pro

PVT LABORATORY
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CONSULTANCY SERVICES

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DESCRIPTION OF EXPERIMENTS

1. A sample of gas was taken from container A-9165 for gas gravity and hydrocarbon analysis (TABLE 2).

2. The separator liquid in container 9024-96 was compressed to single phase and stabilised at 6000 psig before charging to a Ruska visual cell. The validity of the sample was checked at separator temperature. The saturation pressure was 776 psia, somewhat lower than separator pressure, but considering the problems of getting a water free separator sample and considering the very high separator GOR, there would not have been any significant difference in the final reservoir fluid.

3. The separator liquid in the cell was flashed to stock tank conditions for GOR, oil shrinkage factor and stock tank liquid gravity measurements (TABLE 4). The resulting stock tank oil and vapours were measured, collected and analysed by chromatography (TABLE 3).

4. The reservoir fluid composition was mathematically calculated using the compositions from the flash and separator gas and using the corrected GOR (TABLE 5).

5. The separator gas (container A9165) and separator liquid (container 9024/96) were physically recombined in a Ruska see-through condensate cell using stock tank GOR of 329758.91 SCF/STB and at a temperature of 154°F (Recombination data TABLE 4).

6. The cell was maintained at 154°F and a constant composition expansion study was carried out. Several attempts were made to observe a dewpoint between 5000 psi and 1000 psi but there was no visible change in the sample over this pressure range. As a result, it should be noted that the relative volumes in the PV relationship (TABLE 6, FIGURE 3) are relative to the reservoir pressure volume. No retrograde deposits were observed.

7. The depletion study was carried out at 154°F and the produced wellstream analysed by chromatograph (TABLE 8). No retrograde condensation was observed during the study and no residual liquid left at the final stage.

8. The wellstream viscosity was calculated from the compositions (TABLE 7).

9. The first condensate sample container we received (22478-7) contained only about 5cc condensate and the rest was water. This container was then replaced by container no. 22478-95 and this also contained mostly water. Work was then suspended until receipt of container 9024-96.

TABLE 1

Sampling Details

Field	:	TROLL
Well No.	:	31/2 - 12N
Producing Zone	:	Upper Jurassic
Perforations	:	1385 - 1405 Metres
Sampling Date	:	30.8.83
Sampling Time	:	6.30 - 7.00 hrs
Sample Type	:	Separator
Reservoir Pressure	:	2290 psia
Reservoir Temperature	:	154°F
Wellhead Pressure	:	1530 psig
Wellhead Temperature	:	67°F
Separator Pressure	:	840 psig
Separator Temperature	:	67°F
Customer's Identification	:	West Lab. / Shell Explor. - 01 o/g
Container Nos.	:	
	Liquid 9024 - 96	
	Gas A - 9165	
Expro Ref:	:	SH/569/605

TABLE 2

Composition of Separator Gas (Bottle No. A 9165)

Component	Mol.%
N_2	1.42
CO_2	0.53
C_1	93.15
C_2	3.60
C_3	0.50
iC_4	0.36
nC_4	0.09
iC_5	0.06
nC_5	0.02
C_6	0.08
C_7	0.12
C_8	0.06
C_9	0.01

Gas Gravity (Air = 1.0) : 0.6032

TABLE 3

Separator Liquid Composition
(Bottle No. 9024-96)

Component	Wt.%	Mol%
N_2	0.07	0.26
CO_2	0.35	0.83
C_1	3.47	22.57
C_2	1.27	4.40
C_3	0.63	1.49
iC_4	1.49	2.67
nC_4	0.32	0.57
iC_5	0.82	1.18
nC_5	0.27	0.39
C_6	3.58	4.33
C_7	15.62	16.25
C_8	22.50	20.54
C_9	14.16	11.51
C_{10+}	35.47	13.01

Average Molecular Weight of C_{10+} fraction = 284

TABLE 4

Data For Recombination

Separator Gas (A 9165)

Field Gravity	(Air = 1.0) :	0.605
Lab. Gravity	(Air = 1.0) :	0.6032

Separator Liquid (9024-96)

Saturation Pressure at 67°F :776 psia

Single Stage Flash at 67°F from 5703 psia to atmospheric conditions

G.O.R. SCF/STB	: 347
Gas Gravity (Air = 1.0)	: 0.8463
Oil Gravity at 60°F	: 0.7843 = [48.92°API]
Oil Volume Factor Bo[1]	: 1.1603

[1]Oil Volume Factor Bo: Liquid Volume at Saturation Pressure, Per Volume of Stock Tank Liquid at STP

Correction of Field G.O.R.

$$\text{True G.O.R.} = \text{Field G.O.R.} \times \frac{\text{Fg (lab) Fpv (lab)}}{\text{Fg (field) Fpv (field)}}$$

Where $Fg = \dfrac{1}{\sqrt{s.g.}}$ $\qquad$ $Fpv = \dfrac{1}{\sqrt{Z}}$

Fg (lab) =	1.2876	Fpv (lab) = 1.0600
Fg (field) =	1.2856	Fpv (field) = 1.0744

Field G.O.R. = 333730.31 SCF/STB.

∴ True GOR = 333730.31 x 0.9881 = 329758.91 SCF/STB.

Recombination Conditions

Pressure psia	=	5703
Temperature,°F	=	154
G.O.R.	=	329758.91 SCF/STB.

TABLE 5

Reservoir Fluid Composition

Component	Wt.%	Mol.%
N_2	2.21	1.41
CO_2	1.32	0.53
C_1	83.72	92.91
C_2	6.09	3.60
C_3	1.24	0.50
iC_4	1.20	0.37
nC_4	0.30	0.09
iC_5	0.26	0.06
nC_5	0.09	0.02
C_6	0.46	0.09
C_7	1.02	0.18
C_8	0.88	0.14
C_9	0.38	0.05
C_{10+}	0.79	0.05

Mol. wt. of C_{10+} : 284

TABLE 6

Pressure Volume Relationship at Reservoir Temperature

154°F

Pressure, psia	Gas Deviation Factor Z	Relative Volume
5000	0.988	0.507
4500	0.952	0.540
4000	0.925	0.585
3500	0.899	0.659
3000	0.889	0.761
2500	0.885	0.908
*2290	0.892	1.000
2000		1.142
1800		1.274
1600		1.458
1400		1.674
1200		2.012
1000		2.421

* Reservoir pressure

TABLE 7

Calculated Wellstream Viscosity

Pressure psia	Viscosity, cP
4500	0.0236
4000	0.0216
3500	0.0202
3000	0.0184
2500	0.0170
*2290	0.0164
2000	0.0157
1800	0.0152
1600	0.0147
1400	0.0143
1200	0.0138
1000	0.0134

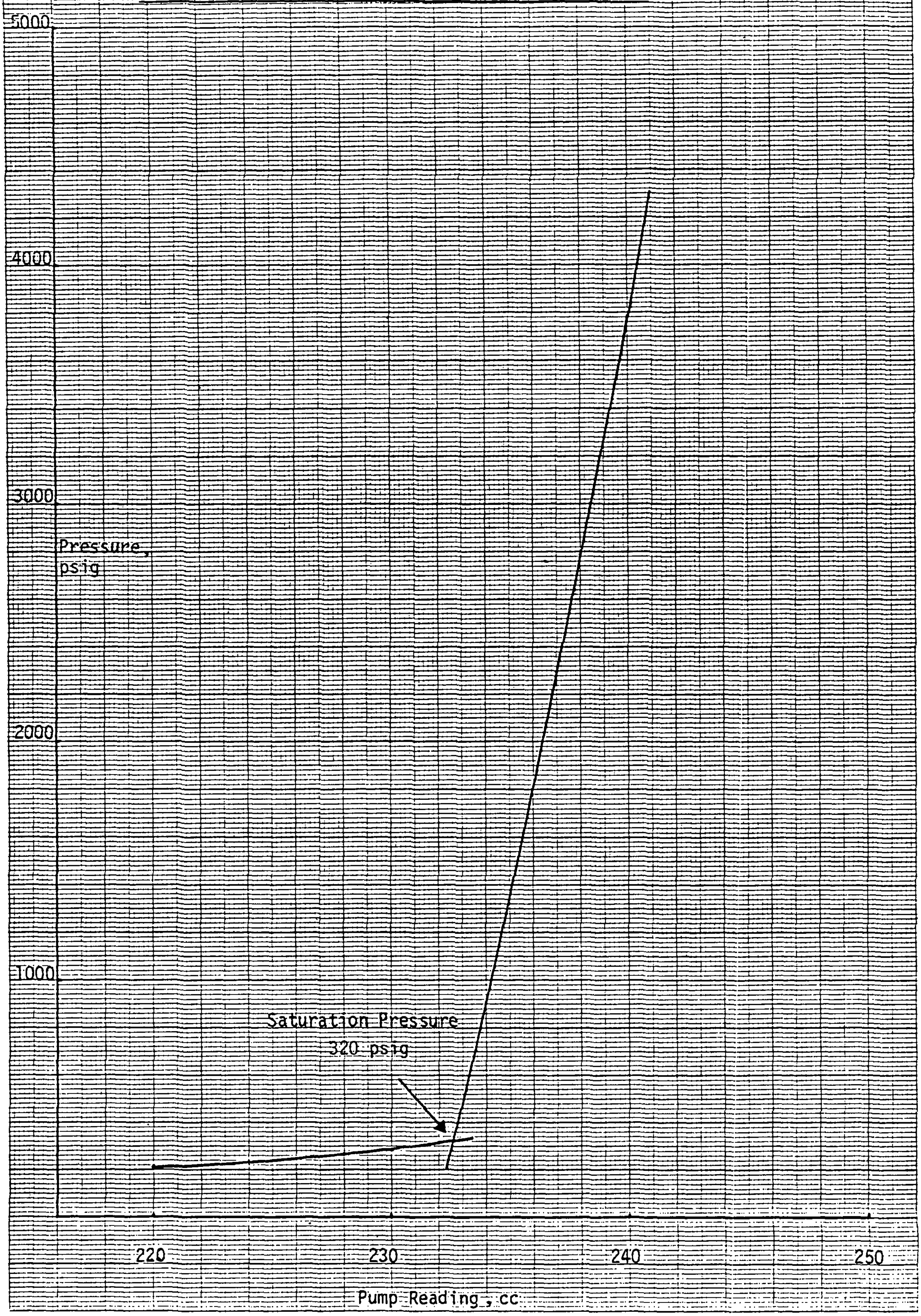
* Reservoir pressure

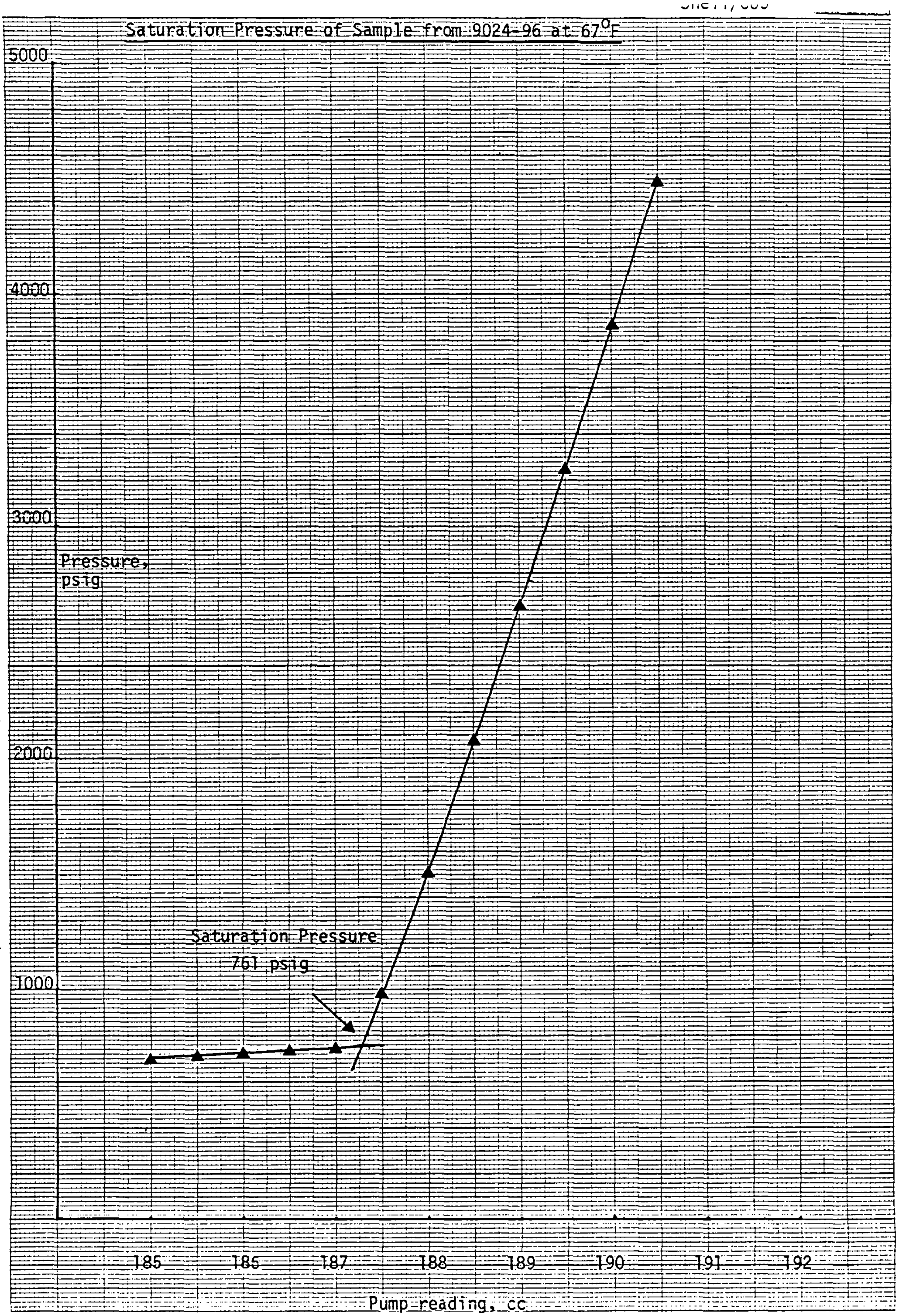
TABLE 8

Depletion study at 154°F
Hydrocarbon Analysis of Produced Wellstream (Mol.%)

	Reservoir Pressure, psia						
Component	1940	1590	1240	890	565	265	14.7
N_2	1.18	2.38	2.44	2.41	2.35	2.26	1.63
CO_2	0.58	0.58	0.55	0.58	0.59	0.64	0.60
C_1	93.40	92.19	92.21	92.09	92.19	92.29	92.87
C_2	3.67	3.64	3.59	3.68	3.66	3.62	3.62
C_3	0.41	0.41	0.41	0.42	0.41	0.39	0.41
iC_4	0.35	0.35	0.35	0.36	0.35	0.34	0.36
nC_4	0.05	0.05	0.05	0.05	0.05	0.05	0.05
iC_5	0.05	0.05	0.05	0.05	0.05	0.05	0.05
nC_5	0.01	0.01	0.01	0.01	0.01	0.01	0.01
C_6	0.07	0.08	0.08	0.09	0.08	0.08	0.09
C_7	0.14	0.16	0.16	0.16	0.16	0.16	0.18
C_8	0.08	0.09	0.09	0.09	0.09	0.10	0.12
C_9	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Gas Gravity (Air=1.0)	0.6018	0.6075	0.6075	0.6087	0.6079	0.6080	0.6069
Z Factor	0.877	0.890	0.908	0.945	0.964	0.983	1.000
Wellstream Produced Cumulative % Initial	14.00	29.83	46.71	63.22	76.78	87.25	100
GPM Smooth Compositions							
C_{3+}	0.40	0.42	0.42	0.45	0.42	0.42	0.46
C_{4+}	0.29	0.31	0.31	0.33	0.31	0.31	0.35
C_{5+}	0.16	0.18	0.18	0.19	0.18	0.18	0.21

Saturation Pressure of sample from 22478.95 @ 60°F





Saturation Pressure of Sample from 9024-96 at 67°F
5000
4000
3000
2000
1000
Pressure, psig
Saturation Pressure
761 psig
185
186
187
188
189
190
191
192
Pump reading, cc

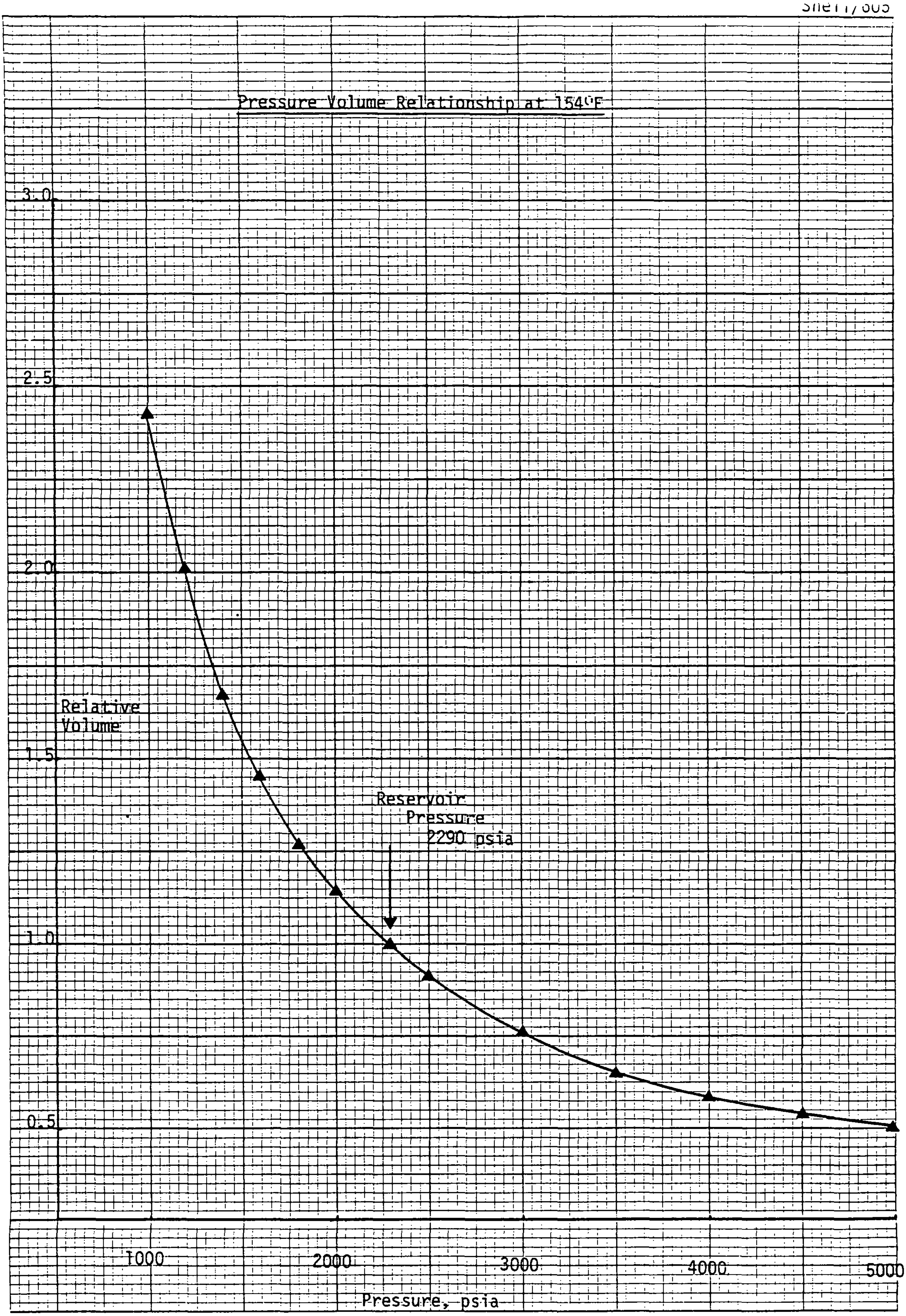

Pressure Volume Relationship at 154°F
3.0
2.5
2.0
Relative
Volume
1.5
Reservoir
Pressure
2290 psia
1.0
0.5
1000
2000
3000
4000
5000
Pressure, psia

Figure 3

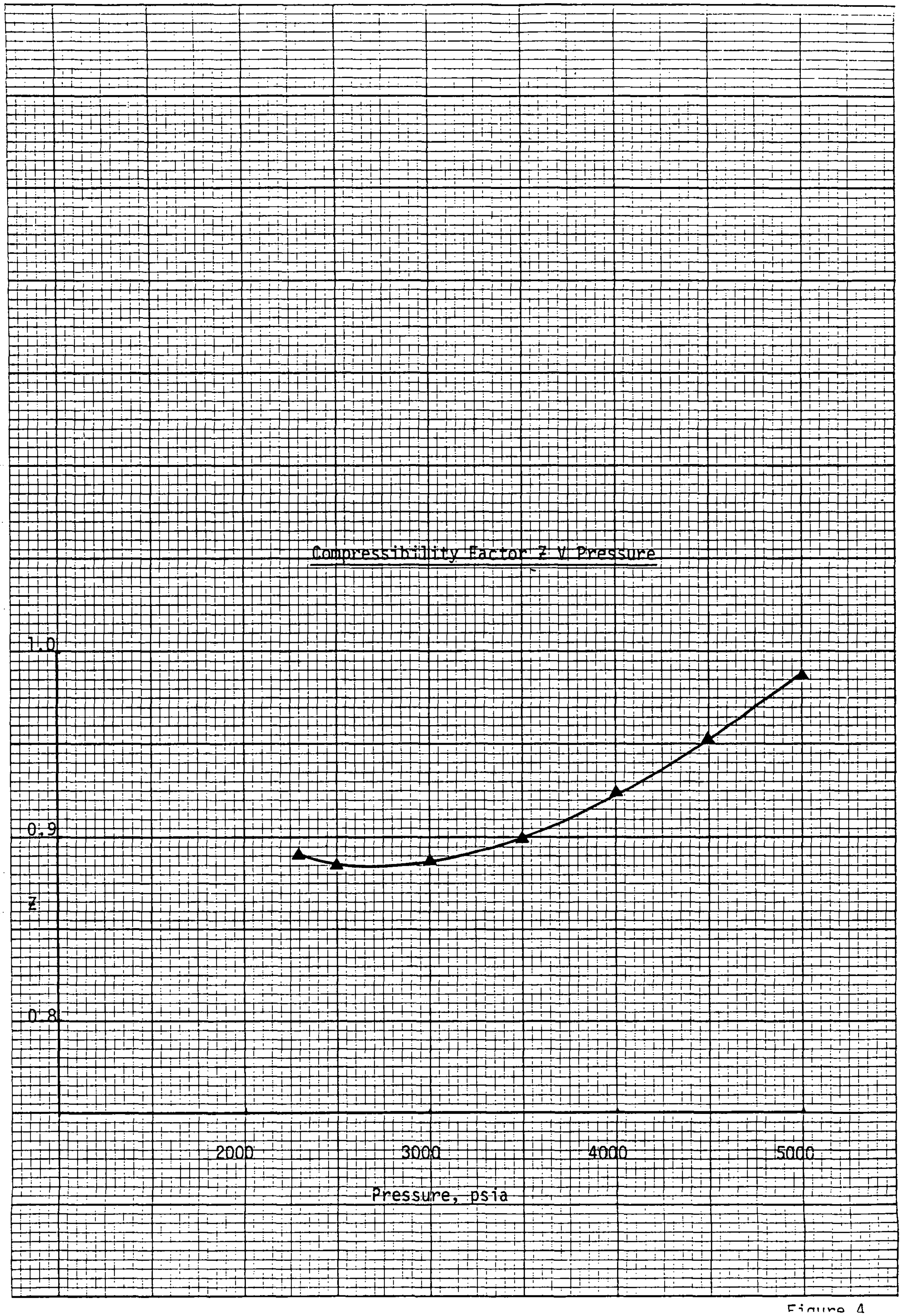
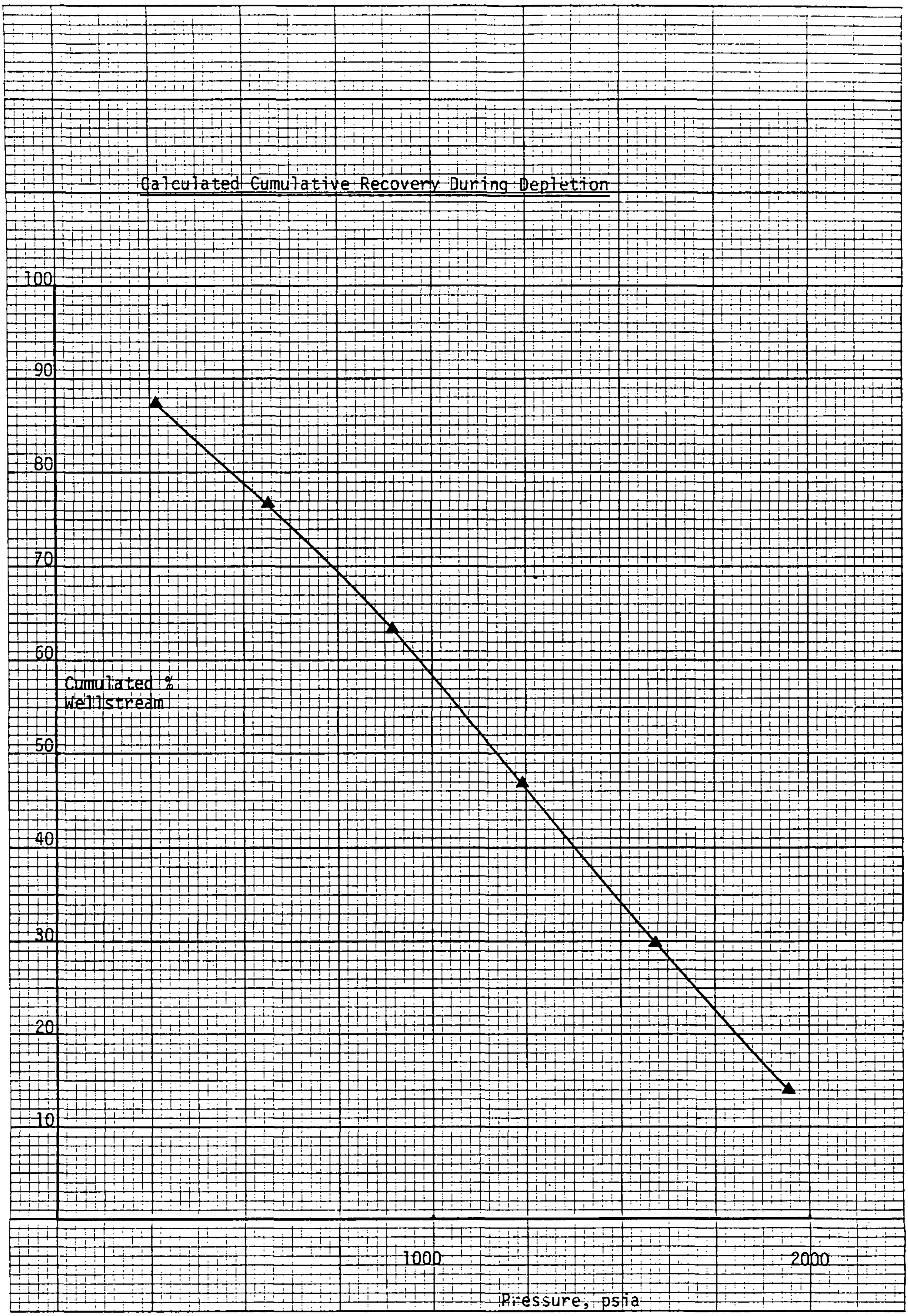
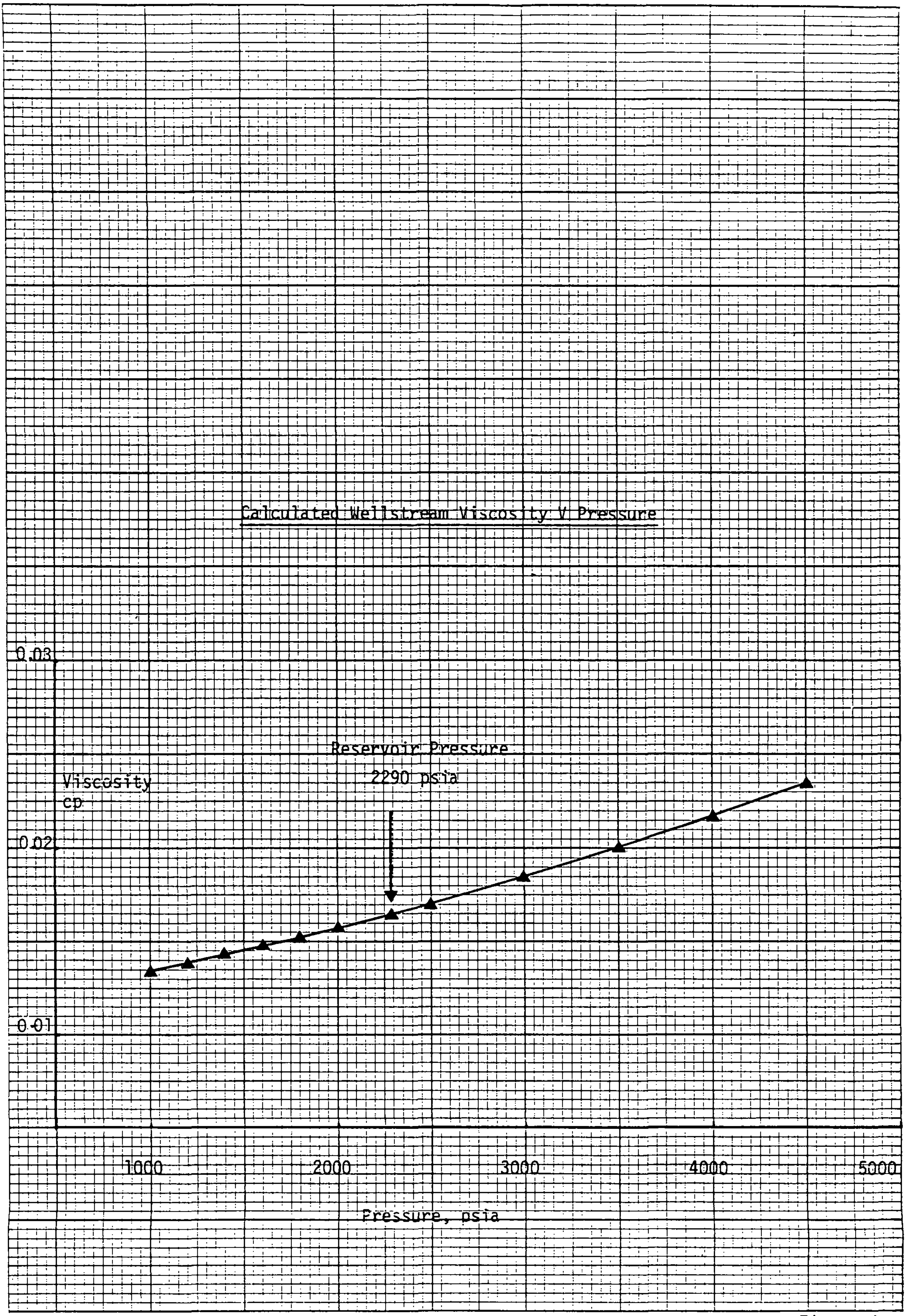

Compressibility Factor Z V Pressure
1.0
0.9
Z
0.8
2000
3000
4000
5000
Pressure, psia

Figure 4


Calculated Cumulative Recovery During Depletion
100
90
80
70
60
50
40
30
20
10
Cumulated %
Wellstream
1000
2000
Pressure, psia



Calculated Wellstream Viscosity V Pressure
0.03
Reservoir Pressure
2290 psia
Viscosity
cp
0.02
0.01
1000
2000
3000
4000
5000
Pressure, psia

Figure 6