

CORE LABORATORIES
Petroleum Reservoir Engineering
CCB, ÅGOTNES

RESERVOIR FLUID STUDY
For
A/S NORSKE SHELL
Well: 6407/9-1

ORIGINAL
Norwegian Sea
Norway

CORE LABORATORIES
Petroleum Reservoir Engineering
CCB, ÅGOTNES
6th September 1984

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

Attention: Mr. L. H. Karsten

Subject: Reservoir Fluid Study
Well: 6407/9-1
Norwegian Sea, Norway
Our File Number: RFLN 840033

Gentlemen,

On the 14th August 1984 a Schlumberger one gallon RFT chamber, containing subsurface fluid collected from the subject well, was received in our Aagotnes laboratory. Presented in the following report are the results of a reservoir fluid study performed on sample transferred from this chamber, as requested by a representative of A/S Norske Shell.

Upon receipt in the laboratory the approximate opening pressure of the chamber and an approximate saturation pressure of the sample at laboratory temperature were measured. After thorough agitation and whilst maintaining the pressure well in excess of the saturation pressure three portions of the sample were transferred to high pressure stainless steel cylinders. The saturation pressures of the transferred samples were determined to be 565 psig, 569 psig and 567 psig at 60°F for samples one, two and three respectively. Thereafter the residual contents of the chamber were bled off and the volumes of gas, oil and water recovered were measured. The chamber was subsequently returned to Schlumberger, Kokstad.

A small portion of fluid from cylinder number 811106 was flashed to ambient conditions to determine gas-oil ratio, gas gravity, stock tank oil gravity and to allow calculation of an approximate formation volume factor. The carbon dioxide content of the liberated gas was determined, by Drager tube, to be 0.7%, this value and the measured gas gravity were confirmed by chromatographic analysis of the liberated gas. A summation of data from this flash separation test is presented, along with the pressure and volume data recorded whilst handling the RFT chamber, on page two of the following report. These data were previously reported by telex.

Sample from cylinder number 811106 was utilized for the remainder of the study.

The hydrocarbon composition of the subsurface fluid was determined by low temperature fractional distillation. The results of this distillation in terms of both mol percent and weight percent are presented on page three.

A small quantity of the reservoir fluid was charged to a high pressure windowed cell and thermally expanded to the reservoir temperature of 149°F. During a constant composition expansion at this temperature, the fluid was found to have a bubble point pressure of 790 psig. The results of the pressure-volume measurements at reservoir temperature may be found on page five.

When subjected to differential pressure depletion at the reservoir temperature, the fluid evolved a total of 425 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 1.331 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 six.

The viscosity of the reservoir fluid was measured over a wide range of pressures at 149°F. in a rolling ball viscosimeter. The viscosity of the fluid was found to vary from a minimum of 0.642 centipoise at the saturation pressure to a maximum of 1.891 centipoises at atmospheric pressure. The results of the viscosity measurements are tabulated on page seven.

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

Thank you for the opportunity to be of service to A/S Norske Shell. If you have any questions 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
Operation Supervisor
Reservoir Fluid Analysis

10 cc Addressee
DMT/ah

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Company	<u>A/S Norske Shell</u>	Date Sampled	<u>6th August 1984</u>
Well	<u>6407/9-1</u>	County	<u>Norwegian Sea</u>
Field	<u></u>	State	<u>Norway</u>

FORMATION CHARACTERISTICS

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

WELL CHARACTERISTICS

Elevation		Ft.
Total Depth		Ft.
Producing Interval		Ft.
Tubing Size and Depth	In. to _____	Ft.
Productivity Index	Bbl/D/PSI @ _____	Bbl/Day
Last Reservoir Pressure	PSIG @ _____	Ft.
Date		, 19____
Reservoir Temperature	149°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	14.7	PSIA
Well Making Water		% Cut

SAMPLING CONDITIONS

Sampled at		Ft.
Status of Well		
Gas-Oil Ratio		SCF/Bbl
Separator Pressure and Temperature	PSIG, _____	°F.
Tubing Pressure		PSIG
Casing Pressure		PSIG
Sampled by	Schlumberger	
Type Sampler	RFT	

REMARKS:

Run 1 RFT number RFS-AD-40

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SUMMATION OF DATA FROM RFT CHAMBER
RFS-AD-40

Opening pressure at 60°F	Less than 600 psig
Saturation pressure (bubble point) at 60°F	Less than 700 psig
Volume of sample at 2377 psig and 60°F	Approximately 3.61 L
Volume of sample transferred at 6300 psig and 60°F	Approximately 2.08 L

RECOVERY FROM BLEED DOWN

Gas recovered at 1 atmosphere and 60°F	Approximately 53.49 L
Oil recovered	1.125 L
Water/Mud-filtrate recovered	0.300 L

AMBIENT TEMPERATURE SATURATION PRESSURES
OF TRANSFERRED SAMPLES

<u>Sample Number</u>	<u>Cylinder Number</u>	<u>Bubble Point Pressure At 60°F</u>
1	J-210882-11	565 psig
2	811106	569 psig
3	J-210882-8	567 psig

FLASH SEPARATION TEST OF RESERVOIR FLUID SAMPLE
(CYLINDER Number 811106)

<u>Separation Pressure PSI Gauge</u>	<u>Separation Temperature °F</u>	<u>Gas/Oil Ratio SCF per Tank Barrel At 60°F</u>	<u>Tank Oil Gravity °API</u>	<u>Formation Volume Factor</u>	<u>Specific Gravity Of Evolved Gas</u>
0	61	353	38.7	1.261	1.210

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HYDROCARBON ANALYSIS OF RESERVOIR FLUID SAMPLE

COMPONENT	MOL PERCENT	WEIGHT PERCENT	DENSITY	API	MOL WEIGHT
Carbon Dioxide	0.20	0.07			
Nitrogen	0.05	0.01			
Methane	14.97	1.82			
Ethane	4.57	1.04			
Propane	8.94	2.98			
iso-Butane	2.40	1.06			
n-Butane	6.28	2.76			
iso-Pentane	2.52	1.38			
n-Pentane	4.17	2.28			
Hexanes	5.17	3.36			
Heptanes plus	50.73	83.24	0.8607	32.7	217
	<u>100.00</u>	<u>100.00</u>			

Cylinder Number: 811106

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VOLUMETRIC DATA OF RESERVOIR FLUID SAMPLE

1. Saturation pressure (bubble-point pressure) 790 PSIG at 149°F.
2. Specific volume at saturation pressure: ft^3/lb 0.02173 at 149°F.
3. Thermal expansion of saturated oil at 5000 PSIG = $\frac{V \text{ at } 149^\circ\text{F.}}{V \text{ at } 61^\circ\text{F.}}$ = 1.04602
4. Compressibility of saturated oil at reservoir temperature: Vol/Vol/PSI:

From	<u>5000</u>	PSI to	<u>4000</u>	PSI =	<u>6.95×10^{-6}</u>
From	<u>4000</u>	PSI to	<u>3000</u>	PSI =	<u>7.48×10^{-6}</u>
From	<u>3000</u>	PSI to	<u>2377</u>	PSI =	<u>7.57×10^{-6}</u>
From	<u>2377</u>	PSI to	<u>2000</u>	PSI =	<u>8.68×10^{-6}</u>
From	<u>2000</u>	PSI to	<u>1500</u>	PSI =	<u>9.42×10^{-6}</u>
From	<u>1500</u>	PSI to	<u>1000</u>	PSI =	<u>9.87×10^{-6}</u>
From	<u>1000</u>	PSI to	<u>790</u>	PSI =	<u>9.88×10^{-6}</u>

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PRESSURE-VOLUME RELATIONS AT 149°F.

<u>Pressure</u> <u>PSIG</u>	<u>Relative</u> <u>Volume(1)</u>	<u>Y</u> <u>Function(2)</u>
5000	0.9664	
4500	0.9697	
4000	0.9731	
3500	0.9767	
3000	0.9804	
2500	0.9843	
2377	0.9851	
1490 2000	0.9883	
1500	0.9930	
1400	0.9940	
1300	0.9950	
1149 1200	0.9960	
1100	0.9970	
1000	0.9979	
900	0.9988	
800	0.9999	
<u>790</u> Saturation Pressure	1.0000	
789	1.0006	2.012
788	1.0012	2.010
787	1.0019	2.008
785	1.0031	2.006
783	1.0044	2.004
768	1.0141	1.992
739	1.0345	1.960
688	1.0757	1.917
609	1.1573	1.844
536	1.2605	1.769
454	1.4249	1.686
385	1.6310	1.605
321	1.9159	1.524
261	2.3272	1.444
208	2.9162	1.362
157	3.8842	1.276

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

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

Disse analysene, eller tokningene baseres på observasjoner og materiell skaffet til veie av klienter, som denne rapporten eksklusivt og fortrolig er laget for. Det utførte arbeidet representerer de beste tolkninger Core Laboratories Norsk er i stand til å gi, (med forbehold om feil og utelatelser). Likevel frasier Core Laboratories Norsk og Deres personell seg alt ansvar og gir derfor ingen overslag på grunnlag av disse data, som f.eks produktivitet, aktuelle operasjoner, og lønnsomhet fra en hver olje, gass eller mineral brønn eller sand, som en slik rapport er basert på.

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DIFFERENTIAL VAPORISATION AT 149°F.

<u>Pressure</u> <u>PSIG</u>	<u>Solution</u> <u>Gas/Oil</u> <u>Ratio(1)</u>	<u>Relative</u> <u>Oil</u> <u>Volume(2)</u>	<u>Relative</u> <u>Total</u> <u>Volume(3)</u>	<u>Oil</u> <u>Density</u> <u>gm/cc</u>	<u>Deviation</u> <u>Factor</u> <u>Z</u>	<u>Gas Formation</u> <u>Volume</u> <u>Factor(4)</u>	<u>Incremental</u> <u>Gas</u> <u>Gravity</u>
790	425	1.331	1.331	0.7372			
700	401	1.329	1.418	0.7400	0.937	0.02257	0.750
600	374	1.309	1.550	0.7434	0.940	0.02633	0.762
500	345	1.296	1.750	0.7469	0.946	0.03164	0.779
400	315	1.283	2.055	0.7506	0.951	0.03984	0.808
300	284	1.269	2.587	0.7542	0.959	0.05246	0.856
200	249	1.251	3.688	0.7593	0.968	0.07762	0.945
118	211	1.233	6.083	0.7629	0.978	0.12688	1.114
77	186	1.214	9.072	0.7687	0.984	0.18474	1.285
0	0	1.041		0.8131			2.130

Gravity of residual oil = 35.6°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.

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VISCOSITY DATA AT 149°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	0.964		
4500	0.925		
4000	0.886		
3500	0.847		
3000	0.810		
2500	0.771		
2380	0.761		
2000	0.733		
1500	0.695		
1200	0.672		
1000	0.657		
<u>790</u> Saturation Pressure	0.642		
700	0.666	0.0129	51.6
600	0.693	0.0127	54.6
500	0.721	0.0124	58.1
400	0.752	0.0121	62.1
300	0.786	0.0118	66.6
200	0.826	0.0113	73.1
100	0.899	0.0103	87.3
0	1.891		

+ Calculated using the correlation of Lee, Gonzalez and Eaken;
Journal of Petroleum Technology, August 1966.

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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	61	37	43			1.169	0.646 +
To 0	61	274	281	38.4	1.233	1.000	1.208
250	61	95	107			1.131	0.680 +
To 0	61	197	197	39.1	1.218	1.000	1.319
150	61	137	151			1.103	0.737 +
To 0	61	141	141	39.6	1.207	1.000	1.394
50	61	210	222			1.058	0.892 +
To 0	61	61	61	40.1	1.199	1.000	1.420

+ Gases collected and analysed for hydrocarbon composition

- (1) Gas/Oil Ratio in cubic feet of gas at 14.7 psia and 60°F. per barrel of oil at indicated pressure and temperature.
- (2) Gas/Oil Ratio in cubic feet of gas at 14.7 psia and 60°F. per barrel of stock tank oil at 60°F.
- (3) Formation Volume Factor is barrels of saturated oil at 790 psig and 149°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

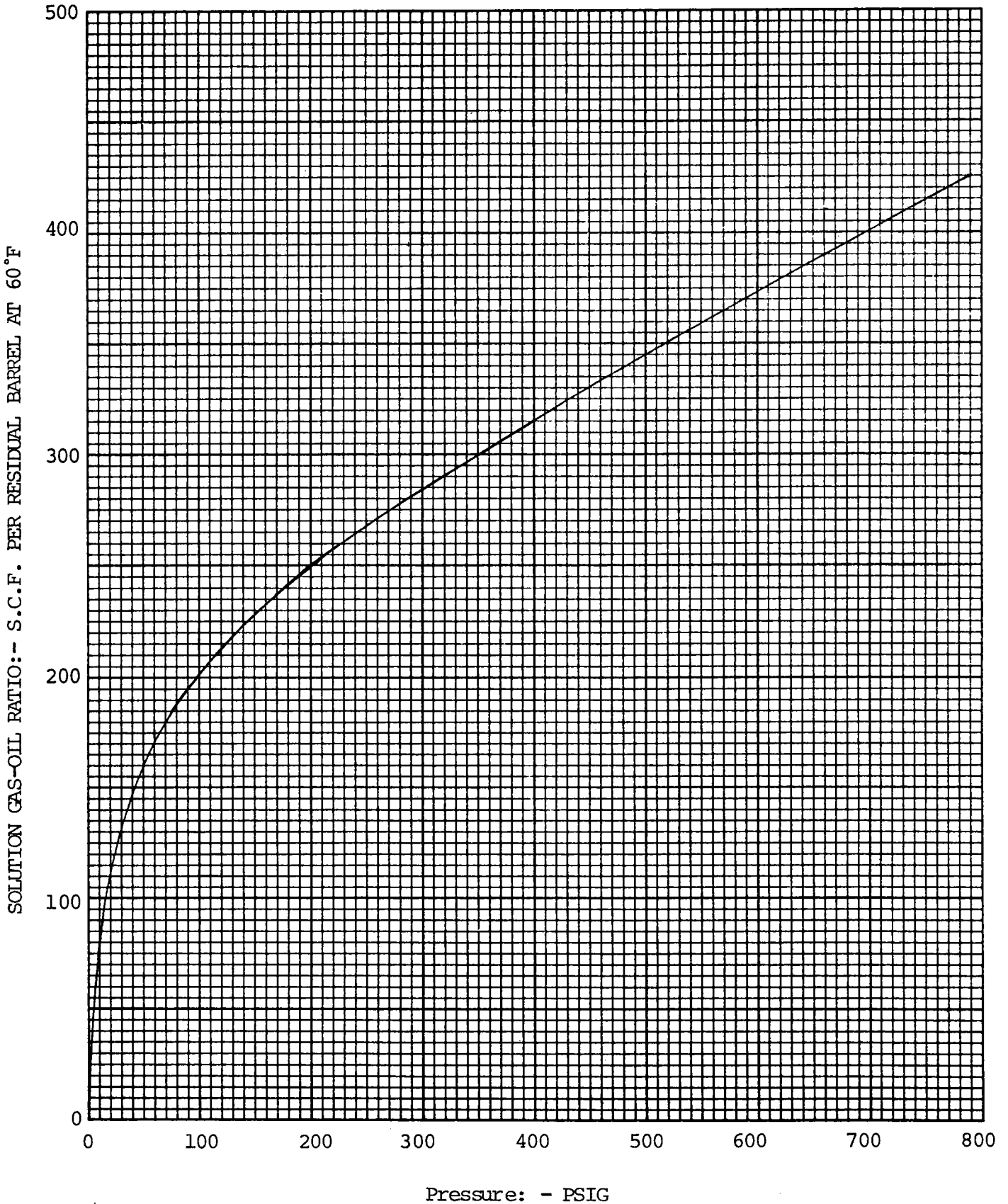
<u>Separator Conditions:</u>	<u>50 PSIG at 61°F.</u>		<u>150 PSIG at 61°F.</u>		<u>250 PSIG at 61°F.</u>		<u>450 PSIG @ 61°F.</u>	
<u>Component</u>	<u>Mol Percent</u>	<u>GPM</u>	<u>Mol Percent</u>	<u>GPM</u>	<u>Mol Percent</u>	<u>GPM</u>	<u>Mol Percent</u>	<u>GPM</u>
Carbon Dioxide	0.74		0.76		0.70		0.52	
Nitrogen	0.06		0.13		0.18		0.49	
Methane	63.31		78.02		84.42		88.50	
Ethane	13.77	3.673	10.40	2.774	7.74	2.065	5.58	1.488
Propane	14.59	4.004	7.45	2.045	4.80	1.318	3.38	0.928
iso-Butane	1.97	0.643	0.93	0.303	0.61	0.199	0.40	0.131
n-Butane	3.56	1.119	1.49	0.469	1.01	0.318	0.72	0.226
iso-Pentane	0.77	0.281	0.33	0.121	0.22	0.080	0.17	0.062
n-Pentane	0.72	0.260	0.27	0.098	0.18	0.065	0.13	0.047
Hexanes	0.31	0.126	0.14	0.057	0.09	0.037	0.07	0.029
Heptanes plus	0.20	0.091	0.08	0.036	0.05	0.023	0.04	0.018
	<u>100.00</u>	<u>10.197</u>	<u>100.00</u>	<u>5.903</u>	<u>100.00</u>	<u>4.105</u>	<u>100.00</u>	<u>2.929</u>
Calculated gas gravity: (air = 1.000)	0.892		0.737		0.680		0.646	
Calculated gross heating value (BTU per cubic foot of dry gas at 14.7 psia and 60°F):	1516		1274		1186		1132	

Disse analysene, eller tolkningene baseres på observasjoner og materiell skaffet til veie av klienter, som denne rapporten eksklusivt og fortrolig er laget for. Det utførte arbeidet representerer de beste tolkninger Core Laboratories Norsk er i stand til å gi, (med forbehold om feil og uteløst). Likevel frasier Core Laboratories Norsk og deres personell seg all ansvar og gir derfor ingen overslag på grunnlag av disse data, som f.eks produktivitet, aktuelle operasjoner, og lønnsomhet fra en hver olje, gass eller mineral brønn eller sand, som en slik rapport er basert på.

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DIFFERENTIAL VAPOURIZATION OF RESERVOIR FLUID AT 149°F

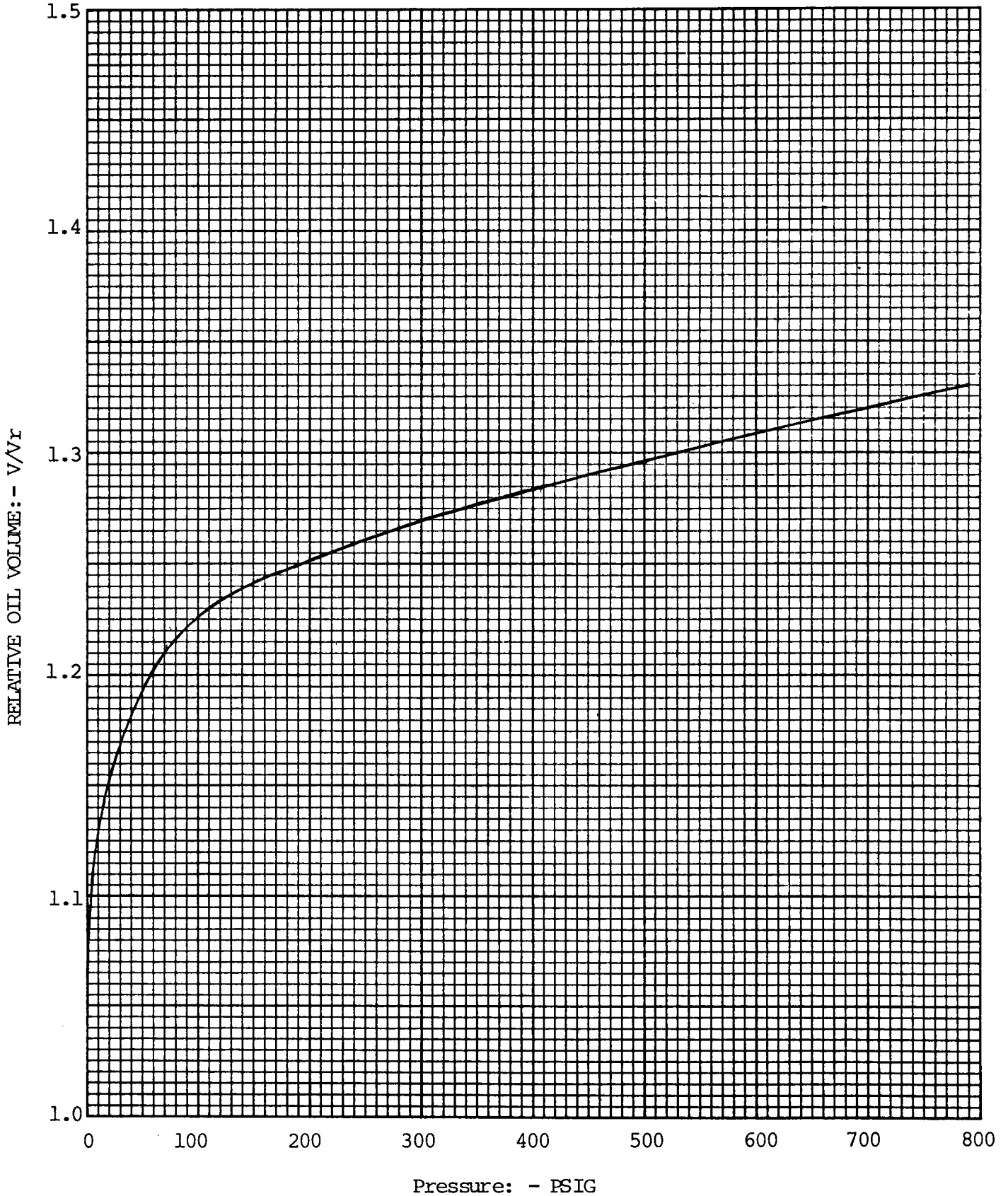
Company A/S Norske Shell Formation _____
Well 6407/9-1 Province Norwegian Sea
Field _____ Country Norway



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DIFFERENTIAL VAPOURIZATION OF RESERVOIR FLUID AT 149°F

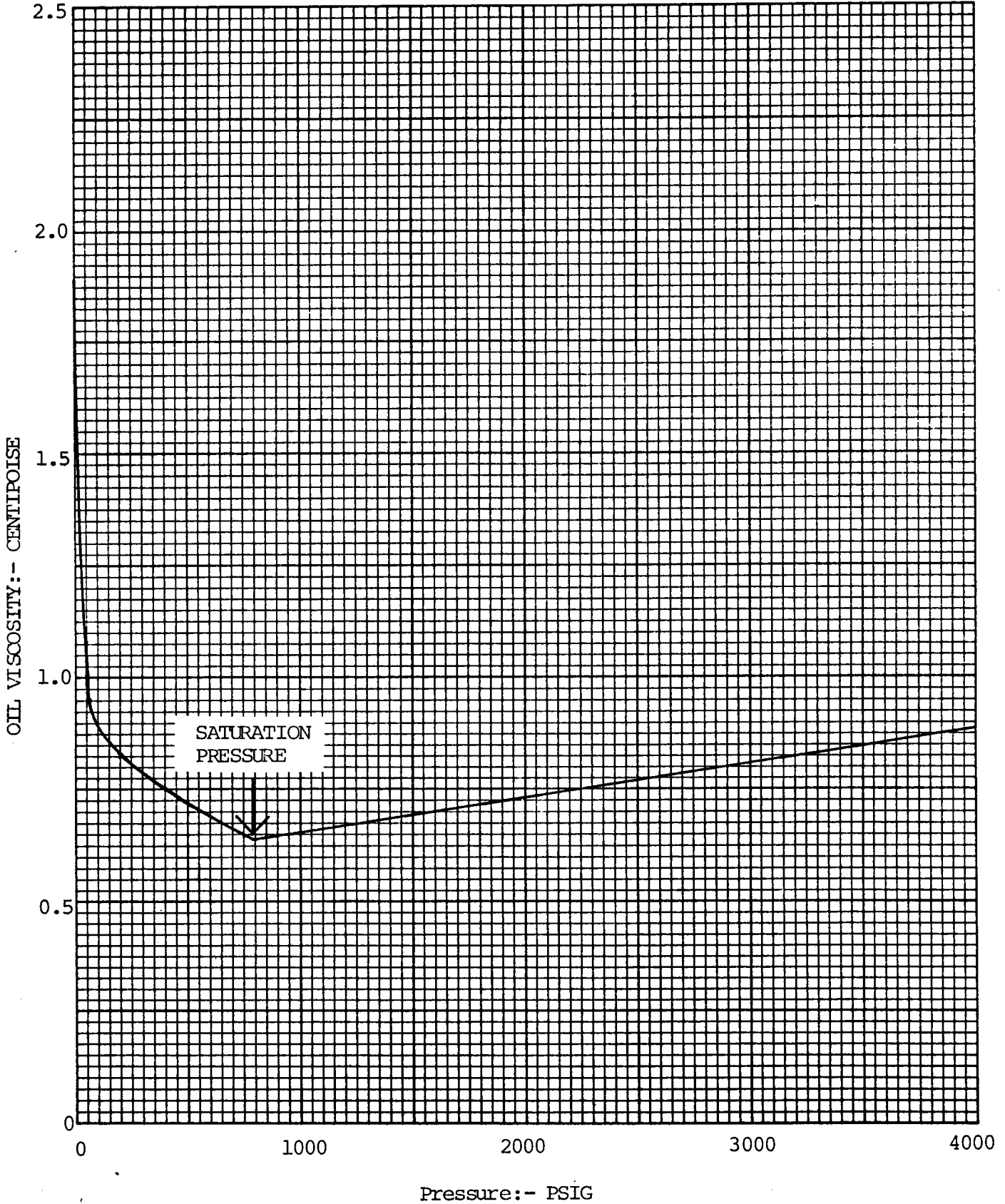
Company A/S Norske Shell Formation _____
Well 6407/9-1 Province Norwegian Sea
Field _____ Country Norway



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VISCOSITY OF RESERVOIR FLUID AT 149°F

Company A/S Norske Shell Formation _____
Well 6407/9-1 Province Norwegian Sea
Field _____ Country Norway

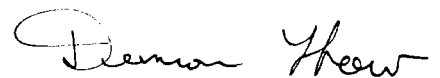


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Well: 6407/9-1

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Core Laboratories Norsk
Reservoir Fluid Laboratory



Duncan Thow
Operations Supervisor