725.5

FLOPETROL JOHNSTON
Schlumberger

P.V.T.STUDY REPORT

Client:STATOIL
Field :SLEIPNER Well : 15/9-15 DST 2
Zone :--- Samp. date:---

Report #:83/L/011 Date: FEBRUARY 1983

MELUN LABORATORY

FLOPETROL JOHNSTON
Schlumberger

COMPANY : STATOIL

WELL : 15/9-15 DST 2

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SUMMARY AND MAIN RESULTS

The present report gives the experimental results of the P.V.T. study carried out on recombined surface samples from well 15/9-15 DST 2

The initial reservoir conditions are :

- Pi : 5075 psig
- T : 248 F

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

- Pd : 4985 psig at 248 F
- Z at Pd : 0.997
- Specific volume at Pd : 0.0577 cu ft/pound

For an abandonment pressure of 443 psig, the cumulative liquid recovery will be :

- 66.10 % of propane plus in place
- 55.86 % of butanes plus in place
- 45.49 % of pentanes plus in place

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TABLE 1

SAMPLING CONDITIONS

I. RESERVOIR AND WELL CHARACTERISTICS

Producing zone	:	---
Static pressure	:	5075 psig
Bottom hole temperature	:	248 F
Tubing diameter	:	---
Casing size	:	---
Casing shoe	:	---

II. SAMPLING CONDITIONS

A) SURFACE SAMPLE(S)

Date	:	---
Choke	:	---
Flowing bottom hole pressure	:	---
Well head pressure	:	---
Separator pressure	:	490 psig
Well head temperature	:	---
Separator temperature	:	66 F
Gas rate (Separator)	:	---
Stock tank temperature	:	---
Compressibility factor	:	0.894
Gas gravity	:	0.71 (Air=1)
Liquid rate (Separator)	:	---
G.L.R.	:	10337 std cu ft/bbl
Sample(s) received	:	gas A13985 A13993
		liq.0110

B) BOTTOM HOLE SAMPLE(S)

Date	:	---
Choke	:	---
Sample(s) received	:	---

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SAMPLE(S) VALIDITY

SEPARATOR LIQUID SAMPLE(S)

1) Sample bottle No 0110

Bubble point pressure determination at 66 F is 480 psig

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TABLE 2

BUBBLE POINT PRESSURE DETERMINATION AT 66 F

Separator liquid sample (cylinder 0110)

Pressure (psig)	Pump reading (cm3)
6000	374.53
5000	373.56
4025	372.63
3040	371.59
2045	370.46
1051	369.22
600	368.62
Pb = 480	368.43
475	368.28
470	367.78
465	366.78
455	364.80
442	361.79
429	358.82
410	353.83

FLASH OF SEPARATOR LIQUID TO STOCK TANK CONDITIONS

GLR : 709 std cu ft/bbl
Shrinkage factor : 0.701 Std bbl/bbl
Liberated gas gravity : 1.296 (Air = 1)
Stock tank liquid gravity: 0.772 60/60 F

This sample has been used for recombination

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BUBBLE-POINT PRESSURE DETERMINATION AT 66 F

Separator liquid sample (cylinder 0110)

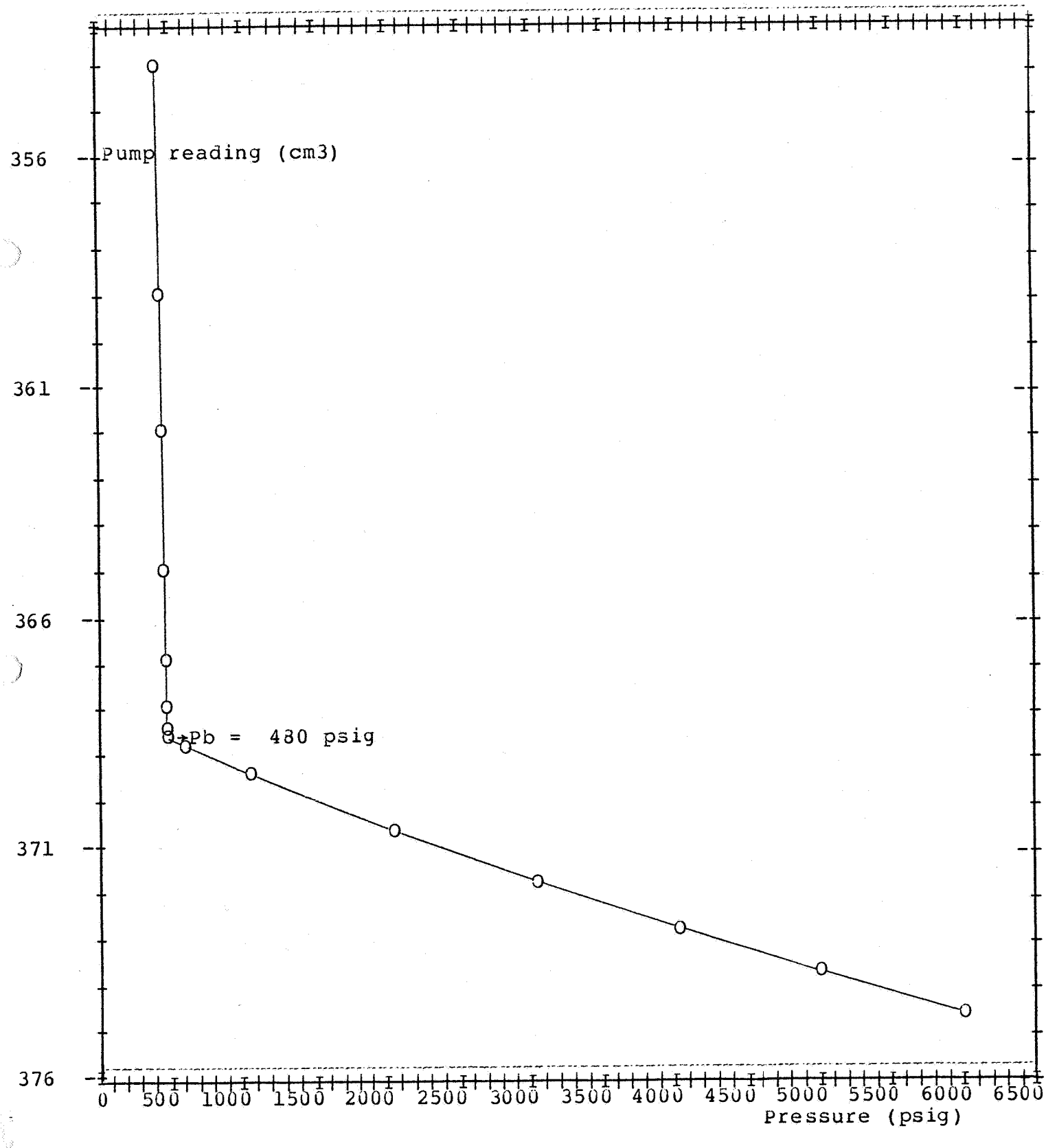

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TABLE 3

MOLECULAR COMPOSITION OF FIELD SEPARATOR GAS(ES)

I-Molecular composition (mole percent)

Components	Cylinder A 13985	Cylinder A 13993
Nitrogen	1.18	1.13
Carbon dioxide	1.25	1.15
Hydrocarbons:		
Methane	78.86	80.37
Ethane	10.52	10.26
Propane	5.44	4.96
I - Butane	0.83	0.68
N - Butane	1.32	1.04
I - Pentane	0.27	0.19
N - Pentane	0.24	0.16
Hexanes	0.07	0.04
Heptanes plus	0.02	0.02
TOTAL	100.00	100.00
Molecular weight	20.792	20.296
Gravity (Air=1)	0.717	0.700
Molecular weight of heptanes plus	100.2	100.2

II-Liquid content (g.p.M)

Propane plus	2.398	2.060
Butanes plus	0.907	0.700
Pentanes plus	0.223	0.153

The cylinder A 13993 has been used for recombination

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TABLE 4

RECOMBINATION OF SEPARATOR SAMPLES

I. FLASH OF SEPARATOR LIQUID TO STOCK TANK CONDITIONS

G.L.R.	: 709	Std cu ft/bbl
Shrinkage factor	: 0.701	Std bbl/bbl
Liberated gas gravity	: 1.296	(Air=1)
Stock tank liquid gravity	: 0.772	60/60 F

II. CORRECTION OF GAS LIQUID RATIO

Field G.L.R. : 10337 Std cu ft/bbl

Separator gas gravity (from chromatographic analysis)

G lab. : 0.700 (Air=1)

Compressibility factor Z at separator conditions

Z lab. : 0.901

$$\text{Corrected G.L.R.} : \text{Field G.L.R.} \times \sqrt{\frac{G\text{ field} \times Z\text{ field}}{G\text{ lab.} \times Z\text{ lab.}}}$$

$$\text{Corrected G.L.R.} : 10337 \sqrt{\frac{0.710 \times 0.894}{0.700 \times 0.901}} = 10364 \text{ Std cu ft /bbl}$$

III. PHYSICAL RECOMBINATION

Surface samples were physically recombined in the ratio of 10364 standard cubic feet of separator gas per barrel of separator liquid

TABLE 5

FLASH OF SEPARATOR LIQUID TO STOCK TANK CONDITIONS
(Molecular composition)

Components	Stock tank liquid (mole percent)	Evolved gas (mole percent)	Recombined separator liquid (mole percent)
Nitrogen	0.00	0.00	0.00
Carbon dioxide	0.00	0.98	0.44
Hydrocarbons:			
Methane	0.00	30.80	13.86
Ethane	0.30	20.76	9.51
Propane	2.99	23.91	12.40
I - Butane	1.98	5.61	3.61
N - Butane	6.32	9.70	7.84
I - Pentane	4.69	2.92	3.89
N - Pentane	6.17	2.64	4.58
Hexanes	9.92	1.61	6.18
Heptanes	15.05	0.89	8.68
Octanes	17.52	0.18	9.72
Nonanes	10.14	0.00	5.58
Decanes plus	24.92	0.00	13.71
TOTAL	100.00	100.00	100.00
Molecular weight	118.4	37.554	82.0
Gravity	0.772 60/60 F	1.296 (Air=1)	-----
Molar ratio	55.00	45.00	100.00
Mass ratio	79.40	20.60	100.00

Molecular weight of Decanes plus in STL: 191

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TABLE 6

MOLECULAR COMPOSITION OF RESERVOIR FLUID

Components	Recombined Separator liquid (mole percent)	Separator gas (mole percent)	Recombined Reservoir fluid (mole percent)
Nitrogen	0.00	1.13	1.02
Carbon dioxide	0.44	1.15	1.08
Hydrocarbons:			
Methane	13.86	80.37	73.94
Ethane	9.51	10.26	10.19
Propane	12.40	4.96	5.68
I - Butane	3.61	0.68	0.96
N - Butane	7.84	1.04	1.70
I - Pentane	3.89	0.19	0.55
N - Pentane	4.58	0.16	0.59
Hexanes	6.18	0.04	0.63
Heptanes	8.68	0.02	0.85
Octanes	9.72	0.00	0.94
Nonanes	5.58	0.00	0.54
Decanes plus	13.71	0.00	1.33
TOTAL	100.00	100.00	100.00
Molecular weight	82.0	20.296	26.2
Gravity	-----	0.700 (Air=1)	0.906 (Air=1)
Molar ratio	9.64	90.36	100.00
Mass ratio	30.12	69.88	100.00

Molecular weight of Decanes plus in reservoir fluid : 191

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TABLE 7

CONSTANT MASS STUDY AND DEW POINT PRESSURE DETERMINATION AT 248 F

	Pressure (psig)	Relative volume (V/V Pd)	Compressibility factor (Z=PV/nRT)	Retrograde liquid deposit (% of hydrocarbon pore space)*
	6000	0.9128	1.095	
	5801	0.9263	1.074	
	5513	0.9494	1.047	
	5271	0.9712	1.024	
Pi =	5075	0.9893	1.004	
Pd =	4985	1.0000	0.997	0.00
	4793	1.0230		0.01
	4578	1.0509		0.11
	4291	1.0941		0.58
	4004	1.1543		1.47
	3731	1.2221		2.30
	3445	1.3017		3.42
	3046	1.4435		4.63
	2537	1.7094		5.75
	2022	2.1437		6.52
	1567	2.8026		6.68
	1288	3.4493		6.53
	1004	4.6424		5.98

-Specific volume at dew point pressure = 0.05773 cu ft/pound

* Percent of retrograde liquid per volume of reservoir fluid at Pd

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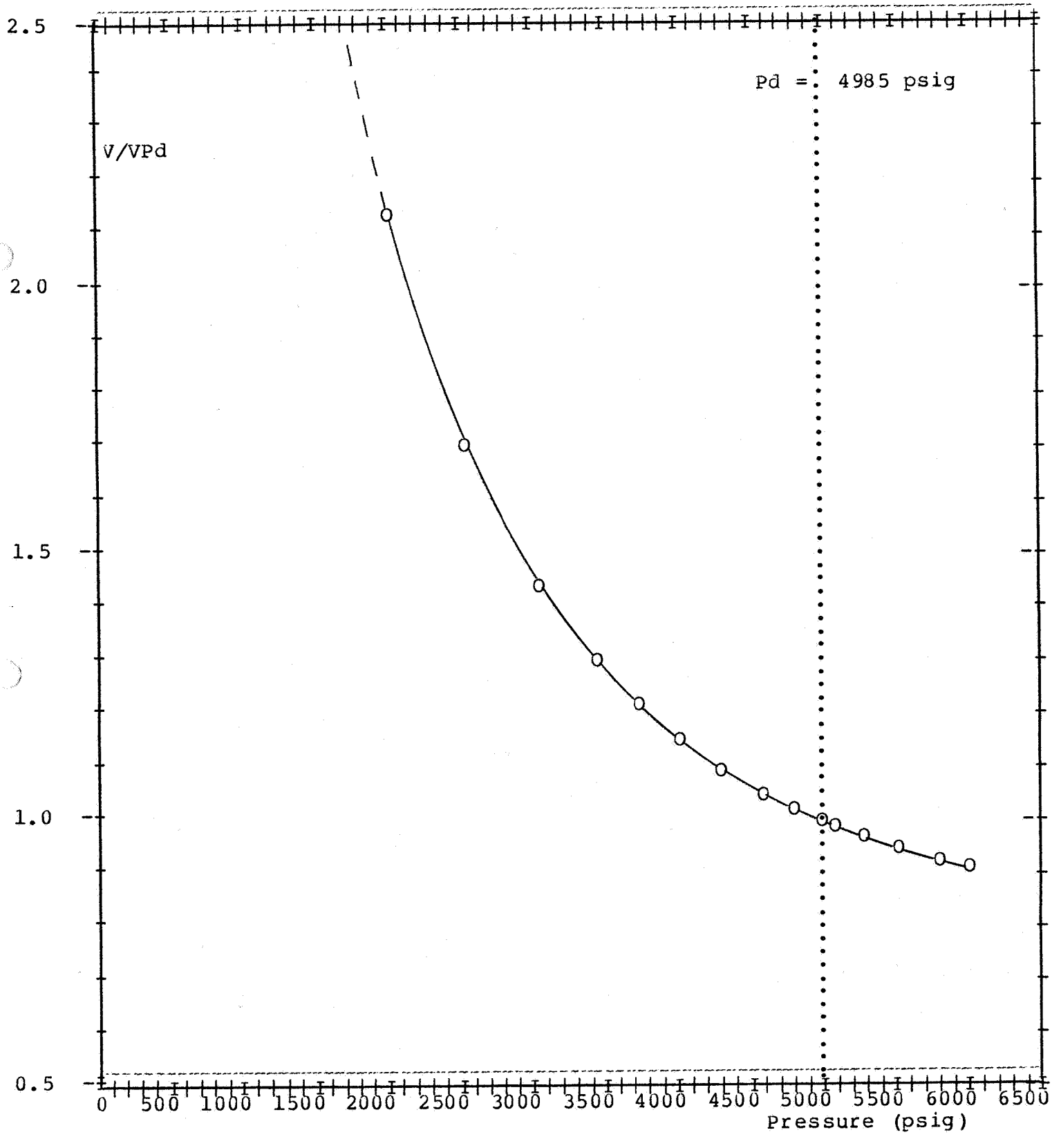
DEW POINT PRESSURE DETERMINATION AND CONSTANT MASS STUDY AT 248 F

Relative volume



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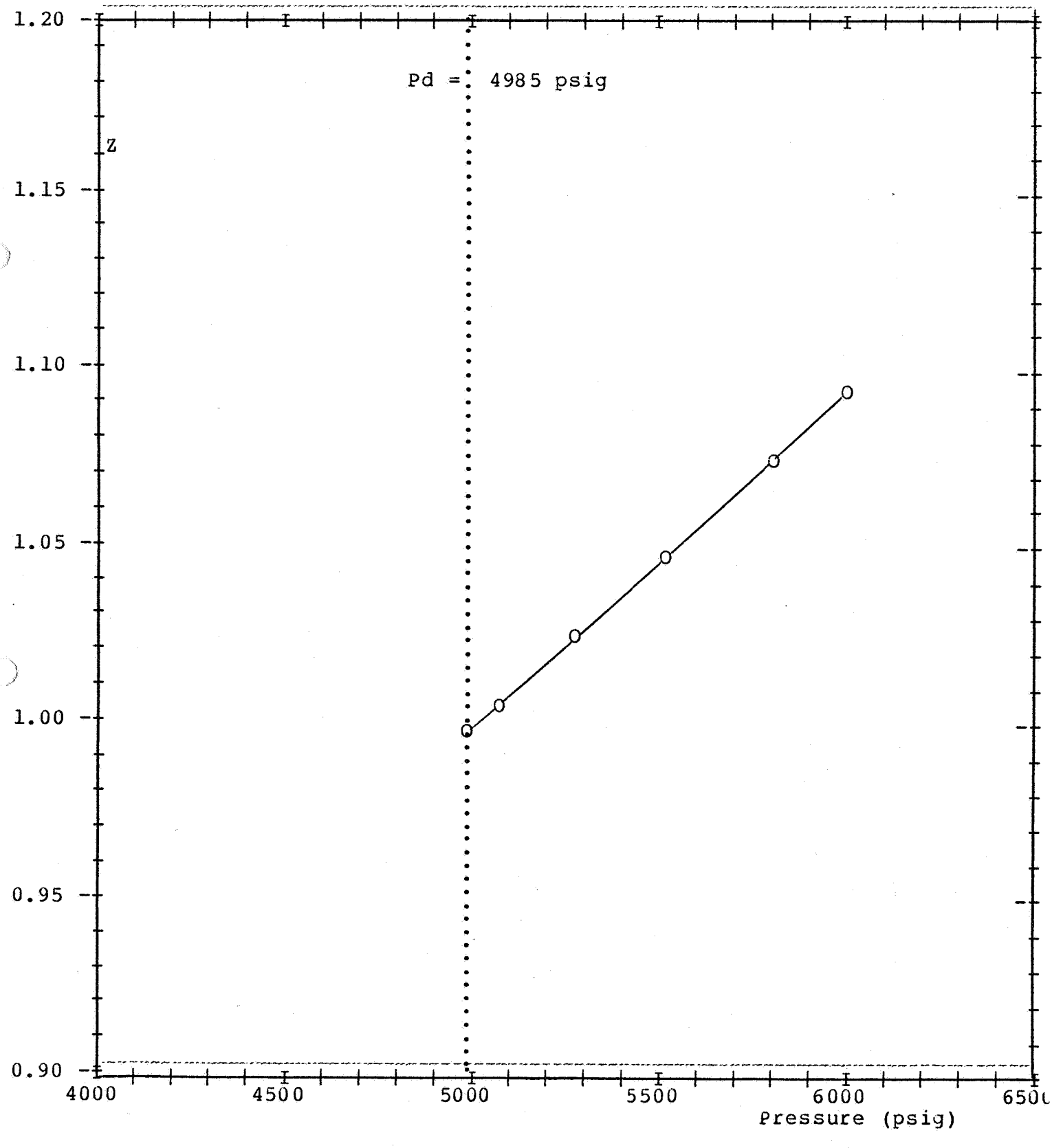
DEW-POINT-PRESSURE-DETERMINATION-AND-CONSTANT-MASS-STUDY-AT-248-F

compressibility factor



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DEW-POINT PRESSURE DETERMINATION AND CONSTANT MASS STUDY AT 248 F

Retrograde liquid deposit

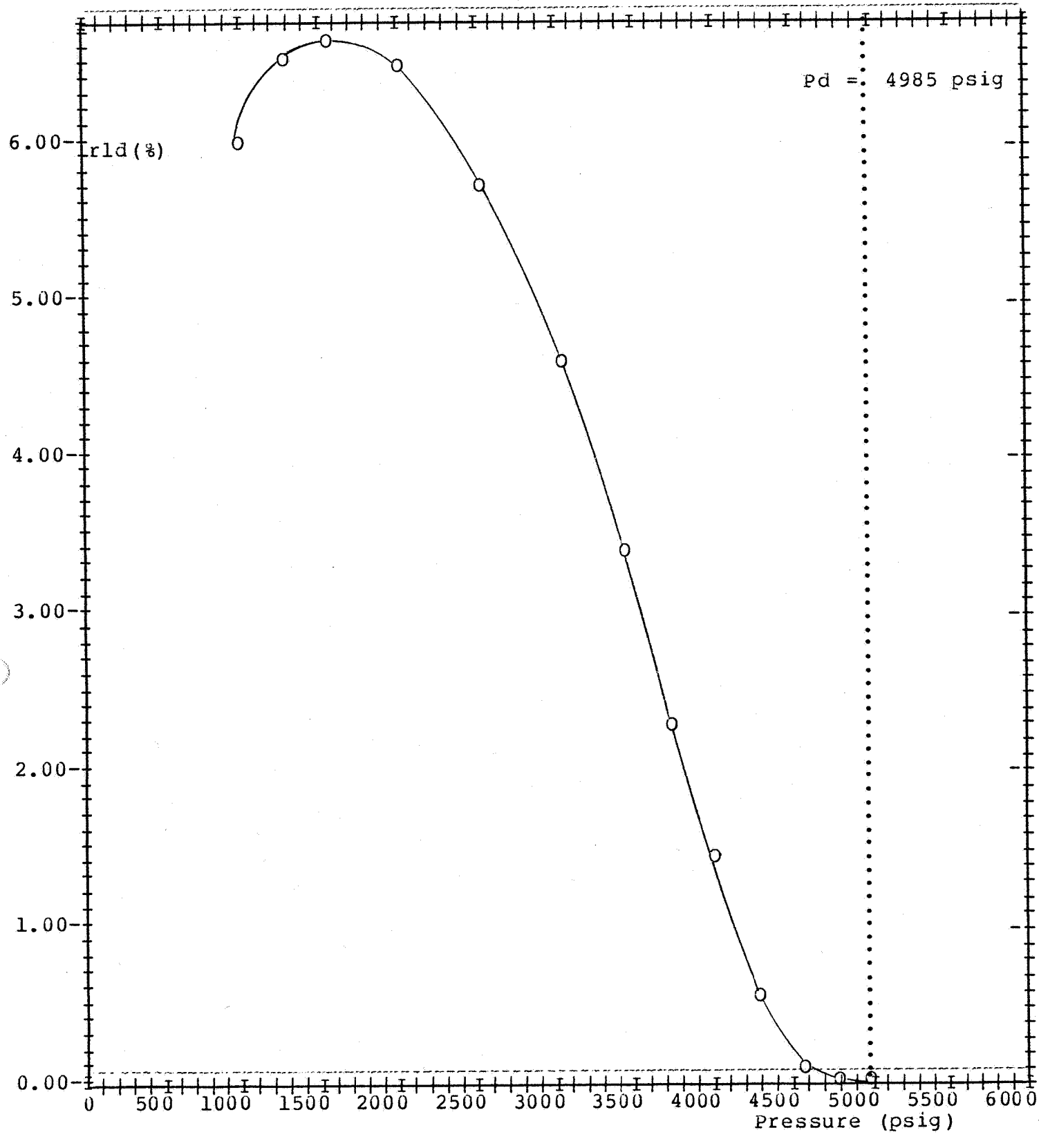

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TABLE 8

DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

Pressure (psig)	retrograde liquid deposit (percent of hydro-carbon pore space)*	Cumulative produced fluid (mole percent of initial fluid)	Compressibility factor of well stream (Z=PV/nRT)
Pd = 4985	0.00	0.00	0.997
4566	0.08	4.51	0.963
4257	0.59	8.80	0.938
3831	1.81	15.42	0.913
3336	3.05	24.19	0.888
2910	3.97	32.94	0.876
2396	4.61	44.12	0.875
1737	4.75	59.62	0.897
1013	4.25	77.08	0.941
652	3.91	84.94	0.961
443	3.69	89.33	0.974

*Percent of retrograde liquid per volume of reservoir fluid at Pd

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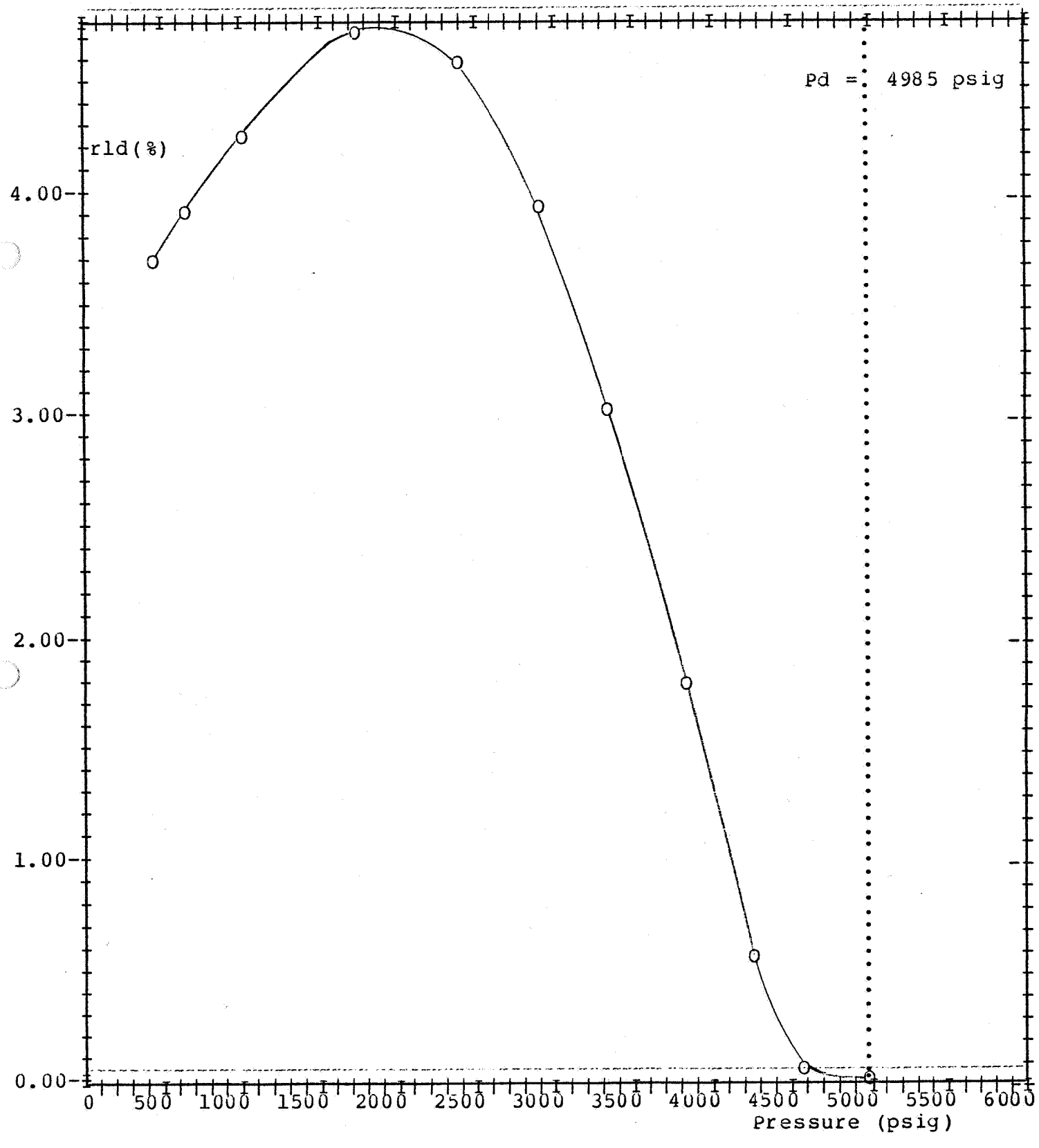
DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

Retrograde liquid deposit



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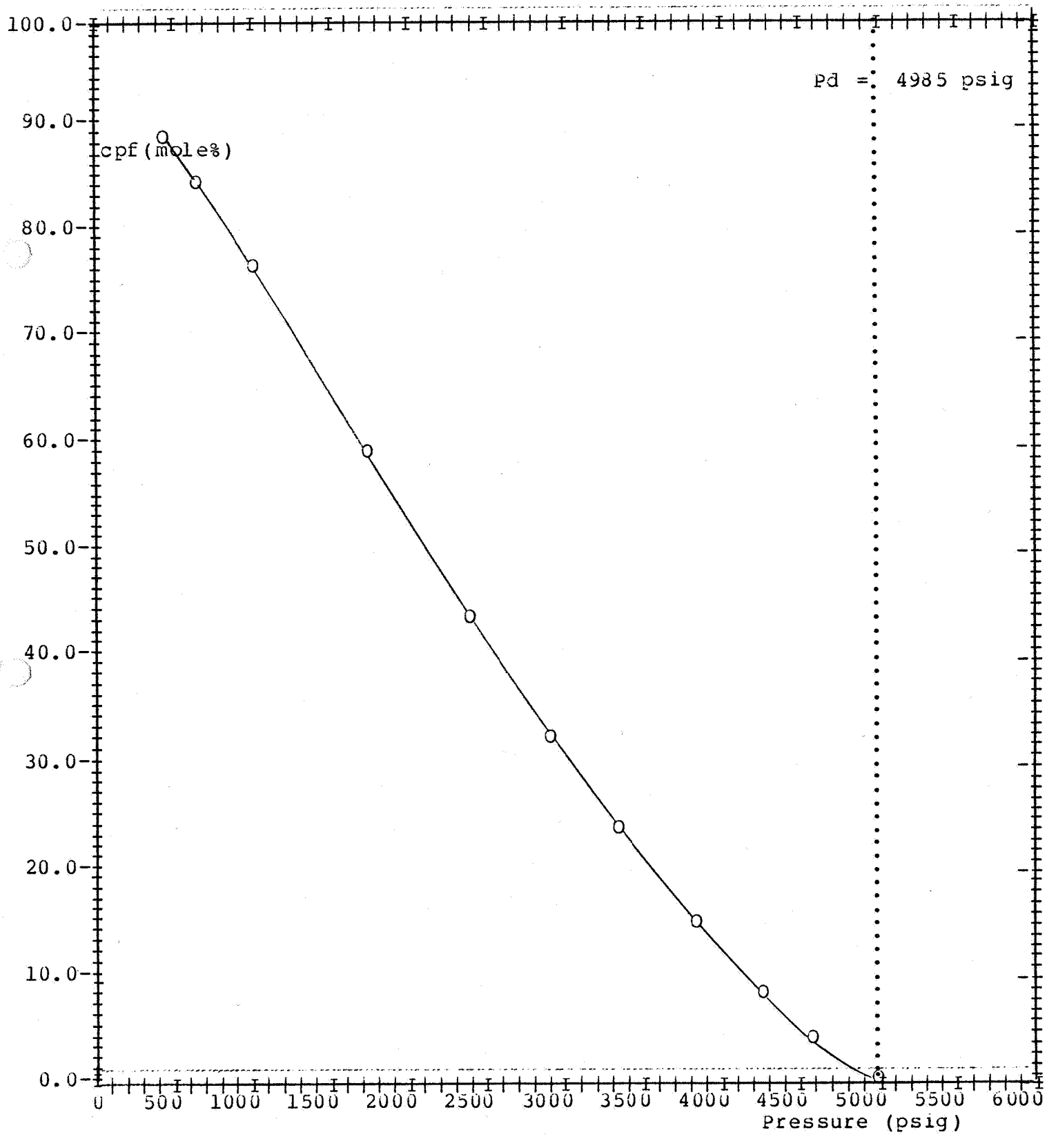
DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

Cumulative produced fluid



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DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

Produced well stream compressibility factor

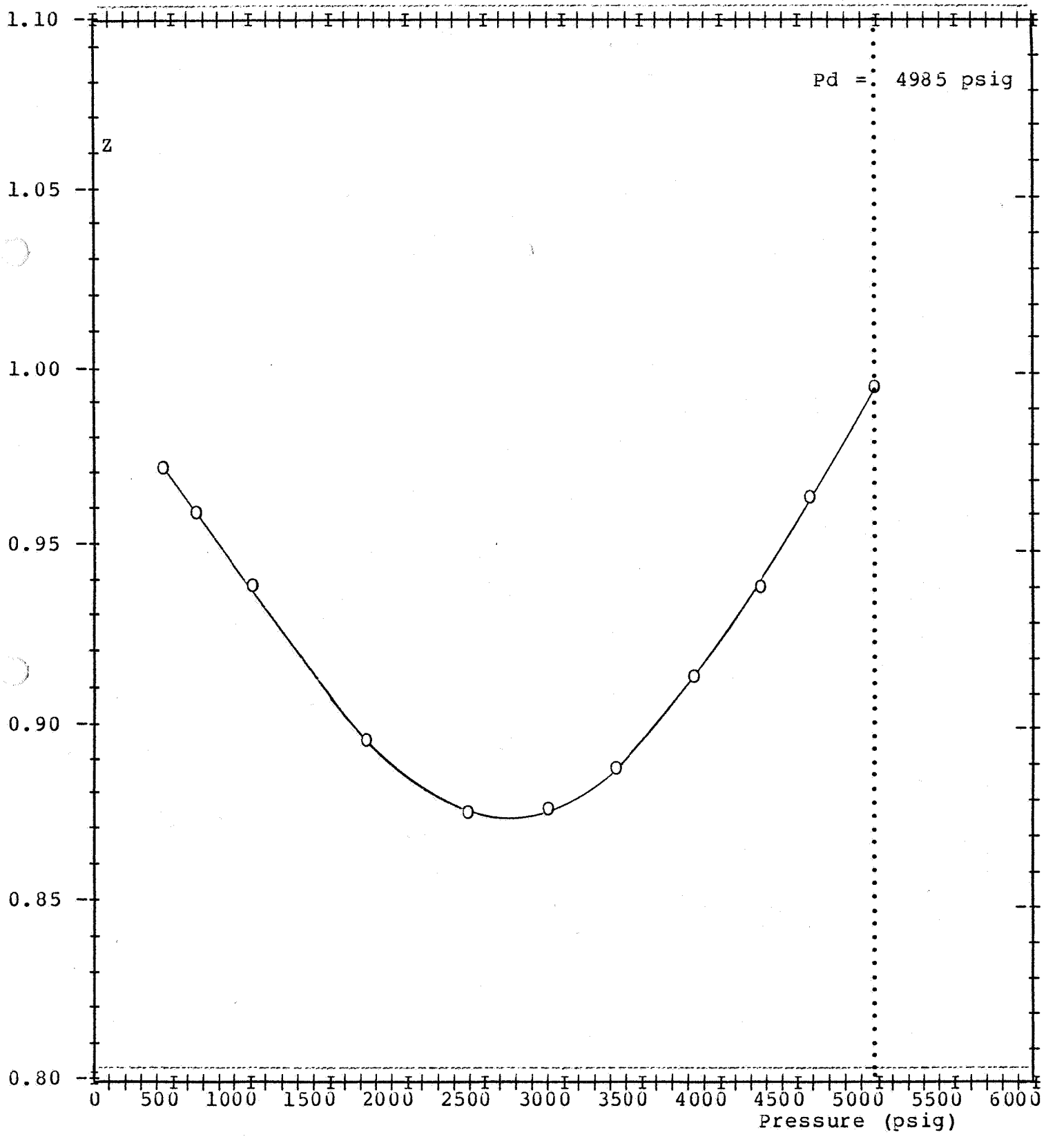

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TABLE 9

DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

I-Molecular composition of produced well stream (mole percent)

Pressure (psig)	4985	4566	4257	3831	3336	2910
Nitrogen	1.02	1.02	1.03	1.04	1.04	1.03
Carbon dioxide	1.08	1.07	1.06	1.06	1.05	1.06
Hydrocarbons:						
Methane	73.94	74.54	74.89	75.25	75.63	75.91
Ethane	10.19	10.22	10.26	10.31	10.38	10.41
Propane	5.68	5.66	5.65	5.65	5.64	5.65
I - Butane	0.96	0.95	0.95	0.94	0.94	0.95
N - Butane	1.70	1.69	1.68	1.67	1.67	1.66
I - Pentane	0.55	0.53	0.52	0.51	0.50	0.49
N - Pentane	0.59	0.57	0.55	0.53	0.52	0.50
Hexanes	0.63	0.60	0.57	0.55	0.51	0.48
Heptanes plus	3.66	3.15	2.84	2.49	2.12	1.86
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00
Molecular weight	26.265	25.476	25.015	24.497	23.963	23.588
Gravity (Air=1)	0.906	0.879	0.863	0.845	0.827	0.814
Viscosity (cp)	0.0277	0.0258	0.0246	0.0229	0.0211	0.0197
Molecular weight of Heptanes +	141.0	138.0	136.5	133.9	130.9	128.4

II-Liquid content of produced well stream (g.p.M)

Propane plus	5.295	4.913	4.684	4.428	4.164	3.978
Butanes plus	3.739	3.362	3.135	2.880	2.618	2.430
Pentanes plus	2.893	2.522	2.299	2.050	1.788	1.599

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TABLE 10

DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

I-Molecular composition of produced well stream (mole percent)

Pressure (psig)	2396	1737	1013	652	443
Nitrogen	1.02	1.00	0.98	0.96	0.94
Carbon dioxide	1.07	1.08	1.10	1.11	1.12
Hydrocarbons:					
Methane	76.12	76.30	75.99	75.73	75.38
Ethane	10.45	10.49	10.73	10.86	10.93
Propane	5.70	5.70	5.90	5.98	6.14
I - Butane	0.97	0.99	1.02	1.06	1.10
N - Butane	1.68	1.71	1.79	1.84	1.93
I - Pentane	0.48	0.48	0.49	0.52	0.55
N - Pentane	0.50	0.50	0.51	0.53	0.55
Hexanes	0.46	0.46	0.45	0.46	0.48
Heptanes plus	1.55	1.29	1.04	0.95	0.88
TOTAL	100.00	100.00	100.00	100.00	100.00
Molecular weight	23.215	22.925	22.766	22.777	22.845
Gravity (Air=1)	0.801	0.791	0.786	0.786	0.788
Viscosity (cp)	0.0181	0.0162	0.0142	0.0133	0.0128
Molecular weight of Heptanes +	125.6	123.1	119.8	118.7	117.4

II-Liquid content of produced well stream (g.p.M)

Propane plus	3.803	3.664	3.609	3.630	3.701
Butanes plus	2.241	2.102	1.992	1.992	2.018
Pentanes plus	1.398	1.243	1.098	1.069	1.054

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TABLE 11

DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

Molar composition of produced well stream up to Dodecanes plus

Pressure (psig)	4985	4566	4257	3831	3336	2910
Nitrogen	1.02	1.02	1.03	1.04	1.04	1.03
Carbon dioxide	1.08	1.07	1.06	1.06	1.05	1.06
Hydrocarbons:						
Methane	73.94	74.54	74.89	75.25	75.63	75.91
Ethane	10.19	10.22	10.26	10.31	10.38	10.41
Propane	5.68	5.66	5.65	5.65	5.64	5.65
I - Butane	0.96	0.95	0.95	0.94	0.94	0.95
N - Butane	1.70	1.69	1.68	1.67	1.67	1.66
I - Pentane	0.55	0.53	0.52	0.51	0.50	0.49
N - Pentane	0.59	0.57	0.55	0.53	0.52	0.50
Hexanes	0.63	0.60	0.57	0.55	0.51	0.48
Heptanes	0.85	0.78	0.74	0.70	0.65	0.61
Octanes	0.94	0.82	0.74	0.65	0.56	0.49
Nonanes	0.54	0.45	0.40	0.34	0.27	0.23
Decanes	0.34	0.29	0.26	0.22	0.18	0.16
Undecanes	0.21	0.18	0.16	0.14	0.12	0.10
Dodecanes plus	0.78	0.63	0.54	0.44	0.34	0.27
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00
Molecular weight	26.265	25.476	25.015	24.497	23.963	23.588
Molecular weight of Dodecanes +	222.0	215.5	214.2	209.4	203.8	199.4

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TABLE 12

DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

Molar composition of produced well stream up to Dodecanes plus

Pressure (psig)	2396	1737	1013	652	443
Nitrogen	1.02	1.00	0.98	0.96	0.94
Carbon dioxide	1.07	1.08	1.10	1.11	1.12
Hydrocarbons:					
Methane	76.12	76.30	75.99	75.73	75.38
Ethane	10.45	10.49	10.73	10.86	10.93
Propane	5.70	5.70	5.90	5.98	6.14
I - Butane	0.97	0.99	1.02	1.06	1.10
N - Butane	1.68	1.71	1.79	1.84	1.93
I - Pentane	0.48	0.48	0.49	0.52	0.55
N - Pentane	0.50	0.50	0.51	0.53	0.55
Hexanes	0.46	0.46	0.45	0.46	0.48
Heptanes	0.55	0.50	0.45	0.43	0.42
Octanes	0.41	0.33	0.26	0.23	0.21
Nonanes	0.18	0.14	0.10	0.09	0.08
Decanes	0.13	0.10	0.08	0.07	0.06
Undecanes	0.08	0.07	0.05	0.04	0.03
Dodecanes plus	0.20	0.15	0.10	0.09	0.08
TOTAL	100.00	100.00	100.00	100.00	100.00
Molecular weight	23.215	22.925	22.766	22.777	22.845
Molecular weight of Dodecanes +	193.4	186.2	178.1	173.9	171.8

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TABLE 13

DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

Cumulative liquid recovery (g.p.M. of initial reservoir fluid)

Pressure (psig)	cumulative produced fluid (mole percent of initial fluid)	Cumulative liquid recovery (g.p.M.)		
		propane plus	butanes plus	pentanes plus
Pd = 4985	0.00	5.295 (1)	3.739 (1)	2.893 (1)
4566	4.51	0.221	0.151	0.114
4257	8.80	0.423	0.286	0.212
3831	15.42	0.716	0.477	0.348
3336	24.19	1.081	0.706	0.505
2910	32.94	1.429	0.919	0.645
2396	44.12	1.854	1.169	0.801
1737	59.62	2.422	1.495	0.994
1013	77.08	3.052	1.843	1.186
652	84.94	3.337	2.000	1.270
443	89.33	3.500	2.088	1.316

(1) Total initial liquid in place (g.p.M.)

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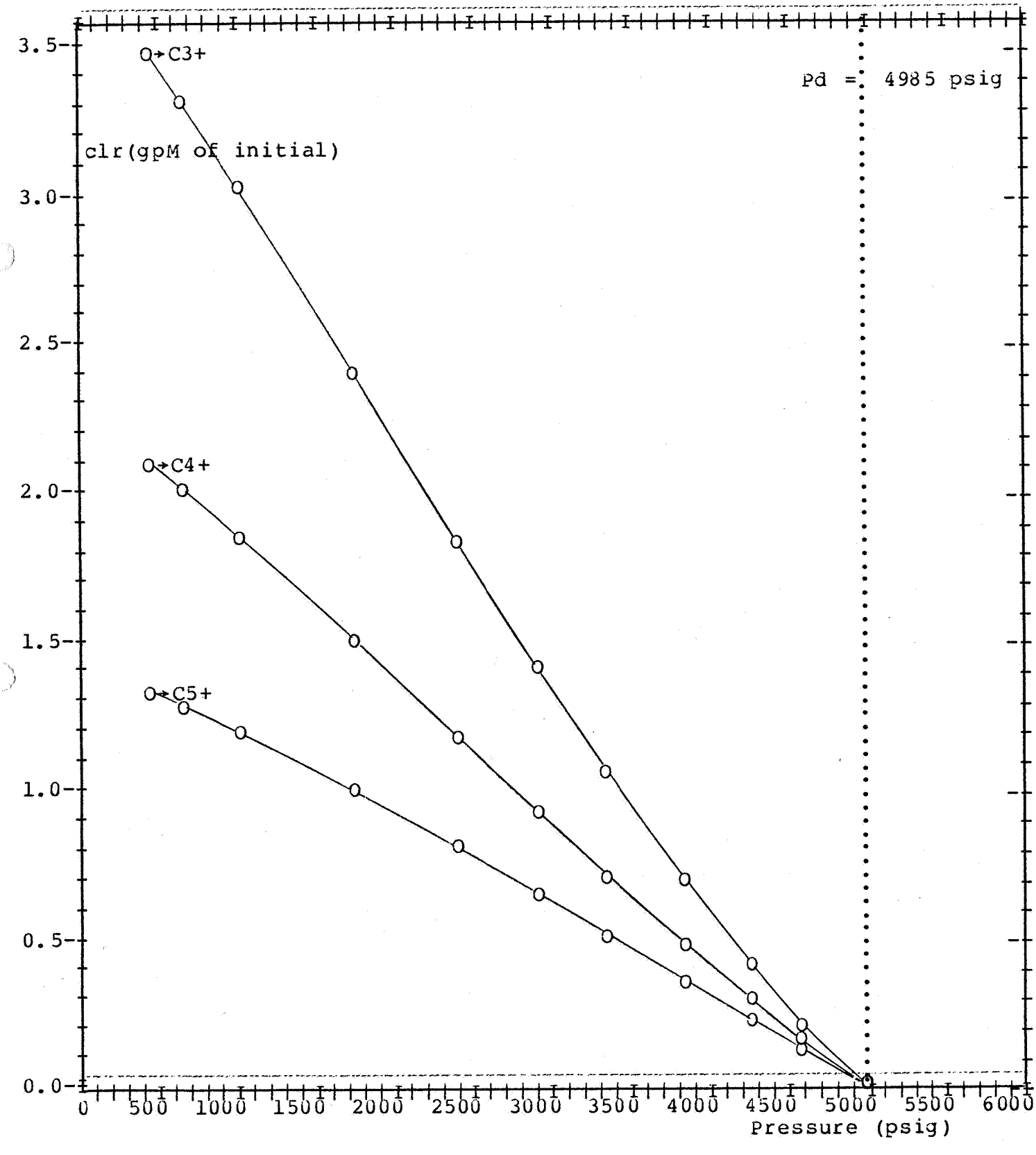
DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

Cumulative liquid recovery



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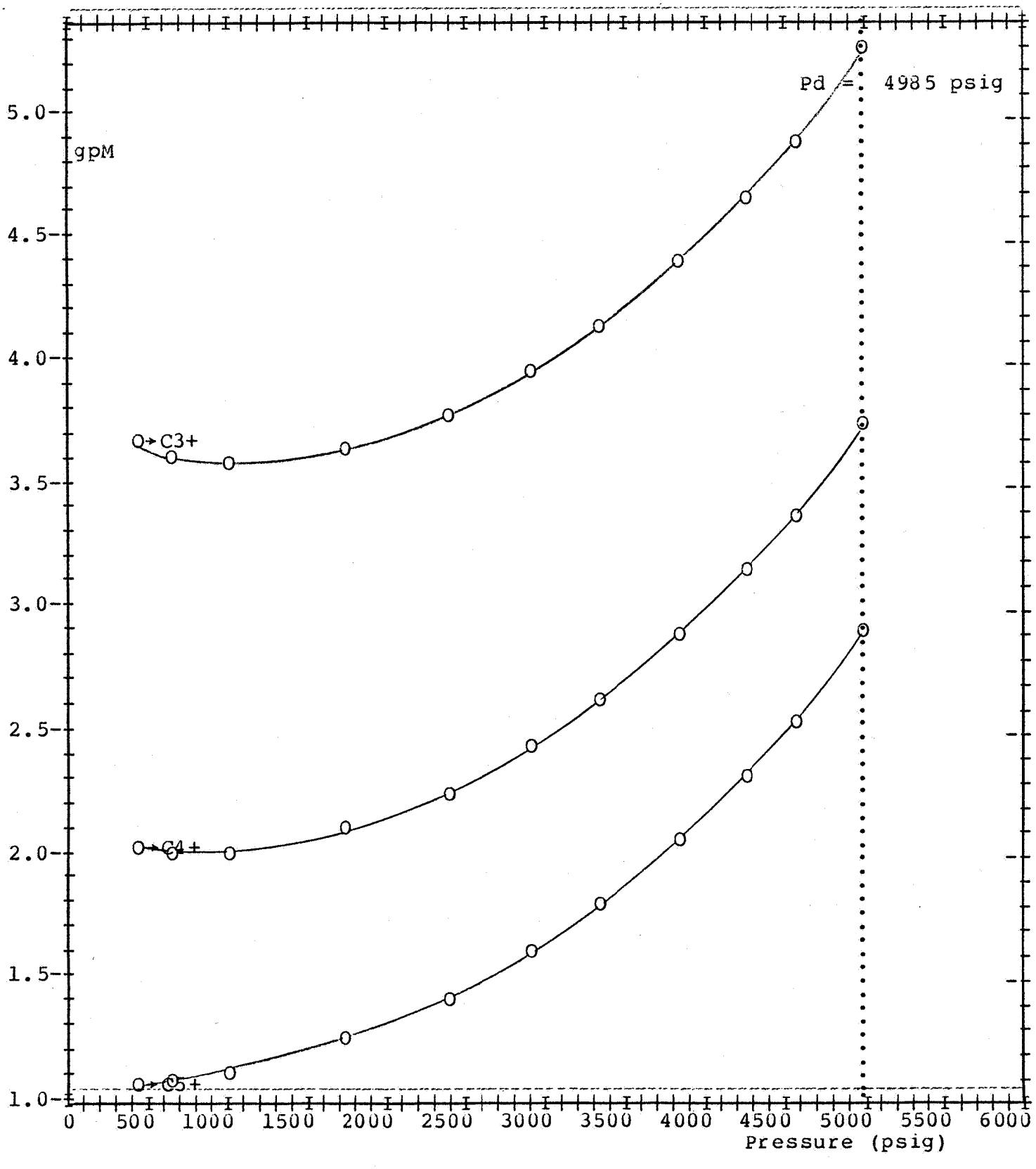
DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

Liquid content of produced well stream



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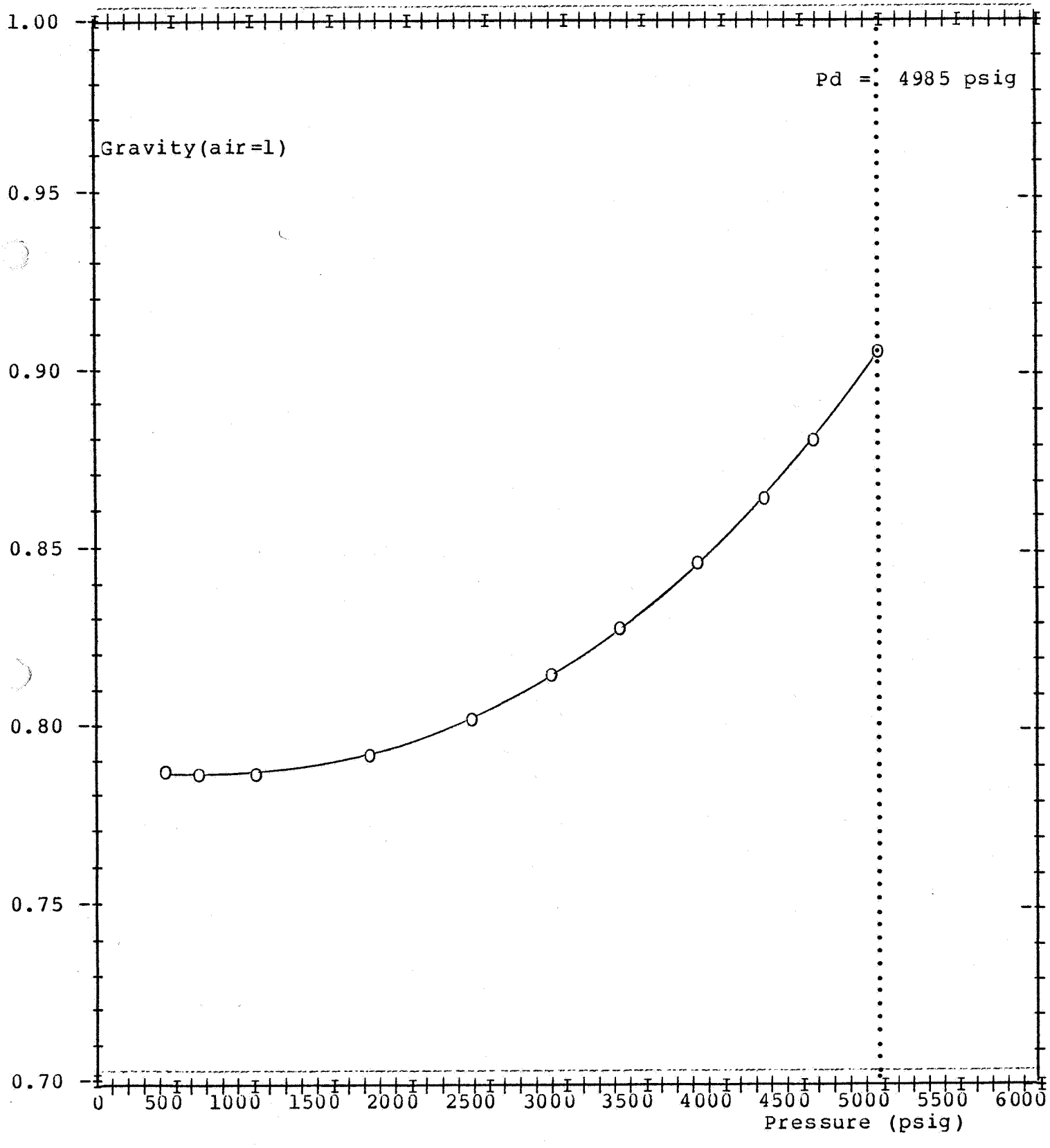
COMPANY : STATOIL

WELL : 15/9-15 DST 2

DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

Produced well stream gravity



Gas P.V.T. software version 1.3,00

83/L/011

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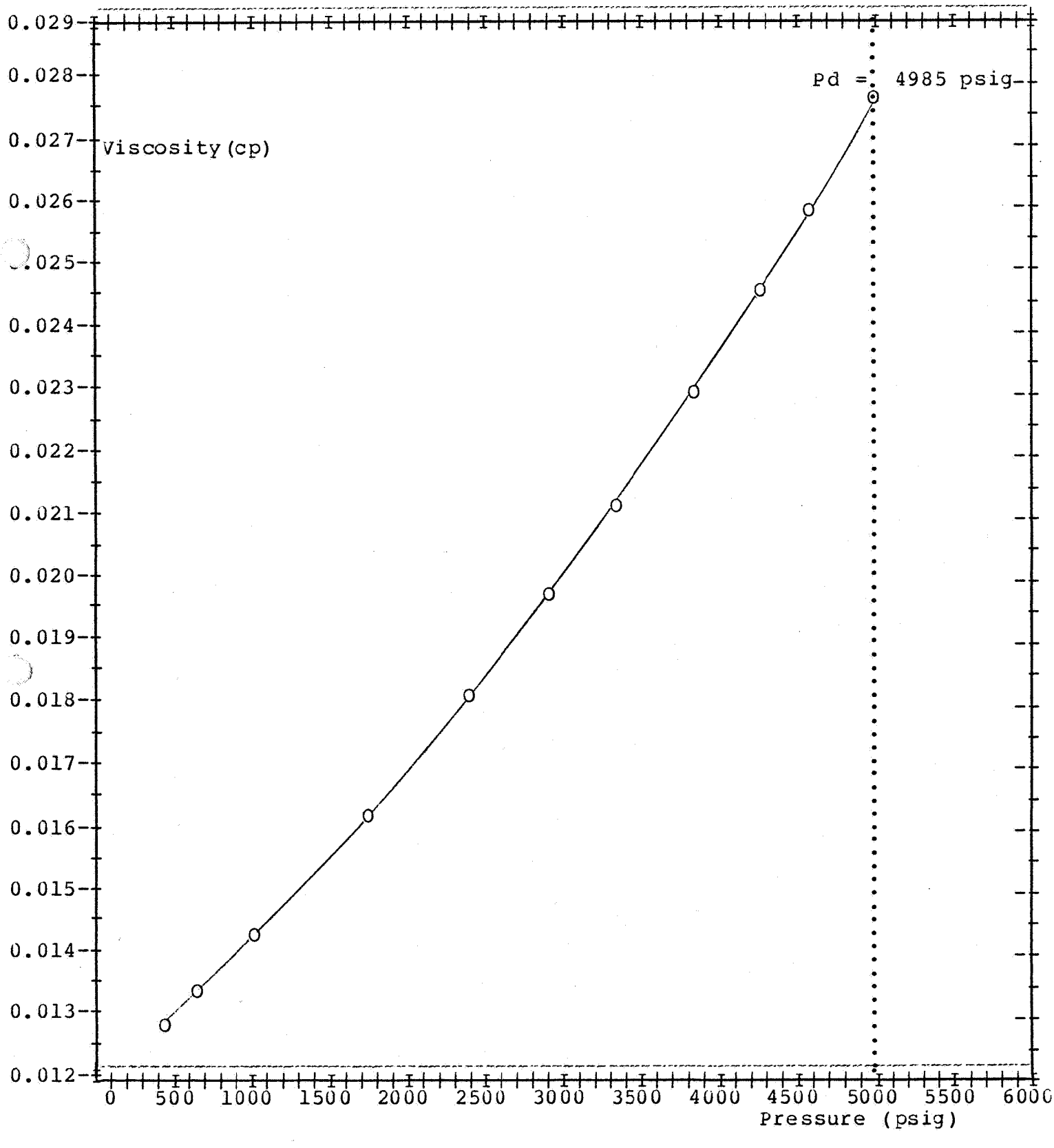
COMPANY : STATOIL

WELL : 15/9-15 DST 2

DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

Produced well stream viscosity



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WELL : 15/9-15 DST 2

TABLE 14

DEPLETION STUDY OF RESERVOIR FLUID AT 248 F

Flash of remaining liquid from 443 psig to atmospheric conditions

(molecular composition of gas free liquid)

Components	Mole percent
Methane	0.00
Ethane	0.52
Propane	1.83
I - Butane	0.79
N - Butane	2.28
I - Pentane	1.59
N - Pentane	2.11
Hexanes	4.29
Heptanes	9.09
Octanes	14.95
Nonanes	11.68
Decanes	8.77
Undecanes	6.30
Dodecanes plus	35.80
TOTAL	100.00

Molecular weight of gas free liquid : 158

Molecular weight of Dodecanes plus in gas free liquid : 239

Specific gravity of gas free liquid : 0.820 (60/60 F)

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TABLE 15

MOLECULAR COMPOSITION OF STOCK TANK LIQUID
(Weight percent)

Components	Weight percent
Nitrogen	0.00
Carbon dioxide	0.00
Hydrocarbons:	
Methane	0.00
Ethane	0.08
Propane	1.11
I - Butane	0.97
N-- Butane	3.10
I - Pentane	2.86
N - Pentane	3.76
Hexanes	7.22
Heptanes	12.74
Octanes	16.90
Nonanes	10.99
Decanes plus	40.27
TOTAL	100.00
Molecular weight	118.4
Gravity	0.772 60/60F

Molecular weight of Decanes plus in STL: 191

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TABLE 16

MOLECULAR COMPOSITION OF TANK GAS
(Weight percent)

Components	Weight percent
Nitrogen	0.00
Carbon dioxide	0.73
Hydrocarbons:	
Methane	13.21
Ethane	16.69
Propane	28.21
I - Butane	8.72
N - Butane	15.08
I - Pentane	5.63
N - Pentane	5.09
Hexanes	3.71
Heptanes	2.38
Octanes	0.55
Nonanes	0.00
Decanes plus	0.00
TOTAL	100.00
Molecular weight	37.554
Gravity	1.296 (Air=1)

TABLE 17

MOLECULAR COMPOSITION OF SEPARATOR GAS
(Weight percent)

Components	Weight percent
Nitrogen	0.79
Carbon dioxide	1.61
Hydrocarbons:	
Methane	64.63
Ethane	15.46
Propane	10.96
I - Butane	1.98
N - Butane	3.03
I - Pentane	0.69
N - Pentane	0.58
Hexanes	0.17
Heptanes	0.10
Octanes	0.00
Nonanes	0.00
Decanes plus	0.00
TOTAL	100.00
Molecular weight	20.296
Gravity	0.700 (Air=1)

TABLE 18

GRAVITY AND MOLECULAR WEIGHT DATA
USED IN CALCULATIONS

	Molecular weight	Gravity
Hexanes	86.178	0.6649
Heptanes	100.205	0.6883
Octanes	114.232	0.7069
Nonanes	128.259	0.7220
Decanes plus	191.272	0.9800

SUMMARY AND MAIN RESULTS

The present report gives the experimental results of the P.V.T. study carried out on recombined surface samples from well 15/9-15 DST 2

The initial reservoir conditions are :

- Pi : 350 bar
- T : 120 C

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

- Pd : 344 bar
- Z at Pd : 0.997
- Specific volume at Pd : 3.6017 cm3/g

For an abandonment pressure of 31 bar, the cumulative liquid recovery will be :

- 66.10 percent of propane plus in place
- 55.86 percent of butanes plus in place
- 45.49 percent of pentanes plus in place

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WELL : 15/9-15 DST 2

NOMENCLATURE

P	:	Pressure
V	:	Volume
T	:	Temperature
Pi	:	Initial static pressure
Pb	:	Bubble point pressure
Pd	:	Dew point pressure
Vr=V/V Pb	:	Relative volume (oil reservoir fluid)
Vr=V/V Pd	:	Relative volume (gas reservoir fluid)
$c = -\frac{1}{V}\times\frac{dV}{dP}$	:	Compressibility factor of reservoir fluid
$\alpha = \frac{1}{V}\times\frac{dV}{dT}$	:	Thermal expansion of reservoir fluid
$Y = \frac{Pb/P-1}{Vr-1}$	:	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)
gpM	:	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)