.852 | 0.010887 |
| N2 | 0.0048 | 0 | 0 | 0.9875 | 0.000537 |
| CO2 | 0.002 | 0 | 0 | 0.9943 | 0.000151 |
| | **1.000** | | **1314.272** | | **0.065911** |

$$Z = 1 - (\sum y_j (1-z_j)^{0.5})^2$$

$$Z = 1 - (0.0834816)^2$$

$$= 0.995656$$

$$L_c = L_{c\ ideal} \ / \ z$$

$$L_c = (1610.634 \text{ Btu/scf}) / 0.995656$$

**Btu / scf = 1320.0067**

**CASE 6:**

| Component | Mole Fraction $y_j$ | Gross Heating value, (Btu/scf) $L_{cj}$ | $y_j * L_{cj}$ | Compressibility Factor at Standard Conditions | |
|---|---|---|---|---|---|
| | | | | $z_j$ | $y_j(1-zj)^{0.5}$ |
| C1 | 0.834 | 1010 | 842.340 | 0.998 | 0.037298 |
| C2 | 0.072 | 1769.6 | 127.411 | 0.9919 | 0.006480 |
| C3 | 0.0274 | 2516.1 | 68.941 | 0.9825 | 0.003625 |
| i-C4 | 0.0054 | 3251.9 | 17.560 | 0.9711 | 0.000918 |
| n-C4 | 0.009 | 3262.3 | 29.361 | 0.9667 | 0.001642 |
| i-C5 | 0.0042 | 4000.9 | 16.804 | 0.948 | 0.000958 |
| n-C5 | 0.003 | 4008.9 | 12.027 | 0.942 | 0.000722 |
| C6 | 0.0058 | 4755.9 | 27.584 | 0.91 | 0.001740 |
| C7+ | 0.0326 | 5502.5 | 179.382 | 0.852 | 0.012541 |
| N2 | 0.0047 | 0 | 0 | 0.9875 | 0.000525 |
| CO2 | 0.0019 | 0 | 0 | 0.9943 | 0.000143 |
| | **1.000** | | **1321.410** | | **0.066593** |

$$Z = 1 - (\sum y_j (1-z_j)^{0.5})^2$$

$$Z = 1 - (0.0834816)^2$$

$$= 0.995565$$

$$L_c = L_{c\ ideal} \ / \ z$$

$$L_c = (1610.634 \text{ Btu/scf}) / 0.995565$$

**Btu / scf = 1327.2956**

**CASE 7:**

| Component | Mole Fraction $y_j$ | Gross Heating value, (Btu/scf) $L_{cj}$ | $y_j * L_{cj}$ | Compressibility Factor at Standard Conditions | |
|---|---|---|---|---|---|
| | | | | $z_j$ | $y_j(1-z_j)^{0.5}$ |
| C1 | 0.7351 | 1010 | 742.451 | 0.998 | 0.032875 |
| C2 | 0.0623 | 1769.6 | 110.246 | 0.9919 | 0.005607 |
| C3 | 0.0301 | 2516.1 | 75.735 | 0.9825 | 0.003982 |
| i-C4 | 0.0289 | 3251.9 | 93.980 | 0.9711 | 0.004913 |
| n-C4 | 0.0365 | 3262.3 | 119.074 | 0.9667 | 0.006661 |
| i-C5 | 0.024 | 4000.9 | 96.022 | 0.948 | 0.005473 |
| n-C5 | 0.0111 | 4008.9 | 44.499 | 0.942 | 0.002673 |
| C6 | 0.0174 | 4755.9 | 82.753 | 0.91 | 0.005220 |
| C7+ | 0.036 | 5502.5 | 198.090 | 0.852 | 0.013849 |
| N2 | 0.0143 | 0 | 0 | 0.9875 | 0.001599 |
| CO2 | 0.0021 | 0 | 0 | 0.9943 | 0.000159 |
| | 1.000 | | 1562.849 | | 0.083010 |

$$Z = 1 - \left(\sum y_j (1-z_j)^{0.5}\right)^2$$

$$Z = 1 - (0.0834816)^2$$

$$= 0.9933109$$

$$L_c = L_{c\ ideal} \ / \ z$$

$$L_c = (1610.634 \text{ Btu/scf}) / 0.993109$$

**Btu / scf = 1573.6924**

**CASE 8:**

| Component | Mole Fraction $y_j$ | Gross Heating value, (Btu/scf) $L_{cj}$ | $y_j * L_{cj}$ | Compressibility Factor at Standard Conditions | |
|---|---|---|---|---|---|
| | | | | $z_j$ | $y_j(1-z_j)^{0.5}$ |
| C1 | 0.7104 | 1010 | 717.504 | 0.998 | 0.031770 |
| C2 | 0.0757 | 1769.6 | 133.959 | 0.9919 | 0.006813 |
| C3 | 0.0348 | 2516.1 | 87.560 | 0.9825 | 0.004604 |
| i-C4 | 0.0064 | 3251.9 | 20.812 | 0.9711 | 0.001088 |
| n-C4 | 0.0143 | 3262.3 | 46.651 | 0.9667 | 0.002610 |
| i-C5 | 0.005 | 4000.9 | 20.005 | 0.948 | 0.001140 |
| n-C5 | 0.0056 | 4008.9 | 22.450 | 0.942 | 0.001349 |
| C6 | 0.0075 | 4755.9 | 35.669 | 0.91 | 0.002250 |
| C7+ | 0.0633 | 5502.5 | 348.308 | 0.852 | 0.024352 |
| N2 | 0.0062 | 0 | 0 | 0.9875 | 0.000693 |
| CO2 | 0.0708 | 0 | 0 | 0.9943 | 0.005345 |
| | **1.000** | | **1432.918** | | **0.082013** |

$$Z = 1 - (\sum y_j (1-z_j)^{0.5})^2$$

$$Z = 1 - (0.0834816)^2$$

$$= 0.993274$$

$$L_c = L_{c\ ideal} \ / \ z$$

$$L_c = (1610.634 \text{ Btu/scf}) / 0.993274$$

**Btu / scf = 1442.6213**

**CASE 9:**

| Component | Mole Fraction $y_j$ | Gross Heating value, (Btu/scf) $L_{cj}$ | $y_j * L_{cj}$ | Compressibility Factor at Standard Conditions | |
|---|---|---|---|---|---|
| | | | | $z_j$ | $y_j(1-z_j)^{0.5}$ |
| C1 | 0.6072 | 1010 | 613.272 | 0.998 | 0.027155 |
| C2 | 0.081 | 1769.6 | 143.338 | 0.9919 | 0.007290 |
| C3 | 0.0637 | 2516.1 | 160.276 | 0.9825 | 0.008427 |
| i-C4 | 0.0398 | 3251.9 | 129.426 | 0.9711 | 0.006766 |
| n-C4 | 0.0445 | 3262.3 | 145.172 | 0.9667 | 0.008120 |
| i-C5 | 0.0291 | 4000.9 | 116.426 | 0.948 | 0.006636 |
| n-C5 | 0.0252 | 4008.9 | 101.024 | 0.942 | 0.006069 |
| C6 | 0.0179 | 4755.9 | 85.131 | 0.91 | 0.005370 |
| C7+ | 0.0885 | 5502.5 | 486.971 | 0.852 | 0.034047 |
| N2 | 0.0013 | 0 | 0 | 0.9875 | 0.000145 |
| CO2 | 0.0018 | 0 | 0 | 0.9943 | 0.000136 |
| | **1.000** | | **1981.035** | | **0.110161** |

$$Z = 1 - (\sum y_j (1-z_j)^{0.5})^2$$

$$Z = 1 - (0.0834816)^2$$

$$= 0.987865$$

$$L_c = L_{c\ ideal} \ / \ z$$

$$L_c = (1610.634 \text{ Btu/scf}) / 0.987865$$

**Btu / scf = 2005.3714**

**CASE 10:**

| Component | Mole Fraction $y_j$ | Gross Heating value, (Btu/scf) $L_{cj}$ | $y_j * L_{cj}$ | Compressibility Factor at Standard Conditions | |
|---|---|---|---|---|---|
| | | | | $z_j$ | $y_j(1-z_j)^{0.5}$ |
| C1 | 0.6372 | 1010 | 643.572 | 0.998 | 0.028496 |
| C2 | 0.0575 | 1769.6 | 101.752 | 0.9919 | 0.005175 |
| C3 | 0.0437 | 2516.1 | 109.954 | 0.9825 | 0.005781 |
| i-C4 | 0.0498 | 3251.9 | 161.945 | 0.9711 | 0.008466 |
| n-C4 | 0.0315 | 3262.3 | 102.762 | 0.9667 | 0.005748 |
| i-C5 | 0.0341 | 4000.9 | 136.431 | 0.948 | 0.007776 |
| n-C5 | 0.0302 | 4008.9 | 121.069 | 0.942 | 0.007273 |
| C6 | 0.0109 | 4755.9 | 51.839 | 0.91 | 0.003270 |
| C7+ | 0.104 | 5502.5 | 572.260 | 0.852 | 0.040010 |
| N2 | 0.0003 | 0 | 0 | 0.9875 | 0.000034 |
| CO2 | 0.0008 | 0 | 0 | 0.9943 | 0.000060 |
| | **1.000** | | **2001.583** | | **0.112089** |

$$Z = 1 - (\sum y_j (1-z_j)^{0.5})^2$$

$$Z = 1 - (0.0834816)^2$$

$$= 0.987436$$

$$L_c = L_{c\ ideal} \ / \ z$$

$$L_c = (1610.634 \text{ Btu/scf}) / 0.987436$$

**Btu / scf = 2027.0513**

# Vitae

Chaibhorn Kittirattanapaiboon was born on June 14th, 1982 in Chaing Mai, Thailand. He received his Bachelor of Engineering in Control System and Instrumentation from the Faculty of Engineering, King Mongkot's University of Technology Thonburi in 2003. He has been a graduate student in the Master's Degree Program in Petroleum Engineering of the Department of Mining and Petroleum Engineering, Chulalongkorn University since 2004.