

Denne rapport
tilhører



L&U DOK. SENTER

L. NR. 20088390031

KODE Well 31/2-3 nr 47

Returneres etter bruk

RESERVOIR FLUID STUDY

for

A/S Norske Shell Exploration & Production

Well: 31/2-3

North Sea, Norway

CORE LABORATORIES UK LTD.

Petroleum Reservoir Engineering

ABERDEEN, SCOTLAND

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CORE LABORATORIES UK LTD.

Petroleum Reservoir Engineering

ABERDEEN, SCOTLAND

6th July 1981

A/S Norske Shell Exploration & Production
Damsle Ferusuei 43
P.O. Box 10
40-33 Forus
NORWAY

Subject: Reservoir Fluid Study
Well: 31/2-3
North Sea, UK.
Our File Number:
RFLA 80192

Attention: Mr. D. C. Jolly.

Gentlemen,

A subsurface fluid sample was collected from the subject well and forwarded to our Aberdeen laboratory for use in a reservoir fluid study. The results of this study as requested by a representative of A/S Norske Shell Exploration & Production are presented in the following report.

Upon arrival in the laboratory the room temperature bubble point pressure of the sample in cylinder 2674-31 was determined to be 1762 psig at 67°F. The sample container was subsequently found to contain approximately 310 ccs of water and approximately 240 ccs of hydrocarbon fluid.

A small portion of the hydrocarbon fluid was charged to a high pressure visual cell and thermally expanded to the reported reservoir temperature of 160°F. During a constant composition expansion at this temperature a bubble-point pressure of 2018 psig was observed. The pressure-volume relationships and compressibility data thus derived may be found on page two. The bubble-point was reported by telex on 24th April 1981.

We were subsequently requested to raise this bubble-point to 2290 psig at 160°F. by the addition of gas from a gas sample from the subject well. All the available subsurface fluid sample was treated by the addition of gas from cylinder number 80523 (see our file number 80167). The resultant reservoir fluid was used in the remainder of the study.

The hydrocarbon composition of the reservoir fluid through hexanes was determined by low temperature fractional distillation. This composition in terms of both mole and weight percent is presented on page three.

A portion of the reservoir fluid was placed in a high pressure visual cell and thermally expanded to the operating temperature of 160°F. During a constant composition expansion at this temperature, a bubble-point pressure of 2290 psig was observed. The results of the pressure-volume relations may be found on page five and the associated compressibility data on page four.

Continued Over/.....

A large portion of reservoir fluid was subjected to differential vaporization at the operating temperature of 160 °F resulting in the liberation of a total of 312 standard cubic feet of gas per barrel of residual oil with an associated relative oil volume of 1.166 barrels of saturated oil per barrel of residual oil. At several pressure levels below the observed saturation pressure, oil density, gas deviation factor and hydrocarbon composition were monitored. These data are tabulated on page eight and graphically represented on pages nine and ten.

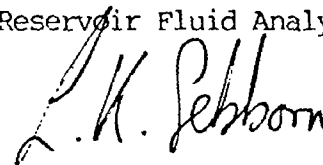
Whilst maintaining the operating temperature of 160°F, the viscosity of the liquid phase was measured in a rolling ball viscosimeter through a wide range of pressures, from well above saturation pressure to atmospheric pressure. The viscosity was found to vary from a minimum of 2.10 centipoise at saturation pressure to a maximum viscosity of 5.83 centipoise at atmospheric pressure. These data are tabulated on page eleven and graphically represented on page twelve.

These tests utilized all the available reservoir fluid and consequently we were unable to conduct the requested flash separation tests.

It has been a pleasure to be of service to A/S Norske Shell Exploration & Production. Should any questions arise concerning data presented in this report, or if we can be of further assistance, please do not hesitate to contact us.

Yours very truly

Core Laboratories UK Limited
Reservoir Fluid Analysis



Les K. Sebborn
Laboratory Manager

LKS/DT/STB
10cc/Addressee

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Company A/S Norske Shell Date Sampled 7th June 1980

Well 31/2-3 State North Sea

Field _____ Country Norway

FORMATION CHARACTERISTICS

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

WELL CHARACTERISTICS

Elevation	RKB	_____
Total Depth		_____ Ft.
Producing Interval		<u>1577.5-1582.5</u> M.
Tubing Size and Depth		_____ In. to _____ Ft.
Productivity Index		_____ Bbl/D/PSI @ _____ Bbl/Day
Last Reservoir Pressure		<u>2084</u> PSIG @ <u>5105</u> Ft.
Date		<u>7th June</u> , 19 <u>80</u>
Reservoir Temperature		_____ °F. @ _____ Ft.
Status of Well		_____
Pressure Gauge		_____
Normal Production Rate		_____ Bbl/Day
Gas-Oil Ratio		_____ SCF/Bbl
Separator Pressure and Temperature		_____ PSIG, _____ °F.
Base Pressure		_____ PSIA
Well Making Water		_____ % Cut

SAMPLING CONDITIONS

Sampled at		<u>5105</u> Ft.
Status of Well		<u>Flowing</u>
Gas-Oil Ratio		_____ SCF/Bbl
Separator Pressure and Temperature		_____ PSIG, _____ °F.
Tubing Pressure		<u>49</u> PSIG
Casing Pressure		_____ PSIG
Sampled by		<u>FLOPETROL</u>
Type Sampler		<u>FLOPETROL</u>

REMARKS: Cylinder Number 2674-31, sample contained 300ccs water.

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 Well 31/2-3

VOLUMETRIC DATA OF SUBSURFACE SAMPLE

1. Saturation pressure (bubble-point pressure) 2018 PSIG @ 160 °F.
2. Thermal expansion of saturated oil @ 5000 PSIG = $\frac{V @ 160 °F.}{V @ 68 °F.} = \underline{1.03975}$
3. Compressibility of saturated oil @ reservoir temperature: Vol/Vol/PSI:

From 5000 PSI to 2200 PSI = 6.32 x 10⁻⁶
 From 2200 PSI to 2018 PSI = 6.68 x 10⁻⁶

3. Pressure-Volume Relations at 160°F.

<u>Pressure,</u> <u>PSIG</u>	<u>Relative</u> <u>Volume (1)</u>
5000	0.9811
4000	0.9868
3000	0.9932
2500	0.9967
2400	0.9974
2300	0.9981
2200	0.9988
2100	0.9995
<u>2018</u> Saturation Pressure	1.0000

(1) Relative Volume : V/Vsat is barrels at indicated pressure per barrel at saturation pressure.

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Company A/S Norske Shell Formation _____

Well 31/2-3 County North Sea

Field _____ State Norway

HYDROCARBON ANALYSIS OF RESERVOIR FLUID SAMPLE*

COMPONENT	MOL PERCENT	WEIGHT PERCENT	DENSITY	API	MOL WEIGHT
Hydrogen Sulfide	NIL	NIL			
Carbon Dioxide	0.19	0.06			
Nitrogen	0.33	0.06			
Methane	35.42	3.66			
Ethane	3.36	0.65			
Propane	0.90	0.26			
iso-Butane	0.69	0.26			
n-Butane	0.26	0.10			
iso-Pentane	0.26	0.12			
n-Pentane	0.14	0.06			
Hexanes	0.72	0.40			
Heptanes plus	57.73	94.37	0.9165	22.7	255
	<u>100.00</u>	<u>100.00</u>			

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Well 31/2-3

VOLUMETRIC DATA OF RESERVOIR FLUID SAMPLE

1. Saturation pressure (bubble-point pressure) 2290 PSIG @ 160 °F.
 $\frac{V @ 160 \text{ °F.}}{V @ 68 \text{ °F.}} = 1.04324$
2. Thermal expansion of saturated oil @ 5000 PSIG = $\frac{V @ 160 \text{ °F.}}{V @ 68 \text{ °F.}} = 1.04324$
3. Compressibility of saturated oil @ reservoir temperature: Vol/Vol/PSI:
From 5000 PSIG to 4000 PSIG = 5.94×10^{-6}
From 4000 PSIG to 3000 PSIG = 6.32×10^{-6}
From 3000 PSIG to 2290 PSIG = 7.13×10^{-6}
4. Specific volume at saturation pressure: ft³/lb 0.01950 @ 160 °F.

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Well 31/2-3

PRESSURE-VOLUME RELATIONS AT 160°F.

<u>Pressure</u> PSIG	<u>Relative</u> <u>Volume(1)</u>	<u>Y</u> <u>Function(2)</u>
5000	0.9828	
4000	0.9887	
3000	0.9949	
2700	0.9970	
2600	0.9977	
2500	0.9984	
2400	0.9992	
2300	0.9999	
<u>2290</u> Saturation Pressure	1.0000	
2131	1.0164	4.518
2024	1.0295	4.424
1847	1.0558	4.264
1644	1.0956	4.072
1442	1.1491	3.900
1232	1.2292	3.699
1079	1.3103	3.567
933	1.4183	3.422
789	1.5670	3.292
679	1.7296	3.182
572	1.9464	3.089
480	2.2174	2.997
364	2.7674	2.872
270	3.5818	2.745
189	4.9456	2.610

(1) Relative Volume: V/V_{sat} is barrels at indicated pressure per barrel at saturation pressure.

(2)
$$Y \text{ Function} = \frac{(P_{sat} - P)}{(P_{abs}) (V/V_{sat} - 1)}$$

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DIFFERENTIAL VAPORIZATION AT 160°F.

Pressure PSIG	Solution Gas/Oil Ratio(1)	Relative Oil Volume(2)	Relative Total Volume(3)	Oil Density gm/cc	Deviation Factor Z	Gas Formation Volume Factor(4)	Incremental Gas Gravity
2290	312	1.166	1.166	0.8215			
2100	289	1.158	1.189	0.8241	0.894	0.00741	0.614
1800	251	1.143	1.239	0.8303	0.911	0.00879	0.610
1500	212	1.130	1.320	0.8354	0.925	0.01070	0.611
1200	175	1.117	1.447	0.8409	0.940	0.01356	0.613
900	134	1.102	1.680	0.8471	0.952	0.01823	0.617
600	94	1.088	2.154	0.8529	0.964	0.02747	0.629
300	52	1.073	3.595	0.8588	0.979	0.05446	0.665
103	19	1.058	8.745	0.8651	0.992	0.14730	0.823
0	0	1.042		0.8737			1.273

At 60°F = 1.000

Gravity of Residual Oil = 23.8 API at 60°F.

- (1) Cubic feet of gas at 14.696 psia and 60°F. per barrel of residual oil at 60°F.
- (2) Barrels of oil at indicated pressure and temperature per barrel of residual oil at 60°F.
- (3) Barrels of oil plus liberated gas at indicated pressure and temperature per barrel of residual oil at 60°F.
- (4) Cubic feet of gas at indicated pressure and temperature per cubic foot at 14.696 psia and 60°F.

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DIFFERENTIAL VAPORIZATION AT 160°F.

HYDROCARBON COMPOSITION OF PRODUCED GASES - MOLE PERCENT

Component	2100	1800	1500	1200	900	600	300	103	0 *
Hydrogen Sulphide	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Carbon Dioxide	0.36	0.28	0.27	0.32	0.36	0.43	0.55	0.84	1.05
Nitrogen	1.52	1.26	1.04	0.85	0.80	0.72	0.53	0.25	0.07
Methane	92.59	92.95	92.92	92.66	92.01	90.48	86.41	71.27	32.66
Ethane	3.65	3.78	3.96	4.30	4.82	5.98	8.66	16.69	30.84
Propane	0.58	0.53	0.58	0.62	0.70	0.86	1.40	3.60	11.83
iso-Butane	0.43	0.42	0.44	0.46	0.50	0.62	1.06	3.24	10.44
n-Butane	0.14	0.13	0.14	0.14	0.15	0.19	0.30	0.88	3.04
iso-Pentane	0.11	0.10	0.11	0.11	0.12	0.14	0.21	0.59	2.59
n-Pentane	0.05	0.04	0.05	0.05	0.05	0.06	0.09	0.22	0.92
Hexanes	0.16	0.13	0.12	0.12	0.12	0.14	0.20	0.71	2.68
Heptanes plus	0.41	0.38	0.37	0.37	0.37	0.38	0.59	1.71	3.88
	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>

Calculated Gas

Gravity(Air = 1.000): 0.614 0.610 0.611 0.613 0.617 0.629 0.665 0.823 1.273

Calculated gross heat-
ing value. BTU per
cubic foot of dry gas
at 14.696 and 60°F.:

1070 1070 1075 1080 1087 1104 1160 1402 2098

* Gas evolved between 103 psig and 0 psig.

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DIFFERENTIAL VAPORIZATION AT 160°F.

GPM VALUES FOR PRODUCED GASES

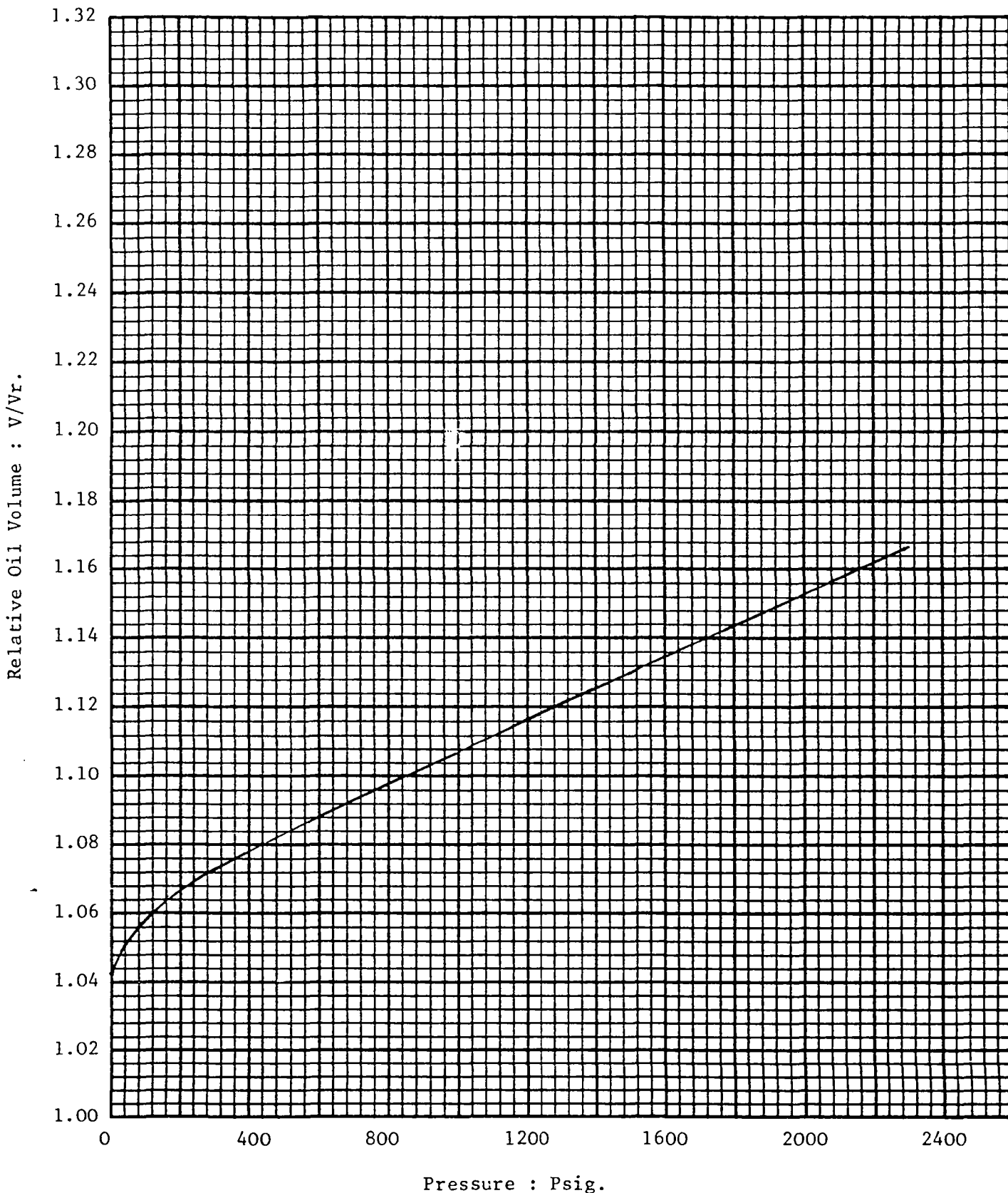
Pressure PSIG:	2100	1800	1500	1200	900	600	300	103	0 *
<u>Component</u>									
Propane	0.159	0.146	0.159	0.170	0.192	0.236	0.384	0.988	3.274
iso-Butane	0.140	0.137	0.144	0.150	0.163	0.202	0.346	1.057	3.406
n-Butane	0.044	0.041	0.044	0.044	0.047	0.060	0.094	0.277	0.956
iso-Pentane	0.040	0.037	0.040	0.040	0.044	0.051	0.077	0.215	0.946
n-Pentane	0.018	0.015	0.018	0.018	0.018	0.022	0.033	0.080	0.333
Hexanes	0.065	0.053	0.049	0.049	0.049	0.057	0.081	0.289	1.091
Heptanes plus	0.186	0.172	0.168	0.168	0.168	0.172	0.267	0.774	1.757
	<u>0.652</u>	<u>0.601</u>	<u>0.622</u>	<u>0.639</u>	<u>0.681</u>	<u>0.800</u>	<u>1.282</u>	<u>3.680</u>	<u>11.763</u>

* Gas evolved between 103 psig and 0 psig.

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Differential Vaporization of Reservoir Fluid at 160°F.

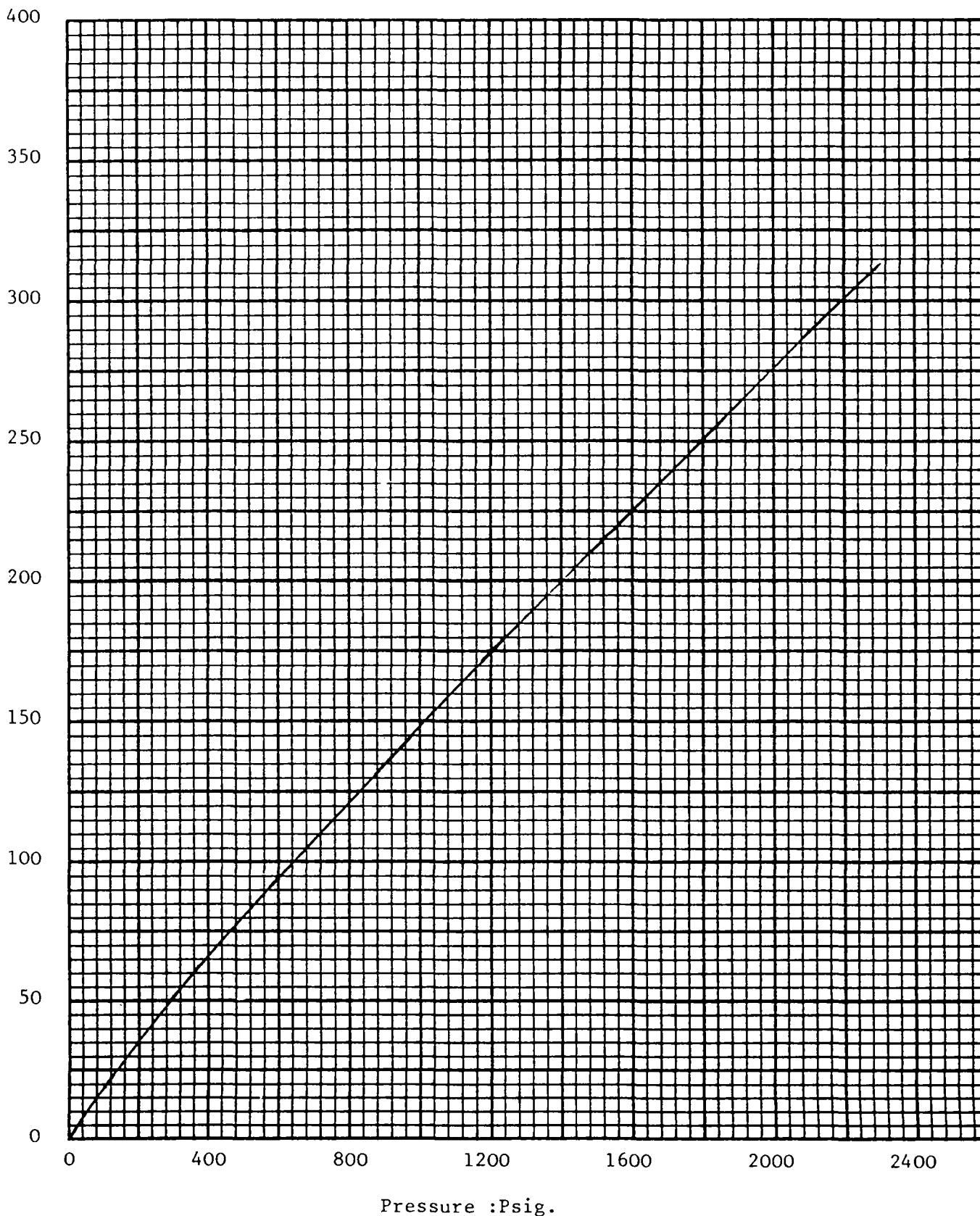
Company A/S Norske Shell Formation _____
Well 31/2-3 County North Sea
Field _____ State Norway



Differential Vaporization of Reservoir Fluid at 160°F.

Company A/S Norske Shell Formation _____
Well 31/2-3 County North Sea
Field _____ State Norway

Solution Gas-Oil Ratio : Standard Cubic Feet of Gas per Barrel of Residual Oil at 60°F.



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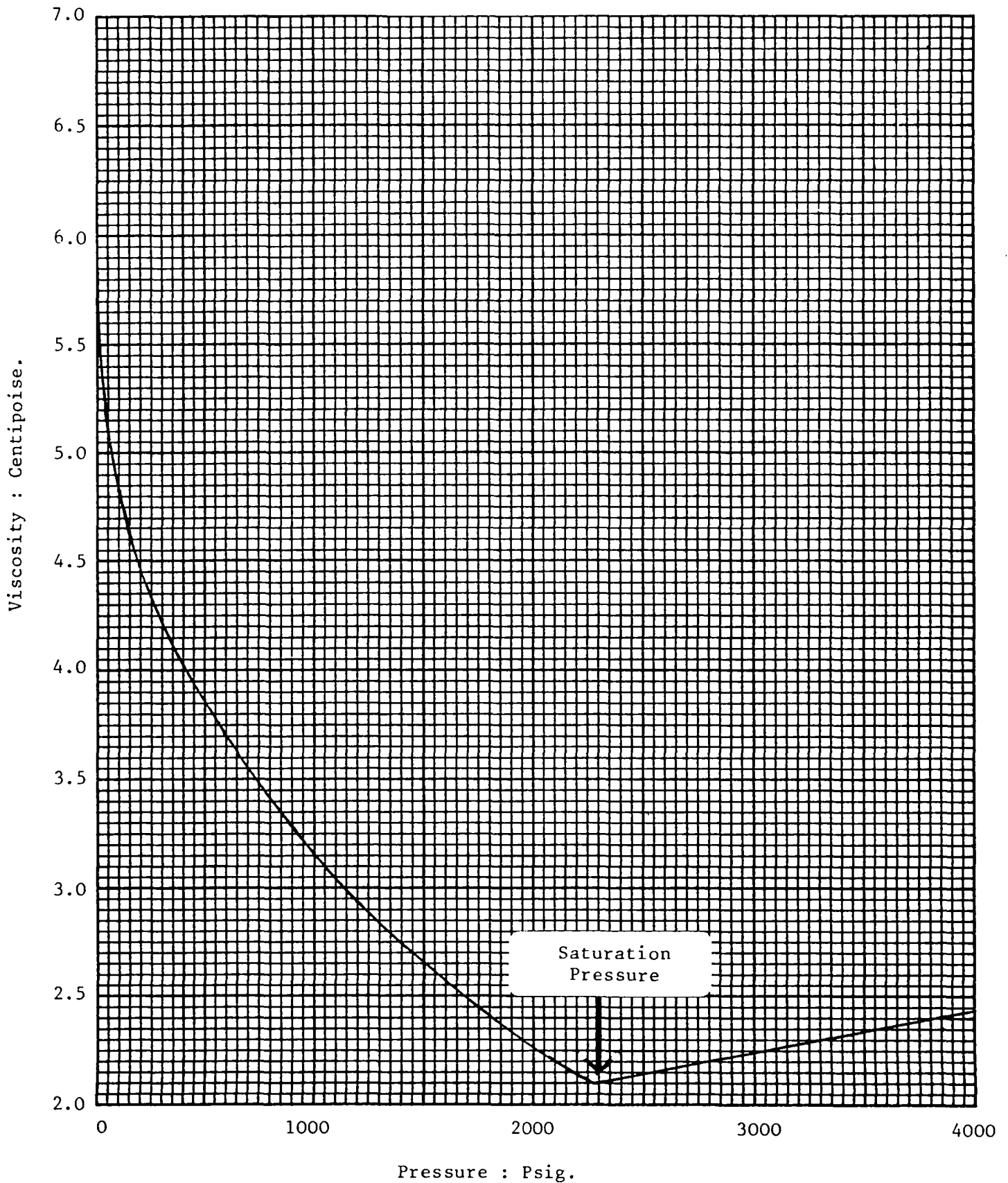
Well 31/2-3

VISCOSITY DATA AT 160°F.

<u>Pressure</u> <u>PSIG</u>	<u>Oil Viscosity</u> <u>Centipoise</u>	<u>Calculated</u> <u>Gas Viscosity</u> <u>Centipoise</u>	<u>Oil/Gas</u> <u>Viscosity</u> <u>Ratio</u>
5000	2.64		
4000	2.44		
3500	2.34		
3000	2.24		
2400	2.12		
<u>2290</u> Saturation Pressure	2.10		
2100	2.21	0.0168	132
1800	2.41	0.0159	152
1500	2.65	0.0151	175
1200	2.93	0.0144	203
900	3.29	0.0139	237
600	3.70	0.0133	278
300	4.23	0.0128	332
100	4.82	0.0118	408
0	5.83		

Viscosity of Reservoir Fluid at 160°F.

Company A/S Norske Shell Formation _____
Well 31/2-3 County North Sea
Field _____ State Norway

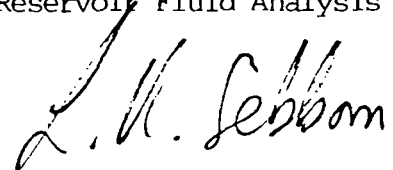


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Petroleum Reservoir Engineering
ABERDEEN, SCOTLAND

A/S NORSKE SHELL EXPLORATION AND PRODUCTION
Well: 31/2-3

RFLA: 80192

Core Laboratories UK Limited
Reservoir Fluid Analysis

A handwritten signature in black ink, appearing to read 'L. K. Sebborn', written in a cursive style.

Les K. Sebborn
Laboratory Manager-RFL