statoil

WELL TEST REPORT

PL. 050

WELL NO. 34/10-4

SEPTEMBER 1980

Den norske stats oljeselskap a.s

WELL TEST REPORT

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LEIF MAGNE MELING

WELL DATA

Operator	:	Den norske stats oljeselskap
Well name	:	34/10-4
Location	:	$61°12'$ $15.12"$N $02°13'$ $55.73"$E
Classification	:	Exploration well
Drilling rig	:	Ross Rig
Spudded	:	12. Aug. 1979
Completed	:	17. Oct. 1979
RKB elevation	:	25 m
Water depth	:	197 m
Total depth	:	2600 m
Objective	:	Jurassic sanstone
Status	:	Plugged and abandonned

TEST REPORT 34/10-4

CONTENTS: PAGE:

1. INTRODUCTION

34/10-4 is the third well drilled in the Delta structure in
block 34/10. The well penetrated the Etive , Rannoch and Broom
members of Brent formation and reached a depth of 2600 m RKB.
(The Brent formation is a deltadeposition of Jurassic age).
The testing of the two previous wells indicated high
productivity and good reservoir characteristics. But the data
collected and analyzed indicate uncertainty owing to:

- wide spread in the results from PVT-analysis.
- proable variation in fluid properties with depth.
- problems with sand production.

2. OBJECTIVES

The purpose of testing 34/10-4 were therefore to:

- get an indication in the variations of fluid properties
  with depth by perforating two intervals one at the top
  and one at the bottom of the Rannoch facies
- investigate sand production and strength in more
  details. (In this facies with good reservoir properties
  this is done by perforating a short interval (2 m) to
  get a high production pr. perforation).

3. CONCLUSIONS

1. Well 34/10-4 can be considered as a high capacity well. The permeability thickness varies between 220 000 and 340 000 md-ft. This results in a permeability range of 850 to 1300 md. These values also correlate well with the the measured core permeabilities.

2. The three "tight zones" in Rannoch formation seem not to be continuous. The permeability thickness calculated from the two drill stem tests (DST 1 at the bottom and DST 2 at the top) represent the total permeability thickness in the Rannoch formation.

3. The skin values calculated are mainly dominated by skin due to partial penetration. Small completion ratios make it difficult to separate true formation damage from the effect of partial penetration.

4. The pressure at -1800 m ss in Rannoch formation is estimated to 4428 psig or 306.3 bar. The gradient is estimated to 0.32 psi/ft or 0.072 bar/m. Indicating only a +-2 psi difference between the RFT data and the pressures obtained from the DST analysis.

5. The "sand test" during DST no. 2 was negative. Rannoch formation produced without sand at a rate of 2500 BOPD/m perforations or 3200 res. bbl/D/m perforations.

6. The sand test was analysed as a deliverability test and indicated non Darcy flow with an IT flow factor (D) of 2.70×10^{-3} STBPD^{-1}. At a rate of 4050 STB/D the skin due to turbulence was approximately + 11. The magnitude of this turbulence factor is probably due to the small completion ratio.

7. Samples show a uniform reservoir hydrocarbon system throught the Rannoch formation.

8. The maximum temperature recorded during DST no. 1 was 72.4°C or 162.3°F and 71.5°C or 160.7°F during DST no. 2.

9. No water was produced.

4. DISCUSSION

4.1 DST analysis

Two drill stem tests were run in well 34/10-4 and both in the Rannoch formation (1821 m RKB - 1905m RKB). DST no. 1 was run at the bottom (1880 m RKB - 1885 m RKB) and DST no. 2 was run at the top (1824 m RKB - 1826 m RKB).

In the middle of the Rannoch formation the summary log indicated three "tight zones" with a measured core permeability of 2 md. The two DST analysis indicated a permeability of 850 - 1300 md by using the net pay thickness of the formation. These values corresponds well with the measured horizontal core permeabilities. The calculated permeability thickness must therefore represent the total zone and indicating that tight zones is probably not continous. (A summary log for well 34/10-4 can be found in the appendix A5).

The skin values calculated was high and are mainly caused by the small completion ratios. In this report no attemt was made to separate formation damage from the effect due partial penetration. Since the completion ratios are small, it is difficult to separate skin due to partial penetation by the commenly used methodes.

A reduced production time was used in the DST analysis. Cummulative production was calculated from the latest average pressure stabilization prior to the analyzed pressure build up.

A thickness of 79 m, an average porosity of 32.7% and a water saturation of 12.7% was used for both DST no. 1 and DST no. 2. These values are taken from the Petrophysical evaluation for this well. PVT Properties were taken from the Core lab. report RFLA 79192 based on a sample taken during DST no. 2. The Lynes gauge no. 1054 was used in the analysis for both DST's. The individual DST analysis, test sequence and rate data etc. can be found in the appendix A1 and A2.

4.2 Sand test

The intension of DST no. 2 was besides of collecting fluid
samples to increase the flow rate in steps by changing choke
size to obtain a critical rate/drawdown for sand production or
until a rate of 5000 STB/D was reached.

During this test the flow rate did not reach the critical level
for total failure of the sand. It was observed no sand slug
production to the surface.

Therefore it could be concluded that wells from this formation
(Rannoch members of Brent) will probably produce sand free at
2500 BOPD/m perforations (3200 res. bbl/D/m perf.) or 230
BOPD/perf. (290 res. bbl/perf.) if 11 of 13 perforations are
open for each perforated meter. This rate corresponds to a
drawdown of approx. 260 psi.

4.3 Deliverability during the sand test.

The data collected during the sand test was analyzed as an flow
after flow test. Both rate and bottom hole pressure stabilized
quickly and therefore pseudo-steady state flow was assumed. The
laminar - inertial - turbulent (LIT) flow equation was used in
the calculations. At a rate of 4050 STBPD the skin factor due
to turbulence was calculated to +11 and the IT flow factor (D)
was calculated to 2.70×10^{-3} $(STBPD)^{-1}$. Only a small
interval was perforated during the sand test (2 m) and the rate
per meter perforations was high (3200 res. bbl/D/m
perforations). This gave a high fluid velocity close to the
wellbore and probably led to turbulence in this region. At
larger completion ratios the turbulence will probably be
minimized.

The analysis of this sand test can be found in appendix A2.

4.4 RFT analysis

The repeat formation tester was run in the Brent formation and
good data was obtained from 1906.5 m RKB to 1821.5 m RKB. The
data was corrected +26 psi due to temperature and pressure.

The RFT data and the pressures obtained from the DST analysis compare perfectly. (+-2 psi difference).

A gradient of 0.32 psi/ft or 0.072 bar/m and a pressure of 4428 psig or 306.3 bar at 1800 m ss has been estimated in the Rannoch formation.

The RFT pressures from this well also compare excellent with other wells located on this structure in the Brent formation (34/10-1, 3, 5, 6, 7, 8, 9). There is approximately +-12 psi range between the RFT pressures from the different wells in the Brent formation.

The RFT data and analysis can be found in appendix A3.

4.5 Reservoir temperature

A maximum bottom hole temperature of about $72^{\circ}C$ ($162^{\circ}F$) was recorded in both tests. This value are within the range $68-77^{\circ}C$ ($155-170^{\circ}F$) of the temperature measurements in 34/10-1 and 34/10-3, but they are scattered and it is difficult to draw a correct line in the temp. vs. depth plot.

A plott of the measured reservoir temperature vs. depth from wells 34/10-1, 3 and 4 can be found in appendix A4.

4.6 Reservoir fluid

In order to obtain good information about the properties of the reservoir fluid in 34/10-4, four bottom hole samples from DST no. 1 and three from DST no. 2 were analyzed by Statoil Production Laboratory. For this well the bubble point, GOR and B_o lay nearest to the mean of all the samples. The variation in composition are only slight and well within the error limits of the analysis. The samples show a uniform reservoir hydrocarbon system throughout the Rannoch.

APPENDIX A1

DST no. 1A

BOTTOM HOLE PRESSURE REPORT

Well   34/10-4

Test no. DST no. 1A

Test Date 5.10.79-7.10-79

Date of analysis 29.7.79

Gauge no. 1054

SUMMARY OF THE RESULTS

	Semilog Analysis	Type Curve Analysis
Kh md·ft	221538	
K md	855	
S	+ 175	
$\bar{P}$ (psia) at -1832.3m ss	4478	

Max recorded Temp. 72.4°C (162.3°F)

Remarks

Signature

Well __34/10-4 DST#1A__   Test date __5.10.79-7.10.79__

Reservoir Parameters

Perforations __1880-1885 m RKB__   Zone(s) __Rannoch (Brent)__

_____   Wellbore radius __0.35__ feet

_____   RKB Elev __25m__

_____

Midpoint Production __-1857.5m__ ss   Bomb at __1857.3m__ RKB   __-1832.3m__ ss

Pressure Functions Evaluated at — _____ ss   Datum Depth — _____ ss

Delta P required to correct to datum _____ psig   Gradient _____ psi/ft

Estimated Average Pressure __4478 psia__

Formation Volume Factor __1.253__ vol/vol   Viscosity __1.21__ cp

Thickness __79m__   Porosity __32.7__ %   Drainage Area __—__ acres

Oil Saturation __87.7__ %   Oil Compressibility __8.37 ×__ 10^{-6} psi $^{-1}$

Water Saturation __12.3__ %   Water Compressibility __3.0 ×__ 10^{-6} psi $^{-1}$

Gas Saturation __—__ %   Gas Compressibility __—__ 10^{-6} psi $^{-1}$

          Formation Compressibility __3.0 ×__ 10^{-6} psi $^{-1}$

System Compressibility $C_t = S_0 C_0 + S_w C_w + S_g C_g + C_f$

$C_t = \underline{0.877} \times \underline{8.37} \, 10^{-6} + \underline{0.123} \times \underline{3.0} \, 10^{-6} + \underline{\quad} \times \underline{\quad} \, 10^{-6} + \underline{3.0} \, 10^{-6}$

$C_t = \underline{10.7} \, 10^{-6}$ psi $^{-1}$

Rates Reported on Test.

Choke __20__ / __64__ inches   Oil Rate __1800__ STBPD   Gas Rate __0.920__ MMSCFD

FTP _____ psig   Water Rate __O__ BWD   GOR __510__ SCF/STB

          ^{0}API _____   Gas Spec. Grav. _____

Cumulative Production* Oil __166.25 STB__   Gas _____

          Water _____

* __Cumulative production from 6.10.79 at 9⁵² to 12⁰⁵.__

Well 34/10-4 DST#1A   Test Date 5.10.79 - 7.10.79

Horner Analysis

Effective Production Time tp = Cumulative Production / Rate Reported on Test.

$$tp = \underline{\quad 166.25 \quad} / \underline{1800 \times 24 \times 10} = \underline{\quad 133 \ min \quad}$$

Straight line starts at __25 min__   Slope = __2.003__ psi/cycle

$P_{wf's} = $ __4160.7__ psia

$P_{1hr} = $ __4477.1__ psia

$P* = $ __4478.1__ psia

Calculated Values

$$Kh = \frac{162.6 \ Q \ Bu}{M} = \frac{162.6 \ (1800)(1.253)(1.21)}{2.003} = \underline{\quad 221538 \quad} \ md.ft$$

$$K = Kh/h = \underline{\quad 221538 \quad} / [(79)(3.281)] = \underline{\quad 855 \quad} \ md.$$

$$S = 1.1513 \left[\left[\frac{P1hr - Pwf \ s}{M} \right] + Log\left[\frac{tp+1}{tp} \right] - Log\left[\frac{K}{\phi \mu C_t \ rw^2} \right] + 3.2275 \right]$$

$$S = 1.1513 \left[\left[\frac{4477.1 - 4160.7}{2.003} \right] + Log\left[\frac{133+60}{133} \right] - Log\left[\frac{855}{(.327)(1.21)(10.7 \times 10^{-6})(.35)^2} \right] + 3.2275 \right]$$

$S = $ __+175__

$$t_{DA} = \frac{0.000264 \ Kt}{\phi \mu C_t \ A} = \frac{0.000264}{\underline{\hspace{5cm}}} = \underline{\hspace{2cm}}$$

$P_{DMBH} = $ __0__

$$\bar{P} = P* - P_{DMBH}\left[\frac{M}{2.303} \right] = \underline{\quad 4478 \quad} \ psia \ @ - \underline{\quad 1832.3 \ m \quad} ss$$

$$= \underline{\hspace{4cm}} \ @ - \underline{\hspace{4cm}} ss \ Datum$$

BRØNN 34-10-4   DST# 1
BUILDUP NUMMER   1
GAUGE 1054

NR.	TID	TRYKK
1	0.00	4160.700
2	1.00	4465.880
3	3.00	4471.930
4	5.00	4473.360
5	9.00	4475.170
6	13.00	4475.520
7	17.00	4476.230
8	19.00	4476.230
9	21.00	4476.230
10	25.00	4476.550
11	27.00	4476.550
12	29.00	4476.950
13	33.00	4476.520
14	35.00	4476.870
15	37.00	4476.520
16	41.00	4476.860
17	43.00	4476.860
18	45.00	4476.860
19	49.00	4476.810
20	51.00	4477.170
21	53.00	4477.170
22	57.00	4477.140
23	59.00	4476.800
24	61.00	4477.140
25	145.00	4477.580
26	321.00	4477.700
27	525.00	4477.950
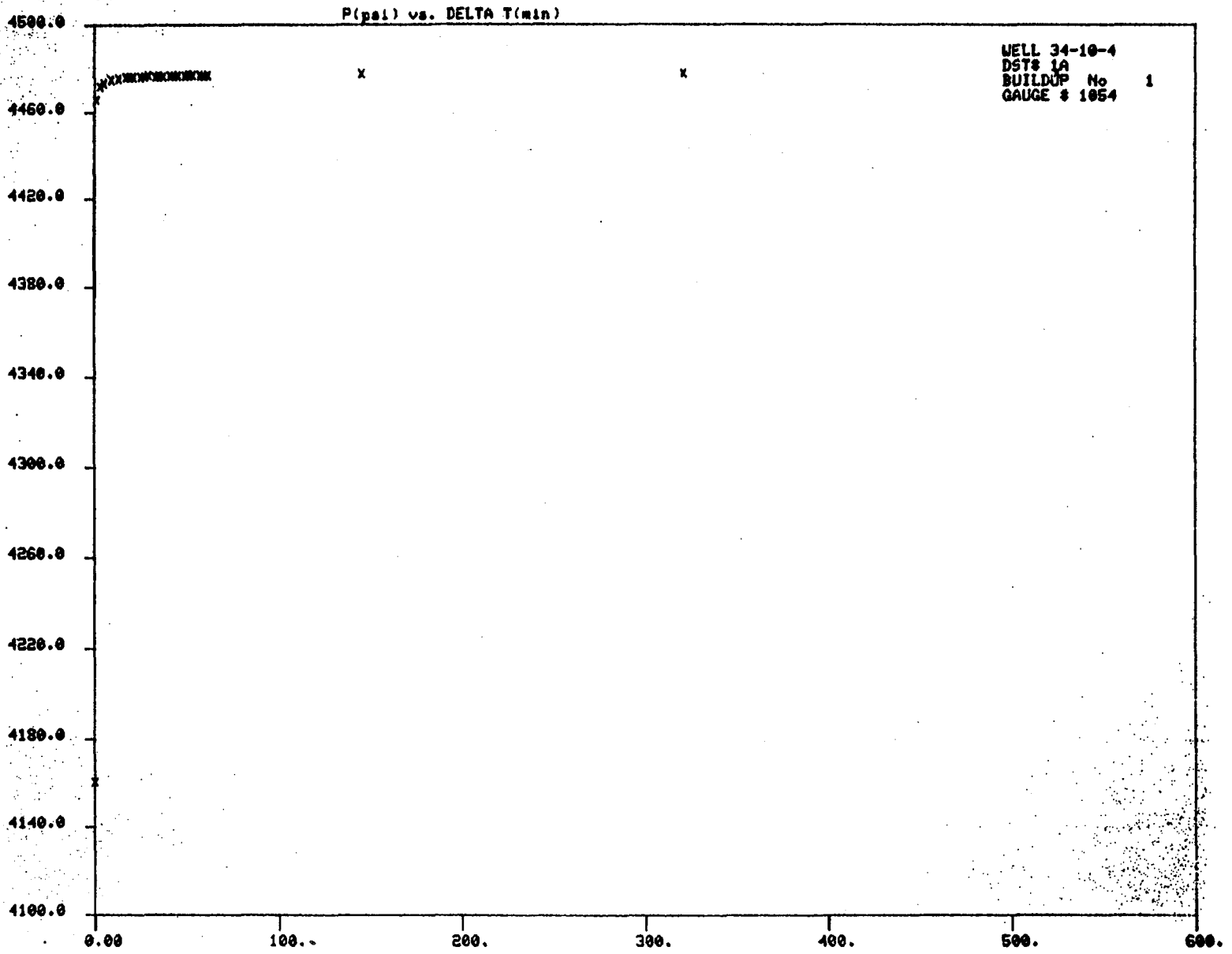
P(psi) vs. DELTA T(min)

WELL 34-10-4
DST# 1A
BUILDUP   No   1
GAUGE # 1054

4500.0
4460.0
4420.0
4380.0
4340.0
4300.0
4260.0
4220.0
4180.0
4140.0
4100.0

0.00   100.   200.   300.   400.   500.   600.

LOG(DELTA P(psi)) vs. LOG(DELTA T(min))

WELL 34-10-4
DST# 1A
BUILDUP No   1
GAUGE # 1054

Pws =   4160.7psi

P(psi) vs. LOG((T+DELTA T)/DELTA T)

WELL 34-10-4
DST# 1A
BUILDUP No   1
GAUGE # 1054
T PROD =   133 min
     m =   2.003
    PX =   4478.1psi
    P1h =   4477.1psi
    DT =   17 - 524min
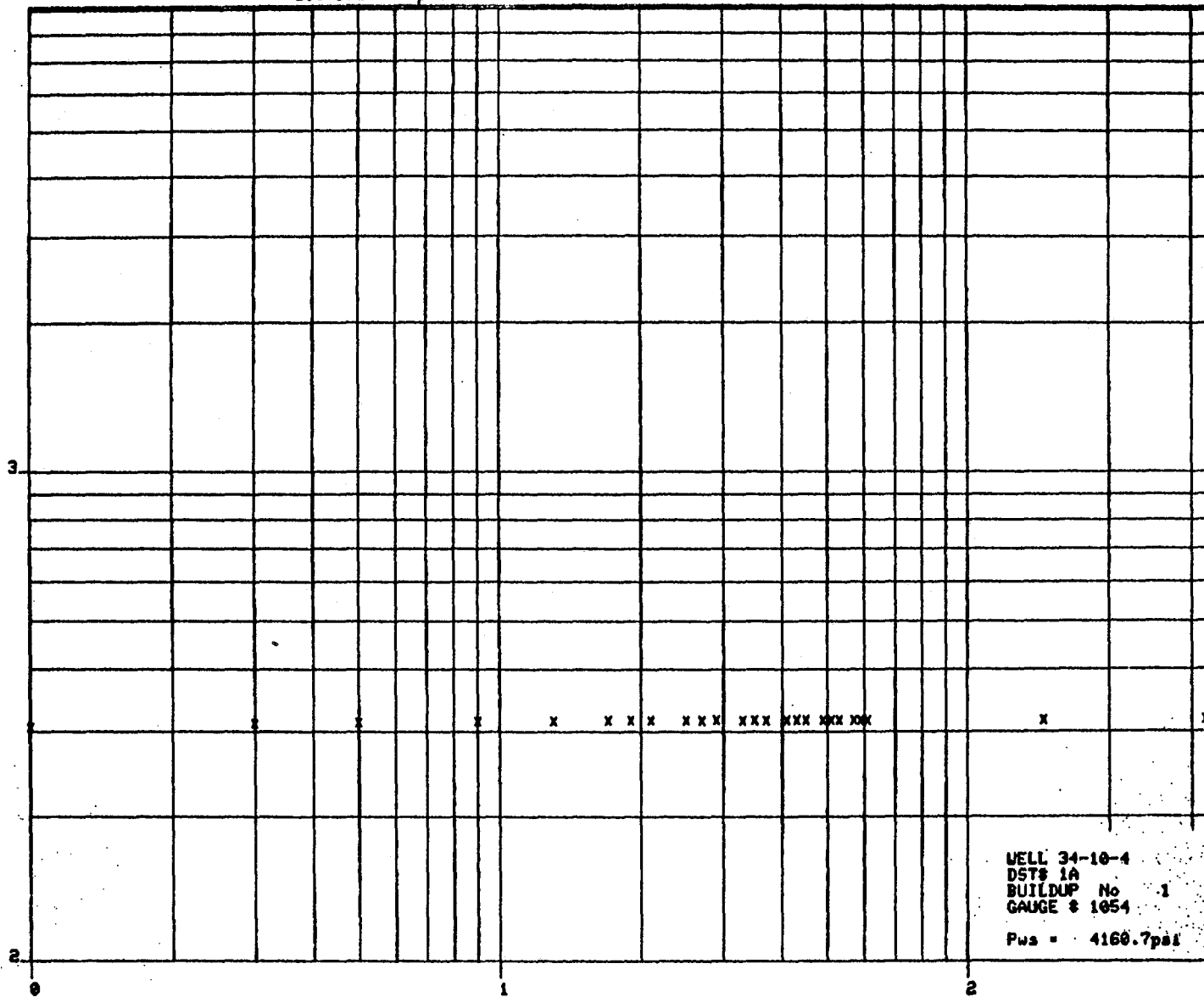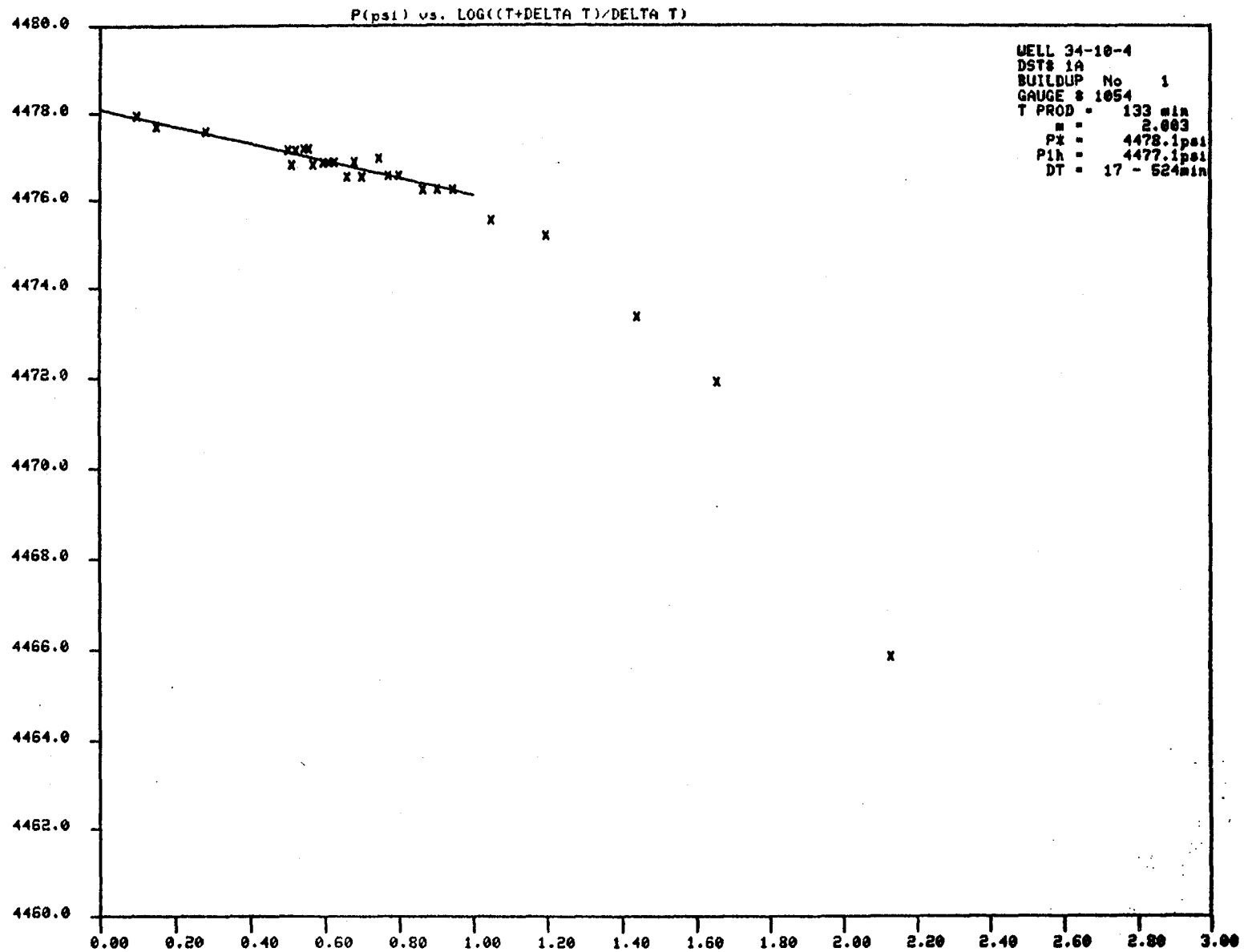
FLOWRATES FROM WELL 34/10-4 DST No. 1A.
(main flow periods)

Date	Time	Choke (1/64")	Qo (STB/D)	Qy (MMSCF/D)	GOR (SCF/STB)
5/10	18.01-23.34	20	1750	.860	490
6/10	09.52-12.05	20	1800	.920	510

SHEET A: PERFORATION AND TEST STRING

Well no. 34/10-4   DST no. 1A   Date: 5/10

Test engineer in charge: J. Hanstveit

1. Perforated interval: 1880-1885   m Ref. ISF/SONIC
2. Casing size: 7   in 29 lb/ft N-80
3. Depth to top plug (before test): 1930   m
   Tagged bottom at (after test): 1926   m
4. Type of test string: TDS   , 3½ in
5. Volume calculations:
   Volume STT - circ.valve   : 6.60 m^3 (41.5 bbl)
   Volume STT - tester valve (cushion) : 6.76 m^3 (42.5 bbl)
   Volume tester valve - lowest perf. (rathole): 0.62 m^3 (3.9 bbl)
6. Type of cushion: _____ Density: 0.998 g/cc
7. Pressure gauges:

Type	Gauge no	Press.range	Depth	Ran on	Remarks
DMR314	1054	0-5000 psi	1857.25	STRING	7+34h
DMR314	1209	0-5000 psi	1858.75	"	7+68h
DMR312	1092	0-10000 psi	1860.65	"	7+68h
RPG-3	11652N	0-5500 psi	1867.05	"	72h
RPG-3	9058	0-8200 psi	1868.93	"	72h
RPG-3	32328	0-10000 psi	1870.73	"	120h

Temperature gauges:

Type	Gauge no.	Temp.range	Depth	Ran on	Remarks
Lynes	1054,1209,1092				

Mud 1.85 g/cc

* Drillers depth, Tagged 8/10

  Sam depth, Tagged 4/10. report no. 55

Test string, DST No. 1A   Perf. interval: 1880-1885 m RKB

Description	ID inch	OD inch	Length m	Depth m RKB
OTIS STT	2.66			
3½ TDS Tubing above RKB	2.75	3.5	5.78	
3½ TDS Tubing below RKB	2.75	3.5	12.90	12.90
OTIS Lubricator Valve	2.88	13.38	2.21	15.11
3½ TDS Tubing (22 jts.)	2.75	3.5	199.12	214.23.
OTIS SSTT + x-overs	1.98	13.38	6.17	220.40
3½ TDS Tubing (153 jts.)	2.75	3.5	1373.75	1594.15
x-over	2.38	5.55	.17	1594.32
Slip Joint (open)	2.25	5.00	5.54	1599.86
Slip Joint (closed)	2.25	5.00	4.02	1603.88
6 stds. Drill Collars	2.25	4.75	171.30	1775.18
x-over	2.375	4.75	.24	1775.42
RTTS Circulating Valve	2.44	4.62	.87	1776.29
x-over	2.55	4.75	.21	1776.50
1 std. Drill Collar	2.25	4.75	28.55	1805.05
Slip Joint (closed)	2.25	5.00	4.02	1809.07
Slip Joint (closed)	2.25	5.00	4.02	1813.09
1 std. Drill Collar	2.25	4.75	28.55	1841.64
APR-A Reversing Valve	2.25	5.00	.92	1842.56
APR-N Tester Valve	2.25	5.00	3.89	1846.45
Big John Jars	2.37	4.63	1.57	1848.02
RTTS Circulating Valve	2.44	4.62	.87	1848.89
RTTS Safety Joint	2.44	4.87	.84	1849.73
RTTS Packer above	2.185	5.75	.51	1850.24
RTTS Packer below	2.185	5.75	.82	1851.06
2 7/8 EUE Pup Joint	2.25	2.875	1.14	1852.20
Sand Screen (0.1 gauge)	2.25	3.5	2.89	1855.09
XN Nipple w/x-overs	2.375	1.79	.9	1855.99
2 7/8 Tubing (2 jts.)	2.25	2.875	18.9	1874.88
Bull Plug				

SHEET D: SEPARATOR AND BOTTOM HOLE SAMPLING

Wel no. 34/10-4   DST no. 1A   Date: 5.10.79

1. Separator samples

Bottle no.	Oil/gas	Time	Oil rate	Gas rate
22400-104	oil	21.45-22.20	1750/STB/D	0.86 MMSCF/D
A 10494	gas	"		
22400-107	oil	22.35-23.10	"	"
A10488	gas	"		

2. Bottom hole samples

Bottle no.	Sampling depth	Sampling pressure	Opering pressure	Transfer BPP	True BPP (lab)
22024-68	1798 m RKB	4391	2180@ 52°	2930@ 54	
73FA230-26	"	"	2040@ 55	2940 @ 54°	
22024-73	"	"	2120 @ 54°	2950 @ 54°	
2657/30	"	"	2120 @ 54°	2950 @54°	

Test sequence, DST No. 1A.

Date	Time	Operations
2/10	13.00-18.00 (5 hrs.)	Ran Schlumberger perforation guns and perforated 1880-1885 m RKB
2-3/10	18.00-18.00 (24 hrs.)	RIH w/teststring. Unable to get through the liner due to a too large outer diameter on the x-over between the top slip joint and the tubing. DST No. 1-a misrun.
3-5/10	18.00-16.29 (46 hrs)	RIH w/teststring. Pressure tested string, test equipment and surface lines. Unable to open APR-N valve. Had to POOH w/test-string. Made a new RIH after circulated bottoms up. Pressure tested again.
5/10	16.29	Opened APR-N tester valve.
	16.35-16.37 (2 mins)	Opened well on 32/64" fixed choke for initial flow. Flowed 4.75 bbls to surge tank.
	16.37-17.37 (60 mins)	Closed APR-N tester valve and choke mani-fold for initial shut in.
	17.37	Opened APR-N tester valve
	17.39-18.01 (22 mins)	Opened well on 16/64" fixed choke for clean up. Flow directed to burner.
	18.01-23.34 (335 mins)	Flowed through 20/64" fixed choke. Mud and gas to surface after 7 mins. Flow directed through separator at 18.58 hrs. Estimated flow rate: 1750 STB/D

Date	Time	Operations
5-6/10	23.34-00.23 (49 mins.)	Flowed through 8/64" fixed choke. Flow directed through surge tank to measure rate for bottom hole sampling.
6/10	00.23-09.52 (9.5 hrs.)	The well closed in at choke manifold. Waited on the weather to run bottom hole samplers.
	09.52-12.05 (133 mins.)	Opened well on 20/64" fixed choke for 3 rd. flow periode. Flow directed through separator and at 10.45 hrs. from separator to surge tank. The surge tank bypassed at 11.50 hrs. Unable to ignite the burner. Estimated flow rate: 1800 STB/D.
6-7/10	12.05-07.49 (20 hrs.)	The well shut in at APR-N tester valve and choke manifold. Final build up. Waited on the weather.
7/10	07.49	Opened APR-N tester valve.
	07.54-13.46 (352 mins.)	Opened well on 8/64" choke for bottom hole sampling, run no. 1. Flowed approximately 380 STB/D to surge tank.
	13.46-16.41 (175 mins.)	Opened well on 8/64" choke for bottom hole sampling, run no. 2. Flowed approximately 350 STB/D to surge tank.
7-8/10	16.41-03.30	The well shut in at choke manifold and bullheaded. Reverse circulated and POOH with test string and retreived Amerada and Lynes recorders.

34/10-4, DST no. 1A
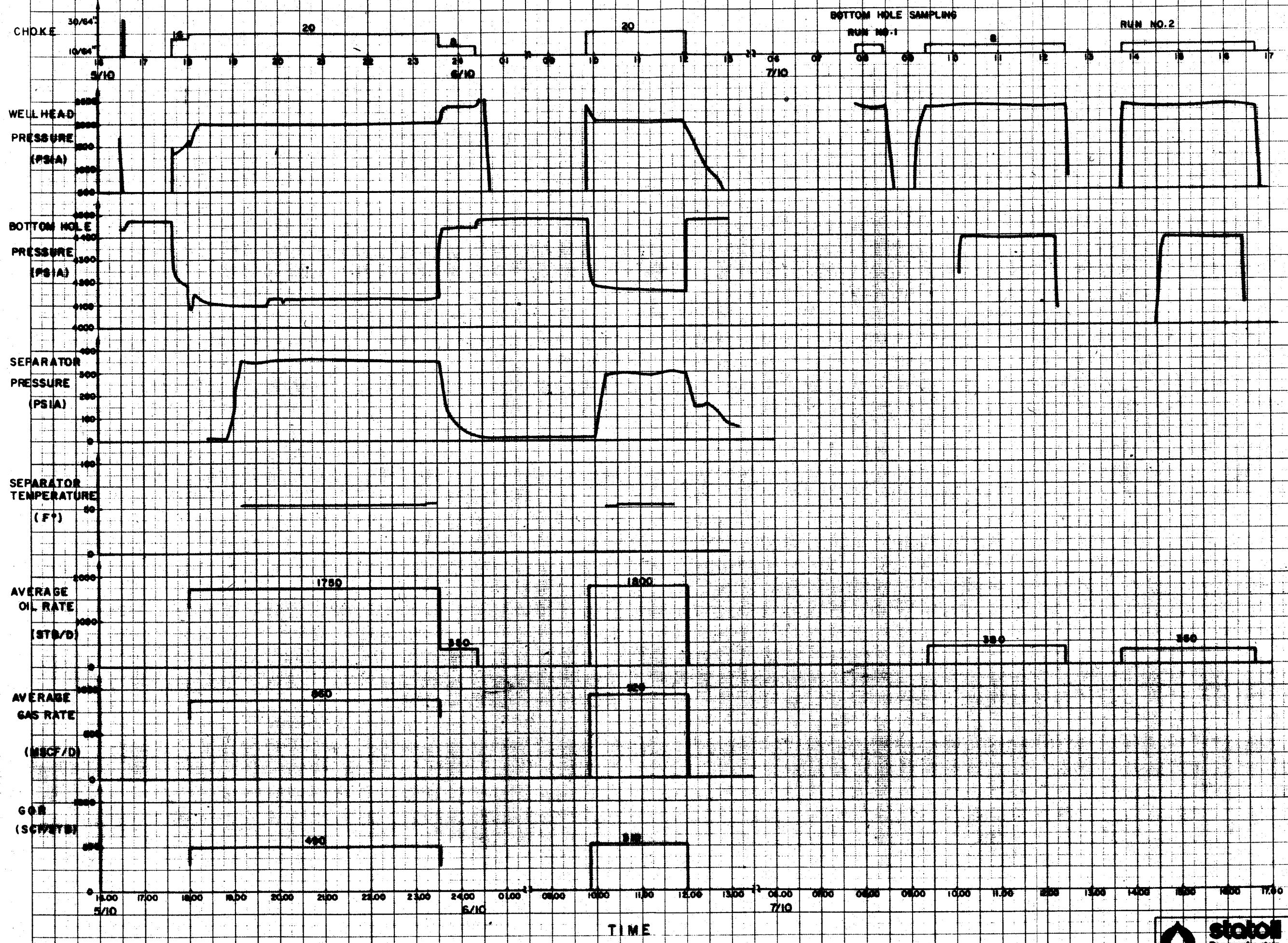
APPENDIX A2

DST No. 2

BOTTOM HOLE PRESSURE REPORT

Well __34/10-4__   Test no. __DST no. 2__

Test Date __10.10.79-13.10.79__   Date of analysis __29.7.79__

Gauge no. __1054__

SUMMARY OF THE RESULTS

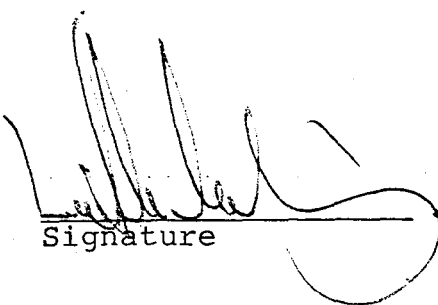|	Semilog Analysis	Type Curve Analysis
Kh md·ft	337760	
K md	1303	
S	+ 76	
$\bar{P}$ (psia) at-1780.3m ss	4420	

Max recorded Temp. __71.5°C (160.7°F)__

Remarks

From deliverability analysis:

$$\bar{P}_r - P_{wf} = 43.1 \times 10^{-3} Q + 1.71 \times 10^{-6} Q^2$$

IT flow factor D = 2.70×10^{-3} STBPD^{-1}

AOF = 39780 STB/D

Signature

Well 34/10-4 DST#2   Test date 10.10.79 - 13.10.79

Reservoir Parameters

Perforations 1824-1826 m RKB   Zone(s) Rannoch (Brent)

ss _____   Wellbore radius 0.35 feet

   _____   RKB Elev 25m

   _____

Midpoint Production − 1800m ss   Bomb at 1805.3 m RKB   − 1780.3 m   ss

Pressure Functions Evaluated at −_____ ss   Datum Depth −_____ ss

Delta P required to correct to datum _____ psig   Gradient _____ psi/ft

Estimated Average Pressure 4420 psia

Formation Volume Factor 1.253 vol/vol   Viscosity 1.21 cp

Thickness 79.0m   Porosity 32.7 %   Drainage Area − acres

Oil Saturation 87.7 %   Oil Compressibility 8.37 × 10^{-6}psi^{-1}

Water Saturation 12.3 %   Water Compressibility 3.0 × 10^{-6}psi^{-1}

Gas Saturation − %   Gas Compressibility − 10^{-6}psi^{-1}

                                Formation Compressibility 3.0 × 10^{-6}psi^{-1}

System Compressibility $C_t = S_0 C_0 + S_w C_w + S_g C_g + C_f$

$C_t = $ 0.877 × 8.37 10^{-6} + 0.123 × 3.0 10^{-6} + − × − 10^{-6} + 3.0 10^{-6}

$C_t = $ 10.7 × 10^{-6}psi^{-1}

Rates Reported on Test.

Choke 32 / 64 inches   Oil Rate 4050 STBPD   Gas Rate 1.990 MMSCFD

FTP _____ psig   Water Rate 0 BWD   GOR ·490 SCF/STB

                    °API 29°   Gas Spec. Grav. _____

Cumulative Production* Oil 1013.2 STB   Gas _____

                       Water _____

* Cumulative production from 12.10.79 at 3$\frac{56}{}$ to 12$\frac{56}{}$

Well __34/10 - 4 DST#2__ Test Date __10.10.79 - 13.10.79__

Horner Analysis

Effective Production Time tp = Cumulative Production / Rate Reported on Test.

$$tp = \frac{1013.2}{9 \text{ min.}} / (4050 \times 24 \times 60) = 360 \text{ min}$$

Straight line starts at __9 min.__   Slope = __2.956__ psi/cycle

$P_{wf's}$ = __4204.7__ psia

P_{1hr} = __4417.2__ psia

$P*$ = __4419.7__ psia

Calculated Values

$$Kh = \frac{162.6 \; Q \; B\mu}{M} = \frac{162.6 \,(4650)(1.253)(1.21)}{2.956} = 337760 \text{ md.ft}$$

$$K = Kh/h = \frac{337760}{} / (79 \times 3.281) = 1303 \text{ md.}$$

$$S = 1.1513 \left[\left[\frac{P1hr - Pwf\,s}{M}\right] + Log\left[\frac{tp+1}{tp}\right] - Log\left[\frac{K}{\emptyset \, \mu \, C_t \, rw^2}\right] + 3.2275 \right]$$

$$S = 1.1513 \left[\left[\frac{4417.2 - 4204.7}{2.956}\right] + Log\left[\frac{360+60}{360}\right] - Log\left[\frac{1303}{(0.327)(1.21)(10.7\times10^{-6})(0.35)^2}\right] + 3.2275 \right]$$

S = __+76__

$$t_{DA} = \frac{0.000264 \; Kt}{\emptyset \, \mu \, C_t \, A} = \frac{0.000264}{} \qquad = \underline{\qquad}$$

P_{DMBH} = __0__

$$\bar{P} = P* - P_{DMBH}\left[\frac{M}{2.303}\right] = \underline{\quad 4420 \text{ psia} \quad} \quad @ - \underline{1780.3 \text{ m}} \text{ ss}$$

$$= \underline{\qquad\qquad} \text{ psig } @ - \underline{\qquad\qquad} \text{ ss Datum}$$

BRØNN 34-10-4   DST# 2
BUILDUP NUMMER   1
GAUGE 1054

NR.	TID	TRYKK
1	0.00	4204.660
2	1.00	4408.410
3	3.00	4412.690
4	5.00	4414.100
5	9.00	4414.840
6	11.00	4415.190
7	13.00	4415.560
8	17.00	4415.890
9	19.00	4415.560
10	21.00	4415.890
11	25.00	4416.240
12	27.00	4416.240
13	29.00	4416.590
14	33.00	4416.230
15	35.00	4416.230
16	37.00	4416.230
17	41.00	4416.580
18	43.00	4416.930
19	45.00	4416.930
20	49.00	4416.580
21	51.00	4416.890
22	53.00	4416.890
23	77.00	4417.160
24	81.00	4417.160
25	83.00	4417.160
26	85.00	4417.160
27	97.00	4417.420
28	113.00	4417.800
29	153.00	4418.060
30	189.00	4418.030

P(psi) vs. DELTA T(min)

WELL 34-10-4
DST# 2
BUILDUP   No   1
GAUGE # 1054

A2-6

LOG(DELTA P(psi)) vs. LOG(DELTA T(min))

WELL 34-10-4
DST# 2
BUILDUP No   1
GAUGE # 1054

Pws =   4204.7psi

P(psi) vs. LOG((T+DELTA T)/DELTA T)

WELL 34-10-4
DST# 2
BUILDUP No   1
GAUGE # 1054
T PROD =   360 min
    m =   2.956
    P* =   4419.7psi
   P1h =   4417.2psi
    DT =   4 - 20min

A2-8
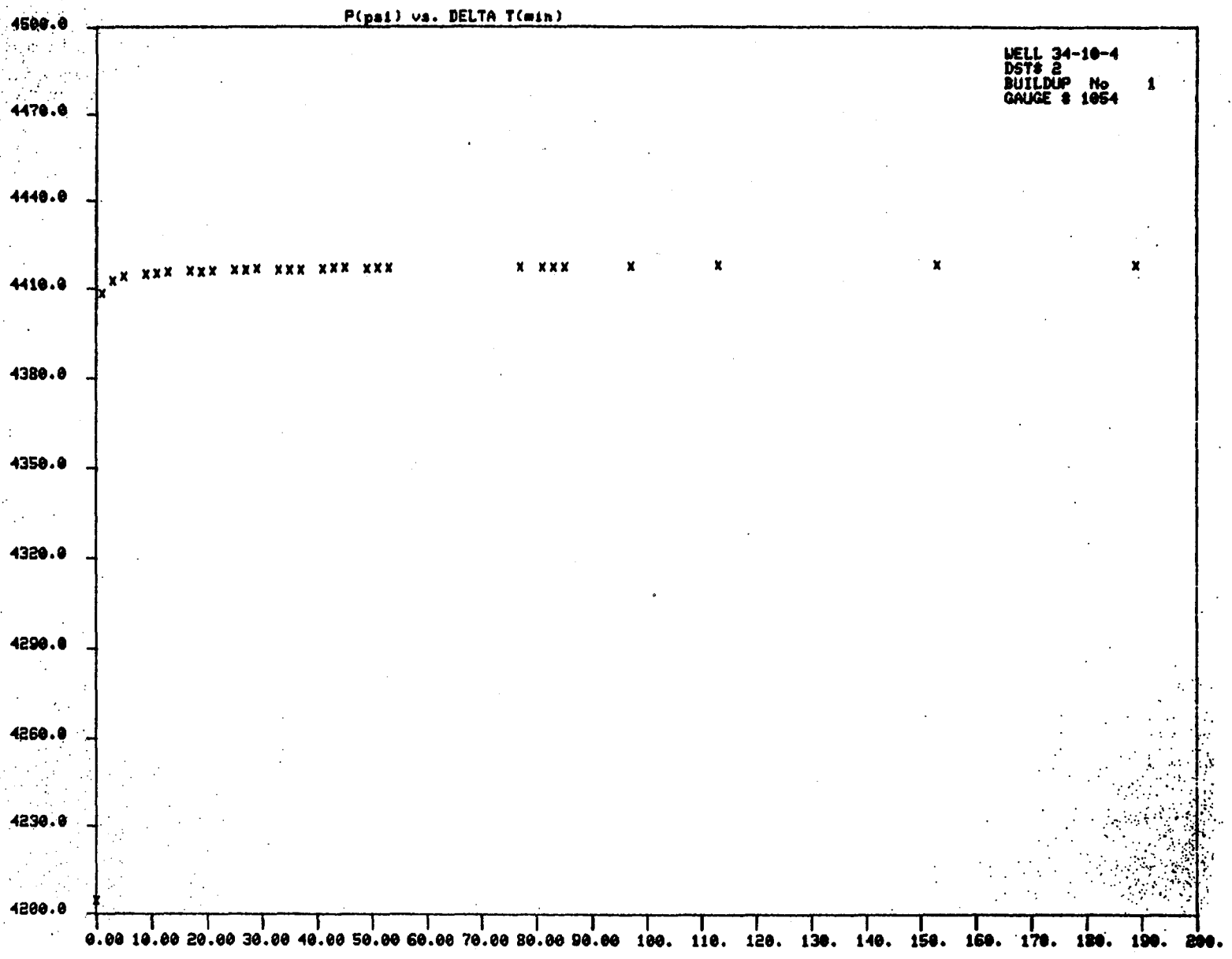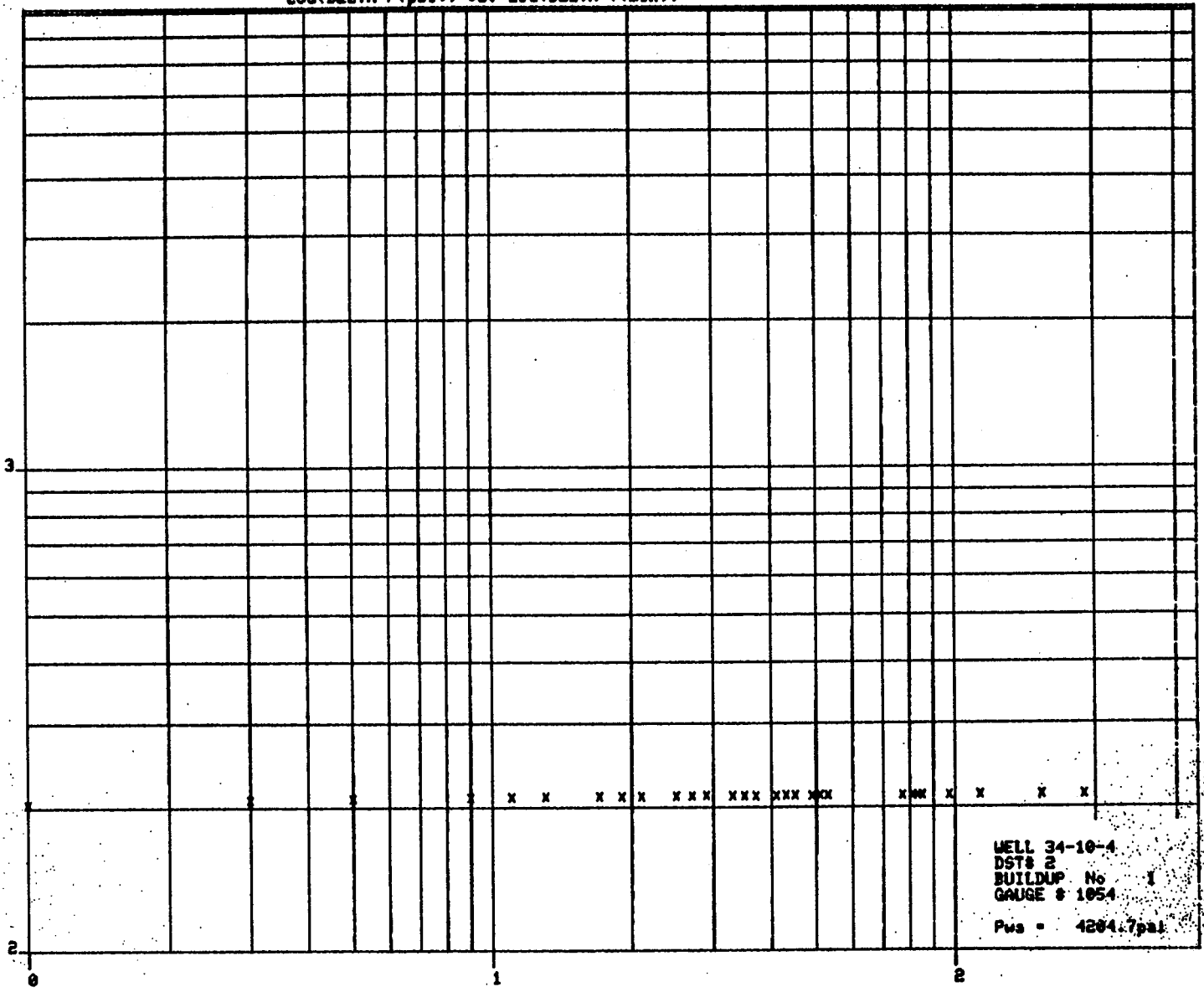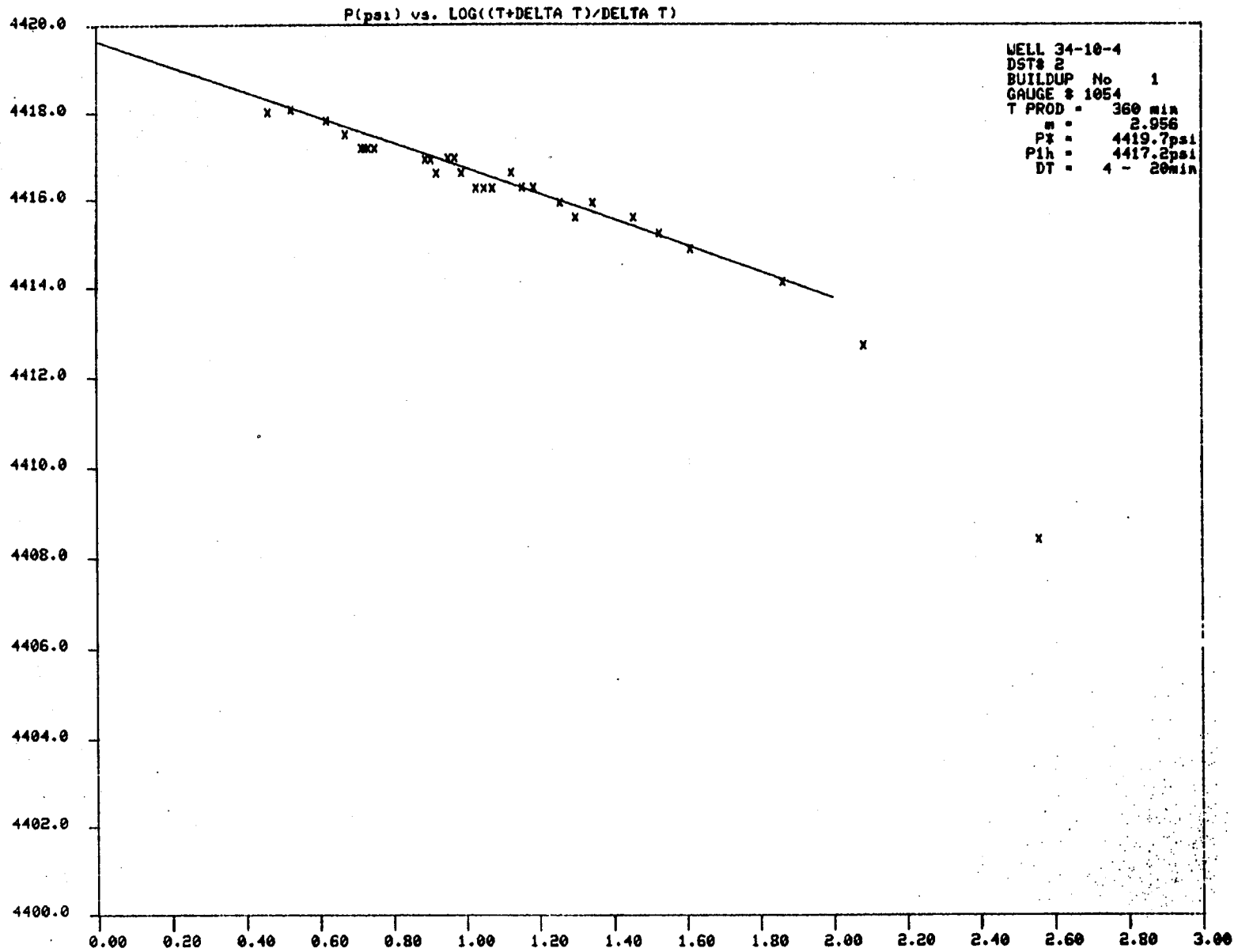
Well $\underline{34/10-4 \; DST \; no \; 2}$ Test Date $\underline{10.10.79}$

DELIVERABILITY CALCULATIONS, LIT ANALYSIS

$A = \underline{43.1 \times 10^{-3} \; psi/STBPD}$

$B = \underline{1.71 \times 10^{-6} \; psi/STBPD^2}$

$$\bar{P}_R - P_{wf} = AQ + BQ^2$$

$$\bar{P}_R - P_{wf} = 43.1 \times 10^{-3} Q + 1.71 \times 10^{-6} Q^2$$

$$AOF = \frac{1}{2B} \left(-A + (A^2 + 4B\bar{P}_R)^{0.5} \right)$$

$AOF = \underline{39780 \; STBPD}$

$$D = \frac{Kh}{141.2 \; \mu_o \; B_o} \; B = \frac{337760}{(141.2)(1.21)(1.253)} \; 1.71 \times 10^{-6}$$

$D = \underline{2.70 \times 10^{-3} \; STBPD^{-1}}$

DATA USED IN THE DELIVERABILITY ANALYSIS.
34/10-4 DST 2

P_i = 4419.7 psia

TIME	CHOKE 1/64"	Qo STBPD	Pwf psia	ΔP psi	$\Delta P/Qo$ psi/STBPD
23.48-03.00	8	350	4404.5	15.2	43.4×10^{-3}
04.07- 5.15	10+16	1800	4336.1	83.6	46.4×10^{-3}
05.20-06.45	14+16	2280	4312.2	107.2	47.1×10^{-3}
07.00-08.00	12+20	2850	4284.7	135.0	47.4×10^{-3}
08.20-09.30	16+20	3280	4260.0	159.7	48.7×10^{-3}
09.45-10.00	14+24	3530	4247.9	171.8	48.7×10^{-3}
10.15-10.45	16+24	3710	4235.7	184.0	49.6×10^{-3}
11.00-11.45	20+24	4020	4205.0	214.7	53.4×10^{-3}
12.05-12.15	32	4050	4204.6	215.1	53.1×10^{-3}
18.15-18.45	20	2100	4319.7	100.0	47.6×10^{-3}
19.00-19.15	24	2750	4287.2	132.5	48.2×10^{-3}
9.30-21.00	32	4150	4212.2	207.5	50.0×10^{-3}
21.15-23.30	12+32	4300	4199.7	220.0	51.2×10^{-3}
24.00-00.30	16+32	4610	4177.2	242.5	52.6×10^{-3}
00.45-01.45	20+32	5100	4164.7	255.0	50.0×10^{-3}

23.48-12.15 : Gauge no. 1054

18.15-01.45 : Gauge no. 1092 + 19.73 psi

A graph plotting $\Delta P/Q_o$ (vertical axis, labeled A4, with values 40×10⁻³, 45×10⁻³, 50×10⁻³) versus Q_o (horizontal axis, 0 to 5000).

$$A = 43.1 \times 10^{-3} \; psi/STB$$
$$B = 1.71 \times 10^{-6} \; psi/B-B^2$$

○ : 13.48 – 12.15, GAUGE # 1054
△ : 18.15 – 01.45, GAUGE # 1092 – 19.7 psi

A2-11

34110-4, DST NO.2

ΔP
PSI

1000

100

10

N=1.0

100   1000   10000   100000

Q_o
STBPD
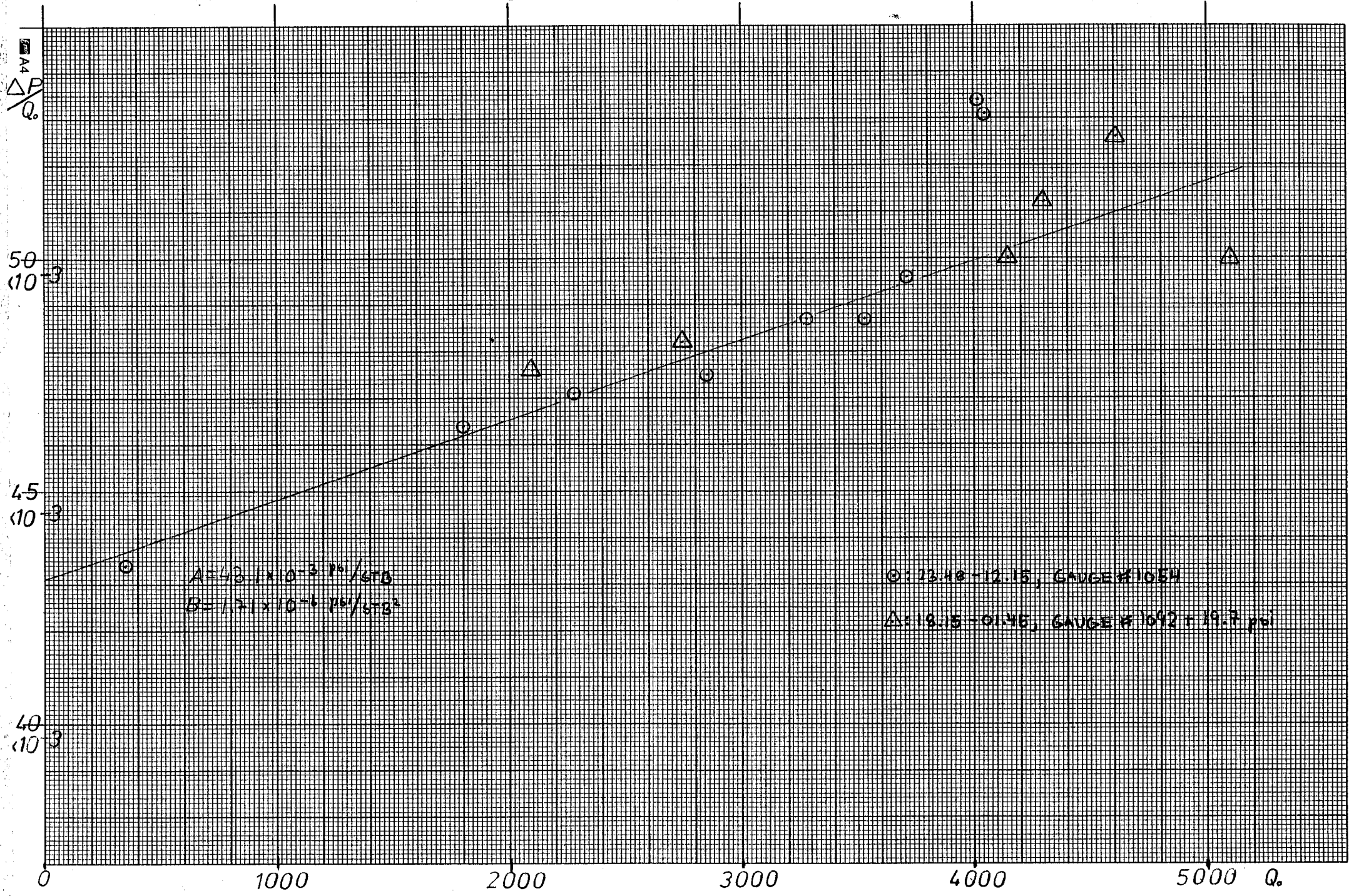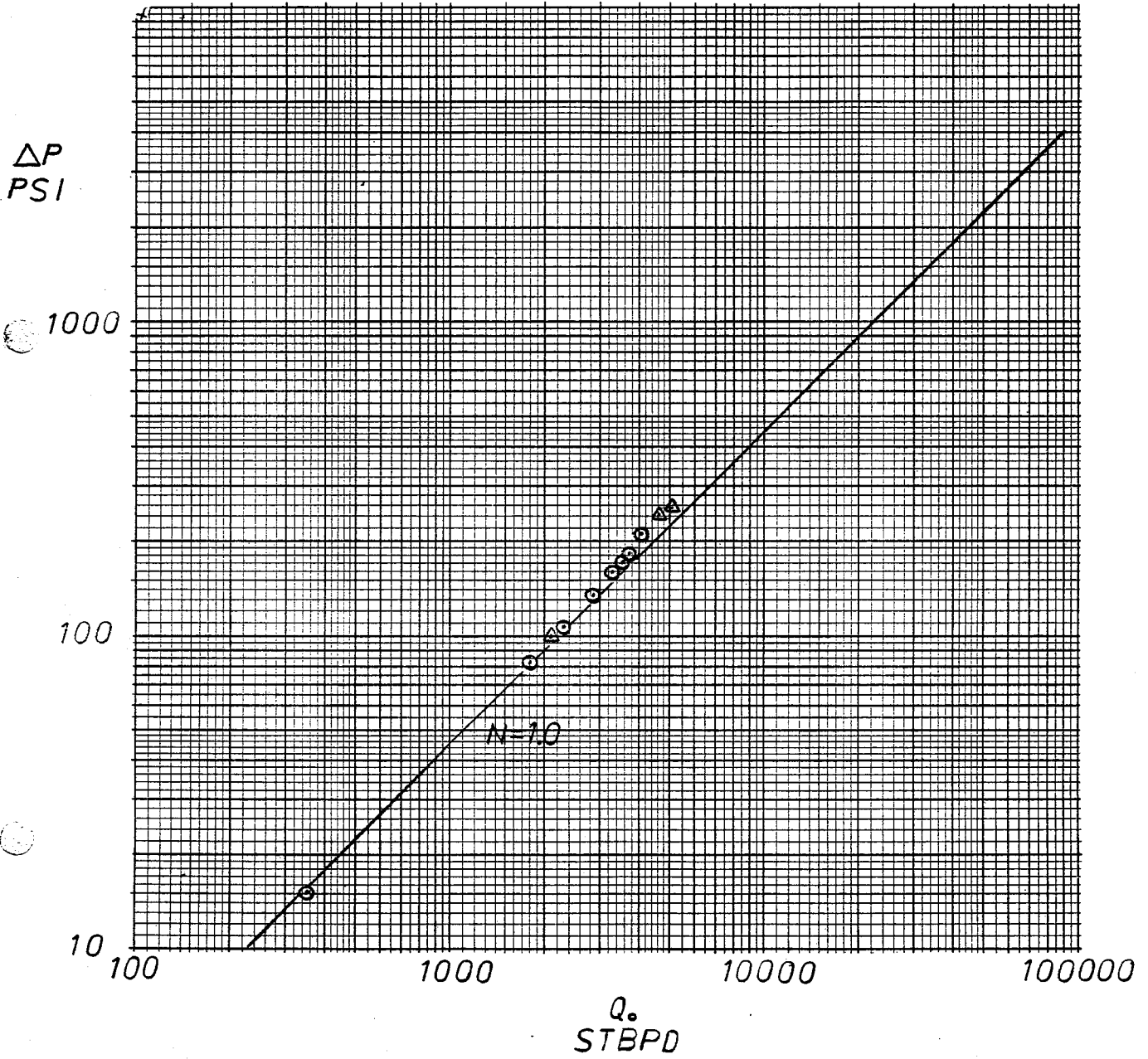
Date	Time	Choke (1/64")	Qo (STB/D)	Qg (MMSCF/D)	GOR (SCF/STB)
11/10	12.24-18.01	16	1250	.585	470
	19.21-22.15	8	365		
11-12/10	23.48-03.00	8	350		
12/10	04.07-05.15	10+16	1800	.775	430
	05.20-06.45	14+16	2280	.975	430
	07.00-08.00	12+20	2850	1.225	430
	08.20-09.30	16+20	3280	1.48	450
	09.45-10.00	14+24	3530	1.61	460
	10.15-10.45	16+24	3710	1.71	460
	11.00-11.45	20+24	4020	1.90	470
	12.05-12.15	32	4050	1.99	490
	18.15-18.45	20	2100	.975	460
	19.00-19.15	24	2750	1.26	460
	19.30-21.00	32	4150	1.85	450
	21.15-23.30	12+32	4300	2.04	470
13/10	24.00-00.30	16+32	4610	2.12	460
	00.45-01.45	20+32	5100	2.38	470

SHEET A: PERFORATION AND TEST STRING

Well no. 34/10-4   DST no. 2   Date: 10/10

Test engineer in charge: J. Hanstveit

1. Perforated interval: 1824-1826   m Ref. ISF/SONIC

2. Casing size: 7"   in   29 lb/ft N-80

3. Depth to top plug (before test):   1832   m

   Tagged bottom at (after test):   1829   m

4. Type of test string: TDS   , 3½   in

5. Volume calculations:

   Volume STT - circ.valve   :   6.42 m^3 (40.37   bbl)

   Volume STT - tester valve (cushion) :   6.60 m^3 (41.50   bbl)

   Volume tester valve - lowest perf. (rathole):   0.52 m^3 (3.3   bbl)

6. Type of cushion: _____   Density: _____

7. Pressure gauges:

Type	Gauge no	Press.range	Depth	Ran on	Remarks
DMR314	1209	0-5000	1803.83	STRING	7+68h
DMR314	1054	0-5000	1805.33	"	7+34h
DMR312	1092	0-10000	1807.23	"	7+68h
RPG-3	11652N	0-5500	1813.63	"	72h
RPG-3	9058	0-8200	1815.51	"	72h
RPG-3	32328	0-10000	1817.31	"	120h

Temperature gauges:

Type	Gauge no.	Temp.range	Depth	Ran on	Remarks
Lynes	1209,1054and1092				

Test string, DST No. 2   Perf. interval: 1824-1826 m RKB

Description	ID inch	OD inch	Length m	Depth m RKB
OTIS STT	2.66			
3½ TDS Tubing above RKB	2.75	3.50	5.40	
3½ TDS Tubing below RKB	2.75	3.50	13.28	13.28
OTIS Lubricator Valve	2.88	13.38	2.21	15.49
3½ TDS Tubing (22 jts.)	2.75	3.50	199.12	214.61
OTIS SSTT + x-overs	1.98	13.38	6.17	220.78
3½ TDS Tubing (147 jts.)	2.75	3.50	1321.70	1542.48
x-over	2.75	5.50	.17	1542.65
Slip joint (open)	2.25	5.00	5.54	1548.19
Slip joint (closed)	2.25	5.00	4.02	1552.21
6 stds. Drill Collar	2.25	4.75	171.30	1723.51
x-over	2.38	4.75	.24	1723.75
RTTS Circulating Valve	2.44	4.62	.87	1724.65
x-over	2.55	4.75	.21	1724.83
1 std. Drill Collar	2.25	4.75	28.55	1753.38
Slip joint (closed)	2.25	5.00	4.02	1757.40
Slip joint (closed)	2.25	5.00	4.02	1761.42
1 std. Drill Collar	2.25	4.75	28.55	1789.97
APR-A Reversing valve	2.25	5.00	.92	1790.89
APR-N Tester valve	2.25	5.00	3.89	1794.78
Big John Jars	2.37	4.63	1.57	1796.35
RTTS Circulating Valve	2.44	4.62	.87	1797.22
RTTS Safety Joint	2.44	4.87	.84	1798.06
RTTS Packer above	2.19	5.75	.51	1798.57
RTTS Packer below	2.19	5.75	.82	1799.39
Perforated 2 7/8 EUE Tubing	2.25	2.875	2.27	1801.66
OTIS XN-nipple + x-overs	1.79	2.375	.90	1802.56
2 jts. 2 7/8 EUE Tubing w/Bull Plug	2.25	2.875	18.9	1821.46

DST SUMMARY DATA

SHEET D: SEPARATOR AND BOTTOM HOLE SAMPLING

Wel no.   34/10-4   DST no. 2   Date: 11/10-79

1. Separator samples

Bottle no.	Oil/gas	Time	Oil rate	Gas rate
2811-13	oil	13.45-14.40	1250 STB/D	.585MMSCF/D
A10459	gas	"		
22461-14	oil	15.00-15.45	"	"
A10483	gas	"		
20475-90	oil	16.15-17.00	"	"
A10462	gas	"	"	"
22461-1	oil	17.10-17.50		
A10477	gas	"	"	"

2. Bottom hole samples

Bottle no.	Sampling depth	Sampling pressure	Opering pressure	Transfer BPP	True BPP (lab)
22226-116	1737 m RKB	4346	2160	2880@54	
20475-62	"	"	2180	2880@55	
20475-66	"	"	2220	2880@57	
14068/66	"	"	2230	2880@57	

Test sequence, DST No. 2
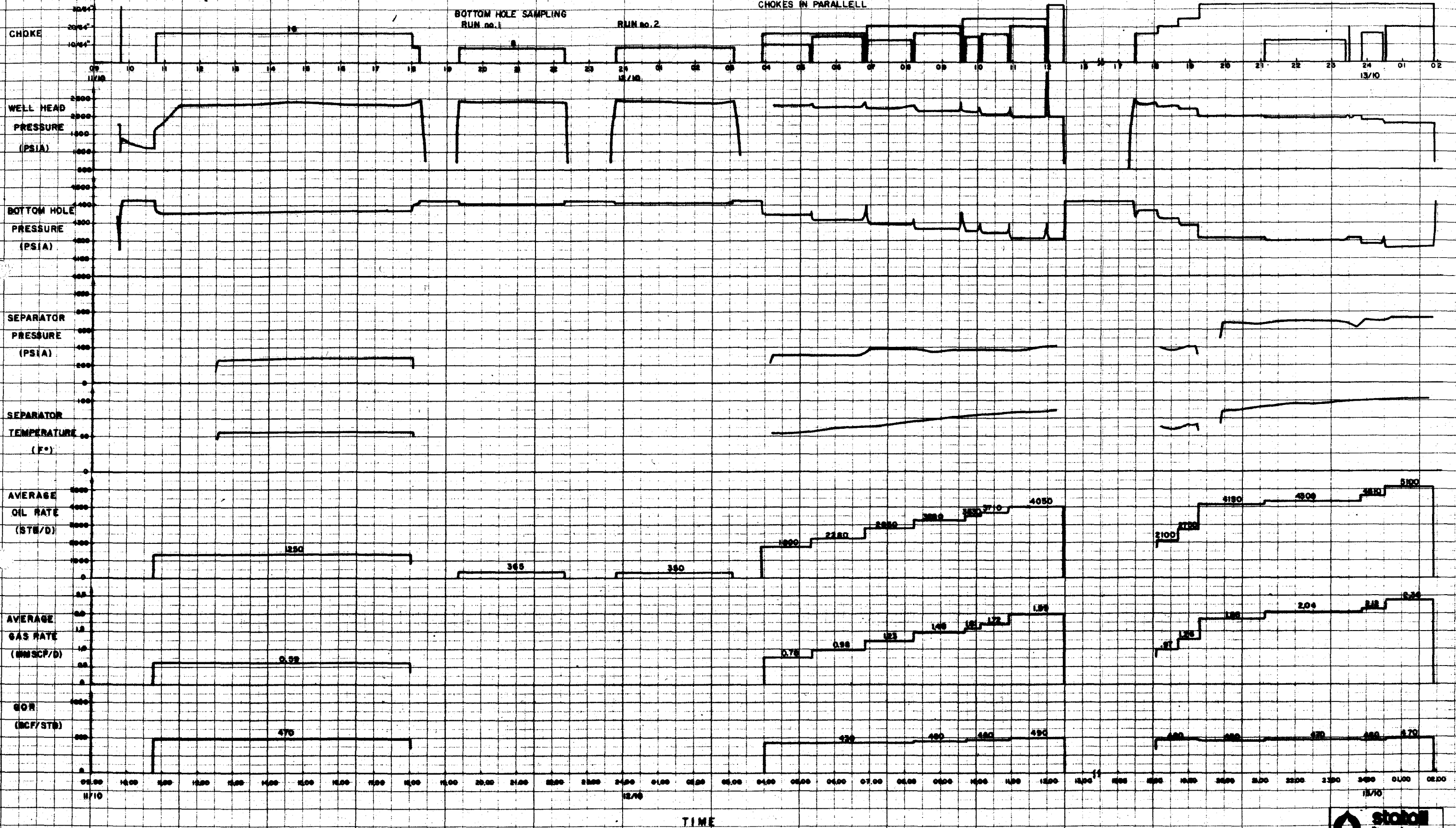
Date	Time	Operations
10/10	20.45-21.55 (70 mins.)	Ran Schlumberger perforation guns and perforated 1824-1825 m RKB.
10-11/10	21.55-09.43 (12 hrs.)	RIH w/teststring and pressure recorders. Installed surface equipment and pressure testet string, surface lines and test equipment.
11/10	09.43	Opened APR-N tester valve.
	09.40-09.47 (1 min 25 sec.)	Opened well on 32/64" fixed choke for initial flow. Flowed 3.5 bbl to surge tank.
	09.47-10.44 (57 mins.)	Closed APR-N tester valve and choke manifold for initial shut in.
	10.44	Opened APR-N tester valve
	10.46-18.01 (435 mins.)	Opened well on 16/64" fixed choke for clean up. Flow directed through burner and at 12.24 hrs. through separator at an estimated rate of 1250 STB/D. Mud and gas to surface after 30 mins.
	18.01-18.14 (13 mins.)	Flowed through 8/64" choke to surge tank to measure rate for bottom hole sampling.
	18.14-19.21 (67 mins.)	Shut well in at choke manifold and prepared for bottom hole sampling, run no. 1.
	19.21-22.22 (181 mins.)	Opened well on 8/64" choke. Flowed surge tank at an estimated flow rate of 365 STB/D. BHS, run no. 1.
	22.22-23.49 (87 mins.)	Closed well at choke manifold and prepared for BHS, run no. 2.

Date	Time	Operations
11-12/10	23.49-03.07 (198 mins.)	Opened well on 8/63" choke. Flowed to surge tank at an estimated flow rate of 350 STB/D. BHS, run no. 2
12/10	03.07	The well closed at choke manifold.
	03.56-05.22 (86 mins.)	Opened well on 10+ 16/64" positive chokes in parallell for 3rd. flow period which is a test for sandproduction. Flow directed to burner at 04.03 hrs. through separator at an estimated rate of 1800 STB/D.
	05.22-06.55 (93 mins.)	Flowed through 14+ 16/64" chokes in parallell. Estimated flow rate: 2280 STB/D.
	06.55-08.16 (81 mins.)	Flowed through 12+ 20/64" chokes in parallell. Estimated flow rate: 2850 STB/D.
	08.16-09.41 (85 mins.)	Flowed through 16+ 20/64" chokes in parallell Estimated flow rate: 3280 STB/D.
	09.41-10.09 (28 mins.)	Flowed through 14+ 24/64" chokes in parallell Estimated flow rate: 3530 STB/D.
	10.09-10.57 (48 mins.)	Flowed through 16+ 25/64" chokes in parallell Estimated flow rate: 3710 STB/D.
	10.57-12.01 (64 mins.)	Flowed through 20+ 24/64" chokes in parallell Estimated flow rate: 4020 STB/D.
	12.01-12.26 (25 mins.)	Flowed through 32/64" choke. Estimated flow rate: 4050 STB/D.
	12.26-17.30 (304 mins.)	APR-N tester valve and choke manifold closed due to leak in chicksans. Final build up.
	17.31-18.08	Opened well on 16/64" choke for 4th. flow periode. Flow directed to burner.

Date	Time	Operations
	18.08-18.43 (35 mins.)	Flowed through 20/64" choke to separator at an estimated rate of 2100 STB/D.
	18.43-19.19 (36 mins.)	Flowed through 24/64" choke. Estimated flow rate: 2750 STB/D.
	19.19-21.09 (50 mins.)	Flowed through 32/64" choke. Estimated flow rate: 4150 STB/D.
	21.09-23.53 (104 mins.)	Flowed through 12+ 32/64" chokes in parallell Estimated flow rate: 4300 STB/D.
12-13/10	23.53-00.34 (41 mins.)	Flowed through 16+ 32/64" chokes in parallell Estimated flow rate: 4610 STB/D.
13/10	00.34-01.56 (82 mins.)	Flowed through 20+ 32/64" chokes in parallell. Estimated flow rate: 5100 STB/D. No sand poduced
	01.56-14.00 (12 hrs.)	The well closed at choke manifold. The formation bullheaded, re. circulated and POOH with test string and all pressure recorders.

34/10-4, DST no. 2   SAND TEST

CHOKES IN PARALLELL

BOTTOM HOLE SAMPLING
RUN no. 1   RUN no. 2

CHOKE

WELL HEAD
PRESSURE
(PSIA)

BOTTOM HOLE
PRESSURE
(PSIA)

SEPARATOR
PRESSURE
(PSIA)

SEPARATOR
TEMPERATURE
(F°)

AVERAGE
OIL RATE
(STB/D)

AVERAGE
GAS RATE
(MMSCF/D)

GOR
(SCF/STB)

TIME

APPENDIX A3

RFT DATA AND ANALYSIS, WELL 34/10-4

Pressure corrections,
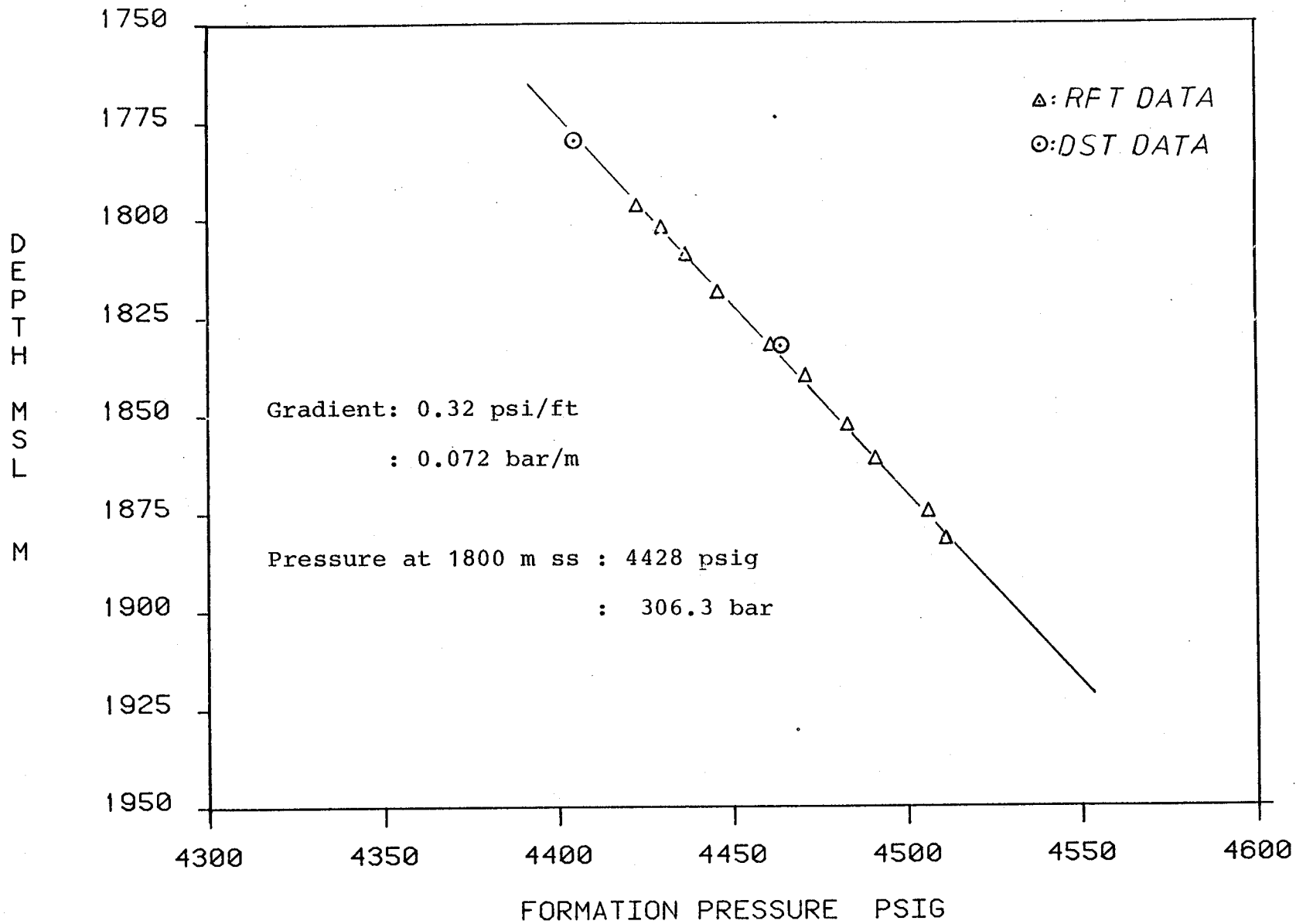
$$P_{TRUE} = P_{LOG} + \Delta P$$

From mastercalibration $\Delta P = + 25$ psi

Sampling was not succesful due to seal failure,

Test no.	Depth (m ss)	Corr. Pressure (psig)
1	-1881.5	4511
2	-1874.5	4506
3	-1861.0	4491
4	-1852.5	4483
5	-1840.0	4471
6	-1832.0	4461
7	-1818.5	4446
8	-1809.0	4437
9	-1802.0	4430
10	-1796.5	4423
11	-1794.0	Seal failure
DST no. 1A	-1780.5	4405
DST no. 2	-1832.5	4463

RFT 34/10-4   BRENT

△: RFT DATA

⊙: DST DATA

Gradient: 0.32 psi/ft

: 0.072 bar/m

Pressure at 1800 m ss : 4428 psig

: 306.3 bar

DEPTH MSL M

FORMATION PRESSURE   PSIG

A3-2

34/10 RESERVOIR TEMPERATURE

DEPTH
m MSL

Max. temp. recorded using:

× Sperry-Sun   MRPG 6
O Lynes   DMR 314
⊗ Sperry-Sun max. temp.
● GRC gauge

34/10-1
DST 3

1800 34/10-4
DST 2

34/10-1
DST 2

1850 34/10-4
DST 1A

34/10-3
DST 3

1900 34/10-3
DST 2

1950 34/10-3
DST 1

65   70   75   °C

150   160   170   °F

APPENDIX A5
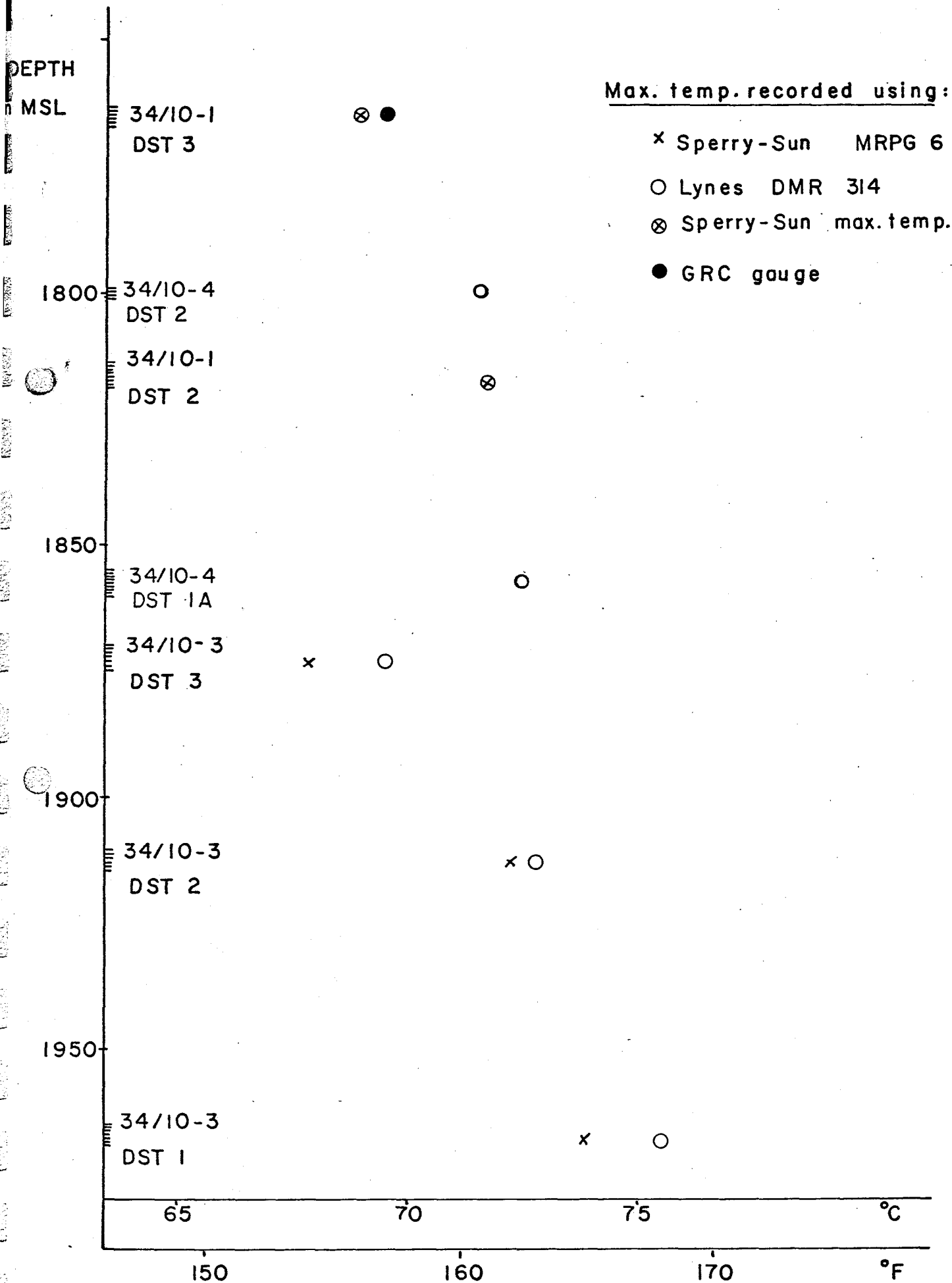
SUMMARY LOG WELL 34/10-4
BRENT FORMATION

| GAMMA RAY | FORMATION DENSITY COMPENSATED(FDC) |
| CALIPER | COMPENSATED NEUTRON POROSITY(CNL) |

COMPUTERIZED LOG INTERPRETATION

| HELIUM POROSITY | HORIZONTAL PERMEABILITY | GRAIN DENSITY | VERTICAL PERMEABILITY | SATURATION RESULTS |
| % | K_{LIQH} (md) | GM/CC | K_{LIQV} (md) | % |

BULK VOLUME   BULK VOLUME   TOTAL PORE VOL.

DEPTH RKB (m)

1850

1900

TARBERT
RANNOCH
BROOM

DST 2
DST 1

50 40 30 20 10 0   2   10   100   1000   10000   2,5   2,75   3,0   2   10   100   1000   10000   0 Sw 100 / 100 So 0

DST DATA

DST no.1	DST no. 2
Interval: 1880–1885	Interval: 1824–1826
Choke: 20/64"	Choke: 20+32/64"
Production: 1800 STBO/D	Production: 5100 STBO/D
No sand.	No sand.

| Location: 61° 12' 15.12" N 02°13' 55.73 E | KBE levation = 25m Wather depth = 197m | Spudded: 12. Aug. 1979 Rig released: 17. Oct. 1979 | Dec. 1979 PE / EVALTEK |

JRa/AM

statoil
Den norske stats
oljeselskap a.s