Core Lab™

RESERVOIR OPTIMIZATION

Gas Condensate Reservoir Fluid Study

for

SM Energy Company

Dynamite State 3975-16-21-1FH
Frontier Sand; 13,403 Ft. - 21,462 Ft. MD Perforations
African Swallow Field
Converse County, Wyoming
Report No: 41998-5014128526

Standard Conditions:
14.73 psia at 60 °F

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December 24, 2014

SM Energy Company
6120 South Yale
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Attention: Mr. Paul Button

Subject: Gas Condensate Reservoir Fluid Study
Dynamite State 3975-16-21-1FH
Frontier Sand; 13,403 Ft. - 21,462 Ft. MD Perforations
African Swallow Field
Converse County, Wyoming

Report No.: 41998-5014128526

Dear Mr. Button:

An RFS technician collected separator samples from the subject well on September 9, 2014. The samples were received on September 12, 2014, at our Broussard, Louisiana facility for use in the performance of a gas condensate reservoir fluid study.

The separator products were utilized to conduct a constant volume depletion study. In the laboratory, the recombined samples exhibited a dew point of 5,800 psia at 254 °F, and the reservoir fluid exists as an under saturated gas at reservoir conditions (8,410 psia at 254 °F).

RFS is very pleased to have been of service to you in this work. Should any questions arise concerning the data presented in this report, or if we may be of assistance in any other matter, please do not hesitate to contact us.

Yours sincerely,

Ross Huval
Project Manager

Scope of Work

Findings and Recommendations

Findings

Please reference sample summary report number 41998-5014098466 dated September 16, 2014, for a complete listing of all samples collected.

Upon arrival in the lab, the saturation pressures of the separator liquid samples and the opening pressures of the separator gas samples were evaluated. It was determined that the samples are representative separator products.

In the laboratory, separator gas and separator liquid were physically recombined in a PVT cell. At the calculated gas-liquid ratio of 5,324 SCF separator gas/bbl of separator liquid (corrected using the shrinkage from the multi-stage flash), the recombined wellstream fluid exhibited a dew point of 5,800 psia at 254 °F and exists as an under saturated gas at reservoir conditions (8,410 psia at 254 ° F). The gas condensate reservoir fluid study presented in this report is based on this recombined fluid.

The produced compositions and volumes from the Constant Volume Depletion study were used in conjunction with RFS' in-house Equation Of State package to calculate cumulative surface recoveries throughout the life of the reservoir. All recoveries are expressed in terms of 1 MMSCF of dew point fluid in place at initial conditions. It should be noted that the constant volume depletion simulates a closed system and cannot account for any free liquid sweep into the well bore.

Recommendations

A full range of PVT testing has been performed on this sample. Additional analyses that could be useful in the future planning and production of this well include:

Stock tank liquid pipeline package: Additional analyses include paraffin content, asphaltene content, pour point, wax appearance temperature by CPM, atmospheric viscosity at 80 °F, 100 °F, and 120 °F, Reid vapor pressure, sulfur content, and total acid number. Any of the analyses in the pipeline package can be performed individually.

Extended liquid and gas analyses, to include the BTEX components could allow for better characterization of the aromatic portion of these samples.

Storage of remaining hydrocarbon samples for possible future testing unless additional samples are easily obtained.

Reservoir Fluid Summary

Reservoir Summary

Sample Depth	13,403 - 21,462	Ft. MD Perforations
Reservoir Pressure	8,410	psia
Reservoir Temperature	254	°F

Separator Gas Properties

Gas Specific Gravity (air = 1.00)	0.760	
Net Heat of Combustion (dry)	1,184.7	Real
Gross Heat of Combustion (dry)	1,304.7	Real
Gross Heat of Combustion (wet)	1,281.8	Saturated
Gas Compressibility (1 atm at 60 °F)	0.996	
GPM at 14.73 psia	6.55	

Heat of combustion is BTU/cu.ft. at 14.73 psia at 60 °F

Stock Tank Liquid Properties

API Gravity (S0F)	45.0	°API at 60 °F (water free)
Paraffin Content	N/M	wt%
Asphaltene Content	N/M	wt%
Sulfur Content	N/M	wt%
Wax Appearance Temp (CPM)	N/M	°F
Pour Point	N/M	°F
Reid Vapor Pressure	N/M	psi
Total Acid Number	N/M	mg KOH / g

Fluid Properties at Reservoir Pressure & Temperature

Reservoir Pressure	8,410	psia at 254 °F
Density	0.441	g/cm^3
Density	27.5	lb/ft^3
Bg	632	bbl gas / MMscf
Bg	0.00355	cu ft gas at P,T/scf
Compressibility (Z)	1.475	

Fluid Properties at Saturation Pressure & Temperature

Saturation Pressure	5,800	psia at 254 °F
Density	0.395	g/cm^3
Density	24.7	lb/ft^3
Bg	704	bbl gas / MMscf
Bg	0.00395	cu ft gas at P,T/scf
Compressibility (Z)	1.134	

Producing Wellstream Composition

Component	Mole %
N_2	0.369
CO_2	0.826
H_2S	0.000
C1	67.227
C2	11.570
C3	5.992
iC4	0.805
nC4	1.932
iC5	0.685
nC5	0.753
C6	0.887
C7	1.312
C8	1.544
C9	0.985
C10	0.745
C11	0.536
C12	0.435
C13	0.427
C14	0.359
C15	0.330
C16	0.261
C17	0.236
C18	0.228
C19	0.184
C20	0.143
C21	0.133
C22	0.113
C23	0.099
C24	0.097
C25	0.087
C26	0.077
C27	0.069
C28	0.062
C29	0.055
C30+	0.438

C30+ Mole Wt	527.75
C30+ SpGr	0.925

Sample Inventory

Sample Inventory

RFS ID No.	Sample Type	Sample Source	Separator Pressure (psia)	Separator Temp. (°F)	Sample Date	Sample Time	Notes	Original Sample Volume (cc)
41998-01	Separator Liquid	Oil Leg	138	99	9/9/2014	1600		481
41998-02	Separator Liquid	Oil Leg	138	99	9/9/2014	1610		450
41998-03	Separator Liquid	Oil Leg	138	99	9/9/2014	1620		450
41998-04	Separator Gas	Meter Run	138	99	9/9/2014	1605	H_2S by Stained Tube Measurement = 2.0 ppm	37,850
41998-05	Separator Gas	Meter Run	138	99	9/9/2014	1625	CO_2 by Stained Tube Measurement = 0.6 vol%	37,850
41998-06	Separator Gas	Meter Run	138	99	9/9/2014	1630		150
41998-07	Condensate	Oil Leg			9/9/2014	1635		900
41998-08	Water (Unpreserved)	Water Leg			9/9/2014	1640		900
41998-09	Recombined Reservoir Fluid	-01 & -04						~100

Samples collected by a representative of RFS.

Sample Validation Data

RFS ID No.	Laboratory Opening Pressure (psia / °F)	Saturation Pressure (psia / °F)	Laboratory Analyses: G / O Ratio (scf / stb)	API Gravity (°API)	Gas Gravity (Air = 1.0)	Liq Analysis	CCE	CVD	MSF	ASTM Tests	Remaining Pressurized Sample (cc)
41998-01	122 / 99	130 / 99	63	45.0	1.197	x			x		299
41998-02	105 / 99	130 / 99									427
41998-04	155 / 140				0.760						33,850
41998-05	162 / 140										37,850
41998-09		5,800 / 254					x	x			0

Compositional Analysis of Separator Gas

RFS ID No. 41998-04
Sample date and time: September 9, 2014 at 1605 hours
Sampling Conditions: 138 psia at 99 °F
Opening Conditions: 155 psia at 140 °F

	Component	Mole %	GPM at 14.73 psia	Weight %	Molecular Weight
N_2	Nitrogen	0.416	0.000	0.531	28.013
CO_2	Carbon Dioxide	0.922	0.000	1.849	44.010
H_2S	Hydrogen Sulfide	0.000	0.000	0.000	34.082
C1	Methane	75.480	0.000	55.176	16.043
C2	Ethane	12.755	3.405	17.476	30.070
C3	Propane	6.355	1.751	12.769	44.097
iC4	Iso-Butane	0.798	0.261	2.115	58.123
nC4	N-Butane	1.801	0.568	4.769	58.123
iC5	Iso-Pentane	0.494	0.181	1.625	72.150
nC5	N-Pentane	0.435	0.158	1.430	72.150
C6	Hexanes	0.271	0.112	1.065	86.177
C7	Heptanes	0.177	0.069	0.728	90.497
C8	Octanes	0.070	0.030	0.327	101.818
C9	Nonanes	0.021	0.010	0.109	116.075
C10+	Decanes Plus	0.005	0.003	0.031	135.957
	Total	100.000	6.548	100.000	

Please note, 2.0 ppm H_2S was detected in field by stain tube measurement.

Calculated Properties of Gas			Data at 14.73 psia	
Gas Specific Gravity (Air = 1.00)		=	0.7603	
Net Heat of Combustion (Btu/Cu.Ft. at 60 °F)	Dry	=	1,184.7	Real
Gross Heat of Combustion (Btu/Cu.Ft. at 60 °F)	Dry	=	1,304.7	Real
Gross Heat of Combustion (Btu/Cu.Ft. at 60 °F)	Wet	=	1,281.8	Water Sat.
Gas Compressibility (1 Atm. at 60 °F)	Z	=	0.9963	

- Heat of combustion is the quantity of heat produced when gas is burned completely to carbon dioxide and water.
- Wet and dry refer to the condition of the gas prior to combustion.
- Wet refers to a gas that is saturated with water vapor, and dry refers to a gas that contains no water vapor prior to combustion.
- Net and gross refer to the condition of the water resulting from combustion.
- Gross heat is the heat produced in complete combustion under constant pressure with the combustion products cooled to standard conditions and the water of the combustion products condensed to the liquid state.
- Net heat is the heat produced in complete combustion under constant pressure with the combustion products cooled to standard conditions and the water of combustion products remains in the vapor phase.

Separator Liquid Composition

RFS ID No. 41998-01

Flash Summary (1,800 psia and 99 °F to atmospheric pressure and 60 °F)

Gas-Liquid Ratio	63	Scf/Stb	Color	Straw	
Vapor Gravity	1.197	(Air = 1.00)	API Gravity (water free)	45.0	°API at 60 °F
Shrinkage	0.940	Vstd / Vsat	Water content by Karl Fisher	0.04	Weight %
Separator Liquid Density	0.768	g/cc at 138 psia and 99 °F			

Component (Symbol / Name)		Flash Vapor (mole %)	Flash Liquid (mole %)	Flash Liquid (weight %)	Molecular Weight	Specific Gravity (water = 1.0)	Separator Liquid (mole %)	Separator Liquid (weight %)
N_2	Nitrogen	0.092	0.000	0.000	28.01	0.809	0.008	0.001
CO_2	Carbon Dioxide	0.924	0.000	0.000	44.01	0.818	0.081	0.023
H_2S	Hydrogen Sulfide	0.000	0.000	0.000	34.08	0.801	0.000	0.000
C1	Methane	33.940	0.123	0.012	16.04	0.300	3.099	0.324
C2	Ethane	25.040	0.173	0.032	30.07	0.356	2.361	0.463
C3	Propane	23.676	1.195	0.319	44.10	0.507	3.173	0.912
iC4	i-Butane	3.348	0.617	0.218	58.12	0.563	0.857	0.325
nC4	n-Butane	7.631	2.503	0.882	58.12	0.584	2.954	1.119
iC5	i-Pentane	2.067	2.176	0.952	72.15	0.624	2.166	1.019
nC5	n-Pentane	1.693	3.367	1.473	72.15	0.631	3.220	1.514
C6	Hexanes	0.969	6.123	3.199	86.18	0.664	5.669	3.184
C7	Heptanes	0.498	11.065	6.220	92.72	0.722	10.135	6.124
C8	Octanes	0.108	14.236	9.102	105.46	0.746	12.993	8.930
C9	Nonanes	0.011	9.289	6.724	119.41	0.769	8.473	6.593
C10	Decanes	0.003	7.117	5.780	134.00	0.779	6.491	5.668
C11	Undecanes		5.154	4.593	147.00	0.790	4.700	4.503
C12	Dodecanes		4.184	4.083	161.00	0.801	3.816	4.004
C13	Tridecanes		4.102	4.352	175.00	0.812	3.741	4.267
C14	Tetradecanes		3.449	3.973	190.00	0.823	3.146	3.895
C15	Pentadecanes		3.169	3.958	206.00	0.833	2.890	3.880
C16	Hexadecanes		2.511	3.379	222.00	0.840	2.290	3.313
C17	Heptadecanes		2.273	3.266	237.00	0.848	2.073	3.202
C18	Octadecanes		2.194	3.338	251.00	0.853	2.001	3.273
C19	Nonadecanes		1.766	2.816	263.00	0.858	1.611	2.760
C20	Eicosanes		1.375	2.292	275.00	0.863	1.254	2.247
C21	Heneicosanes		1.281	2.260	291.00	0.868	1.168	2.216
C22	Docosanes		1.091	2.018	305.00	0.873	0.995	1.978
C23	Tricosanes		0.950	1.831	318.00	0.878	0.866	1.796
C24	Tetracosanes		0.937	1.880	331.00	0.882	0.855	1.843
C25	Pentacosanes		0.833	1.742	345.00	0.886	0.760	1.708
C26	Hexacosanes		0.742	1.615	359.00	0.890	0.677	1.583
C27	Heptacosanes		0.668	1.514	374.00	0.894	0.609	1.485
C28	Octacosanes		0.598	1.408	388.00	0.897	0.545	1.379
C29	Nonacosanes		0.528	1.286	402.00	0.900	0.482	1.262
C30+	Triacontanes Plus		4.211	13.483	527.75	0.925	3.840	13.208
Total		100.000	100.000	100.000			100.000	100.000
Calculated Mole Weight		34.35	164.95				153.45	
Measured Mole Weight			174.36					

- Compositional groupings based on normal to normal carbon distribution.
- Pristane is included as C_{17} and Phytane is included as C_{18}.

Compositional Groupings of Separator Liquid

Group	Mole %	Weight %	MW	SG
Total Fluid	100.000	100.000	153.45	
C7+	76.411	91.116	182.98	0.824
C10+	44.810	69.469	237.89	0.852
C20+	12.051	30.705	390.96	0.899
C30+	3.840	13.208	527.75	0.925

Reservoir Fluid Composition

Mathematical Recombination of Separator Products
Basis of Recombination: 5,324 scf separator gas / barrel separator liquid

Component (Symbol / Name)		Separator Gas (mole %)	Separator Liquid (mole %)	Separator Liquid (weight %)	Molecular Weight	Specific Gravity (water = 1.0)	Reservoir Fluid (mole %)	Reservoir Fluid (weight %)
N_2	Nitrogen	0.416	0.008	0.001	28.01	0.809	0.369	0.280
CO_2	Carbon Dioxide	0.922	0.081	0.023	44.01	0.818	0.826	0.984
H_2S	Hydrogen Sulfide	0.000	0.000	0.000	34.08	0.801	0.000	0.000
C1	Methane	75.480	3.099	0.324	16.04	0.300	67.227	29.196
C2	Ethane	12.755	2.361	0.463	30.07	0.356	11.570	9.418
C3	Propane	6.355	3.173	0.912	44.10	0.507	5.992	7.153
iC4	i-Butane	0.798	0.857	0.325	58.12	0.563	0.805	1.266
nC4	n-Butane	1.801	2.954	1.119	58.12	0.584	1.932	3.041
iC5	i-Pentane	0.494	2.166	1.019	72.15	0.624	0.685	1.337
nC5	n-Pentane	0.435	3.220	1.514	72.15	0.631	0.753	1.470
C6	Hexanes	0.271	5.669	3.184	86.18	0.664	0.887	2.068
C7	Heptanes	0.177	10.135	6.124	92.46	0.718	1.312	3.285
C8	Octanes	0.070	12.993	8.930	105.31	0.745	1.544	4.400
C9	Nonanes	0.021	8.473	6.593	119.34	0.769	0.985	3.181
C10	Decanes	0.005	6.491	5.668	134.01	0.779	0.745	2.701
C11	Undecanes		4.700	4.503	147.00	0.790	0.536	2.133
C12	Dodecanes		3.816	4.004	161.00	0.801	0.435	1.896
C13	Tridecanes		3.741	4.267	175.00	0.812	0.427	2.021
C14	Tetradecanes		3.146	3.895	190.00	0.823	0.359	1.845
C15	Pentadecanes		2.890	3.880	206.00	0.833	0.330	1.838
C16	Hexadecanes		2.290	3.313	222.00	0.840	0.261	1.569
C17	Heptadecanes		2.073	3.202	237.00	0.848	0.236	1.516
C18	Octadecanes		2.001	3.273	251.00	0.853	0.228	1.550
C19	Nonadecanes		1.611	2.760	263.00	0.858	0.184	1.307
C20	Eicosanes		1.254	2.247	275.00	0.863	0.143	1.064
C21	Heneicosanes		1.168	2.216	291.00	0.868	0.133	1.049
C22	Docosanes		0.995	1.978	305.00	0.873	0.113	0.937
C23	Tricosanes		0.866	1.796	318.00	0.878	0.099	0.850
C24	Tetracosanes		0.855	1.843	331.00	0.882	0.097	0.873
C25	Pentacosanes		0.760	1.708	345.00	0.886	0.087	0.809
C26	Hexacosanes		0.677	1.583	359.00	0.890	0.077	0.750
C27	Heptacosanes		0.609	1.485	374.00	0.894	0.069	0.703
C28	Octacosanes		0.545	1.379	388.00	0.897	0.062	0.653
C29	Nonacosanes		0.482	1.262	402.00	0.900	0.055	0.598
C30+	Triacontanes Plus		3.840	13.208	527.75	0.925	0.438	6.256
Total		100.000	100.000	100.000			100.000	100.000
Molecular Weight		21.95	153.45				36.94	

- Compositional groupings based on normal to normal carbon distribution.
- Pristane is included as C_{17} and Phytane is included as C_{18}.

Compositional Groupings of Reservoir Fluid

Group	Mole %	Weight %	MW	SG	T_b
Total Fluid	100.000	100.000	36.94		N/A
C7+	8.955	43.786	180.64	0.822	N/A
C10+	5.114	32.920	237.80	0.852	1,065
C20+	1.374	14.543	390.96	0.899	1,321
C30+	0.438	6.256	527.75	0.925	1,474

* Tb by Correlation

Stock Tank Liquid Properties

Compositional Groupings of Flash Liquid (RFS ID No. 41998-01)

Group	Mole %	Weight %	MW	SG
Total Fluid	100.000	100.000	164.95	0.806
Heptanes plus (C7+)	83.723	92.913	183.04	0.824
Decanes plus (C10+)	49.133	70.867	237.89	0.852
Eicosanes plus (C20+)	13.214	31.329	390.96	0.899
Triacontanes plus (C30+)	4.211	13.483	527.75	0.925

Atmospheric Liquid Pipeline Package (RFS ID No. 41998-01)

Test	Method	Result	Units
Color	Visual	Straw	
API Gravity at 60 °F (water free)	ASTM D 5002	45.0	° API
Water Content	ASTM D 4377	0.04	wt%
Paraffin Content	UOP 46 modified	N/M	wt%
Asphaltene Content *	ASTM D 4055 modified	N/M	wt%
Wax Appearance Temperature	CPM	N/M	°F
Pour Point	ASTM D 97	N/M	°F
Reid Vapor Pressure	ASTM D 323	N/M	psi
Total Acid Number **	ASTM D 664	N/M	mg KOH/g
Total Sulfur **	ASTM D 4294	N/M	wt%
Viscosity at 80 °F	ASTM D 7042	N/M	cPoise
	ASTM D 7042	N/M	cStokes
Viscosity at 100 °F	ASTM D 7042	N/M	cPoise
	ASTM D 7042	N/M	cStokes
Viscosity at 120 °F	ASTM D 7042	N/M	cPoise
	ASTM D 7042	N/M	cStokes

* Asphaltenes defined as pentane insoluble.

** Analysis performed by third party.

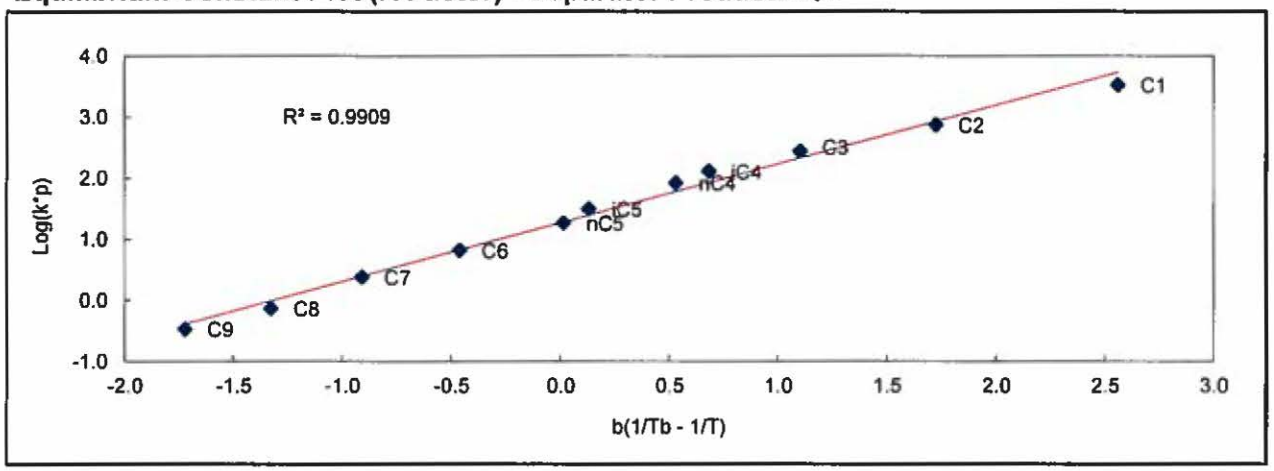
Additional Testing in Mini Assay (performed by third party)

Test	Method	Result	Units
Carbon Residue - Conradson	ASTM D 189	N/M	wt %
Carbon Residue - Ramsbottom	ASTM D 524	N/M	wt %
Hydrogen Content	ASTM D 5291	N/M	wt %
Hydrogen Sulfide	UOP 163	N/M	ppm wt
Mercaptan Sulfur	ASTM D 3227	N/M	ppm wt
Nickel	ASTM D 5708	N/M	ppm wt
Vanadium	ASTM D 5708	N/M	ppm wt
Organically Bound Nitrogen	ASTM D 5762	N/M	ppm wt

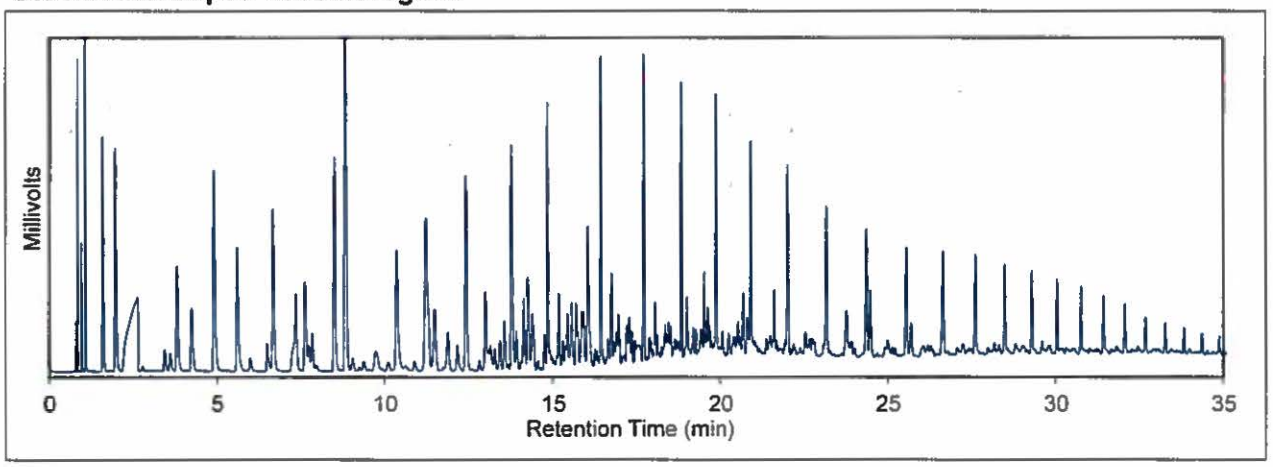
Atmospheric Fluid Properties and Separator Products QC

Residual Liquid from RFS ID No. 41998-01

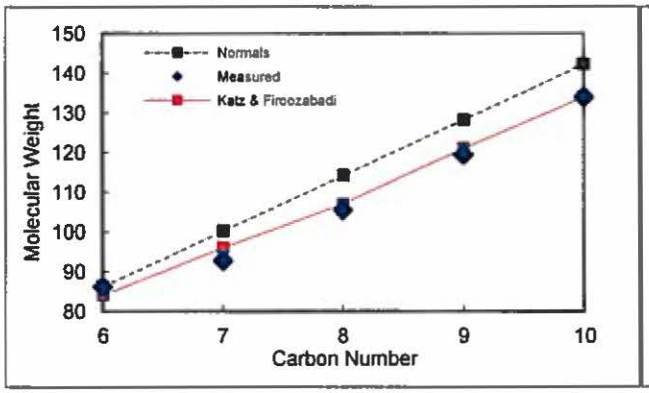
Equilibrium Constant Plot (K Factor) - Separator Products QC

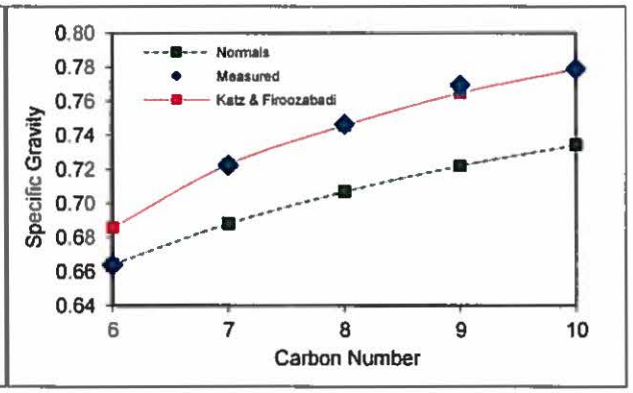


Stock Tank Liquid Chromatogram



Molecular Weight / Specific Gravity Plots





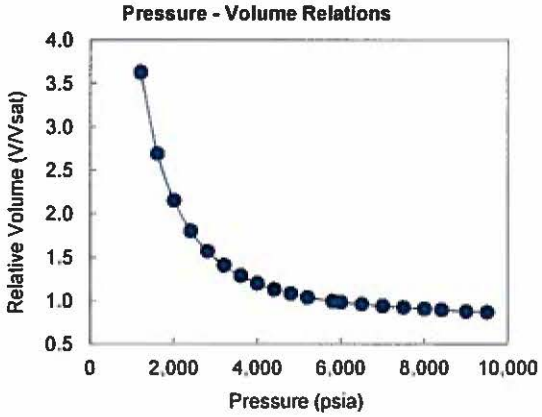
Constant Composition Expansion at 254 °F
Pressure-Volume Relations

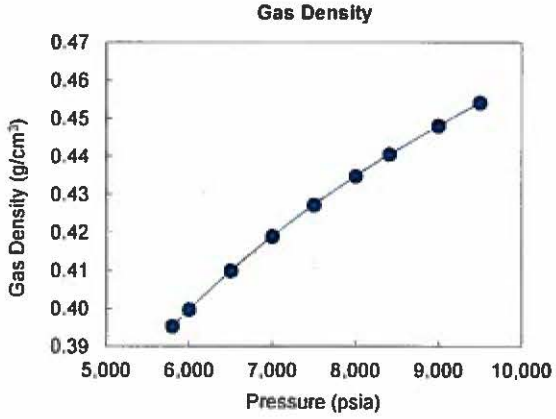
Pressure (psia)		Relative Volume (V / V_{sat})	Gas Density (g/cm^3)	Relative Liquid Volume (%)	Deviation Factor (z)	Correlated Gas Viscosity (cP)
9,500		0.870	0.454		1.616	0.082
9,000		0.882	0.448		1.552	0.079
8,410	**Reservoir**	**0.897**	**0.441**		**1.475**	**0.076**
8,000		0.909	0.435		1.421	0.074
7,500		0.925	0.427		1.356	0.071
7,000		0.943	0.419		1.291	0.067
6,500		0.964	0.410		1.225	0.064
6,000		0.989	0.400		1.160	0.060
5,800	**Saturation**	**1.000**	**0.395**	**0.00**	**1.134**	**0.059**
5,200		1.045		11.13	1.062	
4,800		1.087		17.01	1.020	
4,400		1.138		20.51	0.979	
4,000		1.205		22.75	0.942	
3,600		1.294		24.13	0.910	
3,200		1.412		25.04	0.883	
2,800		1.574		25.66	0.861	
2,400		1.807		25.88	0.848	
2,000		2.154		25.91	0.842	
1,600		2.697		25.51	0.843	
1,200		3.632		24.31	0.852	

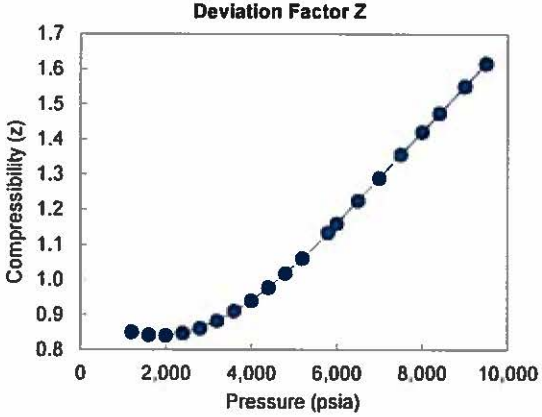
Notes:

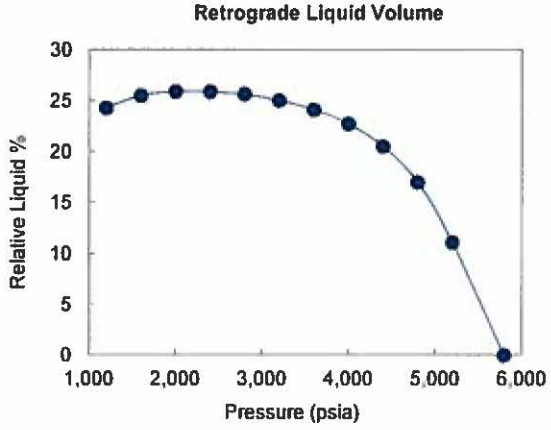
- Relative Volume (V / V_{sat}) is the fluid volume at the indicated pressure and temperature relative to the saturated fluid volume.
- Specific Volume (ft^3/lb) = 1 / Density (g/cm^3) x 62.428
- Density (lb/ft^3) = Density (g/cm^3) x 62.428
- Relative Liquid Volume % is the volume of liquid at indicated P and T / total volume at saturation pressure
- Gas Viscosity is calculated using the Lee - Gonzales correlation

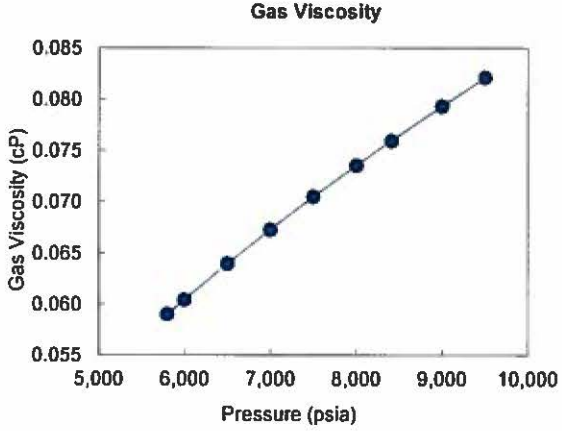
Constant Composition Expansion at 254 °F
Data Presentation Figures











Constant Volume Depletion at 254 °F

Vapor Properties

Pressure (psia)	Gas Density (g/cm^3)	Z Factor (Gas Phase)	Z Factor (2 Phase)	Gas Mole Weight	Correlated Gas Viscosity (cP)	Gas FVF (B_g) (bbl gas at P,T per MMscf)
8,410	**0.441**	**1.475**	**1.475**	**36.94**	**0.076**	**632**
5,800	**0.395**	**1.134**	**1.134**	**36.94**	**0.059**	**704**
5,200	0.338	1.035	1.064	32.17	0.045	717
4,000	0.257	0.909	0.944	27.93	0.031	818
2,800	0.170	0.861	0.858	24.92	0.022	1,108
1,600	0.088	0.899	0.774	23.66	0.016	2,024
500	0.027	0.960	0.557	24.58	0.014	6,919

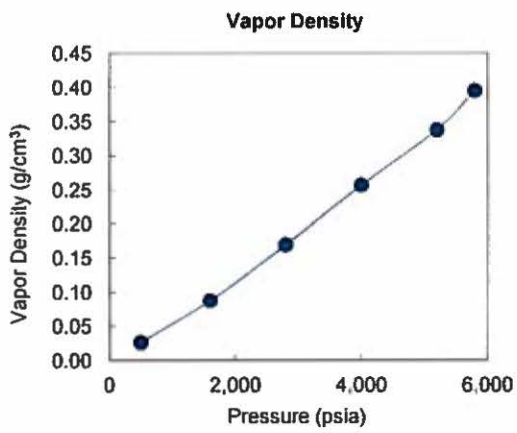
Displaced Volumetrics and Liquid Properties

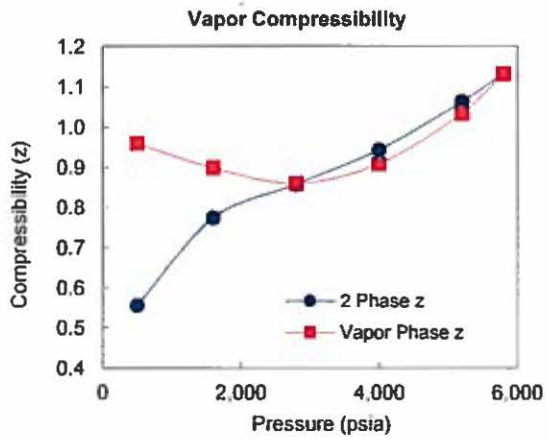
Pressure (psia)	Moles Displaced (gmole)	Reservoir Fluid Displaced (% of initial moles)	Liquid Volume (% of V_{res})	Liquid Volume (% of V_{sat})	Absolute Liquid Volume (% of V_p)
5,800	**0.000**	**0.00**	**0.00**	**0.00**	**0.00**
5,200	0.043	4.54	12.41	11.13	10.63
4,000	0.122	17.25	23.73	21.29	18.52
2,800	0.183	36.31	25.25	22.66	17.39
1,600	0.223	59.63	23.02	20.65	12.31
500	0.219	82.46	19.50	17.50	5.35

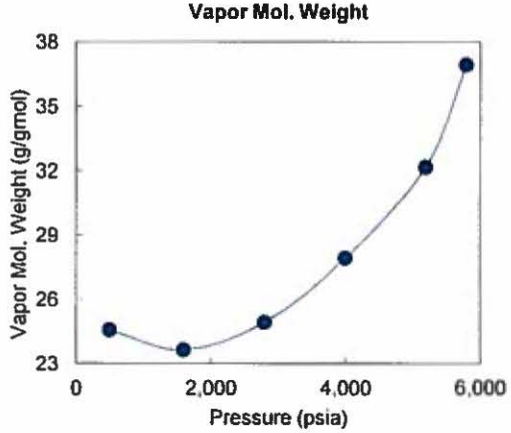
Notes:

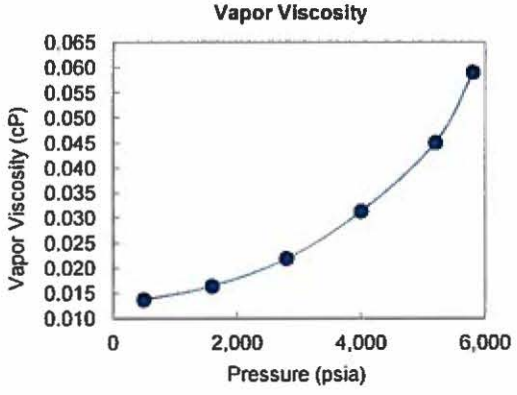
- Vapor Gravity = Vapor Molecular Weight / Air Molecular Weight.
- Reservoir Fluid Displaced = % of initial moles charged to PVT cell.
- Liquid Volume is given relative to the reservoir volume (V_{res}) and saturated volume (V_{sat}).
- Absolute Liquid Volume is given relative to total sample volume at indicated pressure (V_p).
- Gas Viscosity calculated by Lee-Gonzalez correlation.
- See following pages for compositional analysis of the produced gas phase and abandonment liquid.

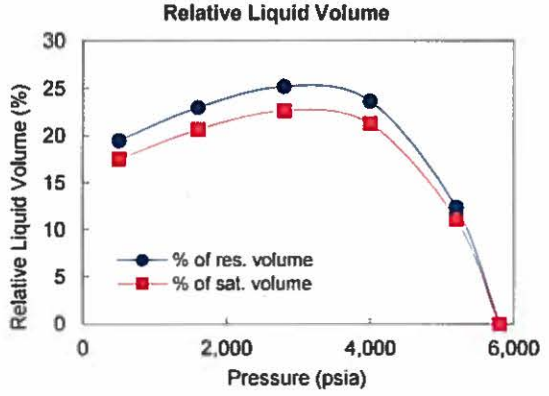
Constant Volume Depletion at 254 °F
Data Presentation Figures

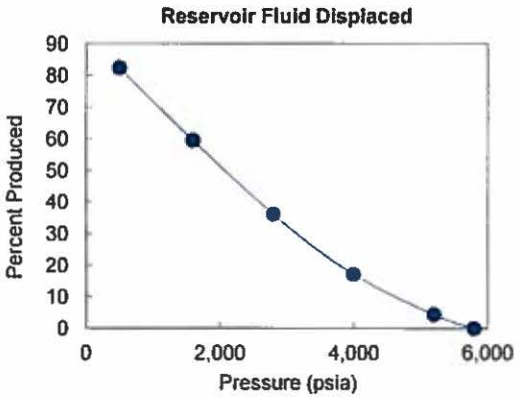












Constant Volume Depletion Fluid Compositions

Component	Saturation Pressure *(mole %)*	5,200 psia *(mole %)*	4,000 psia *(mole %)*	2,800 psia *(mole %)*	1,600 psia *(mole %)*	500 psia *(mole %)*	Liquid at 500 psia *(mole %)*
Nitrogen	0.369	0.409	0.451	0.467	0.453	0.409	0.032
Carbon Dioxide	0.826	0.820	0.858	0.882	0.897	0.906	0.279
Hydrogen Sulfide	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Methane	67.227	69.864	71.877	74.013	74.659	71.975	13.902
Ethane	11.570	11.255	11.601	11.797	12.130	13.029	7.027
Propane	5.992	5.702	5.744	5.665	5.775	6.433	7.130
Iso-Butane	0.805	0.772	0.762	0.735	0.756	0.913	1.377
N-Butane	1.932	1.834	1.790	1.668	1.675	2.010	4.096
Iso-Pentane	0.685	0.646	0.631	0.583	0.548	0.690	1.592
N-Pentane	0.753	0.675	0.628	0.571	0.525	0.661	1.706
Hexanes	0.887	0.812	0.741	0.615	0.535	0.691	2.169
Heptanes	1.312	1.141	0.950	0.754	0.684	0.870	4.174
Octanes	1.544	1.396	1.221	0.895	0.666	0.794	7.197
Nonanes	0.985	0.850	0.657	0.458	0.299	0.319	5.995
Decanes plus	5.114	3.824	2.092	0.898	0.399	0.299	43.324
Totals	100.000	100.000	100.000	100.000	100.000	100.000	100.000
C10+ Mole Weight	237.80	203.48	181.95	164.05	145.95	142.22	247.70
Mole Weight	36.94	32.17	27.93	24.92	23.66	24.58	141.46
Gas Gravity (Air = 1.0)	1.275	1.111	0.964	0.860	0.817	0.849	-
Z Factor (at P & T)	1.134	1.035	0.909	0.861	0.899	0.960	-

Notes:

- Compositional analysis are of the produced gas phase and abandonment liquid.

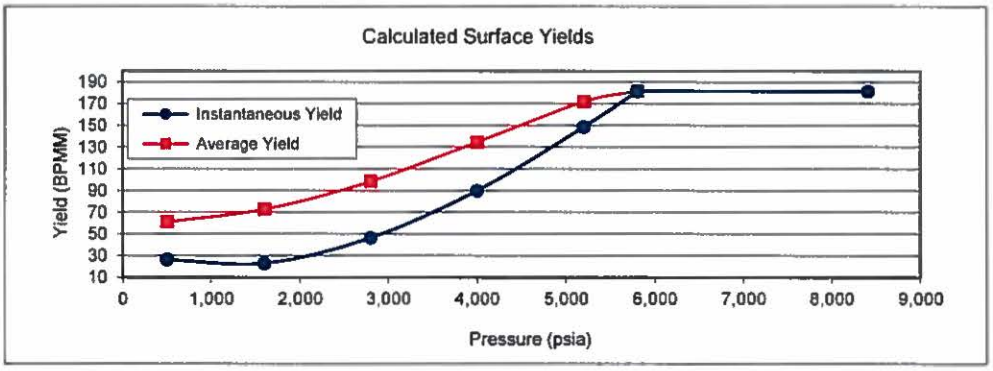
Calculated Surface Gas and Liquid Recovery

Experimental and Equation of State Predictions

		Initial	Pressure (psia)					
		in place	Sat					
		8,410	5,800	5,200	4,000	2,800	1,600	500
Moles in PVT Cell		1.068	0.958	0.914	0.793	0.610	0.387	0.168
Fraction Vapor Liberated / Step			0.110	0.043	0.122	0.183	0.223	0.219
EOS Predicted Liquid Fractions								
1st Stage: 138 psia and 99 °F	(mole fraction)		0.118	0.104	0.072	0.042	0.022	0.027
2nd Stage: 55 psia and 90 °F	(mole fraction)		0.958	0.957	0.956	0.955	0.955	0.951
Stock Tank, 14.73 psia, 60 °F	(mole fraction)		0.966	0.966	0.966	0.965	0.964	0.959
Predicted Liquid Molar Volume	(cc/mole)		197.1	185.9	167.2	154.7	146.6	139.1

Calculated Surface Recovery

Initial Reservoir Fluid in Place	mscf	1,000	897					
Vapor Produced / Step	mscf		102.7	40.7	114.1	171.0	209.3	204.9
Cumulative Vapor Produced	mscf		102.7	143.4	257.5	428.5	637.7	842.7
Predicted Surface Liquids	stb	162	16.6	5.5	9.6	7.6	4.7	5.3
Cumulative Surface Liquids	stb		16.6	22.1	31.6	39.3	44.0	49.2
Predicted Surface Vapor	mscf	891	91.5	36.8	106.5	164.4	205.0	199.9
Cumulative Surface Gas	mscf		91.5	128.3	234.8	399.3	604.2	804.1
Instantaneous Yield	stb/mmscf	181.4	181.4	148.5	89.8	46.4	22.9	26.4
Average Yield	stb/mmscf		181.4	172.0	134.7	98.3	72.7	61.2
Instantaneous GOR	scf/stb	5,513	5,513	6,732	11,141	21,563	43,610	37,814
Average GOR	scf/stb		5,513	5,815	7,425	10,171	13,747	16,331
Gas Recovery Factor	%		9.2	12.8	23.5	39.9	60.4	80.4
Liquid Recovery Factor	%		10.3	13.7	19.6	24.3	27.2	30.5



Notes:

- Gas Recovery Factor: Cumulative Surface Gas / Gas at Reservoir Pressure
- Liquid Recovery Factor: Cumulative Liquid Produced / Predicted Max Surface Production for Original Reservoir Fluid
- All recoveries are based on 1 MMSCF of wellstream fluid in place at initial reservoir conditions
- The laboratory experiment simulates a closed system and cannot account for sweep of free liquid into the wellbore.
- Calculations based on Peng-Robinson/Peneloux generated equation of state data.
- Instantaneous GOR is the EOS prediction of your producing GOR expressed in units of SCF/stock tank barrel

Multi-Stage Separator Test

Performed Using Separator Liquid Sample

Separator Conditions Pressure (psia)	Separator Conditions Temperature (°F)	Liquid Density (g/cm^3)	Gas Density (g/cm^3)	Gas Gravity (Air = 1.0)	Solution GOR, R_s (scf/stb)	Solution GOR, R_s (scf/sep bbl)	Liberated GOR, R_l (scf/stb)	Separator Shrinkage (stb/bbl at P,T)
138	**99**	**0.768**		**N/A**	**54**		**0**	**0.954**
70	90	0.771	0.004	0.830	35	33	19	0.962
15	60	0.800	0.002	1.275	0	0	35	1.000

Summary Data

Total Solution Gas-Oil Ratio	54	scf/stb
Stock Tank Liquid Gravity	45.2	°API at 60 °F
Accumulated Gas Gravity	1.116	(Air = 1.00)
Color of Stock Tank Liquid	Straw	

Notes:

- stb: stock tank barrel at 60 °F
- sep bbl: volume of separator liquid at P,T
- Solution GOR is given as the gas volume per stock tank barrel (stb) and per separator barrel (sep bbl)
- Liberated GOR (R_l) is gas liberated from previous stage to current stage per stock tank barrel (stb)
- See following page for flash gas compositional analyses

Multi-Stage Flash Fluid Compositions

Stage Condition	Stage 1	Stage 2	Stock Tank Liquid
Pressure (psia)	70	15	15
Temperature (°F)	90	60	60
Component	*(mole %)*	*(mole %)*	*(mole %)*
Nitrogen	0.256	0.040	0.000
Carbon Dioxide	1.173	1.007	0.000
Hydrogen Sulfide	0.000	0.000	0.000
Methane	65.654	23.847	0.111
Ethane	19.412	32.525	0.394
Propane	9.667	26.827	1.912
Iso-Butane	1.134	3.411	0.815
N-Butane	0.711	5.423	3.099
Iso-Pentane	0.576	2.285	2.387
N-Pentane	0.487	1.967	3.576
Hexanes	0.340	1.282	6.180
Heptanes	0.258	0.927	10.913
Octanes	0.260	0.406	13.945
Nonanes	0.054	0.048	9.033
Decanes Plus	0.017	0.004	47.635
Totals	100.000	100.000	100.000
Mol. Weight	23.94	36.52	160.85
Gas Gravity (Air = 1.0)	0.830	1.275	-
Net Heat of combustion (dry)	1,286.6	1,944.2	-
Gross heat of combustion (dry)	1,413.9	2,119.1	-
Gross heat of combustion (wet)	1,389.1	2,082.0	-
Gas Compressibility (1 atm at 60 °F)	0.996	0.989	-
GPM at 14.73 psia	9.262	21.642	-

- Heat of combustion is the quantity of heat produced when gas is burned completely to carbon dioxide and water; BTU/cuft.
- Wet and dry refer to the condition of the gas prior to combustion.
- Wet refers to a gas that is saturated with water vapor, and dry refers to a gas that contains no water vapor prior to combustion.
- Net and gross refer to the condition of the water resulting from combustion.
- Gross heat is the heat produced in complete combustion under constant pressure with the combustion products cooled to standard conditions and the water of the combustion products condensed to the liquid state.
- Net heat is the heat produced in complete combustion under constant pressure with the combustion products cooled to standard conditions and the water of combustion products remains in the vapor phase.

Compositional Analysis of Multi-Stage Flash Stock Tank Liquid

	Component	Mole %	Volume %	Weight %	Molecular Weight	Specific Gravity
C1	Methane	0.111	0.030	0.011	16.04	0.300
C2	Ethane	0.394	0.166	0.074	30.07	0.356
C3	Propane	1.912	0.829	0.524	44.10	0.507
iC4	i-Butane	0.815	0.419	0.294	58.12	0.563
nC4	n-Butane	3.099	1.537	1.120	58.12	0.584
iC5	i-Pentane	2.387	1.375	1.071	72.15	0.624
nC5	n-Pentane	3.576	2.038	1.604	72.15	0.631
C6	Hexanes	6.180	3.998	3.311	86.18	0.664
C7	Heptanes	10.913	6.974	6.286	92.67	0.723
C8	Octanes	13.945	9.826	9.145	105.48	0.746
C9	Nonanes	9.033	6.986	6.706	119.42	0.770
C10	Decanes	6.882	5.906	5.733	134.00	0.779
C11	Undecanes	4.981	4.620	4.552	147.00	0.790
C12	Dodecanes	4.037	4.046	4.041	161.00	0.801
C13	Tridecanes	4.020	4.319	4.374	175.00	0.812
C14	Tetradecanes	3.449	3.969	4.074	190.00	0.823
C15	Pentadecanes	3.133	3.862	4.012	206.00	0.833
C16	Hexadecanes	2.423	3.193	3.345	222.00	0.840
C17	Heptadecanes	2.184	3.043	3.218	237.00	0.848
C18	Octadecanes	2.109	3.093	3.291	251.00	0.853
C19	Nonadecanes	1.677	2.562	2.742	263.00	0.858
C20	Eicosanes	1.374	2.182	2.349	275.00	0.863
C21	Heneicosanes	1.264	2.112	2.286	291.00	0.868
C22	Docosanes	1.131	1.970	2.145	305.00	0.873
C23	Tricosanes	1.004	1.813	1.986	318.00	0.878
C24	Tetracosanes	0.836	1.563	1.720	331.00	0.882
C25	Pentacosanes	0.840	1.631	1.803	345.00	0.886
C26	Hexacosanes	0.695	1.397	1.550	359.00	0.890
C27	Heptacosanes	0.634	1.322	1.474	374.00	0.894
C28	Octacosanes	0.570	1.230	1.376	388.00	0.897
C29	Nonacosanes	0.495	1.102	1.237	402.00	0.900
C30+	Triacontanes Plus	3.897	10.887	12.546	517.88	0.924
	Total	100.000	100.000	100.000		

Properties of Liquid at 60/60 °F	Measured	Calculated
Specific Gravity	0.801	0.802
Molecular Weight	166.79	160.85

Calculated Properties of C30+	
Specific Gravity	0.924
Molecular Weight	517.88

* Calculations are based on normal carbon distribution (from normal to normal).

Laboratory Procedures

Sample Quality
The selected samples are heated to collection temperature prior to performing any further testing to avoid wax deposition problems and assure a uniform sample. Depending on the type of sample, either a reservoir to zero flash or a bubble-point and separator to zero flash is performed in duplicate to assure repeatable results. Separator gas samples are heated to some temperature above collection temperature and the opening pressure and hydrocarbon composition is measured.

Sample Restoration
If bottom-hole samples are collected, the samples are restored prior to any laboratory manipulations. Reservoir fluid samples are heated to 170 °F or reservoir temperature, depending on the sample container, pressured to some safe pressure above reservoir and continually agitated for a period of from 24 to 120 hours. This assures that any asphaltenes, if flocculation is reversible, have been dispersed throughout the sample, paraffins have been resoluablized, and the sample is homogenous.

Reservoir Fluid Compositions
Each pressurized liquid is analyzed using a combination of flash separation and gas chromatography. The liquid is flashed at a controlled temperature and separated into liquid and gas components. The gas composition is determined by GPA 2286 method using a multi-column gas chromatograph and the flashed liquid by temperature programmed capillary chromatography. The two analyses are then mathematically recombined to the flash gas-liquid ratio.

Physical Recombination
If surface separator products were collected for the reservoir fluid study, a physical recombination is required to produce a representative reservoir fluid. Following the compositional analyses, portions of the primary separator liquid and gas are physically recombined to the producing ratio in a variable volume, glass-windowed equilibrium PVT cell.

Constant Composition Expansion
A portion of the reservoir fluid sample is charged to a high pressure visual cell that is maintained at reservoir temperature. A constant composition expansion is carried out during which the saturation pressure is determined. Pressure-volume data for the single phase and two-phase fluid are also determined. The density of the single phase fluid is determined by two separate methods. A reservoir to zero flash is performed on a portion of fluid from the PVT cell and the mass of the resulting fluids are used in conjunction with the cell volumetrics. Secondly, a calibrated, high-pressure Anton Paar densitometer is also employed to measure the density of the reservoir fluid. Density data for other pressures are calculated using the volumetric data.

Constant Volume Depletion
This test is performed on gas-condensate and high-shrinkage reservoir oil samples. Performed in a visual PVT cell at reservoir temperature, this test is based on the volume of the reservoir fluid at its saturation pressure. At each step of the depletion, the fluid is expanded to the desired pressure, the volume of retrograde liquid measured using a digital cathetometer, the gas phase is displaced under isobaric conditions to a cryogenic distillation unit until the reservoir fluid is again at the starting volume; the saturation volume. The produced well-stream's composition and volume are determined. The experiment progresses until the abandonment pressure is reached at which time the remaining phases are displaced to the cryogenic distillation apparatus for compositional analysis.

Separator Tests
A multi-stage separator test is carried out using a visual PVT cell. A portion of the sample, at a pressure above saturation pressure, is transferred into the PVT cell and stabilized at the pressure and temperature required for the first stage of separation. The gas evolved is displaced from the cell and the volume and composition are determined. This is repeated for each successive pressurized stage. The final stage is conducted at

Data Used in Gas Compositional Calculations

Component		Mole Weight	Sp Gravity at 60/60 °F	Component		Mole Weight	Sp Gravity at 60/60 °F
Hydrogen	*	2.016	N/A	33DMC5	*	100.2	0.6961
Oxygen/(Argon)	**	32.00	1.1421	Cyclohexane	*	84.16	0.7835
Nitrogen (Corrected)	**	28.01	0.8094	2MC6/23DMC5	*	100.2	0.6924
Methane	**	16.04	0.3000	11DMCYC5/3MC6	*	99.20	0.7260
Carbon Dioxide	**	44.01	0.8180	t13DMCYC5	*	98.19	0.7535
Ethane	**	30.07	0.3562	c13DMCYC5/3EC5	*	99.20	0.7269
Hydrogen Sulphide	**	34.08	0.8014	t12DMCYC5	*	98.19	0.7561
Propane	**	44.10	0.5070	Heptanes (nC7)	*	100.2	0.6882
i-Butane	**	58.12	0.5629	22DMC6	*	114.2	0.7001
n-Butane	**	58.12	0.5840	MCYC6	*	98.19	0.7748
Neo-Pentane	*	72.15	0.5974	ECYC5	*	98.19	0.7712
i-Pentane	**	72.15	0.6244	223TMC5/24&25DMC6	*	114.2	0.7067
n-Pentane	**	72.15	0.6311	ctc124TMCYC5	*	112.2	0.7518
22DMC4	*	86.18	0.6535	ctc123TMCYC5	*	112.2	0.7581
23DMC4/CYC5	*	78.16	0.7137	Toluene	*	92.14	0.8743
2MC5	*	86.18	0.6578	Octanes (nC8)	*	114.2	0.7070
3MC5	*	86.18	0.6689	E-Benzene	*	106.2	0.8744
Hexanes (nC6)	*	86.18	0.6638	M/P-Xylene	*	106.2	0.8680
22DMC5	*	100.2	0.6821	O-Xylene	*	106.2	0.8849
M-C-Pentane	*	84.16	0.7540	Nonanes (nC9)	*	128.3	0.7219
24DMC5	*	100.2	0.6764	Decanes	***	134.0	0.7788
223TMC4	*	100.2	0.6954	Undecanes	***	147.0	0.7898
Benzene	*	78.11	0.8829	Dodecanes	***	161.0	0.8008

Data Source Refs :

* ASTM Data Series Publication DS 4B (1991) - Physical Constants of Hydrocarbon and Non-Hydrocarbon Compounds.
** GPA Table of Physical Constants of Paraffin Hydrocarbons and Other Components of Natural Gas, GPA 2145-96.
*** Journal of Petroleum Technology, Nov 1978, Pages 1,649-1,655.
Predicting Phase Behavior of Condensate/Crude Oil Systems Using Methane Interaction Coefficients - D.L. Katz & A. Firoozabadi.

Note :
The gas mole % compositions were calculated from the measured weight % compositions using the most detailed analysis results, involving as many of the above components as were identified. The reported component mole % compositions were then sub-grouped into the generic carbon number components.

Katz and Firoozabadi Data Used in Liquid Composition Calculations

Component		Mole Weight	Density (g/cc at 60°F)	Component		Mole Weight	Density (g/cc at 60°F)
Hydrogen	*	2.016	N/A	Undecanes	***	147	0.7890
Hydrogen Sulfide	**	34.08	0.8006	Dodecanes	***	161	0.8000
Carbon Dioxide	**	44.01	0.8172	Tridecanes	***	175	0.8110
Nitrogen	**	28.01	0.8086	Tetradecanes	***	190	0.8220
Methane	**	16.04	0.2997	Pentadecanes	***	206	0.8320
Ethane	**	30.07	0.3558	Hexadecanes	***	222	0.8390
Propane	**	44.10	0.5065	Heptadecanes	***	237	0.8470
i-Butane	**	58.12	0.5623	Octadecanes	***	251	0.8520
n-Butane	**	58.12	0.5834	Nonadecanes	***	263	0.8570
i-Pentane	**	72.15	0.6238	Eicosanes	***	275	0.8620
n-Pentane	**	72.15	0.6305	Heneicosanes	***	291	0.8670
Hexanes	**	86.18	0.6631	Docosanes	***	305	0.8720
Me-cyclo-pentane	*	84.16	0.7533	Tricosanes	***	318	0.8770
Benzene	*	78.11	0.8820	Tetracosanes	***	331	0.8810
Cyclo-hexane	*	84.16	0.7827	Pentacosanes	***	345	0.8850
Heptanes	**	92.1	0.7220	Hexacosanes	***	359	0.8890
Me-cyclo-hexane	*	98.19	0.7740	Heptacosanes	***	374	0.8930
Toluene	*	92.14	0.8734	Octacosanes	***	388	0.8960
Octanes	**	106.2	0.7450	Nonacosanes	***	402	0.8990
Ethyl-benzene	*	106.2	0.8735	Triacontanes	***	416	0.9020
Meta/Para-xylene	*	106.2	0.8671	Hentriacontanes	***	430	0.9060
Ortho-xylene	*	106.2	0.8840	Dotriacontanes	***	444	0.9090
Nonanes	**	121.0	0.7640	Tritriacontanes	***	458	0.9120
1-2-4-T-M-benzene	*	120.2	0.8797	Tetratriacontanes	***	472	0.9140
Decanes	**	134.0	0.7780	Pentatriacontanes	***	486	0.9170

Data Source Refs :

* ASTM Data Series Publication DS 4B (1991) - Physical Constants of Hydrocarbon and Non-Hydrocarbon Compounds.
** GPA Table of Physical Constants of Paraffin Hydrocarbons and Other Components of Natural Gas GPA 2145-96.
*** Journal of Petroleum Technology, Nov 1978, Pages 1,649-1,655.
Predicting Phase Behavior of Condensate/Crude Oil Systems Using Methane Interaction Coefficients - D.L. Katz & A. Firoozabadi.

Note :
The residue mole weight and density values (eg heptanes plus, undecanes plus, eicosanes plus) are calculated so that the calculated average mole weights and densities correspond with the measured values. This can lead to anomalous residue mole weights and densities where the Katz and Firoozabadi values may not be suitable for the isomer groups detected.

Normal Hydrocarbon Data Used in Liquid Composition Calculations

Component		Mole Weight	Density (g/cc at 60°F)	Component		Mole Weight	Density (g/cc at 60°F)
Hydrogen	*	2.016	N/A	Undecanes	*	156	0.7438
Hydrogen Sulfide	**	34.08	0.8006	Dodecanes	*	170	0.7520
Carbon Dioxide	**	44.01	0.8172	Tridecanes	*	184	0.7609
Nitrogen	**	28.01	0.8086	Tetradecanes	*	198	0.7625
Methane	**	16.04	0.2997	Pentadecanes	*	212	0.7714
Ethane	**	30.07	0.3558	Hexadecanes	*	226	0.7764
Propane	**	44.10	0.5065	Heptadecanes	*	240	0.7789
i-Butane	**	58.12	0.5623	Octadecanes	*	254	0.7812
n-Butane	**	58.12	0.5834	Nonadecanes	*	269	0.7861
i-Pentane	**	72.15	0.6238	Eicosanes	*	283	0.7916
n-Pentane	**	72.15	0.6305	Heneicosanes	*	297	0.7946
Hexanes	**	86.18	0.6631	Docosanes	*	311	0.7973
Me-cyclo-pentane	*	84.16	0.7533	Tricosanes	*	325	0.7996
Benzene	*	78.11	0.8820	Tetracosanes	*	339	0.8017
Cyclo-hexane	*	84.16	0.7827	Pentacosanes	*	353	0.8019
Heptanes	**	100.2	0.6875	Hexacosanes	*	367	0.8071
Me-cyclo-hexane	*	98.19	0.7740	Heptacosanes	*	381	0.8078
Toluene	*	92.14	0.8734	Octacosanes	*	395	0.8093
Octanes	**	114.2	0.7063	Nonacosanes	*	409	0.8112
Ethyl-benzene	*	106.2	0.8735	Triacontanes	*	423	0.8124
Meta/Para-xylene	*	106.2	0.8671	Hentriacontanes	*	437	0.8141
Ortho-xylene	*	106.2	0.8840	Dotriacontanes	*	451	0.8159
Nonanes	**	128.3	0.7212	Tritriacontanes	*	465	0.8179
1-2-4-T-M-benzene	*	120.2	0.8797	Tetratriacontanes	*	479	0.8200
Decanes	**	142.3	0.7335	Pentatriacontanes	*	493	0.8234

Data Source Refs :

* ASTM Data Series Publication DS 4B (1991) - Physical Constants of Hydrocarbon and Non-Hydrocarbon Compounds.
** GPA Table of Physical Constants of Paraffin Hydrocarbons and Other Components of Natural Gas GPA 2145-96.

Quality Assurance

The above work, and data presented herein, was performed by Reservoir Fluid Services (an ISO 9001 registered company) located at 5820 Highway 90 East, Broussard, LA 70518. As part of our quality assurance program, in addition to mass balance checks that must match within 1%, this data was modeled by equation-of-state (EOS) and met specific matching criteria before these results were approved for release. The signatures below verify that this process, and an overall quality assurance review of this report, was performed. All work was carried out according to Reservoir Fluid Services' ISO approved sample handling and analysis procedures. A detailed listing and explanation of these procedures may be found in Reservoir Fluid Services' Reference Manual.

Reservoir Fluid Services is committed to enhancing production by offering the best available reservoir fluid sampling and analytical technology, methodology, personnel and management. Our equipment is regularly calibrated, checked and upgraded as necessary. Our procedures are continually evolving based on the latest industry findings and requirements. Our people are thoroughly trained and held to the highest standards of professional conduct. Our management is committed to providing the resources and manpower necessary to get the timely answers needed to make informed reservoir engineering and production decisions. Constructive feedback is always welcome and we pledge to incorporate these ideas into our ongoing quest to provide the best available service and data in the reservoir fluid sampling and analysis industry.

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