

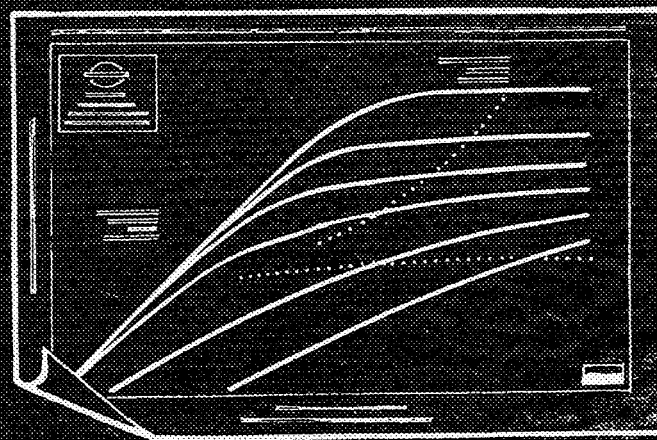
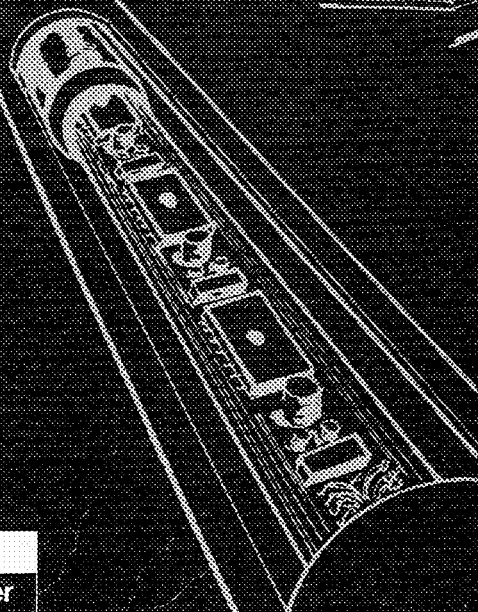
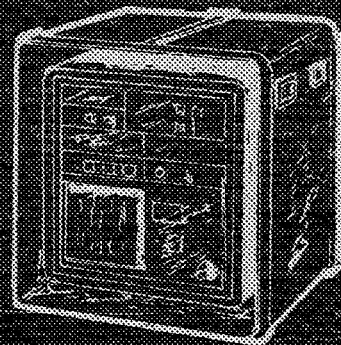
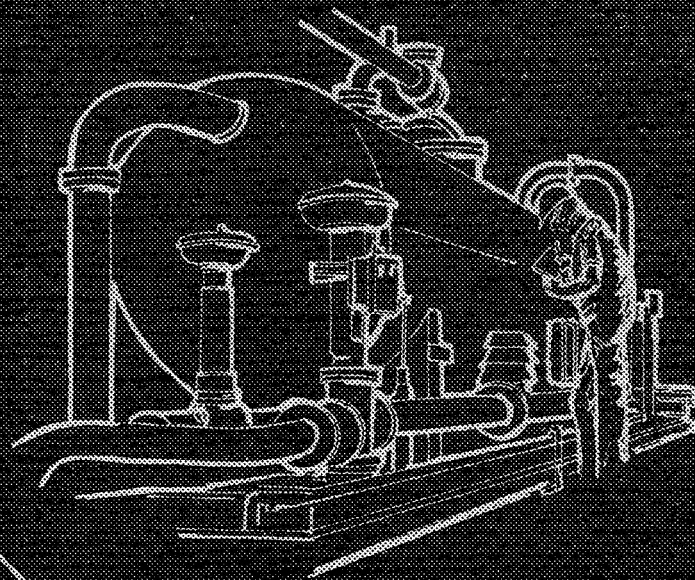
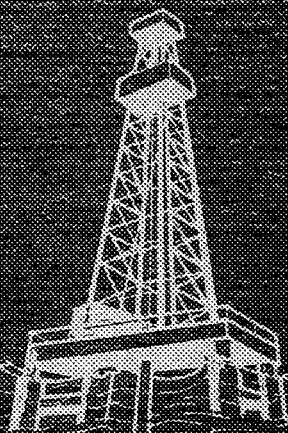
BP003392

FLOPETROL

P.V.T. STUDY REPORT

Client: AMOCO NORWAY OIL COMPANY
Field : 90D Well : 2/11-6 (ST1) DST1
Zone : 3875-3900m Samp. date: 09/02/82

Report #: 82/L/033 Date: APRIL 1982



FLOPETROL
Schlumberger

BP AMOCO
RECORDS MANAGEMENT
AND LIBRARY
Location: NOCS 2/11-6 ST1 W42.1
ID: ... 01038265-1

P.V.T. STUDY REPORT

Client: AMOCO NORWAY OIL COMPANY
Field : HOD Well : 2/11-6 (ST1) DST1
Zone : 3875-3900m Samp. date: 09/02/82

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HEADQUARTERS LABORATORY

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SUMMARY AND MAIN RESULTS

The present report gives the experimental results of the P.V.T. study carried out on bottom hole sample(s) from well 2/11-6 (ST1) DST1

The initial reservoir conditions are :

- P_i : 6950 PSIG
- T : 225 F

Bubble point pressure determined on sample which was selected for complete P.V.T. study is :

- P_b : 3430 psig at 225 F
- c : $11.23 \times 10^{-6} \text{ psi}^{-1}$ (6950-6009 psig)

Main differential vaporization data at reservoir temperature :

	P _i	P _b
oil volume factor (bbl/Std bbl)	1.548	1.616
solution gas-oil ratio (Std cu ft/bbl)	1017	1017
reservoir fluid viscosity (centipoises)	0.46	0.31
reservoir fluid density (g/cm ³)	0.693	0.663
Residual oil gravity	0.860	60/60 F
	33.0	API

TABLE 1

SAMPLING CONDITIONS

I. RESERVOIR AND WELL CHARACTERISTICS

Producing zone : 3875-3900m
 Static pressure : 6950 PSIG
 Bottom hole temperature : 225 F
 Tubing diameter : 3 1/2 Drill Pipe
 Casing size : 7"
 Casing shoe : 4047m

II. SAMPLING CONDITIONS

A) SURFACE SAMPLE(S)

Date : N/A
 Choke : 8/64 Pos
 Flowing bottom hole pressure : 6587 PSIG
 Well head pressure : 3797 PSIG
 Separator pressure : 105 PSIG
 Well head temperature : 62 F
 Separator temperature : 56 F
 Gas rate (Separator) : 0.321 MM SCFD
 Stock tank temperature : N/A
 Compressibility factor : N/A
 Gas gravity : 0.720 (Air=1.00)
 Liquid rate (Separator) : 508.8 BOPD
 G.L.R. : 631.1 Std Cu Ft/bbl
 Sample(s) received : gas none
 liq.none

B) BOTTOM HOLE SAMPLE(S)

Date : 09/02/82
 Choke : 8/64 Pos
 Sample(s) received : 13266/13

COMPANY : AMOCO NORWAY OIL COMPANY

WELL : 2/11-6(ST1)DST1

SAMPLE(S) VALIDITY

BOTTOM HOLE SAMPLE(S)

1) Sample bottle No 13266/13

Bubble point pressure determination at 80 F is 2785 psig

TABLE 2

BUBBLE POINT PRESSURE DETERMINATION AT 80.F

Bottom hole sample (Cylinder 13266/13)

Pressure (psig)	Pump reading (cm3)
7000	286.28
5000	284.45
4000	283.47
3540	282.97
3037	282.39
Pb= 2785	282.10
2708	281.71
2612	280.94
2403	279.06
2107	275.16
1909	271.25

This sample has been used to complete PVT study

BUBBLE-POINT PRESSURE DETERMINATION AT 80 F

Bottom hole sample (cylinder 13266/13)

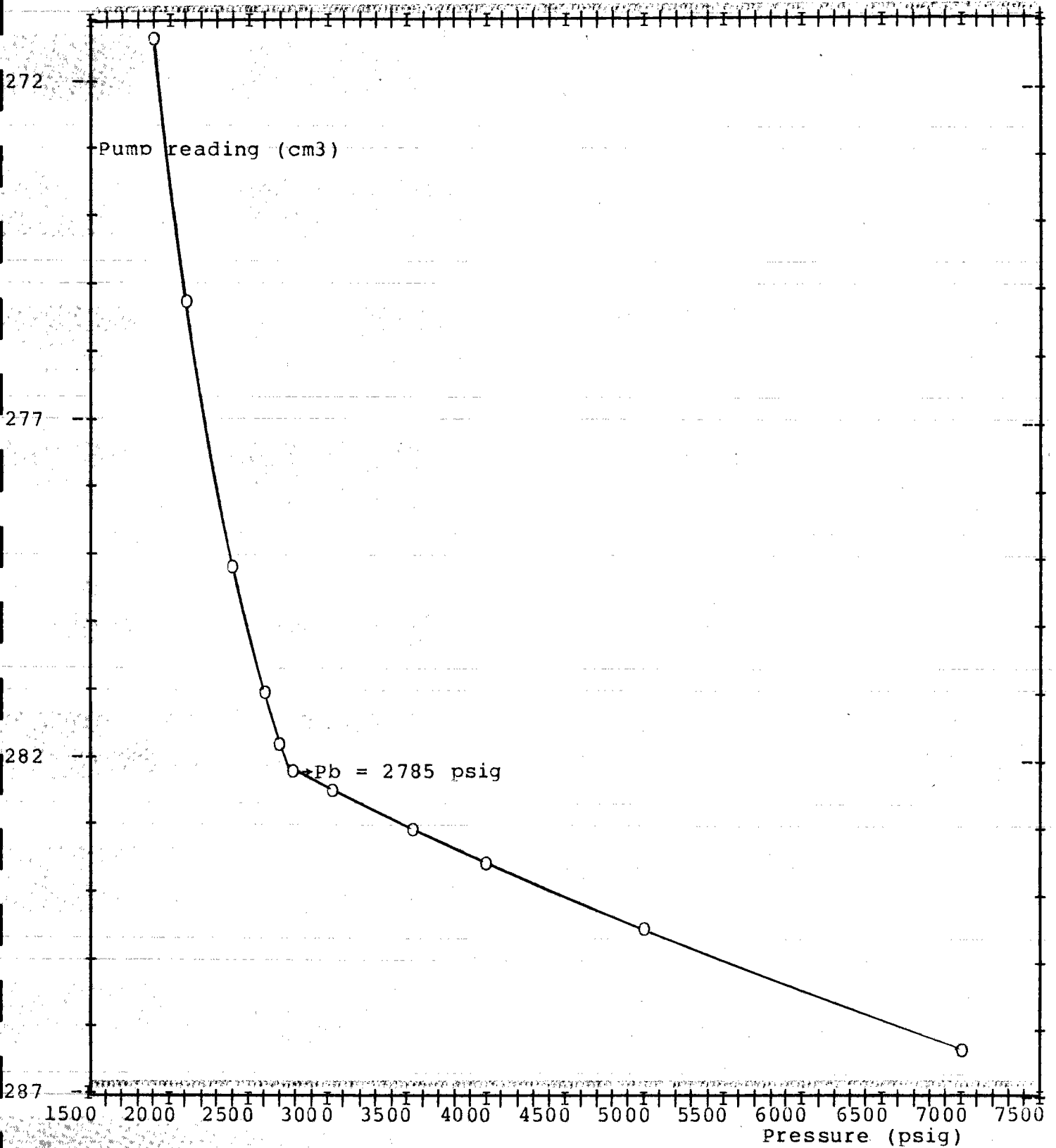


TABLE 3

FLASH OF SEPARATOR LIQUID TO STOCK TANK CONDITIONS

(Molecular composition)

Components	Stock tank liquid (0 psig/ 60 F) (mole percent)	Evolved gas (0 psig/ 60 F) (mole percent)	Recombined separator liquid (10 psig/160 F) (mole percent)
Nitrogen	0.00	0.00	0.00
Carbon dioxide	0.01	1.18	0.04
Hydrogen sulphide	0.00	0.00	0.00
<u>Hydrocarbons:</u>			
Methane	0.05	16.79	0.57
Ethane	0.14	19.57	0.75
Propane	1.10	34.44	2.14
I - Butane	0.40	4.73	0.53
N - Butane	2.16	15.48	2.57
I - Pentane	1.96	3.25	2.00
N - Pentane	3.59	3.02	3.58
Hexanes	6.63	0.99	6.46
Heptanes	9.95	0.38	9.65
Octanes	10.19	0.15	9.88
Nonanes	7.06	0.02	6.84
Decanes	5.24	0.00	5.08
Undecanes plus	51.52	0.00	49.91
TOTAL	100.00	100.00	100.00
Molecular weight	222.8	41.987	217.2
Gravity	0.847 60/60 F	1.449 (Air=1)	-----
Molar ratio	96.89	3.11	100.00
Mass ratio	99.40	0.60	100.00

Molecular weight of Undecanes plus in STO: 336
 Gravity of Undecanes plus in STO : 0.898 (60/60 F)

TABLE 4

MOLECULAR COMPOSITION OF SEPARATOR LIQUID

Components	Recombined Separator liquid (10 psig/160 F) (mole percent)	Separator gas (10 psig/160 F) (mole percent)	Recombined Separator liquid (100 psig/142 F) (mole percent)
Nitrogen	0.00	0.00	0.00
Carbon dioxide	0.04	1.53	0.13
Hydrogen sulphide	0.00	0.00	0.00
<u>Hydrocarbons:</u>			
Methane	0.57	41.60	2.84
Ethane	0.75	16.57	1.62
Propane	2.14	22.51	3.26
I - Butane	0.53	2.92	0.67
N - Butane	2.57	9.67	2.96
I - Pentane	2.00	2.06	2.00
N - Pentane	3.58	1.95	3.49
Hexanes	6.46	0.67	6.14
Heptanes	9.65	0.33	9.14
Octanes	9.88	0.16	9.35
Nonanes	6.84	0.03	6.46
Decanes	5.08	0.00	4.80
Undecanes plus	49.91	0.00	47.14
TOTAL	100.00	100.00	100.00
Molecular weight	217.2	33.596	207.0
Gravity	-----	1.159 (Air=1)	-----
Molar ratio	94.48	5.52	100.00
Mass ratio	99.10	0.90	100.00

TABLE 5

MOLECULAR COMPOSITION OF RESERVOIR FLUID

Components	Recombined Separator liquid (100 psig/142 F) (mole percent)	Separator gas (100 psig/142 F) (mole percent)	Recombined Reservoir fluid (mole percent)
Nitrogen	0.00	0.17	0.10
Carbon dioxide	0.13	1.03	0.67
Hydrogen sulphide	0.00	0.00	0.00
<u>Hydrocarbons:</u>			
Methane	2.84	77.26	47.28
Ethane	1.62	9.64	6.41
Propane	3.26	7.47	5.78
I - Butane	0.67	0.77	0.73
N - Butane	2.96	1.98	2.38
I - Pentane	2.00	0.52	1.12
N - Pentane	3.49	0.58	1.75
Hexanes	6.14	0.32	2.66
Heptanes	9.14	0.19	3.79
Octanes	9.35	0.06	3.80
Nonanes	6.46	0.01	2.61
Decanes	4.80	0.00	1.93
Undecanes plus	47.14	0.00	18.99
TOTAL	100.00	100.00	100.00
Molecular weight	207.0	22.028	96.5
Gravity	-----	0.760 (Air=1)	-----
Molar ratio	40.26	59.74	100.00
Mass ratio	86.37	13.63	100.00

Molecular weight of Undecanes plus in reservoir fluid : 336

TABLE 6

BUBBLE POINT PRESSURE DETERMINATION AND CONSTANT MASS STUDY AT 225 F

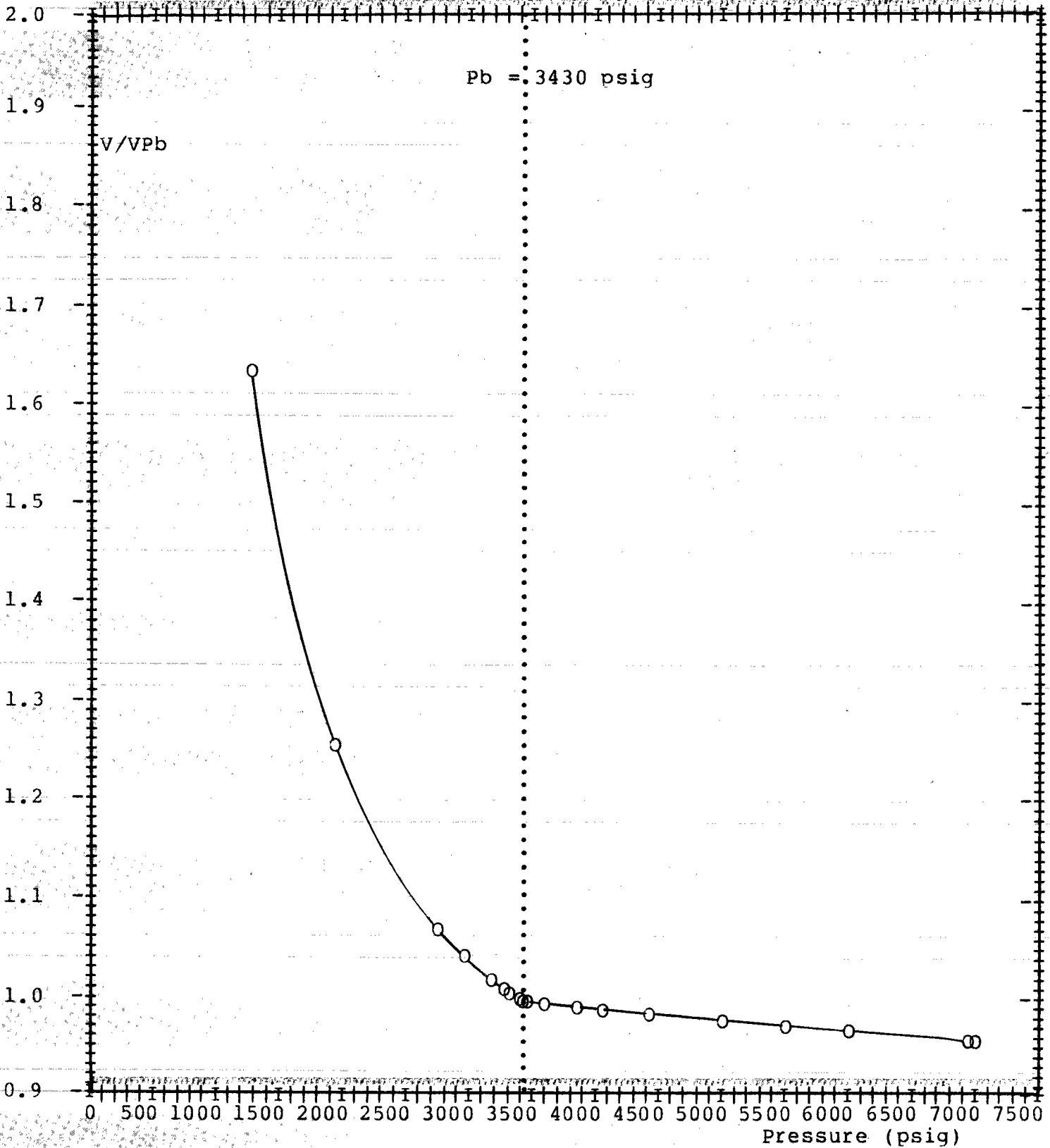
Pressure (psig)	Relative volume V/VPb	Compressibility factor (psi ⁻¹)	Y curve Pb/P-1 V/VPb-1
7000	0.9561		
		10.98 x 10 ⁻⁶	
6950	0.9566		
		11.23 x 10 ⁻⁶	
6009	0.9667		
		11.56 x 10 ⁻⁶	
5506	0.9724		
		11.91 x 10 ⁻⁶	
5005	0.9782		
		12.48 x 10 ⁻⁶	
4429	0.9852		
		13.26 x 10 ⁻⁶	
4056	0.9901		
		14.05 x 10 ⁻⁶	
3856	0.9928		
		15.36 x 10 ⁻⁶	
3588	0.9969		
		18.42 x 10 ⁻⁶	
3453	0.9994		
		25.83 x 10 ⁻⁶	
Pb= 3430	1.0000		
3397	1.0026		3.74
3323	1.0087		3.70
3274	1.0130		3.67
3182	1.0215		3.62
2963	1.0449		3.51
2752	1.0726		3.39
1939	1.2597		2.96
1283	1.6408		2.61
930	2.1092		2.42
731	2.5932		2.32

Thermal expansion factor of reservoir fluid at 7000 psig

between 70 F and 225 F : = 0.539 x 10⁻³ F⁻¹

BUBBLE POINT PRESSURE DETERMINATION AND CONSTANT MASS STUDY AT 225 F

Relative volume



PHASE-POINT PRESSURE-BEHAVIOR FUNCTION - ANALYSIS - MASS-STUDY AT 225-F

Y curve pressure-volume function

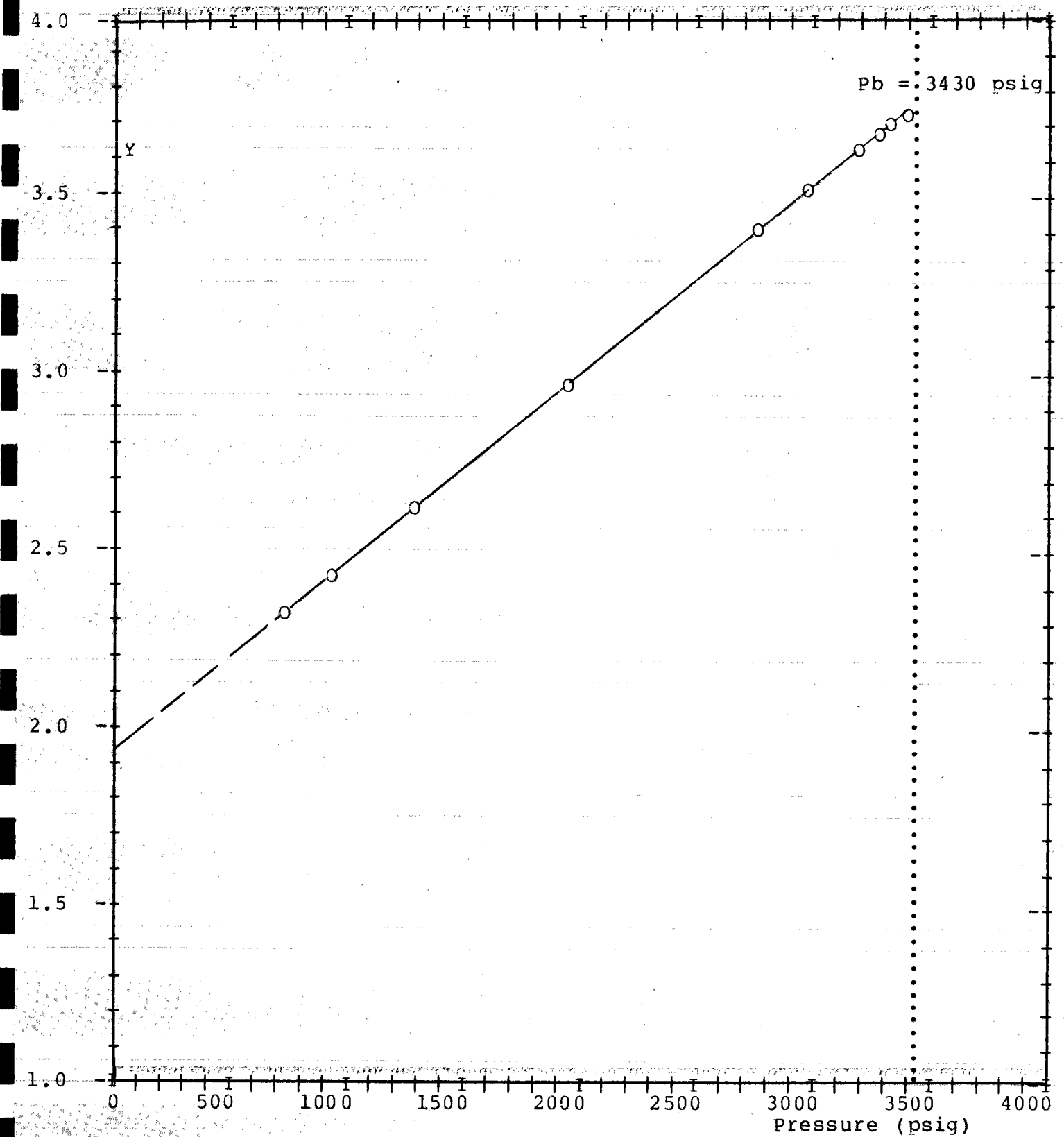


TABLE 7

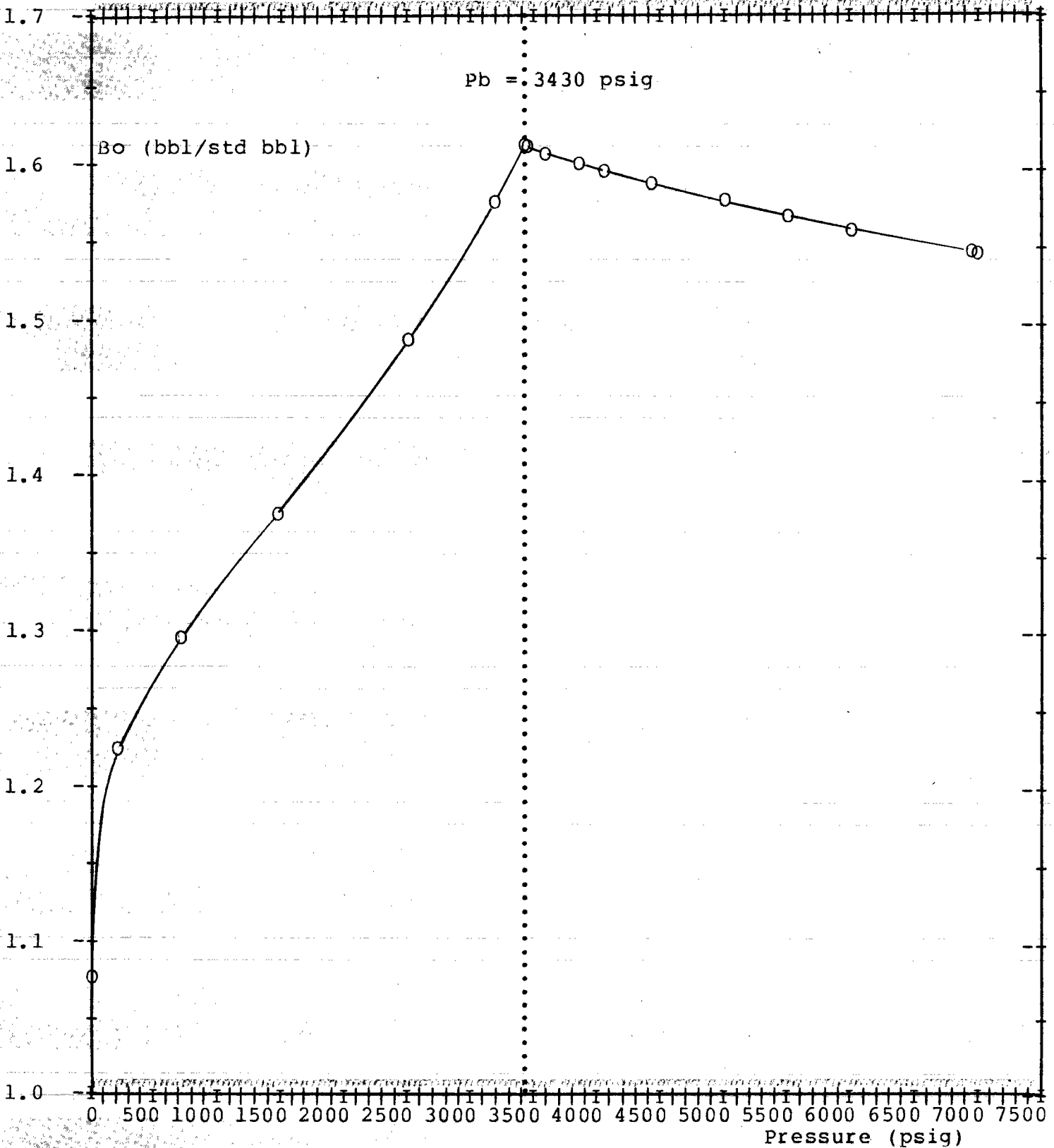
DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 225 F.

Pressure (psig)	Oil volume factor B _o (bbl/Std bbl)	Solution gas-oil ratio R _s (Std cu ft/Std bbl)	Gas volume factor B _g (cu ft/Std cu ft)	Reservoir oil density (g/cm ³)
7000	1.547			0.694
6950	1.548			0.693
6009	1.563			0.686
5506	1.571			0.682
5005	1.581			0.678
4429	1.592			0.673
4056	1.600			0.670
3856	1.604			0.668
3588	1.611			0.665
3453	1.616			0.663
b= 3430	1.616	1017		0.663
3185	1.576	917	0.50 x 10 ⁻²	0.669
2502	1.488	717	0.61 x 10 ⁻²	0.687
1469	1.375	453	1.03 x 10 ⁻²	0.712
701	1.295	271	2.22 x 10 ⁻²	0.731
209	1.225	139	7.46 x 10 ⁻²	0.749
0	1.077	0	-----	0.799

Residual oil gravity : 0.860 60/60 F
33.0 API

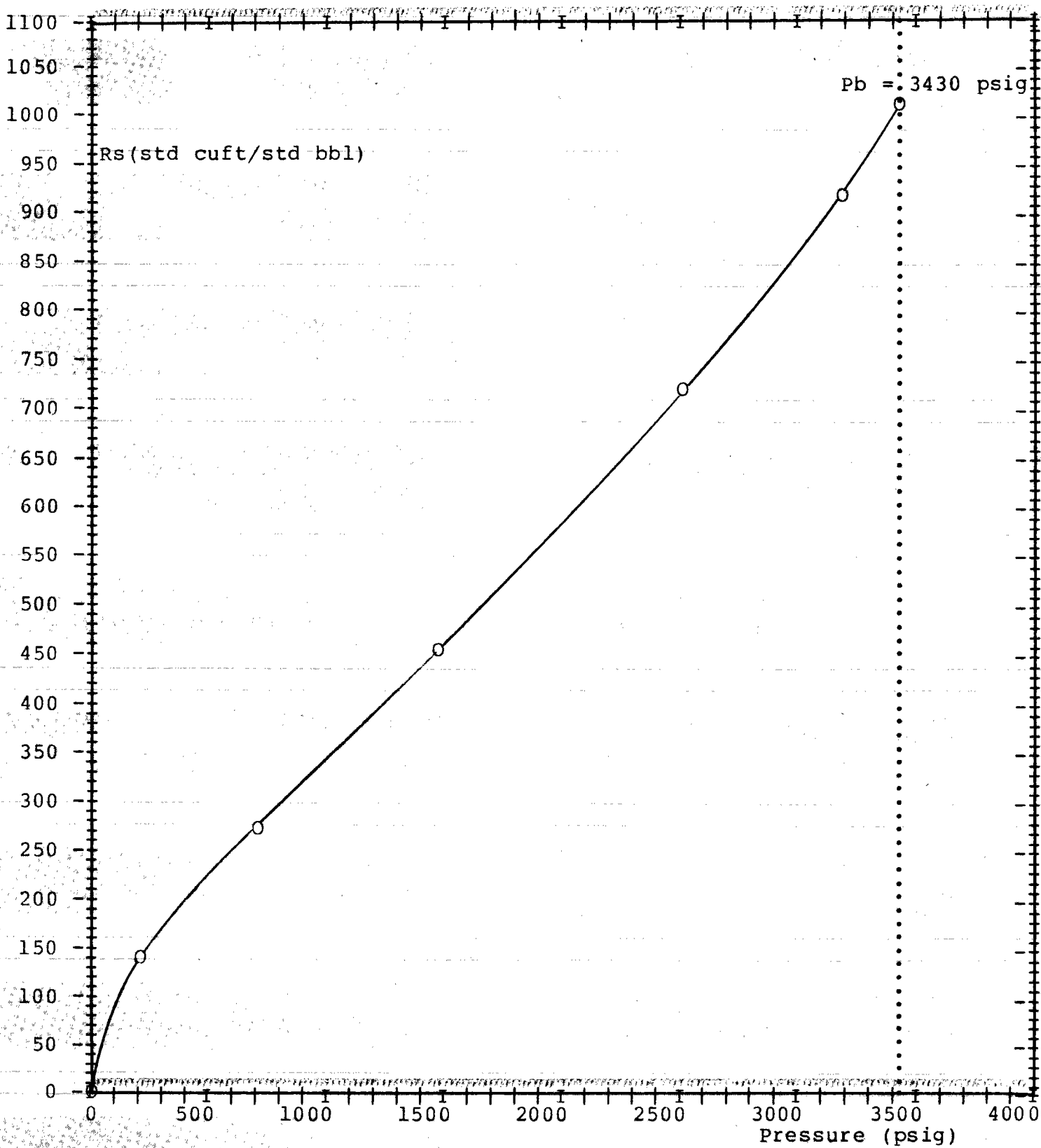
DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 225 F

Oil volume factor



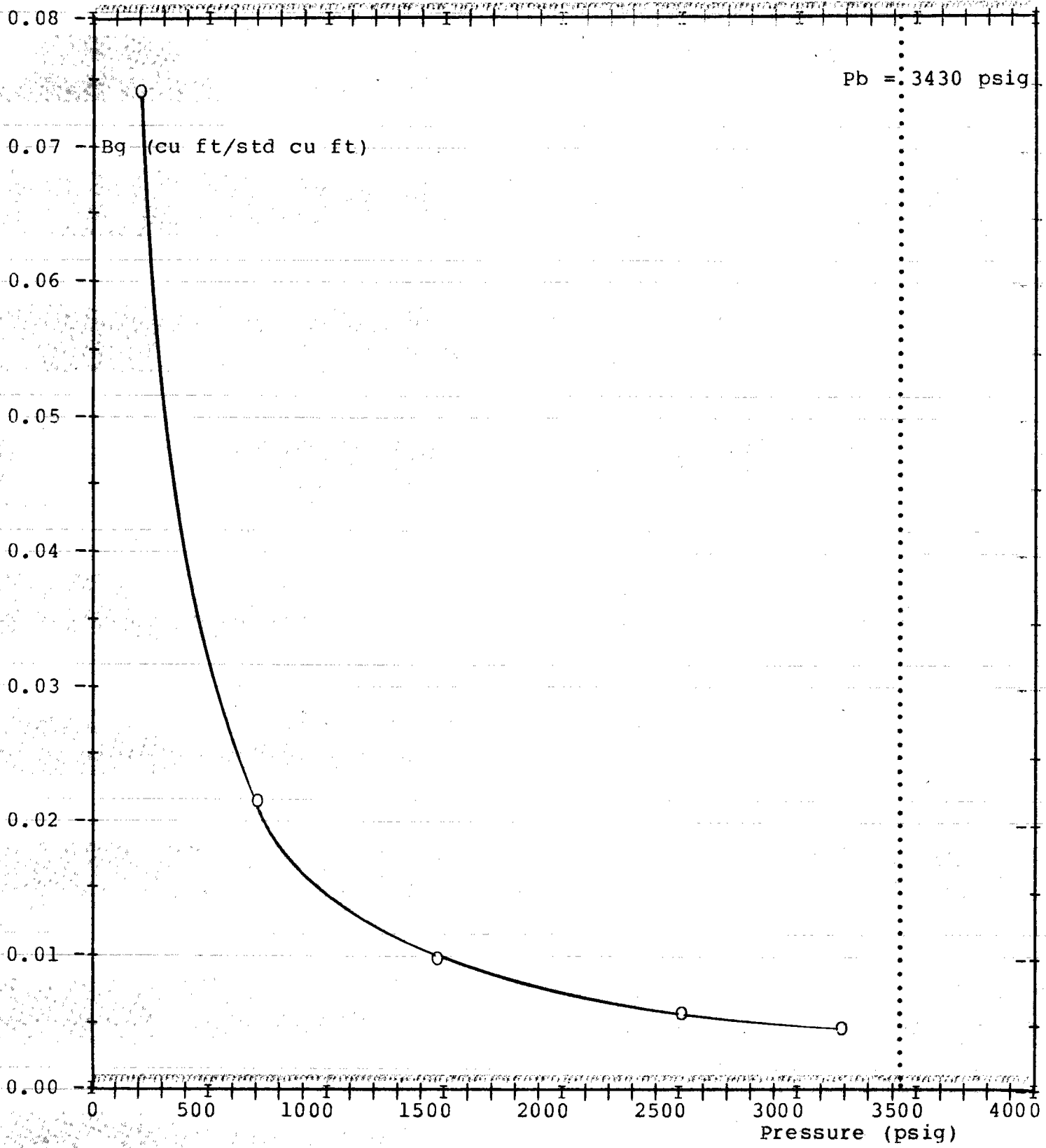
DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 225 F

Solution gas oil ratio



DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 225 F

Gas volume factor



DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 225 F

Reservoir oil density

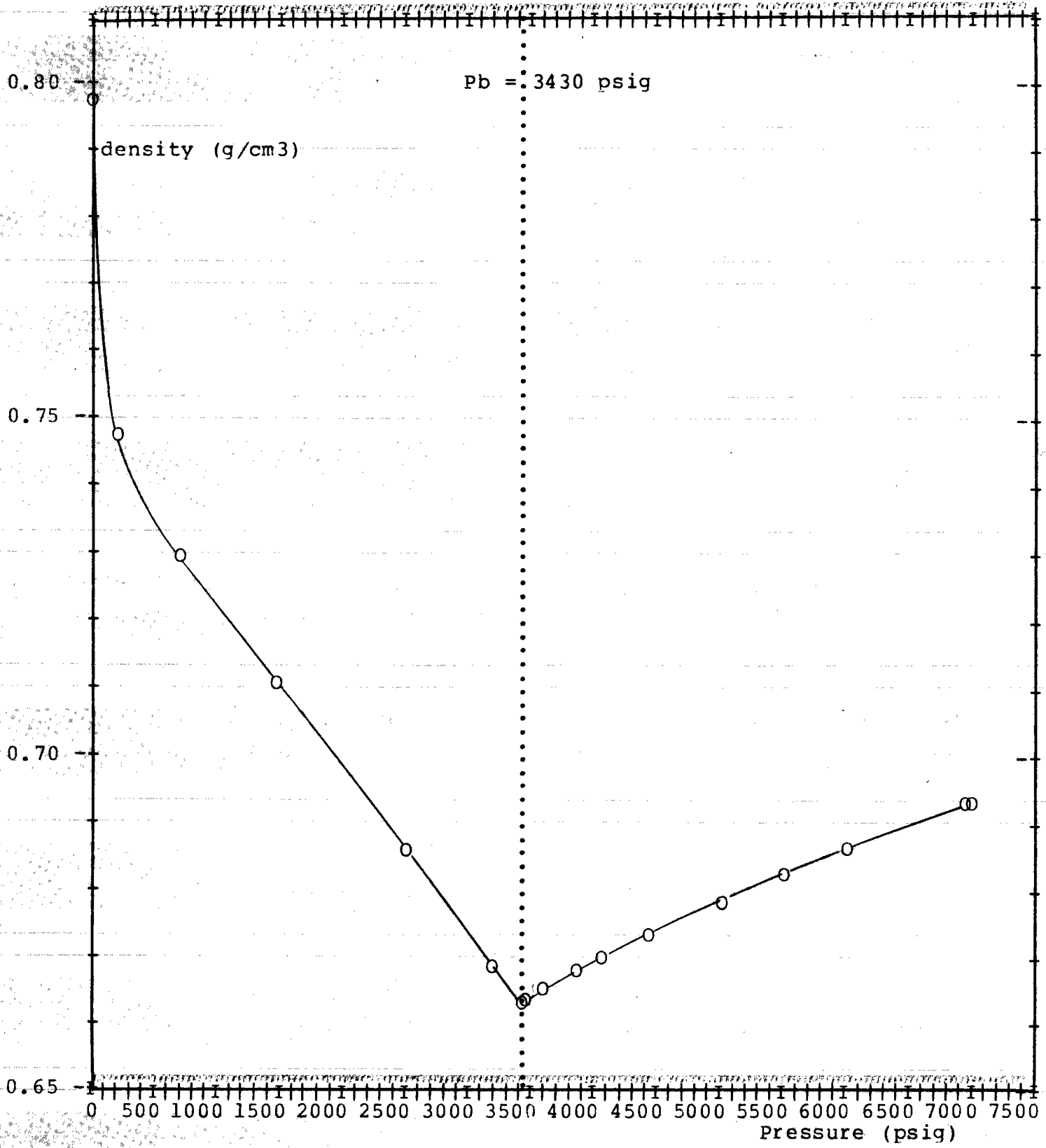


TABLE 8

DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 225 E

Molecular composition of liberated gases (mole percent)

Pressure (psig)	3185	2502	1469	701	209	0
Nitrogen	0.66	0.49	0.27	0.12	0.01	0.00
Carbon dioxide	0.89	0.90	0.96	1.13	1.22	0.57
Hydrogen sulphide	0.00	0.00	0.00	0.00	0.00	0.00
<u>Hydrocarbons:</u>						
Methane	80.25	81.16	80.39	74.76	54.80	15.10
Ethane	6.67	6.78	7.61	9.99	15.12	12.45
Propane	5.17	5.05	5.49	7.37	15.06	23.85
I - Butane	0.63	0.59	0.61	0.81	1.75	3.93
N - Butane	2.24	2.05	2.05	2.78	6.04	15.72
I - Pentane	0.68	0.60	0.55	0.70	1.52	4.98
N - Pentane	0.90	0.77	0.69	0.87	1.89	6.45
Hexanes	0.84	0.70	0.59	0.67	1.38	5.71
Heptanes plus	1.07	0.91	0.79	0.80	1.21	11.24
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00
Molecular weight	22.395	21.902	21.884	23.419	29.990	54.213
Gravity (Air=1)	0.773	0.756	0.755	0.808	1.035	1.871
Molecular weight of heptanes plus	105.3	105.1	105.1	105.5	106.9	112.9

COMPANY : AMOCO NORWAY OIL COMPANY

WELL : 2/11-6 (ST1) DST1

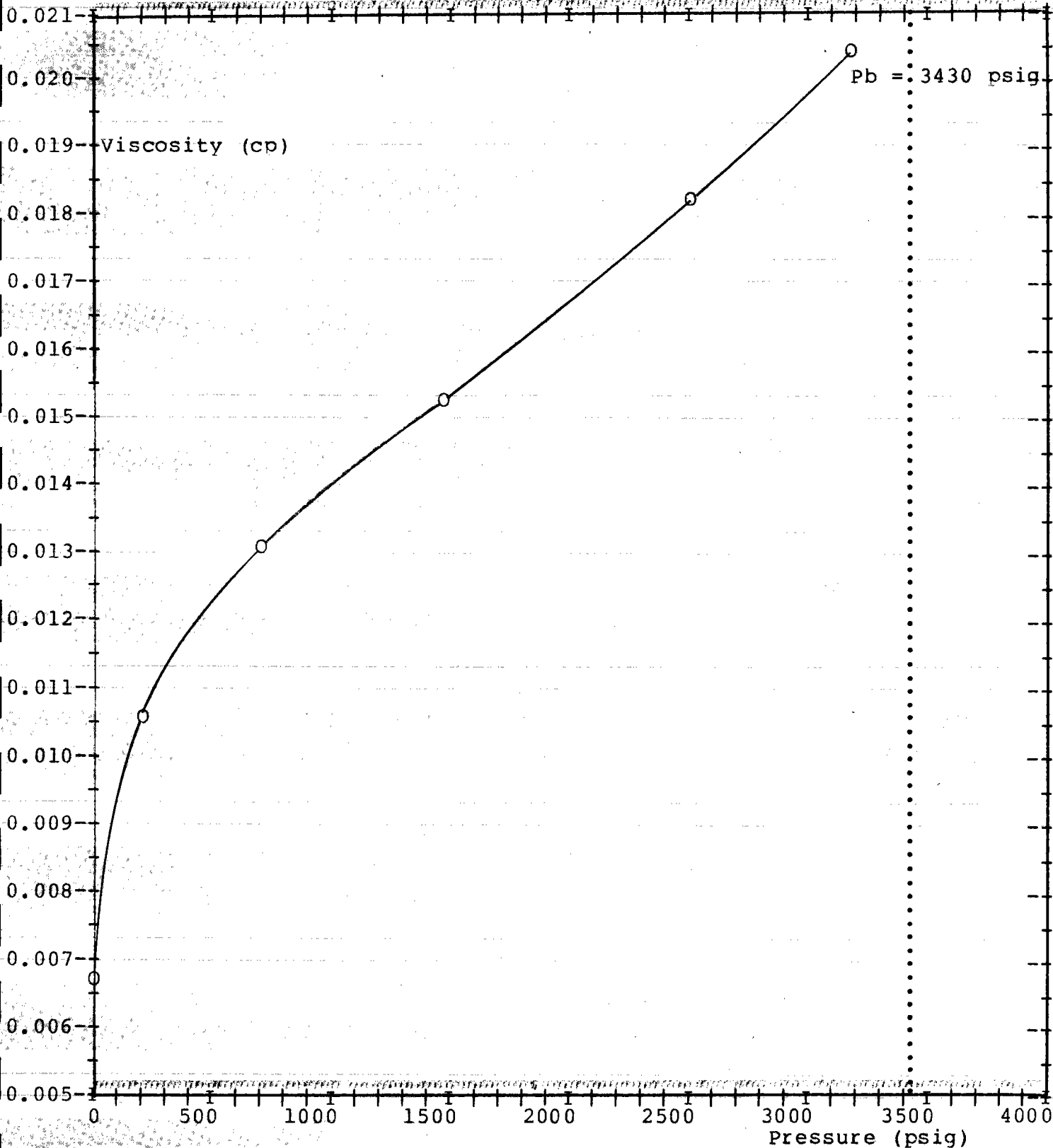
TABLE 9

DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 225 F.

Pressure (psig)	Gas viscosity (centipoises)	Gas gravity (Air=1)	compressibility factor Z
3185	0.0205	0.773	0.823
2502	0.0182	0.756	0.792
1469	0.0152	0.755	0.791
701	0.0131	0.808	0.819
209	0.0106	1.035	0.862
0	0.0067	1.871	1.000

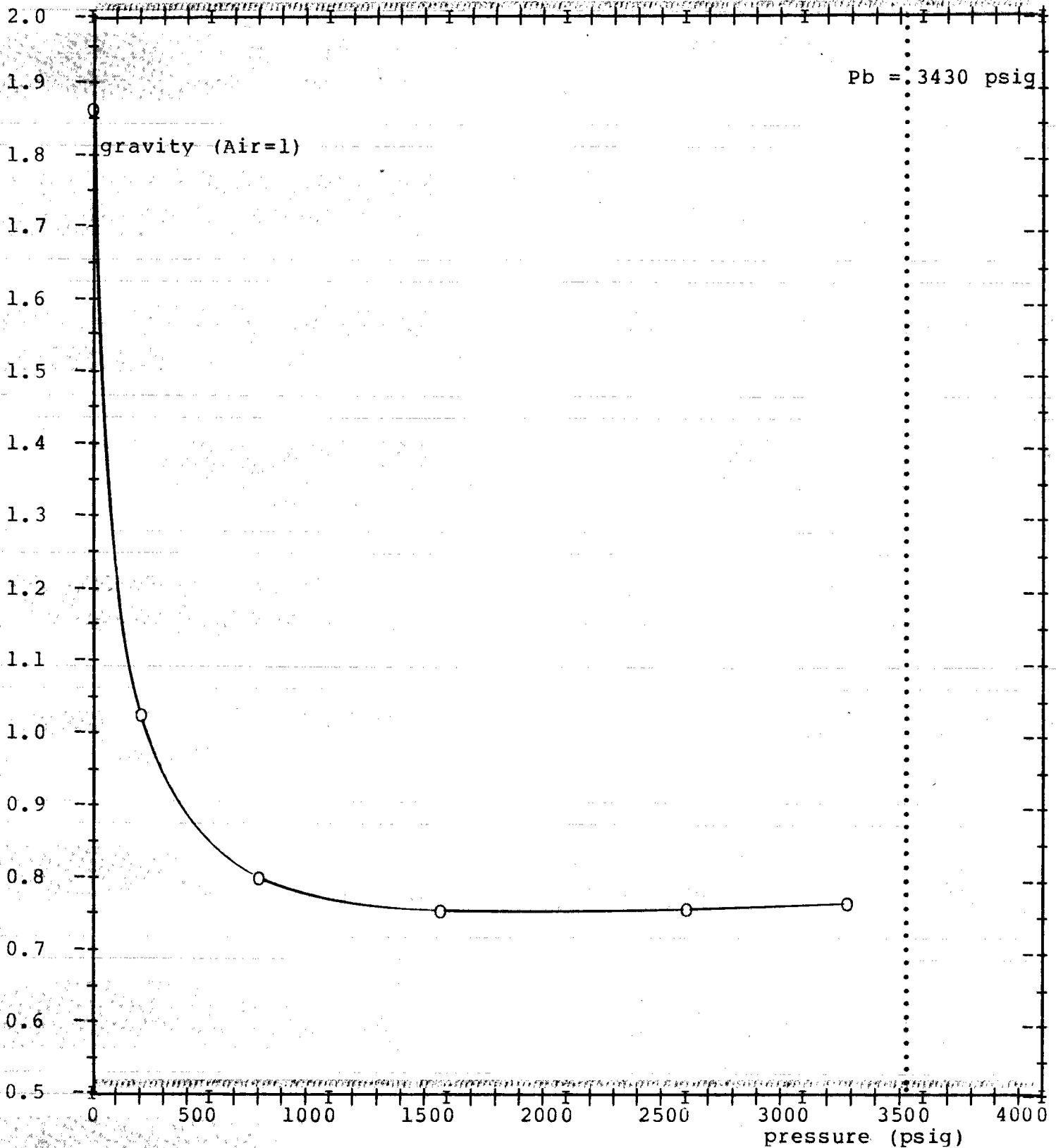
DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 225 F.

liberated gas viscosity



DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 225 F

Liberated gas gravity



DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 225 F

Compressibility factor Z

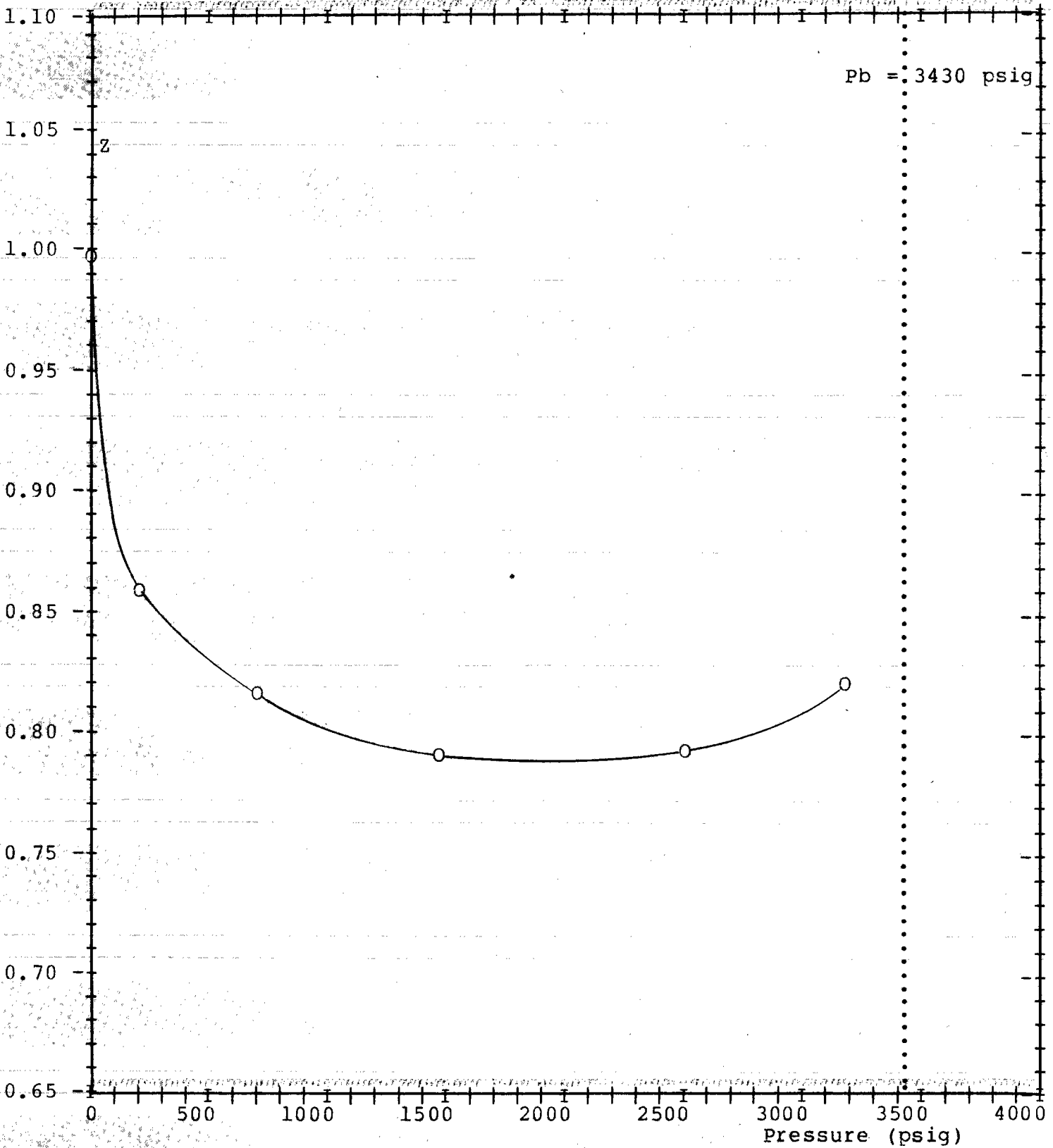


TABLE 10

SEPARATION TEST OF RESERVOIR FLUID

Separator Gas-oil ratio (1)
(Std cu ft/std bbl)

Pres. (psig)	Temp. (F)	Gas-oil ratio (1)		Oil volume factor (2) (bbl/Std bbl)	Sep. liq. density (g/cm ³)	Shrinkage factor (3) (Std bbl/bbl)	sto gravity (60/60 F)
		Sep.	Total				
100	142	819	-	-	0.787	0.916	-
10	160	30	-	-	0.798	0.937	-
0	60	-	16 865	1.501	-	1.000	0.847

(1) Gas volume at standard conditions per volume of stock tank oil at 60 F

(2) Volume of reservoir fluid at saturation pressure per volume of stock tank oil at 60 F

(3) Volume of stock tank oil at 60 F per volume of separator liquid at separator conditions

TABLE 11

SEPARATION TEST OF RESERVOIR FLUID

Molecular composition of liberated gases (mole percent)

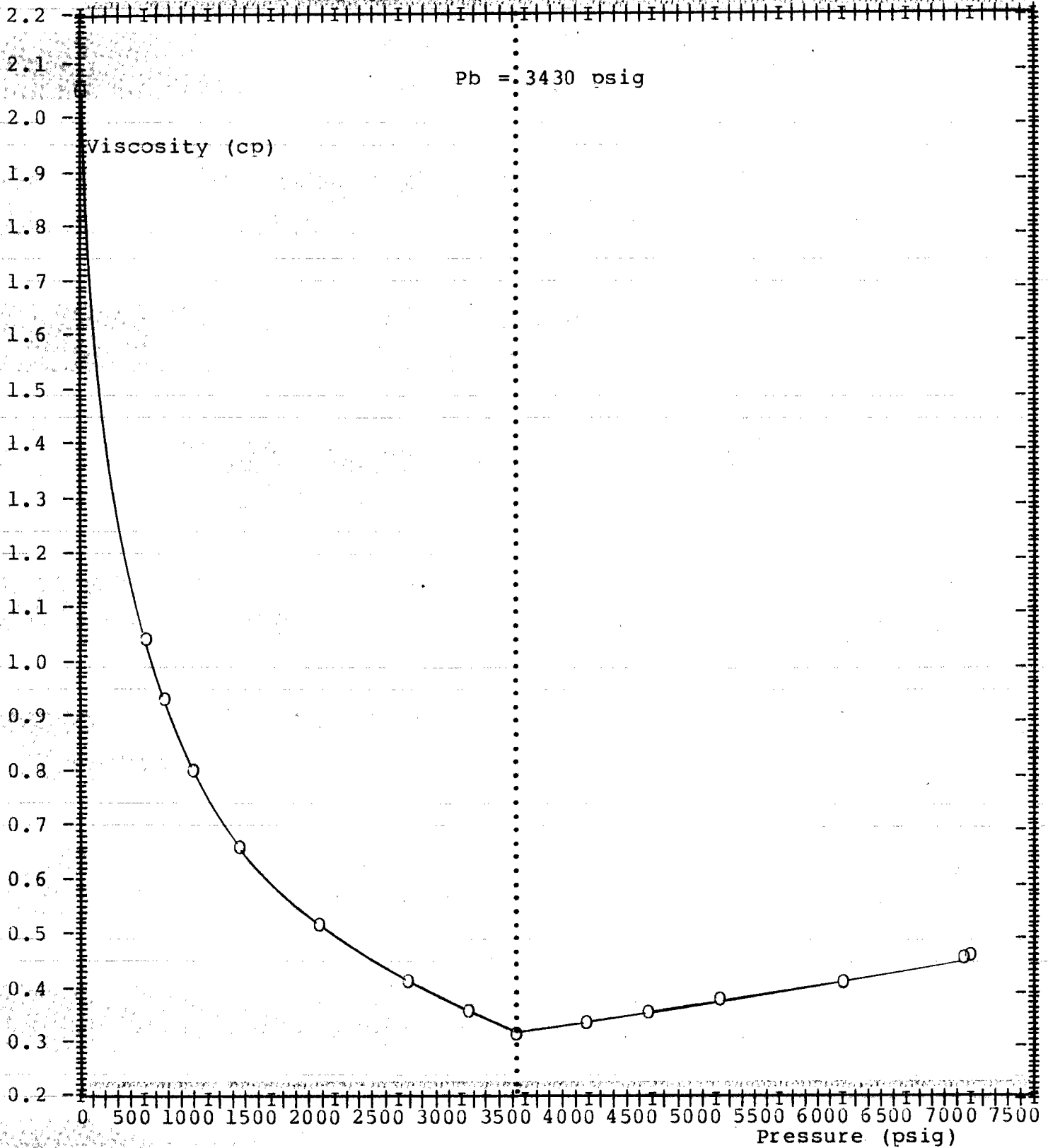
Pressure (psig)	100	10	0
Temperature (F)	142	225	60
Nitrogen	0.17	0.00	0.00
Carbon dioxide	1.03	1.53	1.18
Hydrogen sulphide	0.00	0.00	0.00
<u>Hydrocarbons:</u>			
Methane	77.26	41.60	16.79
Ethane	9.64	16.57	19.57
Propane	7.47	22.51	34.44
I - Butane	0.77	2.92	4.73
N - Butane	1.98	9.67	15.48
I - Pentane	0.52	2.06	3.25
N - Pentane	0.58	1.95	3.02
Hexanes	0.32	0.67	0.99
Heptanes plus	0.26	0.52	0.55
TOTAL	100.00	100.00	100.00
Molecular weight	22.028	33.596	41.987
Gravity (Air=1)	0.760	1.159	1.449
Molecular weight of neptanes plus	104.5	106.1	105.1

TABLE 12

VISCOSITY OF RESERVOIR FLUID AT 225 F

Pressure (psig)	Viscosity (centipoises)
7000	0.47
Pi= 6950	0.46
6000	0.41
5022	0.38
4460	0.35
3972	0.34
Pb= 3430	0.31
3054	0.36
2585	0.42
1880	0.53
1250	0.67
883	0.82
660	0.95
525	1.05
0	2.06

VISCOSITY OF RESERVOIR FLUID AT 225 F



COMPANY : AMOCO NORWAY OIL COMPANY

WELL : 2/11-6 (ST1) DST1

ADDITIONAL ANALYSIS.

A) POUR POINT ON RESIDUAL LIQUID
FROM DIFFERENTIAL VAPORIZATION : 17 F

B) REID VAPOR PRESSURE ON STO : 3.2 psi
NORN ASTM D-323

NOMENCLATURE

- P : Pressure
- V : Volume
- T : Temperature
- Pi : Initial static pressure
- Pb : Bubble point pressure
- Pd : Dew point pressure
- $V_r = V/V_{PB}$: Relative volume (oil reservoir fluid)
- $V_r = V/V_{PD}$: Relative volume (gas reservoir fluid)
- $c = -\frac{1}{V} \frac{dV}{dP}$: Compressibility factor of reservoir fluid
- $\alpha = \frac{1}{V} \frac{dV}{dT}$: Thermal expansion of reservoir fluid
- $\gamma = \frac{P_b/P - 1}{V_r - 1}$: Dimensionless compressibility function
- Bo : Oil formation volume factor
- Rs : Solution gas oil ratio
- Z : Gas compressibility factor or gas deviation factor
- Bg : Gas formation volume factor
- do : Reservoir oil density
- Go : Residual oil gravity
- G : Gas gravity (Air=1)
- sto : Stock tank oil
- GOR : Gas oil ratio
- GLR : Gas liquid ratio
- WOR : Water liquid ratio
- Shrinkage factor : $\frac{\text{Oil volume at standard conditions}}{\text{Oil volume at separator conditions}}$
- $Z = \frac{PV}{nRT}$: n=total moles of a mixture in the gas state
R=Universal gas constant (per mole)
- GPII : Gallons per thousand standard cubic feet
- Standard conditions : For gas volumes =60 F and 14.7 psia
: For oil measurements=60 F and atmospheric pressure

Gross heat content is calculated from API research project 44
Molecular weights, densities, critical values are from CRC Handbook of chemistry and physics
Gas viscosity is calculated with equations from Standing (Behavior of oil field hydrocarbon systems)