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## **CORE LABORATORIES**

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Reservoir Fluid Study  
for  
**Arco Exploration & Production Technology**

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RFL 920279  
19-Nov-92

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## Alaska North Slope Market

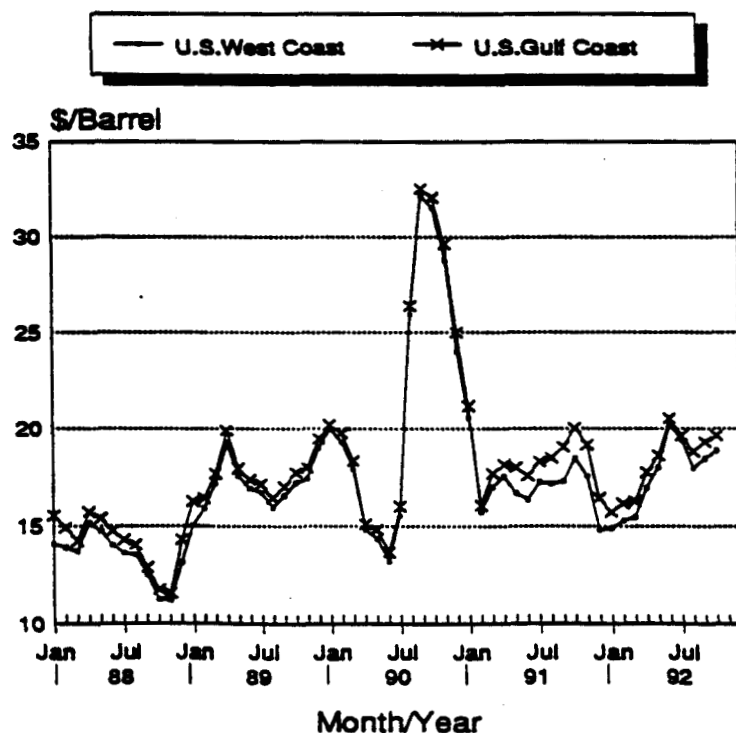
Alaska North Slope (ANS) prices have ranged between \$17.00 and \$20.00/bbl since last Spring. For the past six months, concern over the health of the global economy, plus uncertainty as to when Iraqi exports will return to the world market, have led to the price fluctuations of ANS. The price increase this year has been driven mainly by OPEC's decision to maintain fourth quarter production at its summer quota. ANS Lower 48 price has averaged just under \$19.00/bbl so far for FY 1993.

BP Exploration announced its official selling prices for November 1992 as \$18.80/bbl on the West Coast and \$19.40/bbl on the Gulf Coast. Recent spot prices have been running \$0.10/bbl lower than the official price.

Roughly 85 percent of ANS production is sold on the West Coast while 15 percent is marketed in the Eastern half of the United States and the Caribbean. As ANS production declines, it is expected that shipments to Eastern U.S. destinations will cease after 1996. Greater transportation costs to the more distant markets result in a Gulf Coast derived wellhead price which is lower than the West Coast price. ANS spot prices are graphed below in Figure 6.

Figure 6

### ANS Spot Price January 1988 - October 1992



## Forecast Assumptions

### **ANS Lower 48 Prices**

Beginning with this forecast, the oil price assumptions start with the price of ANS at the U.S. Gulf Coast. ANS Gulf is now used as a benchmark instead of West Texas Intermediate (WTI) for the following practical and theoretical reasons:

1. Saudi Light is marketed in the U.S. based on the Gulf ANS spot price. This provides a link to worldwide markets.
2. WTI is a lighter gravity, lower sulfur crude than ANS, and is thus valued higher. By using ANS itself as a marker, any price variations that occur due to quality differentials are eliminated and forecasting error can be attributed solely to incorrect assumptions about ANS price.

We do continue to forecast a WTI price based on the historical relationship between WTI and ANS.

The discussion of price forecast assumptions starts with the Gulf Coast ANS price and outlines the other variables which translate this price into the wellhead price for ANS crude oil. The wellhead price determines the value of production and thus the state's severance tax and royalty income.

The price of West Coast ANS is forecasted based on its historical relationship to Gulf Coast ANS. West Coast ANS sells at a discount to the Gulf because the presence of ANS on the West Coast creates a crude oil glut there. It is this glut that necessitates the shipment of ANS to the Gulf. The short term forecast for ANS is illustrated below.

Figure 7    **ANS at the U. S. Gulf**

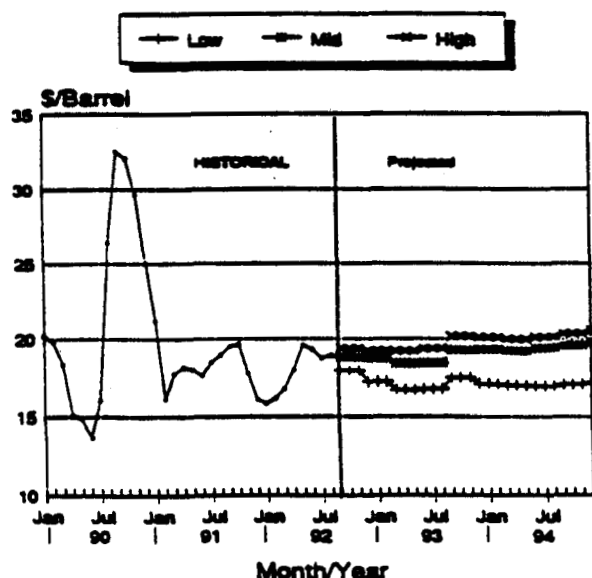
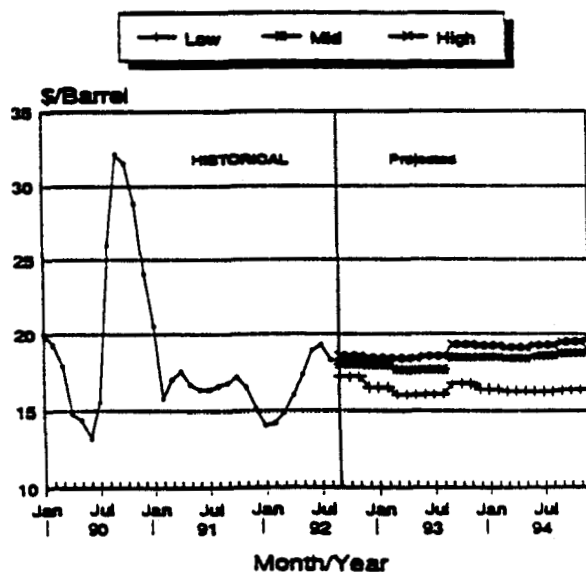


Figure 8    **ANS at the U. S. West Coast**



Over the longer term, as demand on the West Coast grows and ANS production declines, the West Coast oil glut will disappear. In this forecast West Coast and Gulf Coast oil prices are assumed to converge when the West Coast surplus disappears. The long term forecast for ANS is illustrated below.

**Table 8 Scenarios for ANS Oil Price  
Gulf Coast and West Coast  
(\$/bbl)**

Fiscal Year	Low		Mid		High	
	West	Gulf	West	Gulf	West	Gulf
1993	17.13	17.71	18.11	18.73	18.56	19.21
1994	16.35	17.07	18.26	19.07	19.06	19.90
1995	16.43	17.15	18.91	19.74	19.67	20.52
2000	19.48	19.48	24.67	24.67	27.02	27.02
2005	22.65	22.65	30.68	30.68	37.14	37.14

**Table 9 Marine Transportation Costs  
Valdez to Lower 48  
(\$/bbl)**

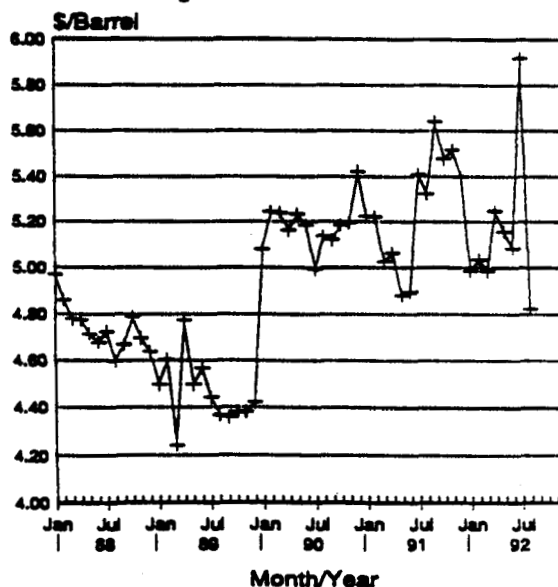
Fiscal Year	Low	Mid	High
1993	1.83	1.83	1.83
1994	1.95	1.95	1.95
1995	1.90	1.90	1.94
2000	1.68	1.71	1.73
2005	1.46	1.50	1.59

### Transportation Costs to Lower 48 Markets

The weighted average Lower 48 shipping cost averaged \$1.75/bbl in FY 1992, \$0.40/bbl higher than in the prior year. This increase was mostly attributable to tight markets in the higher cost Gulf trade, where there is significant chartering, and results of the Oilspill Pollution Act of 1990 (OPA90).

As ANS production declines and West Coast petroleum demand increases, shipments to the Gulf will diminish. This will free up excess tonnage. Consequently, average shipping costs are expected to stay fairly constant over the next few years. In the long term the double hulling requirements of OPA90 will result in increased shipping costs.

**Figure 9  
Total Transportation Costs to Lower 48  
Pipeline and Tanker**



## DIFFERENTIAL VAPORIZATION DATA ADJUSTED TO SURFACE CONDITIONS

### Nomenclature and Equations

$P_b$	=	Bubblepoint Pressure
$B_o$	=	Oil Formation Volume Factor
$B_{ofb}$	=	Formation Volume Factor from field conditions or optimum separator flash test
$B_{od}$	=	Relative Oil Volume from differential vaporization test
$B_{odb}$	=	Value of $B_{od}$ at bubblepoint pressure
$RV$	=	Relative Volume from Pressure-Volume relations

For  $B_o$  above bubblepoint pressure:

$$B_o = RV * B_{ofb}$$

For  $B_o$  below bubblepoint pressure:

$$B_o = (B_{od}) * (B_{ofb} / B_{odb})$$

$R_s$	=	Gas in solution
$R_{sfb}$	=	Sum of separator gas and the stock tank gas from field conditions (or optimum) separator flash test
$R_{sd}$	=	Gas in solution from the differential vaporization test
$R_{sdb}$	=	$R_{sd}$ at bubblepoint pressure

$$R_s = R_{sfb} - [ (R_{sdb} - R_{sd}) * (B_{ofb} / B_{odb}) ]$$

## 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 Volume Factor below bubblepoint pressure:

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

## **PRESSURE-VOLUME RELATIONS**

### **Nomenclature and Equations**

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

For Relative Volume below bubblepoint pressure:

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

For Average Single-Phase Compressibility above bubblepoint pressure:

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

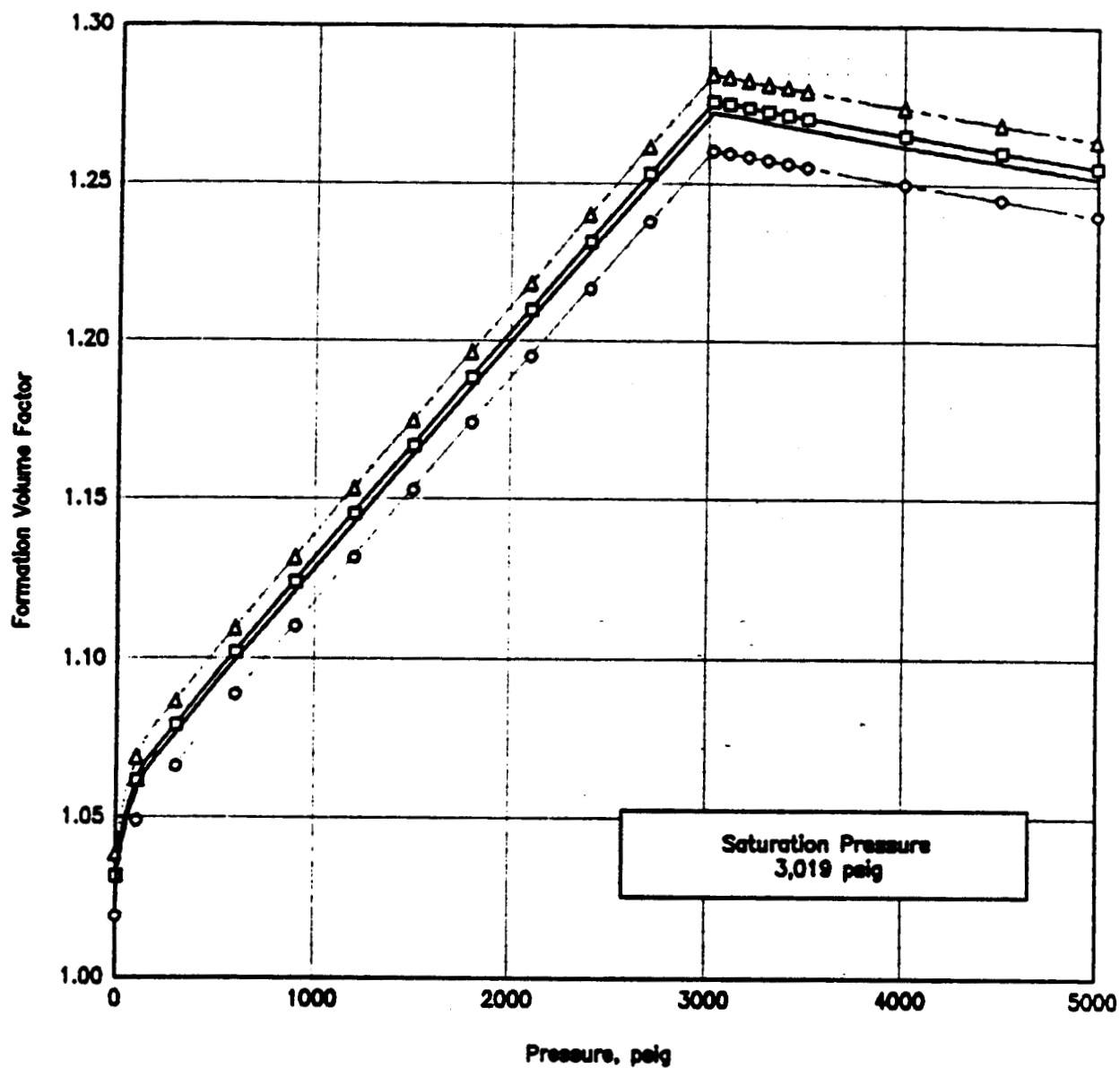
**Appendix**  
**Nomenclature and Equations**



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## FORMATION VOLUME FACTOR

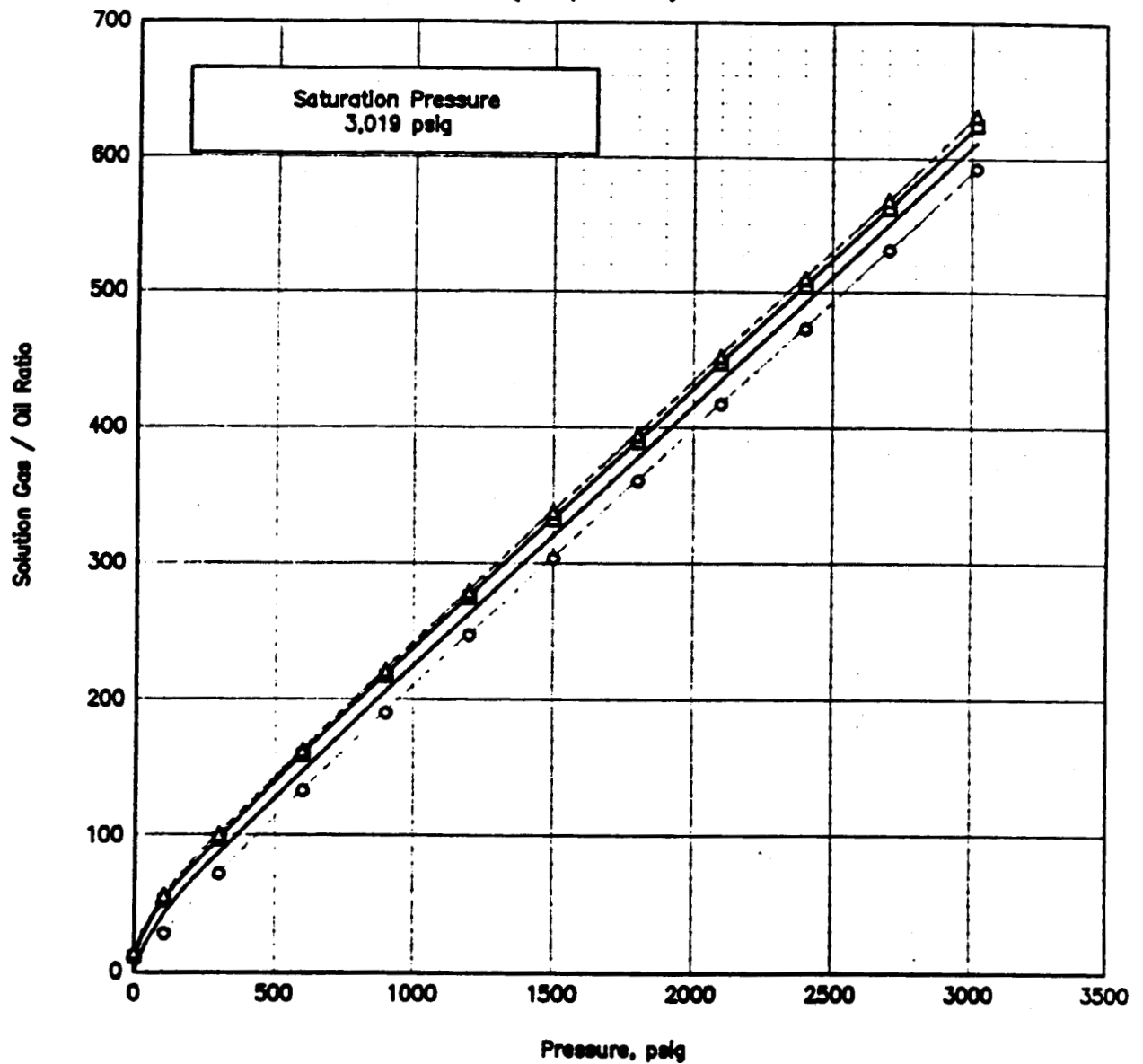


LEGEND		DV Adjusted to Separator Figure D-2
—	Differential Vaporization	
□	100 psig at 90 °F	
△	100 psig at 140 °F	
○	500 psig at 90 °F	

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## SOLUTION GAS/OIL RATIO ( scf/STbbl )



LEGEND	
—	Differential Vaporization
□	100 psig at 90 °F
△	100 psig at 140 °F
○	500 psig at 90 °F

DV Adjusted to Separator  
Figure D-1

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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	593.	1.240		0.7569	
4500	593.	1.245		0.7540	
4000	593.	1.250		0.7510	
3500	593.	1.255		0.7479	
3400	593.	1.256		0.7473	
3300	593.	1.257		0.7466	
3200	593.	1.258		0.7460	
3100	593.	1.260		0.7453	
b» 3019	593.	1.260		0.7448	
2700	532.	1.238	0.00496	0.7512	55.8
2400	474.	1.217	0.00554	0.7576	65.7
2100	418.	1.195	0.00639	0.7644	78.8
1800	361.	1.174	0.00758	0.7715	95.0
1500	304.	1.153	0.00929	0.7789	114.0
1200	248.	1.132	0.01190	0.7866	138.0
900	191.	1.111	0.01627	0.7945	165.0
600	133.	1.089	0.02495	0.8025	198.0
300	72.	1.066	0.05028	0.8107	242.0
105	28.	1.049	0.13489	0.8164	289.0
0		1.019		0.8293	

*Separator Conditions	
First Stage	500 psig at 90 °F
Second Stage	100 psig at 90 °F
Third Stage	25 psig at 140 °F
Stock Tank	0 psig at 60 °F

(A) Cubic Feet of gas at 14.65 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 14.65 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	632.	1.264		0.7569	
4500	632.	1.269		0.7540	
4000	632.	1.274		0.7510	
3500	632.	1.279		0.7479	
3400	632.	1.280		0.7473	
3300	632.	1.281		0.7466	
3200	632.	1.282		0.7460	
3100	632.	1.284		0.7453	
b. 3019	632.	1.284		0.7448	
2700	569.	1.261	0.00496	0.7512	55.8
2400	511.	1.240	0.00554	0.7576	65.7
2100	453.	1.218	0.00639	0.7644	78.8
1800	395.	1.197	0.00758	0.7715	95.0
1500	338.	1.175	0.00929	0.7789	114.0
1200	280.	1.153	0.01190	0.7866	138.0
900	222.	1.132	0.01627	0.7945	165.0
600	163.	1.110	0.02495	0.8025	198.0
300	101.	1.087	0.05028	0.8107	242.0
105	56.	1.069	0.13489	0.8164	289.0
0	14.	1.039		0.8293	

*Separator Conditions	
First Stage	100 psig at 140 °F
Second Stage	25 psig at 140 °F
Stock Tank	0 psig at 60 °F

(A) Cubic Feet of gas at 14.65 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 14.65 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	625.	1.255		0.7569	
4500	625.	1.260		0.7540	
4000	625.	1.265		0.7510	
3500	625.	1.271		0.7479	
3400	625.	1.272		0.7473	
3300	625.	1.273		0.7466	
3200	625.	1.274		0.7460	
3100	625.	1.275		0.7453	
b» 3019	625.	1.276		0.7448	
2700	563.	1.253	0.00496	0.7512	55.8
2400	505.	1.232	0.00554	0.7576	65.7
2100	448.	1.210	0.00639	0.7644	78.8
1800	390.	1.189	0.00758	0.7715	95.0
1500	333.	1.167	0.00929	0.7789	114.0
1200	276.	1.146	0.01190	0.7866	138.0
900	218.	1.124	0.01627	0.7945	165.0
600	160.	1.102	0.02495	0.8025	198.0
300	98.	1.079	0.05028	0.8107	242.0
105	53.	1.062	0.13489	0.8164	289.0
0	11.	1.032		0.8293	

*Separator Conditions	
First Stage	100 psig at 90 °F
Second Stage	25 psig at 140 °F
Stock Tank	0 psig at 60 °F

(A) Cubic Feet of gas at 14.65 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 14.65 psia and 60 °F.

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## SEPARATOR FLASH ANALYSIS\*

Flash Conditions		Gas/Oil Ratio ( scf/bbl )	Gas/Oil Ratio ( scf/STbbl )	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	(A)	(B)					
2200	119							0.7557
100	90	453	466			1.030	0.733	0.8365
25	140	28	29			1.038	0.952	0.8242
0	60	15	15	34.4	1.238	1.000	**	0.8518
Rsfb = 510								
1500	119							0.7706
100	90	314	324			1.033	0.772	0.8359
25	140	33	35			1.039	0.985	0.8239
0	60	10	10	34.6	1.191	1.000	**	0.8537
Rsfb = 369								
800	119							0.7822
100	90	153	159			1.038	0.817	0.8258
25	140	35	36			1.039	1.032	0.8172
0	60	10	10	34.8	1.132	1.000	**	0.8467
Rsfb = 206								

\* Performed on prepared differential vaporization fluids.

\*\* Insufficient quantity for measurement.

(A) Cubic Feet of gas at 14.65 psia and 60 °F per Barrel of oil at indicated pressure and temperature.

(B) Cubic Feet of gas at 14.65 psia and 60 °F per Barrel of Stock Tank Oil at 60 °F.

(C) Barrels of saturated oil at indicated pressure and 119°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.

## Composition of Stock Tank Oil

( From Chromatographic Technique )

Component	Mol %	Wt %	Density (gm/cc)	MW	Vol %
Hydrogen Sulfide	.00	.00			
Carbon Dioxide	.00	.00			
Nitrogen	.00	.00			
Methane	.00	.00			
Ethane	.00	.00			
Propane	2.23	.48	.506	44.1	0.81
Iso-Butane	.00	.00			
n-Butane	3.88	1.10	.583	58.1	1.61
Iso-Pentane	2.56	.90	.624	72.2	1.23
n-Pentane	1.76	.62	.630	72.2	0.84
Hexanes	4.10	1.68	.685	84.0	2.09
Heptanes	6.66	3.12	.722	96.0	3.69
Octanes	9.13	4.79	.745	107.0	5.48
Nonanes	6.74	3.98	.764	121.0	4.45
Decanes	6.32	4.13	.778	134.0	4.53
Undecanes	4.99	3.58	.789	147.0	3.88
Dodecanes	4.33	3.40	.800	161.0	3.63
Tridecanes	4.93	4.21	.811	175.0	4.43
Tetradecanes	4.59	4.25	.822	190.0	4.41
Pentadecanes	4.68	4.70	.832	206.0	4.82
Hexadecanes	3.39	3.67	.839	222.0	3.73
Heptadecanes	3.02	3.49	.847	237.0	3.52
Octadecanes	3.01	3.68	.852	251.0	3.69
Nonadecanes	2.53	3.24	.857	263.0	3.23
Eicosanes	2.15	2.88	.862	275.0	2.85
Heneicosanes	1.84	2.61	.867	291.0	2.57
Docosanes	1.69	2.51	.872	305.0	2.46
Tricosanes	1.49	2.31	.877	318.0	2.25
Tetracosanes	1.33	2.15	.881	331.0	2.08
Pentacosanes	1.27	2.14	.885	345.0	2.07
Hexacosanes	.98	1.72	.889	359.0	1.65
Heptacosanes	1.08	1.97	.893	374.0	1.89
Octacosanes	.97	1.83	.896	388.0	1.74
Nonacosanes	.83	1.62	.899	402.0	1.54
Triacosanes	.88	1.79	.902	416.0	1.69
Hentriacosanes	.78	1.59	.906	430.0	1.49
Dotriacosanes	.60	1.29	.909	444.0	1.21
Tritriacosanes	.56	1.24	.912	458.0	1.16
Tettriacosanes	.50	1.15	.914	472.0	1.08
Pentatriacosanes	.35	.84	.917	486.0	0.79
Hexatriacosanes plu	3.87	15.34	1.149	811.5	11.41
Totals .....	100.00	100.00			100.00

## Sample Characteristics

'Base Case' Separator Test

Total Liquid Molecular Weight ..... 205.0

Total Liquid Density (gm/cc) ..... 0.8538

Total Liquid API Gravity ..... 34.2

## Properties of Heavy Fractions

Plus Fractions	Mol %	Wt %	Density (gm/cc)	°API	MW
Hexanes plus	89.57	96.90	0.866	31.9	221.8
Heptanes plus	85.47	95.22	0.870	31.1	228.4
Decanes plus	62.94	83.33	0.892	27.2	271.5
Undecanes plus	56.62	79.20	0.899	26.0	286.8
Pentadecanes plus	37.78	63.76	0.924	21.6	346.1
Eicosanes plus	21.15	44.98	0.962	15.6	436.1
Pentacosanes plus	12.65	32.52	1.002	9.7	527.0
Triacosanes plus	7.52	23.24	1.054	2.7	633.3
Pentatriacosanes plus	4.22	16.18	1.134	-6.7	784.5

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## Composition of Stock Tank Gas

( From Chromatographic Technique )

Component	Mol %	GPM	MW	Liq Dens (gm/cc)
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.54		44.010	.8172
Nitrogen	0.12		28.013	.8086
Methane	32.39		16.043	.2997
Ethane	16.07	4.274	30.070	.3558
Propane	26.17	7.172	44.097	.5065
iso-Butane	7.06	2.297	58.123	.5623
n-Butane	9.63	3.020	58.123	.5634
iso-Pentane	3.42	1.245	72.150	.6241
n-Pentane	1.78	.641	72.150	.6305
Hexanes	1.50	.579	84.000	.6850
Heptanes	0.88	.368	96.000	.7220
Octanes	0.40	.181	107.00	.7450
Nonanes	0.04	.020	121.00	.7640
Decanes plus	Nil			
Totals .....	100.00	19.797		

### Sampling Conditions

0 psig

60 °F

### Sample Characteristics

\*Base Case\* Separator Test

Critical Pressure (psia) ..... 624.6

Critical Temperature (°R) ..... 572.7

Average Molecular Weight ..... 37.87

Calculated Gas Gravity (air = 1.000) ..... 1.308

### Properties of Plus Fractions

Component	Mol %	MW	Liq Dens (gm/cc)	API Gravity
Heptanes plus	1.32	100.1	0.730	45.4

at 14.65 psia and 60 °F

Gross Heating Value  
(BTU/scf dry gas) ..... 2156



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## Composition of Secondary Separator Gas ( From Chromatographic Technique )

Component	Mol %	GPM	MW	Liq Dens (gm/cc)
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.66		44.010	.8172
Nitrogen	0.00			
Methane	63.64		16.043	.2997
Ethane	12.86	3.421	30.070	.3558
Propane	13.50	3.700	44.097	.5065
iso-Butane	3.14	1.022	58.123	.5623
n-Butane	3.61	1.132	58.123	.5634
iso-Pentane	1.12	.408	72.150	.6241
n-Pentane	0.56	.202	72.150	.6305
Hexanes	0.46	.178	84.000	.6850
Heptanes	0.28	.117	96.000	.7220
Octanes	0.13	.059	107.00	.7450
Nonanes	0.04	.020	121.00	.7640
Decanes plus	Trace			
Totals .....	100.00	10.259		

### Sampling Conditions

25 psig  
140 °F

### Sample Characteristics 'Base Case' Separator Test

Critical Pressure (psia) .....	654.3
Critical Temperature (°R) .....	456.4
Average Molecular Weight .....	26.30
Calculated Gas Gravity (air = 1.000) .....	0.908
Gas Gravity	
Factor, Fg .....	1.0494
Super Compressibility Factor, Fpv	
at sampling conditions .....	1.0036
Gas Z-Factor	
at sampling conditions * .....	0.993

at 14.65 psia and 60 °F

Gross Heating Value (BTU/scf dry gas) .....	1539
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### Properties of Plus Fractions

Component	Mol %	MW	Liq Dens (gm/cc)	API Gravity
Heptanes plus	0.45	101.4	0.732	45.1

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

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## Composition of Primary Separator Gas

( From Chromatographic Technique )

Component	Mol %	GPM	MW	Liq Dens (gm/cc)
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.46		44.010	.8172
Nitrogen	0.15		28.013	.8086
Methane	86.88		16.043	.2997
Ethane	5.85	1.556	30.070	.3558
Propane	4.17	1.143	44.097	.5065
iso-Butane	0.81	.264	58.123	.5623
n-Butane	0.96	.301	58.123	.5634
iso-Pentane	0.30	.109	72.150	.6241
n-Pentane	0.15	.054	72.150	.6305
Hexanes	0.13	.050	84.000	.6850
Heptanes	0.08	.033	96.000	.7220
Octanes	0.04	.018	107.00	.7450
Nonanes	Trace			
Decanes plus	0.02	.011	141.00	.7840
Totals .....	100.00	3.539		

### Sampling Conditions

100 psig  
90 °F

### Sample Characteristics

"Base Case" Separator Test

Critical Pressure (psia) .....	664.5
Critical Temperature (°R) .....	380.7
Average Molecular Weight .....	19.39
Calculated Gas Gravity (air = 1.000) .....	0.670
Gas Gravity	
Factor, Fg .....	1.2221
Super Compressibility Factor, Fpv	
at sampling conditions .....	1.0081
Gas Z-Factor	
at sampling conditions * .....	0.984

at 14.65 psia and 60 °F

Gross Heating Value (BTU/scf dry gas) .....	1172
--	------

### Properties of Plus Fractions

Component	Mol %	MW	Liq Dens (gm/cc)	API Gravity
Heptanes plus	0.14	105.6	0.739	44.2
Decanes plus	0.02	141.0	0.784	38.3

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

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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							

3019	119							0.7425
100	90	580	596			1.026	0.670 *	0.8386
25	140	17	17			1.038	0.908 *	0.8260
0	60	12	12	34.1	1.276	1.000	1.308 *	0.8538
		Rsfb = 625						

3019	119							0.7448
100	140	587	615			1.048	0.745	0.8179
25	140	12	12			1.038	0.782	0.8238
0	60	4	4	34.0	1.284	1.000	1.300	0.8540
		Rsfb = 632						

3019	119							0.7448
500	90	426	457			1.073	0.638	0.8160
100	90	96	99			1.033	0.749	0.8319
25	140	25	26			1.039	1.064	0.8212
0	60	10	10	34.6	1.260	1.000	1.007	0.8510
		Rsfb = 593						

\* Collected and analyzed in the laboratory by gas chromatography.

(A) Cubic Feet of gas at 14.65 psia and 60 °F per Barrel of oil at indicated pressure and temperature.

(B) Cubic Feet of gas at 14.65 psia and 60 °F per Barrel of Stock Tank Oil at 60 °F.

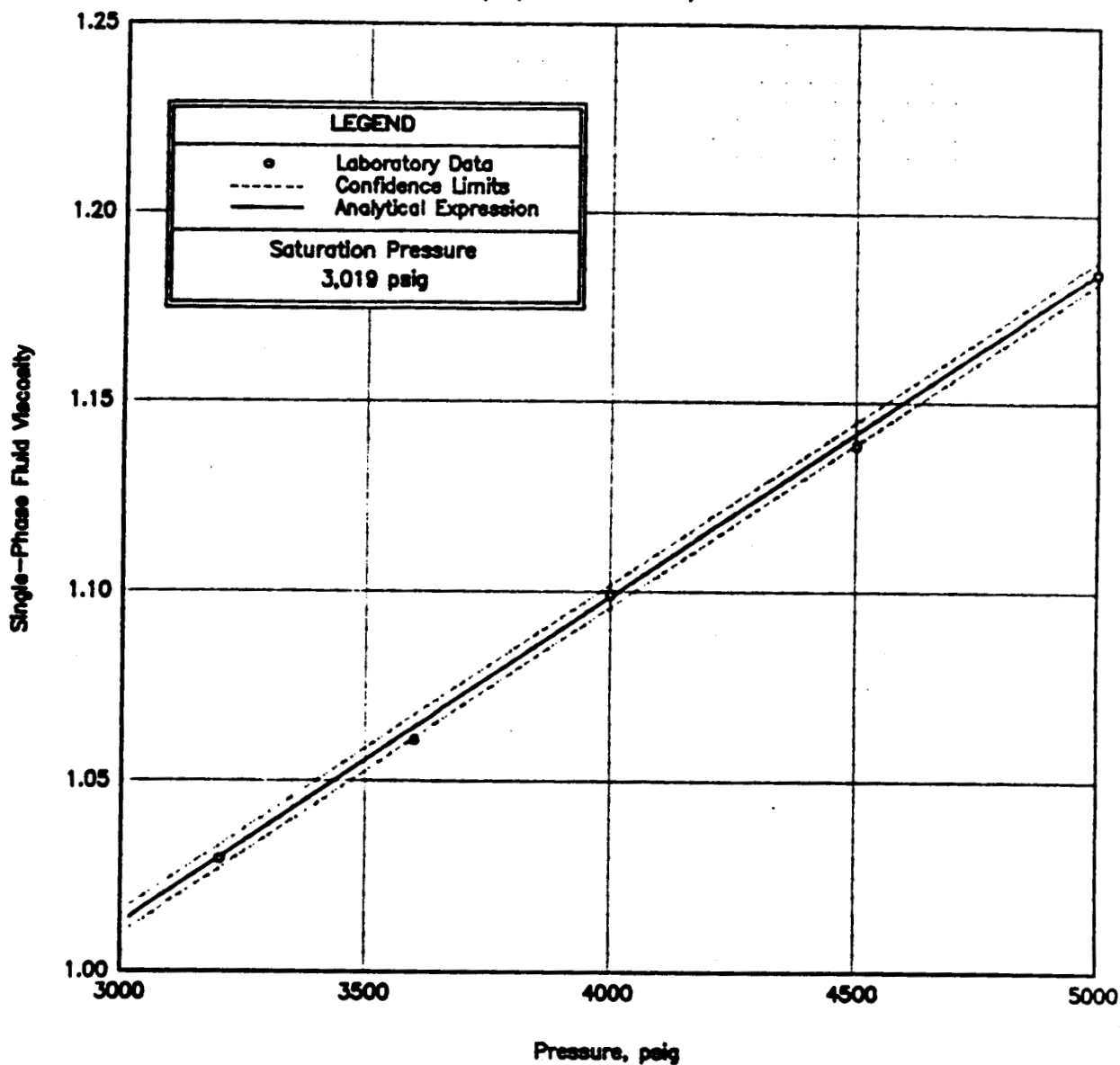
(C) Barrels of saturated oil at 3019 psig and 119 °F per Barrel of Stock Tank Oil at 60 °F.

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

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## SINGLE-PHASE VISCOSITY ( cp at 119 °F )



Analytical Expression

$$1.014E00 + 1.017E00 ( dP )$$

Notes: dP is defined as | P1 - P2 |, psig

### Statistical Summary

r squared: 0.998835  
Confidence Interval (+/-): 0.003  
Confidence: 99 %

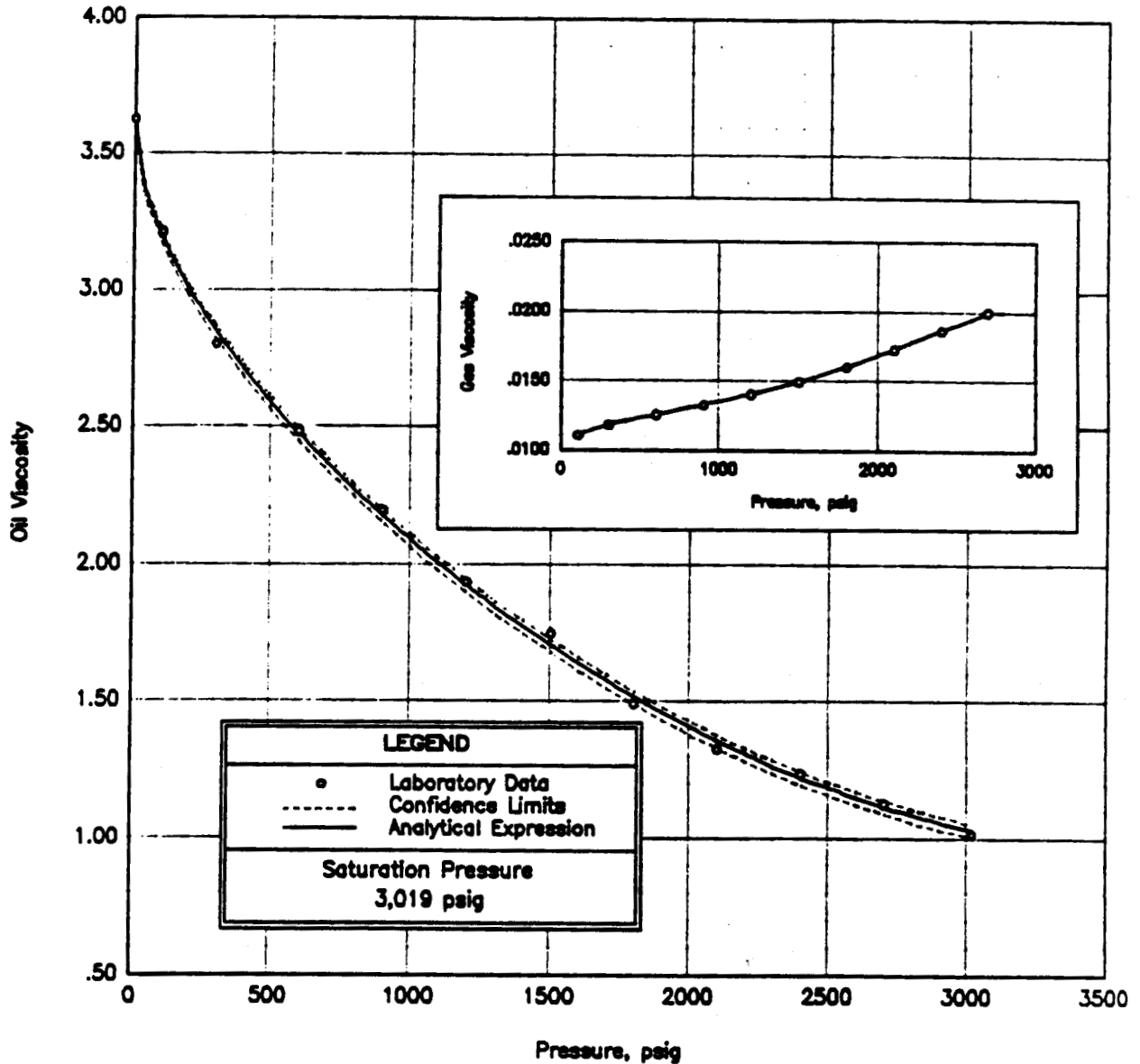
### Viscosity Analyses

Figure C-2

# Arco Exploration & Production Technology

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## RESERVOIR FLUID VISCOSITIES ( cp at 119 °F )



Analytical Expression (below bubblepoint)

$$3.623 \text{ E}00 + -3.144\text{E}-04 ( P1 ) + 4.742\text{E}-10 ( P1 )^{-2.6} + -3.958\text{E}-02 ( P1 )^{-0.5}$$

Note: P1 is defined as pressure, psig

### Statistical Summary

r squared: 0.999161  
Confidence Interval (+/-): 0.023  
Confidence: 99 %

### Viscosity Analyses

Figure C-1

# Arco Exploration & Production Technology

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## RESERVOIR FLUID VISCOSITY

(at 119 °F)

Pressure psig	Oil Viscosity cp	Calculated Gas Viscosity* cp	Oil/Gas Viscosity Ratio
------------------	------------------------	---------------------------------------	-------------------------------

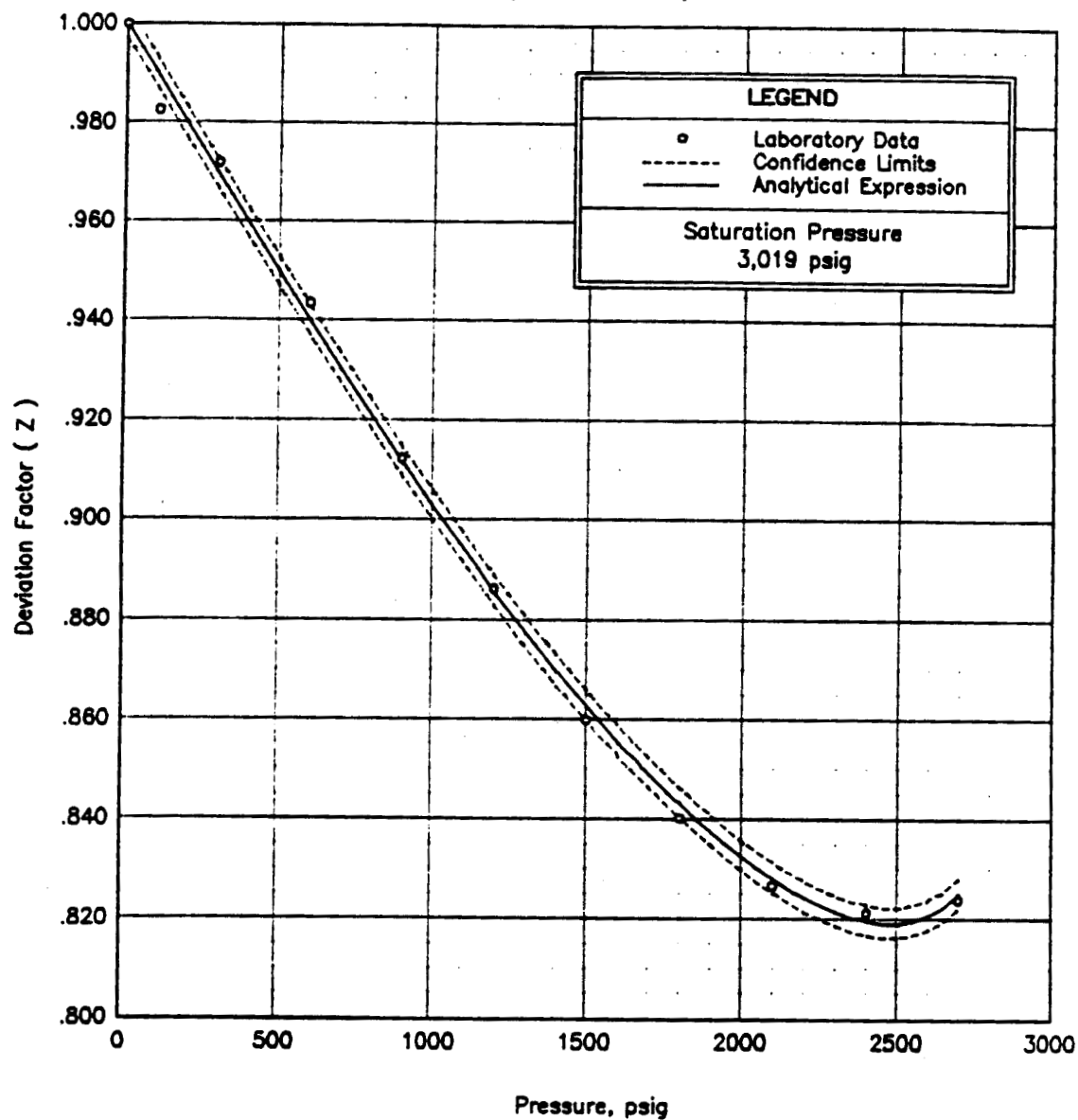
5000	1.18		
4500	1.14		
4000	1.10		
3600	1.06		
3200	1.03		
b=3019	1.01		
2700	1.11	0.0200	55.8
2400	1.22	0.0186	65.7
2100	1.36	0.0172	78.8
1800	1.52	0.0160	95.0
1500	1.70	0.0149	114
1200	1.92	0.0140	138
900	2.18	0.0132	165
600	2.47	0.0125	198
300	2.84	0.0118	242
105	3.19	0.0110	289
0	3.62		

\* 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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## Z-FACTOR ( at 119 °F )



### Analytical Expression

$$1 + -1.012E-04 ( P_i ) + 4.173E-54 ( P_i )^{15} + 4.377E-12 ( P_i )^3$$

Note:  $P_i$  is defined as pressure, psig

### Statistical Summary

r squared: 0.998154  
Confidence Interval (+/-): 0.003  
Confidence: 99 %

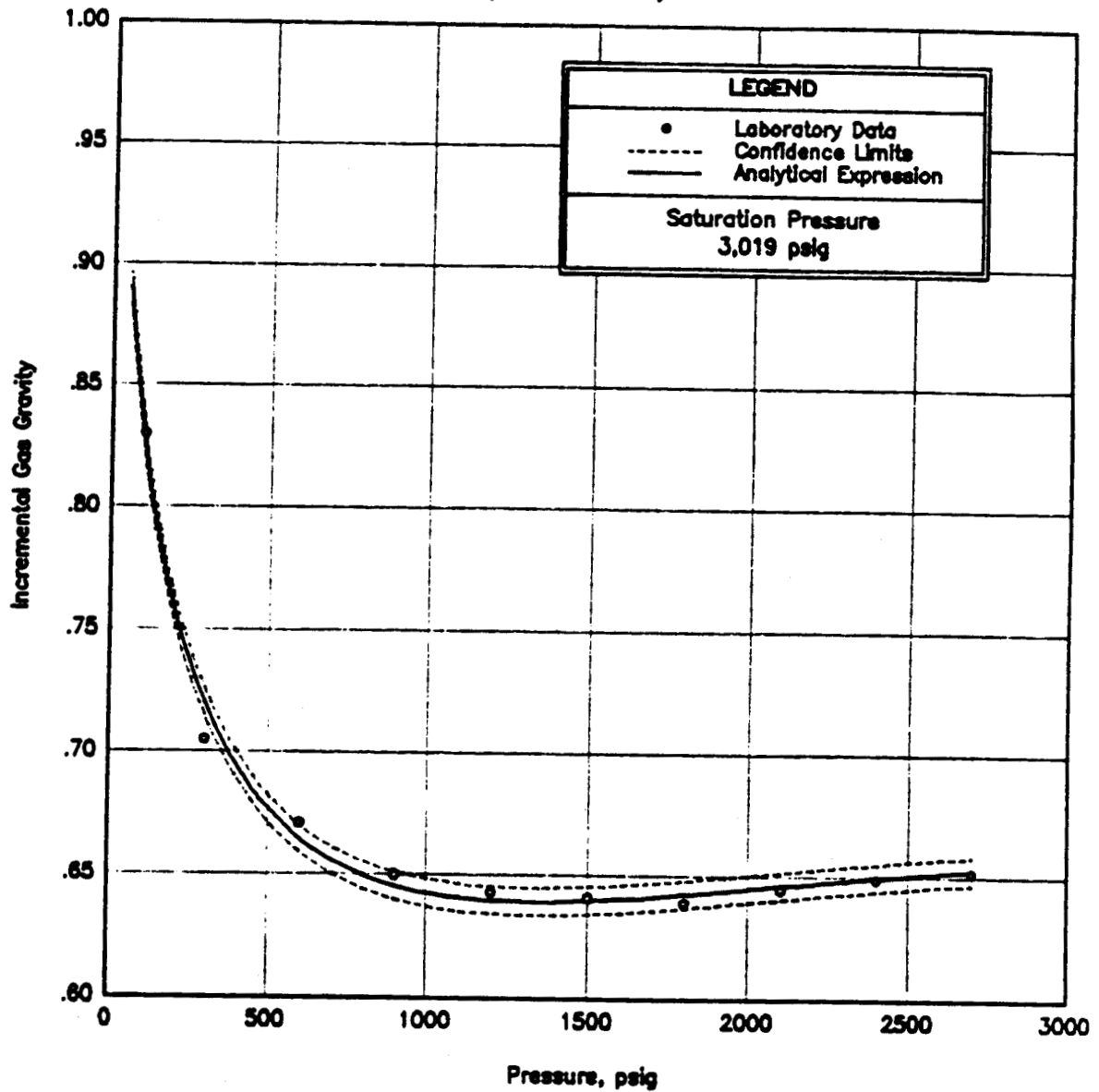
### Differential Vaporization

Figure B-5

# Arco Exploration & Production Technology

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## GAS GRAVITY ( at 119 °F )



### Analytical Expression

$$2.177E00 + -1.221E-01 ( P1 )^{-0.300} + 3.054E-03 ( P1 )^{-0.500} + -9.210E-01 ( \exp(-X_d) )$$

Notes:  $X_d$  is defined as  $P1 / P_{sat}$

### Statistical Summary

r squared: 0.999009  
 Confidence Interval (+/-): 0.0056  
 Confidence: 99 %

### Differential Vaporization

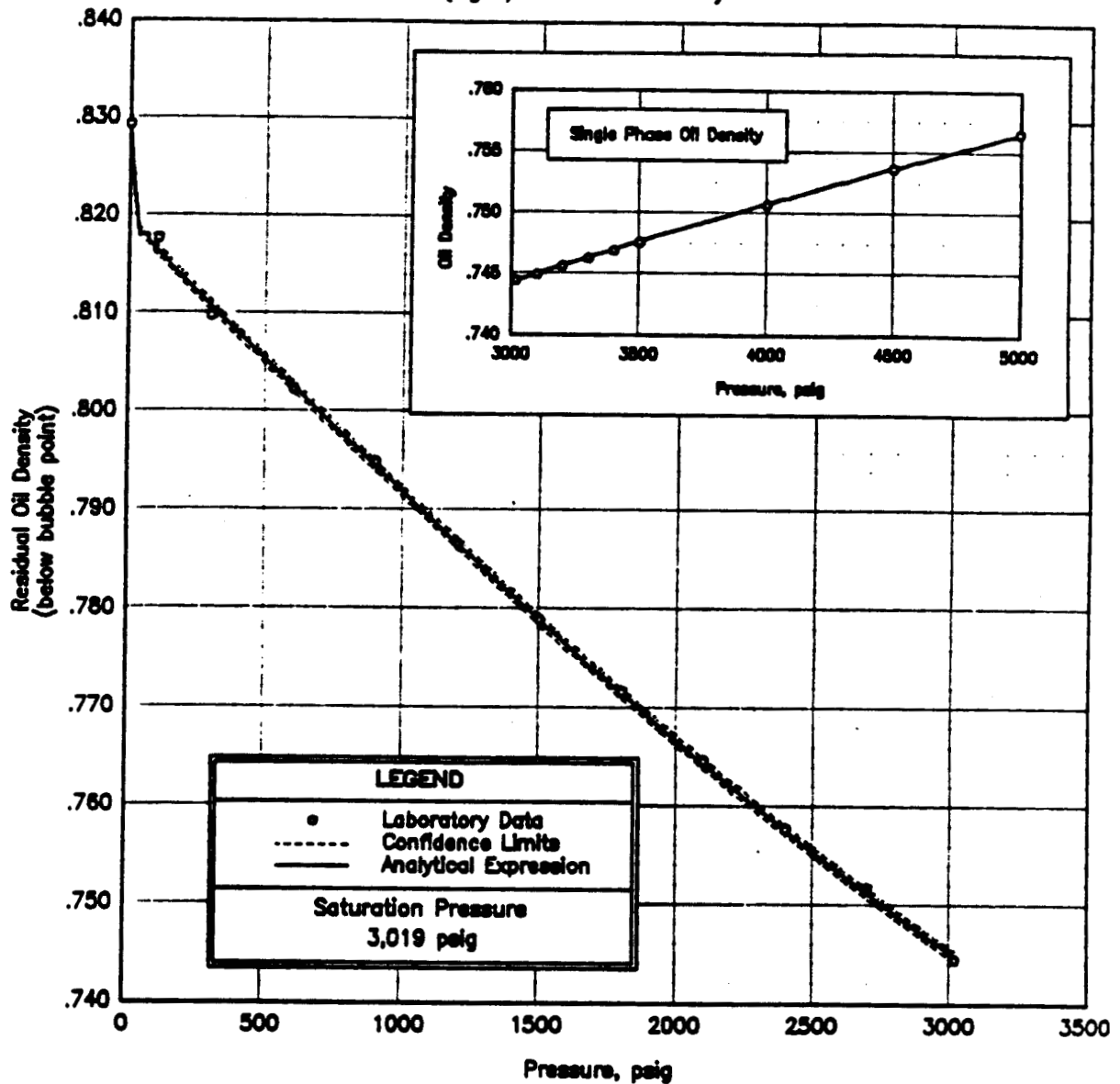
Figure B-4



# Arco Exploration & Production Technology

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## OIL DENSITY ( gm/cc at 119 °F )



Analytical Expression (below bubblepoint)

$$0.82934 + -6.833E-03 (PI)^{-0.1} + -1.241E-05 (PI)^{-1.1} + 2.820E-11 (PI)^{-2.5}$$

Notes: PI is defined as pressure, psig

### Statistical Summary

r squared: 0.999803  
Confidence Interval (+/-): 0.0005  
Confidence: 99 %

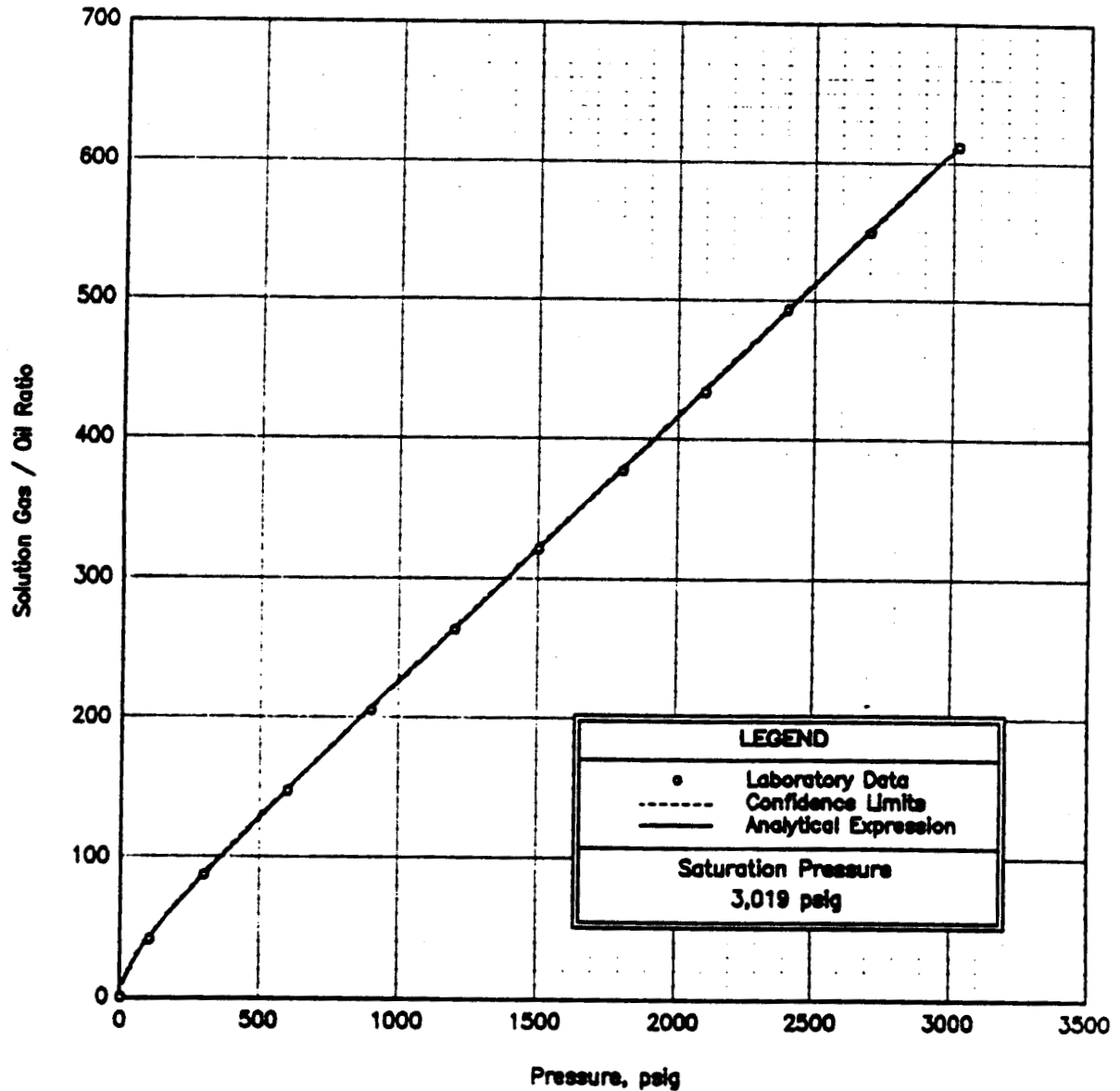
### Differential Vaporization

Figure B-3

# Arco Exploration & Production Technology

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## SOLUTION GAS/OIL RATIO ( scf/bbl at 119 °F )



Analytical Expression (below bubblepoint)

$$6.418E-02 (PI)^{-1.1} + 3.038E00 (PI)^{-0.5} + 1.460E-06 (PI)^{-2}$$

Note: PI is defined as pressure, psig

### Statistical Summary

r squared: 0.999990  
Confidence Interval (+/-): 1  
Confidence: 99 %

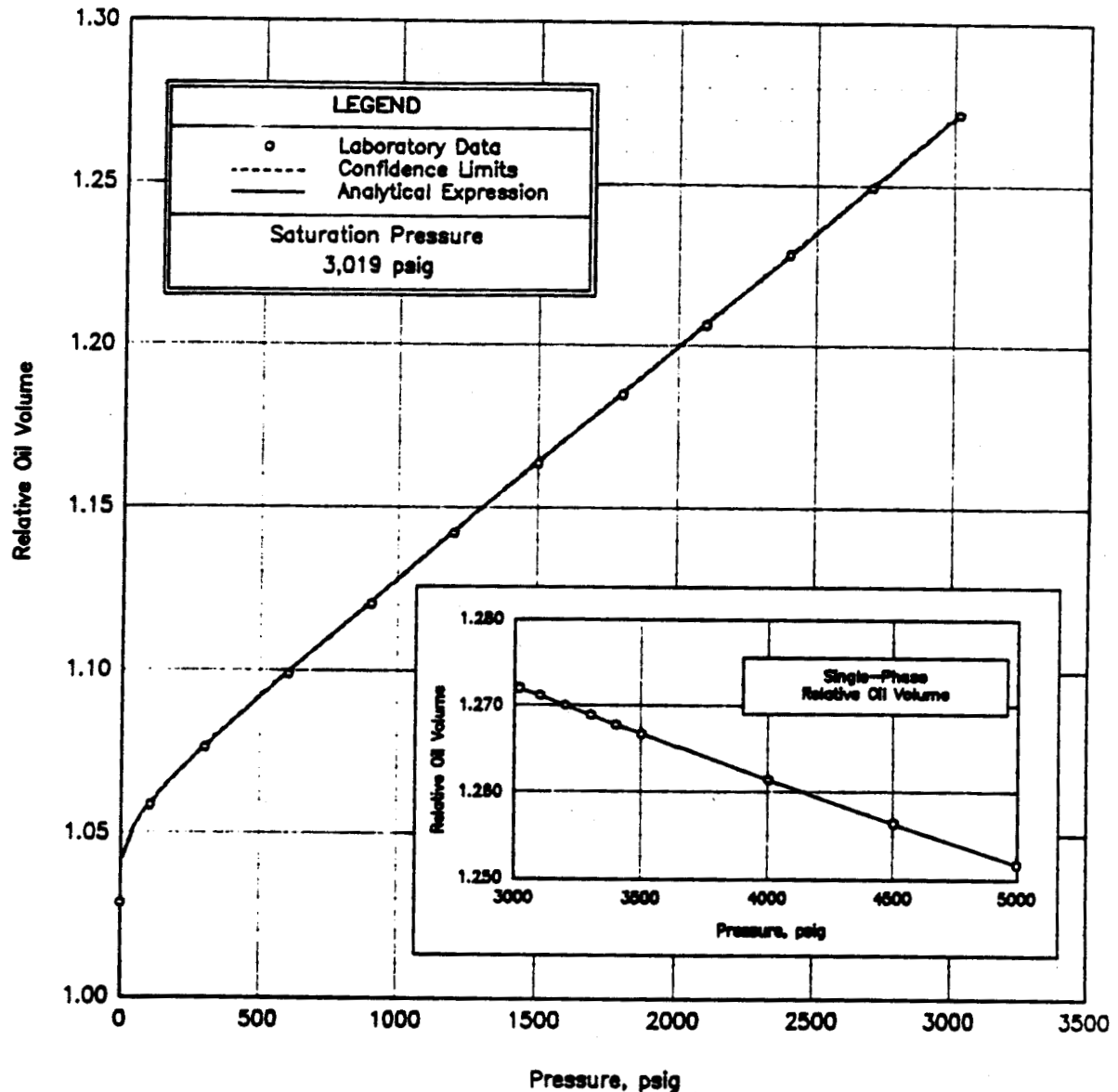
### Differential Vaporization

Figure B-2

# Arco Exploration & Production Technology

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## RELATIVE OIL VOLUME ( at 119 °F )



Analytical Expression (below bubblepoint)

$$1.029E00 + 8.010E-05 (PI) + 2.150E-02 (PI)^{0.4} + -1.435E-02 (PI)^{-0.45}$$

Note: PI is defined as pressure, psig

### Statistical Summary

r squared: 0.999995  
Confidence Interval (+/-): .0002  
Confidence: 99 %

### Differential Vaporization

Figure B-1

# Arco Exploration & Production Technology

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## DIFFERENTIAL VAPORIZATION

(at 119 °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-3019	612	1.272	1.272	0.7448			
2700	550	1.249	1.305	0.7512	0.825	0.00496	0.653
2400	493	1.228	1.344	0.7576	0.820	0.00554	0.650
2100	435	1.207	1.408	0.7644	0.828	0.00639	0.646
1800	378	1.185	1.502	0.7715	0.843	0.00758	0.642
1500	321	1.164	1.645	0.7789	0.863	0.00929	0.640
1200	264	1.142	1.880	0.7866	0.886	0.01190	0.640
900	206	1.121	2.298	0.7945	0.912	0.01627	0.645
600	148	1.099	3.163	0.8025	0.940	0.02495	0.665
300	87	1.076	5.773	0.8107	0.970	0.05028	0.720
105	42	1.059	14.767	0.8164	0.989	0.13489	0.825
0	0	1.029		0.8293			1.256
	@ 60 °F = 1.000						

Gravity of Residual Oil = 34.2 °API at 60 °F

Density of Residual Oil = 0.8531 gm/cc at 60 °F

(A) Cubic Feet of gas at 14.65 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.

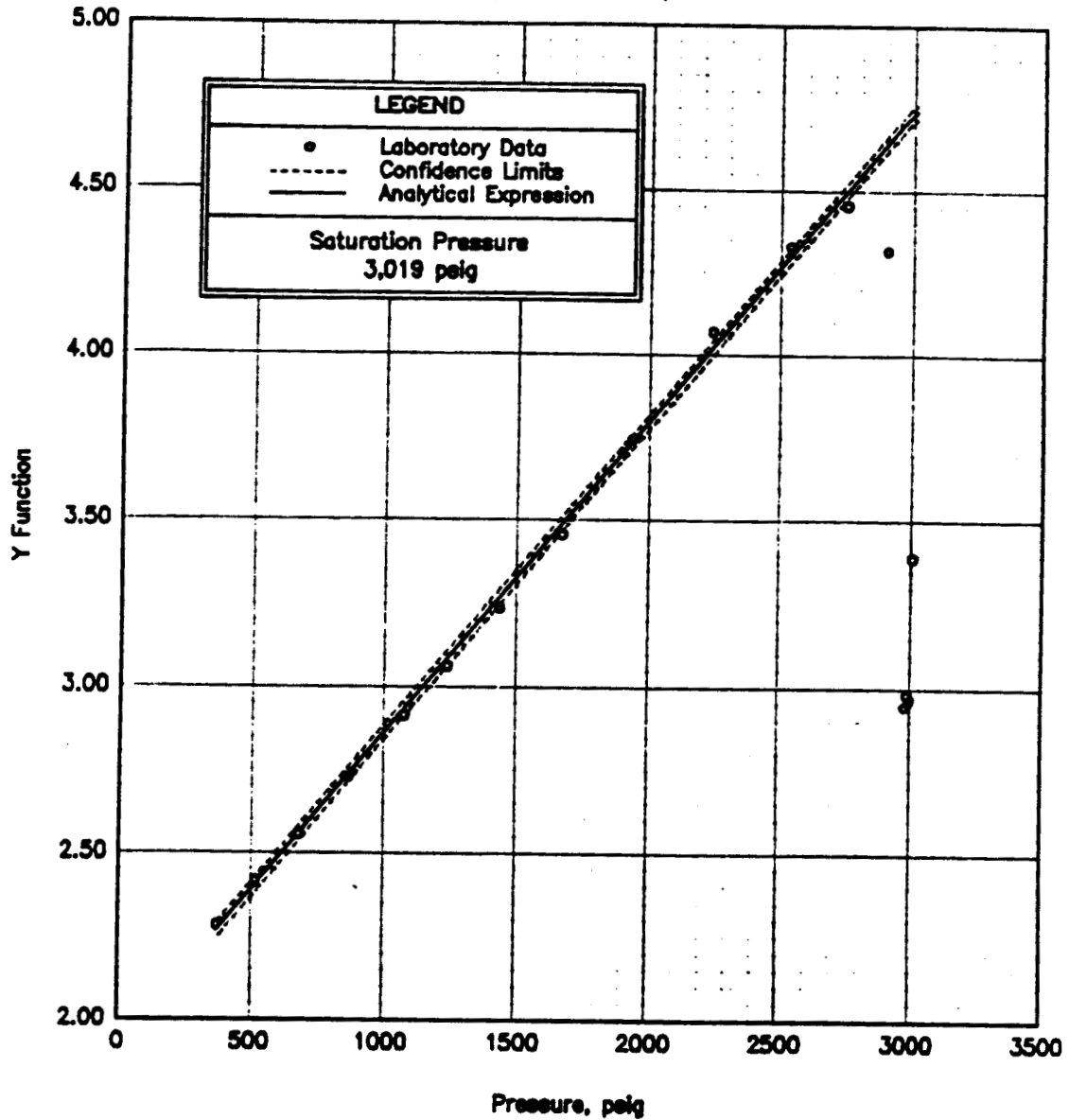
(C) Barrels of oil plus liberated gas at indicated pressure and temperature per Barrel of residual oil at 60 °F.

(D) Cubic Feet of gas at indicated pressure and temperature per Cubic Feet at 14.65 psia and 60 °F.

# Arco Exploration & Production Technology

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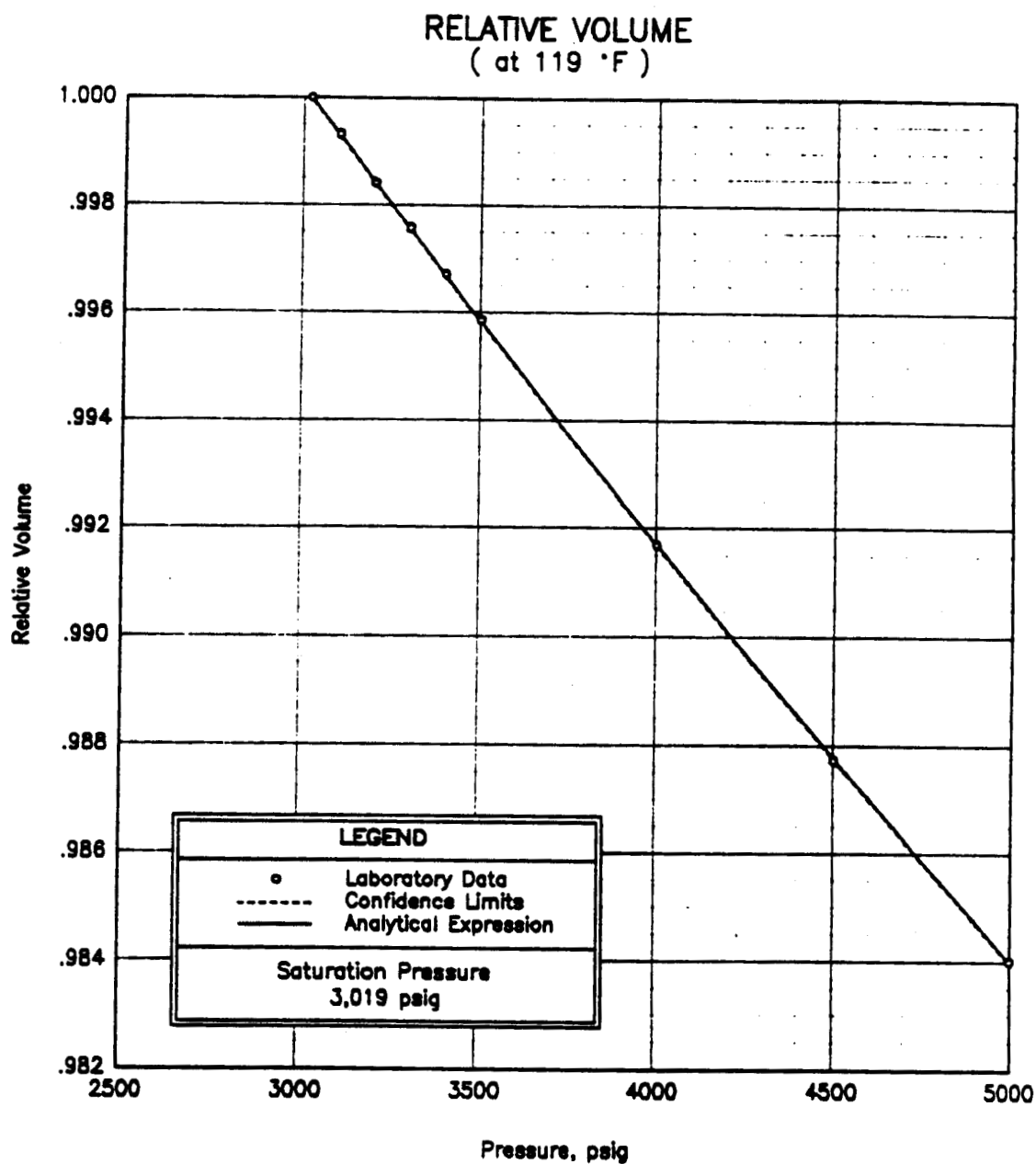
## Y-FUNCTION ( at 119 °F )



Analytical Expression		9.393E-04 (Xd) + 1.918E00	
Note: Xd is defined as PI / Pout			
Statistical Summary		Pressure-Volume Relations Figure A-2	
r squared:	0.998527		
Confidence Interval (+/-):	0.0227		
Confidence:	98 %		

# Arco Exploration & Production Technology

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## Analytical Expression

$$1 - 10^{-5} [ -5.124E00 + 1.033E00 (\log(dP)) + -1.982E-04 (\log(dP))^2 ]$$

Note: dP is defined as  $|P_1 - P_{sat}|$ , psig

## Statistical Summary

r squared: 0.999981  
Confidence Interval (+/-): 0.0000  
Confidence: 99 %

## Pressure-Volume Relations

Figure A-1

# Arco Exploration & Production Technology

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## PRESSURE-VOLUME RELATIONS

(at 119 °F)

Pressure psig	Relative Volume (A)	Y-Function (B)	Density gm/cc
5000	0.9840		0.7569
4500	0.9878		0.7540
4000	0.9917		0.7510
3500	0.9958		0.7479
3400	0.9967		0.7473
3300	0.9976		0.7466
3200	0.9984		0.7460
3100	0.9993		0.7453
b-3019	1.0000		0.7448
3007	1.0008		
2999	1.0014		
2990	1.0020		
2981	1.0027		
2902	1.0086		
2747	1.0219		
2535	1.0442	4.299	
2237	1.0864	4.019	
1937	1.1483	3.737	
1670	1.2297	3.486	
1438	1.3330	3.268	
1241	1.4592	3.083	
1078	1.6062	2.930	
868	1.8917	2.733	
679	2.3201	2.556	
516	2.9634	2.402	
371	4.0298	2.266	

(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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## VOLUMETRIC DATA

(at 119 °F)

Saturation Pressure (Psat)	3019	psig
Density at Psat	0.7448	gm/cc
Thermal Exp @ 5000 psig	1.02791	V at 119 °F / V at 70 °F

## AVERAGE SINGLE-PHASE COMPRESSIBILITIES

Pressure Range psig			Single-Phase Compressibility v/v/psi
5000	to	4500	7.64 E -6
4500	to	4000	7.95 E -6
4000	to	3500	8.31 E -6
3500	to	3019	8.65 E -6



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### Composition of Low Temperature Distillation Residue ( From Chromatographic Technique )

Component	Mol %	Wt %	Density (gm/cc)	MW	Vol %
Hydrogen Sulfide	.00	.00			
Carbon Dioxide	.00	.00			
Nitrogen	.00	.00			
Methane	.00	.00			
Ethane	.00	.00			
Propane	.00	.00			
iso-Butane	.00	.00			
n-Butane	.00	.00			
iso-Pentane	.00	.00			
n-Pentane	.00	.00			
Hexanes	1.07	.39	.685	84.0	0.49
Heptanes	6.47	2.69	.722	96.0	3.23
Octanes	10.09	4.68	.745	107.0	5.44
Nonanes	7.24	3.79	.764	121.0	4.30
Decanes	6.83	3.96	.778	134.0	4.41
Undecanes	5.39	3.43	.789	147.0	3.77
Dodecanes	4.71	3.28	.800	161.0	3.55
Tridecanes	5.45	4.13	.811	175.0	4.41
Tetradecanes	5.13	4.22	.822	190.0	4.45
Pentadecanes	5.29	4.72	.832	206.0	4.91
Hexadecanes	3.80	3.65	.839	222.0	3.77
Heptadecanes	3.39	3.48	.847	237.0	3.56
Octadecanes	3.36	3.65	.852	251.0	3.71
Nonadecanes	2.88	3.28	.857	263.0	3.32
Eicosanes	2.28	2.71	.862	275.0	2.72
Heneicosanes	2.01	2.53	.867	291.0	2.53
Docosanes	1.84	2.43	.872	305.0	2.42
Tricosanes	1.61	2.21	.877	318.0	2.18
Tetracosanes	1.44	2.07	.881	331.0	2.04
Pentacosanes	1.45	2.16	.885	345.0	2.11
Hexacosanes	1.07	1.67	.889	359.0	1.63
Heptacosanes	1.20	1.94	.893	374.0	1.68
Octacosanes	1.05	1.76	.896	388.0	1.70
Nonacosanes	.91	1.58	.899	402.0	1.52
Triacotanes	.99	1.78	.902	416.0	1.71
Hentriacotanes	.84	1.57	.906	430.0	1.50
Dotriacotanes	.67	1.29	.909	444.0	1.23
Tritriacotanes	.62	1.23	.912	458.0	1.17
Tetratriacotanes	.57	1.16	.914	472.0	1.10
Pentatriacotanes	.48	1.00	.917	486.0	0.94
Hexatriacotanes plu	9.87	21.56	1.021	504.2	18.29
Totals .....	100.00	100.00			100.00

### Sample Characteristics

Pb Adjusted Recombination

Total Liquid Molecular Weight ..... 231.0  
 Total Liquid Density (gm/cc) ..... 0.8664  
 Total Liquid API Gravity ..... 31.8

### Properties of Heavy Fractions

Plus Fractions	Mol %	Wt %	Density (gm/cc)	*API	MW
Hexanes plus	100.00	100.00	0.866	31.8	231.0
Heptanes plus	96.93	99.61	0.867	31.7	232.6
Decanes plus	75.13	88.45	0.886	28.3	272.0
Undecanes plus	68.30	84.49	0.891	27.3	285.8
Pentadecanes plus	47.62	69.43	0.912	23.6	336.8
Eicosanes plus	28.90	50.65	0.940	19.0	404.9
Pentacosanes plus	19.72	38.70	0.964	15.3	453.3
Triacotanes plus	14.04	29.59	0.988	11.7	486.7
Pentatriacotanes plus	10.35	22.56	1.016	7.7	503.4

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## Composition of Heptanes Plus Fraction

( From Chromatographic Technique )

Component	Mol %	Wt %	Density (gm/cc)	MW	Vol %
Hydrogen Sulfide	.00	.00			
Carbon Dioxide	.00	.00			
Nitrogen	.00	.00			
Methane	.00	.00			
Ethane	.00	.00			
Propane	.00	.00			
iso-Butane	.00	.00			
n-Butane	.00	.00			
iso-Pentane	.00	.00			
n-Pentane	.00	.00			
Hexanes	.00	.00			
Heptanes	6.54	2.70	.722	96.0	3.24
Octanes	10.25	4.70	.745	107.0	5.47
Nonanes	7.30	3.80	.764	121.0	4.31
Decanes	6.91	3.98	.778	134.0	4.44
Undecanes	5.44	3.44	.789	147.0	3.78
Dodecanes	4.75	3.29	.800	161.0	3.56
Tridecanes	5.52	4.15	.811	175.0	4.44
Tetradecanes	5.19	4.24	.822	190.0	4.47
Pentadecanes	5.35	4.74	.832	206.0	4.94
Hexadecanes	3.83	3.66	.839	222.0	3.78
Heptadecanes	3.43	3.49	.847	237.0	3.57
Octadecanes	3.39	3.66	.852	251.0	3.73
Nonadecanes	2.91	3.29	.857	263.0	3.33
Eicosanes	2.30	2.72	.862	275.0	2.74
Heneicosanes	2.03	2.54	.867	291.0	2.54
Docosanes	1.86	2.44	.872	305.0	2.43
Tricosanes	1.62	2.22	.877	318.0	2.19
Tetracosanes	1.46	2.08	.881	331.0	2.05
Pentacosanes	1.46	2.17	.885	345.0	2.12
Hexacosanes	1.09	1.68	.889	359.0	1.64
Heptacosanes	1.21	1.95	.893	374.0	1.89
Octacosanes	1.06	1.77	.896	388.0	1.72
Nonacosanes	.92	1.59	.899	402.0	1.53
Triacotanes	1.00	1.79	.902	416.0	1.72
Hentriacotanes	.85	1.58	.906	430.0	1.51
Dotriacotanes	.68	1.30	.909	444.0	1.24
Tristriacotanes	.62	1.23	.912	458.0	1.17
Tettriacotanes	.57	1.16	.914	472.0	1.10
Pentatriacotanes	.48	1.00	.917	486.0	0.95
Hexatriacotanes plus	9.98	21.64	1.021	504.2	18.38
Totals .....	100.00	100.00			100.00

### Sample Characteristics

Pb Adjusted Recombination

Total Liquid Molecular Weight ..... 232.6  
 Total Liquid Density (gm/cc) ..... 0.8670  
 Total Liquid API Gravity ..... 31.7

### Properties of Heavy Fractions

Plus Fractions	Mol %	Wt %	Density (gm/cc)	*API	MW
Heptanes plus	100.00	100.00	0.867	31.7	232.5
Decanes plus	75.91	88.80	0.885	28.3	271.9
Undecanes plus	69.00	84.82	0.891	27.3	285.8
Pentadecanes plus	48.10	69.70	0.912	23.6	336.8
Eicosanes plus	29.19	50.86	0.940	19.0	404.9
Pentacosanes plus	19.92	38.86	0.964	15.4	453.3
Triacotanes plus	14.18	29.70	0.988	11.7	486.7
Pentatriacotanes plus	10.46	22.64	1.016	7.8	503.4

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## Composition of Reservoir Fluid\*

Component	Mol %	Wt %	MW	Liq Dens (gm/cc)
Hydrogen	0.00			
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.27	0.110	44.010	0.8172
Nitrogen	0.07	0.020	28.013	0.8086
Methane	45.49	6.790	16.043	0.2997
Ethane	3.59	1.000	30.070	0.3558
Propane	3.75	1.540	44.097	0.5065
i-Butane	1.21	0.650	58.123	0.5623
n-Butane	2.01	1.090	58.123	0.5834
i-Pentane	0.93	0.620	72.15	0.6241
n-Pentane	1.05	0.700	72.15	0.6305
Hexanes	2.02	1.580	84.00	0.6850
Heptanes plus	39.61	85.900	233.00	0.8670
	100.00	100.00		

### Sample Characteristics

Pb Adjusted Recombination

Average Molecular Weight ..... 107.5

Sample Density (at 60 °F) ..... 0.7397

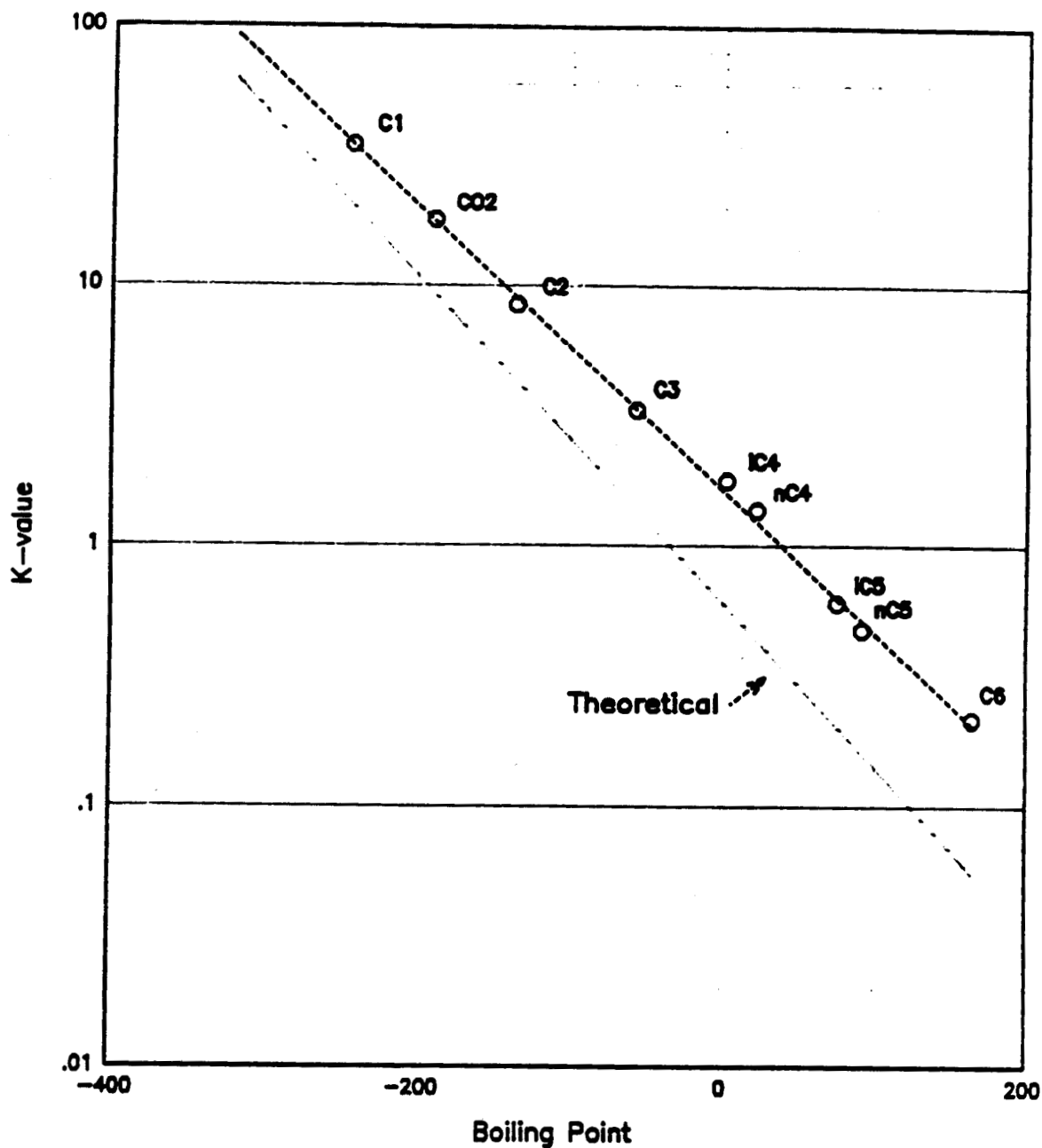
Note: Heptanes plus MW and Density are measured values.

\* Corrected for hexanes minus fraction identified in residue analysis.

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## Equilibrium Ratios (at 106 °F)



	K-Value Plot Figure QC-1
Separator Pressure 127 psig	

CORE LABORATORIES

# Arco Exploration & Production Technology

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## Composition of Low Temperature Distillation Residue ( From Chromatographic Technique )

Component	Mol %	Wt %	Density (gm/cc)	MW	Vol %
Hydrogen Sulfide	.00	.00			
Carbon Dioxide	.00	.00			
Nitrogen	.00	.00			
Methane	.00	.00			
Ethane	.00	.00			
Propane	.00	.00			
iso-Butane	.00	.00			
n-Butane	.04	.01	.583	58.1	0.02
iso-Pentane	.07	.02	.624	72.2	0.03
n-Pentane	.03	.01	.630	72.2	0.02
Hexanes	.71	.25	.685	84.0	0.31
Heptanes	5.65	2.27	.722	96.0	2.74
Octanes	9.00	4.03	.745	107.0	4.73
Nonanes	7.03	3.56	.764	121.0	4.07
Decanes	6.81	3.82	.778	134.0	4.29
Undecanes	5.59	3.44	.789	147.0	3.81
Dodecanes	4.84	3.26	.800	161.0	3.56
Tridecanes	5.50	4.03	.811	175.0	4.34
Tetradecanes	5.07	4.03	.822	190.0	4.28
Pentadecanes	5.15	4.42	.832	208.0	4.67
Hexadecanes	4.00	3.72	.839	222.0	3.87
Heptadecanes	3.58	3.55	.847	237.0	3.66
Octadecanes	3.68	3.86	.852	251.0	3.96
Nonadecanes	2.99	3.29	.857	263.0	3.35
Eicosanes	2.46	2.83	.862	275.0	2.87
Heneicosanes	2.20	2.68	.867	291.0	2.70
Docosanes	2.01	2.56	.872	305.0	2.57
Tricosanes	1.78	2.37	.877	318.0	2.36
Tetracosanes	1.59	2.20	.881	331.0	2.18
Pentacosanes	1.56	2.25	.885	345.0	2.22
Hexacosanes	1.20	1.80	.889	359.0	1.76
Heptacosanes	1.27	1.98	.893	374.0	1.94
Octacosanes	1.18	1.91	.896	388.0	1.86
Nonacosanes	1.06	1.81	.899	402.0	1.76
Triacontanes	1.03	1.80	.902	416.0	1.75
Hentriacontanes	.89	1.60	.906	430.0	1.55
Dotriacontanes	.76	1.42	.909	444.0	1.36
Trtriacontanes	.69	1.32	.912	458.0	1.27
Tetracontanes	.56	1.10	.914	472.0	1.05
Pentatriacontanes	.44	.89	.917	486.0	0.85
Hexatriacontanes pl	9.56	21.91	1.047	546.8	18.25
Totals	100.00	100.00			100.00

### Sample Characteristics

Cylinder No. W3A8814

Total Liquid Molecular Weight ..... 239.0  
Total Liquid Density (gm/cc) ..... 0.8736  
Total Liquid API Gravity ..... 30.5

### Properties of Heavy Fractions

Plus Fractions	Mol %	Wt %	Density (gm/cc)	*API	MW
Hexanes plus	99.86	99.96	0.874	30.4	239.2
Heptanes plus	99.15	99.71	0.874	30.3	240.4
Decanes plus	77.47	89.85	0.891	27.3	277.2
Undecanes plus	70.66	86.03	0.897	26.3	291.0
Pentadecanes plus	49.86	71.27	0.918	22.6	343.0
Eicosanes plus	30.26	52.43	0.948	17.8	414.0
Pentacosanes plus	20.22	39.79	0.975	13.6	470.1
Triacontanes plus	13.93	30.04	1.006	9.2	514.7
Pentatriacontanes plus	10.00	22.80	1.042	4.3	544.1

# Arco Exploration & Production Technology

RFL 920279

## Composition of Heptanes Plus Fraction

( From Chromatographic Technique )

Component	Mol %	Wt %	Density (gm/cc)	MW	Vol %
Hydrogen Sulfide	.00	.00			
Carbon Dioxide	.00	.00			
Nitrogen	.00	.00			
Methane	.00	.00			
Ethane	.00	.00			
Propane	.00	.00			
iso-Butane	.00	.00			
n-Butane	.00	.00			
iso-Pentane	.00	.00			
n-Pentane	.00	.00			
Hexanes	.00	.00			
Heptanes	5.71	2.28	.722	96.0	2.76
Octanes	9.08	4.04	.745	107.0	4.74
Nonanes	7.09	3.57	.764	121.0	4.08
Decanes	6.87	3.83	.778	134.0	4.30
Undecanes	5.64	3.45	.789	147.0	3.82
Dodecanes	4.88	3.27	.800	161.0	3.58
Tridecanes	5.55	4.04	.811	175.0	4.35
Tetradecanes	5.11	4.04	.822	190.0	4.29
Pentadecanes	5.17	4.42	.832	206.0	4.65
Hexadecanes	4.04	3.73	.839	222.0	3.89
Heptadecanes	3.61	3.56	.847	237.0	3.67
Octadecanes	3.71	3.87	.852	251.0	3.97
Nonadecanes	3.02	3.30	.857	263.0	3.37
Eicosanes	2.48	2.84	.862	275.0	2.88
Heneicosanes	2.22	2.69	.867	291.0	2.71
Docosanes	2.03	2.57	.872	305.0	2.58
Tricosanes	1.80	2.38	.877	318.0	2.37
Tetracosanes	1.61	2.21	.881	331.0	2.19
Pentacosanes	1.57	2.26	.885	345.0	2.23
Hexacosanes	1.21	1.81	.889	359.0	1.78
Heptacosanes	1.28	1.99	.893	374.0	1.95
Octacosanes	1.19	1.92	.896	388.0	1.87
Nonacosanes	1.09	1.82	.899	402.0	1.77
Triacontanes	1.05	1.81	.902	416.0	1.76
Hentriacontanes	.89	1.60	.906	430.0	1.55
Dotriacontanes	.77	1.42	.909	444.0	1.36
Tritriacontanes	.69	1.32	.912	458.0	1.27
Tetra triacontanes	.56	1.10	.914	472.0	1.05
Pentatriacontanes	.44	.89	.917	486.0	0.85
Hexatriacontanes plus	9.64	21.97	1.047	546.8	18.35
<b>Totals</b>	<b>100.00</b>	<b>100.00</b>			<b>100.00</b>

### Sample Characteristics

Cylinder No. W3A8814

Total Liquid Molecular Weight .....	240.4
Total Liquid Density (gm/cc) .....	0.8740
Total Liquid API Gravity .....	30.4

### Properties of Heavy Fractions

Plus Fractions	Mol %	Wt %	Density (gm/cc)	*API	MW
Heptanes plus	100.00	100.00	0.874	30.3	240.3
Decanes plus	78.12	90.11	0.891	27.3	277.2
Undecanes plus	71.25	86.28	0.897	26.3	291.0
Pentadecanes plus	50.07	71.48	0.918	22.6	343.1
Eicosanes plus	30.52	52.60	0.948	17.8	414.0
Pentacosanes plus	20.38	39.91	0.975	13.6	470.1
Triacontanes plus	14.04	30.11	1.006	9.2	514.7
Pentatriacontanes plus	10.08	22.86	1.041	4.4	544.1

# Arco Exploration & Production Technology

RFL 920279

## Composition of Separator Liquid\*

Component	Mol %	Wt %	MW	Liq Dens (gm/cc)
Hydrogen	0.00			
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.03	0.010	44.010	0.8172
Nitrogen	0.01	0.000	28.013	0.8086
Methane	2.65	0.200	16.043	0.2997
Ethane	0.74	0.100	30.070	0.3558
Propane	1.72	0.350	44.097	0.5085
i-Butane	0.90	0.240	58.123	0.5623
n-Butane	1.70	0.460	58.123	0.5834
i-Pentane	1.40	0.470	72.15	0.6241
n-Pentane	1.37	0.460	72.15	0.6305
Hexanes	3.71	1.460	84.00	0.6850
Heptanes plus	85.77	96.250	240.00	0.8740
	100.00	100.00		

### Sampling Conditions

127 psig  
106 °F

### Sample Characteristics

Cylinder No. W3A8814

Average Molecular Weight ..... 213.9  
Sample Density (at 60 °F) ..... 0.8575

Note: Heptanes plus MW and Density are measured values.

\* Corrected for hexanes minus fraction identified in residue analysis.

# Arco Exploration & Production Technology

RFL 920279

## Composition of Low Temperature Distillation Residue ( From Chromatographic Technique )

Component	Mol %	Wt %	Density (gm/cc)	MW	Vol %
Hydrogen Sulfide	.00	.00			
Carbon Dioxide	.00	.00			
Nitrogen	.00	.00			
Methane	.00	.00			
Ethane	.00	.00			
Propane	.00	.00			
iso-Butane	.00	.00			
n-Butane	.04	.01	.583	58.1	0.02
iso-Pentane	.10	.03	.624	72.2	0.04
n-Pentane	.10	.03	.630	72.2	0.04
Hexanes	1.21	.44	.685	84.0	0.56
Heptanes	6.62	2.75	.722	96.0	3.33
Octanes	10.40	4.83	.745	107.0	5.67
Nonanes	7.73	4.05	.764	121.0	4.64
Decanes	7.29	4.23	.778	134.0	4.76
Undecanes	5.85	3.72	.789	147.0	4.12
Dodecanes	4.94	3.44	.800	161.0	3.76
Tridecanes	5.50	4.17	.811	175.0	4.50
Tetradecanes	4.91	4.04	.822	190.0	4.29
Pentadecanes	4.83	4.31	.832	206.0	4.53
Hexadecanes	3.80	3.65	.839	222.0	3.80
Heptadecanes	3.33	3.42	.847	237.0	3.53
Octadecanes	3.35	3.64	.852	251.0	3.73
Nonadecanes	2.71	3.08	.857	263.0	3.14
Eicosanes	2.22	2.64	.862	275.0	2.68
Heneicosanes	1.95	2.46	.867	291.0	2.48
Docosanes	1.77	2.34	.872	305.0	2.34
Tricosanes	1.55	2.13	.877	318.0	2.13
Tetracosanes	1.37	1.96	.881	331.0	1.94
Pentacosanes	1.23	1.83	.885	345.0	1.81
Hexacosanes	1.06	1.65	.889	359.0	1.63
Heptacosanes	1.06	1.71	.893	374.0	1.67
Octacosanes	.98	1.65	.896	388.0	1.61
Nonacosanes	.90	1.56	.899	402.0	1.52
Triacotanes	.86	1.55	.902	416.0	1.50
Hentriacotanes	.73	1.35	.906	430.0	1.30
Dotriacotanes	.62	1.20	.909	444.0	1.15
Tritriacotanes	.56	1.11	.912	458.0	1.07
Tetatriacotanes	.45	.91	.914	472.0	0.87
Pentatriacotanes	.35	.73	.917	486.0	0.70
Hexatriacotanes pl	9.63	23.38	1.070	560.3	19.12
Totals	100.00	100.00			100.00

### Sample Characteristics

Cylinder No. 193471D

Total Liquid Molecular Weight .....	231.0
Total Liquid Density (gm/cc) .....	0.8746
Total Liquid API Gravity .....	30.3

### Properties of Heavy Fractions

Plus Fractions	Mol %	Wt %	Density (gm/cc)	*API	MW
Hexanes plus	99.76	99.93	0.875	30.2	231.4
Heptanes plus	99.55	99.49	0.876	30.0	233.2
Decanes plus	73.80	87.86	0.897	26.3	275.0
Undecanes plus	66.51	83.63	0.904	25.1	290.5
Pentadecanes plus	45.31	68.26	0.929	20.8	348.1
Eicosanes plus	27.29	50.16	0.964	15.3	424.7
Pentacosanes plus	18.43	38.63	0.995	10.7	484.3
Triacotanes plus	13.20	30.23	1.028	6.1	528.9
Pentatriacotanes plus	9.98	24.11	1.064	1.4	557.7



# Arco Exploration & Production Technology

RFL 920279

## Composition of Heptanes Plus Fraction

( From Chromatographic Technique )

Component	Mol %	Wt %	Density (gm/cc)	MW	Vol %
Hydrogen Sulfide	.00	.00			
Carbon Dioxide	.00	.00			
Nitrogen	.00	.00			
Methane	.00	.00			
Ethane	.00	.00			
Propane	.00	.00			
iso-Butane	.00	.00			
n-Butane	.00	.00			
iso-Pentane	.00	.00			
n-Pentane	.00	.00			
Hexanes	.00	.00			
Heptanes	6.70	2.76	.722	96.0	3.35
Octanes	10.58	4.85	.745	107.0	5.70
Nonanes	7.84	4.07	.764	121.0	4.67
Decanes	7.40	4.25	.778	134.0	4.78
Undecanes	5.93	3.74	.789	147.0	4.15
Dodecanes	5.01	3.46	.800	161.0	3.79
Tridecanes	5.58	4.19	.811	175.0	4.53
Tetradecanes	4.98	4.08	.822	190.0	4.33
Pentadecanes	4.90	4.33	.832	206.0	4.55
Hexadecanes	3.86	3.67	.839	222.0	3.83
Heptadecanes	3.38	3.44	.847	237.0	3.56
Octadecanes	3.40	3.66	.852	251.0	3.77
Nonadecanes	2.75	3.10	.857	263.0	3.17
Eicosanes	2.25	2.85	.862	275.0	2.69
Heneicosanes	1.98	2.47	.867	291.0	2.50
Docosanes	1.80	2.35	.872	305.0	2.36
Tricosanes	1.57	2.14	.877	318.0	2.14
Tetracosanes	1.39	1.97	.881	331.0	1.96
Pentacosanes	1.24	1.84	.885	345.0	1.82
Hexacosanes	1.08	1.66	.889	359.0	1.64
Heptacosanes	1.07	1.72	.893	374.0	1.69
Octacosanes	1.00	1.66	.896	388.0	1.62
Nonacosanes	.91	1.57	.899	402.0	1.53
Triacotanes	.87	1.56	.902	416.0	1.52
Henotriacotanes	.74	1.36	.906	430.0	1.31
Dotriacotanes	.64	1.21	.909	444.0	1.16
Tritriacotanes	.57	1.12	.912	458.0	1.08
Tetrtriacotanes	.45	.91	.914	472.0	0.88
Pentatriacotanes	.35	.73	.917	486.0	0.70
Hexatriacotanes plus	9.78	23.50	1.070	560.3	19.23
Totals	100.00	100.00			100.00

### Sample Characteristics

Cylinder No. 193471D

Total Liquid Molecular Weight ..... 233.2  
 Total Liquid Density (gm/cc) ..... 0.8760  
 Total Liquid API Gravity ..... 30.0

### Properties of Heavy Fractions

Plus Fractions	Mol %	Wt %	Density (gm/cc)	*API	MW
Heptanes plus	100.00	100.00	0.876	30.0	233.2
Decanes plus	74.88	88.32	0.897	26.3	275.1
Undecanes plus	67.48	84.07	0.904	25.1	290.5
Pentadecanes plus	45.98	68.62	0.929	20.8	348.1
Eicosanes plus	27.69	50.42	0.964	15.3	424.7
Pentacosanes plus	18.70	38.84	0.995	10.6	484.3
Triacotanes plus	13.40	30.39	1.029	6.1	528.9
Pentatriacotanes plus	10.13	24.23	1.065	1.4	557.7

# Arco Exploration & Production Technology

RFL 920279

## Composition of Separator Oil\*

Component	Mol %	Wt %	MW	Liq Dens (gm/cc)
Hydrogen	0.00			
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.05	0.010	44.010	0.8172
Nitrogen	0.00			
Methane	2.34	0.180	16.043	0.2997
Ethane	0.69	0.100	30.070	0.3558
Propane	1.61	0.340	44.097	0.5065
i-Butane	0.63	0.230	58.123	0.5623
n-Butane	1.51	0.420	58.123	0.5834
i-Pentane	1.27	0.440	72.15	0.6241
n-Pentane	1.47	0.510	72.15	0.6305
Hexanes	3.05	1.230	84.00	0.6850
Heptanes plus	87.18	96.540	231.00	0.8750
	100.00	100.00		

### Sampling Conditions

127 psig  
106 °F

### Sample Characteristics

Cylinder No. 193471D

Average Molecular Weight ..... 208.6  
Sample Density (at 60 °F) ..... 0.8596

Note: Heptanes plus MW and Density are measured values.

\* Corrected for hexanes minus fraction identified in residue analysis.

# Arco Exploration & Production Technology

RFL 920279

## Composition of Separator Gas

( From Chromatographic Technique )

Component	Mol %	GPM	MW	Liq Dens (gm/cc)
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.48		44.010	.8172
Nitrogen	0.12		28.013	.8086
Methane	78.87		16.043	.2997
Ethane	5.49	1.460	30.070	.3558
Propane	5.48	1.502	44.097	.5065
iso-Butane	1.62	.527	58.123	.5623
n-Butane	2.41	.756	58.123	.5834
iso-Pentane	1.28	.466	72.150	.6241
n-Pentane	0.80	.288	72.150	.6305
Hexanes	1.27	.490	84.000	.6850
Heptanes	1.47	.615	96.000	.7220
Octanes	0.53	.240	107.00	.7450
Nonanes	0.11	.055	121.00	.7640
Decanes plus	0.07	.040	141.00	.7840
Totals .....	100.00	6.439		

### Sampling Conditions

125 psig

106 °F

### Sample Characteristics

Cylinder No. CLH478

Critical Pressure (psia) ..... 625.8

Critical Temperature (°R) ..... 370.8

Average Molecular Weight ..... 24.09

Calculated Gas Gravity (air = 1.000) ..... 0.832

Gas Gravity  
Factor, Fg ..... 1.0966

Super Compressibility Factor, Fpv  
at sampling conditions ..... 1.0089

Gas Z-Factor  
at sampling conditions \* ..... 0.982

at 14.65 psia and 60 °F

Gross Heating Value  
(BTU/scf dry gas) ..... 1421

### Air Content, mol %

Air Oxygen ..... 0.01

Air Nitrogen ..... 0.04

Total Air Content ..... 0.06

### Properties of Plus Fractions

Component	Mol %	MW	Liq Dens (gm/cc)	API Gravity
Heptanes plus	2.18	101.4	0.732	45.1
Decanes plus	0.07	141.0	0.784	38.3

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

# Arco Exploration & Production Technology

RFL 920279

## Composition of Separator Gas ( From Chromatographic Technique )

Component	Mol %	GPM	MW	Liq Dens (gm/cc)
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.40		44.010	.8172
Nitrogen	0.25		28.013	.8086
Methane	62.65		16.043	.2997
Ethane	5.73	1.524	30.070	.3558
Propane	5.21	1.426	44.097	.5065
iso-Butane	1.39	.452	58.123	.5823
n-Butane	1.87	.586	58.123	.5834
iso-Pentane	0.85	.309	72.150	.6241
n-Pentane	0.49	.176	72.150	.6305
Hexanes	0.51	.197	84.000	.6850
Heptanes	0.36	.151	98.000	.7220
Octanes	0.21	.095	107.00	.7450
Nonanes	0.07	.035	121.00	.7640
Decanes plus	0.01	.006	141.00	.7840
Totals .....	100.00	4.959		

### Sampling Conditions

125 psig  
106 °F

### Sample Characteristics

Cylinder No. G20033

Critical Pressure (psia) .....	646.6
Critical Temperature (°R) .....	377.3
Average Molecular Weight .....	21.49
Calculated Gas Gravity (air = 1.000) .....	0.742
Gas Gravity	
Factor, Fg .....	1.1610
Super Compressibility Factor, Fpv	
at sampling conditions .....	1.0091
Gas Z-Factor	
at sampling conditions * .....	0.982

at 14.65 psia and 60 °F

Gross Heating Value (BTU/scf dry gas) .....	1283
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### Air Content, mol %

Air Oxygen .....	0.10
Air Nitrogen .....	0.37
Total Air Content .....	0.47

### Properties of Plus Fractions

Component	Mol %	MW	Liq Dens (gm/cc)	API Gravity
Heptanes plus	0.65	102.9	0.735	44.8
Decanes plus	0.01	141.0	0.784	38.3

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

# Arco Exploration & Production Technology

RFL 920279

## Composition of Separator Gas ( From Chromatographic Technique )

Component	Mol %	GPM	MW	Liq Dens (gm/cc)
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.43		44.010	.8172
Nitrogen	0.13		28.013	.8086
Methane	81.39		16.043	.2997
Ethane	5.68	1.511	30.070	.3558
Propane	5.28	1.447	44.097	.5065
iso-Butane	1.47	.478	58.123	.5623
n-Butane	2.04	.640	58.123	.5834
iso-Pentane	1.02	.371	72.150	.6241
n-Pentane	0.80	.216	72.150	.6305
Hexanes	0.73	.282	84.000	.6850
Heptanes	0.59	.247	96.000	.7220
Octanes	0.38	.172	107.00	.7450
Nonanes	0.12	.080	121.00	.7640
Decanes	0.09	.049	134.00	.7780
Undecanes plus	0.05	.030	154.00	.7950
Totals .....	100.00	5.503		

### Sampling Conditions

127 psig  
106 °F

### Sample Characteristics Cylinder No. 8EK080

Critical Pressure (psia) .....	639.3
Critical Temperature (°F) .....	374.9
Average Molecular Weight .....	22.46
Calculated Gas Gravity (air = 1.000) .....	0.775
Gas Gravity	
Factor, Fg .....	1.1356
Super Compressibility Factor, Fpv at sampling conditions .....	1.0092
Gas Z-Factor at sampling conditions * .....	0.982

at 14.65 psia and 60 °F

Gross Heating Value (BTU/scf dry gas) .....	1336
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### Air Content, mol %

Air Oxygen .....	0.00
Air Nitrogen .....	0.00
Total Air Content .....	0.00

### Properties of Plus Fractions

Component	Mol %	MW	Liq Dens (gm/cc)	API Gravity
Heptanes plus	1.23	107.0	0.740	44.1
Decanes plus	0.14	141.1	0.784	38.3
Undecanes plus	0.05	154.0	0.795	36.9

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

# Arco Exploration & Production Technology

RFL 920279

## Composition of Separator Gas ( From Chromatographic Technique )

Component	Mol %	GPM	MW	Liq Dens (gm/cc)
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.43		44.010	.8172
Nitrogen	0.14		28.013	.8086
Methane	81.53		16.043	.2997
Ethane	5.81	1.545	30.070	.3558
Propane	5.33	1.461	44.097	.5065
iso-Butane	1.47	.478	58.123	.5623
n-Butane	2.07	.649	58.123	.5834
iso-Pentane	0.97	.353	72.150	.6241
n-Pentane	0.56	.202	72.150	.6305
Hexanes	0.66	.255	84.000	.6850
Heptanes	0.54	.226	98.000	.7220
Octanes	0.37	.167	107.00	.7450
Nonanes	0.10	.050	121.00	.7640
Decanes	0.02	.011	134.00	.7780
Undecanes plus	Trace			
Totals .....	100.00	5.397		

### Sampling Conditions

127 psig  
106 °F

### Sample Characteristics

Cylinder No. 349869D

Critical Pressure (psia) ..... 641.6  
Critical Temperature (°R) ..... 376.7

Average Molecular Weight ..... 22.18

Calculated Gas Gravity (air = 1.000) ..... 0.766

Gas Gravity  
Factor, Fg ..... 1.1426

Super Compressibility Factor, Fpv  
at sampling conditions ..... 1.0093

Gas Z-Factor  
at sampling conditions \* ..... 0.982

at 14.65 psia and 60 °F

Gross Heating Value  
(BTU/scf dry gas) ..... 1321

### Air Content, mol %

Air Oxygen ..... 0.20  
Air Nitrogen ..... 0.72  
Total Air Content ..... 0.92

### Properties of Plus Fractions

Component	Mol %	MW	Liq Dens (gm/cc)	API Gravity
Heptanes plus	1.03	103.1	0.735	44.8
Decanes plus	0.02	134.0	0.779	39.0

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

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## Composition of Separator Gas ( From Chromatographic Technique )

Component	Mol %	GPM	MW	Liq Dens (gm/cc)
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.43		44.010	.8172
Nitrogen	0.13		28.013	.8086
Methane	81.03		16.043	.2997
Ethane	5.86	1.559	30.070	.3558
Propane	5.50	1.507	44.097	.5085
iso-Butane	1.55	.504	58.123	.5623
n-Butane	2.24	.702	58.123	.5834
iso-Pentane	1.07	.389	72.150	.6241
n-Pentane	0.62	.223	72.150	.6305
Hexanes	0.68	.262	84.000	.6850
Heptanes	0.48	.201	96.000	.7220
Octanes	0.25	.113	107.00	.7450
Nonanes	0.10	.050	121.00	.7640
Decanes	0.06	.033	134.00	.7780
Undecanes plus	0.00			
Totals .....	100.00	5.543		

### Sampling Conditions

125 psig  
106 °F

### Sample Characteristics

Cylinder No. 349859C

Critical Pressure (psia) ..... 641.1  
Critical Temperature (°F) ..... 378.3

Average Molecular Weight ..... 22.34

Calculated Gas Gravity (air = 1.000) ..... 0.771

Gas Gravity  
Factor, Fg ..... 1.1387

Super Compressibility Factor, Fpv  
at sampling conditions ..... 1.0093

Gas Z-Factor  
at sampling conditions \* ..... 0.982

at 14.65 psia and 60 °F

Gross Heating Value  
(BTU/scf dry gas) ..... 1330

### Air Content, mol %

Air Oxygen ..... 0.11  
Air Nitrogen ..... 0.40  
Total Air Content ..... 0.52

### Properties of Plus Fractions

Component	Mol %	MW	Liq Dens (gm/cc)	API Gravity
Heptanes plus	0.89	104.5	0.737	44.5
Decanes plus	0.06	134.0	0.778	39.1

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

# Arco Exploration & Production Technology

RFL 920279

## Composition of Separator Gas ( From Chromatographic Technique )

Component	Mol %	GPM	MW	Liq Dens (gm/cc)
Hydrogen Sulfide	0.00			
Carbon Dioxide	0.41		44.010	.8172
Nitrogen	0.24		28.013	.8086
Methane	82.30		16.043	.2997
Ethane	5.67	1.508	30.070	.3558
Propane	5.17	1.417	44.097	.5065
iso-Butane	1.43	.465	58.123	.5623
n-Butane	1.93	.605	58.123	.5834
iso-Pentane	0.88	.320	72.150	.6241
n-Pentane	0.51	.184	72.150	.6305
Hexanes	0.58	.224	84.000	.6850
Heptanes	0.47	.197	96.000	.7220
Octanes	0.29	.131	107.00	.7450
Nonanes	0.09	.045	121.00	.7640
Decanes plus	0.03	.017	141.00	.7840
Totals .....	100.00	5.113		

### Sampling Conditions

125 psig  
106 °F

### Sample Characteristics Cylinder No. 257903D

Critical Pressure (psia) ..... 644.2  
Critical Temperature (°R) ..... 376.3  
  
Average Molecular Weight ..... 21.79  
  
Calculated Gas Gravity (air = 1.000) ..... 0.752  
  
Gas Gravity  
Factor, Fg ..... 1.1528  
Super Compressibility Factor, Fpv  
at sampling conditions ..... 1.0091  
Gas Z-Factor  
at sampling conditions \* ..... 0.982

at 14.65 psia and 60 °F

Gross Heating Value  
(BTU/scf dry gas) ..... 1299

### Air Content, mol %

Air Oxygen ..... 0.20  
Air Nitrogen ..... 0.72  
Total Air Content ..... 0.92

### Properties of Plus Fractions

Component	Mol %	MW	Liq Dens (gm/cc)	API Gravity
Heptanes plus	0.88	103.7	0.736	44.6
Decanes plus	0.03	141.0	0.784	38.3

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



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## PRELIMINARY QUALITY CHECKS PERFORMED ON SAMPLES RECEIVED IN LABORATORY

Separator Gas					
Cylinder Number	Sampling Conditions		Laboratory Opening Conditions		Liquid Recovered (cc)
	psig	°F	psig	°F	

257903D	127	106	125	71	2
349859C	127	106	135	71	2
349869D*	127	106	127	71	2
8EK080	127	106	125	71	2
G20033	127	106	125	71	1
CLH478	127	106	125	71	0

Separator Oil					
Cylinder Number	Sampling Conditions		Laboratory Bubblepoint		Water Recovered (cc)
	psig	°F	psig	°F	

193471D*	127	106	98	71	3
W3A8814	127	106	61	69	2

\* Sample selected for recombination.

# Arco Exploration & Production Technology

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## Production Data

### Data from Original Discovery Well

Location.....	*	
Date.....	*	
Oil Gravity @ STP.....	*	*API
Separator Pressure.....	*	psig
Separator Temperature.....	*	*F
Production Rates		
Gas.....	*	Mscf/D
Liquid.....	*	STbbl/D
Gas/Liquid Ratio.....	*	scf/bbl

### Separator Conditions

Primary Separator Pressure.....	*	psig
Primary Separator Temperature.....	*	*F
Secondary Separator Pressure.....	*	psig
Secondary Separator Temperature.....	*	*F
Primary Separator Gas Production Rate.....	*	Mscf/D

### Gas Factors -

#### Field Values:

Pressure Base.....	*	psia
Temperature Base.....	*	*F
Compressibility Factor (Fpv).....	*	
Gas Gravity Factor (Fg).....	*	

#### Laboratory Values:

Pressure Base.....	14.65	psia
Temperature Base.....	60	*F
Compressibility Factor (Fpv).....		
Gas Gravity Factor (Fg).....		

Primary Separator Liquid Rate.....	*	bbl/D	at	*F
Stock Tank Liquid Rate.....	*	bbl/D	at	*F
Separator Gas / Separator Liquid Ratio.....	*	scf/bbl		
Separator Gas / Stock Tank Liquid Ratio.....	*	scf/bbl		
Stock Tank Liquid / Separator Gas Ratio.....	*	bbl/Mscf		
Separator Liquid / Stock Tank Liquid Ratio.....	*	bbl/bbl	at	*F

\* Data not forwarded to Core Laboratories.

# Arco Exploration & Production Technology

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## General Well Information

Company.....	Arco Exploration & Production Technology
Well Name.....	Brad Berg #1
API Well Number.....	*
File Number.....	RFL 920279
Date Sample Collected.....	*
Sample Type.....	Separator
Geographical Location.....	*
Field.....	*

## Well Description

Formation.....	*	
Pool (or Zone).....	*	
Date Completed.....	*	
Elevation.....	*	ft
Producing Interval.....	*	ft
Total Depth.....	*	ft
Tubing Size.....	*	in
Tubing Depth.....	*	ft
Casing Size.....	*	in
Casing Depth.....	*	ft

## Pressure Survey Data

### Data from Original Discovery Well

Date .....	*	
Reservoir Pressure .....	*	psig

### Data at Sample Collection

Date.....	*	
Reservoir Pressure.....	3000	psig
Reservoir Temperature.....	119	°F
Pressure Tool.....	*	
Flowing Bottom-Hole Pressure.....	*	psig
Flowing Tubing Pressure.....	*	psig

\* Data not forwarded to Core Laboratories.

# Arco Exploration & Production Technology

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## SUMMARY OF PVT DATA

### Reservoir Conditions

Current Reservoir Pressure .....	3000	psig
Reservoir Temperature .....	119	°F

### Pressure-Volume Relations

Saturation Pressure .....	3019	psig
Avg Single-Phase Compressibility .....	8.08	E-6 v/v/psi ( 5000 to 3019 psig )
Thermal Exp @ 5000 psig .....	1.02791	V at 119 °F / V at 70 °F

### Differential Vaporization Data

( at 3019 psig and 119 °F )

Solution Gas/Oil Ratio .....	612	scf / bbl of residual oil at 60 °F
Relative Oil Volume .....	1.272	bbl / bbl of residual oil at 60 °F
Density of Reservoir Fluid .....	0.7448	gm/cc

### Reservoir Fluid Viscosity

1.01 cp at 3019 psig and 119 °F
---------------------------------

### Separator Test Data

Separator Conditions		Formation Volume Factor (A)	Total Solution Gas/Oil Ratio (B)	Tank Oil Gravity ( °API at 60 °F )
psig	°F			
100	90	1.276	625	34.1
100	140	1.284	632	34.0
500	90	1.260	593	34.6

(A) Barrels of oil at 3019 psig and 119 °F 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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## **Arco Exploration & Production Technology**

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The viscosity of the reservoir fluid was measured over a wide range of pressures at 119°F in a rolling ball viscosimeter. The viscosity of the fluid was found to vary from a minimum of 1.014 centipoises at the saturation pressure to a maximum of 3.623 centipoises at atmospheric pressure. The results of the viscosity measurements are presented on page 23.

Small portions of the reservoir fluid were subjected to two two-stage and one three-stage separator tests to determine gas/oil ratio, stock tank oil gravity and formation volume factor. These data can be found on page 24. The gases and stock tank oil evolved from the "base case" separator test were collected and analyzed. These compositions are presented on pages 25 through 28. The separator test data were used to adjust the differential vaporization data to surface conditions and are summarized on pages 30 and 32.

A large portion of reservoir fluid was charged to a PVT cell at 119°F. From this sample three gas depleted oils were prepared at specified saturation pressures. A separator test was performed on the individual "DV" oils at the same conditions as the "base case" multi-stage separator test investigated above. The results of these analyses are presented on page 29.

Equations and nomenclature are included in the appendix of the report which extend and define the analytical expressions and data relationships presented in the study.

## Laboratory Procedures

### Arco Exploration & Production Technology Reservoir Fluid Study

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On October 16, 1992, multiple samples of separator gas and oil were received in our Carrollton, Texas laboratory. Bubblepoint determinations of each liquid sample were measured at lab ambient temperature as a quality check. Gas opening pressures were also measured. A summary of samples received in the laboratory may be found on page four.

Each of the six separator gas samples was analyzed by extended gas chromatography to determine gas composition to the last detectable peak. These data are presented on pages five through ten. The compositions of the two separator oil samples were measured through a heptanes plus residual fraction by low temperature fractional distillation. The heptanes plus fractions were further analyzed by gas chromatography through hexatriacontanes plus. The composition and density of the fluids can be found on pages 11 through 16.

A routine quality control check of separator products' compositions is a "K-value" plot of relative component content versus component boiling point. Specifically, the K-value is the mole percent of a particular hydrocarbon component of the gas divided by the mole percent of this component of the separator oil. When the logs of the K-values of methane through hexanes plus nitrogen, carbon dioxide and hydrogen sulfide are plotted against the boiling points of the individual components, the results should yield a smooth line. Additionally, theoretical equilibrium ratios (K-values) can be determined for specific separator conditions and plotted with the measured data. When these plots were made for the above compositional data, the plots did not agree well with the theoretical data. An example of the K-value plots is presented following the separator products' compositions and is designated figure QC-1.

The separator gas was combined with the separator oil to yield a saturation pressure of 3000 psig at 119°F. This recombined reservoir fluid was used for all further analyses. The composition of the reservoir fluid was determined through a heptanes plus residual fraction by low temperature fractional distillation. The heptanes plus fractions were further analyzed by gas chromatography through hexatriacontanes plus. These data are presented on pages 17 through 19.

A portion of the reservoir fluid was charged to a high pressure, windowed cell heated to the reported reservoir temperature of 119°F. During the constant composition expansion at this temperature, a bubblepoint was observed at 3019 psig. The results of the pressure-volume relations are presented on pages 20 and 21.

During the differential vaporization at the reservoir temperature, the fluid evolved a total of 612 cubic feet of gas at 14.65 psia and 60°F per barrel of residual oil at 60°F. The resulting relative oil volume factor was 1.272 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 and the data included in the summary of the differential vaporization data on page 22.





## CORE LABORATORIES

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November 19, 1992

Arco Exploration and Production Technology  
2300 West Plano Parkway  
Rm PRC -E1115  
Plano, TX 75075

ATTENTION: Mr. Russ Bone

Subject:       Reservoir Fluid Study  
Well:  
File:           RFL 920279

Dear Mr. Bone,

Multiple samples of separator gas and oil were collected from the subject well by representatives of Arco Exploration and Production Technology. These samples were shipped to our laboratory in Carrollton, Texas for use in a reservoir fluid study. The results of this study are presented on the following pages.

It has been a pleasure to perform this reservoir fluid study for Arco Exploration and Production Technology. Should any questions arise or if we may be of further service in any way, please do not hesitate to contact us.

Sincerely,

A handwritten signature in cursive script, reading 'Karl W. Karnes'.

Karl W. Karnes  
Supervising Engineer  
Reservoir Fluid Analysis

KWK

16 cc: Addressee

15 bound & 1 unbound

**Kuvlum #1**  
**Breakeven Oil Rate vs. Oil Price**  
**Paying Quantities Determination**

