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Classification

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Roald Riise

Subtitle

Compositional analysis on samples  
from well 15/9-15.

Co-workers

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**REGISTRERT**  
**OLJEDIREKTORATET**

Title

Compositional analysis for  
Statoil, well 15/9-15

**STATOIL**  
**EXPLORATION & PRODUCTION**  
**LABORATORY**

Tone Ørke

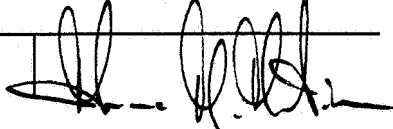
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## 1. INTRODUCTION.

This report presents compositional data on samples from well 15/9-15. Two sets of separator samples from dst no 1 and two sets of separator samples from dst no 2 were analysed for sample validity and molecular composition.

A PVT simulation is performed on the molecular composition of the reservoir fluid from dst no 2, low rate.

This report also includes data from a TBP distillation fractionated from initial boiling point to 331°C.

The separator samples from dst no 2, low rate flow, was sent to Flopetrol for a complete PVT study, including determination of dew point, liquid drop out, and differential depletion. These results will be reported separately.

After Flopetrol had finished the complete PVT study, it has been brought forward that the reservoir temperature is 106°C instead of 120°C which the complete PVT study was performed at.

A PVT simulation is therefore performed at 106°C, and the main results set up together with the experimental and simulated values at 120°C.

## 1.1 Summary and main results.

Calculated reservoir fluid composition of 15/9-15 dst 2.

Component	mole %	mol.weight*	density* (g/cm <sup>3</sup> )
Carbondioxide	0.87		
Nitrogene	0.84		
Methane	73.57		
Ethane	9.96		
Propane	6.30		
iso-Butane	0.96		
n-Butane	1.76		
iso-Pentane	0.60		
n-Pentane	0.63		
Hexanes	0.70	85	0.678
Heptanes	0.93	90	0.747
Octanes	0.95	102	0.776
Nonanes	0.48	121	0.801
Decanes+	1.45	198	0.840
	100.00		

Calculated molecular weight

of reservoir fluid from the composition: 26.49

Calculated gas gravity (air=1) : 0.915

\* Densities and molecular weights are measured values from TBP distillation. (Lab 83.04)

## 2. SAMPLE DISCRIPTION.

2.1 Separator samples from dst no 1.

Surface samples from dst no 1 were collected by Otis, at perforation depht 2880-90m.

Low rate flow

The separator samples were marked:

Oil bottle : 8207011  
Gas bottle : A-13976

Separator conditions

Pressure (barg) : 43.9  
Temperature ( $^{\circ}$ C) : 30.0  
Opening pressure of the sep. gas (barg) : 43

High rate flow

The separator samples were marked:

Oil bottle : 8207001  
Gas bottle : A-13977

Separator conditions

Pressure (barg) : 32.0  
Temperature ( $^{\circ}$ C) : 35.5  
Opening pressure of the sep. gas (barg) : 32

## 2.2 Separator samples from dst no 2

Surface samples from dst no 2 were collected at perforation depth 2830-50m.

### Low rate flow

The separator samples were marked:

Oil bottle : 0110  
Gas bottle : A-13975

Separator conditions

Pressure (barg) : 33.8  
Temperature (°C) : 18.9  
Opening pressure of the sep. gas (barg) : 33

### High rate flow

The separator samples were marked:

Oil bottle : 0217  
Gas bottle : A-13979

Separator conditions

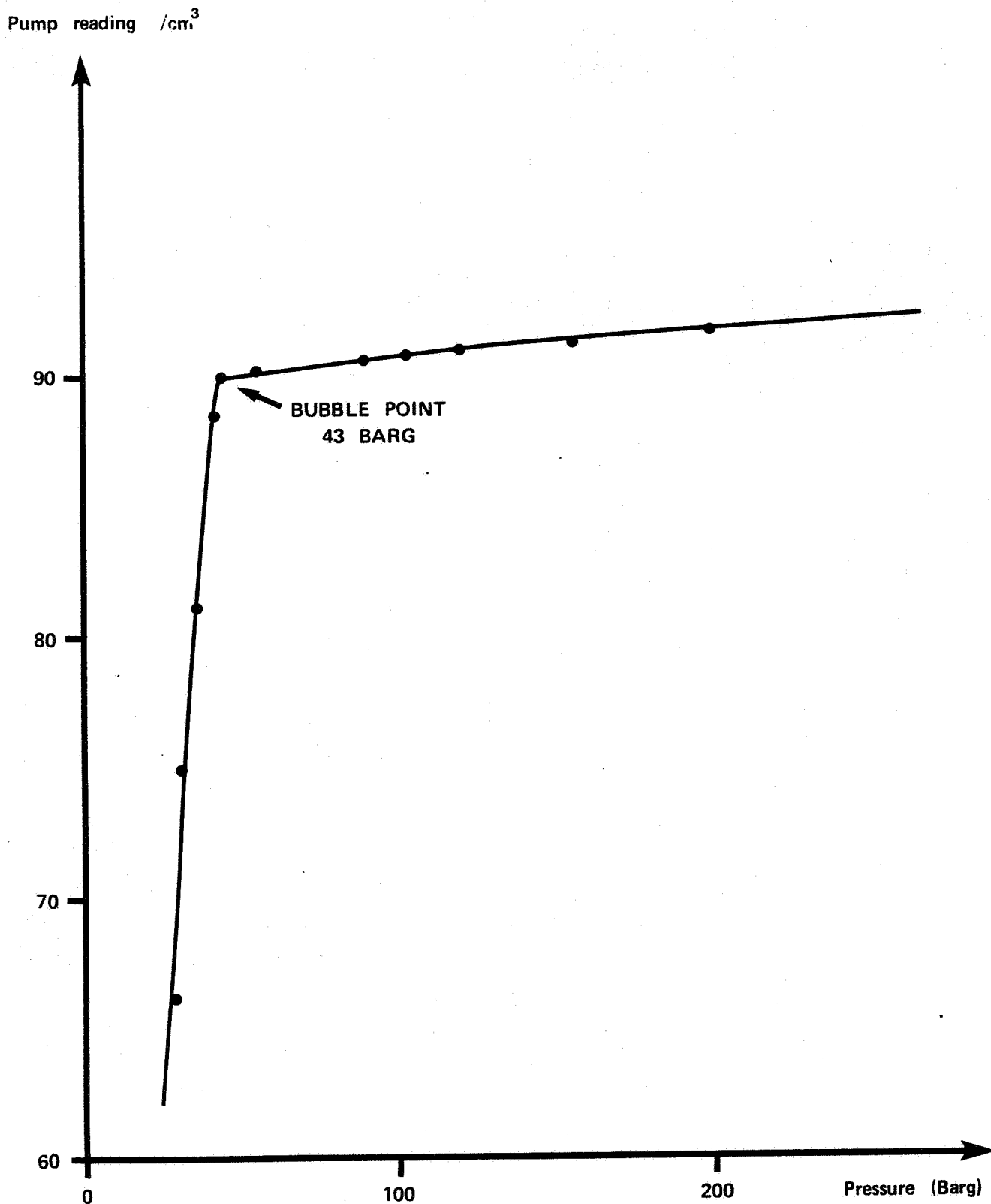
Pressure (barg) : 26.2  
Temperature (°C) : 34.4  
Opening pressure of the sep. gas (barg) : 26

3.1 Bubble point determination at 30.0°C of separator liquid from  
dst no 1, bottle no 8207011.

Pressure Barg	Pump reading cm <sup>3</sup>
200.0	91.71
155.0	91.25
119.3	90.87
104.4	90.70
90.3	90.59
55.7	90.13
43.8	89.95
43.0 (bubble point)	
41.9	88.42
36.2	81.37
32.7	75.22
28.7	66.33



**Bubble point determination at 30.0° C**  
**Separator liquid, Bottle No. 8207011**  
**15/9 - 15 DST No. 1, low rate.**



3.2 Molecular composition of separator liquid (Dst no 1, low rate)

Component	Oil		Gas	Recombined	Mol.* weight	Density* (g/cm <sup>3</sup> )
	Wt%	Mole%	Mole %	separator fluid Mole %		
Carbondioxid	-	-	0.80	0.40		
Nitrogene	-	-	0.10	0.05		
Methane	-	-	30.37	15.11		
Ethane	0.018	0.07	18.00	8.99		
Propane	0.536	1.52	25.28	13.34		
iso-Butane	0.598	1.29	5.43	3.35		
n-Butane	2.017	4.34	10.49	7.40		
iso-Pentane	2.263	3.92	3.10	3.51		
n-Pentane	2.979	5.16	2.84	4.01		
Hexanes	6.178	9.09	1.72	5.42	85	0.678
Heptanes	10.738	14.91	1.30	8.14	90	0.747
Octanes	14.376	17.63	0.50	9.11	102	0.776
Nonanes	9.605	9.92	0.05	5.01	121	0.801
Decanes+	50.692	32.15	0.02	16.16	198	0.840
	100.000	100.00	100.00	100.00		

Properties of stock tank liquid and single flash results:

Density of oil at 15°C (g/cm <sup>3</sup> )	:	0.775
Mean molecular weight of oil	:	128
GOR of separator oil (sm <sup>3</sup> /m <sup>3</sup> )	:	145.1

\* Densities and molecular weights are measured values from TBP distillation.

3.3 Molecular composition of separator samples and  
calculated reservoir fluid (DST 1, low rate)

Component	Separator liquid Mole %	Separator gas Mole %	Reservoir fluid Mole %	*Mole weight	Density* (g/cm <sup>3</sup> )
Carbondioxid	0.40	0.78	0.74		
Nitrogene	0.05	0.88	0.78		
Methane	15.11	79.84	72.23		
Ethane	8.99	10.18	10.04		
Propane	13.34	5.63	6.54		
iso-Butane	3.35	0.71	1.02		
n-Butane	7.40	1.15	1.89		
iso-Pentane	3.50	0.27	0.65		
n-Pentane	4.01	0.24	0.68		
Hexanes	5.42	0.16	0.77	85	0.678
Heptanes	8.14	0.12	1.06	90	0.747
Octanes	9.11	0.04	1.11	102	0.776
Nonanes	5.01	-	0.59	121	0.801
Decanes+	16.16	-	1.90	198	0.840
	100.00	100.00	100.00		

Separator and recombination data:

GOR at separator conditions (SM <sup>3</sup> /M <sup>3</sup> )	:	1436
Bo, (Sep M <sup>3</sup> /M <sup>3</sup> at ambient)	:	1.525
Calculated separator gas gravity (air=1.0)	:	0.714
Calculated Z factor at sep.cond.from composition	:	0.865
Calculated mol. weight of reservoir fluid from composition	:	27.89

\* Densities and molecular weights are measured values from TBP distillation.

3.4 Bubble point determination at 35.5°C of separator  
liquid from dst no 1, Bottle no 8207001

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Pressure Barg	Pump reading cm <sup>3</sup>
200.0	79.24
134.3	78.61
93.0	78.16
56.8	77.75
41.3	77.56

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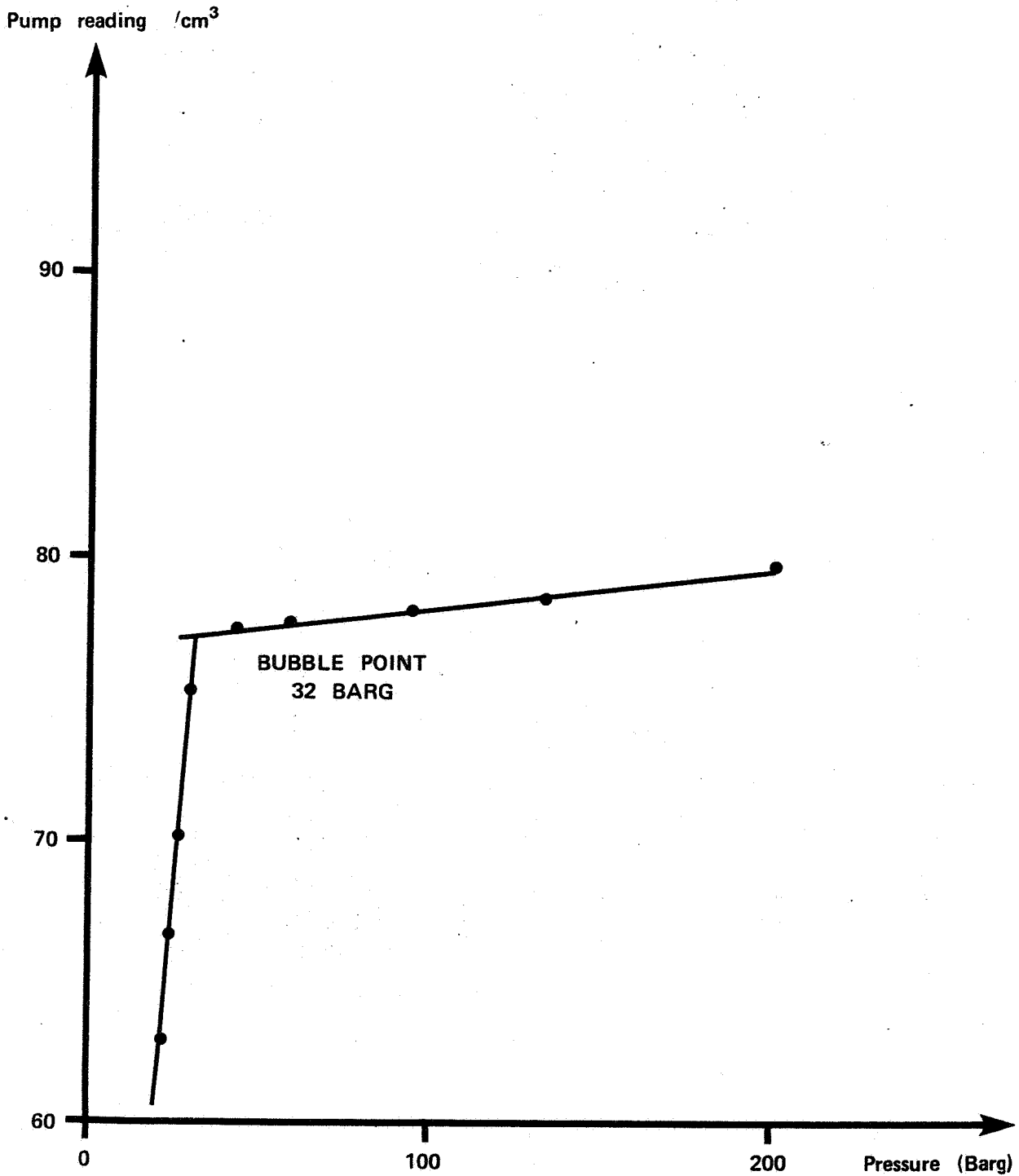
32.0 (bubble point)

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31.9	77.37
29.9	75.42
25.3	70.82
23.7	66.72
22.4	63.48

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**Bubble point determination at 35.5° C.  
Separator liquid, Bottle No. 8207001.  
15/9 - 15 DST No. 1, high rate.**



3.5 Molecular composition of separator liquid  
(DST no. 1, high rate)

Component	Oil		Gas	Recombined	Mol.* weight	Density* (g/cm <sup>3</sup> )
	Wt%	Mole%	Mole %	separator fluid Mole %		
Carbondioxid	-	-	0.74	0.26		
Nitrogene	-	-	0.06	0.02		
Methane	-	-	26.99	9.54		
Ethane	0.015	0.06	18.21	6.48		
Propane	0.538	1.50	26.86	10.48		
iso-Butane	0.622	1.32	5.84	2.92		
n-Butane	2.093	4.43	11.24	6.84		
iso-Pentane	2.333	3.98	3.29	3.73		
n-Pentane	3.068	5.23	2.99	4.44		
Hexanes	6.396	9.25	1.74	6.60	85	0.678
Heptanes	11.124	15.18	1.70	10.41	90	0.747
Octanes	15.021	18.11	0.35	11.83	102	0.776
Nonanes	10.041	10.21	0.02	6.60	121	0.801
Decanes+	48.750	30.73	-	19.87	198	0.840
	100.000	100.00	100.00	100.00		

Properties of stock tank liquid and single flash results:

Density of oil at 15°C (g/cm <sup>3</sup> )	: 0.771
Mean molecular weight of oil	: 123
GOR of separator oil (sm <sup>3</sup> /m <sup>3</sup> )	: 81.1

\* Densities and molecular weights are measured values from TBP distillation.

3.6 Molecular composition of separator samples and  
calculated reservoir fluid (DST no. 1, high rate)

Component	Separator liquid Mole %	Separator gas Mole %	Reservoir fluid Mole %	*Mole weight	Density* (g/cm <sup>3</sup> )
Carbondioxid	0.26	0.91	0.86		
Nitrogene	0.02	0.92	0.85		
Methane	9.54	80.20	74.57		
Ethane	6.48	10.20	9.90		
Propane	10.48	5.48	5.88		
iso-Butane	2.92	0.65	0.83		
n-Butane	6.84	1.03	1.50		
iso-Pentane	3.73	0.21	0.49		
n-Pentane	4.44	0.19	0.52		
Hexanes	6.60	0.10	0.62	85	0.678
Heptanes	10.41	0.08	0.90	90	0.747
Octanes	11.83	0.03	0.97	102	0.776
Nonanes	6.60	-	0.53	121	0.801
Decanes+	19.87	-	1.59	198	0.840
	100.00	100.00	100.00		

Separator and recombination data:

GOR at separator conditions (SM <sup>3</sup> /M <sup>3</sup> )	:	1996
Bo, (Sep M <sup>3</sup> /M <sup>3</sup> at ambient)	:	1.33
Calculated separator gas gravity (air=1.0)	:	0.706
Calculated Z factor at sep.cond.from composition	:	0.914
Calculated mol. weight of reservoir fluid from composition	:	26.29

\* Densities and molecular weights are measured values from TBP distillation.

3.7 Bubble point determination at 18.9°C of separator  
liquid from dst no 2, Bottle no 0110

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Pressure Barg	Pump reading cm <sup>3</sup>
207.0	38.50
162.7	35.00
105.9	30.00
76.0	27.50
50.4	25.00
37.0	23.50

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32.0 (bubble point)

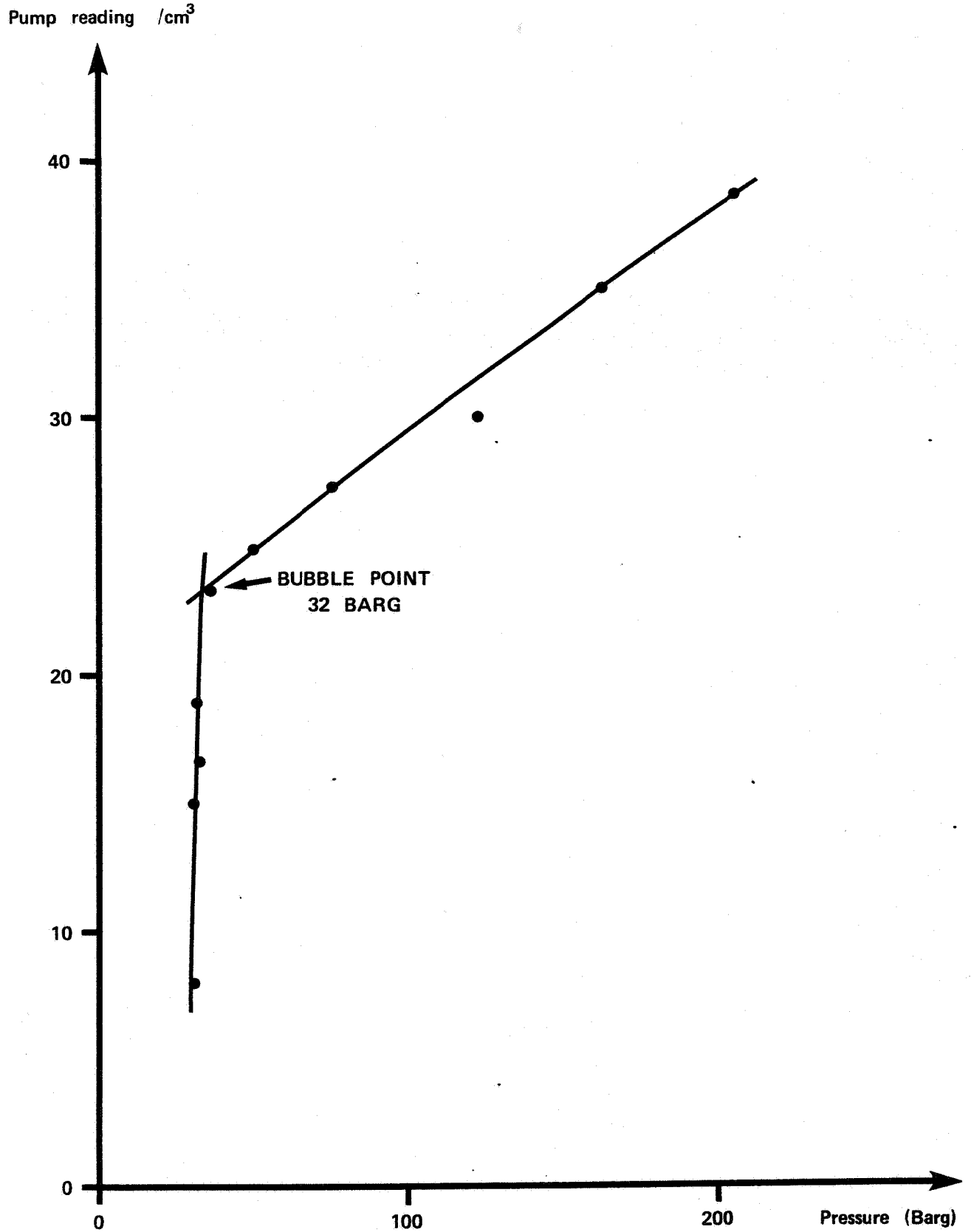
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31.9	19.00
31.6	16.50
31.5	15.00
31.2	8.00

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**Bubble point determination at 18.9° C**  
**Separator liquid Bottle No. 0110**  
**15/9 - 15 DST No. 2, low rate.**



3.8 Molecular composition of separator liquid  
(DST no. 2, low rate)

Component	Oil		Gas	Recombined	Mol.*	Density*
	Wt%	Mole%	Mole %	separator liquid Mole %		
Carbondioxid	-	-	0.85	0.39		
Nitrogene	-	-	-	-		
Methane	-	-	26.38	12.19		
Ethane	0.056	0.22	17.66	8.28		
Propane	0.971	2.62	27.14	13.95		
iso-Butane	0.879	1.80	6.00	3.74		
n-Butane	2.781	5.69	11.74	8.49		
iso-Pentane	2.789	4.60	3.41	4.05		
n-Pentane	3.612	5.96	3.19	4.68		
Hexanes	6.925	9.70	1.88	6.09	85	0.678
Heptanes	11.424	15.14	1.26	8.73	90	0.747
Octanes	14.620	17.06	0.47	9.39	102	0.776
Nonanes	9.326	9.17	0.01	4.94	121	0.801
Decanes+	46.617	28.04	0.01	15.08	198	0.840
	100.000	100.00	100.00	100.00		

Properties of stock tank liquid and single flash results:

Density of oil at 15°C (g/cm <sup>3</sup> )	: 0.776
Mean molecular weight of oil	: 119
GOR of separator oil (sm <sup>3</sup> /m <sup>3</sup> )	: 132.5

\* Densities and molecular weights are measured values from TBP distillation.

3.9 Molecular composition of separator sample  
and calculated reservoir fluid (DST no. 2, low rate)

Component	Separator liquid Mole %	Separator gas Mole %	Reservoir fluid Mole %	*Mole weight	Density* (g/cm <sup>3</sup> )
Carbondioxid	0.39	0.92	0.87		
Nitrogene	-	0.93	0.84		
Methane	12.19	80.12	73.57		
Ethane	8.28	10.14	9.96		
Propane	13.95	5.48	6.30		
iso-Butane	3.74	0.65	0.96		
n-Butane	8.49	1.05	1.76		
iso-Pentane	4.05	0.23	0.60		
n-Pentane	4.68	0.20	0.63		
Hexanes	6.09	0.12	0.70	85	0.678
Heptanes	8.73	0.10	0.93	90	0.747
Octanes	9.39	0.05	0.95	102	0.776
Nonanes	4.94	0.01	0.48	121	0.801
Decanes+	15.08	-	1.45	198	0.840
	100.00	100.00	100.00		

Separator and recombination data:

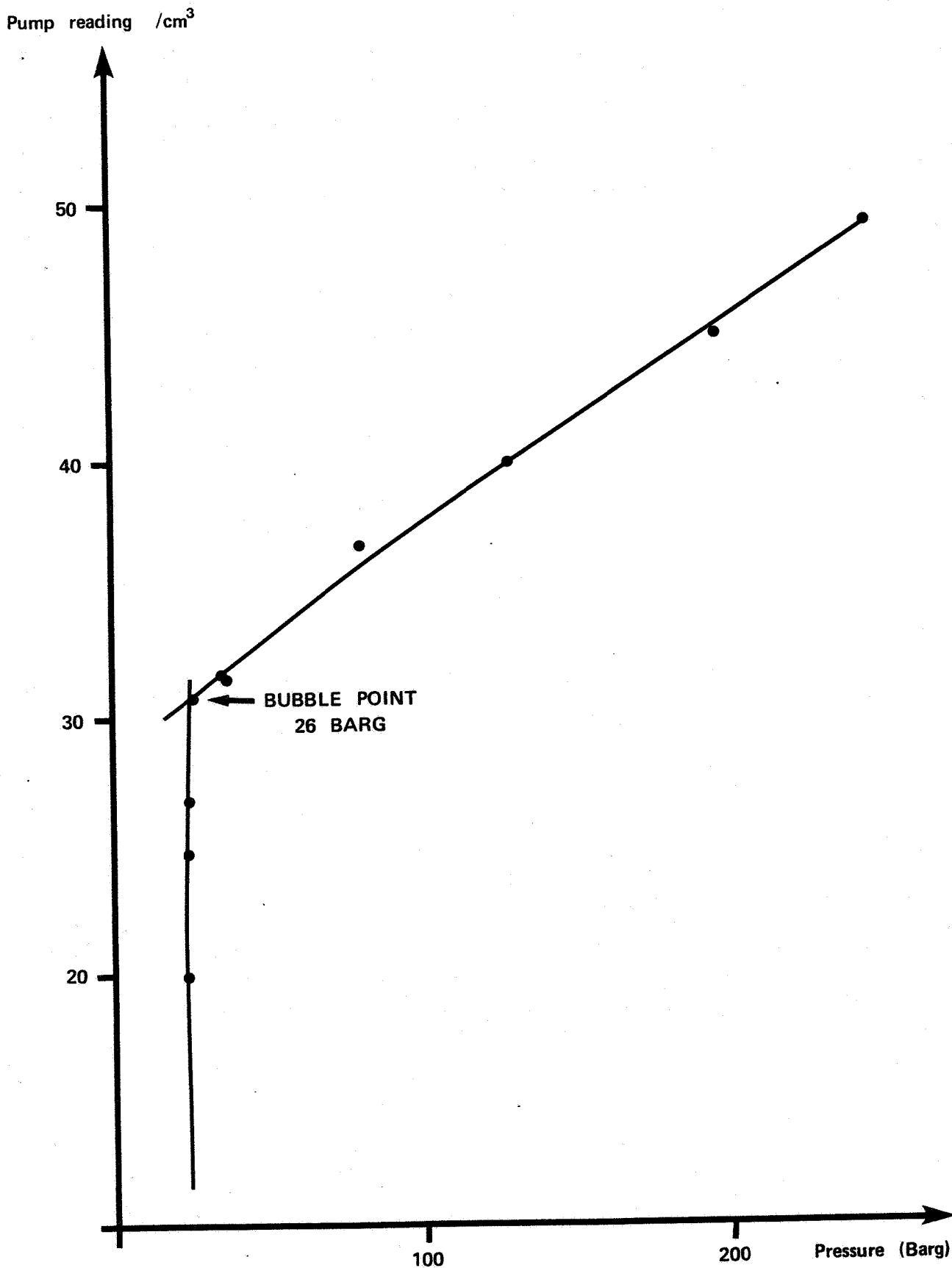
GOR at separator conditions (SM <sup>3</sup> /M <sup>3</sup> )	:	1846
Bo, (Sep M <sup>3</sup> /M <sup>3</sup> at ambient)	:	1.460
Calculated separator gas gravity (air=1.0)	:	0.709
Calculated Z factor at sep.cond.from composition	:	0.890
Calculated mol. weight of reservoir fluid from composition	:	26.49

\* Densities and molecular weights are measured values from TBP distillation.

3.10 Bubble point determination at 34.4<sup>o</sup>C of separator liquid from dst no 2, Bottle no 0217

Pressure Barg	Pump reading g/cm <sup>3</sup>
245.6	49.30
197.3	45.60
130.3	40.15
82.7	36.90
37.7	31.60
26.0 (bubble point)	
24.8	26.90
24.6	24.80
24.3	20.00

**Bubble point determination at 34.4° C**  
**Separator liquid, Bottle No. 0217**  
**15/9 - 15 DST No. 2, high rate.**



3.11 Molecular composition of separator liquid  
(DST 2, high rate)

Component	Oil		Gas	Recombined	Mol.* weight	Density* (g/cm <sup>3</sup> )
	Wt%	Mole%	Mole %	separator liquid Mole %		
Carbondioxid	-	-	0.87	0.26		
Nitrogene	-	-	0.07	0.02		
Methane	-	-	27.86	8.50		
Ethane	0.022	0.09	17.72	5.46		
Propane	0.644	1.78	26.46	9.30		
iso-Butane	0.688	1.45	5.71	2.75		
n-Butane	2.276	4.78	11.10	6.70		
iso-Pentane	2.449	4.14	3.23	3.86		
n-Pentane	3.209	5.43	3.09	4.71		
Hexanes	6.567	9.43	1.94	7.14	85	0.678
Heptanes	11.394	15.45	1.35	11.15	90	0.747
Octanes	15.301	18.31	0.55	12.90	102	0.776
Nonanes	10.063	10.14	0.04	7.07	121	0.801
Decanes+	47.387	29.00	0.01	20.18	198	0.840
	100.000	100.00	100.00	100.00		

Properties of stock tank liquid and single flash results:

Density of oil at 15°C (g/cm <sup>3</sup> )	: 0.772
Mean molecular weight of oil	: 122
GOR of separator oil (sm <sup>3</sup> /m <sup>3</sup> )	: 65.6

\* Densities and molecular weights are measured values from TBP distillation.

3.12 Molecular composition of separator sample  
and calculated reservoir fluid (DST 2, high rate)

Component	Separator liquid Mole %	Separator gas Mole %	Reservoir fluid Mole %	*Mole weight	Density* (g/cm <sup>3</sup> )
Carbondioxid	0.26	0.88	0.83		
Nitrogene	0.02	0.87	0.81		
Methane	8.50	78.30	73.20		
Ethane	5.46	10.43	10.07		
Propane	9.30	6.19	6.42		
iso-Butane	2.75	0.84	0.98		
n-Butane	6.70	1.41	1.80		
iso-Pentane	3.86	0.35	0.60		
n-Pentane	4.71	0.32	0.64		
Hexanes	7.14	0.19	0.70	85	0.678
Heptanes	11.15	0.15	0.95	90	0.747
Octanes	12.90	0.06	1.00	102	0.776
Nonanes	7.07	0.01	0.52	121	0.801
Decanes+	20.18	-	1.48	198	0.840
	100.00	100.00	100.00		

Separator and recombination data:

GOR at separator conditions (SM <sup>3</sup> /M <sup>3</sup> )	:	2204
Bo, (Sep M <sup>3</sup> /M <sup>3</sup> at ambient)	:	1.239
Calculated separator gas gravity (air=1.0)	:	0.732
Calculated Z factor at sep.cond.from composition	:	0.924
Calculated mol. weight of reservoir fluid from composition	:	26.73

\* Densities and molecular weights are measured values from TBP distillation.

3.13 Extended reservoir fluid composition  
of 15/9-15 dst no 2, low rate

Component	Mol %	Mol weight*	density* (g/cm <sup>3</sup> )
CO <sub>2</sub>	0.87		
N <sub>2</sub>	0.84		
C <sub>1</sub>	73.57		
C <sub>2</sub>	9.96		
C <sub>3</sub>	6.30		
i-C <sub>4</sub>	0.96		
n-C <sub>4</sub>	1.76		
i-C <sub>5</sub>	0.60		
n-C <sub>5</sub>	0.63		
C <sub>6</sub>	0.70	85	0.678
C <sub>7</sub>	0.93	90	0.747
C <sub>8</sub>	0.95	102	0.776
C <sub>9</sub>	0.48	121	0.801
C <sub>10</sub>	0.31	133	0.809
C <sub>11</sub>	0.18	146	0.808
C <sub>12</sub>	0.14	160	0.819
C <sub>13</sub>	0.14	176	0.840
C <sub>14</sub>	0.12	187	0.850
C <sub>15</sub>	0.11	200	0.856
C <sub>16</sub>	0.07	212	0.862
C <sub>17</sub>	0.09	230	0.844
C <sub>18</sub>	0.05	243	0.844
C <sub>19</sub>	0.04	256	0.853
<hr/>			
C <sub>20</sub> <sup>+</sup>	0.20	336	0.869

\* Densities and molecular weights are measured values from TBP distillation.



3.14 \*Simulated constant mass expansion at 120°C  
15/9-15, dst no 2.

Pressure (barg)	relative vol (vol/sat PT.vol)	Liquid vol. (% of sat PT.vol)	z factor vapor
400.0	0.915		1.096
375.0	0.946		1.061
350.0	0.981		1.028
338.3	1.000 (SATURATION POINT)		1.012
325.0	1.024	0.93	0.996
275.0	1.145	3.77	0.942
225.0	1.339	5.58	0.904
175.0	1.676	6.64	0.886
150.0	1.947	6.94	0.885
125.0	2.341	7.06	0.891
100.0	2.952	6.98	0.902
75.0	4.000	6.66	0.918
50.0	6.141	6.04	0.940

\* Simulated data, used as backup to the experimental data reported in report 83/L/011.

\*\* Sat. PT. vol. = Saturation point volume.

3.15 A summary of experimental and simulated  
PVT data for 15/9-15, dst no 2 at 120°C

	Experimental PVT data from Flopetrol	*simulated data from Statoil
Molw. reservoir fluid	26.2	26.6
Molw C10 <sup>+</sup> fraction	191	198
dew point (Barg)	343.8	338.3
z-factor at dew point	0.997	1.012
density at dew point (g/cm <sup>3</sup> )	0.277	0.272
Max liq. CM.	6.68	7.06
Max cum. produced fluid (mole)	89.33	89.32

\* Simulated data, used as backup to the experimental values reported in report 83/L/011

3.16 Experimental and simulated data for 15/9-15, dst no 2 at 120°C, and simulated data at 106°C.

	Experimental values at 120°C (Flopetrol)	Simulated values at 120°C (Statoil)	Simulated values at 106°C (Statoil)
Molw. res. fluid	26.3	26.6	26.6
Molw. C <sub>10+</sub>	191	198	198
dew point (barg)	343.8	338.3	335.5
Z-factor at dew point	0.997	1.012	0.997
density at dew point (g/cm <sup>3</sup> )	0.277	0.272	0.284
Max. liq. constant mass	6.68	7.06	8.49
Max. liq. constant volume	4.75	5.67	6.62

## 4. DISCUSSION

Separator samples from dst no 2

The calculated reservoir fluids from the two sets of separator samples, one from the low rate flow and one from the high rate flow, are almost identical in composition.

Separator samples from dst no 1

The two sets of separator samples from dst no 1, show a small difference in the calculated reservoir fluids among themselves. The reservoir fluid composition from high rate flow are however very similar to the calculated compositions from dst no 2, and it is likely to think that the difference in the reservoirfluid from the low rate is a consequence of the uncertainty in the GOR measurements on the rig, rather than an unrepresentative sample.

Experimental and simulated data for 15/9-15

The experimental PVT data from Flopetrol are in good agreement with the simulated data at 120°C.

A simulation performed at 106°C, gives only small differences in dewpoint, z-factor, and density.

The max. liquid dropout, however, is influenced by the temperature drop from 120°C to 106°C. Max liquid dropout from constant mass experiment increases with approx 16 % and max. liquid dropout at constant volume depletion increases with approx 14 % regarding to the simulated values.

An increase in max. liquid dropout is expected with decreasing temperature. The liquid dropout, however, is not a good correlation parameter and the simulated difference in liquid dropout between 120°C and 106°C is not greater than observed in experiments performed on two different sets of

separator samples from the same well, which are almost identical in reported reservoir composition.

The changes in the simulated compositions of produced well streams in the depletion study at the two different temperatures are within experimental limits of error, and are close to the experimental data reported by Flopetrol.

TBP distillation

See part two.

## 5. CONCLUSION.

The good agreement in the calculation of the reservoir fluids from dst no 1 high rate and dst 2 high rate, and lowrate flows, may be a good indication of representative samples from the structure.

The compositional analyses on separator gas and separator liquid and the calculated reservoirfluid performed by Flopetrol, are very similar to the compositional analyses performed by Statoil.

According to the good agreement between the experimental and simulated values at 120°C, and the small differences in the simulated values at 106°C and 120°C, the experimental values reported by Flopetrol (report 83/L/011) seems to be representative also for an PVT experiment performed at 106°C.

## 6. METHODS AND EQUIPMENT

6.1 PVT analysis

A single flash to standard conditions (15°C and 1 atm) was performed in a Ruska flash separator. The gas was sampled in a Ruska gasometer.

6.2 Compositional analysis

Component analyses were performed using a Hewlett Packard 5880 gas chromatographic system. For gas analysis, non hydrocarbons are determined on a porapak R 1/8" x 3 m steel column with TC detector, and hydrocarbons on chromapak Cp <sup>tm</sup> Sil 5 50 m x 0.22 mm quartz capillary column with FI detector. Oil analysis are performed on a gas chromatograph fitted with chromapak cp <sup>tm</sup> Sil 5 25 m x 0.22 mm quartz capillary column and FI detector.

Carrier gas : Helium

Over temp. profile for oil analyses : 10° (4 min)  
4°/min  
310° (200 min)

Over temp. profile for gas analysis of non hydrocarbons  
: -50° (4 min)  
32°/min  
160°

Over temp. profile for gas analysis of hydrobarbons  
: -30°C (4 min)  
8°/min  
160°

Molecular weights are determined by freezing point depression using a Knauer molecular weight instrument, with benzene as a reference substance.

Densities are determined by Paar DMA 602 frequency densitometer.