

**CORE LABORATORIES, INC.**

*Petroleum Reservoir Engineering*

**DALLAS, TEXAS 75207**

October 11, 1971

**RESERVOIR FLUID ANALYSIS**

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

Attention: Mr. P. W. Reynolds

Subject: Reservoir Fluid Study  
2/4-2X Well  
Ekofisk Field  
Norwegian North Sea  
Our File Number: RFL 7233

Gentlemen:

Samples of primary and secondary separator liquid and vapor were collected from the subject well on August 3, 1971. The samples were forwarded to our Dallas laboratory to be used in a reservoir fluid study. Presented on the following pages are the results of this study as requested by Phillips Petroleum Company-Norway.

After correction for gas gravity and super compressibility factor, the producing gas-liquid ratio was calculated to be 1288 cubic feet of primary separator gas at 14.696 psia and 60° F. per barrel of primary separator liquid at 457 psig and 118° F. The separator products were physically recombined in this gas-liquid ratio and the resulting fluid was used for the entire reservoir fluid study. The hydrocarbon composition of the well stream material was calculated on the basis of the producing gas-liquid ratio and is presented on page four of the report along with the measured hydrocarbon compositions of the primary separator products. The separator liquid and vapor samples collected from the second stage separator were also analyzed for hydrocarbons. The results of these analyses are given on pages two and three.

A small quantity of the recombined fluid was charged to the high-pressure windowed cell and thermally expanded to the reservoir temperature of 270° F. At this temperature, the fluid was found to have a bubble-point pressure of 5870 psig. During differential pressure depletion, the fluid liberated a total of 2069 standard cubic feet of gas per barrel of residual oil at 60° F. The corresponding formation volume factor was 2.238 barrels of saturated fluid per barrel of residual oil. The viscosity of the fluid at 270° F. varied from a minimum of 0.226 centipoise at saturation pressure to a maximum of 1.383 centipoises at atmospheric pressure.

A multi-stage separator test was performed and the data from this test, including gas-oil ratios, stock tank oil gravity, formation volume factor, separator volume factors and specific gravities of the flashed gases, are presented on page nine. In addition, the primary separator gas from the multi-stage separator test was collected and analyzed for hydrocarbons. The results of this analysis are presented on page ten.

It has been a pleasure to perform this reservoir fluid study for Phillips Petroleum Company-Norway. If we may answer any questions for you or be of further assistance in any manner, please feel free to contact us.

Very truly yours,

Core Laboratories, Inc.  
Reservoir Fluid Analysis

*P. L. Moses HS*

P. L. Moses  
Manager

PLM:JF:dl

5 cc. - Addressee

4 cc. - Mr. B. M. Boyce  
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Company Phillips Petroleum  
Company-Norway Date Sampled August 3, 1971  
 Well 2/4-2X Province \_\_\_\_\_  
 Field Ekofisk Country Norwegian North Sea

**FORMATION CHARACTERISTICS**

Formation Name \_\_\_\_\_  
 Date First Well Completed \_\_\_\_\_, 19\_\_\_\_  
 Original Reservoir Pressure \_\_\_\_\_ PSIG @ \_\_\_\_\_ Ft.  
 Original Produced Gas-Liquid Ratio \_\_\_\_\_ SCF/Bbl  
     Production Rate \_\_\_\_\_ Bbls/Day  
 Separator Pressure and Temperature \_\_\_\_\_ PSIG \_\_\_\_\_ ° F.  
 Liquid Gravity at 60° F. \_\_\_\_\_ ° API  
 Datum \_\_\_\_\_ Ft. Subsea

**WELL CHARACTERISTICS**

Elevation \_\_\_\_\_ Ft.  
 Total Depth \_\_\_\_\_ Ft.  
 Producing Interval \_\_\_\_\_ Ft.  
 Tubing Size and Depth \_\_\_\_\_ In. to \_\_\_\_\_ Ft.  
 Open Flow Potential \_\_\_\_\_ MMSCF/Day  
 Last Reservoir Pressure \_\_\_\_\_ PSIG @ \_\_\_\_\_ Ft.  
     Date \_\_\_\_\_, 19\_\_\_\_  
     Reservoir Temperature 270\* ° F. @ \_\_\_\_\_ Ft.  
 Status of Well \_\_\_\_\_  
 Pressure Gauge \_\_\_\_\_

**SAMPLING CONDITIONS**

Flowing Tubing Pressure 984 PSIG  
 Flowing Bottom Hole Pressure \_\_\_\_\_ PSIG  
 Primary Separator Pressure 457 PSIG  
 Primary Separator Temperature 118 ° F.  
 Secondary Separator Pressure 1.5 PSIG  
 Secondary Separator Temperature 100 ° F.  
 Field Stock Tank Liquid Gravity 35.8 ° API @ 60° F.  
 Primary Separator Gas Production Rate 14.56 MMSCF/Day  
     Pressure Base 14.696 PSIA  
     Temperature Base 60 ° F.  
     Compressibility Factor ( $F_{pv}$ ) 1.0375  
     Gas Gravity (Laboratory) 0.689  
     Gas Gravity Factor ( $F_g$ ) 1.2048  
 Separator Liquid Production Rate @ 118° F. 11304 Bbls/Day  
 Primary Separator Gas/Separator Liquid @ 118° F. Ratio 1288 SCF/Bbl  
     or \_\_\_\_\_ Bbls/MMSCF

Core Laboratories, Inc., Engineer

**REMARKS:**

\* Analysis temperature.

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Phillips Petroleum  
 Company Company-Norway Formation \_\_\_\_\_  
 Well 2/4-2X Province \_\_\_\_\_  
 Field Ekofisk Country Norwegian North Sea

**HYDROCARBON ANALYSIS OF Secondary Separator GAS SAMPLE**

COMPONENT	MOL PER CENT	G P M
Hydrogen Sulfide	Nil	
Carbon Dioxide	0.03	
Nitrogen	0.03	
Methane	41.08	
Ethane	18.67	4.703
Propane	17.42	4.782
iso-Butane	3.45	1.125
n-Butane	9.05	2.845
iso-Pentane	2.64	0.964
n-Pentane	3.36	1.214
Hexanes	2.18	0.887
Heptanes plus	2.09	0.946
	<u>100.00</u>	<u>17.466</u>

Calculated gas gravity ( air = 1.000) = 1.226

Calculated gross heating value = 2052 BTU  
 per cubic foot of dry gas at 14.696 psia at 60° F.

Collected at 1.5 psig and 100 ° F.

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Company Phillips Petroleum Company-Norway Formation \_\_\_\_\_  
 Well 2/4-2X Province \_\_\_\_\_  
 Field Ekofisk Country Norwegian North Sea

Secondary  
**HYDROCARBON ANALYSIS OF Separator Liquid SAMPLE**

COMPONENT	MOL PER CENT	WEIGHT PER CENT	DENSITY @ 60° F. GRAMS PER CUBIC CENTIMETER	° API @ 60° F.	MOLECULAR WEIGHT
Hydrogen Sulfide	Nil	Nil			
Carbon Dioxide	Trace	Trace			
Nitrogen	0.03	Trace			
Methane	0.20	0.01			
Ethane	0.52	0.08			
Propane	1.59	0.33			
iso-Butane	0.68	0.19			
n-Butane	2.66	0.74			
iso-Pentane	1.63	0.56			
n-Pentane	2.66	0.92			
Hexanes	3.78	1.55			
Heptanes plus	<u>86.25</u>	<u>95.62</u>	0.8621	32.5	232
	100.00	100.00			

Collected at 1.5 psig and 100° F.

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Well 2/4-2X

**Hydrocarbon Analyses of Separator Products and Calculated Well Stream**

<u>Component</u>	<u>Separator Liquid Mol Per Cent</u>	<u>Separator Gas Mol Per Cent</u>	<u>GPM</u>	<u>Well Stream Mol Per Cent</u>
Hydrogen Sulfide	Nil	Nil		Nil
Carbon Dioxide	0.23	1.72		1.23
Nitrogen	0.09	0.24		0.19
Methane	10.19	83.03		59.06
Ethane	4.96	9.23	2.325	7.83
Propane	5.26	3.58	0.983	4.13
iso-Butane	1.23	0.44	0.144	0.70
n-Butane	4.09	0.99	0.311	2.01
iso-Pentane	1.85	0.21	0.077	0.75
n-Pentane	2.70	0.25	0.090	1.06
Hexanes	5.55	0.15	0.061	1.93
Heptanes plus	63.85	0.16	0.072	21.11
	<u>100.00</u>	<u>100.00</u>	<u>4.063</u>	<u>100.00</u>

**Properties of Heptanes plus**

API gravity @ 60° F.	<u>32.0</u>		
Specific gravity @ 60/60° F.	<u>0.8656</u>		<u>0.865</u>
Molecular weight	<u>237</u>	<u>103</u>	<u>236</u>

Calculated separator gas gravity (air = 1.000) = 0.689

Calculated gross heating value for separator gas = 1173 BTU

per cubic foot of dry gas @ 14.696 psia and 60° F.

Primary separator gas collected @ 457 psig and 118 °F.

Primary separator liquid collected @ 457 psig and 118 °F.

Primary separator gas/separator liquid ratio 1288 SCF/Bbl @ 118° F.

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Well 2/4-2X

VOLUMETRIC DATA OF Reservoir Fluid SAMPLE

1. Saturation pressure (bubble-point pressure) 5870 PSIG @ 270 °F.
2. Thermal expansion of saturated oil @ 7500 PSI =  $\frac{V @ 270 \text{ } ^\circ\text{F}}{V @ 73 \text{ } ^\circ\text{F}}$  = 1.14342
3. Compressibility of saturated oil @ reservoir temperature: Vol/Vol/PSI:  
From 7500 PSI to 7000 PSI =  $18.17 \times 10^{-6}$   
From 7000 PSI to 6400 PSI =  $20.85 \times 10^{-6}$   
From 6400 PSI to 5870 PSI =  $24.49 \times 10^{-6}$
4. Specific volume at saturation pressure: ft<sup>3</sup>/lb 0.02758 @ 270 °F.

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Well 2/4-2X

Reservoir Fluid **SAMPLE TABULAR DATA**

PRESSURE PSI GAUGE	PRESSURE-VOLUME RELATION @ 270 °F.. RELATIVE VOLUME OF OIL AND GAS, V/V <sub>SAT.</sub>	VISCOSITY OF OIL @ 270 °F.. CENTIPOISES	DIFFERENTIAL LIBERATION @ 270 °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 <sub>R</sub>
7500	0.9658	0.247			2.161
7100		0.242			
7000	0.9747				2.181
6700	0.9806	0.237			2.194
6400	0.9870				2.209
6300	0.9893	0.232			2.214
6200	0.9918				2.219
6100	0.9940				2.224
6000	0.9965	0.228			2.230
5900	0.9991				2.236
5870	1.0000	0.226	0	2069	2.238
5817	1.0024				
5800		0.229	71	1998	2.195
5777	1.0042				
5677	1.0087				
5600		0.244	270	1799	2.079
5510	1.0173				
5300		0.267	489	1580	1.956
5198	1.0355				
4900		0.300	714	1355	1.835
4818	1.0624				
4500		0.331	890	1179	1.741
4400	1.1000				
4000		0.372	1067	1002	1.650
3923	1.1558				
3500		0.416	1219	850	1.575
3462	1.2308				
3000		0.466	1350	719	1.509
2998	1.3345				
2587	1.4670				
2500		0.517	1470	599	1.451

V = Volume at given pressure

V<sub>SAT.</sub> = Volume at saturation pressure and the specified temperature.

V<sub>R</sub> = Residual oil volume at 14.7 PSI absolute and 60° F.

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Well 2/4-2X

Reservoir Fluid **SAMPLE TABULAR DATA**

PRESSURE PSI GAUGE	PRESSURE-VOLUME RELATION @ 270 °F., RELATIVE VOLUME OF OIL AND GAS, V/V <sub>SAT.</sub>	VISCOSITY OF OIL @ 270 °F., CENTIPOISES	DIFFERENTIAL LIBERATION @ 270 °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 <sub>R</sub>
2237	1.6281				
2000		0.575	1579	490	1.399
1722	1.9993				
1500		0.643	1683	386	1.349
1292	2.5711				
1000		0.730	1781	288	1.301
925	3.5121				
500		0.873	1881	188	1.249
155			1968	101	1.190
0		1.383	2069	0	1.098

@ 60° F. = 1.000

Gravity of residual oil = 31.4° API @ 60° F.

V = Volume at given pressure

V<sub>SAT.</sub> = Volume at saturation pressure and the specified temperature.

V<sub>R</sub> = Residual oil volume at 14.7 PSI absolute and 60° F.

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Well 2/4-2X

Differential Pressure Depletion at 270° 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>
5870	0.5808		
5800	0.5849	0.989	1.077
5600	0.5962	0.970	1.061
5300	0.6096	0.943	1.036
4900	0.6249	0.908	1.006
4500	0.6396	0.874	0.980
4000	0.6551	0.838	0.951
3500	0.6697	0.807	0.932
3000	0.6839	0.782	0.923
2500	0.6975	0.768	0.921
2000	0.7106	0.764	0.923
1500	0.7237	0.773	0.930
1000	0.7373	0.801	0.948
500	0.7522	0.895	0.971
155	0.7698	1.221	0.990
0	0.7899	2.229	

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Well 2/4-2X

**SEPARATOR TESTS OF Reservoir Fluid SAMPLE**

SEPARATOR PRESSURE, PSI GAUGE	SEPERATOR 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	1120	1318			1.177	0.686
to							
250	80	135	145			1.075	0.720
to							
0	60	116	116	36.5	1.905	1.000	1.106

- (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 @ 5870 PSI gauge and 270° 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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Company Phillips Petroleum Company-Norway Formation \_\_\_\_\_  
 Well 2/4-2X Province \_\_\_\_\_  
 Field Ekofisk Country Norwegian North Sea

**HYDROCARBON ANALYSIS OF Primary Separator GAS SAMPLE**

COMPONENT	MOL PER CENT	G P M
Hydrogen Sulfide	Nil	
Carbon Dioxide	1.63	
Nitrogen	0.34	
Methane	84.72	
Ethane	7.94	2.000
Propane	3.10	0.851
iso-Butane	0.39	0.127
n-Butane	0.92	0.289
iso-Pentane	0.23	0.084
n-Pentane	0.29	0.105
Hexanes	0.20	0.081
Heptanes plus	0.24	0.109
	100.00	3.646

Calculated gas gravity ( air = 1.000) = 0.680

Calculated gross heating value = 1161 BTU  
 per cubic foot of dry gas at 14.696 psia at 60° F.

Collected at 1000 psig and 150 ° F. in the laboratory.

Composition does not include 0.57 pound of  
 condensate per MSCF of gas.

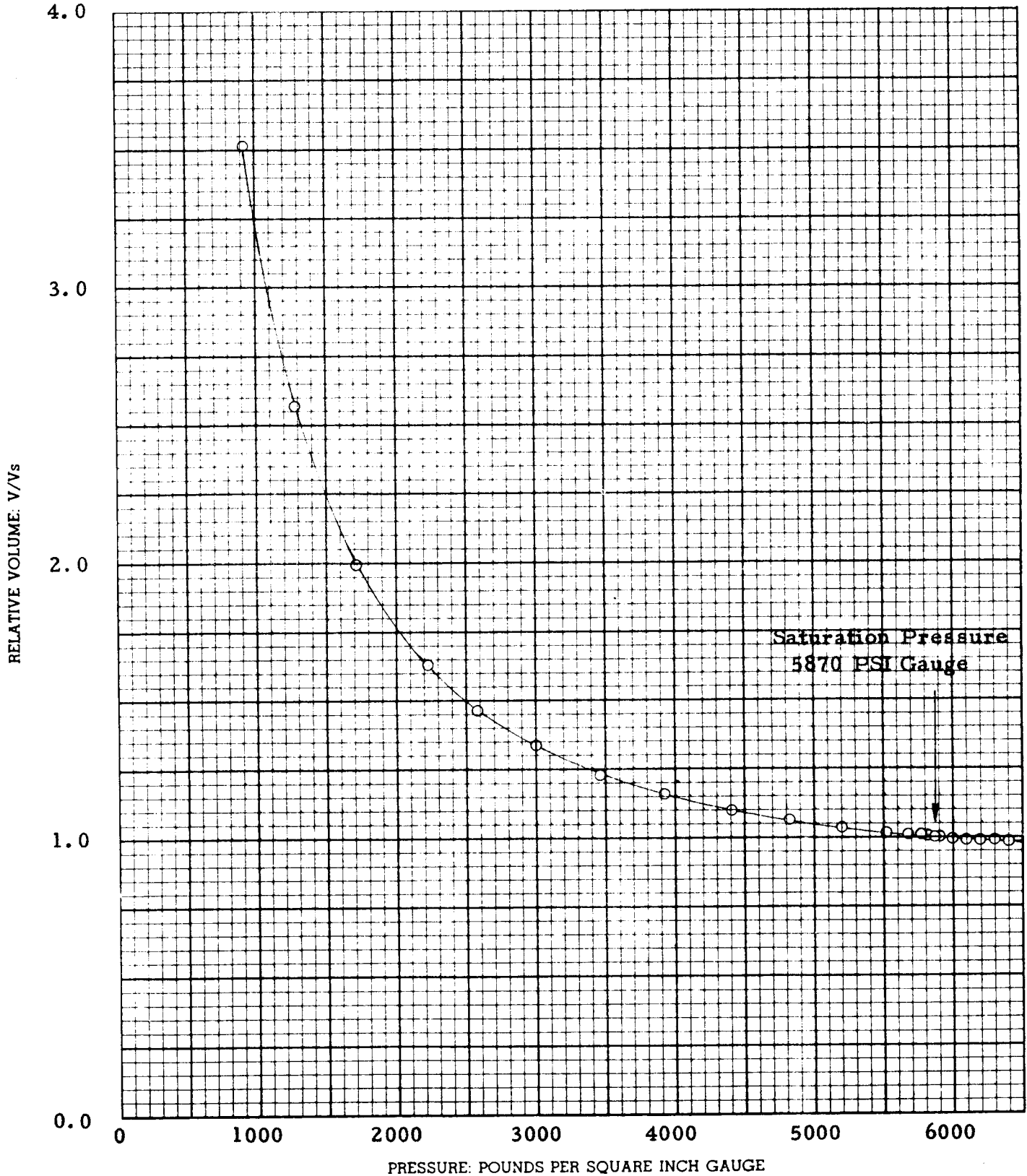
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*P. L. Moses*

P. L. Moses  
 Manager

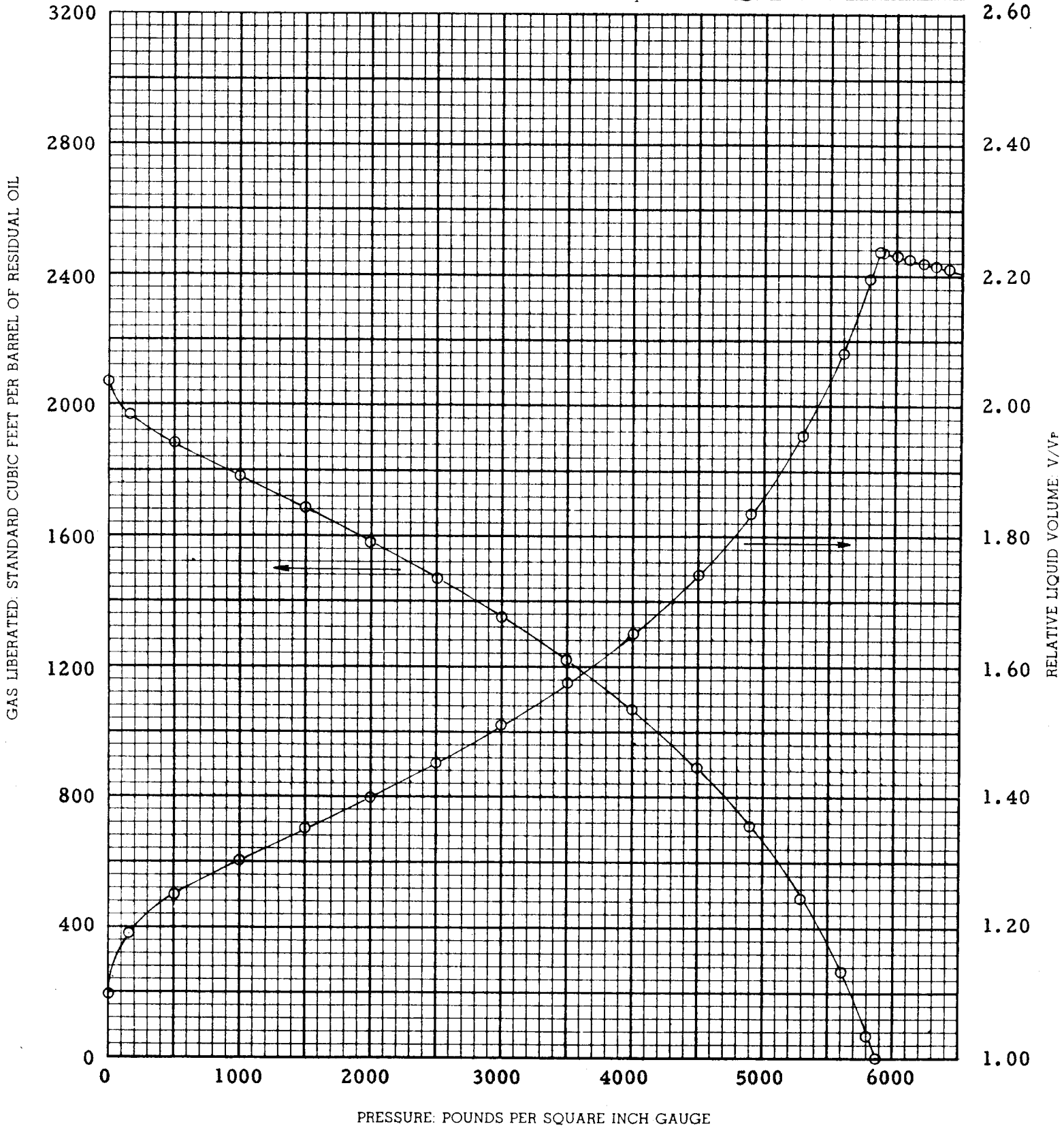
PRESSURE-VOLUME RELATIONS OF RESERVOIR FLUID

Company Phillips Petroleum  
Company-Norway Formation \_\_\_\_\_  
Well 2/4-2X Province \_\_\_\_\_  
Field Ekofisk Country Norwegian North Sea



DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID

Phillips Petroleum  
 Company Company-Norway Formation \_\_\_\_\_  
 Well 2/4-2X Province \_\_\_\_\_  
 Field Ekofisk Country Norwegian North Sea



VISCOSITY OF RESERVOIR FLUID

Company: Phillips Petroleum Company-Norway Formation: \_\_\_\_\_  
Well: 2/4-2X Province: \_\_\_\_\_  
Field: Ekofisk Country: Norwegian North Sea

