

Denne rapport
tilhører

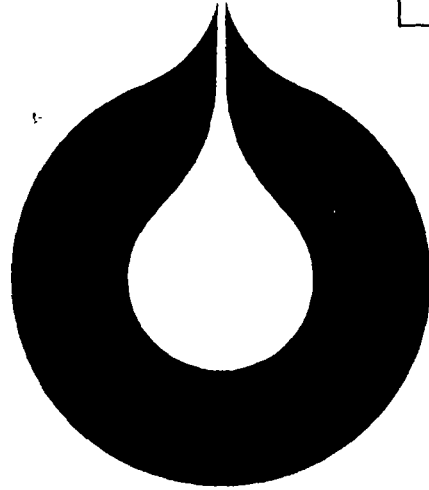
 **STATOIL**

L&U DOK. SENTER

L. NR. 12483220116

KODE Well 31/2-3 nr41

Returneres etter bruk



statoil

RESERVOIR FLUID STUDY

FOR

SHELL WELL 31/2-3 UND — ARKIVET

Nr.: _____

P. Thomassen

STATOIL PRODUCTION LABORATORY

FEB. 1981

LAB 81.12

Den norske stats oljeselskap a.s

Requested by: Shell Exploration and Production Norway.

Subtitle: Reservoir fluid study on a surface
sample from gas zone of 31/2-3.

RESERVOIR FLUID STUDY

FOR

SHELL WELL 31/2-3 UNO - ARNIVET

Nr.:

P. Thomassen

STATOIL PRODUCTION LABORATORY

FEB. 1981

LAB 81.12

Co. workers: G. Aksnes A.M. Martinsen L.I. Rossemyr
E.H. Osjord T. Ørke

SUMMARY

This report presents pvt and compositional data on samples collected during the gas test in 31/2-3.

The samples were recombined to 2.72 STB/MMSCF in our gas condensate cell, constant mass and constant volume experiments were performed at 67.7°C.

The gas is not at reservoir conditions completely dry. Trace amount of liquids are seen. The system temperature are therefore close to its cricondenterm. The dew pt. of the system accepted as being reservoir pressure, 159.4 Bara at 67.7°C.

The reservoir fluid does seem to be biodegraded because of low n-alcane and light aromat concentration.

Representative data for the fluid system can be found on the next page.

Summary of representative data from analysis

<u>Reservoir fluid composition (mole %)</u>	<u>Molecular weight</u>	<u>Density (g/cm³)</u>
Carbondioxide	1.69	
Nitrogene	0.59	
Methane	92.73	
Ethane	3.71	
Propane	0.42	
iso-Butane	0.36	
n-Butane	0.04	
iso-Pentane	0.05	
n-Pentane	0.01	
Cyclopentane	0.01	87 0.680
Hexanes	0.05	
Methylcyclopentane	0.04	91 0.751
Cyclohexane	0.05	
Heptanes	0.04	
Methylcyclohexanes	0.02	102 0.764
Octanes	0.06	
Nonanes	0.04	115 0.794
Decanes	0.03	128 0.807
Undecane +	<u>0.06</u>	167 0.840
	100.00	

Reservoir pressure (Dewpt): 158.4 Barg
Density of reservoir fluid: 0.113 g/cm³
Molecularweight of reservoir fluid: 17.58
Gas formation volume factor at reservoir pressure: 151.4 SM³M³ (862 SCF/BBL)
Liquid dropout: Only trace liquid observed below reservoir pressure.

Note: Only trace amounts of Benzene, Toluene and Xylenes are found in the sample.

INTRODUCTION

Statoil prolab was requested by Shell Exploration and Production Norway to perform PVT analysis of gas from well 31/2-3 (Ref telex FOR 281013 28.10.80)

Sample description:

A set of separator samples collected during the testing of clean sand zone in 1435 - 1460 m perforated interval. The bottles were marked:

Oil: 22024 / 26

Gas: A - 4920

See sampling sheets in appendix. Validity check of samples are summarized in table 1.

One can of stable condensate from the same test was also supplied

Methods

Component analysis are performed using a Hewlett Packard 5880 gas chromatographic systems. For gas analysis, non hydrocarbons are determined on a poropak R 1/8" x 3m steel column with TC detector, and hydrocarbons on chromapak Cp tm 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 tm sil 5 25 m x 0.22 m quartz capillary column and FI detector. To confirm GC analysis and also to determine physical properties of C₆ - C₁₁₊ cuts a preprative distillation is run on a Fischer HMS 500 mini distillation still. Molecular weight is determined by freezing point depression of benzene, density by Paar DMA 602 frequency densitometer and PNA according to ASTM 3238.

PVT analysis are performed on our Elf designed gas condensate cell produced by ABC, Paris. This is a cell of the sloane type and does offer a liquid readability down to 0.1 cm³. Total volume of cell is 3.5 l.

LAB. 81.12.

Results

Compositional results are presented in tables 2 - 6. Table 2 contains analysis of separator oil and gas and recombined reservoir fluid. Table 3. contains the composition from single flash of the separator liquid. Table 4. contains an extended analysis of the condensate liquid from the single flash. This analysis is meant to aid the further splitting of the C_{11+} fraction in reservoir fluid.

In order to get physical properties of $C_6 - C_{11+}$ cuts (mole weight and density and PNA distribution) a preparative distillation is done on the condensate sample supplied. These results can be found in table 5. It was found that this condensate was much lighter than what was produced from single flash of separator liquid. The difference in density $0.799 - 0.779 \text{ g/cm}^3$ is possibly due to the different processes by which they became stabilized. In order to confirm this, gas chromatographic analysis was run on the sample distilled. These data are presented along with the distillation data in table 5. The chromatographic traces of these two samples are presented in Fig. 1, and we can clearly see that they are similar. Molecular weight, density and PNA distribution are measured on cuts $C_6 - C_{11+}$. Results of the PNA analysis are reported in table 6.

The separator gas was charged to our gas condensate cell and separator liquid was added to yield 2.72 STB/MMSCF. This value was corrected for shrinkage of separator liquid (1.065) to 2.90 sep.bbl/MMSCF (345208 SCF/sep.bbl). The resulting volume in the cell was approx. 1.5 l. The sample was allowed to get in single phase while pressure was kept at 195 Bar and temperature at 67.7°C . The system pressure was then gradually lowered in order to determine a dewpt. This was not possible, but wetness on the windows was observed at 145 Bar. When the system was expanded maximum ie. 3.5 l the pressure was approx. 90 Bar and the amount of liquid gathered in the cell was approx. 0.2 cm^3 ie. 0.003 % of total volume.

In order to perform a full PVT analysis, the sample volume had to be reduced, so single phase reservoir fluid was transferred to 600 cm³ storage bottles, leaving approx. 500 cm³ of sample at reservoir conditions for the analysis.

A constant mass pressure-volume relation was run at reservoir temperature. Trace of liquid was observed at pressures below 145 bar (Table 6.). The liquid amounts were not at any point measureable.

The system was again single phased and a constant volume depletion was performed, results of which can be found in table 7. The mole balance during the experiment came to 100.02%. Chromatographic analysis of the gas produced is reported for every stage.

Discussion

We can see from the PVT experiments performed that the system at reservoir conditions is very dry. Its temperature is close to the cricondenthem of the system but inside the two phase region. The amount of liquids dropping out in the reservoir is very small so it can possibly be neglected in recovery calculations.

It was for reasons of low liquid content not possible to determine a dewpoint. We therefore accept reservoir pressure as our dew pt. We did see liquid 10 bar below this pressure.

The oil and gas are rather peculiar in nature. The amount of normal alkanes are low, n-C₆ and n-C₇ are only present in trace amount in the gas and liuqid phase. Also benzene and toluene are present in low concentrations. The dominant components are naphthenes. This fact is typical for a biodegraded oil.

Table 1. Validity check of separator samplesGas composition (Mole %)

CO ₂	0.59
N ₂	1.69
C ₁	92.93
C ₂	3.71
C ₃	0.42
i-C ₄	0.36
n-C ₄	0.04
i-C ₅	0.05
n-C ₅	0.01
C ₆	0.06
C ₇	0.10
C ₈	0.04
C ₉	-
	<hr/> 100.00

Separator conditions: 22.4 Barg (325 psig)
37.8°C (100°F)

Bubble point pressure of separator oil at 37.8°C: 21.7 Barg (315 psig)

Opening pressure of gas bottle: 22.0 Barg (320 psig)

Calculated gas gravity from composition: 0.600.

Rig value: 0.615

Table 2. Hydrocarbon analysis of separator products and calculated reservoir fluid composition (Test sep).

Component	Separator liquid Mole %	Separator gas Mole %	Reservoir fluid Mole %	Mole weight mi	Densi (g/cm ³)
Carbondioxide	0.10	0.59	0.59		
Nitrogen	0.03	1.69	1.69		
Methane	8.08	92.93	92.73		
Ethane	1.58	3.71	3.71		
Propane	0.53	0.42	0.42		
iso-Butane	0.98	0.36	0.36		
n-Butane	0.17	0.04	0.04		
iso-Pentane	0.47	0.05	0.05		
n-Pentane	0.17	0.01	0.01		
Hexanes	2.41	0.06	0.06	87	0.680
Heptanes	12.59	0.10	0.13	91	0.751
Octanes	20.90	0.04	0.08	102	0.764
Nonanes	15.24	-	0.04	115	0.794
Decanes	12.65	-	0.03	128	0.807
Undecane+	<u>24.10</u>		<u>0.06</u>	167	0.840
	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>		

Separator and recombination data:

Primary separator conditions: 325 psig, 100^oF
 Calculated separator gas gravity (air=1.0): 0.600
 GOR at separator conditions: 61479.6 SM³/M³
 345208 SCF/BBL
 Coresponding total CGR: 2.72 STB/MMSCF

Reservoir fluid properties:

Moelcular weight: 17.58 g/g mole
 Density of reservoir fluid at res. cond.: 0.113 g/cm³

Table 3. Hydrocarbon analysis of oil and gas from flash of Separator oil

Component	Oil wt%	Oil mole%	Separator gas Mole %	Recombined separator fluid Mole %	Mole* weight mi	Density (g/cm ³)
Carbondioxide	-	-	0.94	0.10		
Nitrogen	-	-	0.26	0.03		
Methane	-	-	76.14	8.08		
Ethane	0.049	0.21	13.14	1.58		
Propane	0.080	0.23	2.99	0.53		
iso-Butane	0.321	0.71	3.21	0.98		
n-Butane	0.064	0.14	0.40	0.17		
iso-Pentane	0.261	0.47	0.51	0.47		
n-Pentane	0.093	0.17	0.17	0.17		
Hexanes	1.648	2.60	0.77	2.41	87	0.680
Heptanes	9.600	13.96	1.12	12.59	91	0.751
Octanes	18.604	23.34	0.35	20.90	102	0.764
Nonanes	15.992	17.05	-	15.24	115	0.794
Decanes	14.699	14.15	-	12.65	128	0.807
Undecane+	35.589	26.97	-	24.10	167	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:	0.7994 g/cm ³
Mean molecular weight:	129
GOR of separator liquid:	97.7 SM ³ /M ³
Skrinkage of separator liquid:	1.605 sep.liq/stock tank liquid

* Experimental values from distillation. See table. 5.

Table 4. Extended analysis of condensate liquid by gaschromathography

<u>Component</u>	<u>wt %</u>	<u>Mol wt</u>	<u>Mol %</u>
C ₁	-	16	-
C ₂	0.049	30	0.21
C ₃	0.080	44	0.23
iC ₄	0.321	58	0.71
nC ₄	0.064	58	0.14
iC ₅	0.261	72	0.47
nC ₅	0.093	72	0.17
C ₆	1.698	84	2.52
C ₇	9.600	96	12.90
C ₈	18.604	107	22.45
C ₉	15.992	121	17.05
C ₁₀	14.699	134	14.15
C ₁₁	11.209	147	9.84
C ₁₂	8.046	161	6.45
C ₁₃	6.400	175	4.72
C ₁₄	4.714	190	3.20
C ₁₅	3.538	206	2.21
C ₁₆	2.163	222	1.26
C ₁₇	1.238	237	0.67
C ₁₈	0.699	251	0.36
C ₁₉	0.357	263	0.18
C ₂₀	0.165	275	0.08
C ₂₁	<u>0.060</u>	291	<u>0.03</u>
	100.000		100.00

Experimental mol. weight: 129

Calculated mol. weight from this composition: 129

The grouping of components are made according to Katz and Firoozibadi, Jpt Dec 1978 p. 1649. Molecular weights are also from this article.

Table 5 Preparative distillation of condensate sample
and comparison with chromatographic analysis.

<u>Component</u>	<u>wt %</u>	<u>wt %*</u>	<u>Molecular weight</u>	<u>Density at 15°C (g/cm³)</u>
C ₁	0.06	0.055		
C ₂	0.19	0.140		
C ₃	0.20	0.622		
C ₄	0.42	0.183		
C ₅	1.19	0.820		
C ₆	3.79	3.691	87	0.680
C ₇	16.74	17.222	91	0.751
C ₈	24.12	26.363	102	0.764
C ₉	16.97	17.044	115	0.794
C ₁₀	13.62	13.326	128	0.807
C ₁₁₊	<u>20.82</u>	<u>20.494</u>	167	0.840
	98.12	<u>100.000</u>		
Loss	<u>1.88</u>			
	= <u>100.00</u>			

Toluene: 0.056 wt %

Benzene: 0.008 wt %

Properties of condensate sample:

Experimental molecular weight: 114
 Average density at 15°C: 0.7793 g/cm³
 Calculated mole weight from distillation: 113.5

*Results from gas chromatographic analysis

Table 6. PNA* analysis of cuts from the distillation

Cut no	Refractive index	Density	Molecular	CA %	Weight %	
	at 20°C	at 20°	weight		CN %	Cp %
C ₇	1.41105	0.7470	87	0.2	61.8	38.0
C ₈	1.41925	0.7602	91	1.3	55.3	43.4
C ₉	1.43877	0.7899	102	10.3	46.3	43.4
C ₁₀	1.44445	0.8027	115	8.3	49.1	42.6
C ₁₁₊	1.46308	0.8366	128	11.5	40.1	39.2

* ASTM mehod D 32 38

Table 7. Constant mass pressure volume relation at 67.7°C

Pressure (Barg)	Relative vol (V/V SAT)	Liquid	Z-factor
207.4	0.774		0.886
194.2	0.823		0.883
184.4	0.862		0.878
174.1	0.912		0.877
165.1	0.960		0.875
158.4	1.000	Reservoir pressure	0.876
157.4	1.003		
146.1	1.078	Trace	
138.8	1.137	"	
128.0	1.240	"	
117.7	1.349	"	
108.9	1.480	"	
97.6	1.639	"	
88.7	1.807	"	
76.5	2.086	"	
66.2	2.444	"	

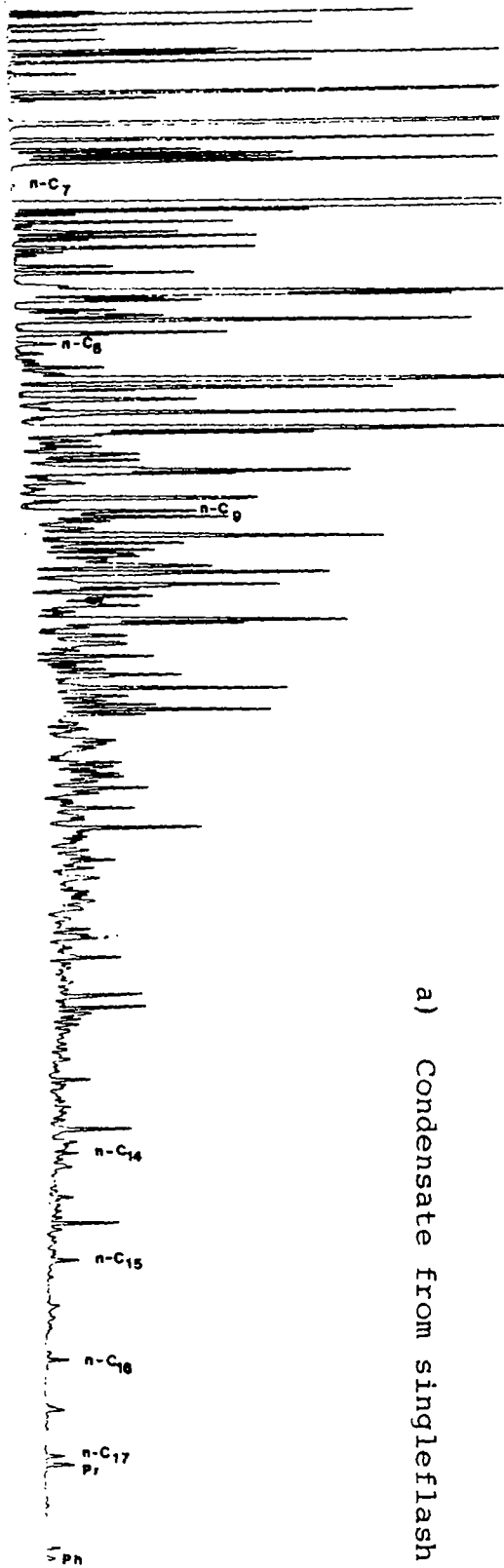
Gas formation volume factor: $\frac{151.4}{862} \frac{\text{SM}^3}{\text{M}^3}$
(862 SCF/BBL)

Table 8. Constant volume depletion exp. at 67.7°C
Hydrocarbon analysis of produced wellstream

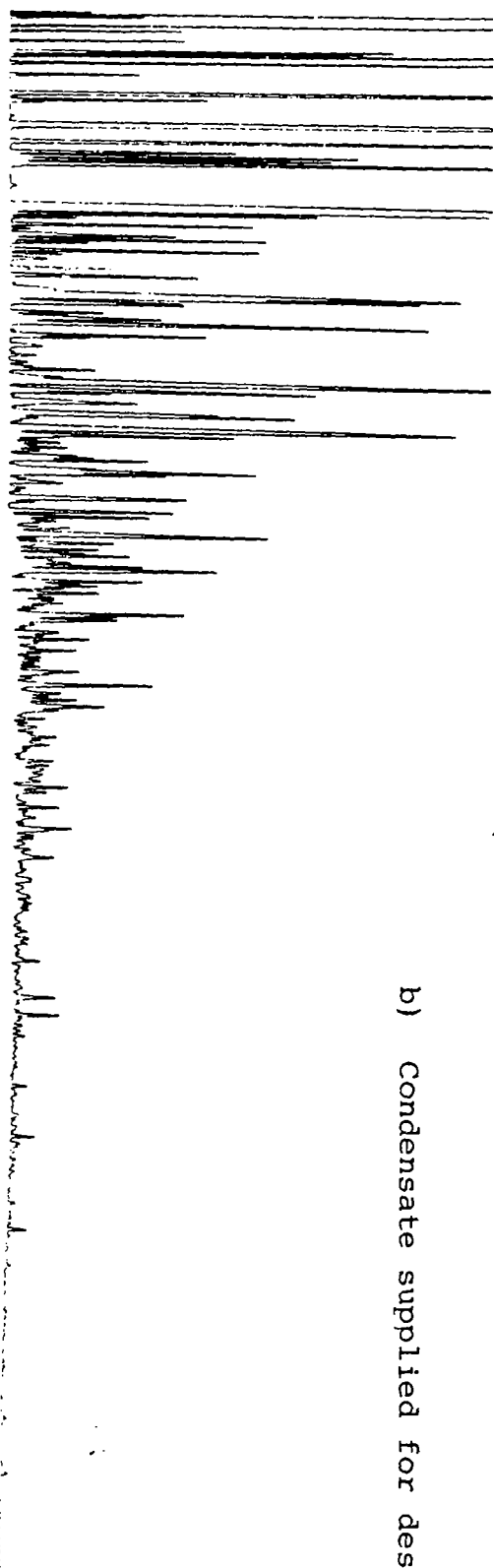
<u>Component</u>	<u>Reservoir pressure (BARA)</u>						
	158.4	138.3	118.7	100.1	79.5	55.0	34.4
Carbondioxide	1.69	1.59	1.70	1.64	1.65	1.69	1.52
Nitrogen	0.59	0.73	0.72	0.68	0.72	0.70	0.72
Methane	92.73	92.92	92.84	92.97	92.88	92.88	93.00
Ethane	3.71	3.56	3.56	3.56	3.58	3.56	3.58
Propane	0.42	0.41	0.41	0.41	0.41	0.40	0.42
iso-Butane	0.36	0.35	0.35	0.35	0.35	0.34	0.35
n-Butane	0.04	0.04	0.05	0.04	0.04	0.04	0.04
iso-Pentane	0.05	0.05	0.05	0.05	0.05	0.05	0.05
n-Pentane	0.01	0.01	0.02	0.01	0.02	0.01	0.01
Hexanes	0.06	0.08	0.08	0.07	0.08	0.08	0.07
Heptanes	0.13	0.15	0.13	0.14	0.14	0.15	0.15
Octanes	0.08	0.09	0.08	0.07	0.07	0.08	0.08
Nonanes	0.04	0.02	0.01	0.01	0.01	0.02	0.01
Decanes	0.03	-	-	-	-	-	-
Undecanes+	0.06	-	-	-	-	-	-
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Mol wt of C ₁₁₊	: 167						
Density of C ₁₁₊	: 0.840						
Real gas deviation							
factor, Z	0.876	0.883	0.881	0.894	0.910	0.937	0.960
Mole % Produced	0	11.6	12.1	12.0	12.4	18.4	12.9
Cum % of initial	0	11.6	23.7	35.7	48.1	66.5	79.4

Fig 1

a) Condensate from singleflash of sep. liquid.



b) Condensate supplied for distillation.



Client : _____

Section : ANNEX

Base : _____

Field : _____

Page : _____

Well : _____

Report N° : _____

SURFACE SAMPLING

Date of sampling : _____ Service order : _____ Sampling No. : _____

Sample nature : _____ Sampling point : _____

A - RESERVOIR AND WELL CHARACTERISTICS-

Producing zone : _____ Perforations : _____ Sampling interval : _____

Depth origin : _____ Tubing Dia. : _____ Casing Dia. : _____

Surface elevation : _____ Shoe : _____ Shoe : _____

Bottom hole static conditions	Initial pressure : _____ at depth : _____ date : _____
	Latest pressure measured : _____ at depth : _____ date : _____
	Temperature : _____ at depth : _____ date : _____

B - MEASUREMENT AND SAMPLING CONDITIONS

Time at which sample was taken : _____ Time elapsed since stabilisation : _____

Bottom hole dynamic conditions	Choke size : _____ since : _____ Well head pressure : _____ Well head temp. : _____
	Bottom hole pressure : _____ at depth : _____ date : _____
	Bottom hole temp. : _____ at depth : _____ date : _____

 Flow measurement of sampled gas - Gravity (air: 1) : _____ Factor $F_{pv} = \frac{1}{VZ}$: _____

Values used for calculations : _____

Separator	Pressure : _____ PSIG	Rates - Gas : _____ mmSCFD	GOR : _____ (separator cond.)
	Temp. : _____ °F	Oil (separator cond.) : _____ BOPD	

Stock tank	Atmosphere : _____ mmHg. _____ °F	Oil at 60°F : _____ BOPD
	Tank temperature : _____ °F	

BSW : _____ % WLR : _____ %

Transferring fluid : _____ Transfer duration : _____

 Final conditions of the shipping bottle : _____
 Pressure : _____ Temp. : _____

C - IDENTIFICATION OF THE SAMPLE

Shipping bottle No. : _____ sent on : _____ by : _____ Shipping order No. : _____

Addressee : _____

Coupled with	LIQUID	GAS
Bottom hole samples No.	_____	_____
_____	_____	_____
_____	_____	_____
Surface samples No.	_____	_____
_____	_____	_____
_____	_____	_____

Measurement conditions.

 Tank -

 Meter -

 Dump -

 Corrected with shrinkage tester -

 Corrected with tank -

D - REMARKS -

Visa Chief Operate

FLOPETROL

Client : Shell

Section : ANNEX

42Base : SWANAGE

Field : _____

Page : _____

Well : 312/3

Report N° : _____

SURFACE SAMPLING

Date of sampling : 8-7-80 Service order : _____ Sampling No. : 3
Sample nature : GAS Sampling point : S.P. GAS OUTLET

A - RESERVOIR AND WELL CHARACTERISTICS-

Producing zone : UPPER SAND Perforations : 1435-1460 Sampling interval : _____
Depth origin : RKB Tubing Dia. : 5" 11/16" Casing Dia. : 4 5/8"
Surface elevation : _____ Shoe : 1465.6 Shoe : 1469Bottom hole static conditions
Initial pressure : 2255 at depth : 1460 date : 7/28/80
Latest pressure measured : 2255 at depth : _____ date : _____
Temperature : 110.5 at depth : _____ date : _____

B - MEASUREMENT AND SAMPLING CONDITIONS

Time at which sample was taken : 02 45 Time elapsed since stabilisation : 34 minBottom hole dynamic conditions
Choke size : 4 1/2" since : 7/28 Well head pressure : 1750 Well head temp. : 50.5
Bottom hole pressure : _____ at depth : _____ date : 7/28/80
Bottom hole temp. : _____ at depth : _____ date : _____Flow measurement of sampled gas - Gravity (air: 1) : 5.15 Factor Fpv = $\frac{1}{\sqrt{Z}}$: 1.022
Values used for calculations :Separator Pressure : 325 PSIG Rates - Gas : 2092 mm SCFD GOR : 135 (separator cond.)
Temp. : 110 °F Oil (separator cond.) : _____ BOPD

B
C

Stock tank Atmosphere : _____ mmHg. _____ °F Oil at 60°F : 25 BOPD
Tank temperature : 50 °F

A	B	C	a	b
---	---	---	---	---

BSW : _____ % WLR : _____ %

Transferring fluid : _____ Transfer duration : 45 minutesFinal conditions of the shipping bottle :
Pressure : 325 Temp. : 60.5

C - IDENTIFICATION OF THE SAMPLE

Shipping bottle No. : A-4420 sent on : _____ by : _____ Shipping order No. : _____
Addressee : _____

Coupled with	LIQUID	GAS
Bottom hole samples No.	<u>22 224 / 26</u>	
Surface samples No.		

Measurement conditions.

 Tank - Meter - Dump - Corrected with shrinkage tester - Corrected with tank -

D - REMARKS -

Visa Chief Operator