

Denne rapport
tilhører



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KODE Well 31/2-7 nr 18

Returneres etter bruk

RESERVOIR FLUID STUDY

for

A/S Norsk Shell Exploration & Production

Well: 31/2-7

North Sea, Norway.

CORE LABORATORIES LTD
Petroleum Reservoir Engineering
ABERDEEN, SCOTLAND

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CORE LABORATORIES UK LTD.
Petroleum Reservoir Engineering
ABERDEEN, SCOTLAND

13th May 1983

A/S Norske Shell Exploration & Production
Ganle Forusvei 43
P.O. Box 10
N-4033
Forus
NORWAY

Subject: Reservoir Fluid Study
Well: 31/2-7
Field: Troll
North Sea, Norway.
Our File: RFLA 820278

Attention: Mr. D. C. Jolly.

Gentlemen,

On the 3rd June 1982, samples of separator gas and liquid were collected from the subject well. These samples were submitted to our Aberdeen Laboratory for use in a reservoir fluid study, the results of which are presented in the following report.

On arrival in the laboratory the hydrocarbon composition of the gas sample was determined by gas chromatography. This composition to heptanes plus is presented in terms of mol percent on page two of this report. Separator liquid and gas were recombined to produce a fluid with a saturation pressure of 2280 psig at 154°F as requested, and the resulting fluid was used for the entire study.

The hydrocarbon composition of the fluid to heptanes plus was determined by low temperature fractional distillation. This composition in terms of both mol and weight percent may be found on page three of this report.

A portion of the reservoir fluid was placed in a high pressure visual cell and thermally expanded to the reservoir temperature of 154°F. During a constant composition expansion at this temperature, a bubble point pressure of 2280 psig was observed. The results of the pressure-volume relations may be found on page five, with the associated volumetric data for the undersaturated fluid presented on page four.

A large volume of reservoir fluid was then subjected to a differential vaporisation at 154°F, resulting in the liberation of a total of 341 standard cubic feet of gas per barrel of residual oil, with an associated relative volume of 1.175 barrels of saturated fluid per barrel of residual oil. At several pressure levels below the observed saturation pressure, oil density, gas gravity and gas compressibility factor were monitored. These data are tabulated on page six, and graphically represented on pages eleven and twelve.

The viscosity of the liquid phase was measured in a rolling ball viscosimeter at the reservoir temperature of 154°F. These measurements were made over a wide range of pressures, from above saturation pressure to atmospheric pressure, and showed a minimum viscosity of 1.83 centipoise at saturation pressure,

Continued Over/.....

and a maximum of 4.10 centipoise at atmospheric pressure. This data, together with the calculated gas viscosity is presented on page seven, and graphically represented on page thirteen.

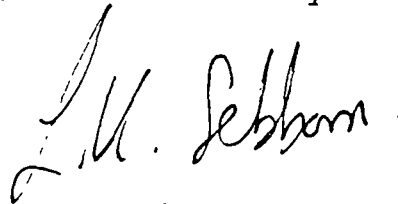
At conditions specified by A/S Norske Shell Exploration & Production, a series of flash separation tests were performed in the laboratory. The factors and data derived from these tests may be found on page eight. On the first separator test at both primary and secondary stages, the gas evolved was collected and analysed for hydrocarbon composition to decanes plus by gas chromatography. These compositions are presented on page nine of this report. It was requested that we analyse the residual liquid from the 450 psig flash separation test to determine pour point, cloud point, wax content and melting point of the wax. These results may be found on page ten.

There was insufficient sample volume to determine the hydrocarbon composition of the fluid to eicosanes plus as requested.

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 may be of assistance in any other matter, please do not hesitate to contact us.

Very truly yours

Core Laboratories UK Limited
Reservoir Fluid Analysis



Les. K. Sebborn
Manager - RFL Aberdeen

LKS/TGB/slc
10cc/Addressee

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Company A/S Norske Shell Expl & Prod. Date Sampled 3rd June 1982

Well 31/2-7 County North Sea

Field Troll State Norway

FORMATION CHARACTERISTICS

Formation Name _____
 Date First Well Completed _____, 19____
 Original Reservoir Pressure _____ PSIG @ _____ M.
 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 _____ RKB _____ M.
 Total Depth _____ M.
 Producing Interval _____ 1584 - 1590.5 M.
 Tubing Size and Depth _____ 5"VAM In. to _____ M.
 Open Flow Potential _____ MMSCF/Day
 Last Reservoir Pressure _____ 2295 PSIG @ 1581.7 M.
 Date _____ 2nd June _____, 1982
 Reservoir Temperature _____ 154* °F. @ _____ M.
 Status of Well _____ Static
 Pressure Gauge _____

SAMPLING CONDITIONS

Flowing Tubing Pressure _____ PSIG
 Flowing Bottom Hole Pressure _____ PSIG
 Primary Separator Pressure _____ 100 PSIG
 Primary Separator Temperature _____ 72 °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}) _____
 Gas Gravity (Laboratory) _____
 Gas Gravity Factor (F_g) _____
 Liquid Production Rate @ _____ °F. _____ Bbls/Day
 Primary Separator Gas/Liquid Ratio _____ SCF/Bbl
 or _____ Bbls/MMSCF
 Sampled by _____

REMARKS: * Requested analysis temperature.

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ABERDEEN, SCOTLANDPage 2 of 13File RFLA 820278Well 31/2-7HYDROCARBON ANALYSIS OF SEPARATOR GAS SAMPLE *

COMPONENT	MOL PERCENT	GPM
Hydrogen Sulfide	NIL	
Carbon Dioxide	1.40	
Nitrogen	0.51	
Methane	88.11	
Ethane	7.59	
Propane	1.27	0.349
iso-Butane	0.72	0.236
n-Butane	0.13	0.041
iso-Pentane	0.10	0.037
n-Pentane	0.02	0.007
Hexanes	0.05	0.020
Heptanes plus	0.10	0.045
	<u>100.00</u>	<u>0.735</u>

Calculated gas gravity (air = 1.000) = 0.637

Calculated gross heating value = 1099 BTU per cubic foot of dry gas at 14.73 psia and 60°F.

Collected at 100 psig and 72°F.

* Cylinder number A 7315

CORE LABORATORIES UK LTD.*Petroleum Reservoir Engineering***ABERDEEN, SCOTLAND**Page 3 of 13File RFLA 820278Well 31/2-7HYDROCARBON ANALYSIS OF RESERVOIR FLUID SAMPLE

COMPONENT	MOL PERCENT	WEIGHT PERCENT	DENSITY	API	MOL WEIGHT
Hydrogen Sulfide	NIL	NIL			
Carbon Dioxide	0.56	0.16			
Nitrogen	0.21	0.04			
Methane	34.45	3.60			
Ethane	3.97	0.78			
Propane	1.14	0.33			
iso-Butane	1.14	0.43			
n-Butane	0.31	0.12			
iso-Pentane	0.54	0.25			
n-Pentane	0.18	0.08			
Hexanes	0.77	0.43			
Heptanes plus	56.73	93.78	0.8906	27.2	254
	<u>100.00</u>	<u>100.00</u>			

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CORE LABORATORIES UK LTD.*Petroleum Reservoir Engineering***ABERDEEN, SCOTLAND**Page 4 of 13File RFLA 820278Well 31/2-7VOLUMETRIC DATA OF RESERVOIR FLUID SAMPLE

1. Saturation pressure (bubble-point pressure) 2280 PSIG @ 154 °F.
2. Specific volume at saturation pressure: ft³/lb 0.02001 @ 154 °F.
V @ 154 °F.
3. Thermal expansion of saturated oil @ 5000 PSIG = $\frac{V @ 154 \text{ °F.}}{V @ 61 \text{ °F.}} = \underline{1.04501}$
4. Compressibility of saturated oil @ reservoir temperature: Vol/Vol/PSI:
From 5000 PSIG to 4000 PSIG = 6.38 x 10⁻⁶
From 4000 PSIG to 3000 PSIG = 6.94 x 10⁻⁶
From 3000 PSIG to 2280 PSIG = 7.64 x 10⁻⁶

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Page 5 of 13File RFLA 820278Well 31/2-7PRESSURE-VOLUME RELATIONS AT 154°F.

<u>Pressure</u> <u>PSIG</u>	<u>Relative</u> <u>Volume(1)</u>	<u>Y</u> <u>Function(2)</u>
5000	0.9813	
4000	0.9876	
3000	0.9945	
2700	0.9967	
2600	0.9975	
2500	0.9982	
2400	0.9990	
2300	0.9998	
<u>2280</u> Saturation Pressure	1.0000	
2214	1.0061	4.893
2107	1.0170	4.788
1914	1.0413	4.595
1671	1.0829	4.358
1360	1.1652	4.050
1120	1.2680	3.813
917	1.4049	3.612
789	1.5312	3.491
665	1.7037	3.375
559	1.9163	3.272
425	2.3401	3.146
314	2.9787	3.020
217	4.0411	2.924

- (1) Relative Volume: V/V_{sat} is barrels at indicated pressure per barrel at saturation pressure.
- (2) Y Function = $\frac{(P_{sat}-P)}{(P_{abs}) (V/V_{sat}-1)}$

RS

DIFFERENTIAL VAPORISATION AT 154°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	341	1.175	1.175	0.8005			
2150	323	1.169	1.192	0.8022	0.875	0.00703	0.688
1800	274	1.152	1.254	0.8082	0.890	0.00853	0.685
1400	217	1.131	1.378	0.8161	0.910	0.01119	0.680
1000	160	1.110	1.625	0.8238	0.933	0.01599	0.677
700	116	1.094	2.022	0.8298	0.952	0.02316	0.681
500	87	1.082	2.556	0.8346	0.965	0.03259	0.694
300	57	1.070	3.804	0.8394	0.979	0.05406	0.723
200	41	1.064	5.326	0.8422	0.986	0.07976	0.792
100	25	1.056	9.509	0.8451	0.993	0.15018	1.133
0	0	1.043		0.8508			
		AT 60°F = 1.000					

Gravity of Residual Oil = 27.8° 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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Well 31/2-7

VISCOSITY DATA AT 154°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	2.38		
4000	2.18		
3500	2.08		
3000	1.97		
2500	1.87		
2280	Saturation		
	Pressure		
2150	1.84	0.0173	106.2
1800	1.92	0.0160	119.6
1400	2.07	0.0148	139.8
1000	2.33	0.0138	168.6
700	2.61	0.0132	197.6
500	2.86	0.0129	222.3
300	3.23	0.0125	258.2
200	3.48	0.0122	284.1
100	3.77	0.0118	319.1
0	4.10		

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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
450	57	217	225			1.035	0.604*
to 0	57	105	105	28.0	1.168	0.999	0.798*
250	57	258	263			1.020	0.617
to 0	57	59	59	28.1	1.164	0.999	0.834
150	57	283	286			1.011	0.630
to 0	57	33	33	28.1	1.163	0.999	0.850
50	57	313	314			1.003	0.668
to 0	57	7	7	28.1	1.164	0.999	0.838

* Gas 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 154°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

<u>Separator Conditions:</u>	<u>450 PSIG @ 57 °F.</u>		<u>0 PSIG @ 57°F.</u>	
<u>Component</u>	<u>Mol Percent</u>	<u>GPM</u>	<u>Mol Percent</u>	<u>GPM</u>
Hydrogen Sulfide	NIL		NIL	
Carbon Dioxide	1.06		1.99	
Nitrogen	0.99		0.32	
Methane	92.54		69.43	
Ethane	4.47		18.41	
Propane	0.47	0.129	4.69	1.290
iso-Butane	0.23	0.075	3.08	1.007
n-Butane	0.05	0.016	0.61	0.192
iso-Pentane	0.03	0.011	0.47	0.172
n-Pentane	0.01	0.004	0.11	0.040
Hexanes	0.02	0.008	0.34	0.139
Heptanes	0.07)		0.38)	
Octanes	0.03)	0.059	0.12)	0.250
Nonanes	0.02)		0.03)	
Decanes plus	0.01)		0.02)	
	<u>100.00</u>	<u>0.302</u>	<u>100.00</u>	<u>3.090</u>
Calculated gas gravity(Air=1.000):		0.604		0.798
Calculated gross heating value (BTU per cubic foot of dry gas at 14.73 psia and 60°F.):		1047		1338

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Well 31/2-7

ANALYSIS OF RESIDUAL LIQUID FROM FLASH SEPARATION TEST*

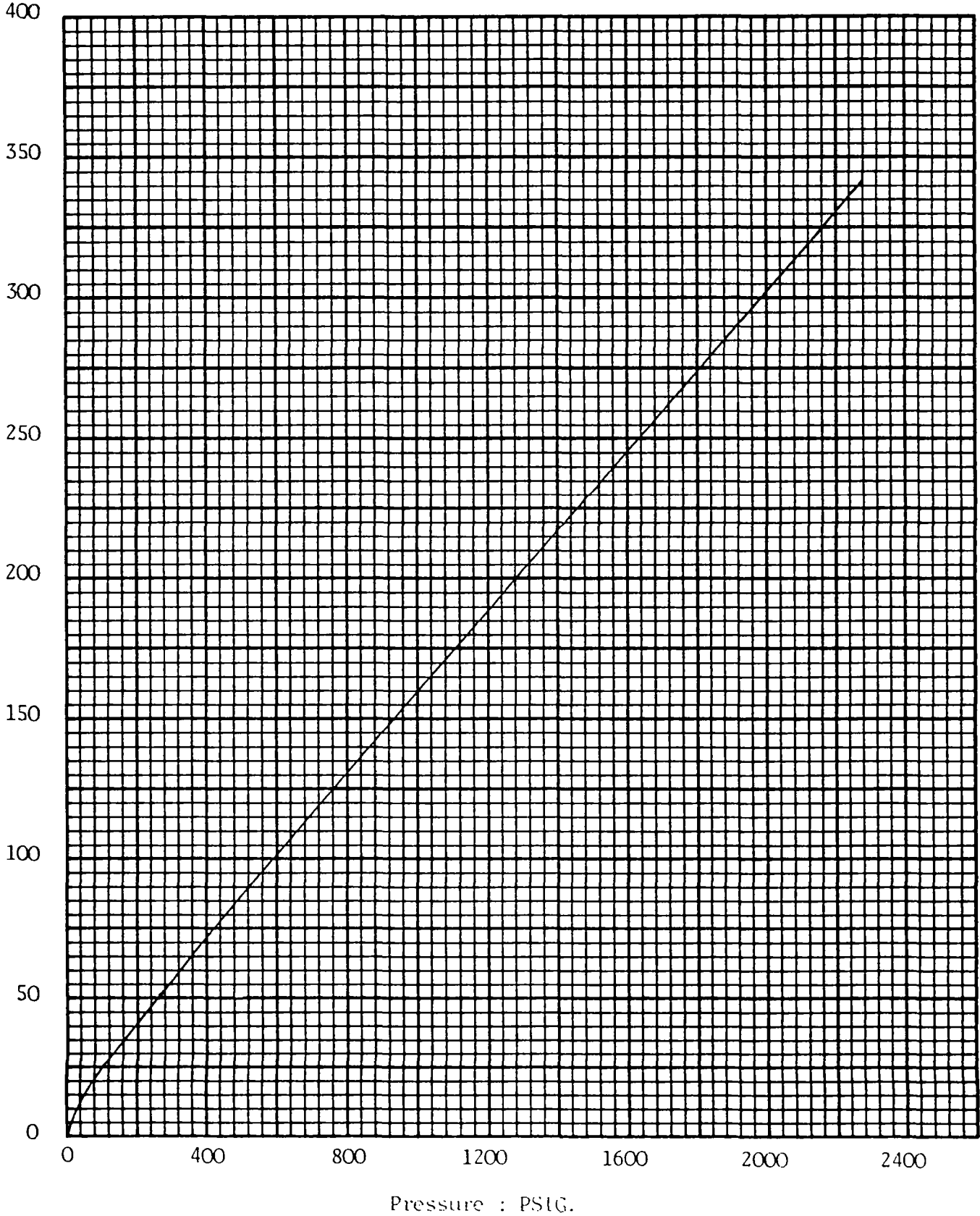
Pour point	:	-15°C
Cloud point	:	- 4°C
Wax content (Precipitated at -30°C)	:	4.3% weight
Drop melting point of wax (IP 133)	:	53.6°C

* 450 psig and 57°F to 0 psig and 60°F

Differential Vaporisation of Reservoir Fluid at 154°F.

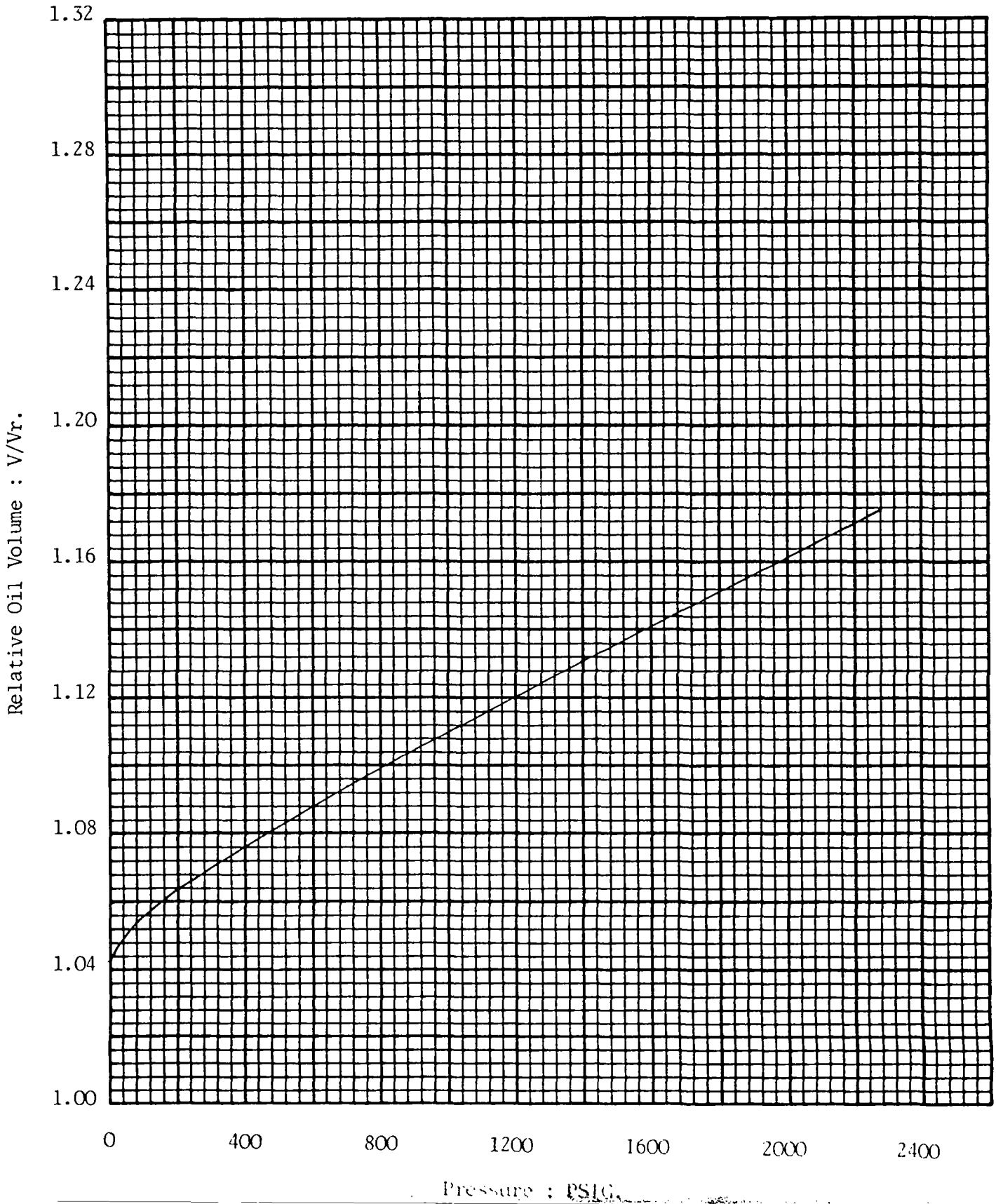
Company A/S Norske Shell Expl. & Prod. Formation _____
Well 31/2-7 County North Sea
Field Troll State Norway

Solution Gas-Oil Ratio : Standard Cubic Feet of Gas per Barrel of Residual Oil.



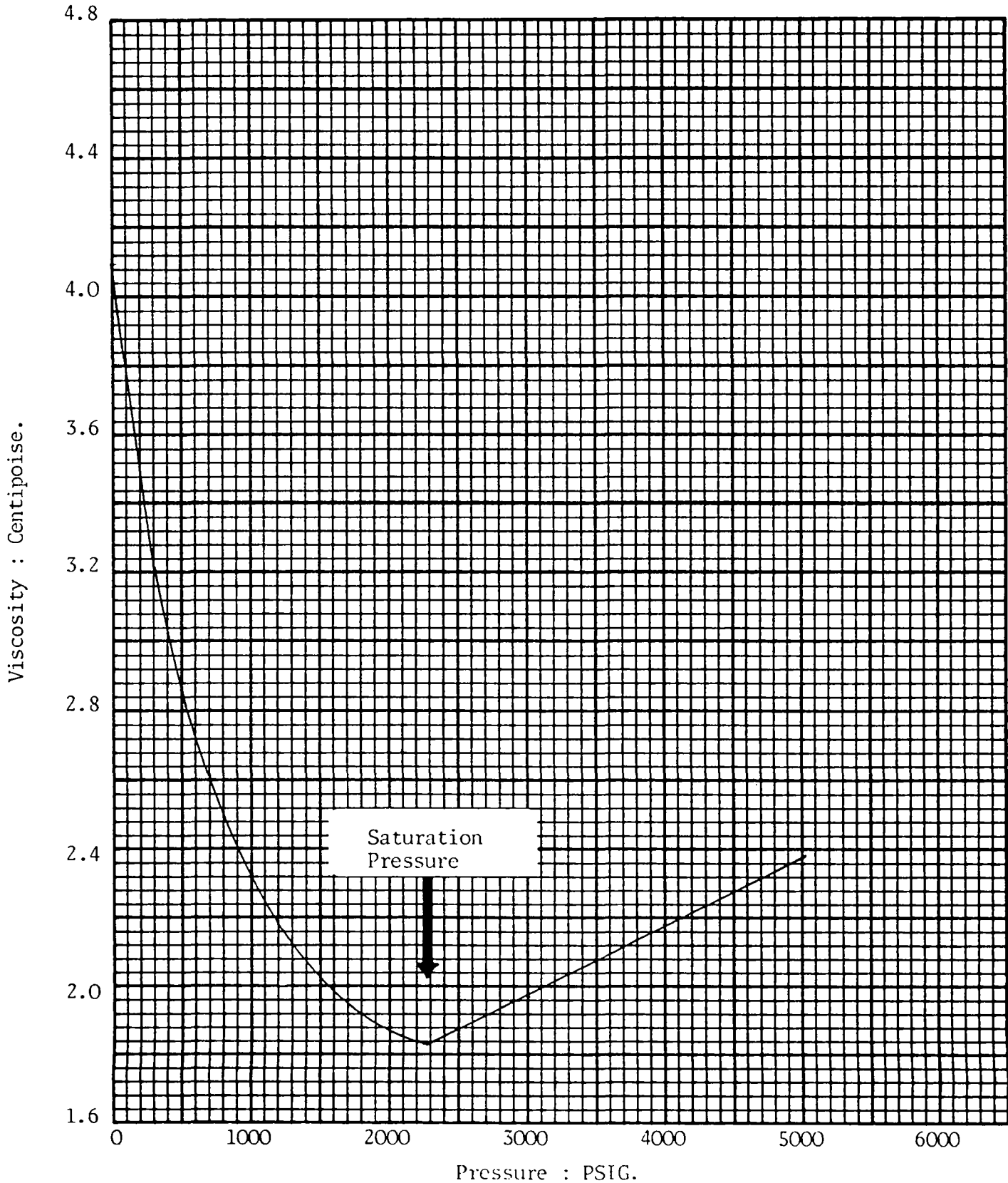
Differential Vaporisation of Reservoir Fluid at 154°F.

Company A/S Norske Shell Expl. & Prod. Formation _____
Well 31/2-7 County North Sea
Field Troll State Norway



Viscosity of Reservoir Fluid at 154°F.

Company A/S Norske Shell Expl. & Prod. Formation _____
Well 31/2-7 County North Sea
Field Troll State Norway

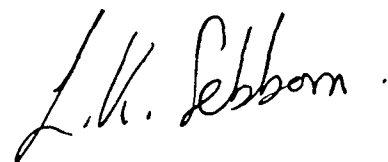


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A/S Norske Shell Exploration & Production
Well: 31/2-7

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Core Laboratories UK Limited
Reservoir Fluid Analysis



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