

CORE LABORATORIES, INC.

Petroleum Reservoir Engineering

DALLAS, TEXAS 75207

November 16, 1970

RESERVOIR FLUID ANALYSIS

Phillips Petroleum Company - Norway
P. O. Box 72
Stavanger, Norway

Attention: Mr. P. W. Reynolds

Subject: Reservoir Fluid Study
2/4-4AX Well
DST No. 4 (9500 Feet)
Ekofisk Field
North Sea, Norway
Our File Number: RFL 6657

Gentlemen:

A bottom-hole sample was collected from the subject well on August 24, 1970 by a representative of Core Laboratories, Inc. The sample was collected at a depth of 9500 feet while the well was flowing from Drill Stem Test No. 4. The sample was forwarded to our Dallas laboratory for use in a reservoir fluid study and the results of this study are presented in the following report.

At the reservoir temperature of 258° F. the fluid was found to have a bubble point pressure of 5534 psig. When subjected to differential pressure depletion the fluid liberated a total of 2139 standard cubic feet of gas per barrel of residual oil at 60° F. The associated formation volume factor was determined to be 2.283 barrels of saturated fluid per barrel of residual oil. The viscosity test was performed over a wide range of pressures at 258° F. and the viscosity of the fluid varied from a minimum of 0.203 centipoise at the saturation pressure to a maximum of 1.211 centipoises at atmospheric pressure.

A multi-stage separator test was performed and the data from this test are presented on page six of the report. In addition, the primary separator

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gas was collected at 1000 psig and 150° F. and a hydrocarbon analysis was performed on the gas sample. This analysis is found on page seven. The hydrocarbon composition of the reservoir fluid sample was determined by means of low temperature, fractional distillation and is given on page eight.

Thank you for the opportunity to perform this reservoir fluid study for Phillips Petroleum Company - Norway. If we may be of further assistance in any manner, please do not hesitate to contact us.

Very truly yours,

Core Laboratories, Inc.
Reservoir Fluid Analysis

P. L. Moses (JF)

P. L. Moses
Manager

PLM:JF:dl

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Phillips Petroleum
 Company Company - Norway Date Sampled August 24, 1970
 Well 2/4-4AX, DST No. 4 Province North Sea
 Field Ekofisk Country Norway

FORMATION CHARACTERISTICS

Formation Name Danian
 Date First Well Completed _____, 19____
 Original Reservoir Pressure _____ PSIG @ _____ Ft.
 Original Produced Gas-Oil Ratio _____ SCF/Bbl
 Production Rate _____ Bbl/Day
 Separator Pressure and Temperature _____ PSIG. _____ °F.
 Oil Gravity at 60° F. 37.5 °API
 Datum _____ Ft. Subsea
 Original Gas Cap _____

WELL CHARACTERISTICS

Elevation 300* Ft.
 Total Depth 10110 PBTB Ft.
 Producing Interval 9980-10110 Ft.
 Tubing Size and Depth 3-1/2 In. to 10068 Ft.
 Productivity Index _____ Bbl/D/PSI @ _____ Bbl/Day
 Last Reservoir Pressure _____ PSIG @ _____ Ft.
 Date _____, 19____
 Reservoir Temperature 258 °F. @ 10035 Ft.
 Status of Well Production testing
 Pressure Gauge _____
 Normal Production Rate _____ Bbl/Day
 Gas-Oil Ratio _____ SCF/Bbl
 Separator Pressure and Temperature _____ PSIG, _____ °F.
 Base Pressure _____ PSIA
 Well Making Water 0 % Cut

SAMPLING CONDITIONS

Sampled at 9500 Ft.
 Status of Well Production testing**
 Gas-Oil Ratio 1637 SCF/Bbl
 Separator Pressure and Temperature 580 PSIG, 89 °F.
 Tubing Pressure 3534 PSIG
 Casing Pressure 200 PSIG
 Core Laboratories Engineer RFB
 Type Sampler Wofford

REMARKS:

* From sea floor to RKB.

** Well flowing at 317 BOPD.

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VOLUMETRIC DATA OF Reservoir Fluid SAMPLE

1. Saturation pressure (bubble-point pressure) 5534 PSIG @ 258 °F.
2. Thermal expansion of saturated oil @ 7000 PSI = $\frac{V @ 258 \text{ } ^\circ\text{F}}{V @ 73 \text{ } ^\circ\text{F}}$ = 1.14034
3. Compressibility of saturated oil @ reservoir temperature: Vol/Vol/PSI:
From 7000 PSI to 6500 PSI = 20.00 x 10⁻⁶
From 6500 PSI to 6000 PSI = 23.15 x 10⁻⁶
From 6000 PSI to 5534 PSI = 25.99 x 10⁻⁶
4. Specific volume at saturation pressure: ft³/lb 0.02806 @ 258 °F.

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Well 2/4-4AX, DST No. 4

Reservoir Fluid SAMPLE TABULAR DATA

PRESSURE PSI GAUGE	PRESSURE-VOLUME RELATION @ 258 °F. RELATIVE VOLUME OF OIL AND GAS, V/V_{SAT} .	VISCOSITY OF OIL @ 258 °F.. CENTIPOISES	DIFFERENTIAL LIBERATION @ 258 °F.		
			GAS/OIL RATIO LIBERATED PER BARREL OF RESIDUAL OIL	GAS/OIL RATIO IN SOLUTION PER BARREL OF RESIDUAL OIL	RELATIVE OIL VOLUME, V/V_R
7000	0.9667	0.229			2.207
6700		0.223			
6500	0.9765				2.229
6400		0.218			
6100		0.213			
6000	0.9879				2.255
5900	0.9906				2.261
5800	0.9931	0.208			2.267
5700	0.9956				2.273
5600	0.9986				2.279
<u>5534</u>	1.0000	0.203	0	2139	2.283
5479	1.0029				
5441	1.0049				
5348	1.0100				
5285		0.219	254	1885	2.130
5202	1.0181				
4900		0.244	560	1579	1.957
4898	1.0384				
4518	1.0691				
4400		0.277	837	1302	1.806
4114	1.1104				
3900		0.313	1050	1089	1.695
3657	1.1730				
3400		0.351	1224	915	1.607
3207	1.2569				
2900		0.392	1373	766	1.534
2772	1.3730				
2410	1.5108				
2400		0.439	1505	634	1.469
2108	1.6689				
1900		0.492	1626	513	1.410

v = Volume at given pressure

V_{SAT} = Volume at saturation pressure and the specified temperature.

V_R = Residual oil volume at 14.7 PSI absolute and 60° F.

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Reservoir Fluid SAMPLE TABULAR DATA

PRESSURE PSI GAUGE	PRESSURE-VOLUME RELATION @ 258 °F.. RELATIVE VOLUME OF OIL AND GAS, V/V _{SAT} .	VISCOSITY OF OIL @ 258 °F.. CENTIPOISES	DIFFERENTIAL LIBERATION @ 258 °F.		
			GAS/OIL RATIO LIBERATED PER BARREL OF RESIDUAL OIL	GAS/OIL RATIO IN SOLUTION PER BARREL OF RESIDUAL OIL	RELATIVE OIL VOLUME, V/V _R
1610	2.0793				
1400		0.553	1740	399	1.355
1197	2.7138				
900		0.630	1848	291	1.303
840	3.7586				
400		0.763	1957	182	1.244
118			2040	99	1.185
0		1.211	2139	0	1.094
				@ 60° F. = 1.000	

Gravity of residual oil = 33.5° API @ 60° F.

- v = Volume at given pressure
 V_{SAT} = Volume at saturation pressure and the specified temperature.
 V_R = Residual oil volume at 14.7 PSI absolute and 60° F.

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Differential Pressure Depletion at 258° F.

<u>Pressure</u> <u>PSIG</u>	<u>Oil Density</u> <u>Gms/Cc</u>	<u>Gas</u> <u>Gravity</u>	<u>Deviation Factor</u> <u>Z</u>
5534	0.5709		
5285	0.5862	0.982	1.032
4900	0.6059	0.946	0.985
4400	0.6265	0.896	0.949
3900	0.6442	0.854	0.925
3400	0.6603	0.816	0.915
2900	0.6750	0.792	0.906
2400	0.6892	0.777	0.902
1900	0.7036	0.775	0.909
1400	0.7175	0.787	0.930
900	0.7315	0.820	0.952
400	0.7481	0.948	0.978
118	0.7636	1.444	
0	0.7831	2.244	

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SEPARATOR TESTS OF Reservoir Fluid SAMPLE

SEPARATOR PRESSURE, PSI GAUGE	SEPARATOR TEMPERATURE, ° F.	GAS/OIL RATIO (1)	GAS/OIL RATIO (2)	STOCK TANK GRAVITY, ° API @ 60° F.	Formation Volume Factor (3)	Separator Volume Factor (4)	SPECIFIC GRAVITY OF FLASHED GAS
1000	150	1141	1333			1.168	0.695
to							
250	80	134	143			1.069	0.720
to							
0	60	123	123	38.9	1.895	1.000	1.102

- (1) Gas/Oil Ratio in cubic feet of gas @ 60° F. and 14.7 PSI absolute per barrel of oil @ indicated pressure and temperature.
- (2) Gas/Oil Ratio in cubic feet of gas @ 60° F. and 14.7 PSI absolute per barrel of stock tank oil @ 60° F.
- (3) Formation Volume Factor is barrels of saturated oil @ 5534 PSI gauge and 258° F. per barrel of stock tank oil @ 60° F.
- (4) Separator Volume Factor is barrels of oil @ indicated pressure and temperature per barrel of stock tank oil @ 60° F.

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HYDROCARBON ANALYSIS OF Separator GAS SAMPLE

COMPONENT	MOL PER CENT	G P M
Hydrogen Sulfide		
Carbon Dioxide	2.44	
Nitrogen	0.31	
Methane	83.27	
Ethane	8.36	2.106
Propane	3.21	0.881
iso-Butane	0.37	0.121
n-Butane	0.98	0.308
iso-Pentane	0.24	0.088
n-Pentane	0.29	0.105
Hexanes	0.22	0.090
Heptanes plus	0.31	0.140
	100.00	3.839

Calculated gas gravity (air = 1.000) = 0.695

Calculated gross heating value = 1163 BTU
 per cubic foot of dry gas at 14.696 psia at 60° F.

Collected at 1000 psig and 150 ° F.

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HYDROCARBON ANALYSIS OF Reservoir Fluid SAMPLE

COMPONENT	MOL PER CENT	WEIGHT PER CENT	DENSITY @ 60° F. GRAMS PER CUBIC CENTIMETER	° API @ 60° F.	MOLECULAR WEIGHT
Hydrogen Sulfide					
Carbon Dioxide	1.83	1.25			
Nitrogen	0.19	0.08			
Methane	58.33	14.48			
Ethane	7.35	3.42			
Propane	4.46	3.05			
iso-Butane	0.86	0.77			
n-Butane	2.01	1.81			
iso-Pentane	0.57	0.63			
n-Pentane	1.27	1.42			
Hexanes	2.09	2.77			
Heptanes plus	21.04	70.32	0.8506	34.7	216
	100.00	100.00			

Core Laboratories, Inc.
 Reservoir Fluid Analysis

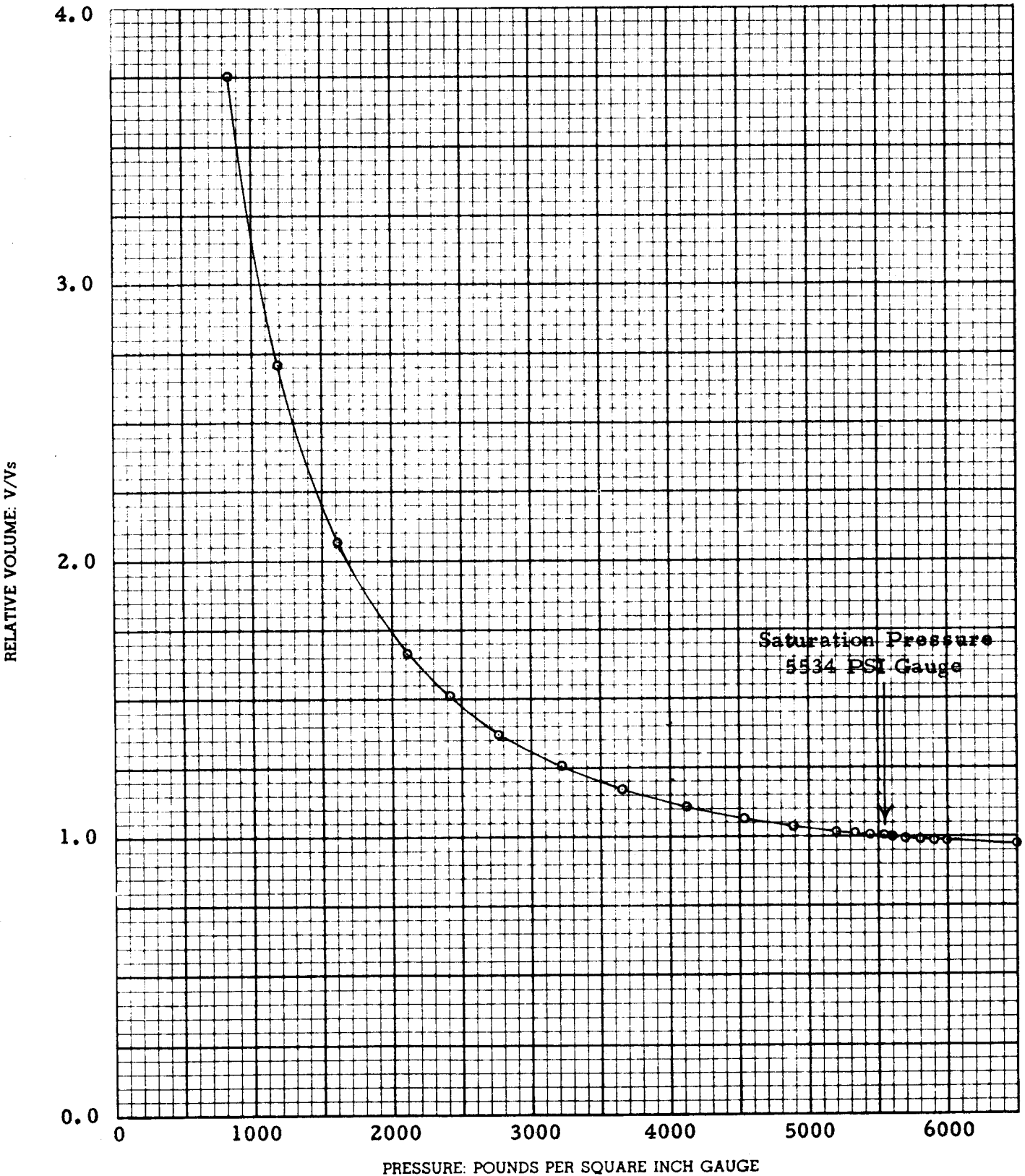
P. L. Moses (JF)

P. L. Moses
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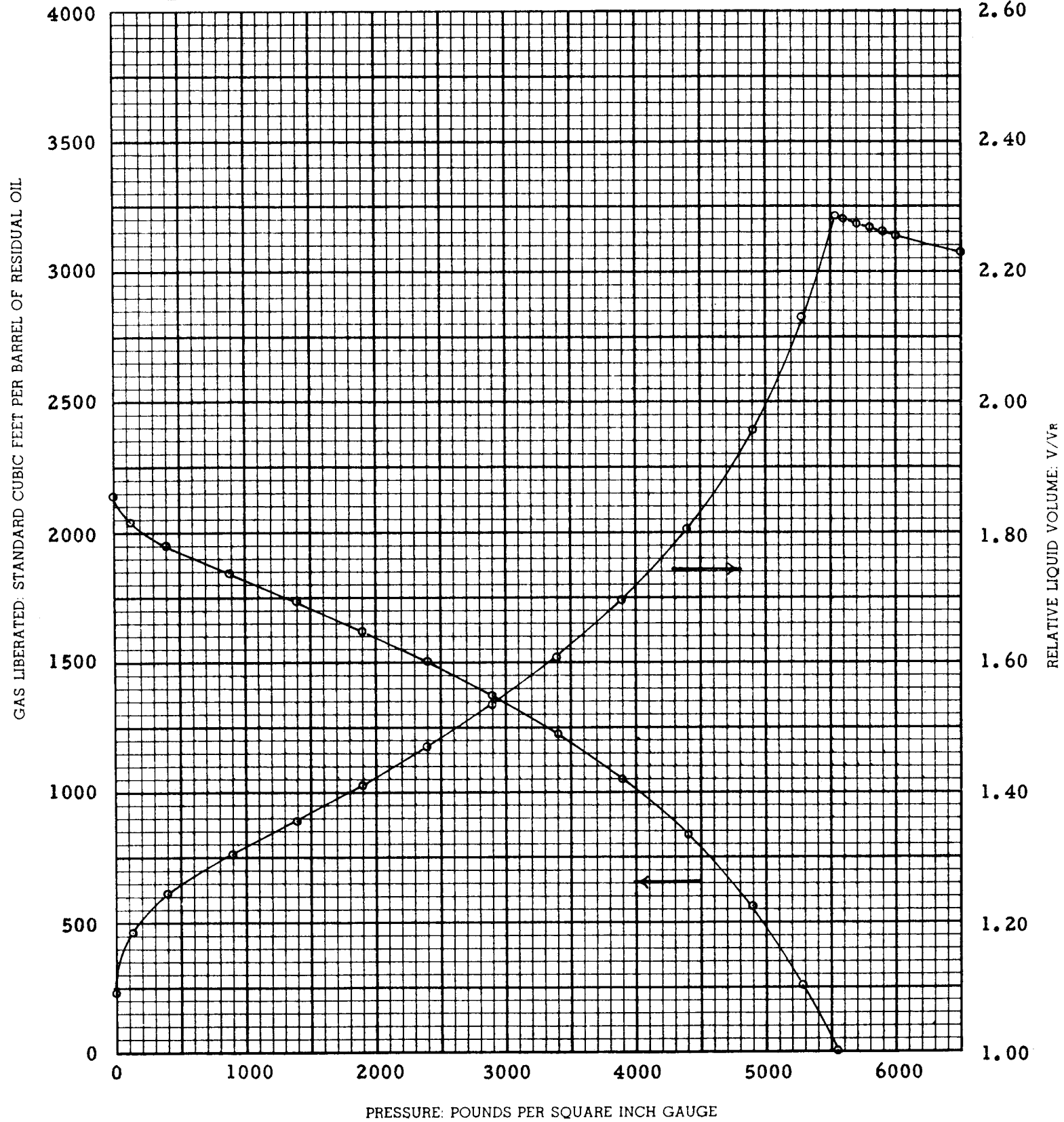
PRESSURE-VOLUME RELATIONS OF RESERVOIR FLUID

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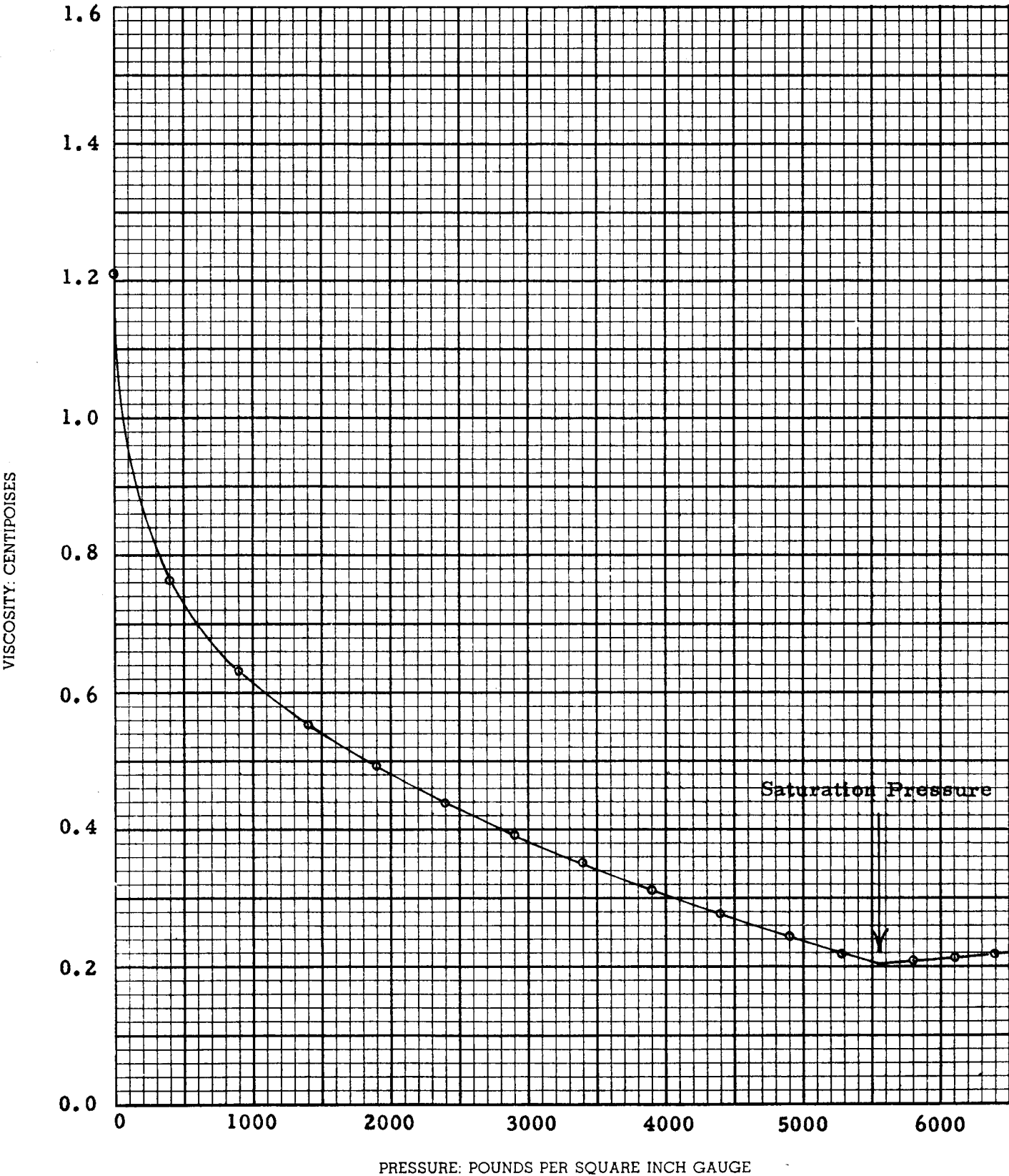
DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID

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VISCOSITY OF RESERVOIR FLUID

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Well	2/4-4AX, DST No. 4	Province	North Sea
Field	Ekofisk	Country	Norway



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