

Denne rapport
tilhører



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KODE Well 34/10-16 nr38

Returneres etter bruk

RESERVOIR FLUID STUDY
FOR
STATOIL
WELL: 34/10-15 DST 2
north sea, Norway

CORE LABORATORIES
Petroleum Reservoir Engineering
CCB, ÅGOTNES

Statoil
Well: 34/10-16 DST 2

RFLN 830008A

Core Laboratories Norsk
Reservoir Fluid Analysis



Duncan Thow
RFL Operations Supervisor

CORE LABORATORIES
Petroleum Reservoir Engineering
CCB, ÅGOTNES

RESERVOIR FLUID STUDY
FOR
STATOIL
WELL: 34/10-16 DST 2
NORTH SEA, NORWAY

CORE LABORATORIES
Petroleum Reservoir Engineering
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5th April 1984

Statoil
Damsgårdsgaten 131
P.O.Box 1212
5001 Bergen

Attention: Jon Hanstveit

Subject: Reservoir Fluid Study
Well: 34/10-16 DST No. 2
North Sea, Norway
Our File No.: RFLN 830008A

Gentlemen:

A sample of separator liquid and two samples of separator vapour were collected from the subject well. These samples were forwarded to our Ågotnes laboratory for use in a reservoir fluid study, the results of which are presented in the following report. This report replaces the report previously issued (our file number RFLN 830008).

On arrival in the laboratory the ambient temperature bubble point of the separator liquid was found to be 48.2 Barg at 15.5°C. The opening pressures of the gas sample cylinders were found to be in good agreement with separator pressure at separator temperature, although both cylinders were found to contain small amounts of excess condensate. The hydrocarbon composition to decanes plus of the separator gas was determined by gas chromatography, and of the separator liquid by low and high temperature fractional distillation. After correction for the factors shown on page one, the producing gas-liquid ratio was calculated to be 3531 standard cubic metres separator gas per cubic metre of primary separator liquid at 60.3 Barg and 51°C. The hydrocarbon composition of the well stream material was calculated by utilising the producing gas liquid ratio, in conjunction with the measured hydrocarbon compositions of the separator products. These data are tabulated on page two of this report.

Samples of the gas and liquid were physically recombined in the above gas/liquid ratio. The resultant reservoir fluid was subjected to constant composition expansion at the reported reservoir temperature of 117°C. During this expansion, a retrograde dew point of 417.5 bar A was observed. The results of the pressure-volume measurements are presented on page four along with the deviation factor measurements at the dew point pressure and above.

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Well: 34/10-16

Page Two

A large portion of the recombined fluid was then subjected to a constant volume depletion at the reservoir temperature of 117°C. After determining the original saturated sample volume, a series of expansions and constant pressure displacements were made, with each displacement terminating at the original sample volume. Each displacement well stream was charged to low temperature fractional distillation equipment for compositional analysis, deviation factor measurement and determination of produced volume. The composition of the heptanes plus fraction from each displacement well stream was determined by gas - liquid chromatography. A summary of the data resultant from the constant volume depletion may be found on page five.

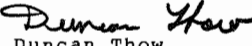
Calculations were then performed to predict the cumulative surface recoveries that may be expected during the pressure depletion of the reservoir. These calculations were performed by utilising the smooth compositional data in conjunction with published equilibrium ratios. The results of these surface recovery calculations may be found on pages six and seven.

Visual measurements of the retrograde condensation were performed at several points during the constant composition expansion, and at each point during the constant volume depletion. The maximum observed volume of retrograde condensation was approximately 4.3% of the hydrocarbon pore space. A tabulation of these retrograde volume measurements may be found on page eight and are graphically represented on page fifteen.

The smooth well stream compositions were then used in conjunction with the correlation of Carr, Kobayashi and Burrows to calculate the viscosity of the well streams during the depletion at 117°C. The results of these calculations may be found on page nine and are graphically represented on page sixteen.

The hydrocarbon composition of the equilibrium liquid remaining in the cell at the termination of the depletion was determined by gas - liquid chromatography and may be found on page ten.

It has been a pleasure to be of service to Statoil. Should any questions arise concerning data presented in this report, or if we may be of service in any other matter, please do not hesitate to contact us.

Very truly yours,
Core Laboratories Norsk

Duncan Thow
RFL Operations Supervisor

DT/JDT
7cc/Addressee

Hydrocarbon Analyses of Separator Products and Calculated Well Stream.

| <u>Component</u> | <u>Separator Liquid</u> | | <u>Separator Gas</u> | | <u>Well Stream</u> | |
|------------------|-------------------------|--|----------------------|--|--------------------|--|
| | <u>Mol %</u> | | <u>Mol %</u> | <u>m³/10⁶m³</u> | <u>Mol %</u> | <u>m³/10⁶m³</u> |
| Hydrogen Sulfide | NIL | | NIL | | NIL | |
| Carbon Dioxide | 0.75 | | 1.84 | | 1.79 | |
| Nitrogen | Trace | | 0.33 | | 0.32 | |
| Methane | 20.19 | | 87.34 | | 84.44 | |
| Ethane | 5.36 | | 6.32 | 224.08 | 6.28 | 222.66 |
| Propane | 5.19 | | 2.46 | 90.21 | 2.58 | 94.61 |
| iso-Butane | 1.37 | | 0.35 | 15.24 | 0.39 | 16.99 |
| n-Butane | 3.37 | | 0.66 | 27.70 | 0.78 | 32.73 |
| iso-Pentane | 1.96 | | 0.20 | 9.75 | 0.28 | 13.65 |
| n-Pentane | 2.64 | | 0.19 | 9.17 | 0.30 | 14.48 |
| Hexanes | 3.47 | | 0.14 | 7.25 | 0.28 | 14.87 |
| Heptanes | 8.17 | | 0.12 | 6.74 | 0.47 | 24.63 |
| Octanes | 11.03 | | 0.03 | 1.82 | 0.50 | 28.02 |
| Nonanes | 7.62 | | 0.01 | 0.67 | 0.34 | 20.92 |
| Decanes Plus | 28.88 | | 0.01 | 0.73 | 1.25 | 139.79 |
| | 100.00 | | 100.00 | 393.36 | 100.00 | 623.35 |

Properties of Heptanes Plus

| | | | |
|-----------------------|--------|------|-------|
| Density, Gm/Cc (15°C) | 0.8082 | 0.73 | 0.805 |
| Molecular Weight | 159 | 95 | 155 |

Calculated separator gas gravity (air=1.000) = 0.658
 Calculated gross heating value for separator gas = 41.74 MJ
 per cubic metre of dry gas at 1.01325 Bar A and 15°C.

Primary separator gas collected at 60.3 Bar G and 51°C.
 Primary separator liquid collected at 60.3 Bar G and 51°C.

Primary separator gas/separator liquid ratio = 3531 m³/m³ at 51°C.
 Primary separator gas/well stream ratio = 0.957 m³/m³.

Measured Properties of Liquid Fractions
From Hydrocarbon Analysis of Separator Liquid.

| <u>Fraction</u> | <u>Molecular Weight</u> | <u>Density Kg/m³ at 15°C</u> |
|-----------------|-------------------------|---|
| Heptanes | 90 | 725.1 |
| Octanes | 101 | 760.9 |
| Nonanes | 113 | 775.3 |
| Decanes | 127 | 789.5 |
| Undecanes | 221 | 834.2 |

Pressure-Volume Relations at 117°C

| <u>Pressure</u> <u>Bar A</u> | <u>Relative</u> <u>Volume (1)</u> | <u>Deviation</u> <u>Factor Z</u> |
|---------------------------------|--------------------------------------|-------------------------------------|
| 483.6 | 0.9287 | 1.207 |
| 449.2 | 0.9626 | 1.161 |
| 448.7 Reservoir Pressure | 0.9629 | 1.160 + |
| <u>442.3</u> | 0.9701 | 1.153 |
| 435.4 | 0.9780 | 1.144 |
| 428.5 | 0.9862 | 1.135 |
| 421.6 | 0.9948 | 1.127 |
| 417.5 Dew Point Pressure | 1.0000 | 1.121 ++ |
| <u>414.7</u> | 1.0036 | |
| 407.8 | 1.0127 | |
| 400.9 | 1.0225 | |
| 394.0 | 1.0327 | |
| 387.1 | 1.0434 | |
| 373.3 | 1.0664 | |
| 359.5 | 1.0918 | |
| 345.8 | 1.1195 | |
| 332.0 | 1.1500 | |
| 304.4 | 1.2227 | |
| 276.8 | 1.3137 | |
| 249.2 | 1.4289 | |
| 221.6 | 1.5796 | |
| 194.1 | 1.7845 | |
| 166.5 | 2.0696 | |
| 138.9 | 2.4832 | |
| 111.3 | 3.1180 | |
| 97.5 | 3.5844 | |
| 70.0 | 5.0741 | |

++ Gas Formation Volume Factor = 271 Sm³/m³
 + Gas Formation Volume Factor = 282 Sm³/m³

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

Depletion Study at 117 °C.

Hydrocarbon Analyses of Produced Well Stream - Mol Percent

| Component | Reservoir Pressure - Bar A | | | | | | | | | |
|------------------------------------|----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|---|
| | 417.5 | 380.2 | 325.1 | 269.9 | 207.9 | 145.8 | 90.6 | 49.3 | 24.7+ | 0 |
| Carbon Dioxide | 1.79 | 1.79 | 1.79 | 1.80 | 1.80 | 1.80 | 1.81 | 1.82 | 1.83 | |
| Nitrogen | 0.32 | 0.33 | 0.34 | 0.35 | 0.36 | 0.36 | 0.36 | 0.36 | 0.35 | |
| Methane | 84.44 | 84.78 | 85.32 | 85.78 | 86.04 | 86.12 | 85.84 | 85.31 | 84.62 | |
| Ethane | 6.28 | 6.27 | 6.25 | 6.23 | 6.24 | 6.27 | 6.36 | 6.43 | 6.51 | |
| Propane | 2.58 | 2.57 | 2.53 | 2.47 | 2.43 | 2.44 | 2.54 | 2.72 | 2.87 | |
| iso-Butane | 0.39 | 0.39 | 0.38 | 0.37 | 0.37 | 0.37 | 0.39 | 0.42 | 0.45 | |
| n-Butane | 0.78 | 0.78 | 0.75 | 0.74 | 0.73 | 0.75 | 0.79 | 0.83 | 0.89 | |
| iso-Pentane | 0.28 | 0.28 | 0.27 | 0.26 | 0.25 | 0.25 | 0.27 | 0.30 | 0.35 | |
| n-Pentane | 0.30 | 0.30 | 0.28 | 0.28 | 0.27 | 0.27 | 0.29 | 0.32 | 0.37 | |
| Hexanes | 0.28 | 0.27 | 0.26 | 0.24 | 0.23 | 0.23 | 0.24 | 0.29 | 0.44 | |
| Heptanes | 0.47 | 0.46 | 0.43 | 0.41 | 0.40 | 0.39 | 0.41 | 0.46 | 0.50 | |
| Octanes | 0.50 | 0.47 | 0.42 | 0.38 | 0.35 | 0.35 | 0.36 | 0.41 | 0.47 | |
| Nonanes | 0.34 | 0.32 | 0.28 | 0.22 | 0.22 | 0.19 | 0.18 | 0.18 | 0.19 | |
| Decanes Plus | 1.25 | 0.99 | 0.70 | 0.47 | 0.31 | 0.21 | 0.16 | 0.15 | 0.16 | |
| | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | |
| <u>Properties of heptanes plus</u> | | | | | | | | | | |
| Molecular weight | 155 | 133 | 123 | 116 | 109 | 105 | 105 | 106 | 112 | |
| Density | 0.805 | 0.785 | 0.775 | 0.768 | 0.760 | 0.754 | 0.754 | 0.756 | 0.763 | |
| <u>Deviation Factor - Z</u> | | | | | | | | | | |
| Equilibrium gas | 1.121 | 1.074 | 1.013 | 0.963 | 0.930 | 0.936 | 0.957 | 0.976 | | |
| Two-phase | 1.121 | 1.075 | 1.019 | 0.978 | 0.944 | 0.934 | 0.950 | 0.942 | | |
| Well Stream produced- | | | | | | | | | | |
| Cumulative % of initial | 0.000 | 4.978 | 14.299 | 25.900 | 40.837 | 58.077 | 74.361 | 85.948 | 98.750 | |
| + Mid-Point of Producing Interval | | | | | | | | | | |

Diese analyser, eller tolkningene baseres på observasjoner og materiell skaffet til veis av tilveier, som denne rapporten eksklusivt og fortløpig 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 overtakelse 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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Calculated Cumulative Recovery During Depletion

| | Initial in place | 417.5+ | 380.2 | 325.1 | 269.9 | 207.9 | 145.8 | 90.6 | 49.3 |
|---|---------------------|--------|-------|--------|--------|--------|--------|--------|--------|
| Cumulative Recovery per Sm ³ x10 ⁶ of Original Fluid | | | | | | | | | |
| Well Stream - Sm ³ x10 ³ | 1000 | 0 | 49.78 | 142.99 | 259.00 | 408.37 | 580.77 | 743.61 | 859.48 |
| <u>Normal Temperature Separation ++</u> | | | | | | | | | |
| Stock Tank Liquid - m ³ | 205.99 | 0 | 7.89 | 18.95 | 29.16 | 39.63 | 49.82 | 59.26 | 64.97 |
| Primary Separator Gas - Sm ³ x10 ³ | 946.39 | 0 | 47.99 | 138.54 | 251.99 | 398.61 | 568.26 | 728.53 | 843.25 |
| Stock Tank Gas - Sm ³ x10 ³ | 14.14 | 0 | 0.62 | 1.53 | 2.41 | 3.36 | 4.30 | 5.20 | 5.35 |
| Total "Plant Products" in ³ | | | | | | | | | |
| Primary Separator Gas - m ³ +++ | 211.73 | 0 | 10.70 | 30.83 | 55.97 | 88.46 | 126.24 | 162.44 | 188.75 |
| Ethane | 85.37 | 0 | 4.35 | 12.48 | 22.51 | 35.31 | 50.17 | 64.81 | 76.21 |
| Propane | 41.03 | 0 | 2.10 | 6.03 | 10.99 | 17.41 | 24.98 | 32.54 | 38.49 |
| Butanes (total) | 43.87 | 0 | 2.27 | 6.60 | 12.09 | 19.18 | 27.36 | 35.49 | 43.66 |
| Pentanes plus | | | | | | | | | |
| Total "Plant Products" in | | | | | | | | | |
| Stock Tank Gas - m ³ | 7.55 | 0 | 0.33 | 0.81 | 1.28 | 1.78 | 2.28 | 2.76 | 2.85 |
| Ethane | 6.09 | 0 | 0.27 | 0.66 | 1.03 | 1.42 | 1.82 | 2.21 | 2.27 |
| Propane | 4.04 | 0 | 0.18 | 0.44 | 0.70 | 0.97 | 1.25 | 1.53 | 1.57 |
| Butanes (total) | 2.75 | 0 | 0.12 | 0.31 | 0.49 | 0.69 | 0.89 | 1.09 | 1.12 |
| Pentanes plus | | | | | | | | | |
| Total "Plant Products" in | | | | | | | | | |
| Well Stream - m ³ +++ | 222.66 | 0 | 11.07 | 31.72 | 57.35 | 90.39 | 128.72 | 165.44 | 191.86 |
| Ethane | 94.61 | 0 | 4.69 | 13.34 | 23.85 | 37.16 | 52.58 | 67.75 | 79.31 |
| Propane | 49.72 | 0 | 2.47 | 6.95 | 12.42 | 19.41 | 27.61 | 35.77 | 41.93 |
| Butanes (total) | 251.07 | 0 | 10.09 | 25.29 | 40.75 | 57.92 | 75.93 | 93.05 | 106.55 |
| Pentanes plus | | | | | | | | | |

† Saturation Pressure

++ Separation Basis: Primary Stage 60.3 Bar G at 51°C, Stock Tank 0 Bar G at 15°C. (Final point primary stage

+++ Assumes 100% Plant efficiency. : 20.7 Bar G at 51°C).

Disse analyser, eller tolkninger baseres på observasjoner og materielle skaffet til veie av klienter, som denne rapporten ekskludert og fortløpelig er laget for. Det utføres arbeidet representert av disse tolkningene Core Laboratories Norsk er i stand til å gi, imed forbehold om feil og utslippsfeil. Likvel frasier Core Laboratories Norsk og deres personell seg all ansvar og gir derfor ingen overslag på grunnlag av disse data, som selskaps produktivitet, aktuelle operasjoner, og lemsomhet fra en hver olje, gass eller mineral brenn eller sand, som en slik rapport er basert på

Calculated Instantaneous Recovery During Depletion

| | Reservoir Pressure - Bar A | | | | | | | |
|--|----------------------------|--------------|--------------|--------------|--------------|--------------|-------------|-------------|
| | <u>417.5+</u> | <u>380.2</u> | <u>325.1</u> | <u>269.9</u> | <u>207.9</u> | <u>145.8</u> | <u>90.6</u> | <u>49.3</u> |
| <u>Normal Temperature Separation ++</u> | | | | | | | | |
| Stock Tank Liquid Density, Kg/m ³ at 15°C | 785.8 | 765.0 | 754.8 | 747.6 | 739.8 | 733.7 | 732.5 | 737.9 |
| Separator Gas/Well Stream Ratio, Sm ³ /Sm ³ | 0.9584 | 0.9640 | 0.9715 | 0.9779 | 0.9816 | 0.9841 | 0.9842 | 0.9901 |
| Separator Gas/Stock Tank Liquid Ratio, Sm ³ /m ³ | 4653 | 6079 | 8193 | 11109 | 14010 | 16649 | 16966 | 20096 |

m³/m³ x 10⁶ from Smooth Well Stream Compositions

| | | | | | | | | |
|---------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Ethane plus | 623.05 | 568.94 | 525.49 | 491.93 | 472.03 | 463.82 | 473.94 | 497.33 |
| Propane plus | 400.69 | 346.64 | 303.89 | 271.05 | 250.79 | 241.52 | 248.44 | 269.37 |
| Butanes plus | 306.08 | 252.39 | 211.11 | 180.47 | 161.68 | 152.04 | 155.30 | 169.62 |
| Pentanes plus | 256.36 | 202.67 | 163.09 | 133.30 | 114.93 | 104.45 | 105.16 | 116.50 |

+ Saturation Pressure

++ Separation Basis: Primary Stage 60.3 Bar G at 51°C, Stock Tank 0 Bar G at 15°C, except the 49.3 Bar A Well Stream where the primary stage is 20.7 at 51°C.

Disse analysene, eller tolkningene baseres på observasjoner og materiell stoffet til veie av klienter, som denne rapporten ekskluser og fortløpig 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 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 brenn eller sand, som en slik rapport er basert på.

RETROGRADE CONDENSATION DURING GAS DEPLETION AT 117°C.

| <u>Pressure</u> <u>Bar A</u> | <u>Retrograde Liquid Volume,</u> <u>Percent of Hydrocarbon Pore Space</u> |
|----------------------------------|--|
| <u>417.5</u> Dew Point Pressure | 0.0 |
| 414.7 | TRACE |
| 407.8 | 0.1 |
| 400.9 | 0.2 |
| 394.0 | 0.3 |
| 387.1 | 0.4 |
| <u>380.2</u> 1st Depletion Level | 0.4 |
| 325.2 | 1.2 |
| 269.9 | 2.0 |
| 207.9 | 3.1 |
| 145.8 | 3.9 |
| 90.6 | 4.3 |
| 49.3 | 4.2 |
| 0 | 3.6 |

Calculated Gas Viscosity at 117°C

| <u>Pressure</u> <u>Bar A</u> | <u>Gas Viscosity,</u> <u>Pascal-Seconds x 10⁻³ +</u> |
|---------------------------------|--|
| <u>448.7</u> Reservoir Pressure | 0.0317 |
| <u>417.5</u> Dew Point Pressure | 0.0303 |
| 380.2 | 0.0275 |
| 352.1 | 0.0243 |
| 269.9 | 0.0216 |
| 207.9 | 0.0190 |
| 145.8 | 0.0167 |
| 90.6 | 0.0148 |
| 49.3 | 0.0135 |

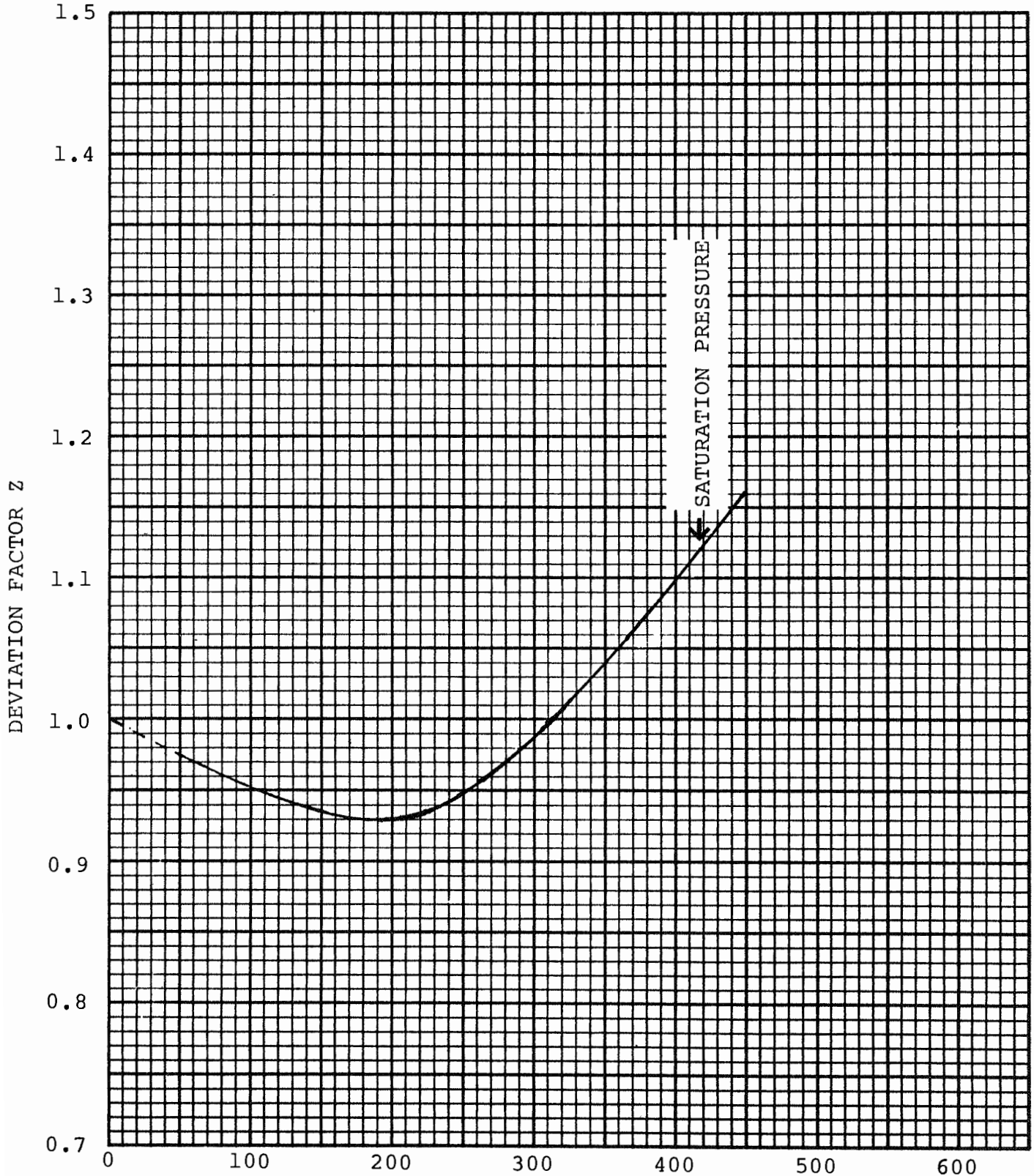
+ Calculated using the correlation of Carr, Kobayashi
and Burrows, Aime Transactions, 1954, Vol 201, p264.

Hydrocarbon Analysis of Depletion Residual Liquid.

| <u>Component</u> | <u>Mol Percent</u> | <u>Weight Percent</u> |
|------------------|------------------------|---------------------------|
| Carbon Dioxide | NIL | NIL |
| Nitrogen | NIL | NIL |
| Methane | NIL | NIL |
| Ethane | NIL | NIL |
| Propane | NIL | NIL |
| Butane | NIL | NIL |
| Pentanes | 0.12 | 0.05 |
| Hexanes | 0.36 | 0.17 |
| Heptanes | 3.05 | 1.52 |
| Octanes | 9.36 | 5.39 |
| Nonanes | 10.10 | 6.77 |
| Decanes | 77.11 | 86.10 |
| | <u>100.00</u> | <u>100.00</u> |

DEVIATION FACTOR Z OF WELLSTREAM DURING DEPLETION AT 117°C.

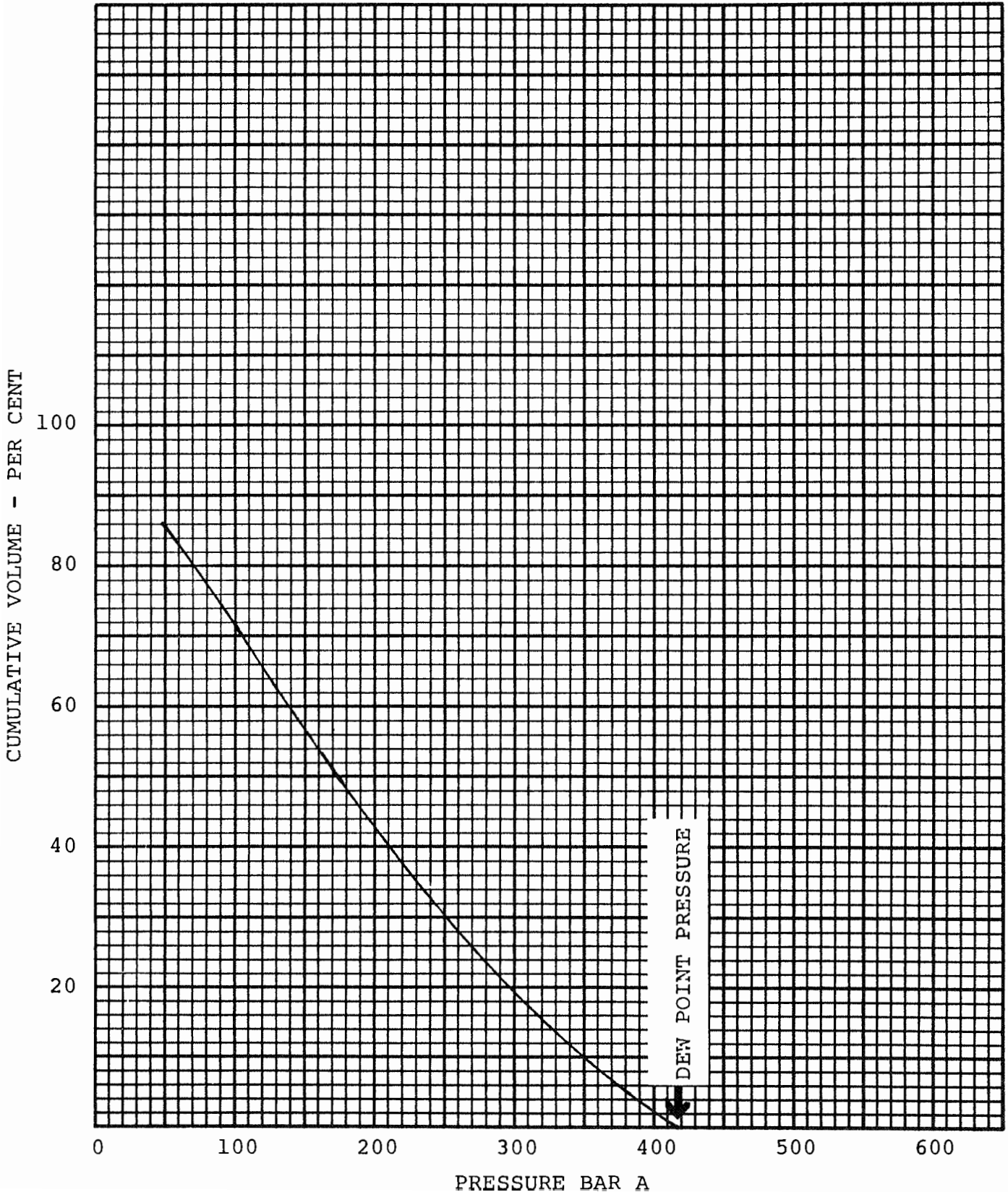
| | | | |
|---------|----------|-----------|-----------|
| Company | STATOIL | Formation | BRENT |
| Well | 34/10-16 | Province | NORTH SEA |
| Field | | Country | NORWAY |



BERGEN, NORWAY

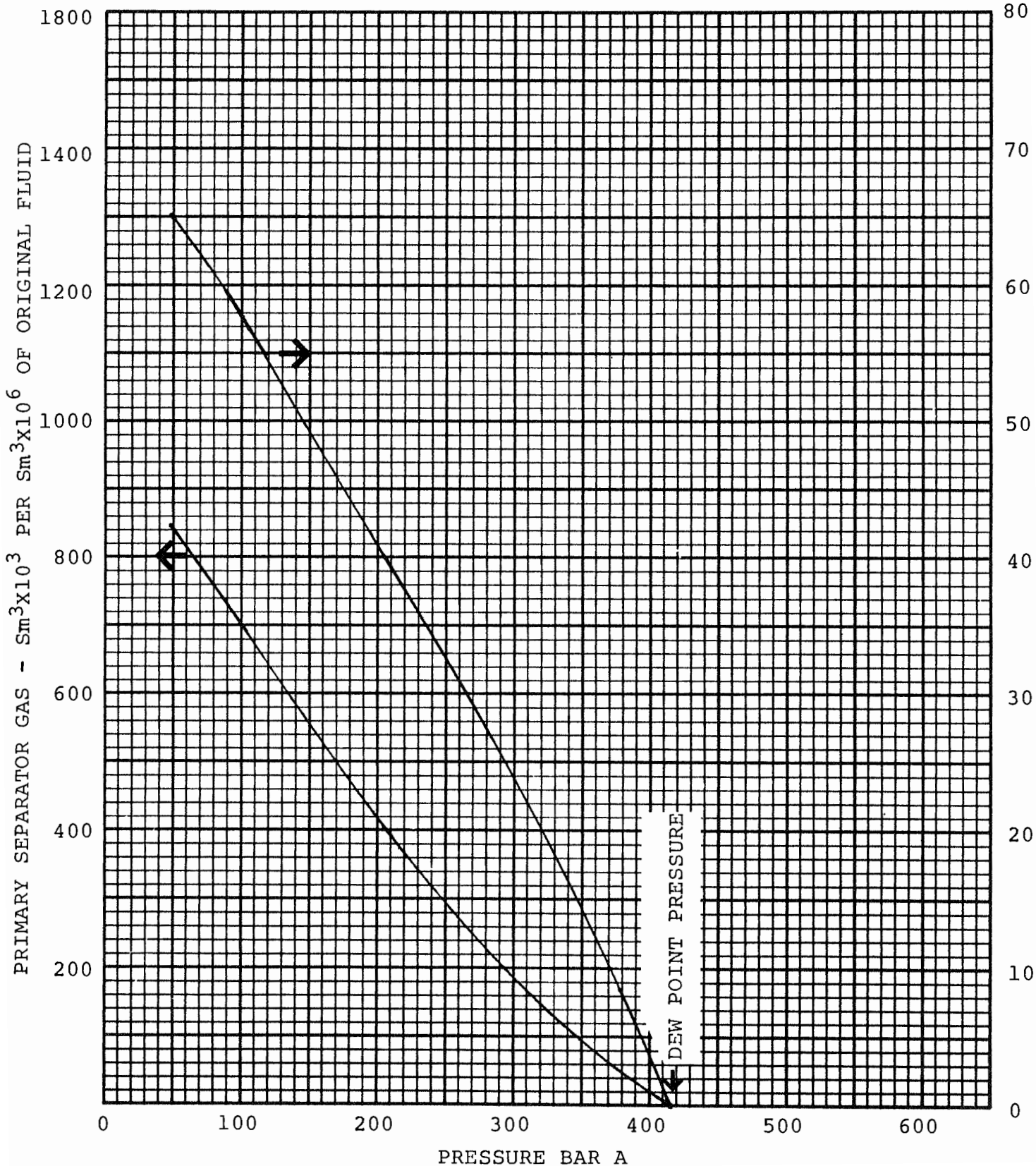
VOLUME OF WELL STREAM PRODUCED DURING DEPLETION

| | | | |
|---------|----------|-----------|-----------|
| Company | STATOIL | Formation | BRENT |
| Well | 34/10-16 | Province | NORTH SEA |
| Field | | Country | NORWAY |



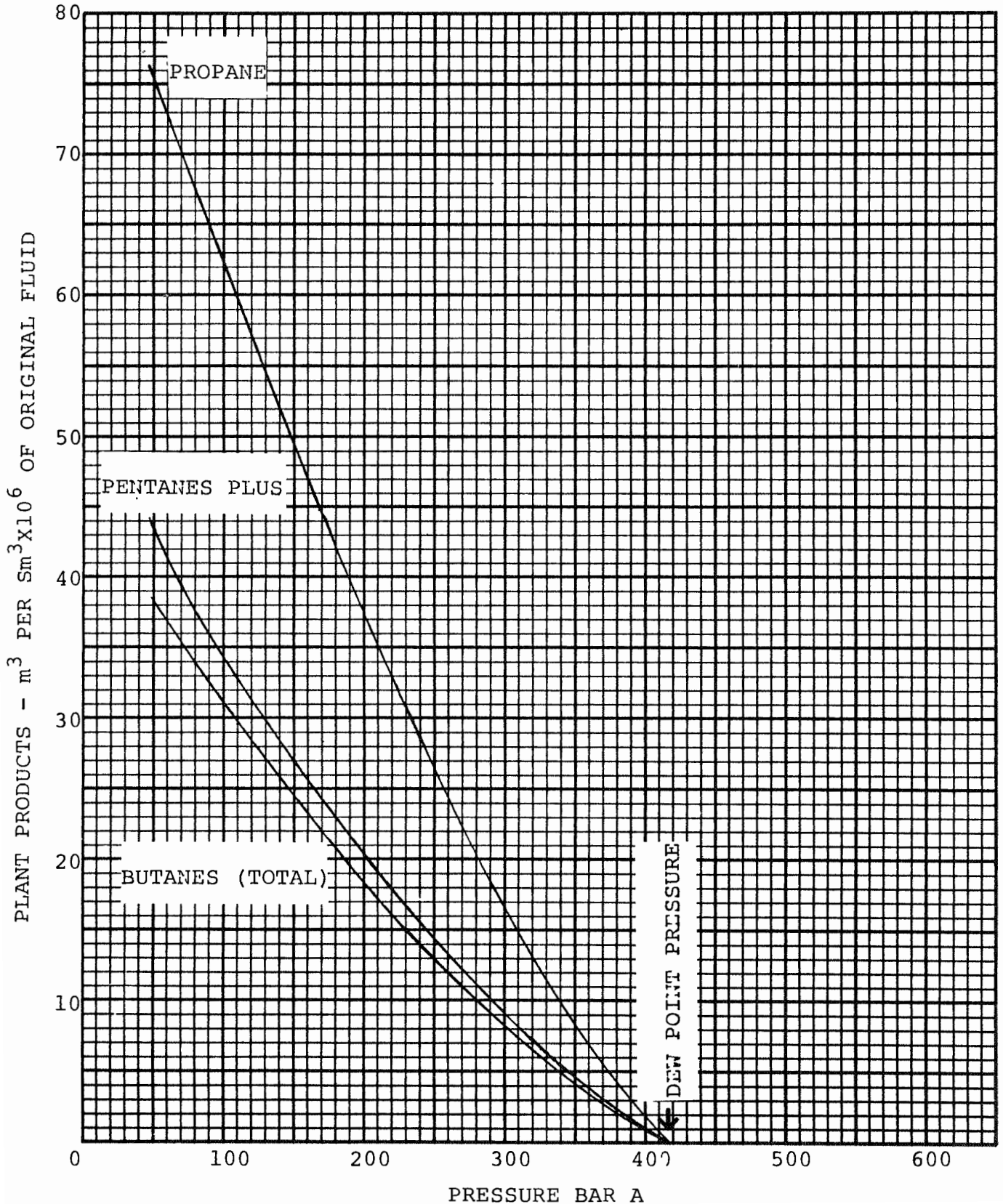
CUMULATIVE RECOVERY DURING DEPLETION

| | | | |
|---------|----------|-----------|-----------|
| Company | STATOIL | Formation | BRENT |
| Well | 34/10-16 | Province | NORTH SEA |
| Field | | Country | NORWAY |



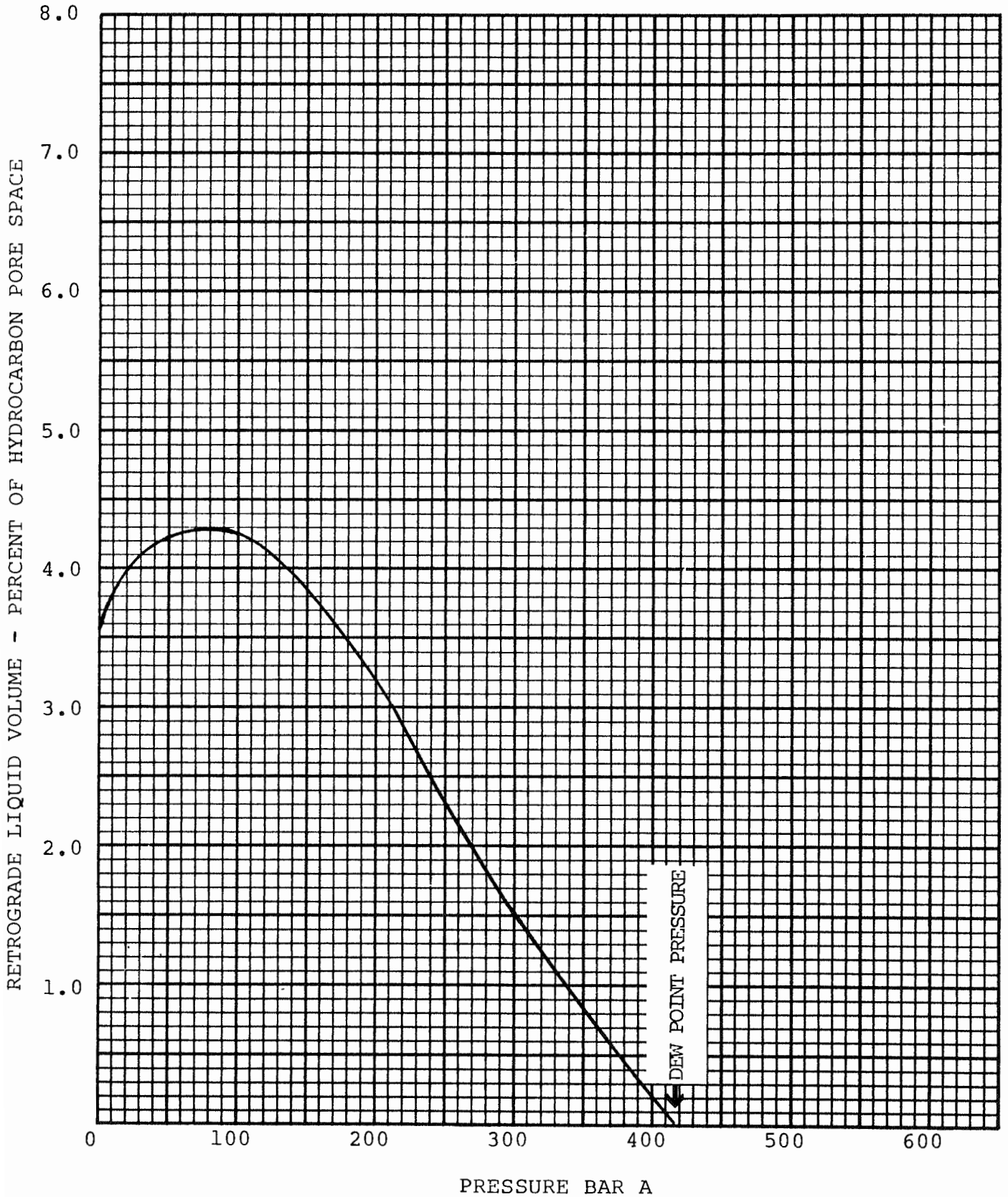
CUMULATIVE RECOVERY-PLANT PRODUCTS IN PRIMARY SEPARATOR GAS

| | | | |
|---------|----------|-----------|-----------|
| Company | STATOIL | Formation | BRENT |
| Well | 34/10-16 | Province | NORTH SEA |
| Field | | Country | NORWAY |



RETROGRADE CONDENSATION DURING DEPLETION AT 117°C.

Company STATOIL Formation BRENT
Well 34/10-16 Province NORTH SEA
Field _____ Country NORWAY



CALCULATED GAS VISCOSITY AT 117°C.

| | | | |
|---------|----------|-----------|-----------|
| Company | STATOIL | Formation | BRENT |
| Well | 34/10-16 | Province | NORTH SEA |
| Field | | Country | NORWAY |

