

Denne rapport
tilhører



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KODE Well 31/2-13 nr.12

Returneres etter bruk

RESERVOIR FLUID STUDY

for

A/S NORSKE SHELL

Well: 31/2-13

North Sea, Norway

SH01

P5.16-01

31/2-13

CORE LABORATORIES
Petroleum Reservoir Engineering
CCB, ÅGOTNES

RESERVOIR FLUID STUDY
for
A/S NORSKE SHELL
Well: 31/2-13
North Sea, Norway

CORE LABORATORIES
Petroleum Reservoir Engineering
CCB, ÅGOTNES

3rd July 1984

A/S Norsk Shell
P.O.Box 10
N-4033 Forus

Attention: Mr.L.H.Kreston

Subject: Reservoir Fluid Study
Well: 31/2-B, Troll Field
North Sea, Norway
Our File Number: RFLN 840011

Gentlemen,

On the 26th of April 1984 one set of separator samples and five litres of stock tank oil, collected from the subject well, were received in our Aagotnes laboratory for use in a reservoir fluid study. The results of this study as requested by a representative of A/S Norske Shell are presented in the following report.

Upon receipt in the laboratory, and as a quality check, the ambient temperature bubble point of the separator liquid was measured and the opening pressure of the gas sample at sampling temperature determined. These were found to be 64 psig at 60°F. and 105 psig at 102°F. respectively. The five litre sample of crude oil was forwarded to our Aberdeen laboratory for high temperature fractional distillation.

The hydrocarbon compositions of the separator products were measured and are presented on page two. The hydrocarbon composition of the crude oil, through eicosanes plus, adjusted to the molar and weight fractions of the heptanes plus fraction of the separator liquid may be found on page three.

Using the factors shown on page one, the producing gas/oil ratio was calculated to be 337 standard cubic feet of separator gas at 14.7 psia and 60°F. per barrel of separator liquid. The separator products were physically recombined to this gas/oil ratio and then sufficient excess gas added to create a gas cap at 2280 psig and 155°F. After stabilization at these conditions the gas cap was removed and the resultant reservoir fluid used throughout the remainder of the study.

The hydrocarbon composition of the resultant reservoir fluid was determined by low temperature fractional distillation, and is presented in terms of both mol and weight percent on page four.

A small quantity of the reservoir fluid was charged to a high pressure windowed cell and thermally expanded to the reservoir temperature of 155°F. During a constant composition expansion at this temperature, the fluid was found to have a bubble point pressure of 2280 psig. The results of the pressure-volume measurements at reservoir temperature may be found on page six.

When subjected to differential pressure depletion at the reservoir temperature, the fluid evolved a total of 372 cubic feet of gas at 14.7 psia and 60°F. per barrel of residual oil at 60°F. The resulting relative oil volume factor was 1.194 barrels of saturated fluid per barrel of residual oil. The oil density and the properties of the evolved gases were measured at each point during the differential pressure depletion and these data are included in the summary of the differential depletion data on page seven.

The viscosity of the reservoir fluid was measured over a wide range of pressures at 155°F, in a rolling ball viscosimeter. The viscosity of the fluid was found to vary from a minimum of 1.48 centipoises at the saturation pressure to a maximum of 3.66 centipoises at atmospheric pressure. The results of the viscosity measurements are tabulated on page eight.

Four single-stage separator tests were performed at laboratory temperature to determine the effects of separator pressure upon gas-oil ratio, stock tank oil gravity and formation volume factor. The results of these separator tests are tabulated on page nine. The separator gases from each of the four tests were collected and analyzed. The results of these separator gas analyses are given on page ten.

Thank you for the opportunity to be of service to A/S Norske Shell. If you have any questions concerning the data presented in this report or if we may be of further assistance in any way, please feel free to call upon us.

Very truly yours,

Core Laboratories Norsk



Duncan Thow
Operations Supervisor
Reservoir Fluid Analysis

10cc Addressee
DMT/ace

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File RFLN 840011

Company <u>A/S NORSKE SHELL</u>	Date Sampled <u>3rd MARCH 1984</u>
Well <u>31/2-13</u>	State <u>NORTH SEA</u>
Field <u>TROLL</u>	Country <u>NORWAY</u>

FORMATION CHARACTERISTICS

Formation Name	
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.
Liquid Gravity at 60°F.	°API
Datum	Ft. Subsea

WELL CHARACTERISTICS

Elevation	
Total Depth	RKB
Producing Interval	Ft.
Tubing Size and Depth	1801 - 1807 M.
Open Flow Potential	In. to Ft.
Last Reservoir Pressure	MMSCF/Day
Date	2295 PSIA @ Ft.
Reservoir Temperature	, 19
Status of Well	155 °F. @ Ft.
Pressure Gauge	

SAMPLING CONDITIONS

Flowing Tubing Pressure		
Flowing Bottom Hole Pressure	616	PSIG
Primary Separator Pressure	90	PSIG
Primary Separator Temperature	102	°F.
Secondary Separator Pressure		PSIG
Secondary Separator Temperature		°F.
Field Stock Tank Liquid Gravity		°API @ 60°F.
Primary Separator Gas Production Rate	320.5	MSCF/Day
Pressure Base	14.7	PSIA
Temperature Base	60	°F.
Compressibility Factor (Fpv)	1.0081	
Gas Gravity (Laboratory)	0.687	
Gas Gravity Factor (Fg)	1.2065	
Separator Liquid Production Rate @ 90 PSIG and 102°F	952	Bbls/Day
Primary Separator Gas/Separator Liquid Ratio	337	SCF/Bbl
		Bbls/MMSCF
Sampled by	or <u>FLOPETROL</u>	

REMARKS:

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Well 31/2-13

HYDROCARBON ANALYSES OF SEPARATOR PRODUCTS

<u>Component</u>	<u>Separator Liquid *</u>	<u>Separator Gas +</u>	
	<u>Mol Percent</u>	<u>Mol Percent</u>	<u>GPM</u>
Carbon Dioxide	0.13	2.13	
Nitrogen	TRACE	0.59	
Methane	2.30	84.00	
Ethane	1.26	8.48	2.263
Propane	1.19	2.27	0.623
iso-Butane	1.13	1.15	0.375
n-Butane	0.50	0.33	0.104
iso-Pentane	1.21	0.34	0.124
n-Pentane	0.40	0.07	0.025
Hexanes	3.84	0.23	0.094
Heptanes plus	88.04	0.41	0.186
	<u>100.00</u>	<u>100.00</u>	<u>3.794</u>

Properties of Heptanes plus

API gravity @ 60°F.	<u>25.7</u>
Specific gravity @ 60/60°F.	<u>0.8999</u>
Molecular weight	<u>244</u>

Calculated separator gas gravity (air=1.000) = 0.687
 Calculated gross heating value for separator gas = 1154 BTU
 per cubic foot of dry gas @ 14.7 psia and 60°F.

Primary separator gas collected @ 90 psig and 102 °F.
 Primary separator liquid collected @ 90 psig and 102 °F.

Primary separator gas/separator liquid ratio 337 SCF/Bbl @ 102°F.

* Cylinder Number: 9214/308
 + Cylinder Number: A-4911

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 Well 31/2-13

Company A/S NORSKE SHELL Date Sampled 3rd MARCH 1984
 Well 31/2-13 State NORTH SEA
 Field TROLL Country NORWAY

HYDROCARBON ANALYSIS OF CRUDE OIL SAMPLE

COMPONENT	MOL PERCENT	WEIGHT PERCENT	DENSITY	API	MOL WEIGHT
Heptanes	10.64	4.46	0.7538	56.0	94
Octanes	7.24	3.39	0.7807	49.6	105
Nonanes	6.36	3.32	0.8010	45.0	117
Decanes	4.78	2.74	0.8171	41.5	129
Undecanes	4.81	3.06	0.8286	39.1	143
Dodecanes	5.12	3.56	0.8397	36.8	156
Tridecanes	4.69	3.56	0.8506	34.7	170
Tetradecanes	4.30	3.51	0.8601	32.9	183
Pentadecanes	3.92	3.43	0.8692	31.1	196
Hexadecanes	3.51	3.27	0.8774	29.6	209
Heptadecanes	3.32	3.29	0.8848	28.3	222
Octadecanes	2.73	2.85	0.8894	27.4	234
Nonadecanes	2.68	2.93	0.8946	26.5	245
Eicosanes plus	23.94	53.59	0.9359	19.5	501
	<u>88.04</u>	<u>96.96</u>			
Heptanes plus	88.04	96.96	0.8888	27.5	247

Composition of stock-tank oil sample, expressed in terms of heptanes plus fraction from analysis of cylinder 9214/308.

Heptanes plus properties from material balance calculation.

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HYDROCARBON ANALYSIS OF RESERVOIR FLUID SAMPLE

COMPONENT	MOL PERCENT	WEIGHT PERCENT	DENSITY	API	MOL WEIGHT
Hydrogen Sulphide	NIL	NIL			
Carbon Dioxide	0.90	0.27			
Nitrogen	0.22	0.04			
Methane	33.10	3.63			
Ethane	4.07	0.84			
Propane	1.39	0.42			
iso-Butane	1.00	0.40			
n-Butane	0.32	0.13			
iso-Pentane	0.84	0.41			
n-Pentane	0.33	0.16			
Hexanes	2.14	1.26			
Heptanes plus	<u>55.69</u>	<u>92.44</u>	0.8968	26.1	243
	<u>100.00</u>	<u>100.00</u>			

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VOLUMETRIC DATA OF RESERVOIR FLUID SAMPLE

1. Saturation pressure (bubble-point pressure) 2280 PSIG at 155 °F
2. Specific volume at saturation pressure: 0.02018 at 155 °F
3. Thermal expansion of saturated oil at 5000 PSI = $\frac{V \text{ at } 155 \text{ °F}}{V \text{ at } 63 \text{ °F}} = 1.04228$
4. Compressibility of saturated oil at reservoir temperature: Vol/Vol/PSI:

From 5000 PSI to 3000 PSI = 6.95×10^{-6}
From 3000 PSI to 2500 PSI = 7.63×10^{-6}
From 2500 PSI to 2280 PSI = 7.74×10^{-6}

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Well 31/2-13

PRESSURE-VOLUME RELATIONS AT 155 °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	0.9873	
3000	0.9945	
2600	0.9975	
2500	0.9983	
2400	0.9991	
2300	0.9998	
<u>2280</u> Saturation Pressure	1.0000	
2273	1.0007	4.154
2258	1.0023	4.146
2248	1.0034	4.136
2239	1.0044	4.126
2229	1.0055	4.119
2183	1.0108	4.079
2099	1.0213	4.020
1959	1.0417	3.904
1786	1.0730	3.758
1611	1.1142	3.603
1443	1.1662	3.455
1286	1.2294	3.330
1129	1.3134	3.211
985	1.4184	3.095
858	1.5446	2.991
734	1.7131	2.895
624	1.9239	2.805
482	2.3480	2.684
361	2.9809	2.576
255	4.0133	2.492

(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 155°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	372	1.194	1.194	0.7939	0.893	0.00734	0.684
2100	345	1.184	1.219	0.7878	0.896	0.00858	0.670
1800	301	1.167	1.276	0.8041	0.900	0.01033	0.664
1500	256	1.150	1.363	0.8102	0.910	0.01302	0.660
1200	211	1.133	1.506	0.8166	0.927	0.01762	0.661
900	167	1.116	1.759	0.8232	0.948	0.02681	0.671
600	121	1.099	2.298	0.8306	0.974	0.05381	0.698
300	73	1.080	3.946	0.8382	0.983	0.07960	0.722
200	54	1.073	5.581	0.8409	0.992	0.15036	0.828
100	33	1.064	10.143	0.8437			1.228
0	0	1.041		0.8519			

Gravity of residual oil = 27.9° API @ 60°F.

- (1) Cubic feet of gas at 14.7 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 14.7 psia and 60°F.

Disse analysene, eller innligningene baseres på observasjoner og materiell skaffet til veie av klienter, som denne rapporten eksklusivt og i utrettelig er laget for. Det utferste arbeidet representerer de beste innligninger Core Laboratories' Norsk er i stand til å gi (med forbehold om feil og uteløst). I alle tilfeller skal det forstås at disse resultatene er basert på de opplysninger som er gitt av klienten, og ikke på grunnlag av disse data, som f.eks produktivitet, aktuelle operasjoner, og lemsamhet fra en hver ulje, gass eller mineral brønn eller sand, som en slik rapport er basert på.

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Well 31/2-13

VISCOSITY DATA AT 155°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	1.83		
4000	1.77		
3000	1.60		
2800	1.57		
2500	1.52		
<u>2280</u>	1.48		
	Saturation Pressure		
2100	1.49	0.0171	87.1
1800	1.54	0.0159	96.9
1500	1.64	0.0149	110.1
1200	1.82	0.0139	130.9
900	2.01	0.0130	154.6
600	2.27	0.0122	186.1
300	2.61	0.0118	221.2
200	2.75	0.0117	235.0
100	2.91	0.0112	259.8
0	3.66		

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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 to 0	60	238	250			1.049	0.613+
250 to 0	60	119	119	27.8	1.187	1.000	0.844
150 to 0	60	287	294			1.025	0.628+
50 to 0	60	68	68	28.0	1.182	1.000	0.872
150 to 0	60	317	321			1.014	0.643+
50 to 0	60	43	43	28.0	1.181	1.000	0.879
50 to 0	60	367	369			1.005	0.685+
0	60	16	16	27.9	1.186	1.000	0.866

+ Evolved gasses collected and analysed for hydrocarbon composition,

- (1) Gas/Oil Ratio in cubic feet of gas at 60 °F and 14.7 PSI absolute per barrel of oil at indicated pressure and temperature.
- (2) Gas/Oil Ratio in cubic feet of gas at 60 °F and 14.7 PSI absolute per barrel of stock tank oil at 60 °F.
- (3) Formation Volume Factor is barrels of saturated oil at 2280 PSI gauge and 155 °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 ANALYSIS OF LABORATORY SINGLE - STAGE SEPARATOR TEST GASES

Separator Conditions:	450 PSIG at 60 °F		250 PSIG at 60 °F		150 PSIG at 60 °F		50 PSIG at 60 °F	
	Mol Percent	GPM	Mol Percent	GPM	Mol Percent	GPM	Mol Percent	GPM
Carbon Dioxide	1.76		1.95		2.07		2.17	
Nitrogen	0.96		0.89		0.83		0.73	
Methane	91.45		89.41		87.52		83.38	
Ethane	4.62	1.233	6.05	1.614	7.23	1.929	9.01	2.404
Propane	0.71	0.195	0.99	0.272	1.34	0.368	2.43	0.667
iso-Butane	0.24	0.078	0.36	0.118	0.51	0.167	1.16	0.379
n-Butane	0.07	0.022	0.10	0.032	0.15	0.047	0.33	0.104
iso-Pentane	0.05	0.018	0.08	0.029	0.12	0.044	0.31	0.113
n-Pentane	0.02	0.007	0.02	0.007	0.03	0.011	0.05	0.018
Hexanes	0.04	0.016	0.05	0.020	0.07	0.029	0.18	0.073
Heptanes plus	0.08	0.036	0.10	0.045	0.13	0.059	0.25	0.113
	100.00	1.605	100.00	2.137	100.00	2.654	100.00	3.871

Calculated gas gravity (Air = 1.000) 0.613 0.628 0.643 0.685

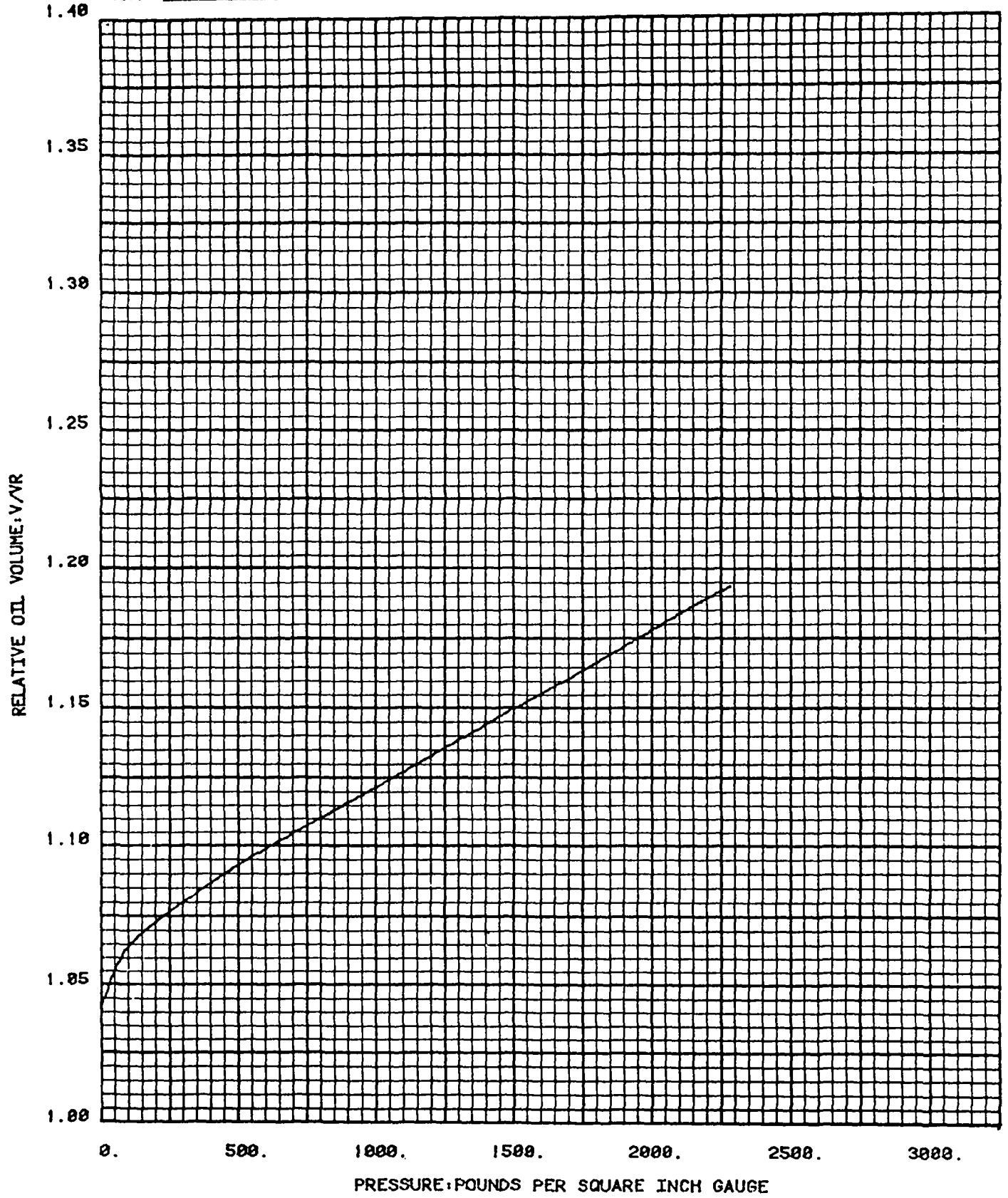
Calculated gross heating value (BTU per cubic foot of dry gas at 14.7 PSIA and 60°F): 1043 1084 1148

These analyses, either total-gas or separator-gas, are made on samples of gas obtained from the well or separator. The analyses are made on a dry basis, that is, the water content of the gas has been removed. The analyses are made on a dry basis, that is, the water content of the gas has been removed. The analyses are made on a dry basis, that is, the water content of the gas has been removed.

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DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 155° F.

Company	A/S NORSKE SHELL	Formation	
Well	31/2-13	Province	NORTH SEA
Field	TROLL	Country	NORWAY



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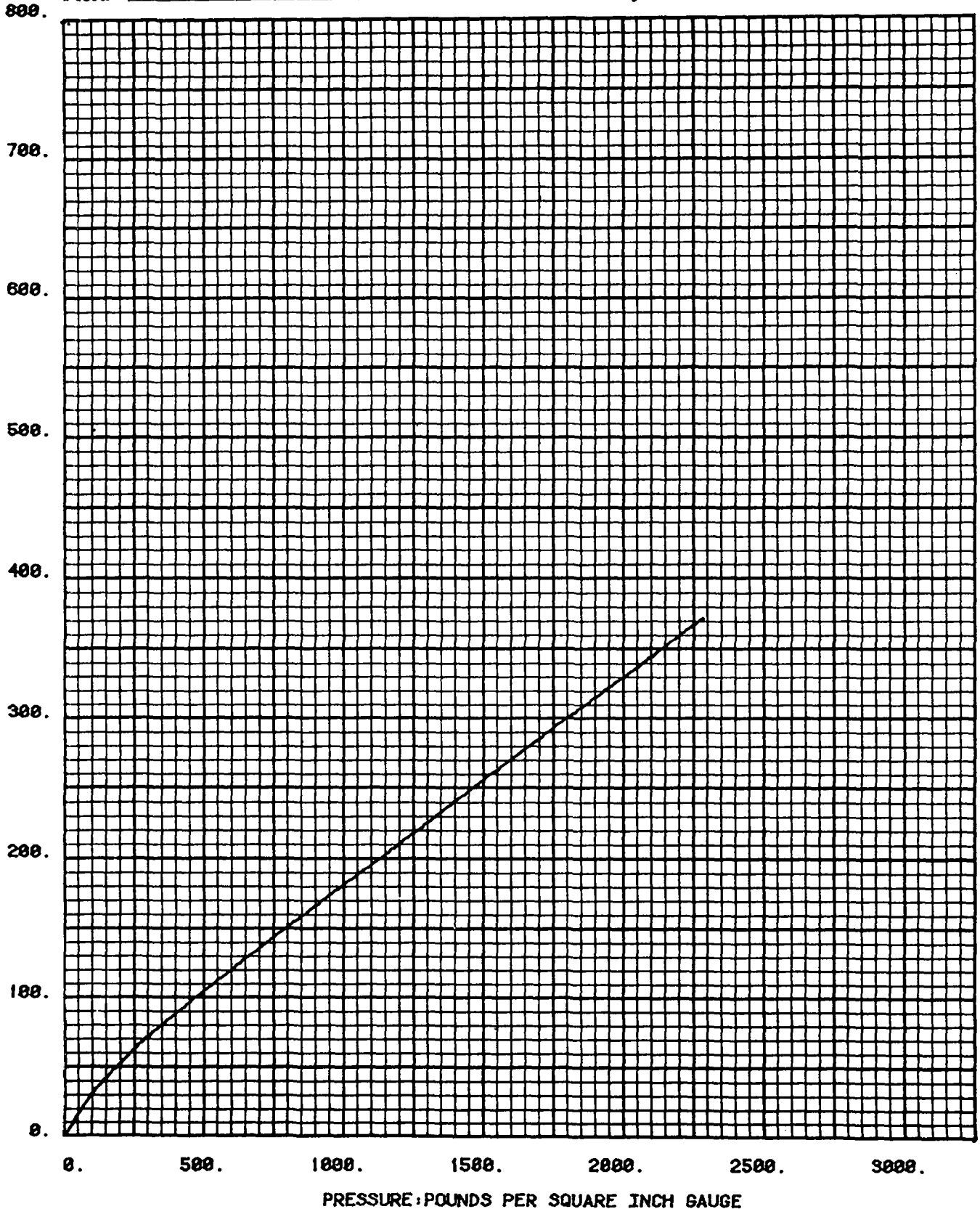
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DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 155° F.

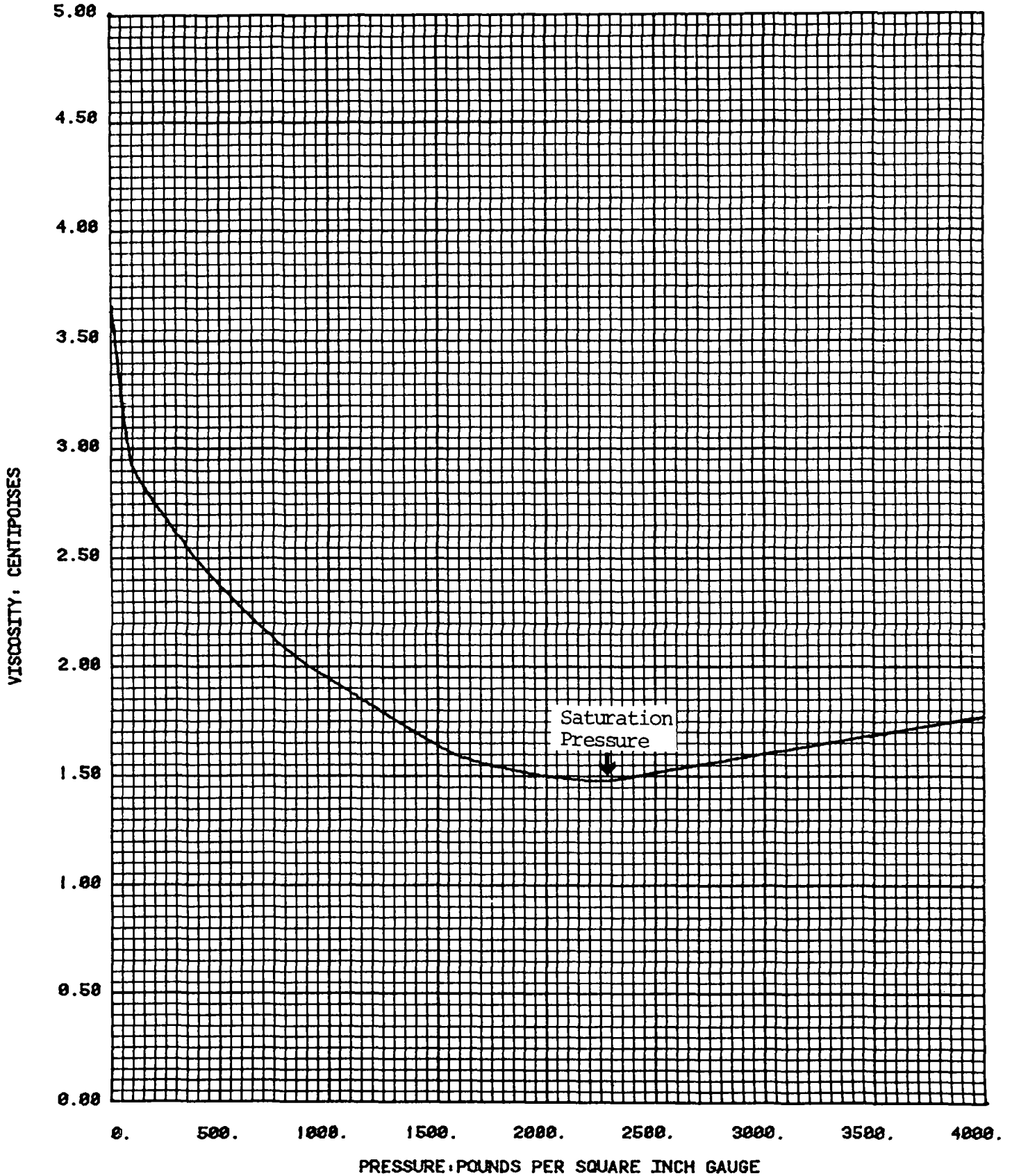
Company	A/S NORSK SHELL	Formation	
Well	31/2-13	Province	NORTH SEA
Field	TROLL	Country	NORWAY

GAS IN SOLUTION: STANDARD CUBIC FEET PER BARREL OF RESIDUAL OIL



BERGEN, NORWAY
VISCOSITY OF RESERVOIR FLUID AT 155° F.

Company A/S NORSKE SHELL Formation _____
Well 31/2-13 Province NORTH SEA
Field TROLL Country NORWAY



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A/S NORSKE SHELL
Well: 31/2-13

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Core Laboratories Norsk
Reservoir Fluid Laboratory



Duncan Thow
Operations Supervisor