

Denne rapport

STATOIL

SPECIAL FLUID STUDY

for

STATOIL

Wells: 6407/1-2 and 6407/1-3

Norwegian Sea, Norway

CORE LAB

CORE LABORATORIES
Petroleum Reservoir Engineering
CCB, ÅGOTNES

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CCB, ÅGOTNES

26th July 1984

Statoil
Damsgaardsgaten 131
P.O. Box 1212
N-5001 Bergen

Attention: Mr. Jon Hanstveit

Subject: Special Fluid Study
Wells: 6407/1-2 and 6407/1-3
Norwegian Sea, Norway
Our File Number: RFLN 840017

Gentlemen,

On the 7th June 1984, various samples from the subject wells were received in our Aagotnes laboratory for use, along with samples previously received, in a special fluid study. Presented in the following report are the results of analyses as requested by a representative of Statoil.

A complete list of the samples received is presented on page one of the following report, along with the results of sample quality check measurements performed and an index of PVT study reports referred to during the course of this study.

For initial comparative purposes small portions of samples were removed from cylinder numbers 8212717 (6407/1-2 DST number 1) and 14068/64 (6407/1-3 DST number 1). The resultant dead oils were subjected to chromatographic analyses, these "Fingerprint" chromatographic analyses indicated the liquids to be similar in nature despite the obvious differences in physical appearance and composition. Representations of the resultant traces may be found on pages two and three of the following report.

The hydrocarbon compositions of the separator products from well 6407/1-2 DST number 1 were determined, by gas chromatography in the case of the separator gas sample and by low temperature fractional distillation, in conjunction with gas chromatography, in the case of the separator liquid. Utilizing the factors presented on page four a producing gas-liquid ratio of 706.02 standard cubic metres of separator gas per cubic metre of separator liquid was calculated. Using this ratio in conjunction with the experimentally determined compositions of the separator products a producing well stream composition was calculated, these compositional data may be found on page five of the following report.

The separator products were then physical recombined to the above ratio and the resultant recombined reservoir fluid examined in a high pressure visual cell. During a constant composition expansion at the reported reservoir temperature of 136°C the fluid exhibited a retrograde dew point at 389.0 Bar a. During this expansion a number of pressure-volume relationship, deviation factor and percentage liquid phase measurements were performed. These data are tabulated on page six of the following report.

We were subsequently requested to examine the recombined reservoir fluid at a temperature of 125°C. During a constant composition expansion at this temperature the fluid exhibited a retrograde dew point at 389.7 Bar a. The resultant pressure-volume and percentage liquid phase data may be found on page seven. This concluded testing on samples from well 6407/1-2 Dst number 1.

To determine if a mixture of gas condensate reservoir fluid and oil reservoir fluid samples from well 6407/1-3 could produce a fluid similar to the 6407/1-2 DST number 1 recombined reservoir fluid, compositional data from previous PVT reports was examined. This examination suggested that combining fluids from well 6407/1-3, in any ratio, would not produce a fluid with a composition similar to that reported for the 6407/1-2 wellstream composition. The molar ratios that would be required for mixing to produce either a fluid with a similar mole fraction methane or a similar mole fraction heptanes plus were calculated. These ratios and resultant mix compositions are presented on page seven.

After discussion with a representative of Statoil it was agreed to proceed with an examination of the 3.396 moles gas condensate reservoir fluid to one mole oil reservoir fluid mixture. Separator products from well 6407/1-3 Dst number 2 were physically recombined to a ratio of 3029 standard cubic metres of separator gas per cubic metre of separator oil. The resultant reservoir fluid was mixed with bottom hole sample from cylinder number 14068/64 to the ratio specified above. The resultant fluid was found to exist in two distinct phases at 449.2 Bar a and 132.5°C, the liquid volume being approximately 23 percent of the total sample volume. No further analyses were requested.

Thank you for the opportunity to be of service to Statoil. If you have any questions concerning the analyses performed during this study or if we may be of further service in any way, please feel free to call upon us.

Very truly yours
Core Laboratories Norsk
Reservoir Fluid Laboratory



Duncan Thow
Operations Supervisor

DMT/ah
7cc Addressee

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Wells 6407/1-2 and 6407/1-3

Samples Received and Quality Check Measurements

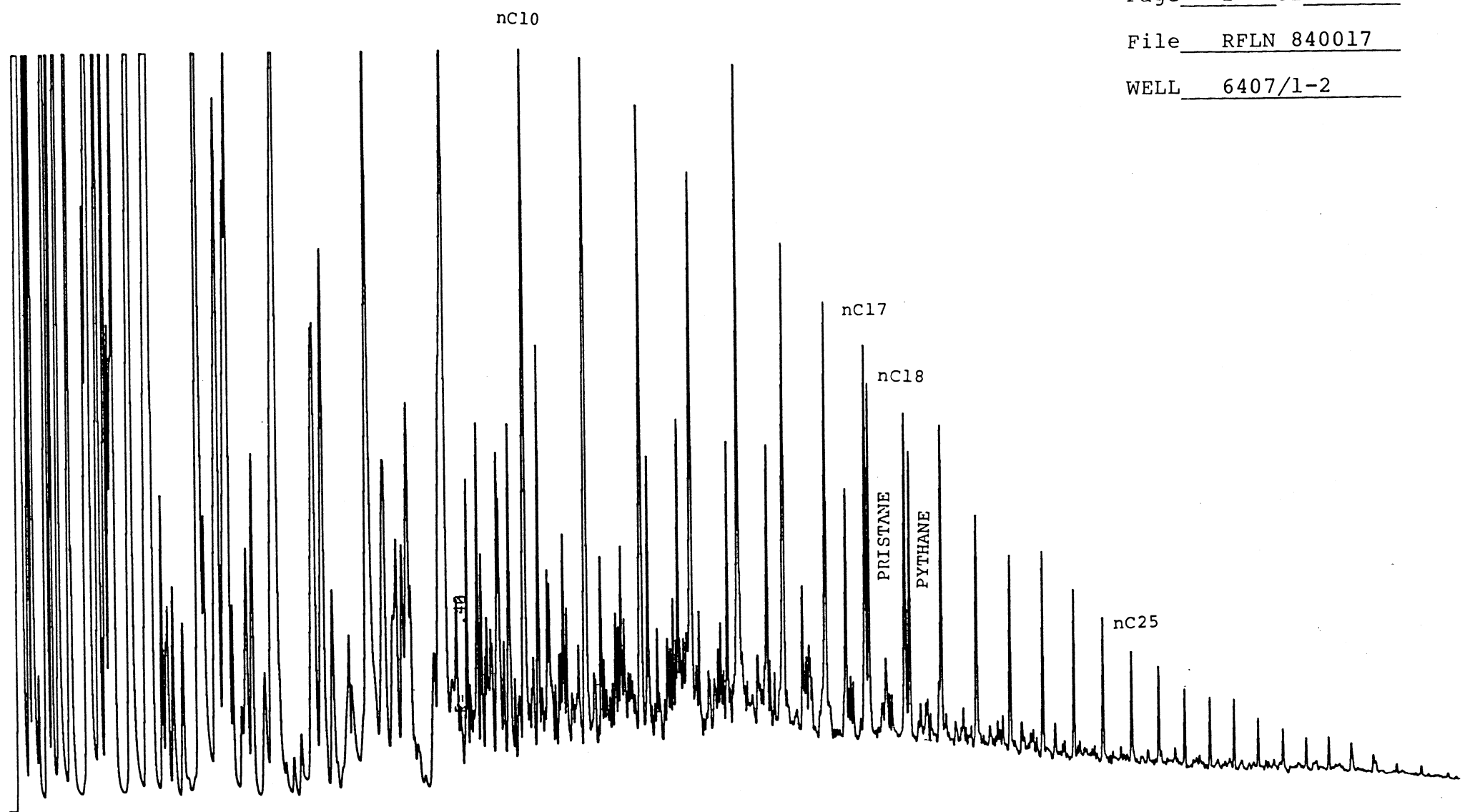
| Well | Sample Type | Cylinder Number | Ambient Temp. Bubble Point | Gas Cylinder Opening Pressure |
|----------------|---------------|-----------------|----------------------------|-------------------------------|
| 6407/1-2 DST 1 | Separator Oil | 8212717 | 27.6 Barg | 40.0 Barg at 42°C |
| | Separator Gas | A-14416 | | |
| | Separator Gas | A-14414 | | |
| 6407/1-3 DST 1 | Bottom Hole | 14068/64 | | |
| 6407/1-3 DST 2 | Separator Oil | 83081603 | 53.9 Barg | |
| | Separator Gas | A-14768 | | |
| | Separator Gas | A-14767 | | |

Separator Samples Held from Previous Analysis

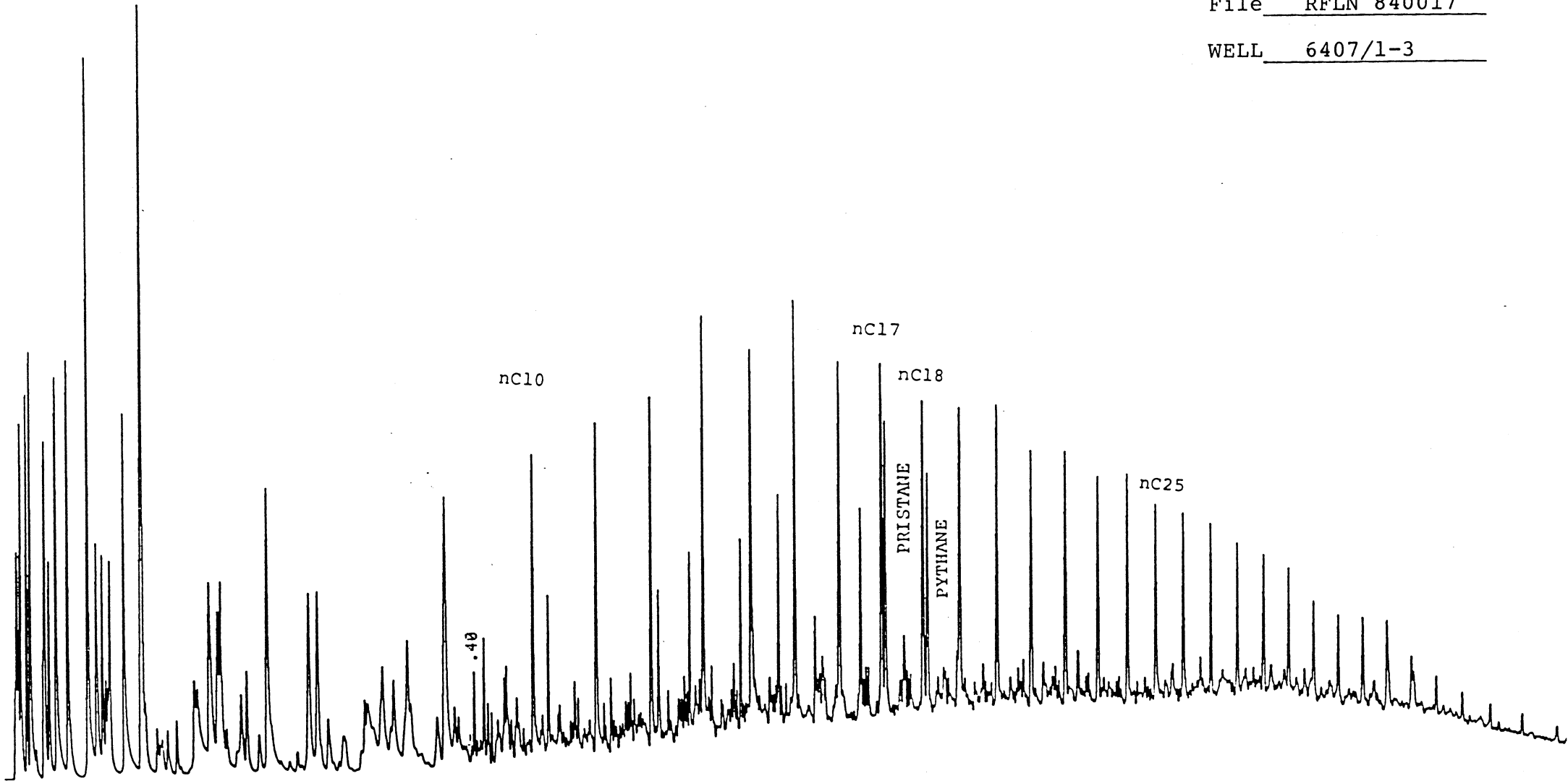
| | | | | |
|----------------|---------------|----------|-----------|--|
| 6407/1-3 DST 2 | Separator Oil | 83081313 | 58.4 Barg | 70.3 Barg at 36°C 76.5 Barg at 36°C |
| | Separator Gas | A-14048 | | |
| | Separator Gas | A-14770 | | |

Previous PVT Reports Referred To During This Study

| Well | Laboratory | Reference | Date of Issue |
|----------------|-------------------------|-------------|----------------|
| 6407/1-2 DST 1 | Flopetrol | 83/L/61 B | September 1983 |
| 6407/1-3 DST 1 | Statoil | Lab 84.222 | April 1984 |
| 6407/1-3 DST 2 | Core Laboratories Norsk | RFLN 840009 | May 1984 |



CHROMATOGRAPHIC "FINGERPRINT" ANALYSIS



CHROMATOGRAPHIC "FINGERPRINT" ANALYSIS

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| | | | |
|---------|-----------------------|--------------|---------------------|
| Company | <u>Statoil</u> | Date Sampled | <u>May 1983</u> |
| Well | <u>6407/1-3 DST 1</u> | Region | <u>Haltenbanken</u> |
| Field | <u>Tyrihans</u> | Country | <u>Norway</u> |

FORMATION CHARACTERISTICS

| | |
|------------------------------------|---|
| Formation Name | <u>Jura Sands</u> |
| Date First Well Completed | <u>19</u> |
| Original Reservoir Pressure | <u>378</u> Bara @ <u> </u> M. |
| Original Produced Gas-Oil Ratio | <u> </u> Sm ³ /m ³ |
| Production Rate | <u> </u> m ³ /Day |
| Separator Pressure and Temperature | <u> </u> Barg @ <u> </u> °C. |
| Liquid Density at 15°C. | <u> </u> Kg/m ³ |
| Datum | <u> </u> M. Subsea |

WELL CHARACTERISTICS

| | |
|-------------------------|-----------------------------------|
| Elevation | <u> </u> M. |
| Total Depth | <u> </u> M. |
| Producing Interval | <u> </u> M. |
| Tubing Size and Depth | <u> </u> Cm. to <u> </u> M. |
| Open Flow Potential | <u> </u> Sm ³ /Day |
| Last Reservoir Pressure | <u>378</u> Barg @ <u> </u> M. |
| Date | <u> </u> 19 |
| Reservoir Temperature | <u>136</u> °C. @ <u> </u> M. |
| Status of Well | <u> </u> |
| Pressure Gauge | <u> </u> |

SAMPLING CONDITIONS

| | |
|---|--|
| Flowing Tubing Pressure | <u> </u> Bara |
| Flowing Bottom Hole Pressure | <u> </u> Bara |
| Primary Separator Pressure | <u> </u> Barg |
| Primary Separator Temperature | <u> </u> °C. |
| Secondary Separator Pressure | <u> </u> Barg |
| Secondary Separator Temperature | <u> </u> °C. |
| Field Stock Tank Liquid Density | <u> </u> Kg/m ³ @ 15°C. |
| Primary Separator Gas Production Rate | <u> </u> SM/Day |
| Pressure Base | <u>1.0132</u> Bara |
| Temperature Base | <u>15</u> °C. |
| Compressibility Factor (Fpv) | <u>1.0426</u> |
| Gas Gravity (Laboratory) | <u>0.724</u> |
| Gas Gravity Factor (Fg) | <u>1.1753</u> |
| Liquid Production Rate @ <u> </u> °C. | <u> </u> m ³ /Day |
| Primary Separator Gas/ <u> </u> Liquid Ratio | <u>706.02</u> Sm ³ /m ³ |
| | <u> </u> or <u> </u> m ³ /Sm ³ |
| Sampled by | <u>Flopetrol</u> |

REMARKS:

Data taken from Flopetrol PVT report 83/L/61 B and converted to metric format, excepting Core Laboratories measured gas properties.

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Well 6407/1-2 DST 1

HYDROCARBON ANALYSES OF SEPARATOR PRODUCTS AND CALCULATED WELL STREAM

| Component | Separator Liquid * | Separator Gas + | | Well Stream |
|-------------------|--------------------|-----------------|-----------------------------|---------------|
| | Mol Percent | Mol Percent | $\text{m}^3/10^6\text{m}^3$ | Mol Percent |
| Hydrogen Sulphide | NIL | NIL | | NIL |
| Carbon Dioxide | 0.99 | 3.31 | | 2.90 |
| Nitrogen | NIL | 0.66 | | 0.54 |
| Methane | 12.03 | 79.51 | | 67.64 |
| Ethane | 5.96 | 8.90 | 315.56 | 8.38 |
| Propane | 9.08 | 4.87 | 178.59 | 5.61 |
| iso-Butane | 2.44 | 0.69 | 30.05 | 1.00 |
| n-Butane | 6.63 | 1.28 | 53.71 | 2.22 |
| iso-Pentane | 2.84 | 0.27 | 13.16 | 0.72 |
| n-Pentane | 4.51 | 0.27 | 13.03 | 1.02 |
| Hexanes | 4.96 | 0.13 | 7.17 | 0.98 |
| Heptanes plus | 50.56 | 0.11 | 5.73 | 8.99 |
| | <u>100.00</u> | <u>100.00</u> | <u>617.00</u> | <u>100.00</u> |

Properties of Heptanes plus

| | | | |
|-----------------------|---------------|--------------|---------------|
| Density, g/cc at 15°C | <u>0.8275</u> | <u>0.753</u> | <u>0.8268</u> |
| Molecular weight | <u>179</u> | <u>93</u> | <u>178</u> |

Calculated separator gas gravity (air=1.000) = 0.724
 Calculated gross heating value for separator gas = 44.00 MJ
 per cubic metre of dry gas @ 1.013 Bara and 15°C.

Primary separator gas collected @ 36.5 barg and 42°C.
 Primary separator liquid collected @ 36.5 barg and 42°C.

Primary separator gas/separator liquid ratio 706.02 Sm^3/m^3 @ 42°C.

- * Cylinder Number: 8212717
- + Cylinder Number: A-14414

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 Well 6407/1-2 DST 1

PRESSURE-VOLUME RELATIONS AT 136°C.
 (Constant Composition Expansion)

| <u>Pressure</u> Bar a | <u>Relative</u> <u>Volume(1)</u> | <u>Deviation Factor</u> <u>Z</u> | <u>Retrograde Liquid</u> <u>Volume (2)</u> |
|-------------------------------------|-------------------------------------|-------------------------------------|---|
| 449.2 | 0.9507 | 1.139 | |
| 414.7 | 0.9769 | 1.081 | |
| 400.9 | 0.9887 | 1.057 | |
| 394.0 | 0.9952 | 1.046 | |
| <u>389.0</u> SATURATION PRESSURE | 1.0000 | 1.038 | 0.00 |
| 388.2 | 1.0010 | | 0.17 |
| 387.1 | 1.0021 | | 0.20 |
| 383.7 | 1.0056 | | 0.48 |
| 380.2 | 1.0094 | | 1.52 |
| 376.8 | 1.0133 | | 2.58 |
| 373.3 | 1.0172 | | 3.70 |
| 366.4 | 1.0258 | | 6.49 |
| 352.6 | 1.0445 | | 11.15 |
| 338.9 | 1.0655 | | 14.99 |
| 325.1 | 1.0893 | | 18.30 |
| 311.3 | 1.1160 | | 20.55 |
| 297.5 | 1.1465 | | 22.26 |
| 269.9 | 1.2208 | | 24.44 |
| 207.9 | 1.5072 | | 26.52 |
| 138.9 | 2.2149 | | |
| 70.0 | 4.5101 | | |

- (1) Relative Volume: V/V_{sat} is volume at indicated pressure per volume at saturation pressure
- (2) Expressed as Percent of Hydrocarbon Pore Space

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Well 6407/1-2 DST 1

PRESSURE-VOLUME RELATIONS AT 125°C.
 (Constant Composition Expansion)

| <u>Pressure</u> <u>Bar a</u> | <u>Relative</u> <u>Volume(1)</u> | <u>Retrograde Liquid Volume,</u> <u>Percent of Hydrocarbon Pore Space</u> |
|---------------------------------|-------------------------------------|--|
| 449.2 | 0.9520 | |
| 428.5 | 0.9665 | |
| 421.6 | 0.9718 | |
| 414.7 | 0.9769 | |
| 407.8 | 0.9826 | |
| 400.9 | 0.9885 | |
| 394.0 | 0.9947 | |
| <u>389.7</u> | 1.0000 | 0.00 |
| | SATURATION PRESSURE | |
| 387.1 | 1.0022 | 0.37 |
| 383.7 | 1.0057 | 0.89 |
| 380.2 | 1.0091 | 1.94 |
| 373.3 | 1.0165 | 4.54 |
| 366.4 | 1.0239 | 7.66 |
| 359.5 | 1.0324 | 9.81 |
| 345.8 | 1.0515 | 14.32 |
| 332.0 | 1.0720 | |
| 318.2 | 1.0957 | |
| 304.4 | 1.1226 | |
| 290.6 | 1.1468 | |
| 276.8 | 1.1879 | |
| 242.3 | 1.2988 | |
| 207.8 | 1.4605 | |

(1) Relative Volume: V/V_{sat} is volume at indicated pressure per volume at saturation pressure

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Well 6407/1-3

HYDROCARBON COMPOSITIONS OF FLUIDS FROM TWO ZONES
AND CALCULATED MIX COMPOSITIONS

| <u>Component</u> | <u>DST 2</u> Gas Condensate Well Stream Mol Percent | <u>DST 1</u> Bottom Hole Oil Sample Mol Percent | <u>MIX</u> Ratio One Mol Percent | <u>MIX</u> Ratio Two |
|--|--|--|---|----------------------------|
| Carbon Dioxide | 2.41 | 1.97 | 2.15 | 2.31 |
| Nitrogen | 0.67 | 0.32 | 0.46 | 0.59 |
| Methane | 84.37 | 56.75 | 67.74 | 78.09 |
| Ethane | 4.59 | 4.44 | 4.50 | 4.56 |
| Propane | 2.53 | 3.12 | 2.89 | 2.66 |
| iso-Butane | 0.45 | 0.56 | 0.52 | 0.48 |
| n-Butane | 0.89 | 1.40 | 1.20 | 1.01 |
| iso-Pentane | 0.31 | 0.53 | 0.44 | 0.36 |
| n-Pentane | 0.39 | 0.76 | 0.67 | 0.47 |
| Hexanes | 0.42 | 1.07 | 0.81 | 0.57 |
| Heptanes plus | 2.97 | 29.08 | 18.69 | 8.91 |
| | <u>100.00</u> | <u>100.00</u> | <u>100.00</u> | <u>100.00</u> |
| <u>Molecular weights</u> of Heptanes plus | <u>146</u> | <u>270</u> | <u>262</u> | <u>238</u> |
| <u>MOLAR RATIOS</u> - moles of gas condensate fluid per one mole of oil fluid | | | <u>0.661</u> | <u>3.396</u> |

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