

054- PS.16 Væskeanalyser.

RESERVOAR - ARKIV

CORE LABORATORIES UK LTD.
Petroleum Reservoir Engineering
ABERDEEN, SCOTLA

Denne rapport
tilhører



L&U DOK.SENTER

L.NR. 30285320018

KODE Well 31/2-5 nr. 50

Returneres etter bruk

RESERVOIR FLUID STUDY

for

A/S Norske Shell Exploration & Production

Well: 31/2-5

North Sea, Norway.

CORE LABORATORIES UK LTD.
Petroleum Reservoir Engineering
ABERDEEN, SCOTLAND

24th November 1981

A/S Norske Shell Exploration & Production
Gamle Forusvei 43
P.O. Box 10
N-4033
FORUS
Norway

Subject: Reservoir Fluid Study
Well: 31/2-5
North Sea, Norway.
Our File Number:
RFLA 81172

Attention: Mr. D. C. Jolly.

Gentlemen,

On the 14th August 1981 two sets of separator oil and gas from the subject well were received in our Aberdeen laboratory for use in a reservoir fluid study. The results of the reservoir fluid 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 hydrocarbon compositions of the separator gas samples were determined by gas chromatography. The room temperature bubble points of the separator liquid samples were determined to be approximately 162 psig and 159 psig at 63°F for cylinder numbers 9214/330 and 9214/386 respectively. The hydrocarbon composition of the separator liquid sample contained in cylinder number 9214/386 was determined through hexanes by low temperature fractional distillation. The hydrocarbon composition of the heptanes plus fraction was determined through nonadecanes by high temperature fractional distillation. The heptanes plus fraction of the gas sample contained in cylinder number A11209 was examined using chromatographic techniques.

Separator gas from cylinder number A11209 was recombined with separator liquid from cylinder number 9214/386 in increments such that reservoir fluid exhibiting a saturation pressure of 2280 psig at 150°F was obtained. The reservoir fluid thus created was used for the remainder of the study.

The composition of the reservoir fluid was determined and may be found on page two along with the compositions of the separator products. The density and molecular weight of each fraction collected during the distillation of the heptanes plus fraction of the separator liquid may be found on page three.

A portion of reservoir fluid was placed in a high pressure visual cell and thermally expanded to the reported reservoir temperature of 150°F. During a constant composition expansion at this temperature, a saturation pressure of 2280 psig was observed. The results of the pressure-volume relations may be found on page five. The associated compressibility data for the undersaturated fluid are presented on page four.

A large portion of reservoir fluid was subjected to differential vaporization at 150°F resulting in the liberation of a total of 381 standard cubic feet of gas per barrel of residual oil with an associated relative oil volume of 1.193 barrels of saturated oil per barrel of residual oil. At several pressure levels below the observed saturation pressure, oil density, gas gravity and gas formation volume factor were monitored. These data are tabulated on page six and graphically represented on pages seven and eight.

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Whilst maintaining the operating temperature of 150°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 1.34 centipoise at saturation pressure to a maximum viscosity of 3.61 centipoise at atmospheric pressure. These data are tabulated on page nine and graphically represented on page ten.

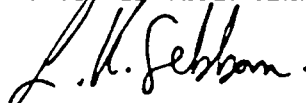
At conditions stipulated by A/S Norske Shell Exploration & Production, a series of flash separations were performed at laboratory temperature. The factors and data derived from these tests may be found on page eleven.

At each stage of separation, the gas evolved was collected and analysed for hydrocarbon composition. These compositions are presented on pages twelve and thirteen.

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 Expl. & Prod Date Sampled 2nd July 1981

Well 31/2-5 County North Sea

Field _____ State Norway

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	32 M.	RKB
Total Depth	_____	Ft.
Producing Interval	1582 - 1588	M.
Tubing Size and Depth	5 In VAM to 1579	M.
Open Flow Potential	_____	MMSCF/Day
Last Reservoir Pressure	2293 PSIG @ 1576	M.
Date	29th June _____, 1981	
Reservoir Temperature	150 °F. @ _____	Ft.
Status of Well	_____	
Pressure Gauge	_____	

SAMPLING CONDITIONS

Flowing Wellhead Pressure	450	PSIG
Flowing Bottom Hole Pressure	1864	PSIG
Primary Separator Pressure	180	PSIG
Primary Separator Temperature	58	°F.
Secondary Separator Pressure	_____	PSIG
Secondary Separator Temperature	_____	°F.
Field Stock Tank Liquid Gravity	_____	°API @ 60°F.
Primary Separator Gas Production Rate	_____	MSCF/Day
Pressure Base	14.73	PSIA
Temperature Base	60	°F.
Compressibility Factor (F _{pv})	1.015	
Gas Gravity (Laboratory)	0.630	
Gas Gravity Factor (F _G)	1.260	
Primary Sep Liquid Production Rate @ 180 psig and 58°F.	6016	Bbls/Day
Primary Separator Gas/Primary Sep Liquid Ratio	303	SCF/Bbl
	_____	Bbls/MMSCF

Sampled by _____ or FLOPETROL

REMARKS:

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Well 31/2-5

HYDROCARBON ANALYSES OF SEPARATOR PRODUCTS AND RESERVOIR FLUID COMPOSITION

Component	Separator Liquid	Separator Gas	Reservoir Fluid
	Mol Percent	Mol Percent	Mol Percent
Hydrogen Sulfide	NIL	NIL	NIL
Carbon Dioxide	0.28	1.86	0.87
Nitrogen	0.17	0.64	0.33
Methane	5.87	89.31	36.23
Ethane	2.84	6.25	4.14
Propane	1.94	1.13	1.65
iso-Butane	1.58	0.41	1.16
n-Butane	0.71	0.12	0.50
iso-Pentane	1.26	0.10	0.83
n-Pentane	0.30	0.02	0.19
Hexanes	1.94	0.05	1.25
Benzene	0.15	TRACE)	0.09
Heptanes	7.48	0.07)	4.78
Toluene	1.59	TRACE)	0.99
Octanes	5.29	0.03)	3.39
Xylene	2.95	TRACE)	1.83
Nonanes	3.08	0.01)	2.00
Decanes	5.85	TRACE)	3.72
Undecanes	4.15	TRACE)	2.64
Dodecanes	4.00	NIL) 0.050	2.54
Tridecanes	5.05	NIL)	3.21
Tetradecanes	4.87	NIL)	3.09
Pentadecanes	4.35	NIL)	2.77
Hexadecanes	3.87	NIL)	2.46
Heptadecanes	4.10	NIL)	2.60
Octadecanes	2.97	NIL)	1.89
Nonadecanes	1.46	NIL)	0.93
Eicosanes plus	21.90	NIL)	13.92
	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>

Properties of Heptanes plus

API gravity @ 60°F.	<u>26.6</u>	
Density gm/cc	<u>0.8945</u>	<u>0.8943</u>
Molecular weight	<u>244</u>	<u>244</u>

Calculated separator gas gravity (air=1.000) = 0.630
 Calculated gross heating value for separator gas = 1074 BTU
 per cubic foot of dry gas @ 14.73 psia and 60°F.

Primary separator gas collected @ 180 psig and 58 °F.
 Primary separator liquid collected @ 180 psig and 58 °F.

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Well 31/2-5

PROPERTIES OF SEPARATOR LIQUID FRACTIONS

<u>Component</u>	<u>Density</u> <u>gm/ml @ 60°F</u>	<u>Molecular</u> <u>Weight</u>
Heptanes	0.7566	91
Octanes (1)	0.7750	102
Nonanes (2)	0.8051	116
Decanes	0.8131	129
Undecanes	0.8280	145
Dodecanes	0.8426	158
Tridecanes	0.8509	172
Tetradecanes	0.8607	186
Pentadecanes	0.8673	198
Hexadecanes	0.8735	213
Heptadecanes	0.8798	223
Octadecanes	0.8850	234
Nonadecanes	0.8905	243
Eicosanes plus	0.9340	485

(1) Including Toluene

(2) Including Xylenes

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VOLUMETRIC DATA OF RESERVOIR FLUID SAMPLE

1. Saturation pressure (bubble-point pressure) 2280 PSIG @ 150 °F.
 $\frac{V @ 150 \text{ } ^\circ\text{F.}}$
2. Thermal expansion of saturated oil @ 5000 PSIG = $\frac{V @ 62 \text{ } ^\circ\text{F.}}{V @ 62 \text{ } ^\circ\text{F.}} = \underline{1.04231}$
3. Compressibility of saturated oil @ reservoir temperature: Vol/Vol/PSI:
From 5000 PSIG to 3000 PSIG = 6.92×10^{-6}
From 3000 PSIG to 2280 PSIG = 7.64×10^{-6}
4. Specific volume at saturation pressure: ft³/lb 0.02028 @ 150 °F.

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PRESSURE-VOLUME RELATIONS AT 150°F.

<u>Pressure</u> <u>PSIG</u>	<u>Relative</u> <u>Volume(1)</u>	<u>Y</u> <u>Function(2)</u>
5000	0.9807	
4000	0.9875	
3000	0.9945	
2700	0.9969	
2600	0.9977	
2500	0.9984	
2400	0.9992	
2300	0.9998	
<u>2280</u> Saturation Pressure	1.0000	
2271	1.0011	4.106
2250	1.0032	4.091
2231	1.0053	4.075
2154	1.0145	4.011
2076	1.0247	3.951
2006	1.0348	3.888
1882	1.0554	3.792
1728	1.0862	3.671
1566	1.1276	3.542
1381	1.1897	3.394
1202	1.2728	3.247
1068	1.3560	3.143
965	1.4394	3.054
843	1.5644	2.967
726	1.7314	2.867
620	1.9401	2.783
481	2.3576	2.673
360	2.9847	2.580
254	4.0289	2.483

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

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

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DIFFERENTIAL VAPORISATION AT 150°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
2280	381	1.193	1.193	0.7900			
2100	354	1.183	1.217	0.7934	0.868	0.00709	0.662
1800	308	1.166	1.274	0.7993	0.876	0.00834	0.652
1500	261	1.149	1.364	0.8052	0.884	0.01009	0.647
1200	214	1.132	1.510	0.8115	0.896	0.01274	0.644
900	166	1.115	1.771	0.8180	0.907	0.01713	0.647
600	118	1.097	2.316	0.8248	0.928	0.02609	0.661
300	67	1.078	4.020	0.8324	0.959	0.05260	0.704
200	51	1.071	5.659	0.8349	0.971	0.07807	0.740
100	32	1.063	10.284	0.8385	0.985	0.14835	0.817
0	0	1.039		0.8498			1.171

At 60°F = 1.000

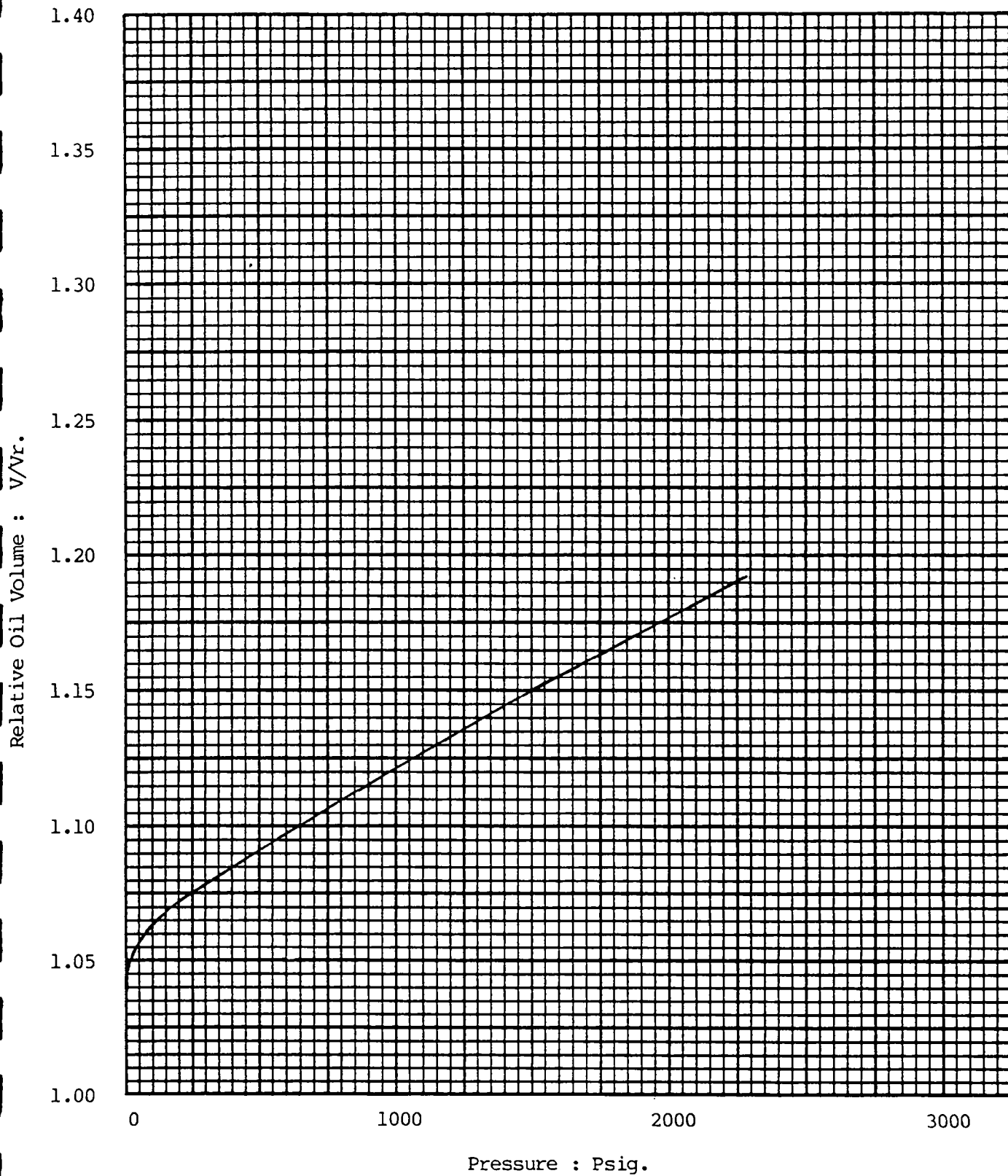
Gravity of Residual Oil = 28.6°API at 60°F.

- (1) Cubic feet of gas at 14.73 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 14.73 psia and 60°F.

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Differential Vaporisation of Reservoir Fluid at 150°F.

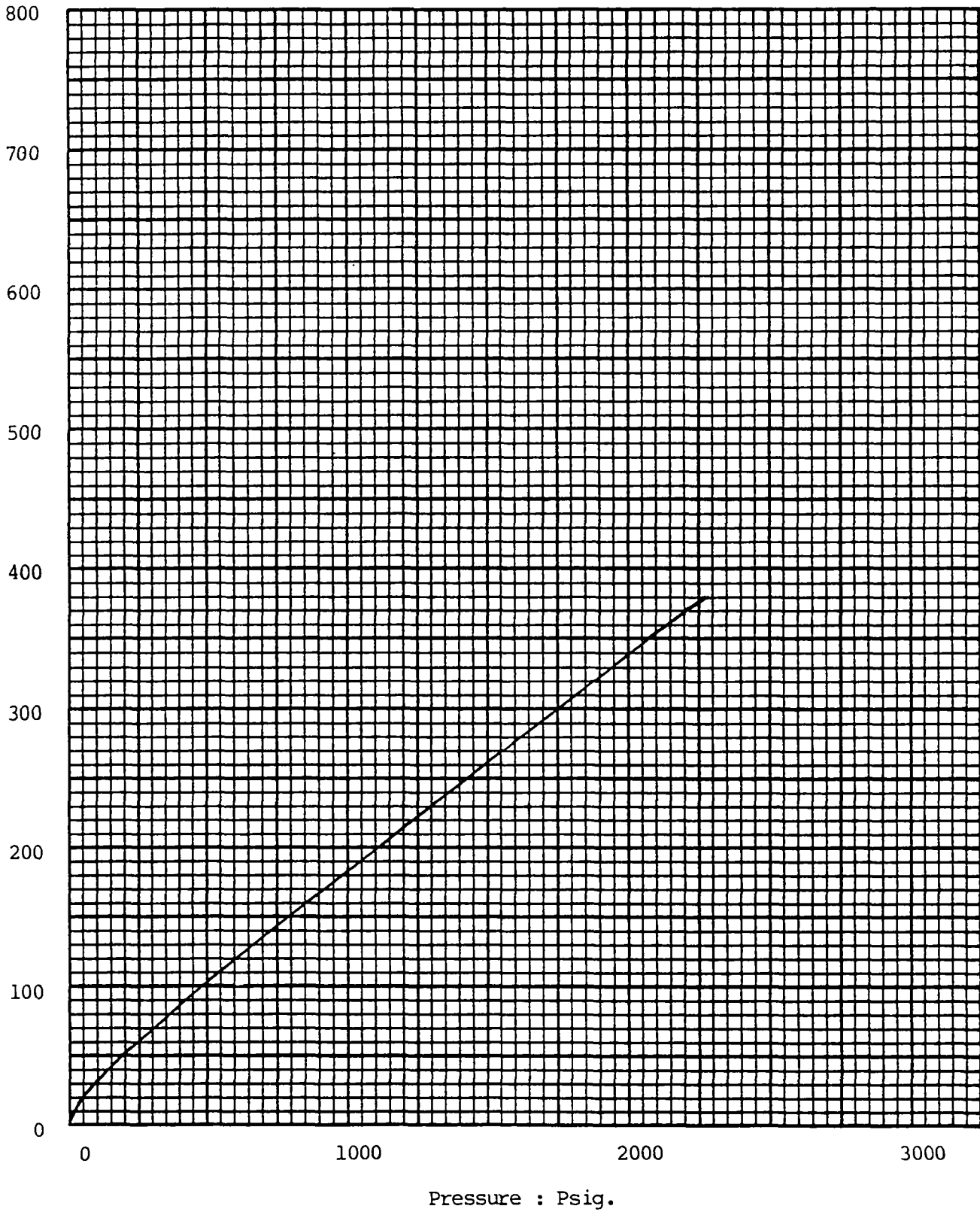
Company A/S Norske Shell Expl & Prod Formation _____
Well 31/2-5 County North Sea
Field _____ State Norway



Differential Vaporisation of Reservoir Fluid at 150°F.

Company A/S Norske Shell Expl & Prod Formation _____
Well 31/2-5 County North Sea
Field _____ State Norway

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



Pressure : Psig.

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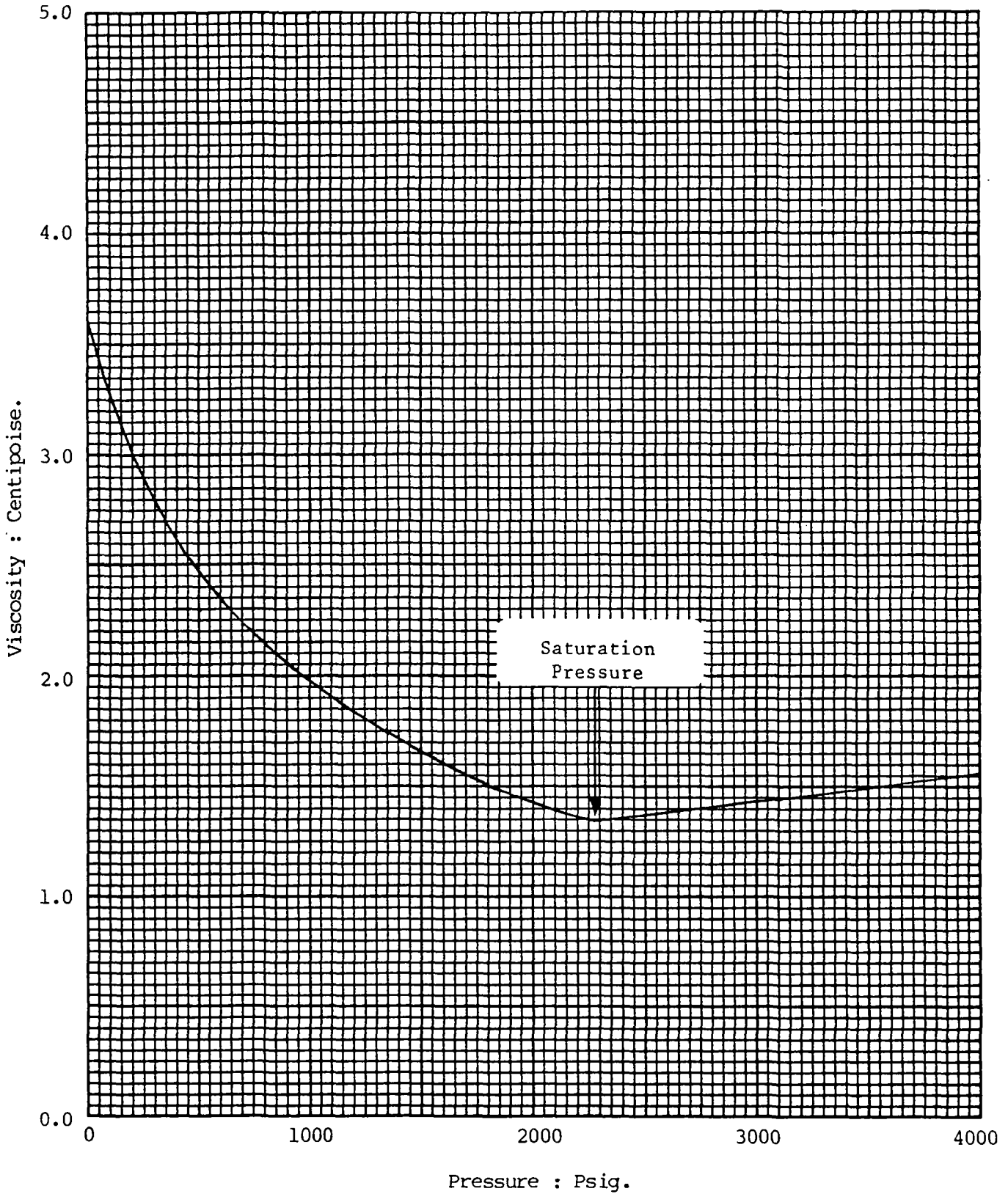
Well 31/2-5

VISCOSITY DATA AT 150°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	1.69		
4000	1.56		
3000	1.43		
2500	1.37		
2300	1.35		
<u>2280</u> Saturation Pressure	1.34		
2100	1.39	0.0171	81.4
1800	1.50	0.0160	93.6
1500	1.66	0.0151	109.6
1200	1.84	0.0144	128.1
900	2.06	0.0137	150.4
600	2.36	0.0131	180.6
300	2.79	0.0124	225.0
200	3.02	0.0121	249.5
100	3.28	0.0116	281.9
0	3.61		

Viscosity of Reservoir Fluid at 150°F.

Company A/S Norske Shell Expl & Prod Formation _____
Well 31/2-5 County North Sea
Field _____ State Norway



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Well 31/2-5

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
450	62	250	260			1.042	0.607
to 0	62	115	115	28.7	1.185	1.001	0.814
250	62	295	303			1.026	0.621
to 0	62	68	68	28.8	1.183	1.001	0.864
150	62	321	326			1.017	0.634
to 0	62	44	44	29.0	1.182	1.001	0.894
50	62	356	358			1.006	0.664
to 0	62	15	15	28.8	1.185	1.001	0.876

All gases evolved collected and analysed for hydrocarbon composition.

- (1) Gas/Oil Ratio in cubic feet of gas at 14.73 psia and 60°F. per barrel of oil at indicated pressure and temperature.
- (2) Gas/Oil Ratio in cubic feet of gas at 14.73 psia and 60°F. per barrel of stock tank oil at 60°F.
- (3) Formation Volume Factor is barrels of saturated oil at 2280 psig and 150°F. per barrel of stock tank oil at 60°F.
- (4) Separator Volume Factor is barrels of oil at indicated pressure and temperature per barrel of stock tank oil at 60°F.

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HYDROCARBON ANALYSES OF SEPARATOR GAS SAMPLES

Component	450 PSIG @ 62 °F.		0 PSIG @ 62 °F.		250 PSIG @ 62 °F.		0 PSIG @ 62 °F.	
	Mol Percent	GPM	Mol Percent	GPM	Mol Percent	GPM	Mol Percent	GPM
Hydrogen Sulfide	NIL		NIL		NIL		NIL	
Carbon Dioxide	1.14		2.81		1.79		2.86	
Nitrogen	1.15		0.27		0.70		0.21	
Methane	92.07		68.04		90.33		62.11	
Ethane	4.53		17.58		5.65		20.73	
Propane	0.62	0.171	6.00	1.651	0.90	0.248	7.65	2.105
iso-Butane	0.23	0.075	2.87	0.939	0.31	0.101	3.61	1.180
n-Butane	0.07	0.022	0.92	0.290	0.09	0.028	1.07	0.337
iso-Pentane	0.05	0.018	0.77	0.282	0.07	0.026	0.89	0.326
n-Pentane	0.02	0.007	0.13	0.047	0.02	0.007	0.15	0.054
Hexanes	0.04	0.016	0.33	0.135	0.05	0.020	0.36	0.147
Benzene	TRACE	)	NIL	)	NIL	)	NIL)
Heptanes	0.04	)	0.23	)	0.02	)	0.25)
Toluene	TRACE	)	NIL	)	TRACE	)	TRACE)
Octanes	0.03	)	0.04	)	0.02	)	0.08)
Xylenes	TRACE	)	NIL	)	TRACE	)	NIL)
Nonanes	0.01	)	0.01	)	0.02	)	0.02)
Decanes	TRACE	)	TRACE	)	0.01	)	0.01)
Undecanes	TRACE	)	NIL	)	0.01	)	TRACE)
Dodecanes plus	TRACE	)	NIL	)	0.01	)	NIL)
	<u>100.00</u>	<u>0.345</u>	<u>100.00</u>	<u>3.471</u>	<u>100.00</u>	<u>0.471</u>	<u>100.00</u>	<u>4.312</u>

Calculated gas gravity (Air=1.000): 0.607 0.814 0.621 0.864

Calculated gross heating value (BTU per cubic foot of dry gas at 14.73 psia and 60°F.): 1047 1343 1062 1421

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HYDROCARBON ANALYSES OF SEPARATOR GAS SAMPLES

Component	150 PSIG @ 62 °F.		0 PSIG @ 62 °F.		50 PSIG @ 62 °F.		0 PSIG @ 62 °F.	
	Mol Percent	GPM	Mol Percent	GPM	Mol Percent	GPM	Mol Percent	GPM
Hydrogen Sulfide	NIL		NIL		NIL		NIL	
Carbon Dioxide	1.91		2.94		1.98		3.05	
Nitrogen	0.68		0.19		0.62		0.18	
Methane	88.82		58.83		85.85		61.96	
Ethane	6.53		22.28		7.88		19.92	
Propane	1.19	0.327	8.64	2.377	1.90	0.523	7.67	2.110
iso-Butane	0.43	0.141	3.90	1.275	0.82	0.268	4.00	1.308
n-Butane	0.13	0.041	1.24	0.391	0.28	0.088	1.23	0.388
iso-Pentane	0.10	0.037	0.97	0.355	0.24	0.088	0.99	0.362
n-Pentane	0.02	0.007	0.17	0.062	0.05	0.018	0.18	0.065
Hexanes	0.07	0.029	0.40	0.163	0.15	0.061	0.40	0.163
Benzene	NIL		NIL		NIL		NIL	
Heptanes	0.07		0.33		0.15		0.34	
Toluene	NIL		NIL		TRACE		NIL	
Octanes	0.03		0.09		0.06		0.08	
Xylenes	NIL	0.055	NIL	0.200	NIL	0.104	NIL	0.191
Nonanes	0.01		0.02		0.01		TRACE	
Decanes	0.01		TRACE		0.01		NIL	
Undecanes	TRACE		NIL		TRACE		NIL	
Dodecanes plus	TRACE		NIL		TRACE		NIL	
	<u>100.00</u>	<u>0.637</u>	<u>100.00</u>	<u>4.823</u>	<u>100.00</u>	<u>1.150</u>	<u>100.00</u>	<u>4.587</u>
Calculated gas gravity (Air=1.000):	0.634		0.894		0.664		0.876	
Calculated gross heating value (BTU per cubic foot of dry gas at 14.73 psia and 60°F.):	1078		1466		1124		1434	

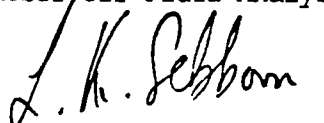
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Petroleum Reservoir Engineering
ABERDEEN, SCOTLAND

A/S NORSKE SHELL EXPLORATION & PRODUCTION
Well: 31/2-5

RFLA 81172

Core Laboratories UK Limited
Reservoir Fluid Analysis



Les K. Sebborn
Laboratory Manager