

RES.10.10
LO16-14 "BASAL SAND"
Oct-96

FLUID ANALYSIS LOBITOS

CENTRAL FILE
GEOSCIENCES

PVT

Reservoir Fluid Study
for

R. Lobos

PETRO-TECH PERUANA S.A.

LO16-14
Lobitos
Talara-Offshore

7000 T. 1.0-10

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GEOSCIENCES

RFL 96190
21-Oct-96

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Core Laboratories Venezuela, S.A.

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**CORE LABORATORIES
VENEZUELA, S.A.**

RFLC9610.010

October 21, 1996

PETRO-TECH PERUANA, S.A.

Av. Los Incas 460. Lima 27-Perú

*Attention: Mr. John W. Mayers
Production Manager*

*Subject: Reservoir Fluid Study
Well: LO16-14
Field: LOBITOS
File: RFL 96190*

Gentlemen:

Separator gas and liquid samples from the subject well were collected by representatives of Core Laboratories Venezuela, S.A. on July 24, 1996. The samples were delivered to our fluids laboratory in Maracaibo for use in the performance of a reservoir fluid study. The final report of this study may be found on the following pages

It has been a pleasure to perform this reservoir fluid study for PETRO-TECH PERUANA, S.A. Should any questions arise or if we may be of further service in any way, please do not hesitate to contact us.

Sincerely,
CORE LABORATORIES VENEZUELA, S.A.


James Fortner
Manager
Reservoir Fluids Lab

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JF/sr.

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LABORATORY PROCEDURES

PETRO-TECH PERUANA, S.A.

Reservoir Fluid Study

LO16-14 Well

Lobitos Field

RFL 96190

On July 24 of 1996, separator gas and separator liquid samples were collected by Core Laboratories representatives and delivered to our Maracaibo laboratory. The quality checks were performed at laboratory temperature, measuring the bubble point pressure of the separator liquid samples, opening pressures and air content for the separator gases. A summary of the samples received may be found on page four (4).

The composition of the separator gas was measured through C_{11+} by routine, and temperature programmed chromatography. The composition of the separator liquid was measured through C_{20+} using the spikeflash/chromatography technique. The results of these analyses are presented on pages five (5) and six (6), respectively.

After correcting the separator gas and stock tank liquid production rates for the factors shown on page seven (7), the producing gas-liquid ratio was calculated to be 683 cubic feet of separator gas at 14.7 psia and 60 °F per barrel of separator liquid at 40 psig and 62 °F. This gas/liquid ratio was used in conjunction with the measured hydrocarbon compositions of the separator products to calculate the reservoir fluid composition. This composition is presented on page eight (8). The gas and liquid samples were then physically recombined at their producing gas/liquid ratio, and the resulting fluid was used for the remainder of the study.

A portion of the recombined reservoir fluid was charged to a high pressure, windowed cell and then heated to the reported original reservoir temperature of 129 °F. During the constant composition expansion at this temperature, a bubble point was observed at 3580 psig. The results of the pressure-volume relations are presented on pages nine (9) through twelve (12).

During the differential vaporization at the reservoir temperature, the fluid evolved a total of 731 cubic feet of gas at 14.7 psia and 60 °F per barrel of residual oil at 60 °F. The resulting relative oil volume factor was 1.350 barrels of saturated fluid per barrel of residual oil at 60 °F. The oil density and the properties of the evolved gases were measured at each point during the differential pressure depletion. The data are included in the summary of the differential vaporization analysis on pages thirteen (13) through eighteen (18).

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The viscosity of the reservoir fluid was measured over a wide range of pressures at reservoir temperature in a rolling-ball viscosimeter. The viscosity of the fluid was found to vary from a minimum of 0.92 centipoises at the saturation pressure to a maximum of 3.72 centipoises at atmospheric pressure. The results of the viscosity measurements are presented on pages nineteen (19) through twenty-one (21).

Small portions of the reservoir fluid were subjected to three separator tests to determine the effects of separator pressure on gas/oil ratio, stock tank oil gravity and formation volume factor. These data can be found on page twenty-two (22). The separator gases from the separator tests were collected and chromatographically analyzed in the laboratory. The results of the separator gas compositions are presented on pages twenty three (23) through twenty-five (25).

The separator test data were then used to adjust the differential vaporization results. The adjusted differential vaporization data are presented on pages twenty-six (26) through thirty (30).

The report includes graphical representations with analytical expressions which model the data sets as a function of pressure at the reported reservoir temperature. An appendix is also provided which defines the nomenclature and extends the analytical relationships.

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SUMMARY OF PVT DATA**Reported Reservoir Conditions**

Average Reservoir Pressure	4216	psig
Average Reservoir Temperature	129	°F

Pressure-Volume Relations

Saturation Pressure	3580	psig
Avg Single-Phase Compressibility	8.85	E-6 v/v/psi (5000 to 3580 psig)
Thermal Exp @ 5000 psig	1.03834	V at 129 °F / V at 60 °F

Differential Vaporization Data

(at 3580 psig and 129 °F)

Solution Gas/Oil Ratio	731	scf / bbl of residual oil at 60 °F
Relative Oil Volume	1.350	bbl / bbl of residual oil at 60 °F
Density of Reservoir Fluid	0.7263	gm/cc

Reservoir Fluid Viscosity

0.920 cp at 3580 psig and 129 °F

Separator Test Results

Separator Conditions		Formation Volume Factor (A)	Total Solution Gas/Oil Ratio (B)	Tank Oil Gravity (°API at 60 °F)
psig	°F			
135	70	1.317	681	33.8
90	70	1.319	685	33.7
40	70	1.329	702	33.6

(A) Barrels of saturated oil per barrel of stock tank oil at 60 °F.

(B) Total standard cubic feet of gas per barrel of stock tank oil at 60 °F.

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**LO16-14
RFL 96190**

General Well Information

Company.....	PETRO-TECH PERUANA S.A.
Well Name.....	LO16-14
API Well Number.....	*
File Number.....	RFL 96190
Date Sample Collected.....	24-Jul-96
Sample Type.....	Separator
Geographical Location.....	Talara-Offshore
Field.....	Lobitos

Well Description

Formation.....	Basal Salina	
Pool (or Zone).....	Lobitos Offshore	
Date Completed.....	13-Apr-96	
Elevation.....	*	ft
Producing Interval.....	9464-9460 MD	ft
Total Depth.....	*	ft
Tubing Size.....	*	in
Tubing Depth.....	*	ft
Casing Size.....	5 1/2"	in
Casing Depth.....	Plug at 9750 MD	ft

Pressure Survey Data

Data from Original Discovery Well

Date	12-Dec-95	
Reservoir Pressure	4216	psig

Data at Sample Collection

Date.....	24-Jul-96	
Reservoir Pressure.....	*	psig
Reservoir Temperature.....	129	°F
Pressure Tool.....	*	
Flowing Bottom-Hole Pressure.....	1360	psig
Flowing Tubing Pressure.....	135	psig

* Data not forwarded to Core Laboratories.

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Production Data

Data from Original discovery Well

Location.....	Lobitos Offshore	
Date.....	13-Apr-96	
Oil Gravity @ STP.....	*	°API
Separator Pressure.....	*	psig
Separator Temperature.....	*	°F
Production Rates		
Gas.....	777	Mscf/D
Liquid.....	1120	STbbl/D
Gas/Liquid Ratio.....	694	scf/bbl

Separator Conditions

Primary Separator Pressure.....	40	psig
Primary Separator Temperature.....	62	°F
Secondary Separator Pressure.....	*	psig
Secondary Separator Temperature.....	*	°F
Primary Separator Gas Production Rate.....	777	Mscf/D

Gas Factors -

Field Values:		
Pressure Base.....	14.7	psia
Temperature Base.....	60	°F
Compressibility Factor (Fpv).....	1.0029	
Gas Gravity Factor (Fg).....	1.2092	
Laboratory Values:		
Pressure Base.....	14.7	psia
Temperature Base.....	60	°F
Compressibility Factor (Fpv).....	1.0047	
Gas Gravity Factor (Fg).....	1.1964	

Adjusted Primary Separator Gas Prod Rate.....	770	Mscf/D		
Primary Separator Liquid Rate.....	1128	bbl/D	at	62 °F
Stock Tank Liquid Rate.....	1120	bbl/D	at	60 °F
Separator Gas / Separator Liquid Ratio.....	683	scf/bbl		
Separator Gas / Stock Tank Liquid Ratio.....	688	scf/bbl		
Stock Tank Liquid / Separator Gas Ratio.....	*	bbl/Mscf		
Separator Liquid / Stock Tank Liquid Ratio.....	1.007	bbl/bbl	at	60 °F

* Data not forwarded to Core Laboratories.

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**PRELIMINARY CHECKS OF SAMPLE QUALITY
AND SUMMARY OF SAMPLES RECEIVED**

Separator Gas					
Cylinder Number	Sampling Conditions		Laboratory Opening Conditions		
	psig	°F	psig	°F	Air Content (mol %)
A-9233	40	62	38	70	0.33
A-10989*	40	62	38	70	0.61

Separator Liquid					
Cylinder Number	Sampling Conditions		Laboratory Bubblepoint		Water Recovered (cc)
	psig	°F	psig	°F	
CV-03-0003	40	62	40	70	0
464213D*	40	62	40	72	0

* These samples selected for recombination and further analysis.

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COMPOSITION OF PRIMARY STAGE SEPARATOR GAS

(by Programmed-Temperature, Capillary Chromatography)

Component	Mol %	Plant Products (GPM)	Liquid Density (gm/cc)	MW
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.11		0.8172	44.010
Nitrogen	0.25		0.8086	28.013
Methane	84.72		0.2997	16.043
Ethane	6.69	1.784	0.3562	30.070
Propane	4.16	1.143	0.5070	44.097
iso-Butane	1.06	0.346	0.5629	58.123
n-Butane	1.62	0.509	0.5840	58.123
iso-Pentane	0.51	0.186	0.6244	72.150
n-Pentane	0.34	0.123	0.6311	72.150
Hexanes	0.24	0.093	0.6850	84.0
Heptanes	0.18	0.076	0.7220	96.0
Octanes	0.10	0.045	0.7450	107
Nonanes	0.02	0.010	0.7640	121
Totals	100.00	4.315		

SAMPLING CONDITIONS

40 psig

62 °F

Gas Cylinder

A-10989

Average Sample Properties

Critical Pressure, psia 660.9

Critical Temperature, °R 388.3

Average Molecular Weight 20.23

Calculated Gas Gravity (air = 1.000) 0.699

at 14.7 psia and 60 °F

Heating Value, Btu/scf dry gas*

Gross 1228

Properties of Plus Fractions

Component	Mol %	Liquid Density (gm/cc)	Liquid API Gravity	MW
Heptanes plus	0.30	0.7332	61.3	101.3

Note: Component properties assigned from literature.

* ref: Gas Producers & Suppliers Association (GPSA) Engineering Data Book

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(by Flash/Extended Chromatography)

SAMPLING CONDITIONS

40 psig
62 °F

Liquid Cylinder
464213D

Average Sample Properties

Average Molecular Weight	208.73
Calculated Density at 0 psig and 60 °F	0.8541

Properties of Plus Fractions

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WELLSTREAM RECOMBINATION CALCULATION

(based on field production data)

Conditions for Recombination Calculations

Primary Stage at 40 psig and 62 °F

Stock Tank at 0 psig and 60 °F

Field Gas Rate Correction Factors -

Gas Gravity (air=1.000)	0.684
Gas Gravity Factor, Fg	1.2092
Gas Deviation Factor, Z	0.994
Super Compressibility Factor, Fpv	1.0029
Pressure Base, psia	14.7

Laboratory Gas Rate Correction Factors -

Gas Gravity (air=1.000)	0.699
Gas Gravity Factor, Fg	1.1964
Gas Deviation Factor*, Z	0.991
Supercompressibility Factor, Fpv	1.0047
Pressure Base, psia	14.7

Laboratory Liquid Rate Correction Factors -

Liquid Volume Factor, S [*] bbl/STbbl @ 60 °F	1.0070
Bitumen, Sediment & Water (BS&W) Factor	1.000

Field Measured Rates and Ratios -

Primary Stage Gas Flow Rate, Mscf/D	777.00
Stock Tank Liquid Flow Rate, bbl/D	1120
Field Gas / Oil Ratio, scf/STbbl	693.75

Recombination Rates and Ratios -

Primary Stage Gas Flow Rate, Mscf/D	770.20
Primary Stage Liquid Flow Rate, bbl/D	1128
Primary Stage Gas / Oil Ratio, scf/S [*] bbl	682.90
Stock Tank Liquid Flow Rate, bbl/D	1120
Corrected Gas / Oil Ratio, scf/STbbl	687.68

Wellstream Recombination Ratio
mol/mol

1.2560

* From: Standing, M.B., "Volumetric and Phase Behavior of Oil Field Hydrocarbon Systems", SPE (Dallas), 1977, 8th Edition, Appendix II.

** Data not supplied to Core Laboratories

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COMPOSITION OF RECOMBINED WELLSTREAM

(from calculated recombination of separator products)

Component	Mol %	Wt%	Liquid Density (gm/cc)	MW
Hydrogen Sulfide	0.00	0.00		
Carbon Dioxide	0.06	0.03	0.8172	44.010
Nitrogen	0.14	0.04	0.8086	28.013
Methane	47.54	7.35	0.2997	16.043
Ethane	3.97	1.15	0.3562	30.070
Propane	3.00	1.27	0.5070	44.097
iso-Butane	1.75	0.98	0.5629	58.123
n-Butane	2.35	1.32	0.5840	58.123
iso-Pentane	1.38	0.96	0.6244	72.150
n-Pentane	0.99	0.69	0.6311	72.150
Hexanes	1.93	1.56	0.6850	84.0
Heptanes	3.79	3.50	0.7220	96.0
Octanes	5.48	5.65	0.7450	107
Nonanes	3.78	4.41	0.7640	121
Decanes	2.89	3.73	0.7780	134
Undecanes	2.30	3.26	0.7890	147
Dodecanes	1.85	2.87	0.8000	161
Tridecanes	2.09	3.52	0.8110	175
Tetradecanes	1.78	3.26	0.8220	190
Pentadecanes	1.66	3.29	0.8320	206
Hexadecanes	1.15	2.46	0.8390	222
Heptadecanes	1.12	2.56	0.8470	237
Octadecanes	1.15	2.78	0.8520	251
Nonadecanes	0.70	1.77	0.8570	263
Eicosanes plus	7.15	41.59	0.9764	604
Totals	100.00	100.00		

RECOMBINATION CONDITIONS

**40 psig
62 °F**

Recombination Parameters

Primary Stage Gas / Oil Ratio, scf/S*bbbl
at recombination conditions 682.90

Wellstream Recombination Ratio
moles gas / mole liquid 1.2560

Average Wellstream Properties

Average Molecular Weight 103.8

Calculated Density at 0 psig and 60 °F 0.7348

Properties of Plus Fractions

Plus Fraction	Mol%	Wt%	Liquid Density (gm/cc)	Liquid API Gravity	MW
Heptanes plus	36.89	84.65	0.8740	30.2	238
Undecanes plus	20.95	67.36	0.9120	23.5	334
Pentadecanes plus	12.93	54.45	0.9416	18.6	438
Eicosanes plus	7.15	41.59	0.9764	13.3	604

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VOLUMETRIC DATA

(at 129 °F)

Saturation Pressure (Psat) 3580 psig
Density at Psat 0.7263 gm/cc
Thermal Exp @ 5000 psig 1.03834 V at 129 °F / V at 60 °F

AVERAGE SINGLE-PHASE COMPRESSIBILITIES

Pressure Range psig			Single-Phase Compressibility v/v/psi
5000	to	4500	8.46 E -6
4500	to	4216	8.68 E -6
4216	to	4000	9.00 E -6
4000	to	3900	9.26 E -6
3900	to	3800	9.44 E -6
3800	to	3700	9.65 E -6
3700	to	3600	9.87 E -6
3600	to	3580	10.01 E -6

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PRESSURE-VOLUME RELATIONS
(at 129 °F)

Pressure psig	Relative Volume (A)	Y-Function (B)	Density gm/cc
5000	0.9874		0.7356
4500	0.9916		0.7325
4216	0.9941		0.7307
4000	0.9960		0.7293
3900	0.9969		0.7286
3800	0.9979		0.7279
3700	0.9988		0.7272
3600	0.9998		0.7265
3580	1.0000		0.7263
3535	1.0022		
3510	1.0035		
3490	1.0046		
3480	1.0051		
3420	1.0084		
3075	1.0320	5.107	
2640	1.0769	4.603	
2215	1.1479	4.139	
1860	1.2431	3.775	
1580	1.3580	3.504	
1345	1.4999	3.288	
1160	1.6589	3.126	
1000	1.8495	2.993	
940	1.9391	2.944	
720	2.4031	2.774	
610	2.7647	2.694	
530	3.1227	2.638	
370	4.2966	2.531	

(A) Relative Volume: V/V_{sat} or volume at indicated pressure per volume at saturation pressure.

(B) Where: Y-Function =
$$\frac{(P_{sat} - P)}{(P_{abs}) * (V/V_{sat} - 1)}$$

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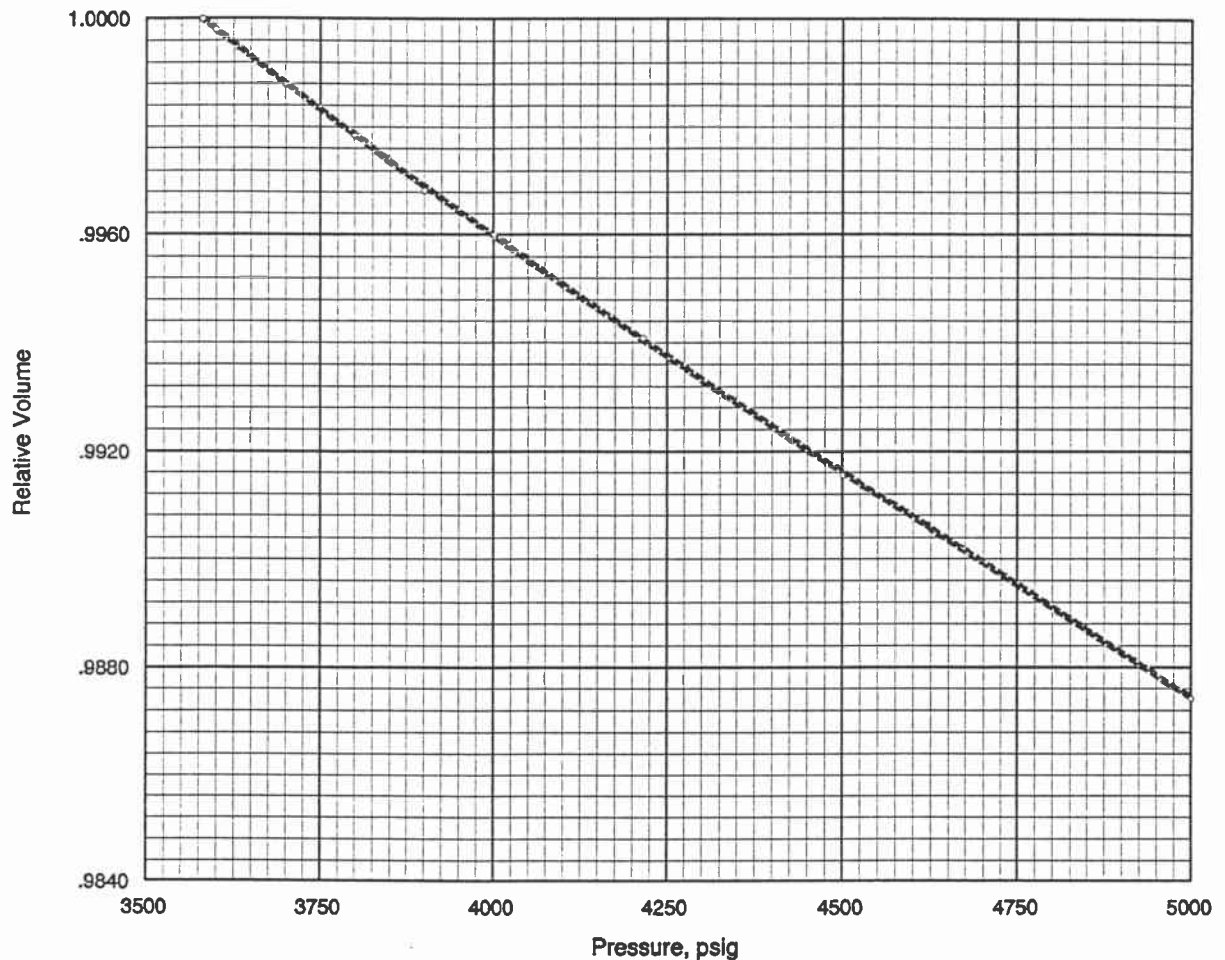
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RELATIVE VOLUME

(at 129 °F)



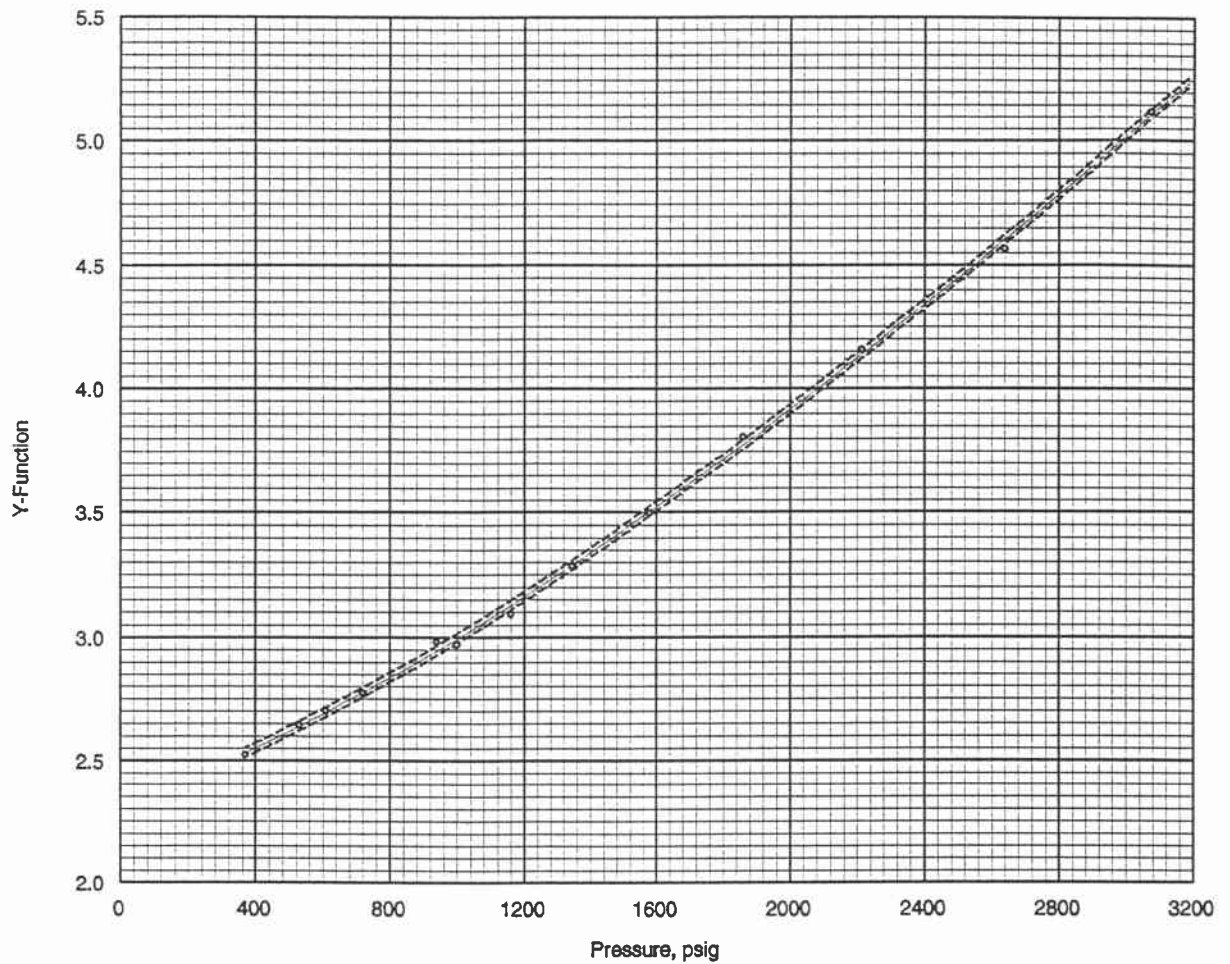
Relative Volume Expression: $y = a + b (X_d)^i + c (X_d)^j$	LEGEND ○ Laboratory Data ----- Confidence Limits ————— Analytical Expression Saturation Pressure: 3580 psig Current Reservoir Pressure: 4216 psig	
where: a= 3.37200e+ 00 b= -2.37196e+ 00 c= -3.91443e- 05 i= 0.015 j= 8.584 Note: X_d (dimensionless 'X') = P_i / P_{sat}		
Confidence level: 99 % Confidence interval: +/- 0.00005 'r squared': .999906	Pressure-Volume Relations Figure A-1	

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Y-FUNCTION (at 129 °F)



Y-Function Expression: $y = a + b (X_d)^i + c (X_d)^j$	LEGEND ○ Laboratory Data ----- Confidence Limits ————— Analytical Expression Saturation Pressure: 3580 psig Current Reservoir Pressure: 4216 psig
where: a= 2.29585e+ 00 b= 4.87540e- 01 c= 2.94200e+ 00 i= 0.614 j= 1.431 Note: X_d (dimensionless 'X') = P_i / P_{sat},	
Confidence level: 99 % Confidence interval: +/- 0.0195 'r squared': .999498	Pressure-Volume Relations Figure A-2

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DIFFERENTIAL VAPORIZATION

(at 129 °F)

Pressure psig	Solution Gas/Oil Ratio Rsd (A)	Relative Oil Volume Bod (B)	Relative Total Volume Btd (C)	Oil Density gm/cc	Deviation Factor Z	Gas Formation Volume Factor (D)	Incremental Gas Gravity (Air=1.000)
b»3580	731	1.350	1.350	0.7263			
3200	657	1.319	1.377	0.7345	0.841	0.00436	0.689
2800	580	1.288	1.424	0.7431	0.849	0.00502	0.676
2400	504	1.259	1.498	0.7518	0.859	0.00592	0.665
2000	430	1.230	1.616	0.7606	0.869	0.00718	0.655
1600	356	1.202	1.809	0.7697	0.881	0.00908	0.649
1200	283	1.175	2.155	0.7790	0.895	0.01227	0.650
800	207	1.147	2.888	0.7888	0.913	0.01866	0.662
400	126	1.116	5.184	0.7997	0.939	0.03771	0.706
150	62	1.089	12.754	0.8087	0.968	0.09783	0.798
0	0	1.033		0.8296			1.728

@ 60 °F = 1.000

Gravity of Residual Oil = 33.4 °API at 60 °F

Density of Residual Oil = 0.8573 gm/cc at 60 °F

(A) Cubic Feet of gas at 14.7 psia and 60 °F per Barrel of residual oil at 60 °F.

(B) Barrel of oil at indicated pressure and temperature per Barrel of residual oil at 60 °F.

(C) Barrels of oil plus liberated gas at indicated pressure and temperature per Barrel of residual oil at 60 °F.

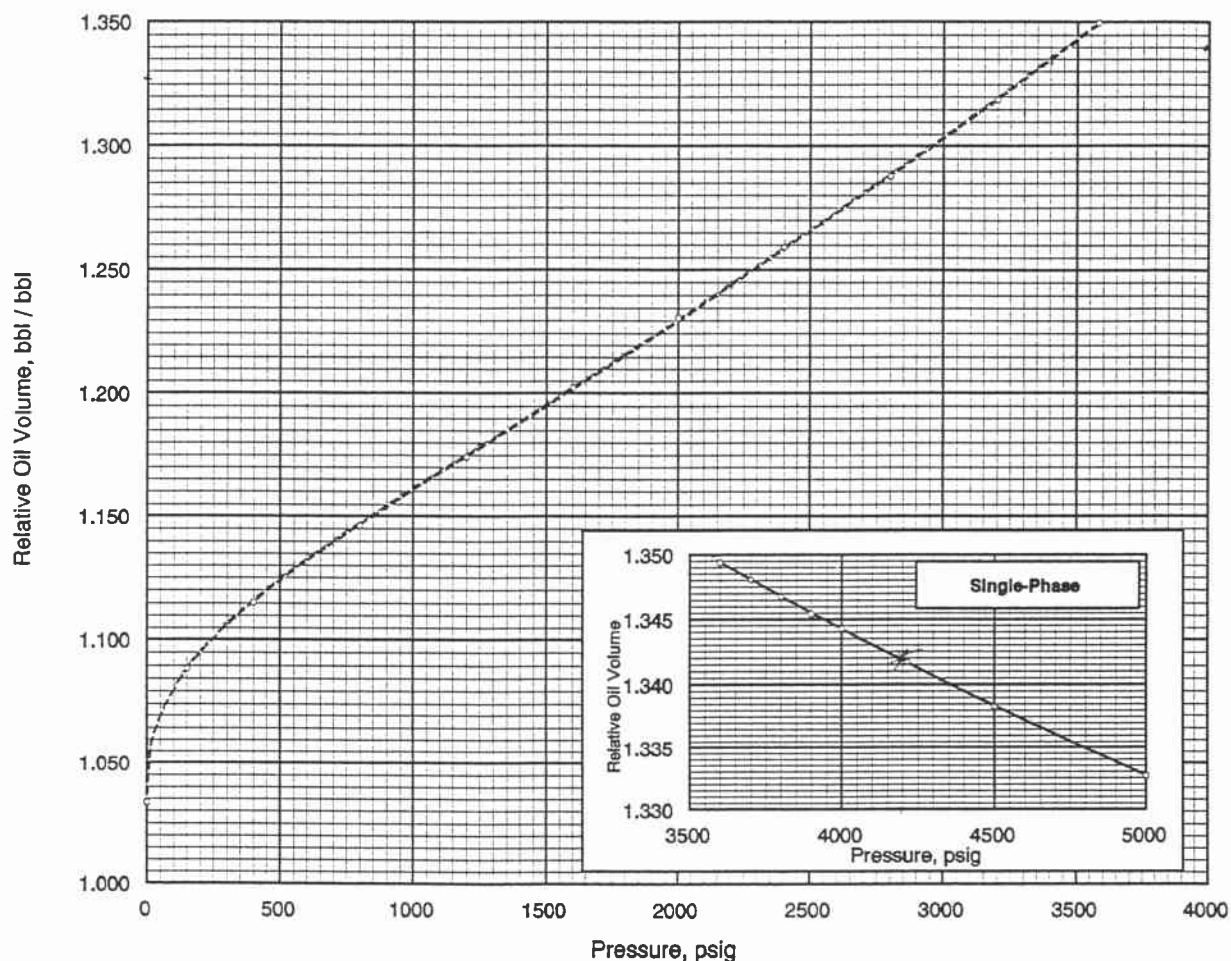
(D) Cubic Feet of gas at indicated pressure and temperature per Cubic Feet at 14.7 psia and 60 °F.

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RELATIVE OIL VOLUME (at 129 °F)



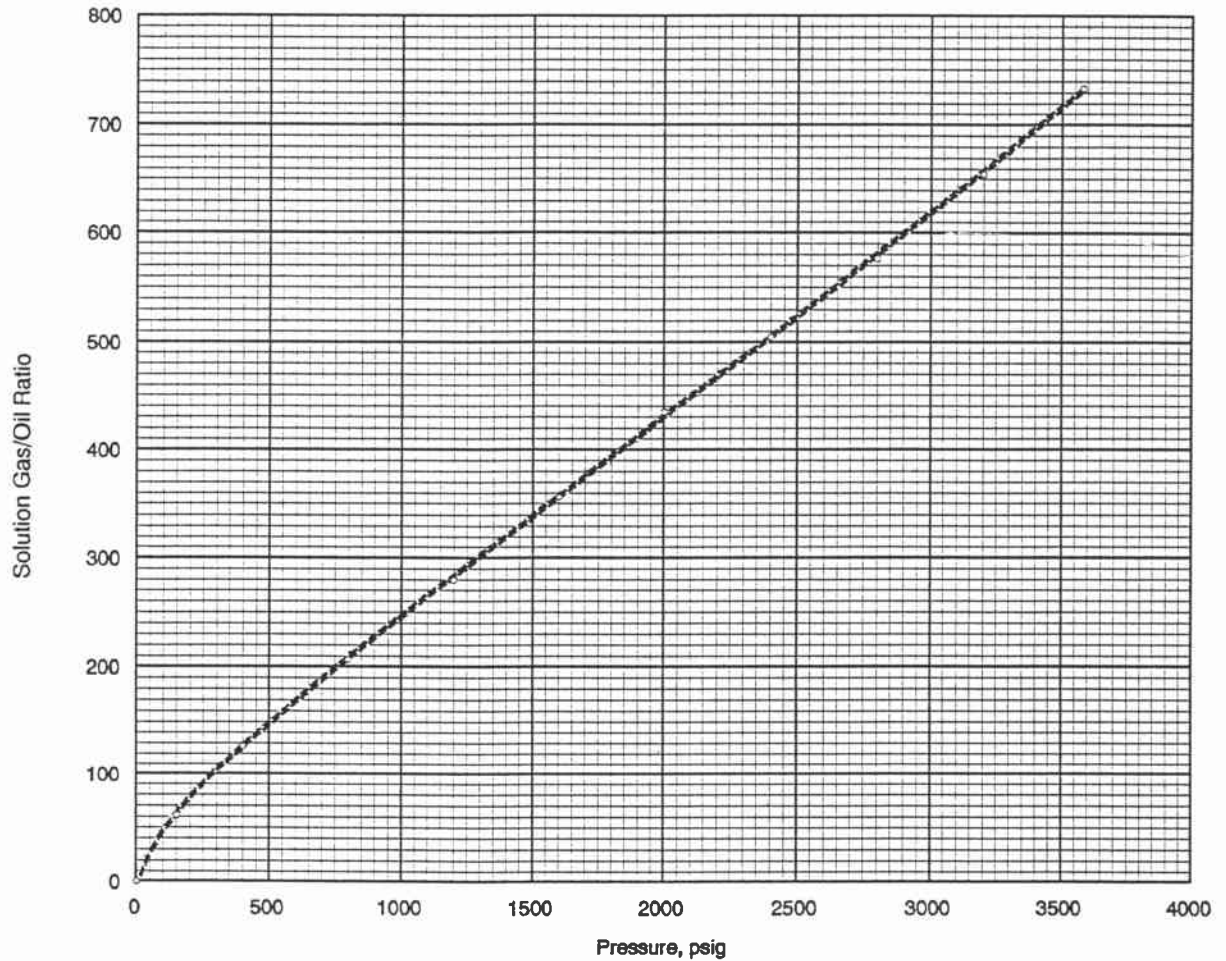
Relative Oil Volume Expression: $y = a + b (Xi)^i + c (Xi)^j$	LEGEND
where: a= 1.03312e+ 00 i= 0.371 b= 8.51102e- 03 j= 1.630 c= 2.24533e- 07 Note: Xi (incremental 'X') = pressure, psig	○ Laboratory Data ----- Confidence Limits _____ Analytical Expression Saturation Pressure: 3580 psig
Confidence level: 99 % Confidence interval: +/- 0.00059 'r squared': .999962	Differential Vaporization Figure B-1

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SOLUTION GAS/OIL RATIO (scf/bbl at 129 °F)



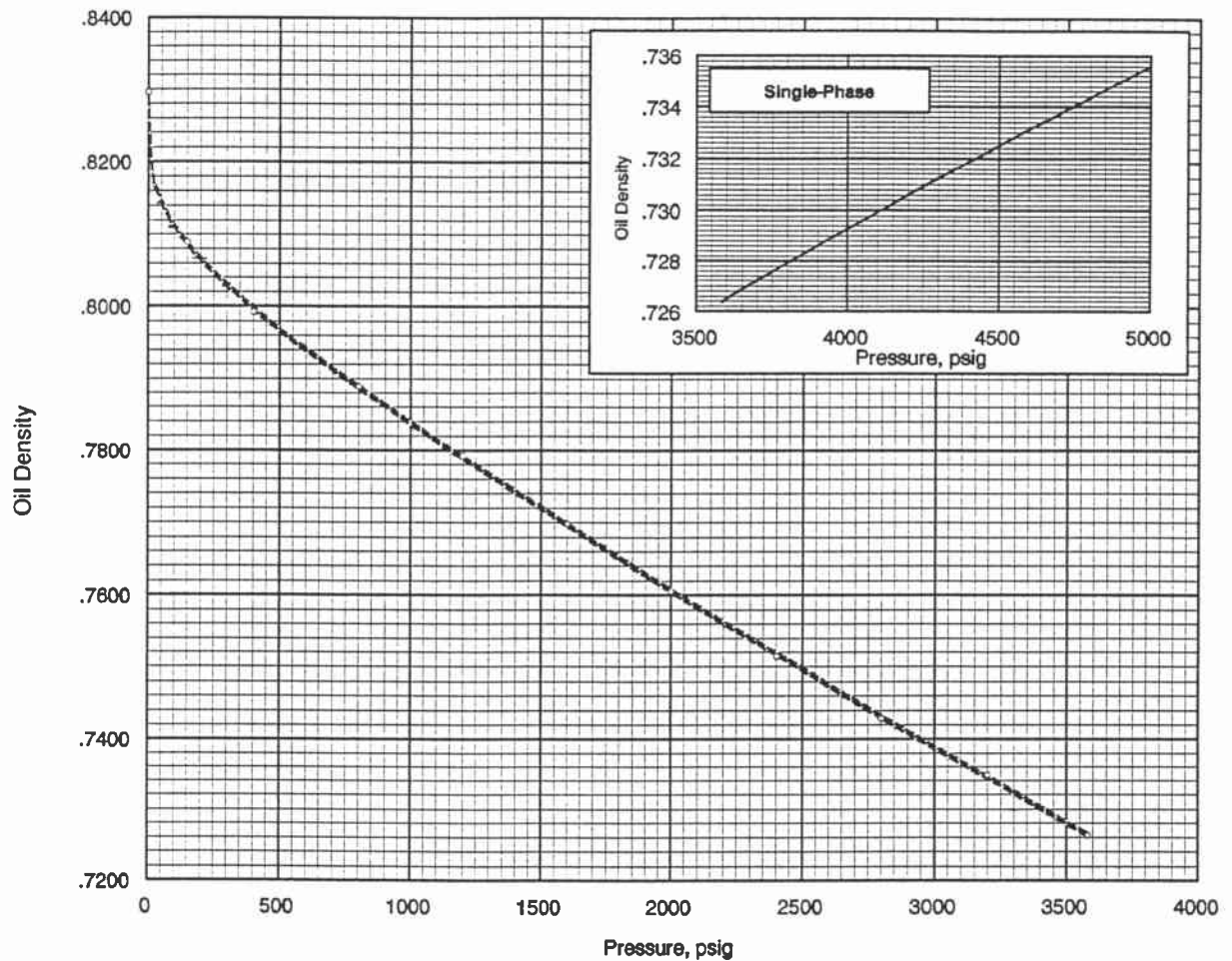
Solution Gas/Oil Ratio Expression: $y = a + b (X_i)^i + c (X_i)^j + d (X_i)^k$	LEGEND ○ Laboratory Data ----- Confidence Limits ————— Analytical Expression Saturation Pressure: 3580 psig
where: a= -7.62491e- 04 b= 7.49502e+ 00 c= 2.40293e- 03 d= -2.19470e+ 01 i= 0.492 j= 1.452 k= 0.061 Note: X_i (incremental 'X') = pressure, psig	
Confidence level: 99 % Confidence interval: +/- 2.14 scf/bbl 'r squared': .999917	Differential Vaporization Figure B-2

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OIL DENSITY (gm/cc at 129 °F)



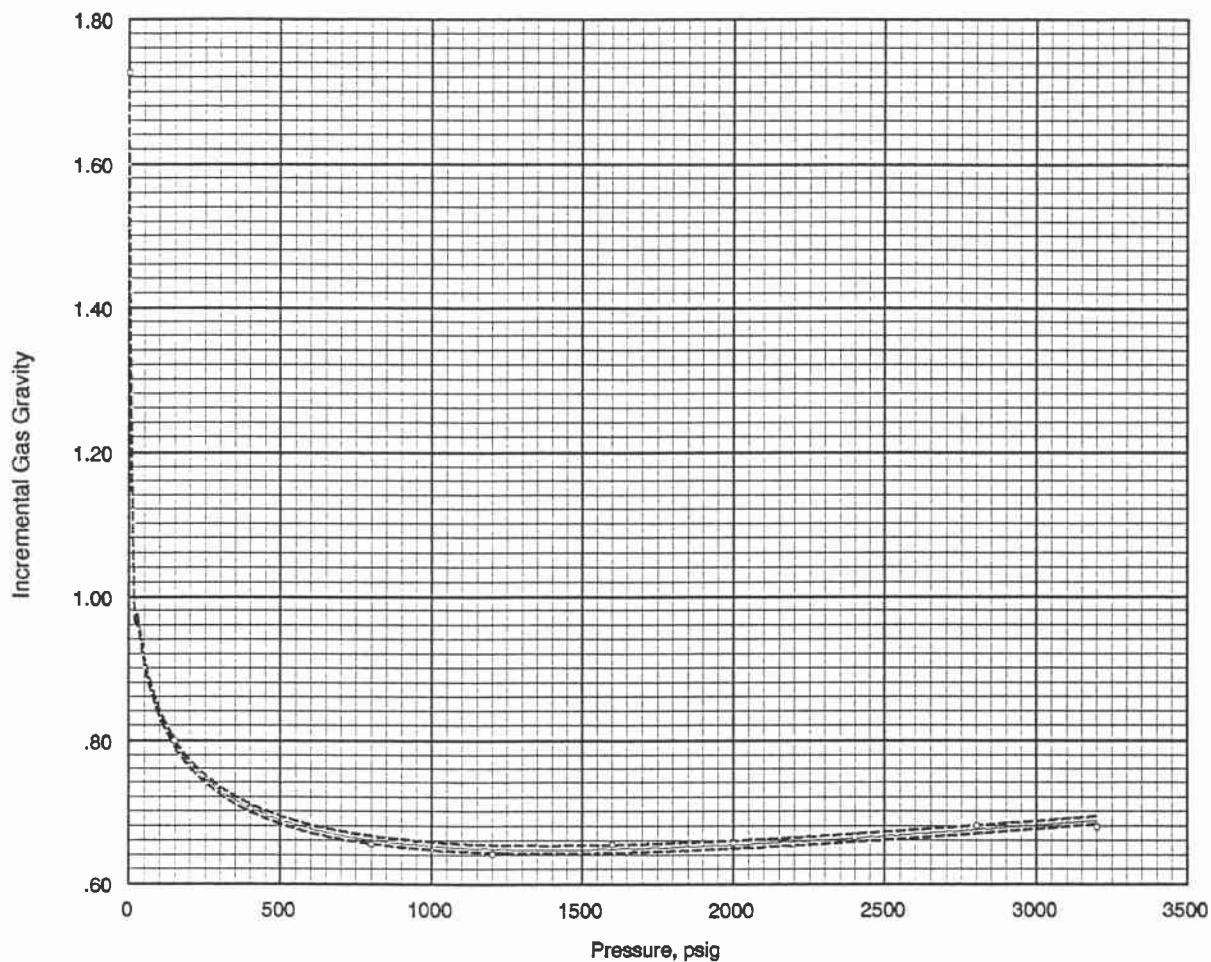
Oil Density Expression (below bubblepoint): $y = a + b (X_d)^i + c (X_d)^j + d (X_d)^k$	LEGEND
where: $a = 8.29561e-01$ $b = 5.18514e-02$ $c = -6.85093e-02$ $d = -8.65717e-02$ $i = 0.551$ $j = 0.307$ $k = 0.969$	○ Laboratory Data ----- Confidence Limits ———— Analytical Expression Saturation Pressure: 3580 psig
Note: X_d (dimensionless 'X') = P_i / P_{sat}	
Confidence level: 99 % Confidence interval: +/- 0.00025 gm/cc 'r squared': .999934	Differential Vaporization Figure B-3

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GAS GRAVITY (at 129 °F)



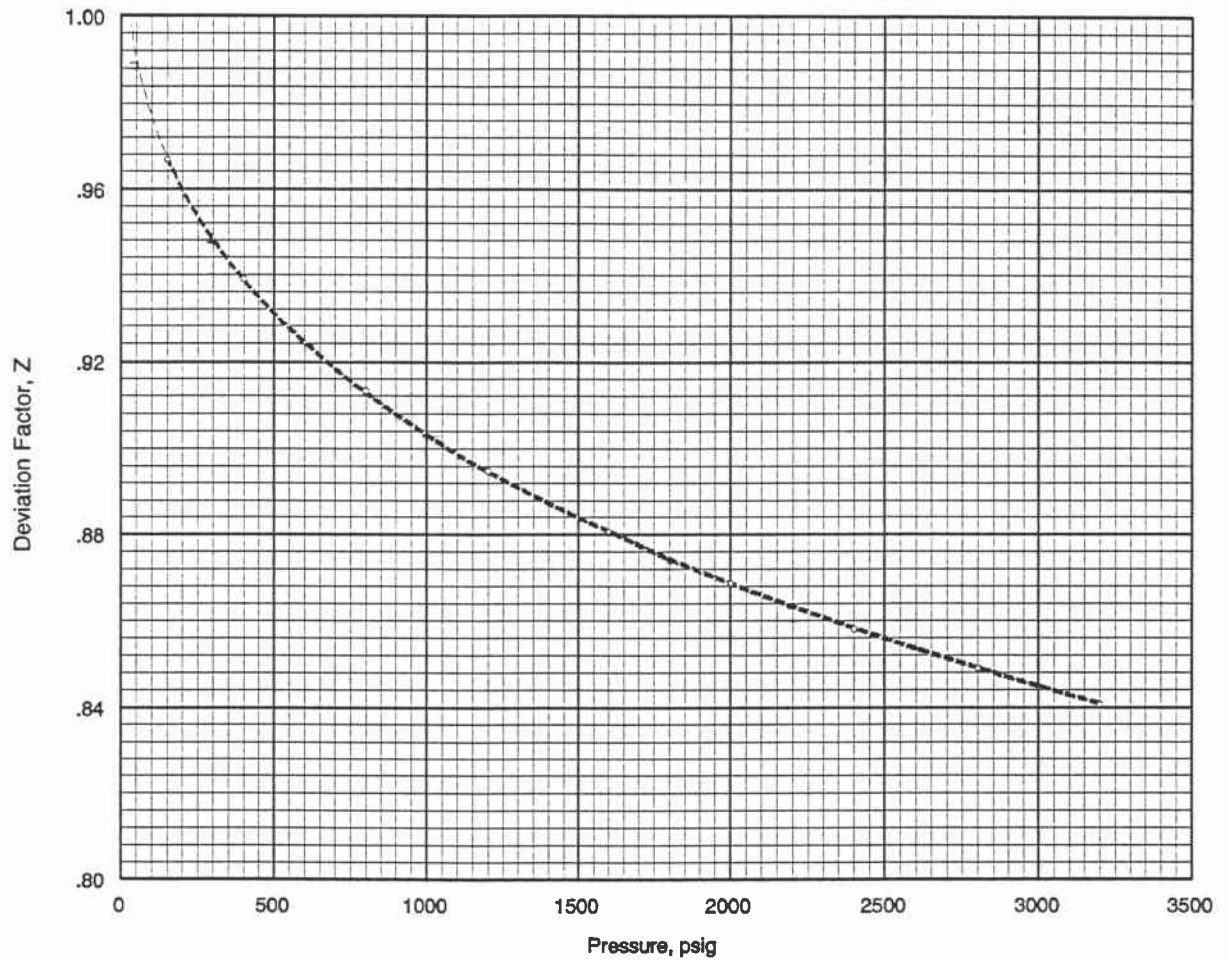
Gas Gravity Expression: $y = a + b (X_d)^i + c (X_d)^j$	LEGEND
where: $a = 1.72789e+00$ $b = 1.09423e+00$ $c = -2.12070e+00$ $i = 0.476$ $j = 0.187$ Note: X_d (dimensionless 'X') = P_i / P_{sat}	$\circ$ ----- _____ Laboratory Data Confidence Limits Analytical Expression Saturation Pressure: 3580 psig
Confidence level: 99 % Confidence interval: +/- 0.0055 'r squared': .999742	Differential Vaporization Figure B-4

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DEVIATION FACTOR, Z (at 129 °F)



Deviation Factor Expression: $y = a + b (X_d)^i + c (X_d)^j$	LEGEND ○ Laboratory Data ----- Confidence Limits ————— Analytical Expression Saturation Pressure: 3580 psig
where: a= 9.99995e- 01 b= -2.23277e- 01 c= 5.69562e- 02 i= 0.300 j= 0.018 Note: X_d (dimensionless 'X') = P_i / P_{sat},	
Confidence level: 99 % Confidence interval: +/- 0.0003 'r squared': .999977	Differential Vaporization Figure B-5

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RESERVOIR FLUID VISCOSITY

(at 129 °F)

Pressure psig	Oil Viscosity cp	Gas Viscosity cp	Oil/Gas Viscosity ratio
5000	1.06		
4500	1.01		
4000	0.962		
3800	0.942		
b»3580	0.920		
3200	0.959	0.0229	41.9
2800	1.01	0.0203	49.9
2400	1.09	0.0182	59.5
2000	1.18	0.0166	71.3
1600	1.31	0.0152	86.0
1200	1.48	0.0141	105
800	1.73	0.0131	132
400	2.13	0.0122	175
150	2.61	0.0114	229
0	3.72		

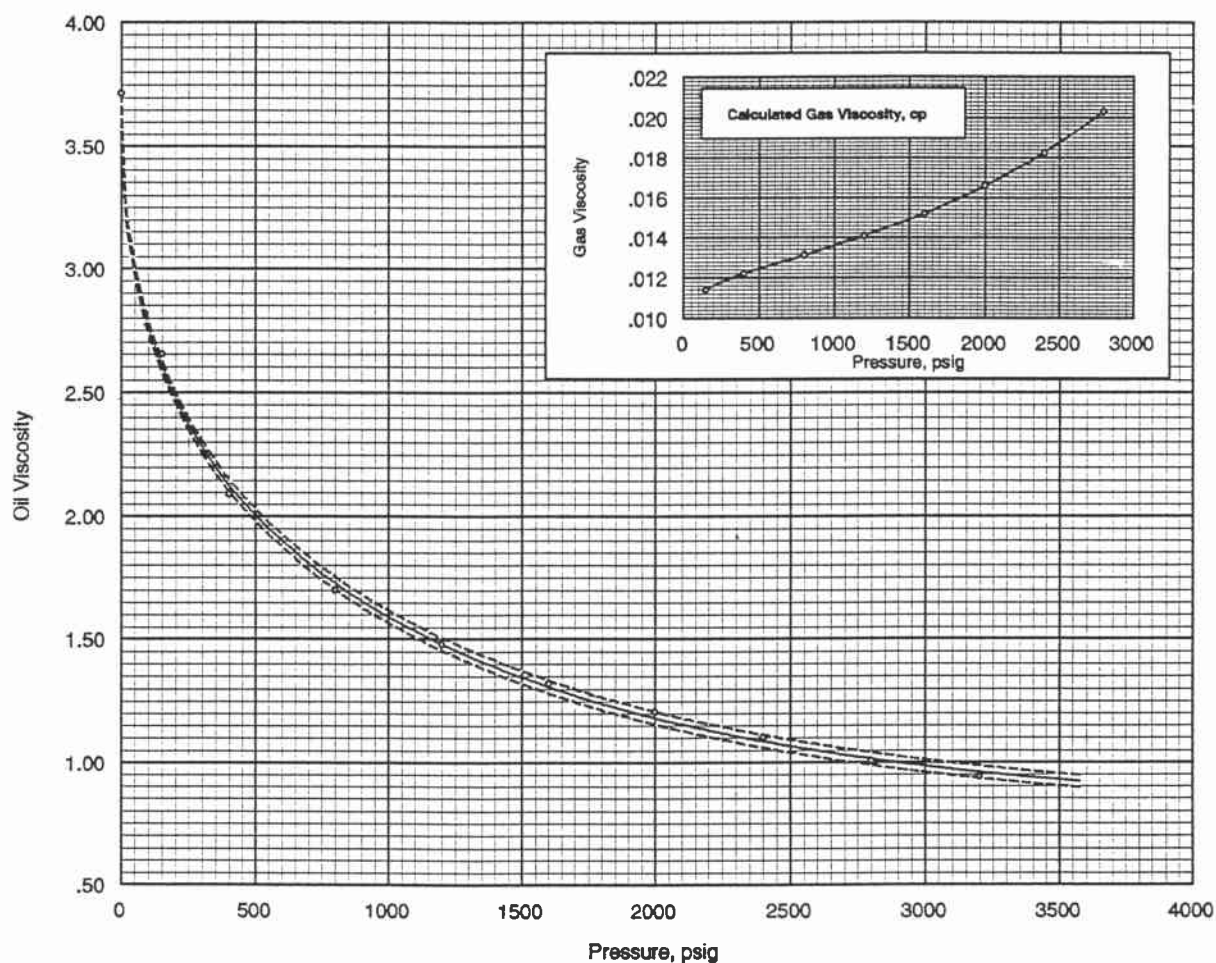
* Gas Viscosity data calculated from correlation of Lee A.L., Gonzalez M.H., and Eakin B.E., "The Viscosity of Natural Gases", Journal of Petroleum Technology, August, 1966, pp. 997-1000.

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RESERVOIR FLUID VISCOSITY (cp at 129 °F)



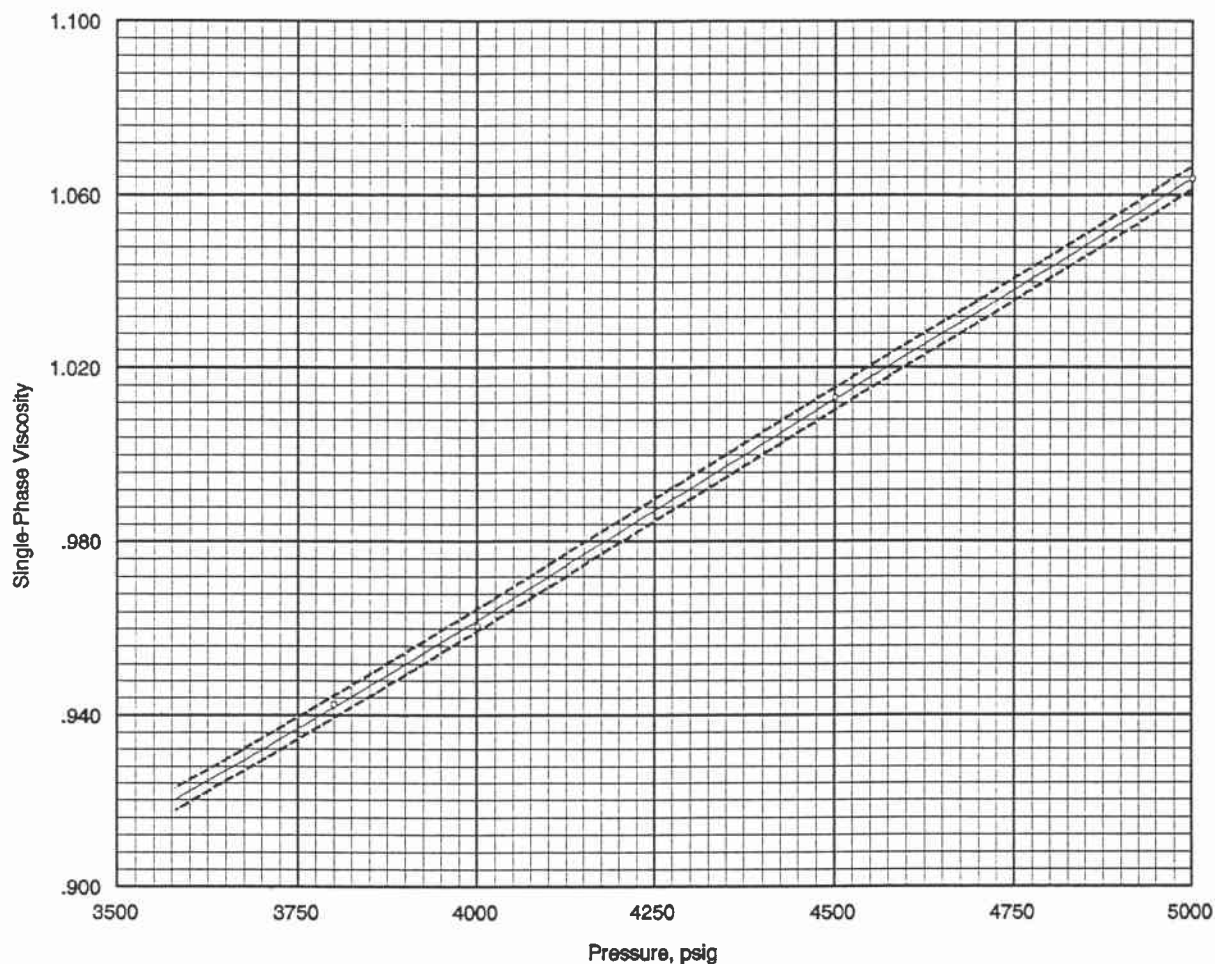
Oil Viscosity Expression: $y = a + b (X_d)^i + c (X_d)^j + d (X_d)^k$	LEGEND	
where: $a = 3.72318e+00$ $b = 1.36498e+01$ $c = -1.72721e+01$ $d = 8.19205e-01$ $i = 0.550$ $j = 0.500$ $k = 1.000$ Note: X_d (dimensionless 'X') = P_i / P_{sat}	$\circ$ ----- _____ Laboratory Data Confidence Limits Analytical Expression Saturation Pressure: 3580 psig	
Confidence level: 99 % Confidence interval: +/- 0.0259 cp 'r squared': .999186	Rolling-Ball Viscosity Figure C-1	

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SINGLE-PHASE FLUID VISCOSITY (cp at 129 °F)



Single-Phase Viscosity Expression: $y = a + b (dX)^i$	LEGEND
where: $a = 9.20082e-01$ $b = 9.07943e-05$ $i = 1.015$ Note: $dX (\text{delta 'X'}) = P_{sat} - P_i $, psig	$\circ$ $\cdots$ --- Laboratory Data Confidence Limits Analytical Expression Saturation Pressure: 3580 psig
Confidence level: 99 % Confidence interval: ± 0.0026 cp 'r squared': 0.999764	Rolling-Ball Viscosity Figure C-2

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SEPARATOR FLASH ANALYSIS

Flash Conditions		Gas/Oil Ratio (scf/bbl) (A)	Gas/Oil Ratio (scf/STbbl) (B)	Stock Tank Oil Gravity at 60 °F (°API)	Formation Volume Factor Bofb (C)	Separator Volume Factor (D)	Specific Gravity of Flashed Gas (Air=1.000)	Oil Phase Density (gm/cc)
psig	°F							
3580	129							0.7265
135	70	612	630			1.029	0.650 *	0.8435
0	70	51	51	33.8	1.317	1.005	1.109	0.8512
			Rsfb = 681					
3580	129							0.7266
90	70	638	650			1.019	0.667 *	0.8475
0	70	35	35	33.7	1.319	1.005	1.093	0.8514
			Rsfb = 685					
3580	129							0.7266
40	70	682	690			1.012	0.710 *	0.8489
0	70	12	12	33.6	1.329	1.005	1.010	0.8522
			Rsfb = 702					

* Collected and analyzed in the laboratory by gas chromatography.

(A) Cubic Feet of gas at 14.7 psia and 60 °F per Barrel of oil at indicated pressure and temperature.

(B) Cubic Feet of gas at 14.7 psia and 60 °F per Barrel of Stock Tank Oil at 60 °F.

(C) Barrels of saturated oil at 3580 psig and 129 °F per Barrel of Stock Tank Oil at 60 °F.

(D) Barrels of oil at indicated pressure and temperature per Barrel of Stock Tank Oil at 60 °F.

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Composition of Separator Test Gas

(From Chromatographic Technique)

Component	Mol %	GPM	MW	Liq Dens (gm/cc)
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.10		44.010	.8172
Nitrogen	0.34		28.013	.8086
Methane	88.57		16.043	.2997
Ethane	5.98	1.596	30.070	.3558
Propane	2.89	.795	44.097	.5065
iso-Butane	0.61	.199	58.123	.5623
n-Butane	0.84	.264	58.123	.5834
iso-Pentane	0.23	.084	72.150	.6241
n-Pentane	0.15	.054	72.150	.6305
Hexanes	0.11	.043	84.000	.6850
Heptanes	0.08	.034	96.000	.7220
Octanes	0.06	.027	107.00	.7450
Nonanes	0.02	.010	121.00	.7640
Decanes	0.01	.005	134.00	.7780
Undecanes	0.01	.006	147.00	.7890
Dodecanes plus	Trace			
Totals	100.00	3.117		

Sampling Conditions

135 psig

70 °F

Sample Characteristics

Critical Pressure (psia) 663.8

Critical Temperature (°R) 374.4

Average Molecular Weight 18.82

Calculated Gas Gravity (air = 1.000) 0.650

Gas Gravity

Factor, Fg 1.2404

Super Compressibility Factor, Fpv

at sampling conditions 1.0117

Gas Z-Factor

at sampling conditions * 0.977

at 14.7 psia and 60 °F

Gross Heating Value

(BTU/scf dry gas) 1151

Test Conditions

135 Psig

70 °F

0 Psig

70 °F

Properties of Plus Fractions

Component	Mol %	MW	Liq Dens (gm/cc)	API Gravity
Heptanes plus	0.18	107.4	0.743	58.8
Decanes plus	0.02	140.5	0.786	48.3
Undecanes plus	0.01	147.0	0.794	46.5

* From: Standing, M.B., "Volumetric and Phase Behavior of Oil Field Hydrocarbon Systems", SPE (Dallas), 1977, 8th Edition, Appendix II.

PETROTECH PERUANA, S.A.

LO16-14

RFL 96190

Composition of Separator Test Gas

(From Chromatographic Technique)

Component	Mol %	GPM	MW	Liq Dens (gm/cc)
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.11		44.010	.8172
Nitrogen	0.31		28.013	.8086
Methane	87.19		16.043	.2997
Ethane	6.28	1.676	30.070	.3558
Propane	3.37	.927	44.097	.5065
iso-Butane	0.76	.248	58.123	.5623
n-Butane	1.09	.343	58.123	.5834
iso-Pentane	0.31	.113	72.150	.6241
n-Pentane	0.20	.072	72.150	.6305
Hexanes	0.14	.054	84.000	.6850
Heptanes	0.11	.046	96.000	.7220
Octanes	0.07	.032	107.00	.7450
Nonanes	0.03	.015	121.00	.7640
Decanes	0.02	.011	134.00	.7780
Undecanes	0.01	.006	147.00	.7890
Dodecanes plus	Trace			
Totals	100.00	3.543		

Sampling Conditions

90 psig

70 °F

Sample Characteristics

Critical Pressure (psia) 662.9

Critical Temperature (°R) 379.5

Average Molecular Weight 19.32

Calculated Gas Gravity (air = 1.000) 0.667

Gas Gravity

Factor, Fg 1.2245

Super Compressibility Factor, Fpv

at sampling conditions 1.0083

Gas Z-Factor

at sampling conditions * 0.984

at 14.7 psia and 60 °F

Gross Heating Value

(BTU/scf dry gas) 1178

Test Conditions

90 Psig

0 Psig

70 °F

70°F

Properties of Plus Fractions

Component	Mol %	MW	Liq Dens (gm/cc)	API Gravity
Heptanes plus	0.24	107.6	0.742	59.0
Decanes plus	0.03	138.3	0.784	48.8
Undecanes plus	0.01	147.0	0.793	46.8

* From: Standing, M.B., "Volumetric and Phase Behavior of Oil Field Hydrocarbon Systems", SPE (Dallas), 1977, 8th Edition, Appendix II.

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LO16-14

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Composition of Separator Test Gas (From Chromatographic Technique)

Component	Mol %	GPM	MW	Liq Dens (gm/cc)
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.11		44.010	.8172
Nitrogen	0.34		28.013	.8086
Methane	83.94		16.043	.2997
Ethane	6.85	1.828	30.070	.3558
Propane	4.32	1.188	44.097	.5065
iso-Butane	1.10	.359	58.123	.5623
n-Butane	1.70	.535	58.123	.5834
iso-Pentane	0.54	.197	72.150	.6241
n-Pentane	0.37	.134	72.150	.6305
Hexanes	0.28	.108	84.000	.6850
Heptanes	0.23	.097	96.000	.7220
Octanes	0.15	.068	107.00	.7450
Nonanes	0.03	.015	121.00	.7640
Decanes	0.02	.011	134.00	.7780
Undecanes	0.01	.006	147.00	.7890
Dodecanes plus	0.01	.007	168.00	.8060
Totals	100.00	4.553		

Sampling Conditions

40 psig

70 °F

Sample Characteristics

Critical Pressure (psia)	659.8
Critical Temperature (°R)	391.7
Average Molecular Weight	20.57
Calculated Gas Gravity (air = 1.000)	0.710
Gas Gravity	
Factor, Fg	1.1866
Super Compressibility Factor, Fpv	
at sampling conditions	1.0046
Gas Z-Factor	
at sampling conditions *	0.991

at 14.7 psia and 60 °F

Gross Heating Value	
(BTU/scf dry gas)	1245

Test Conditions

40 Psig	0 Psig
70 °F	70 °F

Properties of Plus Fractions

Component	Mol %	MW	Liq Dens (gm/cc)	API Gravity
Heptanes plus	0.45	105.8	0.739	59.8
Decanes plus	0.04	145.8	0.787	48.1
Undecanes plus	0.02	157.5	0.797	45.9

* From: Standing, M.B., "Volumetric and Phase Behavior of Oil Field Hydrocarbon Systems", SPE (Dallas), 1977, 8th Edition, Appendix II.

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DIFFERENTIAL VAPORIZATION ADJUSTED TO SEPARATOR CONDITIONS*

Pressure psig	Solution Gas/Oil Ratio Rs (A)	Formation Volume Factor Bo (B)	Gas Formation Volume Factor (C)	Oil Density gm/cc	Oil/Gas Viscosity Ratio
5000	681	1.300		0.7356	
4500	681	1.306		0.7325	
4216	681	1.309		0.7307	
4000	681	1.312		0.7293	
3900	681	1.313		0.7286	
3800	681	1.314		0.7279	
3700	681	1.315		0.7272	
3600	681	1.317		0.7265	
b» 3580	681	1.317		0.7263	
3200	608	1.287	0.00436	0.7345	42.2
2800	533	1.257	0.00502	0.7431	49.9
2400	459	1.228	0.00592	0.7518	59.3
2000	387	1.200	0.00718	0.7606	70.9
1600	315	1.173	0.00908	0.7697	85.7
1200	243	1.146	0.01227	0.7790	105
800	170	1.119	0.01866	0.7888	132
400	90	1.089	0.03771	0.7997	176
150	28	1.062	0.09783	0.8087	229
0		1.008		0.8296	

*Separator Conditions	
First Stage Stock Tank	135 psig at 70 °F 0 psig at 70 °F

(A) Cubic Feet of gas at 14.7 psia and 60 °F per Barrel of Stock Tank Oil at 60 °F.

(B) Barrel of oil at indicated pressure and temperature per Barrel of Stock Tank Oil at 60 °F.

(C) Cubic Feet of gas at indicated pressure and temperature per Cubic Feet at 14.7 psia and 60 °F.

PETRO-TECH PERUANA S.A.

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DIFFERENTIAL VAPORIZATION ADJUSTED TO SEPARATOR CONDITIONS*

Pressure psig	Solution Gas/Oil Ratio Rs (A)	Formation Volume Factor Bo (B)	Gas Formation Volume Factor (C)	Oil Density gm/cc	Oil/Gas Viscosity Ratio
5000	685	1.302		0.7356	
4500	685	1.308		0.7325	
4216	685	1.311		0.7307	
4000	685	1.313		0.7293	
3900	685	1.315		0.7286	
3800	685	1.316		0.7279	
3700	685	1.317		0.7272	
3600	685	1.318		0.7265	
b» 3580	685	1.319		0.7263	
3200	612	1.289	0.00436	0.7345	41.9
2800	537	1.259	0.00502	0.7431	49.9
2400	463	1.230	0.00592	0.7518	59.5
2000	390	1.202	0.00718	0.7606	71.3
1600	318	1.174	0.00908	0.7697	86.0
1200	247	1.148	0.01227	0.7790	105
800	173	1.121	0.01866	0.7888	132
400	93	1.090	0.03771	0.7997	175
150	31	1.064	0.09783	0.8087	229
0		1.009		0.8296	

*Separator Conditions	
First Stage Stock Tank	90 psig at 70 °F 0 psig at 70 °F

(A) Cubic Feet of gas at 14.7 psia and 60 °F per Barrel of Stock Tank Oil at 60 °F.

(B) Barrel of oil at indicated pressure and temperature per Barrel of Stock Tank Oil at 60 °F.

(C) Cubic Feet of gas at indicated pressure and temperature per Cubic Feet at 14.7 psia and 60 °F.

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DIFFERENTIAL VAPORIZATION ADJUSTED TO SEPARATOR CONDITIONS*

Pressure psig	Solution Gas/Oil Ratio Rs (A)	Formation Volume Factor Bo (B)	Gas Formation Volume Factor (C)	Oil Density gm/cc	Oil/Gas Viscosity Ratio
5000	702	1.312		0.7356	
4500	702	1.318		0.7325	
4216	702	1.321		0.7307	
4000	702	1.324		0.7293	
3900	702	1.325		0.7286	
3800	702	1.326		0.7279	
3700	702	1.327		0.7272	
3600	702	1.329		0.7265	
b» 3580	702	1.329		0.7263	
3200	629	1.299	0.00436	0.7345	41.9
2800	553	1.268	0.00502	0.7431	49.9
2400	479	1.239	0.00592	0.7518	59.5
2000	405	1.211	0.00718	0.7606	71.3
1600	333	1.184	0.00908	0.7697	86.0
1200	261	1.157	0.01227	0.7790	105
800	187	1.129	0.01866	0.7888	132
400	106	1.098	0.03771	0.7997	175
150	43	1.072	0.09783	0.8087	229
0		1.017		0.8296	

*Separator Conditions	
First Stage Stock Tank	40 psig at 70 °F 0 psig at 70 °F

(A) Cubic Feet of gas at 14.7 psia and 60 °F per Barrel of Stock Tank Oil at 60 °F.

(B) Barrel of oil at indicated pressure and temperature per Barrel of Stock Tank Oil at 60 °F.

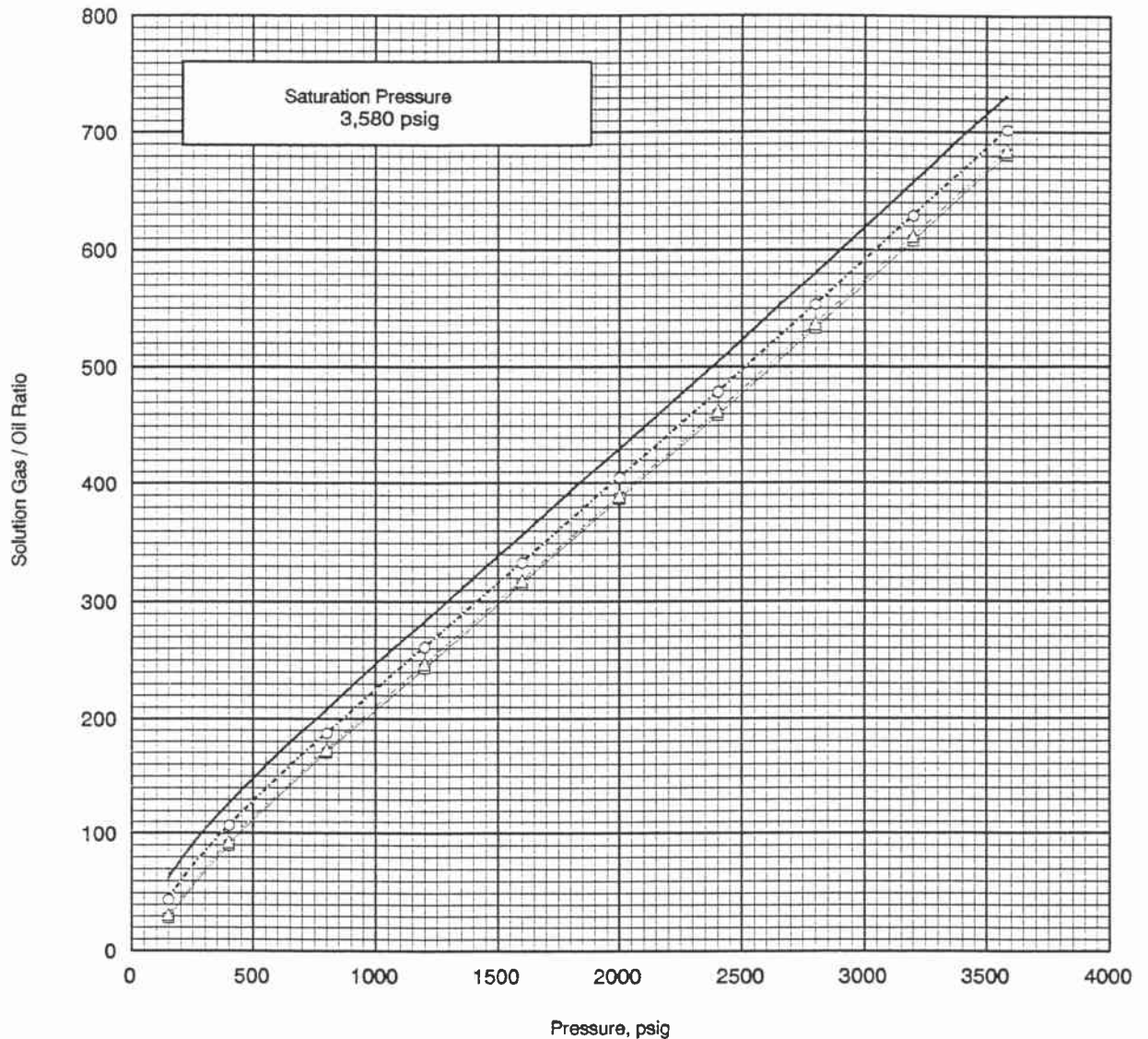
(C) Cubic Feet of gas at indicated pressure and temperature per Cubic Feet at 14.7 psia and 60 °F.

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SOLUTION GAS/OIL RATIO (scf/STbbl)



LEGEND		DV Adjusted to Separator Figure D-1
—	Differential Vaporization	
□	135 psig at 70 °F	
△	90 psig at 70 °F	
○	40 psig at 70 °F	
◇		

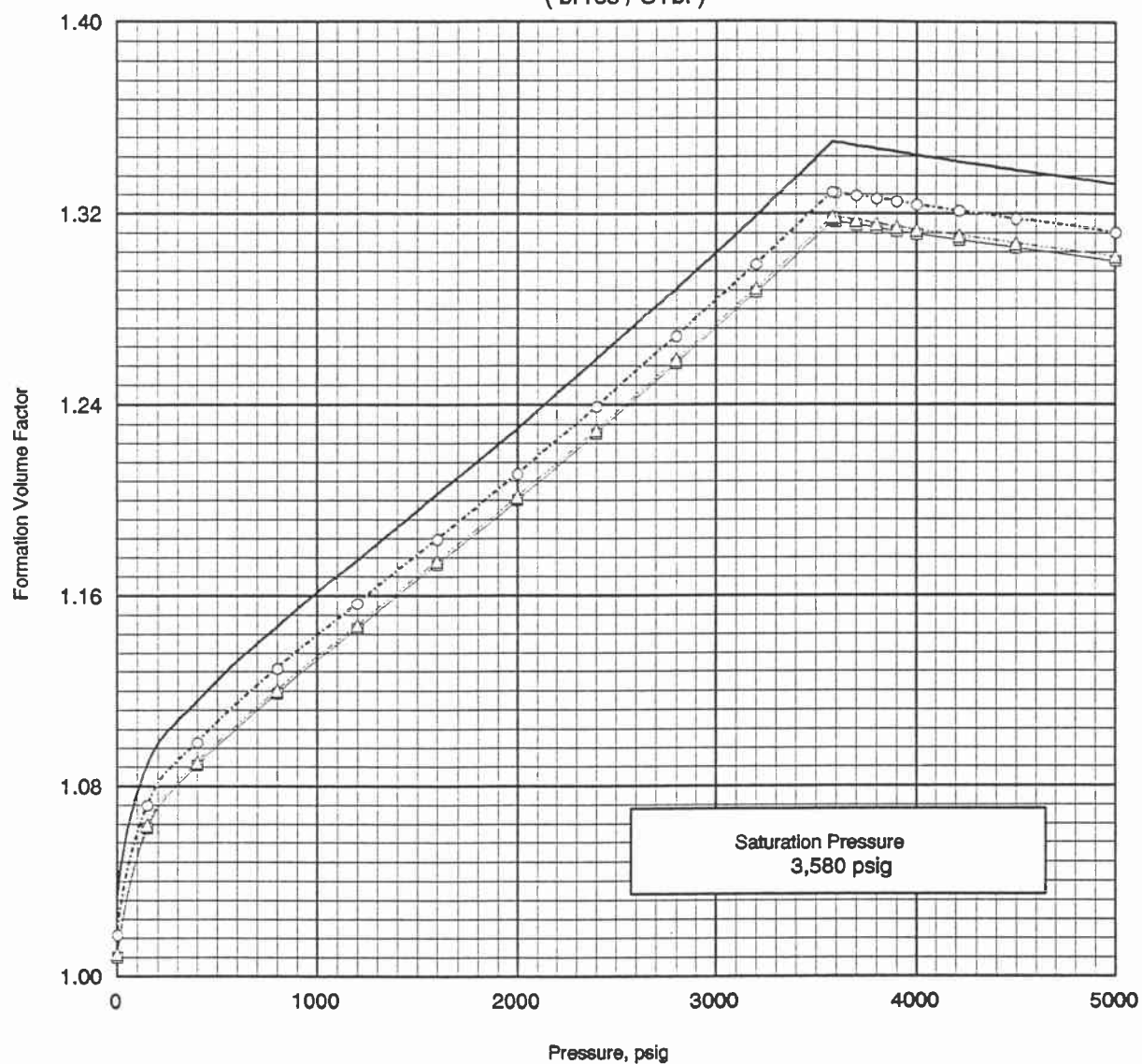
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FORMATION VOLUME FACTOR

(bl res / STbl)



LEGEND

- Differential Vaporization
- 135 psig at 70 °F
- △ 90 psig at 70 °F
- 40 psig at 70 °F
- ◇

DV Adjusted to Separator
Figure D-2

Appendix
Nomenclature and Equations

CENTRAL FILE
GEOSCIENCES

PRESSURE-VOLUME RELATIONS

Nomenclature and Equations

<i>P_b</i>	=	<i>Bubblepoint Pressure</i>
<i>X_d</i>	=	<i>Dimensionless Pressure (P_i/P_b)</i>
<i>dP</i>	=	<i>Pressure Difference (P_i/P_b)</i>
<i>Y_f</i>	=	<i>Y-Function (dimensionless compressibility)</i>
<i>RV</i>	=	<i>PV Relative Volume</i>
<i>C_{sp}</i>	=	<i>Average Single-Phase Compressibility of Reservoir Fluid</i>

For Relative Volume below bubblepoint pressure:

$$RV_i = (P_b - P_i) / P_i \cdot Y_f$$

For Average Single-Phase Compressibility above bubblepoint pressure:

$$C_{sp} = (RV_i - RV_{i-1}) / [RV_i(P_i - P_{i-1})]$$

DIFFERENTIAL VAPORIZATION

Nomenclature and Equations

P_b	=	Bubblepoint Pressure
P_{base}	=	Base Pressure
T_{base}	=	Base Temperature
T_{res}	=	Reservoir Temperature
X_d	=	Dimensionless Pressure (P_i/P_b)
dP	=	Pressure Difference ($P_i - P_b$)
RV	=	Relative Volume from Pressure-Volume Relations
$Dens$	=	Single-Phase Oil Density
$Dens_b$	=	Oil Density at Bubblepoint Pressure
ROV	=	Relative Oil Volume
ROV_b	=	Relative Oil Volume at Bubblepoint Pressure
B_g	=	Gas Formation Volume Factor

For Oil Density above bubblepoint pressure:

$$Dens_i = Dens_b / RV_i$$

For Relative Oil Volume above bubblepoint pressure:

$$ROV_i = ROV_b * RV_i$$

For Gas Formation Factor below bubblepoint pressure:

$$B_g = P_{base} * Z_i * T_{res} / (P_i * T_{base})$$

**DIFFERENTIAL VAPORIZATION
ADJUSTED TO SURFACE CONDITIONS**

Nomenclature and Equations

<i>Pb</i>	=	<i>Bubblepoint Pressure</i>
<i>Bo</i>	=	<i>Oil Formation Volume Factor</i>
<i>Bofb</i>	=	<i>Formation Volume Factor from field conditions or optimum separator flash test</i>
<i>Bod</i>	=	<i>Relative Oil Volume from differential vaporization test</i>
<i>Bodb</i>	=	<i>Value of Bod at bubblepoint pressure</i>
<i>RV</i>	=	<i>Relative Volume from Pressure-Volume Relations</i>

For Bo above bubblepoint pressure:

$$Bo = RV * Bofb$$

For Bo below bubblepoint pressure:

$$Bo = (Bod) * (Bofb/Bodb)$$

<i>Pb</i>	=	<i>Gas in solution</i>
<i>Bo</i>	=	<i>Sum of separator gas and the stock tank gas from field conditions (or optimum) separator flash test</i>
<i>Rsd</i>	=	<i>Gas in solution from the differential vaporization test</i>
<i>Rbdb</i>	=	<i>Rsd at bubblepoint pressure</i>

$$Rs = Rsfb - [(Rbdb - Rsd) * (Bofb/Bodb)]$$

**CENTRAL FILE
GEOSCIENCES**