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# Comparison of separator samples taken with $H_2O$ and Hg, on well 30/2-1

STATOIL
EXPLORATION & PRODUCTION
LABORATORY

by

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Comparison of separator samples taken with
$H_2O$ and Hg, on well 30/2-1.

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Title

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APPENDIX

## 1. INTRODUCTION

Mercury (Hg) is usually used in the process of transferring high pressure (70 bars) liquid samples from the separator to PVT-cells used in the laboratory experiments. The transfere of the samples offshore is often associated with a contamination of the enviorment on the rigg, and the personell handling the transfer operations. It is therefore of importance to see if it is possible to substitute Hg with a nontoxic fluid with properties which do not alter the PVT properties or the chemical composition.

The present report gives experimental results on parallel liquid samples taken from separator with either Hg or $H_2O$, (sea water) as transfer medium during the test on well 30/2-1.

The aims of the present study was to determine if any differences could be observed in either PVT properties or chemical composition, when Hg was substituted with sea water as transfer fluid offshore.

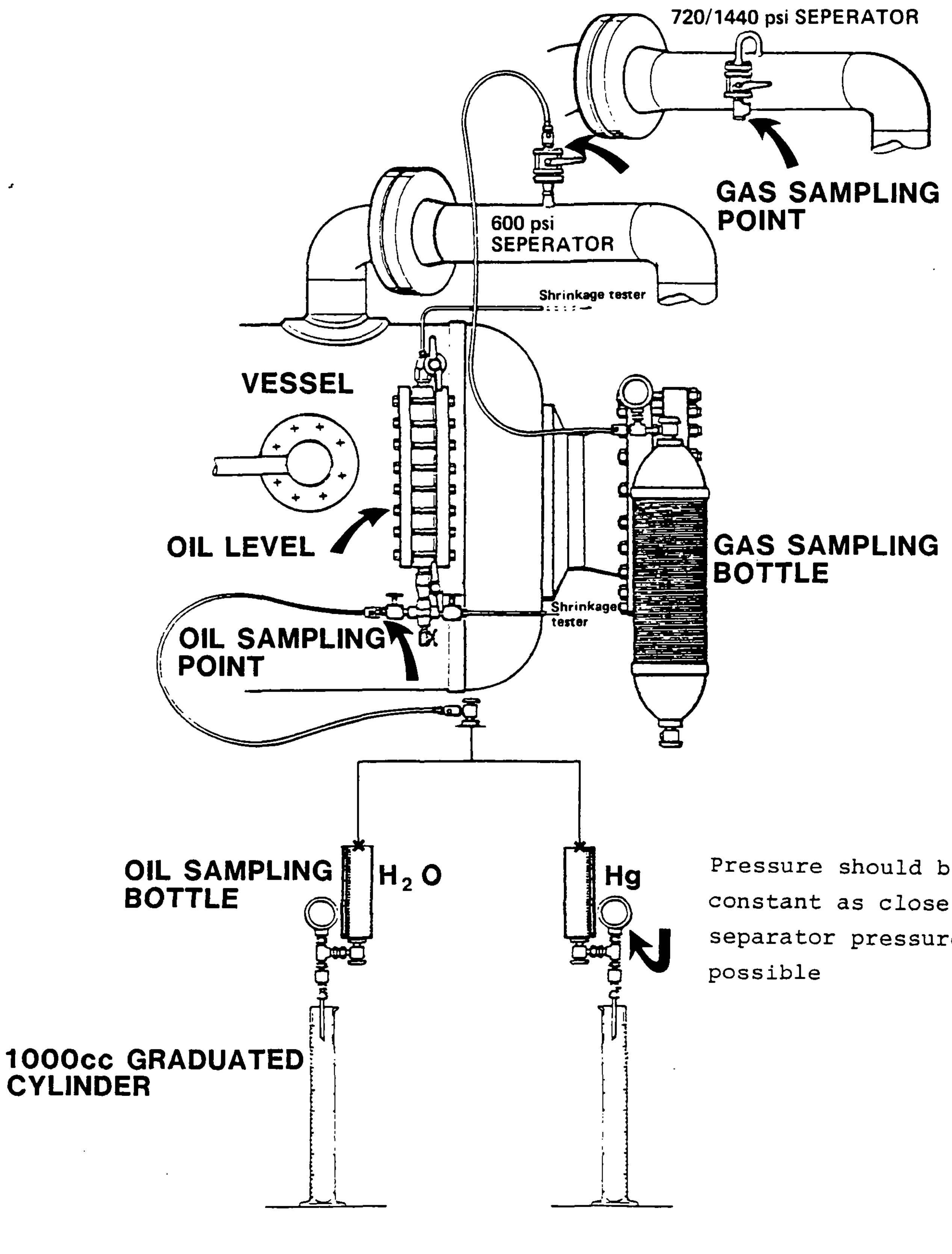
# 2. METHODS AND EQUIPMENT

## 2.1 Sampling

Two samples are taken simultaneously from the separator. (see fig. 1 for set up on separator).
The two parallel samples were filled after "standard Flopetrol method", until 50 $cm^3$ of Hg and $H_2O$ remained.

In order to create a gas cap inside the bottle containing Hg approx. 40$cm^3$ Hg was drained off, leaving 10$cm^3$ in the bottle. In order to create a gas cap inside the bottle containing water, the drain off line was taken away, and the remaining water in the bottle was removed carefully. The bottom valve was closed as soon as traces of condensate was observed. The "shipping pressure" of the bottle was not measured on the rig.

# SURFACE SAMPLING TYPICAL INSTALLATION




Pressure should be kept constant as close to separator pressure as possible

Fig.1

## 2.2 PVT - analysis

PVT properties of the samples were determined. The bubble points were measured at room conditions. The GOR, shrinkage, and composition of each set were checked through a single flash. (See table 3.5 - 3.10)

The bubble point was measured in the sampling bottle at room conditions. (see table 3.1 - 3.4, and fig: 2,3,4).

The single flash of separator liquid was performed from the sampling bottle through a Ruska Flash Separator. A Ruska Gasometer was used in order to collect the gas.

Standard conditions:

gas: 15°C, 1atm
oil: 15°C, atmospheric pressure.

## 2.3 Compositional analysis

Component analysis was performed using a Hewlett Packard 5880 gas chromatographic system. For gas analysis, inorganic components in the natural gas are determined on a porpack R 1/8" x 3 m steel column with TC detector, and hydrocarbons on chromapack Cp $\underline{tm}$ Sil 5 50 m x 0.22 mm quarts capillary column with FI detector. Oil analysis is performed on a gas chromatograph fitted with chromapack cp $\underline{tm}$ Sil 5 25 m x 0.22 mm quartz capillary column and FI detector.

| | | |
|---|---|---|
| Carrier gas | : | Helium |
| Over temp. profile for oil analyses | : | $10^{\circ}$(4 min)<br>$4^{\circ}$/min<br>$310^{\circ}$(200 min) |
| Over temp. profile for gas analysis of non hydrocarbons | : | $-50^{\circ}$(4 min)<br>$32^{\circ}$/min<br>$160^{\circ}$ |
| Over temp. profile for gas analysis of hydrocarbons | : | $-30^{\circ}$C(4 min)<br>$8^{\circ}$/min<br>$160^{\circ}$ |

Molecular weights were determined by freezing point depression using a Cryosett, with benzene as a reference substance.

Densities are determined by Paar DMA 602 frequency densitometer.

## 2.4 Sample description.

A total of 4 parallel sets of PVT samples were taken with different transfer fluids. During transportation and storage one of the bottles had leaked, therefore only 3 parallel sets were analysed.

Table 2.1 Description of the different PVT-samples.

| Set no. 1 (DST no. 2) | transfer fluid |
|---|---|
| Bottle no. 8207521 | Hg |
| Bottle no. 8207505 | $H_2O$ |
| **Set no. 2 (DST no. 2)** | |
| Bottle no. 8207608 | Hg |
| Bottle no. 8207324 | $H_2O$ |
| **Set no. 3 (DST no. 3)** | |
| Bottle no. 8208516 | Hg |
| Bottle no. 8208301 | $H_2O$ |

## 3. RESULTS

The results of the bubble point determinations are given in table 3.1 - 3.4.

Table 3.1 Bubble point of separator liquid samples at room temperature

| | | |
|---|---|---|
| <u>Set no. 1</u> | | |
| Bottle no. 8207521 | (Hg) | 49 Barg |
| Bottle no. 8207505 | ($H_2O$) | 50 Barg |
| <u>Set no. 2</u> | | |
| Bottle no. 8207608 | (Hg) | 48 Barg |
| Bottle no. 8207324 | ($H_2O$) | 47 Barg |
| <u>Set no. 3</u> | | |
| Bottle no. 8208516 | (Hg) | 52.5 Barg |
| Bottle no. 8208301 | ($H_2O$) | 48 Barg |

Table 3.2 Bubble point Determination of Separator Liquid at room temperature.

Set no. 1

| Bottle no. 8207521 (Hg) | | | Bottle no. 8207505 ($H_2O$) | | |
|---|---|---|---|---|---|
| | P/Barg | Volume/cm$^3$ | | P/Barg | Volume/cm$^3$ |
| | 41.3 | 348.28 | | 34.4 | 266.40 |
| | 42.9 | 358.70 | | 35.7 | 284.81 |
| | 44.1 | 367.15 | | 36.8 | 297.13 |
| | 45.9 | 380.12 | | 39.3 | 324.70 |
| | 48.3 | 394.26 | | 42.5 | 354.62 |
| $P_b$= | 49.0 | | | 45.5 | 378.11 |
| | 84.4 | 399.52 | | 48.4 | 395.24 |
| | 123.5 | 402.08 | $P_b$= | 50.0 | |
| | 149.8 | 403.72 | | 74.2 | 404.52 |
| | 192.7 | 406.36 | | 115.1 | 407.30 |
| | | | | 154.2 | 409.85 |
| | | | | 197.2 | 412.50 |

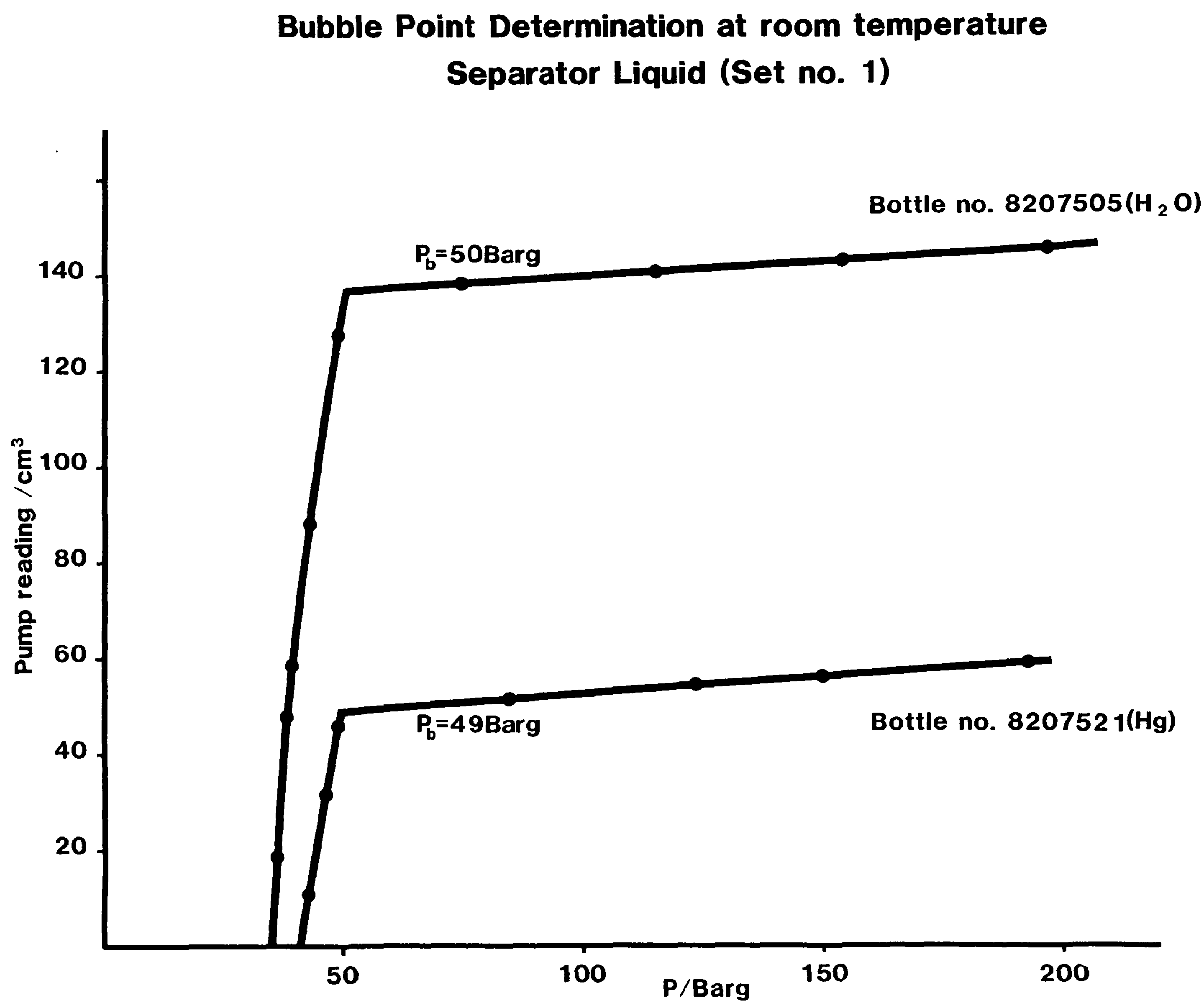

Bubble Point Determination at room temperature
Separator Liquid (Set no. 1)
Bottle no. 8207505($H_2O$)
$P_b$=50Barg
$P_b$=49Barg
Bottle no. 8207521(Hg)
Pump reading /cm$^3$
140
120
100
80
60
40
20
50
100
150
200
P/Barg

Fig.2

Table 3.3 Bubble Point Determination of Separator Liquid at room temperature.

Set no. 2

| Bottle no. 8207608 (Hg) P/Barg | Volume/$cm^3$ | Bottle no. 8207324 ($H_2O$) P/Barg | Volume/$cm^3$ |
|---|---|---|---|
| 39.3 | 375.50 | 33.1 | 127.00 |
| 41.0 | 387.76 | 36.4 | 166.96 |
| 42.3 | 397.14 | 41.0 | 210.50 |
| 44.9 | 411.67 | 43.5 | 229.89 |
| $P_b$ = 48.0 | | 46.0 | 246.34 |
| 67.6 | 424.17 | $P_b$ = 47.0 | |
| 117.5 | 427.15 | 55.6 | 249.84 |
| 150.2 | 429.05 | 95.0 | 252.55 |
| 192.7 | 431.43 | 145.8 | 255.90 |
| | | 199.8 | 259.30 |

Bubble Point Determination at room temperature
Separator Liquid (Set no. 2)

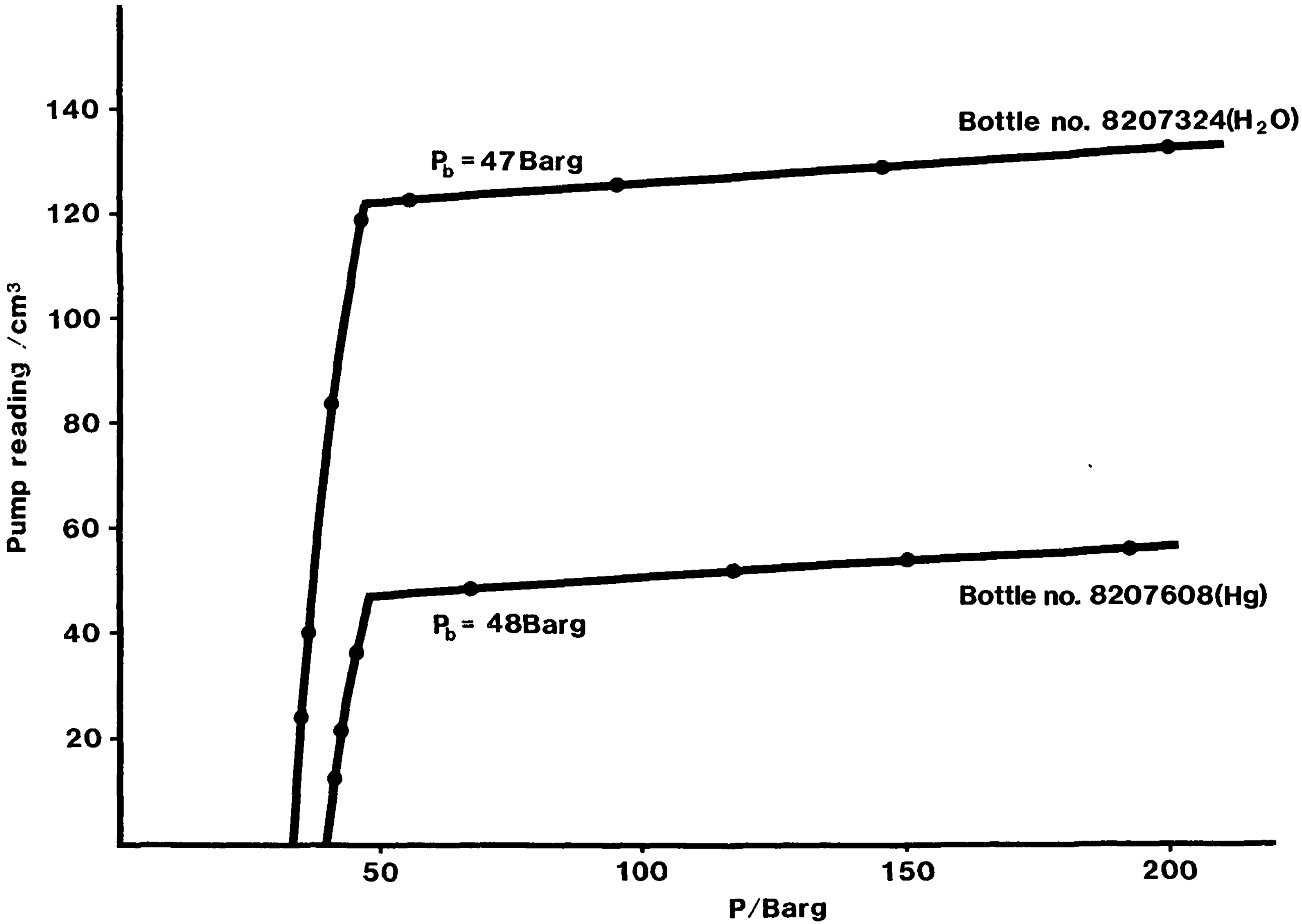



Fig.3

Table 3.4 Bubble Point Determination of Separator Liquid at room temperature.

Set no. 3

| Bottle no. 8208516 (Hg) | | Bottle no. 8208301 ($H_2O$) | |
|---|---|---|---|
| P/Barg | Volume/$cm_3$ | P/Barg | Volume/$cm_3$ |
| 40.2 | 231.80 | 40.1 | 370.71 |
| 42.3 | 246.85 | 40.9 | 379.56 |
| 43.8 | 257.06 | 45.5 | 410.14 |
| 45.2 | 265.78 | $P_b$= 48.0 | |
| 46.8 | 275.08 | 59.9 | 418.15 |
| 50.8 | 280.53 | 80.9 | 419.61 |
| $P_b$= 52.5 | | 117.4 | 422.00 |
| 86.6 | 282.72 | 165.2 | 425.02 |
| 121.3 | 284.76 | 200.0 | 427.11 |
| 162.0 | 287.04 | | |
| 197.3 | 288.97 | | |

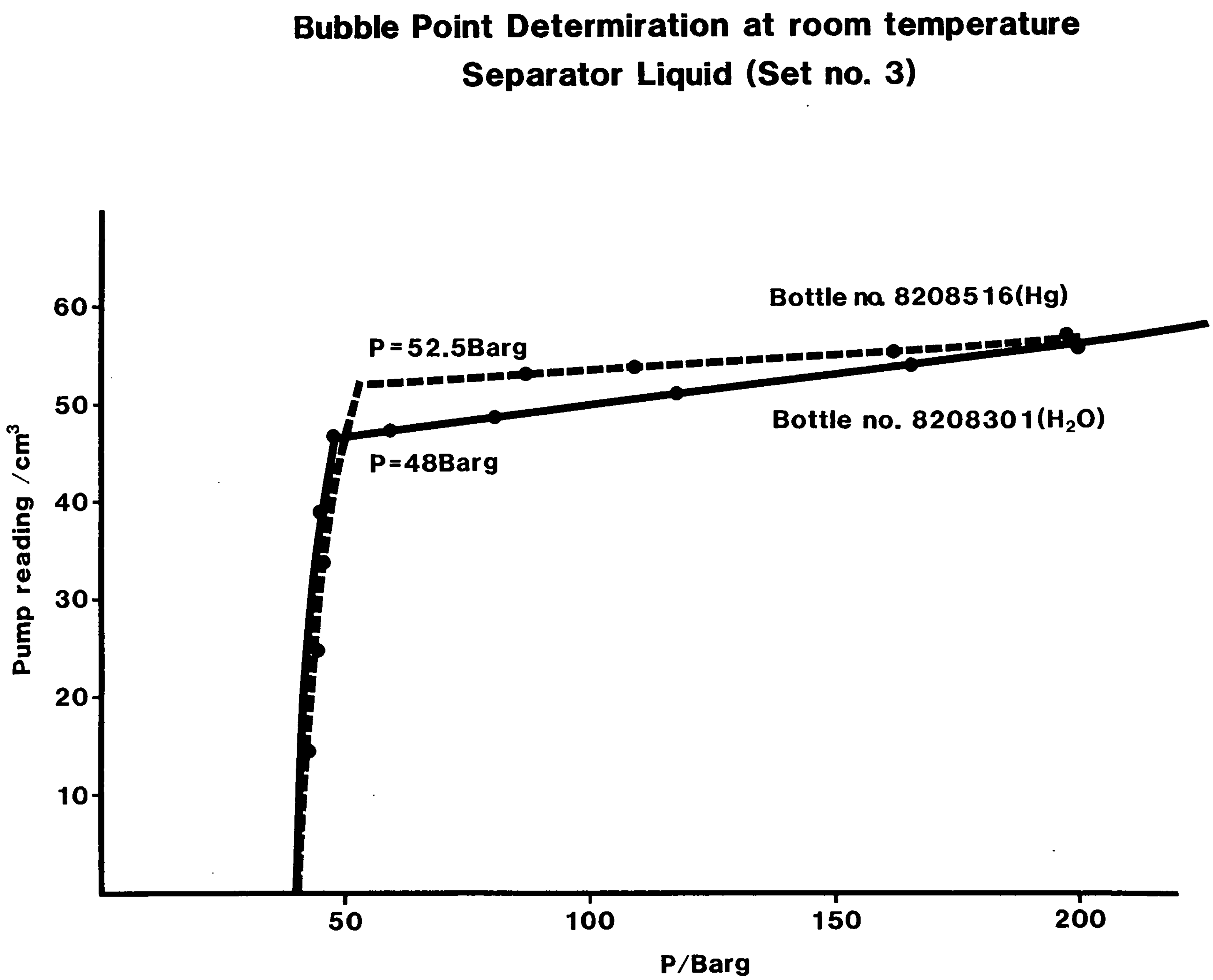

Bubble Point Determiration at room temperature
Separator Liquid (Set no. 3)
Bottle no. 8208516(Hg)
P=52.5Barg
Bottle no. 8208301($H_2O$)
P=48Barg
Pump reading /$cm^3$
60
50
40
30
20
10
50
100
150
200
P/Barg

Fig.4

Table 3.5 Flash of separator liquid to stock tank conditions
(Chemical composition)

Set nr 1, Bottle no. 8207521 (Hg)

| Component | Stock tank oil weight% | Stock tank oil mol% | Evolved gas mol% | Recombined sep. liquid mol% |
|---|---|---|---|---|
| Nitrogen | - | - | 0.09 | 0.03 |
| Carbondioxide | - | - | 4.32 | 1.43 |
| Methane | - | - | 55.07 | 18.22 |
| Ethane | 0.011 | 0.06 | 14.56 | 4.86 |
| Propane | 0.192 | 0.70 | 12.30 | 4.54 |
| iso-Butane | 0.191 | 0.53 | 2.41 | 1.15 |
| n-Butane | 0.732 | 2.02 | 5.25 | 3.09 |
| iso-Pentane | 0.830 | 1.84 | 1.61 | 1.76 |
| n-Pentane | 1.255 | 2.78 | 1.74 | 2.44 |
| Hexanes | 3.102 | 5.82 | 1.23 | 4.30 |
| Heptanes | 6.905 | 12.15 | 0.99 | 8.46 |
| Octanes | 9.688 | 14.98 | 0.39 | 10.15 |
| Nonanes | 7.130 | 9.43 | 0.03 | 6.32 |
| Decanes+ | 69.965 | 49.69* | 0.01 | 33.25 |
| | 100.000 | 100.00 | 100.00 | 100.00 |

| | | | |
|---|---|---|---|
| Density of stock tank oil at 15C | : | 0.803 | $g/cm^3$ |
| Molecular weight | : | 160 | |
| GOR | : | 58.7 | $Sm^3/m^3$ |
| Shrinkage factor of sep.liq. | : | 0.8577 | $Sm^3/m^3$ |
| Liberated gas gravity (air=1) | : | 1.028 | |
| *Molecular weight | : | 225 | |

Table 3.6 Flash of separator liquid to stock tank conditions (Chemical composition)

Set nr 1, Bottle no. 8207505 ($H_2O$)

| Component | Stock tank oil weight% | Stock tank oil mol% | Evolved gas mol% | Recombined sep. liquid mol% |
|---|---|---|---|---|
| Nitrogen | - | - | 0.09 | 0.03 |
| Carbondioxide | - | - | 4.21 | 1.38 |
| Methane | - | - | 55.33 | 18.18 |
| Ethane | 0.019 | 0.10 | 14.51 | 4.84 |
| Propane | 0.242 | 0.87 | 12.23 | 4.60 |
| iso-Butane | 0.218 | 0.59 | 2.40 | 1.19 |
| n-Butane | 0.816 | 2.22 | 5.22 | 3.21 |
| iso-Pentane | 0.889 | 1.95 | 1.61 | 1.83 |
| n-Pentane | 1.332 | 2.92 | 1.68 | 2.51 |
| Hexanes | 3.235 | 6.00 | 1.20 | 4.42 |
| Heptanes | 7.131 | 12.39 | 1.06 | 8.67 |
| Octanes | 9.981 | 15.25 | 0.42 | 10.38 |
| Nonanes | 7.375 | 9.63 | 0.03 | 6.48 |
| Decanes+ | 68.762 | 48.08* | 0.01 | 32.28 |
| | 100.000 | 100.00 | 100.00 | 100.00 |

| | | | |
|---|---|---|---|
| Density of stock tank oil at 15C | : | 0.803 | $g/cm^3$ |
| Molecular weight | : | 158 | |
| GOR | : | 58.8 | $Sm^3/m^3$ |
| Shrinkage factor of sep.liq. | : | 0.8606 | $Sm^3/m^3$ |
| Liberated gas gravity (air=1) | : | 1.027 | |
| *Molecular weight | : | 225 | |

Table 3.7 Flash of separator liquid to stock tank conditions
(Chemical composition)

Set nr 2, Bottle no. 8207608 (Hg)

| Component | Stock tank oil weight% | Stock tank oil mol% | Evolved gas mol% | Recombined sep. liquid mol% |
|---|---|---|---|---|
| Nitrogen | - | - | 0.06 | 0.02 |
| Carbondioxide | - | - | 3.32 | 0.99 |
| Methane | - | - | 59.45 | 17.63 |
| Ethane | 0.024 | 0.13 | 14.18 | 4.29 |
| Propane | 0.225 | 0.82 | 11.21 | 3.90 |
| iso-Butane | 0.193 | 0.53 | 2.11 | 1.00 |
| n-Butane | 0.710 | 1.96 | 4.51 | 2.71 |
| iso-Pentane | 0.772 | 1.71 | 1.36 | 1.61 |
| n-Pentane | 1.156 | 2.56 | 1.42 | 2.22 |
| Hexanes | 2.930 | 5.50 | 1.02 | 4.17 |
| Heptanes | 6.805 | 11.96 | 0.93 | 8.69 |
| Octanes | 10.036 | 15.52 | 0.38 | 11.03 |
| Nonanes | 7.721 | 10.21 | 0.04 | 7.19 |
| Decanes+ | 69.428 | 49.10* | 0.01 | 34.55 |
| | 100.000 | 100.00 | 100.00 | 100.00 |

| | | | |
|---|---|---|---|
| Density of stock tank oil at 15C | : | 0.808 | $g/cm^3$ |
| Molecular weight | : | 160 | |
| GOR | : | 50.3 | $Sm^3/m^3$ |
| Shrinkage factor of sep.liq. | : | 0.8795 | $Sm^3/m^3$ |
| Liberated gas gravity (air=1) | : | 0.974 | |
| *Molecular weight | : | 226 | |

Table 3.8 Flash of separator liquid to stock tank conditions
(Chemical composition)

Set nr 2, Bottle no. 8207324 ($H_2O$)

| Component | Stock tank oil weight% | Stock tank oil mol% | Evolved gas mol% | Recombined sep. liquid mol% |
|---|---|---|---|---|
| Nitrogen | - | - | 0.08 | 0.02 |
| Carbondioxide | - | - | 4.21 | 1.24 |
| Methane | - | - | 58.99 | 17.43 |
| Ethane | 0.029 | 0.15 | 14.08 | 4.27 |
| Propane | 0.260 | 0.94 | 11.09 | 3.94 |
| iso-Butane | 0.207 | 0.57 | 2.08 | 1.02 |
| n-Butane | 0.739 | 2.03 | 4.43 | 2.74 |
| iso-Pentane | 0.778 | 1.73 | 1.34 | 1.61 |
| n-Pentane | 1.156 | 2.56 | 1.39 | 2.22 |
| Hexanes | 2.912 | 5.47 | 0.99 | 4.14 |
| Heptanes | 6.752 | 11.86 | 0.93 | 8.63 |
| Octanes | 10.034 | 15.52 | 0.35 | 11.04 |
| Nonanes | 7.647 | 10.11 | 0.03 | 7.13 |
| Decanes+ | 69.488 | 49.06* | 0.01 | 34.57 |
| | 100.000 | 100.00 | 100.00 | 100.00 |

| | | | |
|---|---|---|---|
| Density of stock tank oil at 15C | : | 0.807 | $g/cm^3$ |
| Molecular weight | : | 160 | |
| GOR | : | 50.0 | $Sm^3/m^3$ |
| Shrinkage factor of sep.liq. | : | 0.8826 | $Sm^3/m^3$ |
| Liberated gas gravity (air=1) | : | 0.977 | |
| *Molecular weight | : | 226 | |

Table 3.9 Flash of separator liquid to stock tank conditions
(Chemical composition)

Set nr 3, Bottle no. 8208516 (Hg)

| Component | Stock tank oil weight% | Stock tank oil mol% | Evolved gas mol% | Recombined sep. liquid mol% |
|---|---|---|---|---|
| Nitrogen | - | - | 0.06 | 0.02 |
| Carbondioxide | - | - | 3.47 | 1.06 |
| Methane | - | - | 59.19 | 18.03 |
| Ethane | 0.031 | 0.17 | 14.04 | 4.39 |
| Propane | 0.248 | 0.90 | 11.16 | 4.03 |
| iso-Butane | 0.200 | 0.55 | 2.13 | 1.03 |
| n-Butane | 0.718 | 1.98 | 4.54 | 2.76 |
| iso-Pentane | 0.765 | 1.70 | 1.39 | 1.60 |
| n-Pentane | 1.142 | 2.53 | 1.45 | 2.20 |
| Hexanes | 2.874 | 5.40 | 1.06 | 4.07 |
| Heptanes | 6.664 | 11.72 | 1.02 | 8.46 |
| Octanes | 9.838 | 15.22 | 0.42 | 10.71 |
| Nonanes | 7.516 | 9.94 | 0.05 | 6.93 |
| Decanes+ | 70.004 | 49.89* | 0.02 | 34.71 |
| | 100.000 | 100.00 | 100.00 | 100.00 |

| | | | |
|---|---|---|---|
| Density of stock tank oil at 15C | : | 0.806 | $g/cm^3$ |
| Molecular weight | : | 160 | |
| GOR | : | 52.2 | $Sm^3/m^3$ |
| Shrinkage factor of sep.liq. | : | 0.8718 | $Sm^3/m^3$ |
| Liberated gas gravity (air=1) | : | 0.981 | |
| *Molecular weight | : | 225 | |

Table 3.10 Flash of separator liquid to stock tank conditions
(Calculated composition)

Set nr 3, Bottle no. 8208301 ($H_2O$)

| Component | Stock tank oil weight% | Stock tank oil mol% | Evolved gas mol% | Recombined sep. liquid mol% |
|---|---|---|---|---|
| Nitrogen | - | - | 0.03 | 0.01 |
| Carbondioxide | - | - | 3.17 | 0.96 |
| Methane | - | - | 59.36 | 17.90 |
| Ethane | 0.020 | 0.11 | 14.26 | 4.38 |
| Propane | 0.216 | 0.80 | 11.28 | 3.96 |
| iso-Butane | 0.185 | 0.52 | 2.14 | 1.00 |
| n-Butane | 0.672 | 1.87 | 4.53 | 2.68 |
| iso-Pentane | 0.731 | 1.64 | 1.38 | 1.56 |
| n-Pentane | 1.088 | 2.44 | 1.42 | 2.14 |
| Hexanes | 2.771 | 5.27 | 1.03 | 3.99 |
| Heptanes | 6.486 | 11.55 | 1.00 | 8.37 |
| Octanes | 9.635 | 15.08 | 0.37 | 10.64 |
| Nonanes | 7.311 | 9.79 | 0.02 | 6.84 |
| Decanes+ | 70.884 | 50.93* | 0.01 | 35.57 |
| | 100.000 | 100.00 | 100.00 | 100.00 |

| | | | |
|---|---|---|---|
| Density of stock tank oil at 15C | : | 0.806 | g/cm$^3$ |
| Molecular weight | : | 162 | |
| GOR | : | 50.8 | Sm$^3$/m$^3$ |
| Shrinkage factor of sep.liq. | : | 0.8757 | Sm$^3$/m$^3$ |
| Liberated gas gravity (air=1) | : | 0.976 | |
| *Molecular weight | : | 225 | |

## 4. FINGER PRINT ANALYSIS

The gas chromatograms of the different liquid samples after the flash were used for comparison of chemical composition. No significan differences could be detected between samples taken with Hg or $H_2O$ as transfer fluid. The gas chromatograms are shown in the appendix. The same profile and the same distribution of hydrocarbons can be seen in the chromatograms either taken by Hg or $H_2O$.

## 5. DISCUSSION

During the test 4 parallel samples were taken from the separator, using different sorts of transfer fluids. (salt water or mercury).

The sampling method used is described on page: 3 and fig: 1.

Comparing the results for each individual set, the PVT properties are very similar. The existing variations is mainly caused by the experimental error and not by the different transfer fluids used.

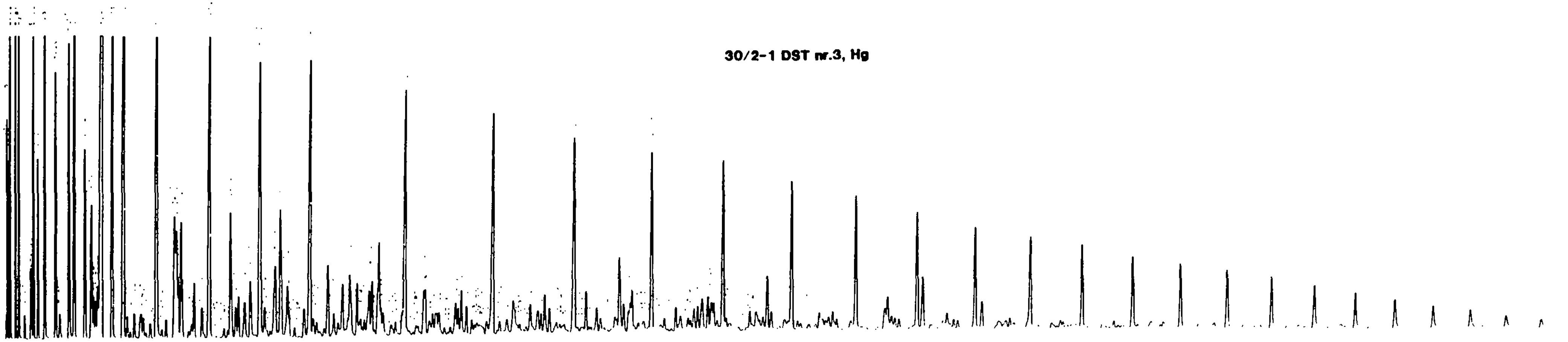
In addition on sample set no. 3 (Bottle no. 8208301), the water used in the transfer was accidentally not drained off after the sampling. This was not discovered until the bottle was opened in the laboratory after approx. 3 months. Despite the long contact with water no significient change in the composition or PVT properties could be detected.

## 6. CONCLUSION

The data obtained from the present study seems to indicate that water can be used as a transfer medium, instead of mercury, on separator samples.

For further verification and analysis, Prolab recommend that a similar set of samples are taken during a test in an oil bearing formation.

It is important at this stage to verify that both condensates and oil samples from the separator can be transferred with water as transfer fluid instead of mercury.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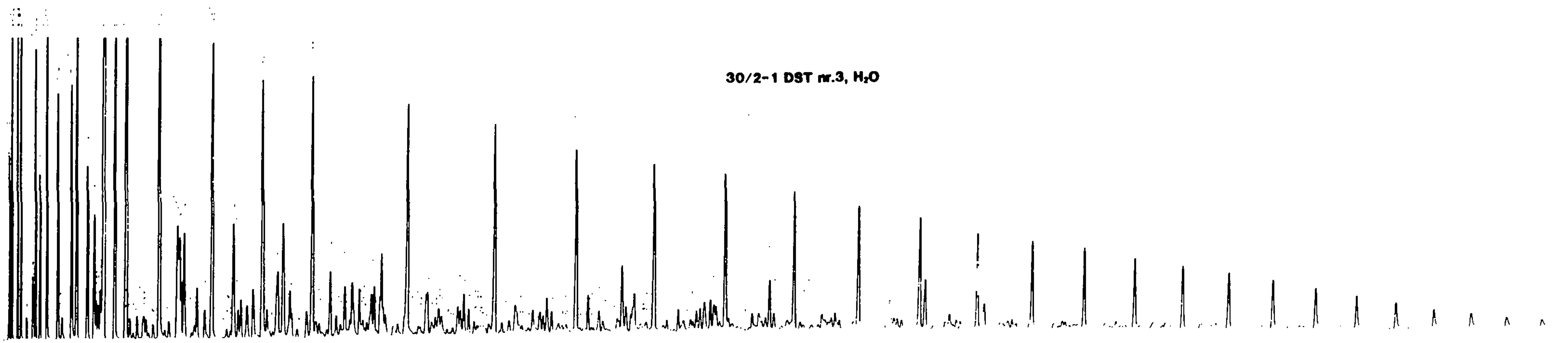
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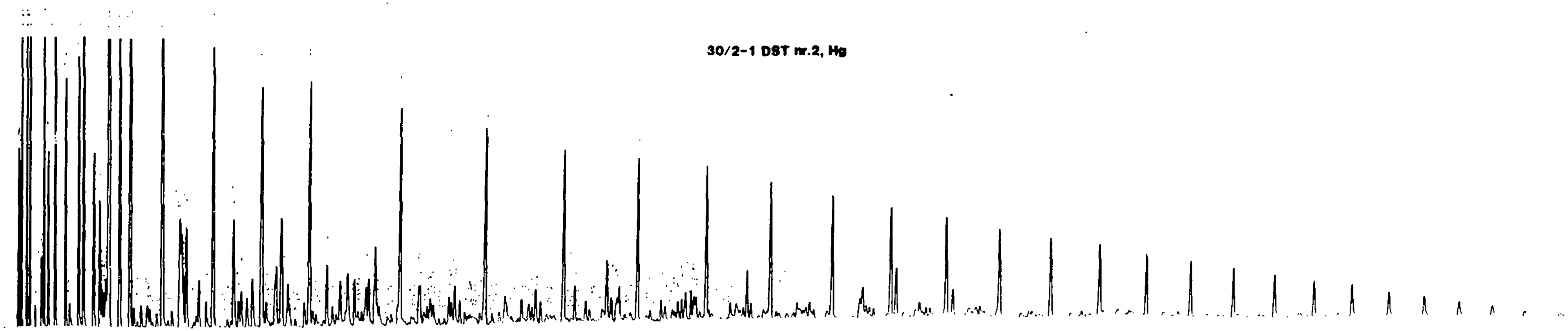
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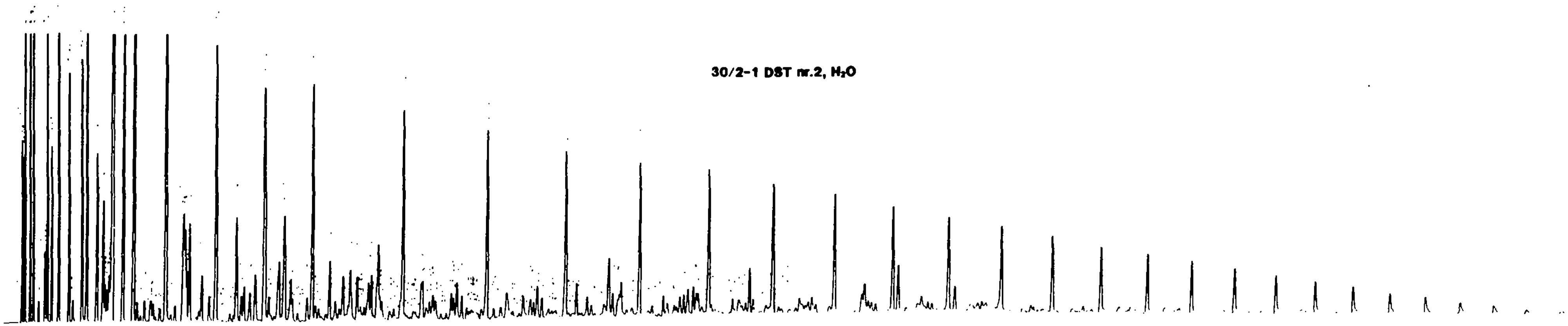
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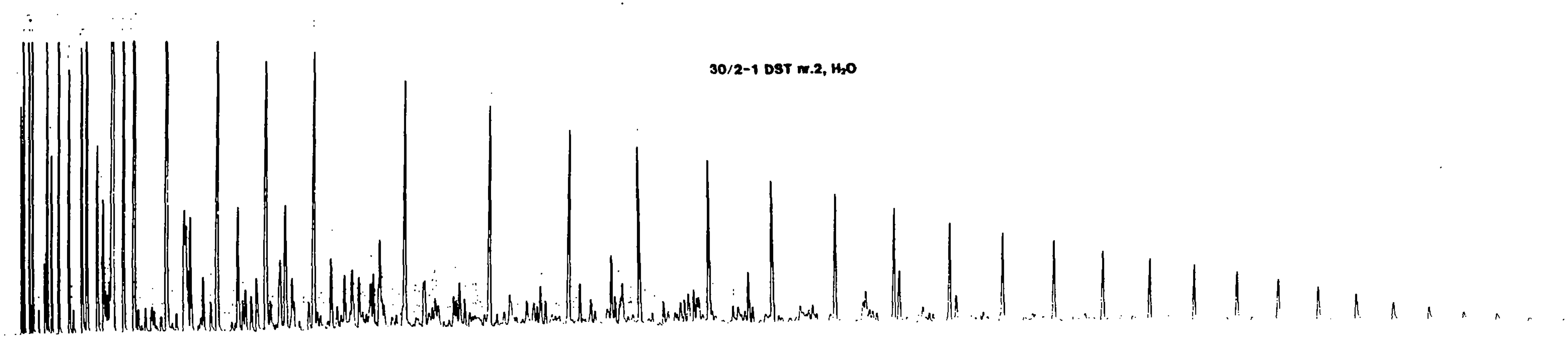
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