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Petroleum Reservoir Engineering  
ABERDEEN, SCOTLAND

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RESERVOIR FLUID STUDY

for

B.P. Petroleum Development Limited

Well: 7/12-6 DST 2

North Sea, Norway.

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*Petroleum Reservoir Engineering*  
ABERDEEN, SCOTLAND

12th October 1981

B.P. Petroleum Development Limited  
Sorflateveien 11  
P.O. Box 3077  
Mariero  
4001 Stavanger  
Norway

Subject: Reservoir Fluid Study  
Well: 7/12-6 DST 2  
Field: Ula  
North Sea, Norway.  
Our File Number:  
RFLA 81169

Attention: Mr. T. N. D. Hares.

Gentlemen,

On the 16th July 1981 samples of single phase reservoir fluid were collected from the subject well and forwarded to our Aberdeen laboratory for analysis. The results of these analyses as requested by a representative of B.P. Petroleum Development Limited are presented in the following report.

Prior to analysis the room temperature bubble point pressures of the three samples were determined as 1552 psig, 1547 psig and 1562 psig for cylinders 9214-377, 9214-179 and 9214-168. Since these figures were in good agreement, the samples were blended and the resulting fluid used for the entire study.

The hydrocarbon composition of the reservoir fluid though nonanes was determined by the use of both low and high temperature fractional distillation. This composition may be found on page two.

A portion of reservoir fluid was placed in a high pressure visual cell and pressure-volume relations performed at the requested temperatures of 60°F, 180°F and 290°F. During these tests bubble point pressures of 1554 psig, 2019 psig and 2334 psig respectively were observed. The results of the pressure-volume relations and the associated compressibility data may be found on pages three through eight.

A large volume of the fluid was then subjected to differential vaporization at the reservoir temperature of 290°F resulting in the liberation of a total of 882 standard cubic feet of gas per barrel of residual oil with an associated relative oil volume of 1.728 barrels of saturated oil per barrel of residual oil. The test was performed over a series of eleven steps during which oil density, gas gravity and gas deviation factor were monitored. These data are presented on page nine.

The viscosity of the reservoir fluid was determined over the full range of pressures in a rolling ball viscosimeter. The viscosity ranged from a minimum 0.224 centipoise at saturation pressure to a maximum of 1.037 centipoise at atmospheric pressure. These data are presented on page twelve. The gas viscosity data was calculated using the correlation of Burrows and Edwards.

Continued Over/.....

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A single stage flash separation test was performed at zero psig and 60°F and the oil and gas collected and analysed for hydrocarbon composition. The factors and data derived from this test may be found on page fourteen.

The hydrocarbon composition of the separator gas to decanes plus was determined by gas chromatography. The hydrocarbon composition of the separator liquid to decanes plus was determined by both low and high temperature fractional distillation.

Utilising the experimentally determined hydrocarbon compositions of the separator products in conjunction with the measured gas-oil ratio, a wellstream composition was calculated. These compositions are presented on page fifteen.

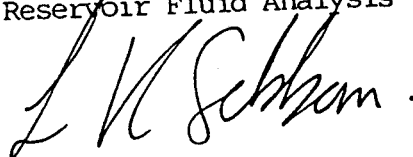
At conditions specified by B.P. Petroleum Development Limited two multistage flash separations were performed in the laboratory. The factors and data derived from these tests may be found on pages sixteen and eighteen.

The gas evolved at each stage of separation was collected and analysed for hydrocarbon composition. These data may be found on pages seventeen and nineteen.

It has been a pleasure to be of service to B.P. Petroleum Development Limited. 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/STB  
15cc/Addressee



ADDENDUM

Following are the correlations used in the attached report.

- A) Pages 4, 6, 8. "Y" Function is calculated internally by the computer based on the actual volumes measured by the mercury pump. Thus, using the relative volume figures there will still be some variations to the "Y" data quoted.
- B) Page 9. Calculation of Bg (Gas formation volume factor). The following equation is used by the computer to calculate these data:

For each pressure

$$Bg = \frac{\text{Reservoir temp } (^{\circ}R) \times \text{atmospheric pressure} \times \text{compressibility}}{520 (^{\circ}R) \times \text{Pressure (Psia)}}$$

i.e. Rearrangement of  $\frac{P_1 V_1}{T_1 Z_1} = \frac{P_2 V_2}{T_2 Z_2}$  to give  $\frac{P_2 T_1 Z_1}{P_1 T_2} = \frac{V_1}{V_2} = Bg$

- C) Gas Viscosity - calculated using the correlation of Burrows and Edwards which utilises the gas compressibility, gas gravity, absolute pressure and reservoir temperature.



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Company B.P. Petroleum Development Ltd Formation Ula

Well 7/12-6 DST 2 County North Sea

Field Ula State Norway

HYDROCARBON ANALYSIS OF RESERVOIR FLUID SAMPLE

COMPONENT	MOL PERCENT	WEIGHT PERCENT	DENSITY	API	MOL WEIGHT
Hydrogen Sulfide	NIL	NIL			
Carbon Dioxide	1.16	0.48			
Nitrogen	1.92	0.51			
Methane	29.03	4.42			
Ethane	7.24	2.07			
Propane	6.92	2.90			
iso-Butane	1.30	0.71			
n-Butane	4.79	2.64			
iso-Pentane	1.88	1.29			
n-Pentane	3.30	2.26			
Hexanes	3.52	2.88			
Heptanes	4.45	4.18	0.7232	64.0	99
Octanes	5.13	5.12	0.7434	58.7	105
Nonanes	3.60	4.04	0.7639	53.6	119
Decanes plus	25.76	66.50	0.8644	32.0	272
	<u>100.00</u>	<u>100.00</u>			

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VOLUMETRIC DATA OF RESERVOIR FLUID SAMPLE

1. Saturation pressure (bubble-point pressure) 1554 PSIG @ 60 °F.
2. Thermal expansion of saturated oil @ 5000 PSIG =  $\frac{V @ 60 \text{ } ^\circ\text{F.}}{V @ 60 \text{ } ^\circ\text{F.}} = \underline{1.00000}$
3. Compressibility of saturated oil @ reservoir temperature: Vol/Vol/PSI:  
From 8000 PSIG to 6000 PSIG =  $5.42 \times 10^{-6}$   
From 6000 PSIG to 4000 PSIG =  $6.20 \times 10^{-6}$   
From 4000 PSIG to 2000 PSIG =  $7.25 \times 10^{-6}$   
From 2000 PSIG to 1554 PSIG =  $8.23 \times 10^{-6}$

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PRESSURE-VOLUME RELATIONS AT 60°F.

<u>Pressure</u> <u>PSIG</u>	<u>Relative</u> <u>Volume(1)</u>	<u>Y</u> <u>Function(2)</u>
8000	0.9592	
7000	0.9643	
6000	0.9697	
5000	0.9755	
4000	0.9819	
3000	0.9888	
2000	0.9963	
1900	0.9972	
1800	0.9980	
1700	0.9988	
1600	0.9966	
<u>1554</u> Saturation Pressure	1.0000	
1522	1.0059	3.520
1439	1.0232	3.408
1389	1.0351	3.351
1309	1.0571	3.241
1187	1.0990	3.085
1046	1.1651	2.900
917	1.2503	2.731
791	1.3658	2.588
696	1.4957	2.434
624	1.6257	2.326
549	1.7990	2.230
480	2.0157	2.136
384	2.4556	2.015
299	3.1063	1.898
219	4.1962	1.785

(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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VOLUMETRIC DATA OF RESERVOIR FLUID SAMPLE

1. Saturation pressure (bubble-point pressure) 2019 PSIG @ 180 °F.

2. Thermal expansion of saturated oil @ 5000 PSIG =  $\frac{V @ 180 \text{ } ^\circ\text{F.}}{V @ 60 \text{ } ^\circ\text{F.}} = \underline{1.06761}$

3. Compressibility of saturated oil @ reservoir temperature: Vol/Vol/PSI:

From 8000 PSIG to 6000 PSIG = 7.61 x 10<sup>-6</sup>

From 6000 PSIG to 4000 PSIG = 9.20 x 10<sup>-6</sup>

From 4000 PSIG to 2019 PSIG = 11.50 x 10<sup>-6</sup>

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PRESSURE-VOLUME RELATIONS AT 180°F.

<u>Pressure</u> <u>PSIG</u>	<u>Relative</u> <u>Volume(1)</u>	<u>Y</u> <u>Function(2)</u>
8000	0.9446	
7000	0.9517	
6000	0.9592	
5000	0.9677	
4000	0.9772	
3000	0.9877	
2500	0.9938	
2400	0.9950	
2300	0.9963	
2200	0.9976	
2100	0.9989	
<u>2019</u> Saturation Pressure	1.0000	
1991	1.0047	2.979
1945	1.0128	2.942
1894	1.0226	2.902
1840	1.0336	2.870
1714	1.0634	2.781
1576	1.1039	2.681
1415	1.1646	2.567
1255	1.2457	2.448
1062	1.3676	2.323
958	1.4899	2.226
833	1.6528	2.142
720	1.8566	2.063
570	2.2677	1.954
442	2.8799	1.836
325	3.9047	1.715

(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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VOLUMETRIC DATA OF RESERVOIR FLUID SAMPLE

1. Saturation pressure (bubble-point pressure) 2334 PSIG @ 290 °F.
2. Specific volume at saturation pressure = 0.02465 at 290 °F.  
 $\frac{V @ 290 \text{ °F.}}{V @ 60 \text{ °F.}} = 1.14040$
3. Thermal expansion of saturated oil @ 5000 PSIG =  $\frac{V @ 290 \text{ °F.}}{V @ 60 \text{ °F.}} = 1.14040$
4. Compressibility of saturated oil @ reservoir temperature: Vol/Vol/PSI:  
From 8000 PSIG to 6000 PSIG = 10.26 x 10<sup>-6</sup>  
From 6000 PSIG to 4000 PSIG = 13.44 x 10<sup>-6</sup>  
From 4000 PSIG to 3000 PSIG = 17.74 x 10<sup>-6</sup>  
From 3000 PSIG to 2334 PSIG = 20.22 x 10<sup>-6</sup>

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PRESSURE-VOLUME RELATIONS AT 290°F.

<u>Pressure</u> <u>PSIG</u>	<u>Relative</u> <u>Volume(1)</u>	<u>Y</u> <u>Function(2)</u>
8000	0.9236	
7000	0.9326	
6000	0.9430	
5000	0.9550	
4000	0.9690	
3000	0.9865	
2800	0.9903	
2700	0.9924	
2600	0.9944	
2500	0.9965	
2400	0.9988	
<u>2334</u> Saturation Pressure	1.0000	
2296	1.0065	2.522
2247	1.0154	2.502
2154	1.0337	2.464
2029	1.0619	2.412
1889	1.0997	2.345
1720	1.1564	2.263
1543	1.2322	2.187
1376	1.3271	2.106
1223	1.4411	2.034
1070	1.5933	1.964
931	1.7837	1.893
740	2.1724	1.801
578	2.7443	1.698
429	3.6955	1.592

*to 7115*  $\frac{V}{V_{sat}} = 0.9316$

- (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 VAPORIZATION AT 290°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>
2334	882	1.728	1.728	0.6499			
2200	841	1.705	1.768	0.6541	0.916	0.00879	0.903
1900	748	1.652	1.894	0.6643	0.912	0.01012	0.900
1600	660	1.602	2.078	0.6739	0.914	0.01202	0.902
1300	575	1.554	2.367	0.6840	0.921	0.01489	0.913
1000	492	1.507	2.864	0.6941	0.933	0.01953	0.940
700	409	1.458	3.831	0.7048	0.948	0.02817	1.001
400	317	1.401	6.388	0.7175	0.968	0.04956	1.133
220	236	1.353	11.557	0.7255	0.981	0.08869	1.332
130	193	1.317	19.081	0.7344	0.988	0.14476	1.656
87	162	1.285	27.781	0.7416	0.992	0.20662	1.920
0	0	1.111		0.7694			2.772

At 60°F = 1.000

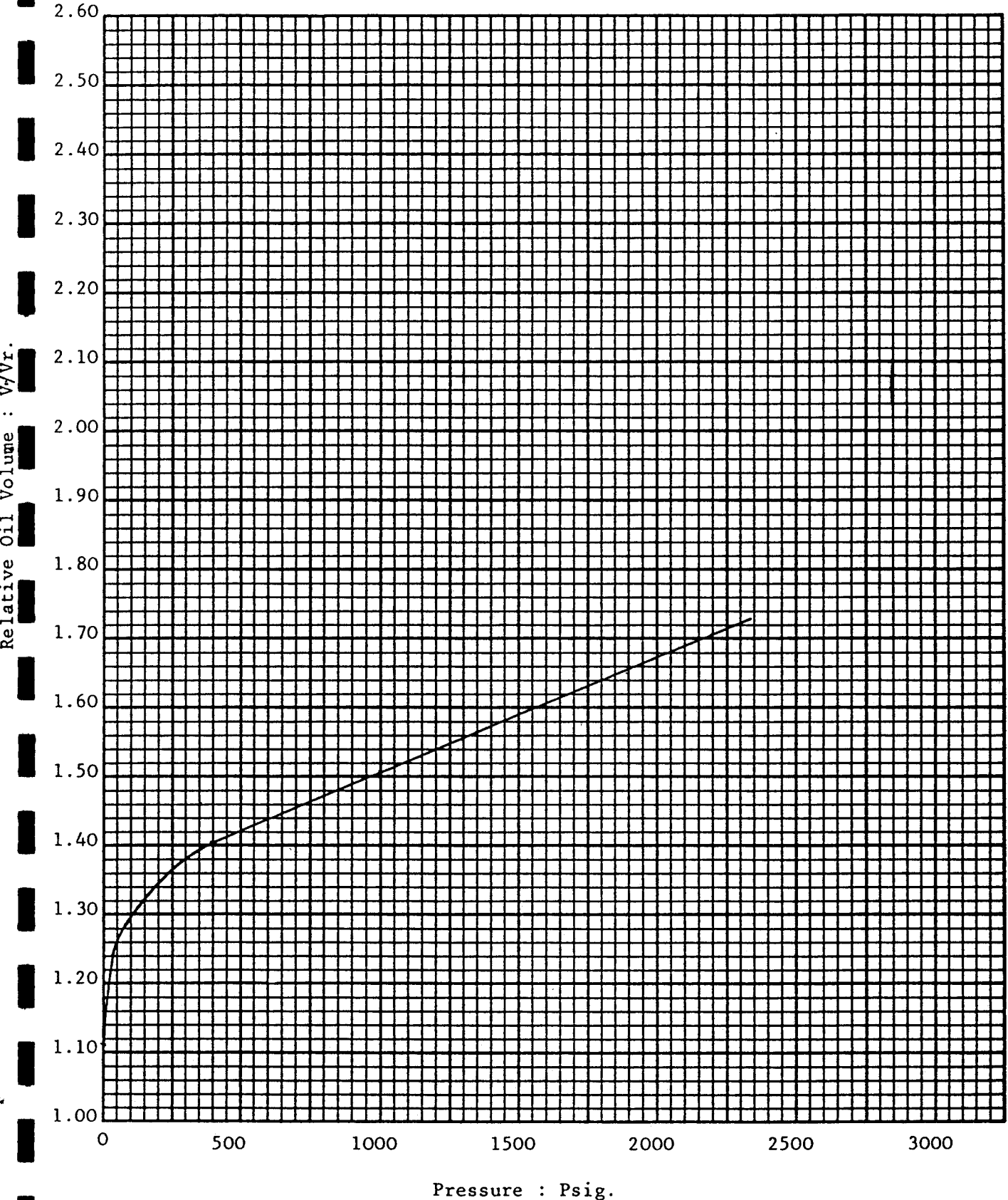
Gravity of Residual Oil = 33.9°API at 60°F.

- (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 290°F.

Company	B.P. Petroleum Development Ltd	Formation	Ula
Well	7/12-6 DST 2	County	North Sea
Field	Ula	State	Norway



Differential Vaporisation of Reservoir Fluid at 290°F.

Company B.P. Petroleum Development Ltd Formation Ula  
Well 7/12-6 DST 2 County North Sea  
Field Ula State Norway



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Well 7/12-6 DST 2

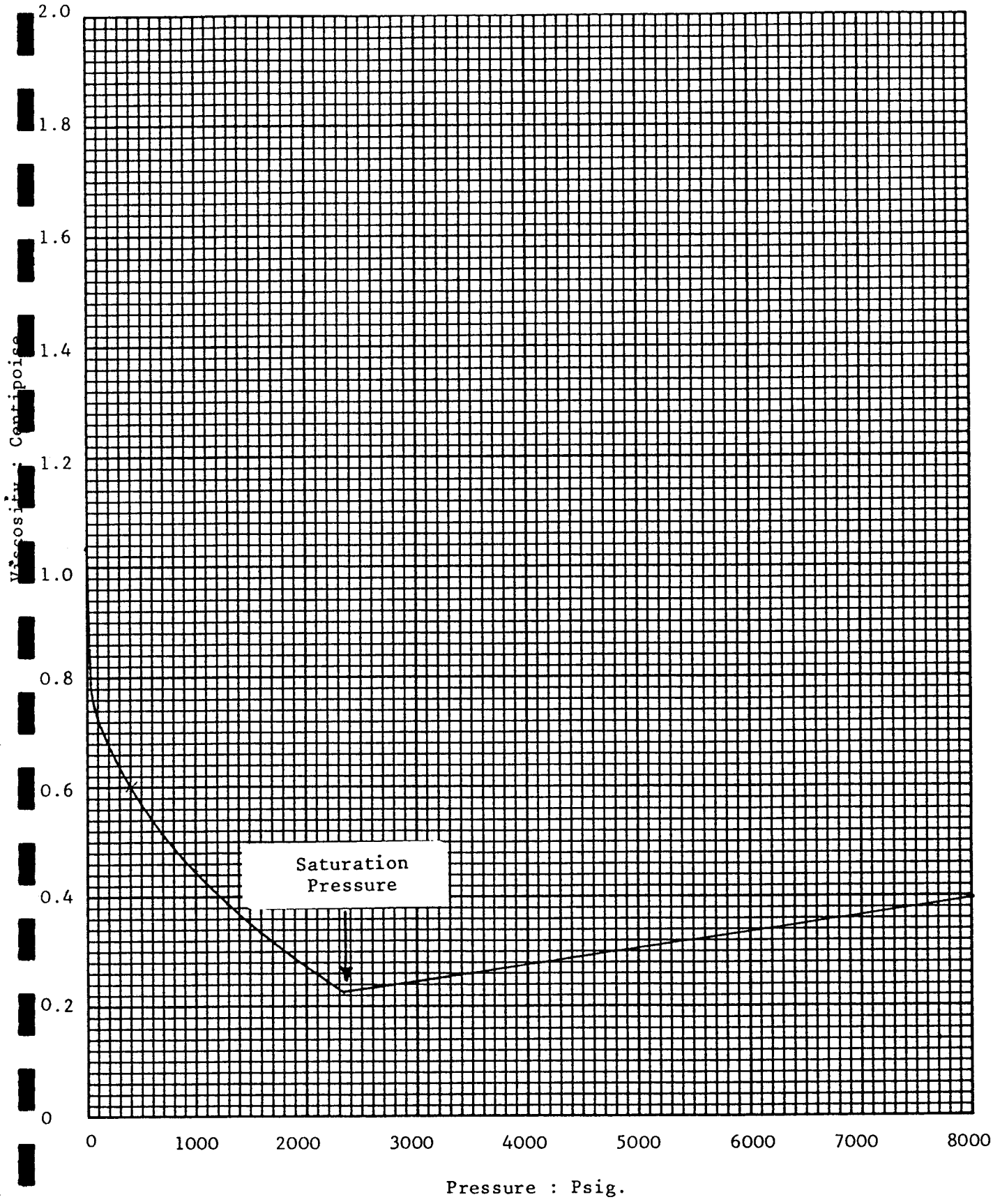
VISCOSITY DATA AT 290°F.

<u>Pressure PSIG</u>	<u>Oil Viscosity Centipoise</u>	<u>Calculated Gas Viscosity Centipoise</u>	<u>Oil/Gas Viscosity Ratio</u>
8000	0.395		
7000	0.365		
6000	0.335		
5000	0.305		
4000	0.275		
3000	0.245		
2600	0.233		
<u>2334</u> Saturation Pressure	0.224		
2200	0.242	0.0189	12.80
1900	0.288	0.0179	16.09
1600	0.334	0.0170	19.65
1300	0.385	0.0161	23.91
1000	0.445	0.0153	29.08
700	0.515	0.0144	35.76
400	0.600	0.0134	44.78
220	0.668	0.0124	53.87
120	0.710	0.0113	62.83
87	0.742	0.0106	70.00
0	1.037		



Viscosity of Reservoir Fluid at 290°F.

Company B.P. Petroleum Development Ltd Formation Ula  
Well 7/12-6 DST 2 County North Sea  
Field Ula State Norway



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SINGLE STAGE FLASH OF RESERVOIR FLUID SAMPLE

Separator Pressure, I Gauge	Separator Temperature °F.	Separator Gas/Oil Ratio(1)	Stock Tank Gas/Oil Ratio(1)	Stock Tank Gravity °API @ 60°F.	Shrinkage Factor, Vr/Vsat(2)	Formation Volume Factor Vsat/Vr(3)	Specific Gravity of Flashed Gas
0	60	672		38.8*	0.661	1.513	0.998+

\* Oil collected and analysed for hydrocarbon composition.

+ Gas collected and analysed for hydrocarbon composition.

- (1) Separator and Stock Tank Gas/Oil Ratio in cubic feet of gas at 14.73 psia and 60°F. per barrel of stock tank oil at 60°F.
- (2) Shrinkage Factor: Vr/Vsat is barrels of stock tank oil at 60°F. per barrel of saturated oil at 2334 psig and 290°F.
- (3) Formation Volume Factor: Vsat/Vr is barrels of saturated oil at 2334 psig and 290°F. per barrel of stock tank oil at 60°F.

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HYDROCARBON ANALYSES OF SEPARATOR PRODUCTS AND CALCULATED WELLSTREAM

Component	Separator Liquid	Separator Gas		Wellstream
	Mol Percent	Mol Percent	GPM	Mol Percent
Hydrogen Sulphide	NIL	NIL		NIL
Carbon Dioxide	0.02	2.26		1.22
Nitrogen	0.01	3.38		1.82
Methane	0.48	55.93		30.23
Ethane	0.63	13.53		7.55
Propane	2.01	11.83	3.254	7.28
iso-Butane	0.78	1.88	0.615	1.37
n-Butane	3.30	5.99	1.888	4.74
iso-Pentane	2.14	1.40	0.512	1.74
n-Pentane	4.40	1.92	0.695	3.07
Hexanes	5.63	1.21	0.494	3.26
Heptanes	8.27	0.46	)	4.08
Octanes	10.12	0.10	) 0.304	4.74
Nonanes	7.57	0.06	)	3.54
Decanes plus	54.64	0.05	)	25.36
	<u>100.00</u>	<u>100.00</u>	<u>7.762</u>	<u>100.00</u>

Properties of Decanes Plus

API gravity @ 60°F.	<u>32.0</u>	
Specific gravity @ 60/60°F	<u>0.8642</u>	<u>0.864</u>
Molecular Weight	<u>272</u>	<u>272</u>

Calculated separator gas gravity (air=1.000) = 0.998  
 Calculated gross heating value for separator gas = 1590 BTU  
 per cubic foot of dry gas @ 14.73 psia and 60°F.

Primary separator gas collected @ 0 psig and 60 °F.  
 Primary separator liquid collected @ 0 psig and 60 °F.

Primary separator gas/separator liquid ratio 672 SCF/Bbl @ 60°F.

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Well 7/12-6 DST 2

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
520	255	399	475			1.190	0.917*
to 140	215	89	102			1.150	1.078*
to 30	195	52	57			1.099	1.500*
to 0	60	7	7	39.6	1.469	1.000	+

\* Gas collected and analysed for hydrocarbon composition.

+ Insufficient gas for analysis.

- (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 2334 psig and 290°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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Well 7/12-6 DST 2

HYDROCARBON ANALYSES OF SEPARATOR GAS SAMPLES

Separator Conditions:    520 PSIG @ 255°F.    140 PSIG @ 215°F.    30 PSIG @ 195°F.

<u>Component</u>	<u>Mol Percent</u>	<u>GPM</u>	<u>Mol Percent</u>	<u>GPM</u>	<u>Mol Percent</u>	<u>GPM</u>
Hydrogen Sulfide	NIL		NIL		NIL	
Carbon Dioxide	2.28		2.32		1.49	
Nitrogen	4.63		1.69		0.36	
Methane	62.79		49.08		20.86	
Ethane	12.19		17.22		18.95	
Propane	8.47	2.330	14.57	4.008	25.21	6.935
iso-Butane	1.20	0.392	2.11	0.690	4.38	1.432
n-Butane	3.75	1.182	6.52	2.055	14.25	4.490
iso-Pentane	0.93	0.340	1.56	0.571	3.54	1.295
n-Pentane	1.43	0.518	2.32	0.840	5.20	1.883
Hexanes	1.06	0.432	1.48	0.604	2.97	1.211
Heptanes	0.83	)	0.70	)	1.95	)
Octanes	0.34	)	0.22	)	0.63	)
Nonanes	0.07	) 0.577	0.07	) 0.513	0.10	) 1.262
Decanes plus	0.03	)	0.14	)	0.11	)
	<u>100.00</u>	<u>5.771</u>	<u>100.00</u>	<u>9.281</u>	<u>100.00</u>	<u>18.508</u>

Calculated gas gravity (Air=1.000):                      0.917                      1.078                      1.500

Calculated gross heating value (BTU per cubic foot of dry gas at 14.73 psia and 60°F.):                      1444                      1741                      2441

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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
520	255	400	476			1.191	0.919*
to 125	160	79	86			1.091	0.981*
to 0	60	53	53	40.5	1.441	1.000	1.315*

\* 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 2334 psig and 290°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

Separator Conditions:    520 PSIG @ 255°F.    125 PSIG @ 160°F.    0 PSIG @ 60°F.

<u>Component</u>	<u>Mol Percent</u>	<u>GPM</u>	<u>Mol Percent</u>	<u>GPM</u>	<u>Mol Percent</u>	<u>GPM</u>
Hydrogen Sulfide	NIL		NIL		NIL	
Carbon Dioxide	2.26		2.53		1.79	
Nitrogen	4.64		1.98		0.03	
Methane	62.72		56.23		28.65	
Ethane	12.11		16.51		21.54	
Propane	8.47	2.330	11.78	3.241	25.35	6.974
iso-Butane	1.20	0.392	1.54	0.504	3.75	1.226
n-Butane	3.83	1.207	4.62	1.456	10.87	3.425
iso-Pentane	0.96	0.351	1.03	0.377	2.12	0.776
n-Pentane	1.48	0.536	1.51	0.547	2.67	0.967
Hexanes	1.07	0.436	0.98	0.400	1.45	0.591
Heptanes	0.82		0.80		1.25	
Octanes	0.34		0.34		0.26	
Nonanes	0.07	0.572	0.11	0.586	0.15	0.808
Decanes plus	0.03		0.04		0.12	
	<u>100.00</u>	<u>5.824</u>	<u>100.00</u>	<u>7.111</u>	<u>100.00</u>	<u>14.767</u>

Calculated gas gravity (Air=1.000):                      0.919                      0.981                      1.315

Calculated gross heating value (BTU per cubic foot of dry gas at 14.73 psia and 60°F.):                      1448                      1582                      2151

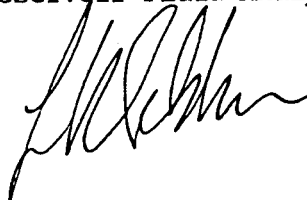
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Core Laboratories UK Limited  
Reservoir Fluid Analysis



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