1.4 Ingen prod. vater er mont.

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15/9-11 Testevaluering

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WELL TEST REPORT

PL 046

WELL NO: 15/9-11

JUNE 1982

BY: LET-SVG

ENGINEERS: K.A. Grini

A. Singelstad

K. Haraldseide

WELL TEST REPORT 15/9-11

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WELL DATA

Operator:	Den norske stats oljeselskap a.s
Well name:	15/9-11
Classification:	Appraisal well
Drilling rig:	Ross Rig
Spudded:	17 September, 1981
Completed:	23 December, 1981
KB elevation:	25 meters
Water depth:	87.5 meters
Total depth:	2950 m RKB
Objectives:	Sandstone of lower Paleocene age (Heimdal formation) and of Jurassic/ Triassic age (lower Mesozoic)
Results:	Discoveries in Paleocene sandstone and in Mesozoic sand.

WELL SUMMARY

Well 15/9-11 was spudded by Ross Rig on 17th September 1981 and reached TD of 2950 m RKB within Triassic sediments. After a period of logging and testing the well was abandoned on 23rd December 1981. The 15/9-11 well was the second well to be drilled on the Gamma structure.

One of the obejctives with 15/9-11 was to delinate the hydrocarbon accumulation found in the Heimdal formation of Paleocene age in 15/9-9. The Heimdal formation was encountered at a depth of 2387 m RKB. The sand is hydrocarbon bearing between 2387 and 2442 m RKB and below approximately 2425 m RKB water is also mobile. This is verified by two DST's, and by RFT and log interpretations.

The Mesozoic sand was encountered at a depth of 2795 m RKB. The sand is hydrocarbon bearing down to the GWC at 2825 m RKB. One DST was performed in this interval.

1. REPEAT FORMATION TESTER (RFT)

Two RFT runs were conducted in the Heimdal Fm., and two RFT runs were completed in Lower Mesozoic (Jurassic/Triassic).

Run no. 1., Heimdal Fm.:
2349.5 - 2522.0 m RKB
31 pretests records out of 35 were obtained. One segregated sample was taken at 2387.5 m RKB.

Run no. 2., Heimdal Fm.:
The purpose of run 2 was sampling, but was not successful due to slow response. Two sampling attempts at 2434.0 m RKB and 2431.5 m RKB were done.

Run no. 1., Jurassic/Triassic:
2790.5 - 2830.5 m RKB
22 pretests records out of 23 were obtained. One segregated sample was taken at 2812.0 m RKB.

Run no. 2., Jurassic/Triassic:
2925.0 - 2938.0 m RKB
6 pretests records out of 8 were obtained. One segregated sample was taken at 2825.8 - 2826.5 m RKB

A discussion of these RFT runs and the results of the analysis performed on some of the samples are given in an own report:

RFT-report 15/9-11, Heimdal and Jurassic/Triassic formation, March 1982.

A summary of the RFT results is presented in appendix 1.

DRILL STEM TESTS (DST)

One DST-test was carried out in Lower Mesozoic (Jurassic and/or Triassic sand) and two in the Heimdal sand.

Results of the tests are presented in appendix 2, 3 and 4. A discussion of each test follows below.

2. DST NO. 1

2.1. Objectives

- Fluid samples
- Reservoir pressure/temperature
- Permeability
- Gas inpurities
- Sand stability

Interval perforated: 2797 - 2807 m RKB.

2.2. Test string

The test string used was 5 in VAM tubing with Halliburton APR-N tester valve, drill pipe tester valve and an APR-M valve situated above the 244.5 mm (9 5/8 inch) RTTS packer. The packer was set at 2764.5 m RKB. The test string was run with fresh water except for the upper 500 m which was air. Two Flopetrol SSDR and two Sperry Run MRPG pressure/ temperature gauges were run with the string.

2.3. Test operation

DST no. 1. was successfully completed. The test consisted of an initial flow and an intial shut-in followed by a main flow period. The test was terminated by a final shut-in period.

2.4. Fluid production and sampling

During the main flow on 16.7 mm (42/64") choke an average rate of 571 000 Sm^3/D (20.2 MMSCF/D) of gas and 238 Sm^3/D (1500 STB/D) of condensate was obtained. Total water production was 1.6 m^3 (10 bbl). The water was fresh and interpreted to be associated with the gas.

Gas and condensate rates were stable at the end of the flow period. The gas rates between 18:30 hrs. and 20:00 hrs are probably erroneous due to blockage in the Daniel orifice box.

Fluid samples were taken at the separator during the flow period. The specific gravity of the condensate was 0.75 (57^{o} API) and the gas specific gravity was 0.73 at separator conditions 31.72 bara (460 psia) and 35.6^{o}C (96^{o}F).

No H_2S was observed, but 2% CO_2 was measured.

No sand production was detected.

Three setes of PVT-samples were taken from the separator.

Shrinkage was measured by using the shrinkage tester and by using the stock tank. The result from the latter has been used for the condensate production rate calculations. The stock tank shrinkage was 15%. The shrinkage from the shrinkage tester was 11% and this value is used to correct the gas rate for the gas solubility of the condensate leaving the separator (260 SCF/STB).

2.5. Interpretation of DST no. 1.

Interpretation of the test is carried out by using the Flopetrol SSDR gauge no. 81049. The resolution of the Sperry Sun MRPG gauges is not good enough for the pressure build-up analysis.

The stabilized bottom hole temperature recorded during the final build up is 102.8^{o}C (217^{o}F) which is believed to represent the reservoir temperature.

- Initial build-up

  Fig. 2.2. and 2.5. indicate that the APR-N valve did not close completely when the annulus pressure was bled off. First after 5 minutes the pressure starts to build up to static pressure. The start and the end of semilog straight line used in the Horner plot occurs after 8 and 14 minutes respectively (Fig. 2.3. and 2.4.). The extrapolated pressure P* is 299.80 bara (4348.3 psia). After the semilog straight line the build-up curve flattens.

- Final build-up.

The pressure build-up is analysed by the Horner method (Fig. 2.8. - 2.9.). The anomalous pressure build-up in fig. 2.9. is probably caused by phase redistribution. Phase redistribution produce a pressure overshoot or hump of small magnitude. The semilog straight line starts 169 minutes after shut in and ends after 780 minutes where the curve flattens. An extrapolated pressure P* of 299.48 bara (4343.6 psia) and a slope of 0.1108 bar/cycle (1.607 psi/cycle) are obtained from the plot. A permeability thickness of 16235 md m (53266 md ft) is calculated. Assuming that the whole gas bearing sand section (30 m, 98.4 ft) is contributing flow to the wellbore gives a permeability of 541 md. The estimated total skin factor is 147 and the skin due to partial penetration is 5. One of the reasons for this high total skin may be due to condensate accumulation around the wellbore. The dew point pressure which is 292 bar (4235 psi), is 7.5 bar (109 psi) below initial reservoir pressure, and the drawdown during the test was approximately 17.2 bar (250 psi). Another reason may be that the number of effective perforations were small. Such a completion has excess pressure drop from both turbulence and a large partial penetration skin effect.

2.4. Conclusion

DST no. 1. was successful according to the objectives and also mechanically. Three sets of PVT samples were obtained and they are analysed at our laboratories.

Initial reservoir pressure is 299.48 bara (4343.6 psia, 1.093 g/cc e.m.w.) and the reservoir temperatures is 102.8°C (217°F) at 2783.73 m RKB. The permeability is estimated to be 541 md. No H_2S was observed, but 2% CO_2 was measured. No sand production was detected.

3. DST NO. 2.

3.1. Objectives

- Check the potential gas/water contact
- Fluid sampling
- Pressure/temperature
- Permeability
- Check for sandproduction

Interval perforated: 2432 - 2440 m RKB.

3.2. Test string

A standard Halliburton test string was run with an APR-N tester valve, Drill Pipe tester valve and APR-M valve situated above the 245 mm (9 5/8") RTTS packer. The packer was set at 2395 m. A water cushion of 1500 m was run above the DP Tester valve.

3.3. Test operation

The test was planned to consist of one long flow period, followed by a build-up period. Because of a leak in the heater outlet, the well had to be shut in before stable separator conditions were obtained.

7 minutes after the APR-N valve was opend, the well was opened on the choke manifold on 25.4 mm (64/64") choke.

After flowing for 10 minutes on 25.4 mm (64/64") choke, the choke was reduced to 19.1 mm (48/64") and 20 minutes later it was reduced to 11.1 mm (28/64") because of water and sand production. No water was produced on 11.1 mm (28/64") choke. The flow was led through the heater and the separator on a 12.7 mm (32/64") choke.

No glycol was injected to the wellstream.

3.4. Fluid production and sampling

When flowing on 12.7 mm (32/64") choke an average rate of 229 MSm^3/D (8.1 MMSCF/D) of gas, 100 Sm^3/D (630 STB/D) of condensate and 114 Sm^3/D (720 BBLS/D) of water was obtained. On 12.7 mm (28/64") choke no water was produced.

During the flow, fluid samples were taken on "Goose Neck" for BSW measurements. 60% - 75% of water and 0.3% - 0.5% of sand was observed.

A condensate specific gravity of 0.75 (57.4^o API) and gas gravity of 0.72 was measured on separator at 9.6 barg (140 psig).

No H_2S or N_2 and just traces of CO_2 was detected.

Separator samples of water and condensate were taken during flow and after shut-in.

Only one set of PVT sample was taken, because of a leak in the heater outlet.

3.5. Interpretation of DST no. 2

The interpretation of DST no. 2. is based upon pressure data from the Sperry Sun MK III 2 gauge (Fig. 3.1. - 3.3.). Stabilized bottom hole temperature recorded after shut in is 87.2^{o}C (189^{o}F), and this temperature is believed to represent the reservoir temperature. Six gauges were run and the initial reservoir pressure from four of these fall on a straight line, which correlate very well to pressures and the gradient from RFT.

Wellhead data during the build-up indicate a slight leak in the APR-N valve, which does not seem to affect the quality of the downhole pressure data.

Factors which are difficult to control, affect the interpretation and the results.

The well was shut in before stabilized separator conditions were obtained. At this time the condensate rate is still increasing while the water rate is decreasing.

In addition, the two phase flow (here, water and gas) is difficult to interprete, and in this case a water saturation gradient occurs, which complicates the problem. The water saturation increases from top to bottom of the test interval. This implies that the phase mobility and total mobility change through the whole section.

When flowing on 11.1 mm (28/64") choke no water was produced at surface, but it is obvious that water has been flowing to the wellbore where it has been accumulated. After the choke was increased to 12.7 mm (32/64") the well started to produce water. While the accumulated water in and around the wellbore was drained, the water rate and the saturation decreased, while the gas saturation and the gas mobility increased. It is reasonable to assume that the well was shut in when the accumulated water still was drained.

- Build up

  The Horner method is used for the pressure build up analysis.

  A P* of 244.2 bar (3541.8 psia) and a slope of 0.1329 bar/cycle (1.928 psi/cycle) was estimated from the Horner plot. The semi-log straght line starts 72 minutes after shut in, and continue through out the build-up (Fig. 3.4. - 3.5.).

  An effective gas permeability of 424.5 md and an effective water permeability of 555 md is calculated, assuming the hole sand section (12 m, 39.4 ft) is contributing to the flow.

  Estimated total skin facotr is 55.3, and the skin due to partial peenetration is estimated to 1.43.

Accumulation of water and presence of two phase flow is probably the main contribution to the skin factor.

3.6. Conclusion

The results are restricted because of aborted flow, but seems to be in agreement with results from 15/9-9 test in Heimdal sand. Logs indicate the zone to be mostly water bearing (Sw = 80%), with some gas, which was confirmed by the test. An average water rate of 114 Sm^3/D (720 BPD) was obtained.

Some sand was produced, at high rates about 8% and on 12.7 mm (32/64") choke 0.3 - 0.5%. No H_2S and only traces of CO_2 was proved. The reservoir pressure is normal, 1.022 g/cc emv.

Permeability is good, effective gas permeability is 424.5 md and effective water permeability is 555 md.

Only one set of PVT sample was taken, while the objective was two sets.

Except of the aborted flow due to mechanical problems, the test was successful according to the objectives.

4. DST NO. 3.

4.1. Objectives

- Permeability
- Fluid samples
- Reservoir pressure/temperature
- Sand stability
- Determination of trace elements

Interval perforated: 2395 - 2415 m RKB.

4.2. Test string

The test string was the same as for DST no. 1 and 2. The RTTS packer was set at 2361 m and 2000 m of water cushion was originally filled on top of the drill pipe tester valve. Flopetrol and Sperry Sun pressure gauges were run with the string.

4.3. Test operation

No major problems occured during the test. The RTTS circulating valve was accidentally opened while setting the packer. Mud u-tubed into the tubing and compressed the air cushion from originally 350 m to approximately 5 m. This would not have allowed the well to flow. Therefore 61 bbls of water and 60 bbls of diesel was pumped into the tubing, and the mud displaced back in the annulus.

When shutting the well in for first build-up and second build-up, there was no indications that the APR-N valve was closed. Therefore both must be considered as surface shut-in.

4.4. Fluid production and sampling

The main problem concerning production was the correction factors for the metered condensate flow rate. Tank readings indicated significant correction and shrinkage tester indicated high shrinkage. The condensate rates used for this test is only corrected for shrinkage from skrinkage tester assuming meter factor to be 1.0. This is to avoid a dobble correction for shrinkage.

Otherwise, separator and wellhead conditions were satisfactory stable during most of the test.

Traces of water was produced (1 - 2 %). This was analysed on the rig by the mud engineer and by Schlumberger and was found to be fresh (4 - 6000 ppm Cl^-). It is probably vapor associated with the gas.

PVT sampling at the separator was not successful. Two out of three samples were invalide due to gas in the liquid container. Third set was good.

KSLA (Shell) did trace analysis for us, and found 0.2 - 0.3 % CO_2 in the gas. No H_2S or mercury was found. Separate report will follow from KSLA.

4.5. Interpretation of DST no. 3

This test was performed in the best part of the reservoir (ref. attached CPI). The sand is fairly clean with an average porosity of 20 % and water saturation of 23 %. This zone is equivalent to DST no. 3. in 15/9-9.

The test analysis is based on analysis of the two build-ups, the last one after a multiple rate flow.

The Flopetrol SSDR-no 81049 gauge at 2365.7 m RKB is used for the pressure build-up analysis.

The stabilized bottom hole temperature recorded during the first build up is 85.6^{o}C (186^{o}F) which is believed to represent the reservoir temperature.

- First build-up

  The build up followed a 1005 minutes flow period of which 971 minutes were on 19.1 mm (48/64") choke. The flow was fairly stable at the end of this period.

The pressure build-up was analysed using the Horner method. Fig. 4.3. and 4.4. shows Horner plots with a P* of 242.83 bara (3522 psia) and a slope of 0.1055 bar/ cycle (1.53 psi/cycle). The build-up is dominated by afterflow the first 4 minutes (Fig. 4.5.). End of semi-log straight line occurs after approximately 210 minutes.

A permeability thickness of 15672 md-m (51714 md-ft) is calculated. Assuming the whole sand section 38 m (124.7 ft) is contributing, this gives a permeability of 415 md.

A total positive skin of 57 and a partial penetration skin factor of 3.6 are calculated. The dew point pressure is measured to be 234 bar (3394 psi) in 15/9-9, DST 3. The flowing bottom hole pressure is 2.76 bar (40 psi) above this dew point. This may indicate that condensate accumulation is not present. The flowing bottom hole pressure during DST 2 in well 15/9-9 was approximately 15 bar (220 psi) below this dew point and the calculated total skin was 335. All the other estimated skin factors in the Heimdal formation are between 50 and 60.

- Multiple rate build-up

The interpretation was carried out by using the multiple rate build-up technique (Fig. 4.7. - 4.8.). An extrapolated pressure P* of 242.88 bar (3522.7 psia) and a slope of 0.1610 bar/cycle (2.335 psi/cycle) are obtained from the plot.

The build up is affected by afterflow the first 2 minutes and the interval used for the semi-log straight line is 15 - 134 minuts.

The analysis gave a positive skin of 55 and a permeability thickness of 16327 mdm (53566 mdft). Assuming that the entire sand section (38 m) is contributing flow to the wellbore gives a permeability of 430 md.

Both the permeability and the skin values match very well to the same parameters obtained from the first build-up.

It is not possible to performe deliverability calculations. The flowing bottom hole pressure increases during all three flow periods.

4.6. Conclusions

No major problems occured during the test, but the APR-N tester valve did not close when the annulus pressure was bled off for first and second build up. Therefore both must be considered as surface shut in.

Two of three sets of PVT samples were invalid due to gas in the liquid bottle.

Initial reservoir pressure is 242.83 bara (3522 psia, 1.047 g/cc emw.) and the reservoir temperature is 85.6 ^{o}C (186 ^{o}F) at 2365.7 m RKB. The permeability is estimated to be in the range of 400 md. No H_2S was observed, but 0.3 % CO_2 was measured. No sand production was detected.

APPENDIX 1

REPEAT FORMATION TESTER (RFT)

Content:

- Pretest recorded data
- Fig. 1.1.: 15/9-11 Formation pressure, Heimdal Fm.
- Fig. 1.2.: Formation pressure comparison 15/9-9 and 15/9-11, Heimdal Fm.
- Fig. 1.3.: 15/9-11 Formation pressure Jurassic/ Triassic Fm.

PRETEST RECORDED DATA

HEIMDAL FORMATION

WELL: 15/9-11
DATE: 21/10-81
RUN NO.: 1

Max. rec. temp.: 66.7°C (152°F)

Test	Depth	Log hydr. pr. before/after test	Log pretest pressure	Cor.pretest pressure	Cor.hydr.pr. after test	Remarks
No	mRKB	psig	psig	psig, gm/cc	psig, gm/cc	
1	2349.5	4157 / 4163	3531	3505 / 1.049	4138 / 1.24	Lista Formation
2	2361.0	4177 / 4180	3535	3509 / 1.045	4155 / 1.24	Lista Formation
3	2388.5	4230 / 4232	3546	3520 / 1.036	4207 / 1.24	
4	2395.0	4243 / 4242	3548	3522 / 1.034	4217 / 1.24	
5	2401.0	4254 / 4258	3554	3528 / 1.033	4233 / 1.24	
6	2405.0	4268 / 4275	3564	3538 / 1.035	4250 / 1.24	Supercharge
7	2405.0	4269 / 4276	3564	3538 / 1.035	4251 / 1.24	Supercharge
8	2410.0	4291 / 4298	-	-	4273 / 1.25	Sueprcharge
9	2416.0	4294 / 4296	3573	3547 / 1.032	4271 / 1.24	
10	2423.0	4299 / 4303	3572	3546 / 1.029	4278 / 1.24	
11	2431.0	4309 / 4318	3577	3551 / 1.027	4293 / 1.24	
12	2436.5	4316 / 4322	3578	3552 / 1.025	4297 / 1.24	
13	2439.0	4316 / 4319	3577	3551 / 1.024	4294 / 1.24	
14	2444.0	4321 / 4331	3589	3563 / 1.025	4306 / 1.24	
15	2446.0	4324 / 4332	3590	3564 / 1.025	4307 / 1.24	
16a	2469.5	4369 / 4373	-	-	4348 / 1.24	
16b	2469.5	4369 / 4373	3621	3595 / 1.024	4348 / 1.24	
17	2475.5	4373 / 4376	3623	3597 / 1.022	4351 / 1.24	
18	2483.0	4386 / 4392	3637	3611 / 1.023	4367 / 1.24	
19a	2488.5	4397 / -	-	-	-	Power shut down
19b	2488.5	4396 / 4404	3697	3671 / 1.037	4379 / 1.24	Supercharge
19c	2488.5	4404 / 4405	3650	3624 / 1.024	4380 / 1.24	

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HEIMDAL FORMATION

ELL: 15/9-11
TE: 21/10-81
UN NO.: 1

Max. rec. temp.: 66.7°C (152°F)

est	Depth	Log hydr. pr. before/after test	Log pretest pressure	Cor.pretest pressure	Cor.hydr.pr. after test	Remarks
No	mRKB	psig	psig	psig, gm/cc	psig, gm/cc	
20a	2495.3	4409 / 4414	3729	3703 / 1.044	4389 / 1.24	Supercharge
20b	2495.3	4414 / 4413	3660	3634 / 1.024	4388 / 1.24	
21a	2500.0	4412 / -	-	-	-	Lost seal
21b	2500.0	4419 / 4422	3666	3640 / 1.024	4397 / 1.24	
22	2517.0	4443 / 4446	3683	3657 / 1.022	4421 / 1.24	
23	2522.0	4452 / 4457	3693	3667 / 1.023	4432 / 1.24	Supercharge
24	2414.0	4341 / -	-	-	-	Blocked eq. valve
25	2410.0	4248 / 4253	3559	3533 / 1.031	4228 / 1.23	
26a	2388.5	4205 / 4224	3556	3530 / 1.039	4199 / 1.24	
26b	2388.5	- / 4225	3560	3534 / 1.040	4200 / 1.24	
27	2351.0	4136 / 4152	3603	3577 / 1.070	4127 / 1.23	Supercharge
28	2436.5	4301 / 4299	3563	3537 / 1.021	4274 / 1.23	
29	2435.0	4294 / -	3563	3537 / 1.021	-	Att. sampling
30	2436.0	4296 / 4301	3569	3543 / 1.023	4276 / 1.23	Att. sampling
31	2434.0	4295 / -	3567	3541 / 1.023	-	Att. sampling
32	2437.0	4296 / -	3568	3542 / 1.022	-	Att. Sampling
33	2432.0	4287 / 4286	3566	3540 / 1.024	4261 / 1.23	Att. Sampling
34	2388.5	4201 / 4206	3548	3522 / 1.037	4181 / 1.23	Att. Sampling
35	2387.5	4203 / 4205	3547	3521 / 1.037	4180 / 1.23	Sampling

PR[illegible]EST [illegible]COR[illegible] DA[illegible]

HEIMDAL FORMATION

WELL: 15/9-11
DATE: 21/10-81
RUN NO.: 2

Max. rec. temp.:

Test	Depth	Log hydr. pr. before/after test	Log pretest pressure	Cor.pretest pressure	Cor.hydr.pr. after test	Remarks
No	mRKB	psig	psig	psig, gm/cc	psig, gm/cc	
1	2434.0	4305 / -	3564	3538 / 1.022	-	Att. sampling
2	2431.5	4294 / -	3559	3533 / 1.022	-	Att. sampling

PR[illegible]EST [illegible]COR[illegible] DA[illegible]
JURASSIC/TRIASSIC FM.

WELL: 15/9-11
DATE: 1/11-81
RUN NO.: 1

Max. rec. temp.: 190°F (87.8°C)

Test	Depth	Log hydr. pr. before/after test	Log pretest pressure	Cor.pretest pressure	Cor.hydr.pr. after test	Remarks
No	mRKB	psig	psig	psig, gm/cc	psig, gm/cc	
1	2790.5	5124 / 5126	-	-	5097 / 1.284	Tight, Heather Fm.
2	2796.0	5045 / 5048	4367	4336 / 1.090	5019 / 1.262	Heather Formation
3	2791.0	5036 / 5040	4373	4342 / 1.094	5011 / 1.262	
4	2798.0	5051 / 5050	4368	4337 / 1.090	5021 / 1.262	
5	2801.0	5057 / 5055	4370	4339 / 1.089	5026 / 1.262	
6	2804.0	5059 / 5058	4370	4339 / 1.088	5029 / 1.261	
7	2806.0	5061 / 5062	4372	4341 / 1.088	5033 / 1.262	
8	2809.0	5065 / 5067	4373	4342 / 1.087	5038 / 1.262	
9	2812.0	5069 / 5071	4374	4343 / 1.086	5042 / 1.261	
10	2816.0	5081 / 5081	4377	4346 / 1.085	5052 / 1.262	
11	2820.0	5086 / 5088	4380	4349 / 1.085	5059 / 1.262	
12	2823.0	5090 / 5094	4383	4352 / 1.084	5065 / 1.262	
13	2825.0	5092 / 5093	4384	4353 / 1.084	5064 / 1.261	
14	2826.0	5094 / 5096	4386	4355 / 1.084	5067 / 1.261	
15	2827.0	5098 / 5098	4388	4357 / 1.084	5069 / 1.261	
16	2829.0	5100 / 5101	4397	4366 / 1.085	5072 / 1.261	
17	2830.0	5102 / 5106	4397	4366 / 1.085	5077 / 1.262	
18	2830.5	5104 / 5105	4398	4367 / 1.085	5076 / 1.262	
19	2828.0	5099 / 5099	4392	4361 / 1.085	5070 / 1.262	
20	2822.0	5088 / 5092	4382	4351 / 1.084	5063 / 1.262	
21	2813.5	5074 / 5079	4379	4348 / 1.087	5050 / 1.262	
22	2790.8	5036 / 5038	4380	4349 / 1.096	5009 / 1.262	Heather Formation
23	2812.0	5075 / 5060	4372	4341 / 1.086	5031 / 1.258	Sample

PR[redacted]ST [redacted]COR[redacted] DA[redacted]
JURASSIC/TRIASSIC FM.

WELL: 15/9-11
DATE: 1/11-81
RUN NO.: 2

Max. rec. temp.: 190^{o}F (87.8^{o}C)

Test	Depth	Log hydr. pr. before/after test	Log pretest pressure	Cor.pretest pressure	Cor.hydr.pr. after test	Remarks
No	mRKB	psig	psig	psig, gm/cc	psig, gm/cc	
1	2925.0	5269 / 5269	-	-	5240 / 1.260	Tight
2	2926.5	5270 / 5271	-	-	5242 / 1.260	Tight
3	2927.5	5272 / 5275	4585	4554 / 1.094	5246 / 1.260	
4	2929.0	5275 / 5275	4586	4555 / 1.093	5246 / 1.260	
5	2934.0	5284 / 5279	4589	4558 / 1.092	5250 / 1.258	
6	2938.0	5289 / 5289	4597	4566 / 1.093	5260 / 1.259	
7	2936.0	5286 / 5287	4596	4565 / 1.093	5358 / 1.260	
8	2932.5	5275 / 5279	4590	4559 / 1.093	5250 / 1.259	
9	2826.5	5099 / 5153	4389	4358 / 1.084	5124 / 1.275	Sampling, plugging
10	2826.0	5092 / 5084	4384	4353 / 1.083	5055 / 1.258	Sampling, plugging
11	2825.8	5089 / 5088	4380	4349 / 1.082	5059 / 1.259	Sampling

Fig.1.1.

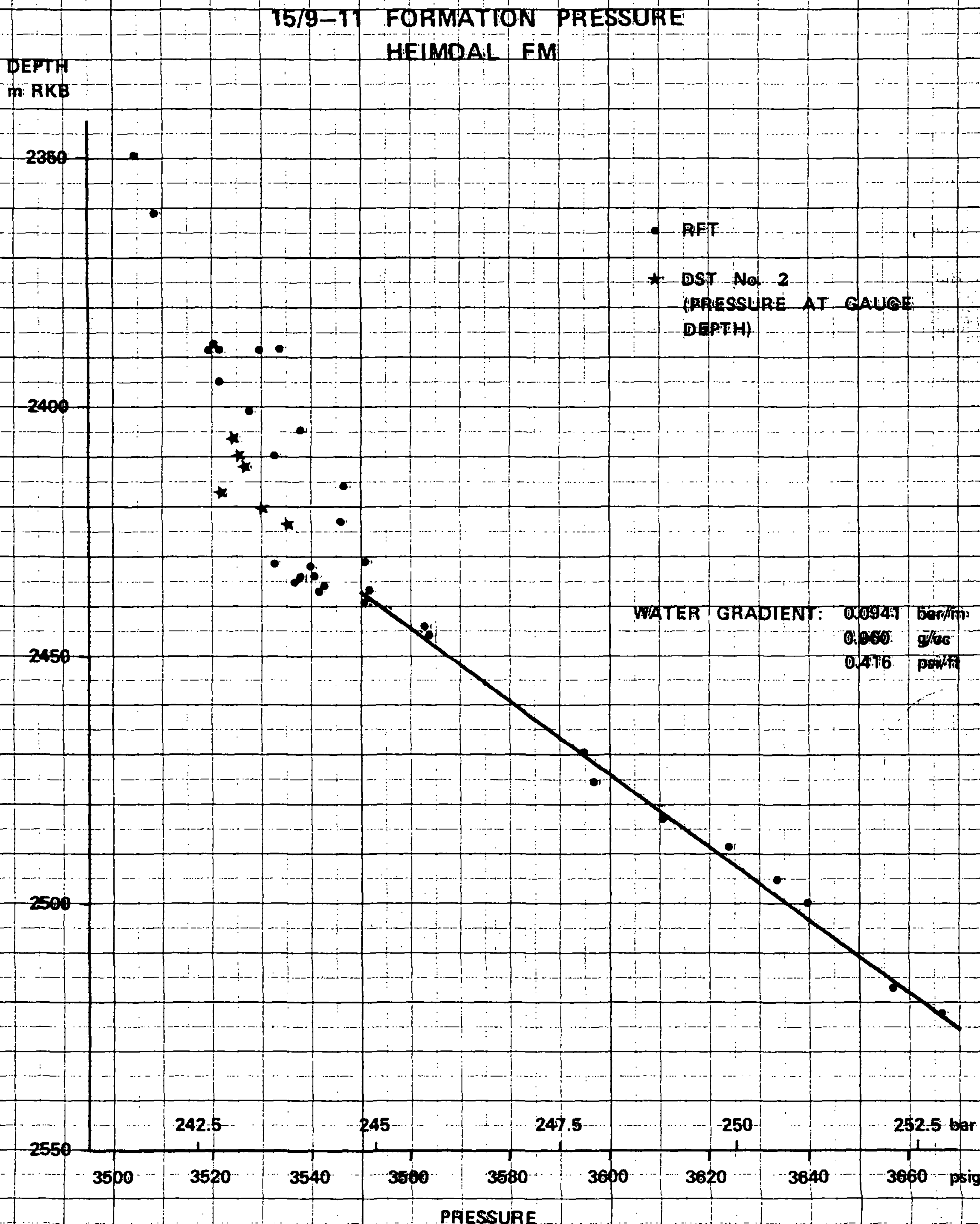
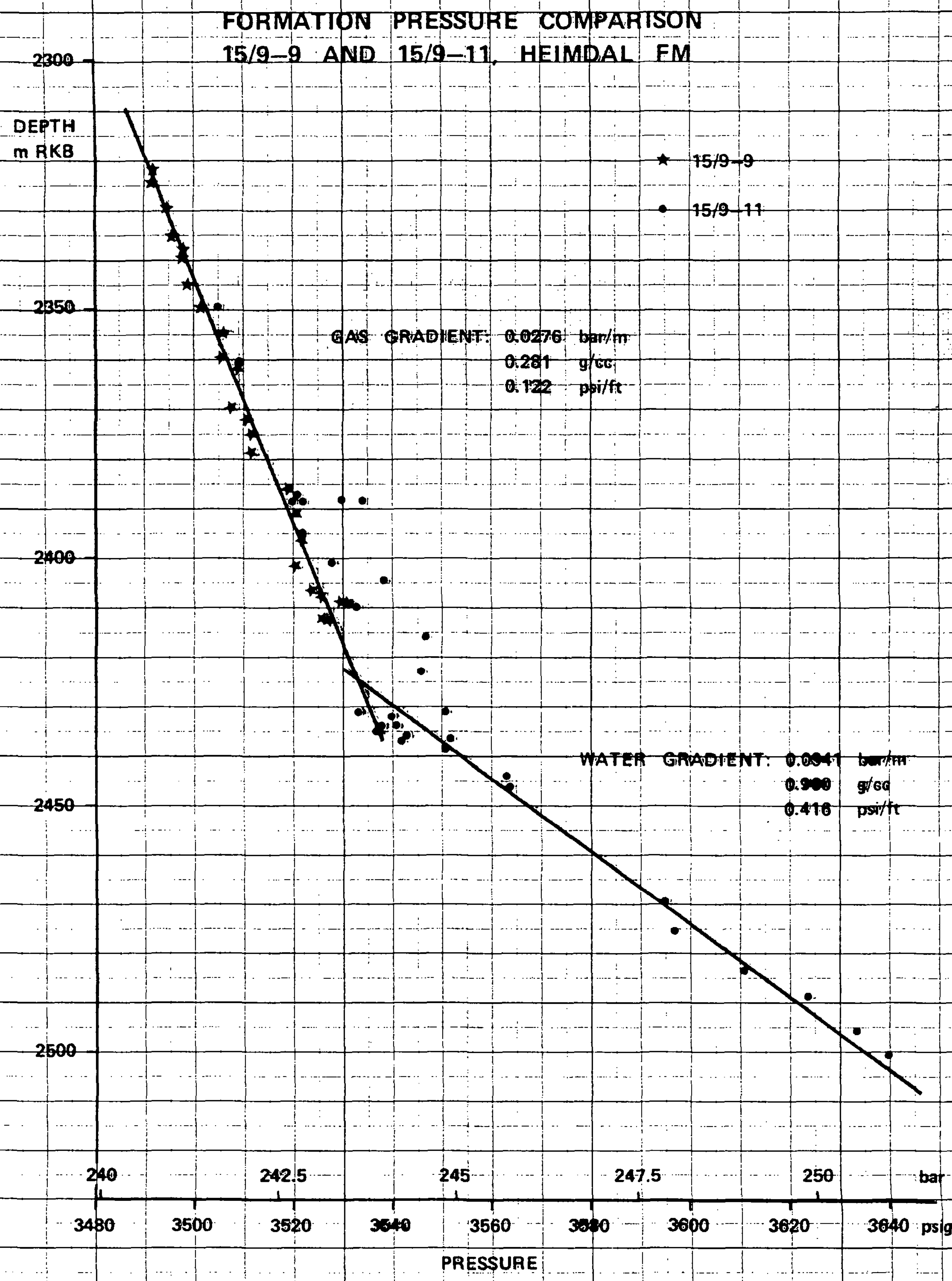
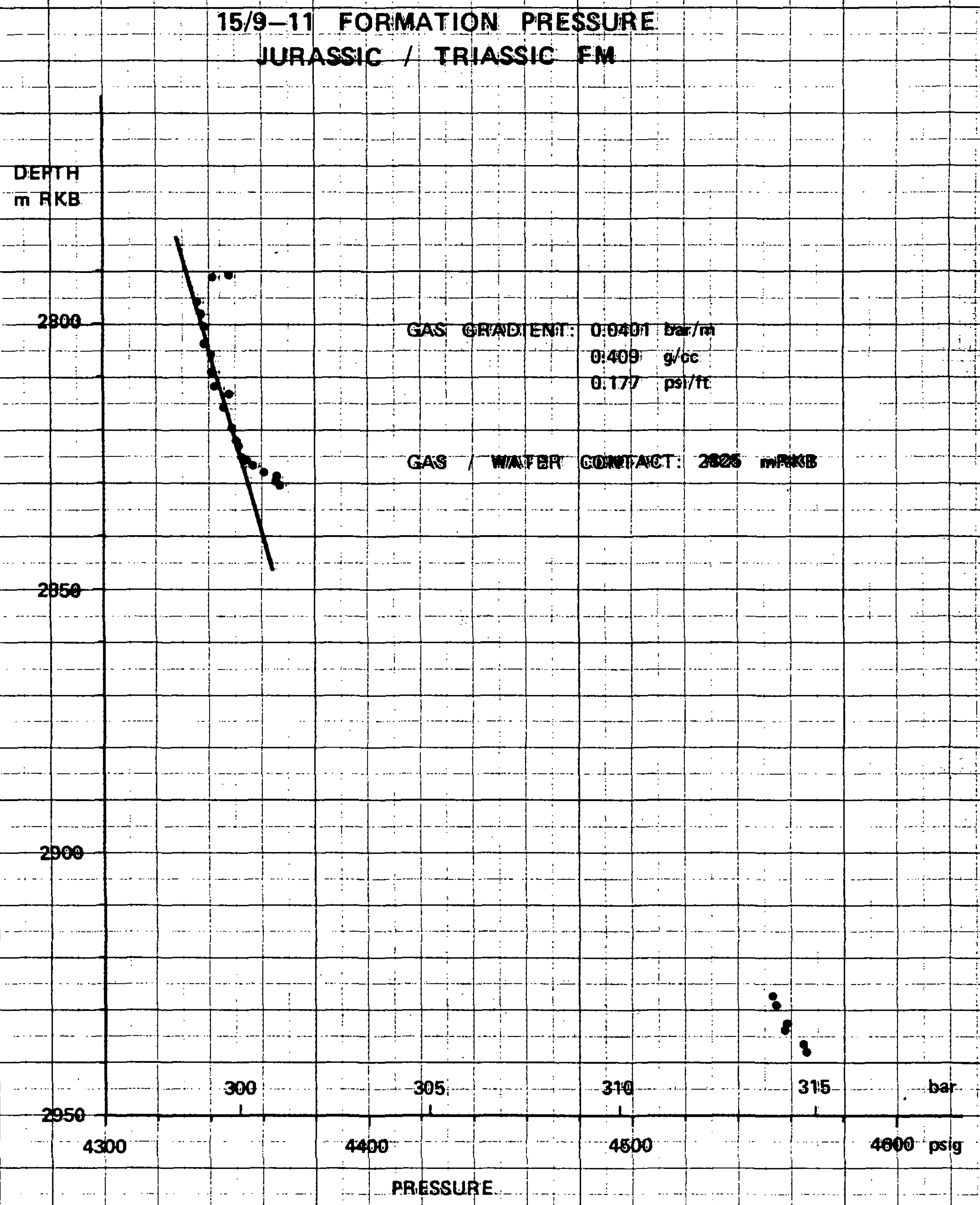

15/9–11 FORMATION PRESSURE
HEIMDAL FM
DEPTH
m RKB
2350
2400
2450
2500
2550
RFT
DST No. 2
(PRESSURE AT GAUGE DEPTH)
WATER GRADIENT: 0.0941 bar/m
0.960 g/cc
0.416 psi/ft
242.5
245
247.5
250
252.5 bar
3500
3520
3540
3560
3580
3600
3620
3640
3660 psig
PRESSURE

Fig.1.2.



FORMATION PRESSURE COMPARISON
15/9–9 AND 15/9–11, HEIMDAL FM
DEPTH
m RKB
2300
2350
2400
2450
2500
15/9–9
15/9–11
GAS GRADIENT: 0.0276 bar/m
0.281 g/cc
0.122 psi/ft
WATER GRADIENT:
bar/m
g/cc
0.416 psi/ft
240
242.5
245
247.5
250
bar
3480
3500
3520
3540
3560
3580
3600
3620
3640
psig
PRESSURE

Fig. 1.3.



15/9–11 FORMATION PRESSURE
JURASSIC / TRIASSIC FM
DEPTH
m RKB
2800
2850
2900
2950
GAS GRADIENT: 0.0401 bar/m
0.409 g/cc
0.177 psi/ft
GAS / WATER CONTACT: 2825 mRKB
300
305
310
315
bar
4300
4400
4500
4600 psig
PRESSURE

APPENDIX 2

DST NO. 1

Content:

- Summary of DST no. 1.
- Lay out of test string
- Pressure recorders
- Diary of events
- Pressure, choke and flowdiagram
- Flow data
- Separator sampling
- Surface sampling
- Test analysis

Figures:

Bottom hole pressures during initial and final build up from SSDR 81049 gauge are listed and plotted:

- Flopetrol plot: P,T vs time
- P_{ws} vs Δ t
- P_{ws} vs log $((t + \Delta t)/\Delta t)$
- Log Δ P vs log Δ t

The figures are with two different pressure scales.

SUMMARY OF DST NO. 1.

Perforated interval: 2797 - 2807 m RKB.

- Initial flow: 2 minutes
- Initial build-up: 61 minutes
- Second flow
  12.7 mm (32/64") choke: 3 minutes
  15.9 mm (40/64") choke: 41 minutes
  16.7 mm (42/64") choke: 754 minuets
- Final build-up: 971 minutes

Average flow rate on 16.7 mm (42/64") choke:

- 517 000 Sm^3/D
  (20.2 MMSCF/D) of gas
- 238 Sm^3/D
  (1500 STB/D) of condensate

Gravities:

- Gas: 0.73 sp.gr.
- Condensate: 0.75 sp.gr (57°API)

Separator conditions:

- Pressure: 31.72 bara (460 psia)
- Temperature: 35.6°C (96°F)

Gauges:

Two Flopetrol SSDR and two Sperry Sun MRPG gauges were run with the string. SSDR 8148 did not work.

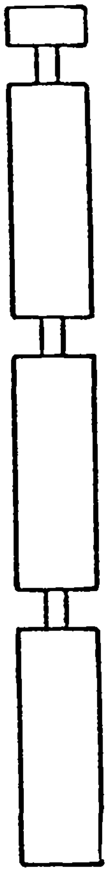
TEST STRING TALLY   ROSS RIG   15/9-11   DST no. 1.

All measurements to top of each item

	EQUIPMENT DESCRIPTION	MIN ID(")	MAX OD(")	LENGTH (m)	DEPTH (m)
	Otis STT w/X-over				
2	Jnts 5" VAM tbg. 18 lbs/ft	4.25	5.56	20.02	- 6.05
1	Pupjnt. 5" VAM tbg	4.25	5.56	4.53	13.93
1	X-over 5" VAM box x 4½" SA pin (0-22)	4.25	5.51	0.40	18.46
1	Otis lubricator valve	2.99	13.88	1.62	18.86
1	X-over 4½" SA box x 5" VAM pin (0-23)	4.25	5.51	0.41	20.48
1	Jnt. 5" VAM	4.25	5.56	10.32	20.89
1	Jnt. 5" VAM	4.25	5.56	9.43	31.21
2	Stds. 5" VAM	4.25	5.56	59.86	40.64
1	Pupjnt. 5" VAM	4.25	5.56	4.53	100.50
1	X-over 52 VAM box x 4½" SA pin (F-24)	3.00	6.00	0.29	105.03
1	Flopetrol EZ-tree	3.00	17.00	2.61	105.32
1	Flopetrol 5" OD Slick Jnt 4½"-4 SA pin x pin (F-17)	3.00	5.00	2.95	107.93
1	Flopetrol Fluted Hanger	3.00	16.00	0.29	110.88
1	X-over 4½"-4SA pin x 5" VAM pin (F-25)	3.00	6.00	0.31	111.17
1	Pupjnt. 5" VAM	4.25	5.56	1.22	111.48
1	Jnts. 5" VAM	4.25	5.56	9.67	112.70
78	Stds. 5" VAM	4.25	5.56	2296.41	122.37
1	X-over 5" VAM box x 3½" TDS pin	2.75	6.50	0.27	2418.78
3	Stds. 3½" TDS tbg 12.7 lbs/ft L-80	2.75	3.50	84.54	2419.05
1	X-over 3½" TDS box x 3½" IF pin	2.75	4.50	0.24	2503.59
1	Slip Jnt (open)	2.00	4.63	5.54	2503.83
1	Slip Jnt (closed)	2.00	4.63	4.01	2509.37
6	Stds Drill Collars	2.25	4.75	171.06	2513.38
1	X-over 3½" IF box x 2 7/8" EUE pin	2.50	4.75	0.20	2684.44
1	RTTS mech. circ valve	2.44	4.87	0.84	2684.64
1	X-over 2 7/8" EUE box x 3½" IF pin	2.62	4.75	0.20	2685.48
1	Std Drill Collar	2.25	4.75	28.60	2685.68
1	Slip Jnt (closed)	2.00	4.63	4.01	2714.28
1	Slip Jnt (closed)	2.00	4.63	4.01	2718.29
1	Std. Drill Collar	2.25	4.75	28.61	2722.30
1	APR-M Safety/circ. Valve	2.25	5.00	2.55	2750.91

	EQUIPMENT DESCRIPTION	MIN ID(")	MAX OD(")	LENGTH (m)	DEPTH (m)
1	DP tester valve	2.25	5.00	1.46	2753.46
1	APR-N tester valve	2.25	5.00	3.89	2754.92
1	Ful Flo Hydr. Bypass	2.25	4.62	1.92	2758.81
1	Big John Jars	2.32	4.62	1.92	2760.73
1	RTTS Safety Joint	2.44	4.62	1.08	2762.65
1	RTTS Packer (above)	2.40	5.75	0.72	2763.73
1	RTTS Packer (below)	2.40	5.75	0.66	2764.45
1	Perf. Pupjnt. 2 7/8" EUE	2.44	2.88	3.54	2765.11
1	X-over 2 7/8" EUE box x 2 3/8" EUE pin	2.00	3.70	0.26	2768.65
1	Collar 2 3/8" EUE	-	2.88	0.13	2768.91
1	Otis XN-nipple 2 3/8" EUE box x 2 7/8" EUE pin	1.79	2.38	0.22	2769.04
1	X-over 2 3/8" EUE box x 2 7/8" EUE pin	2.00	3.70	0.26	2769.26
1	Jnt. 2 7/8" EUE tbg	2.44	2.88	9.41	2769.52
	Flopetrol DST-hanger	-	-	-	-
1	Jnt. 2 7/8" EUE tbg	2.44	2.88	8.93	2778.93
1	Perf. pupjnt. 2 7/8" EUE	2.44	2.88	2.05	2787.86
1	X-over 2 7/8" EUE box x 3 1/8" 8 N pin	2.25	4.25	0.31	2789.91
1	Halliburton APBT carrier	-	3.00	1.51	2790.22
1	X-over 3 1/8" 8 N box x 2 7/8" EUE pin	1.88	3.88	0.18	2791.73
1	Bullplug w/cross 2 7/8" EUE	-	4.00	0.21	2791.91
	TOTAL DEPTH				2792.1

WELL NO.: 15/9-11 DST NO.: 1 DATE: 30.11.81.

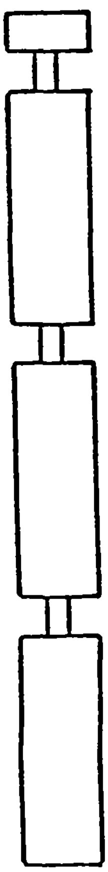


WIRELINE NIPPLE XN at 2769.04 m

GAUGE TYPE AND NUMBER: SSDR 81048
DEPTH, PRESSURE ELEMENT: 2774.11 m RANGE: 10000 psi
MODE: 1 min DELAY: -
ACTUATED: time 1141 date: 30.11.81.
WILL RUN OUT: time 0041 date: 04.12.81.

GAUGE TYPE AND NUMBER: MRPG 0049
DEPTH, PRESSURE ELEMENT: 2777.63m RANGE: 6000 psi
MODE: 2 min DELAY: 512 min
ACTUATED: time: 1145 date: 30.11.81.
WILL RUN OUT: time: 0457 date: 03.11.81.

GAUGE TYPE AND NUMBER:
DEPTH, PRESSURE ELEMENT: RANGE:
MODE: DELAY:
ACTUATED: time: date:
WILL RUN OUT: time: date:



D.S.T. HANGER

GAUGE TYPE AND NUMBER: SSDR 81049
DEPTH, PRESSURE ELEMENT: 2783.73m RANGE: 10000 psi
MODE: 1 min DELAY: -
ACTUATED: time: 1144.5 date: 30.11.81.
WILL RUN OUT: time: 0044.5 date: 04.11.81.

GAUGE TYPE AND NUMBER: MRPG 0121
DEPTH, PRESSURE ELEMENT: 2787.24 m RANGE: 6000 psi
MODE: 2 min DELAY: 512 min
ACTUATED: time: 1147 date: 30.11.81.
WILL RUN OUT: time: 0459 date: 03.11.81.

GAUGE TYPE AND NUMBER:
DEPTH, PRESSURE ELEMENT: RANGE:
MODE: DELAY:
ACTUATED: time: date:
WILL RUN OUT: time: date:

DIARY OF EVENTS

WELL NO.:	15/9-11	DST NO.:	1
ZONE TESTED:	Lower Mesozoic	PERFS.:	2797 - 2807 m

DATE/TIME	OPERATIONS
30.11.81.	
05:25	PERFORATING
	Schlumberger perforated test interval. Partial misrun lower 1/3 of zone only perforated.
07:15	Run in hole to perforate remainder of zone
07:55	Perforated remainder of zone, guns lost in hole. Rig up and run junk basket & gauge ring to 2795 m
	RIH w/TEST STRING
11:30	Started to pick up test tools
12:35	Gauges in hole, pick up test string
01.12.81.	
09:04	Picked up to extend slip joints
09:10	Set packer, land string in wear bushing
09:17	Pressure annulus to 1400 psi, no response due to DPTV being shut
09:21	Bled annulus, pick up and cycle pipe to open DPTV
09:34	String landed in wear bushing
	INITIAL FLOW
09:38	Opened APR-N. Initial well head pressure 24 psi
	INITIAL SHUT IN
09:40	Closed APR-N. Well head pressure 34 psia. Estimated production 8.5 bbl. Pressure rose to 975 psia then stabilized.
	SECOND FLOW
10:41	Reopened APR-N
10:42	Opened choke manifold to flare line. Adj. choke size 32/64"
10:45	Adj. choke increased to 40/64"
11:00	Gas to surface. WHP 1614 psia
11:26	Switched to 42/64" fixed choke

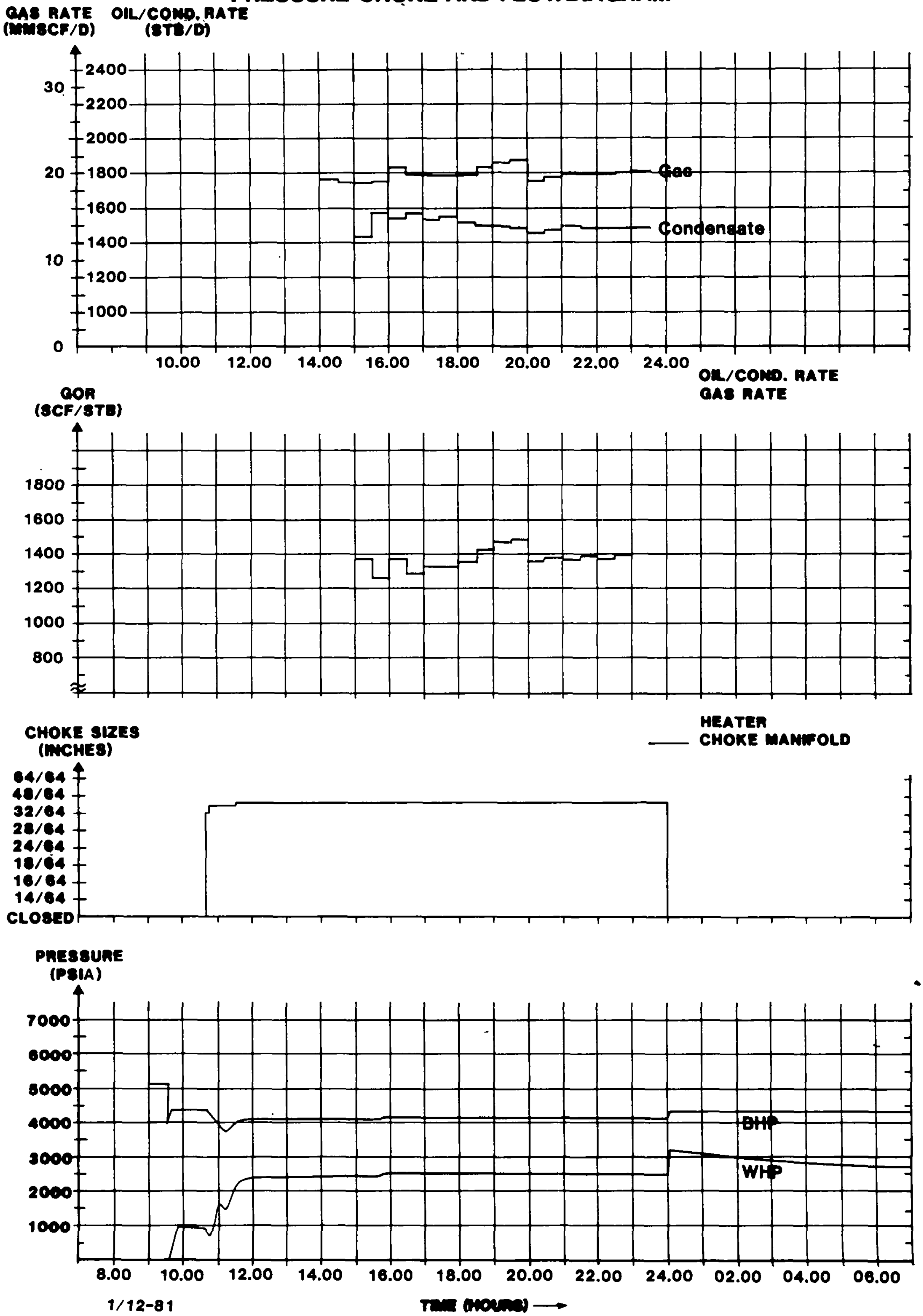
DIARY OF EVENTS

WELL NO.: 15/9-11 DST NO.: 1
ZONE TESTED: Lower Mesozoic PERFS.: 2797 - 2807 m

DATE/TIME	OPERATIONS
13:00	Switched flow through separator. WHP = 2379 psia
19:20	Commenced sampling PVT set no. 1.
21:10	Commenced sampling PVT set no. 2.
22:10	Commenced sampling PVT set no. 3.
22:32	Changed to starboard burner
23:05	Ran meter check to tank
23:55	Bypassed separator
24:00	Closed APR-N and choke manifold. WHP = 2474 psia
02.12.81	
	Pressure increased to 3171 psia then began decreasing
14:57	Began bleeding tubing through flare line. 24/64" choke
15:09	Increased to 42/64" choke
15:11	Shut in to observe
15:18	Continued bleeding tubing pressure 42/64" choke
15:40	Closed failsafe on surface test tree
15:50	Opened kill valve and pumped to fill tubing. 6 bbl water followed of mud
16:12	Opened APR-N. Commenced bullheading
16:57	Broke down formation with 3500 psig
17:12	Completed bullheading
17:27	Sheared APR-M and commenced reversing
	Released packer and POOH

WELL NO : 15/9-11 DST NO.: 1

PRESSURE CHOKE AND FLOWDIAGRAM



FLOW DATA

Date/Time	Bottom hole SSDR 81049		Well head		Chokes		Separator data							Liq. and gas analysis at goos neck, separator					
	Press. Psia	Temp. F	Press. Psia	Temp. F	Manifold	Heater 64. inc.	Press. Psia	Temp. F	Gas rat. mmscf/d	Cond. rate stb/d	GCP scf/stb	Cond. API	Gas S.G.	Water %	PH	Sedim. %	Oil API	CO_2 %	H_2S ppm
01.12.81																			
1041			959				Opened APR-N valve												
1042					32/64		Opened choke manifold												
1045	4229	215	778	50	40/64		Increased choke size												
1100	3888	215	1614	68	"		Gas to surface												
1126	3900	215	1734	84	42/64		Switched to fixed choke											1.5	
1300	4075	217	2379	98	"		Directed flow through separator							Trace		Trace		"	0
1430	4078	217	2395	102	"		470	83	19.62					"		"		"	
1500	4080	218	2405	104	"		470	83	19.34					"		"		"	
1530	4080	218	2401	106	"		465	88	19.37	1431	13537	57	0.73	"		"		2.0	
1600	4106	218	2479	107	"		470	90	19.75	1578	12516	"		"	7.0	"		"	
1630	4108	218	2490	110	"		470	92	21.03	1546	13604	"							
1700	4109	218	2497	110	"		455	93	20.14	1573	12803	"							
1730	4110	218	2495	110	"		460	90	20.32	1539	13203	"						1.0	0
1800	4108	218	2490	110	"		460	90	20.32	1547	13137	"						0.6	
1830	4103	218	2471	111	"		460	92	20.26	1513	13392	"							
1900	4103	218	2474	112	"		455	94	21.11	1501	14064	"	0.73		7.0				
1930	4103	218	2471	114	"		455	94	21.60	1488	14514	"							
2000	4103	218	2472	115	"		455	95	21.81	1484	14694	"		Drain Daniels orifice box				0.5	
2030	4103	218	2472	117	"		460	96	19.63	1465	13400	"		Trace				0.6	
2100	4102	218	2472	118	"		460	95	20.18	1475	13684	"							
2130	4102	218	2472	118	"		460	95	20.32	1494	13600	"		"				0.8	
2200	4101	219	2472	118	"		460	95	20.45	1490	13723	"			7.0				
2230	4108	219	2473	118	"		455	96	20.31	1489	13638	"		"				0.8	0
2300	4109	219	2474	120	"		460	97	20.66	1493	13837	"		Tank shrinkage = 15%					
2330	4109	219	2474	120	"		465	97	20.78	1492	13926	"	0.73	"				0.9	
2355	4117	219	2474		"		Separator bypassed												
2400	4127	219	2475																
			The gas rate is corrected for the gas solubility of the cond. leaving the separator (260 SCF/STB)																

WELL no. 15/9-11 DST no. 1 DATE Dec. 1st 1981

1. Separator samples

Bottle no.	Oil/gas	Time	Cond. rate STB/D	Gas rate MMSCF/D
9209-37	Cond.	1920/1945	1488	21.60
A-1556	Gas	1920/1945	1488	21.60
A-7220	Gas	1951/2011	1484	21.81
8088 86	Cond.	2110/2130	1494	20.32
A-7636	Gas	2110/2130	1494	20.32
A-4286	Gas	2140/2200	1490	20.45
8088 51	Cond.	2210/2225	1489	20.31
A-11342	Gas	2210/2225	1489	20.31
A-7148	Gas	2229/2245	1493	20.66

SURFACE SAMPLING

Condensate samples from separator during 2nd flow on 16.7 mm (42/64") choke:

- 6 x 1 l bottles
- Three 20 l jerry cans
- 1 drum

TEST ANALYSIS

Reservoir parameters:

Vapor volume equivalent:

V_{CS} = 189 m^3/M^3 (1060 SCF/STB) at 57.0^{o}API and 460 psia on separator

Main flow rate on 16.7 mm (42/64") choke:

Q_g = 20200000 SCF/D + 1060 SCF/STB x 1500 STB/D = 21.8 MMSCF/D (616 000 SM^3/D)

$t_{eff} = t_{prod}$ = 798 minutes

Reservoir pressure, P:	299.48 bara (4343.6 psia)
Reservoir temperature, T:	102.8^{o} C (217^{o}F)
Specific gravity of reservoir gas, γg:	0.939
Compressibility factor, Z:	0.961
Viscosity of reservoir gas, μg:	0.0319 cp
Gas formation volume factor, Bg:	4.25 x 10^{-3} m^3/m^3 (7.57 x 10^{-4} RB/SCF)
Compressibility of reservoir gas, Cg:	20.5 x 10^{-4} bar^{-1} (1.41 x 10^{-4} psi^{-1})
Compressibility of formation water, Cw:	39.0 x 10^{-6} bar^{-1} (2.69 x 10^{-6} psi^{-1})
Compressibility of the formation, Cf:	51.5 x 10^{-6} bar^{-1} (3.55 x 10^{-6} psi^{-1})
Water saturation, Sw:	0.16
Hydrocarbon saturation, Sg:	0.84
Porosity, Ø:	0.215
Perforation height, hp:	10 m (32.8 ft)
Formation height, ht:	30 m (98.4 ft)
Wellbore radius, rw:	0.11 m (0.35 ft)
Total compressibility, Ct:	17.7 x 10^{-4} bar^{-1} (1.22 x 10^{-4} psi^{-1})

The compressibility factor and the specific gravity of the reservoir gas are PVT data from Statoil production lab.

The Flopetrol SSDR gauge no. 81049 at 2783.73 m is used for the analysis.

Results from Horner plot of final build-up:

P^* = 299.48 bara (4343.6 psia)
P_{1hr} = 299.35 bara (4341.7 psia)
m = 0.1108 bar/cycle (1.607 psia)
P_{wfs} = 284.52 bara (4126.6 psia)

Permeability thickness:

$$Kh = \frac{162.6 \times Qg \times Bg \times ug}{m} = 16235 \text{ md m } (53266 \text{ md-ft})$$

The thickness of the zone which is contributing flow to the wellbore is assumed to be the formation height.

$h = h_t = 30$ m   Permeability $\underline{K = 541 \text{ md}}$

Total skin factor $\underline{St = 147}$

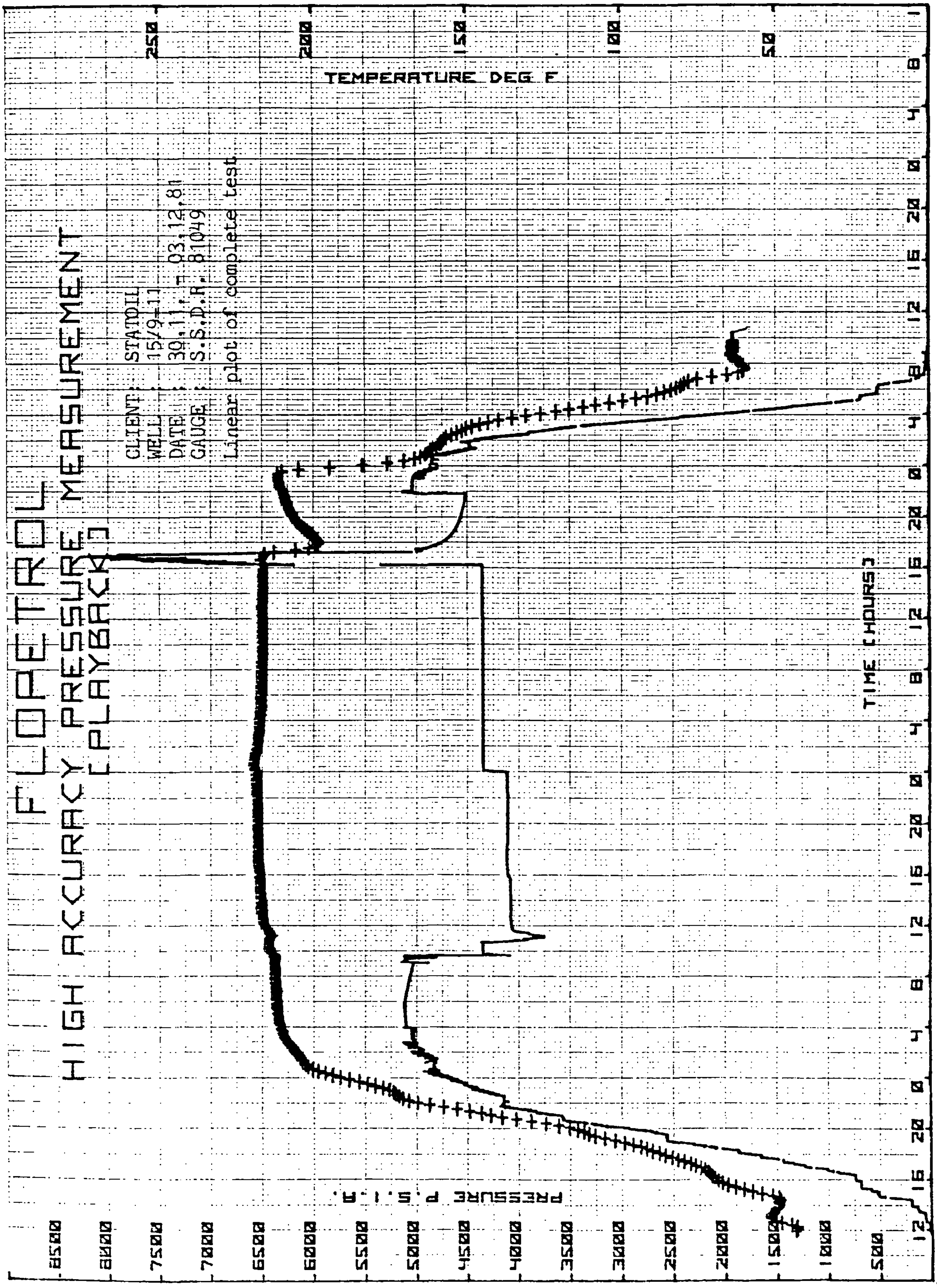
Partial penetration skin factor Sp = 5

Pressure drop due to skin: $\underline{\Delta Ps = 14.20 \text{ bar}}$ (206 psi)

PI (real) = Qg/(P* - Pwfs) = 41200 Sm^3/D/bar
(100460 SCF/D/psi)

PI (ideal) = Qg/(P* - Pwfs - ΔPs) = 810500 Sm^3/D
(1.98 MMSCF/D/psi)

Fig. 2.1.


FLOPETROL
HIGH ACCURACY PRESSURE MEASUREMENT
[PLAYBACK]
CLIENT : STATOIL
WELL : 15/9-11
DATE : 30.11. - 03.12.81
GAUGE : S.S.D.R. 81049
Linear plot of complete test
TEMPERATURE DEG F
TIME (HOURS)
PRESSURE P.S.I.A.

BRØNN 15-9-11   DST$ 1
BUILDUP NUMMER   1
GAUGES81049

NR.	TID	TRYKK
1	9.41	4216.730
2	9.42	4218.160
3	9.43	4217.170
4	9.44	4221.940
5	9.45	4253.260
6	9.46	4301.020
7	9.47	4338.770
8	9.48	4345.200
9	9.49	4345.480
10	9.50	4345.860
11	9.51	4346.040
12	9.52	4346.200
13	9.53	4346.270
14	9.54	4346.410
15	9.55	4346.430
16	9.56	4346.420
17	9.58	4346.410
18	10.00	4346.460
19	10.02	4346.480
20	10.04	4346.530
21	10.06	4346.500
22	10.08	4346.490
23	10.10	4346.500
24	10.12	4346.480
25	10.14	4346.490
26	10.16	4346.510
27	10.18	4346.490
28	10.20	4346.430
29	10.22	4346.470
30	10.24	4346.490
31	10.26	4346.490
32	10.28	4346.510
33	10.30	4346.380
34	10.32	4346.460
35	10.34	4346.470
36	10.36	4346.450
37	10.38	4346.460
38	10.40	4346.460

GI TYPE EDITERING
0 = SLUTT
1 = LISTING
2 = SLETTING
3 = ADDERING
4 = ERSTATTING

Fig. 2.2.

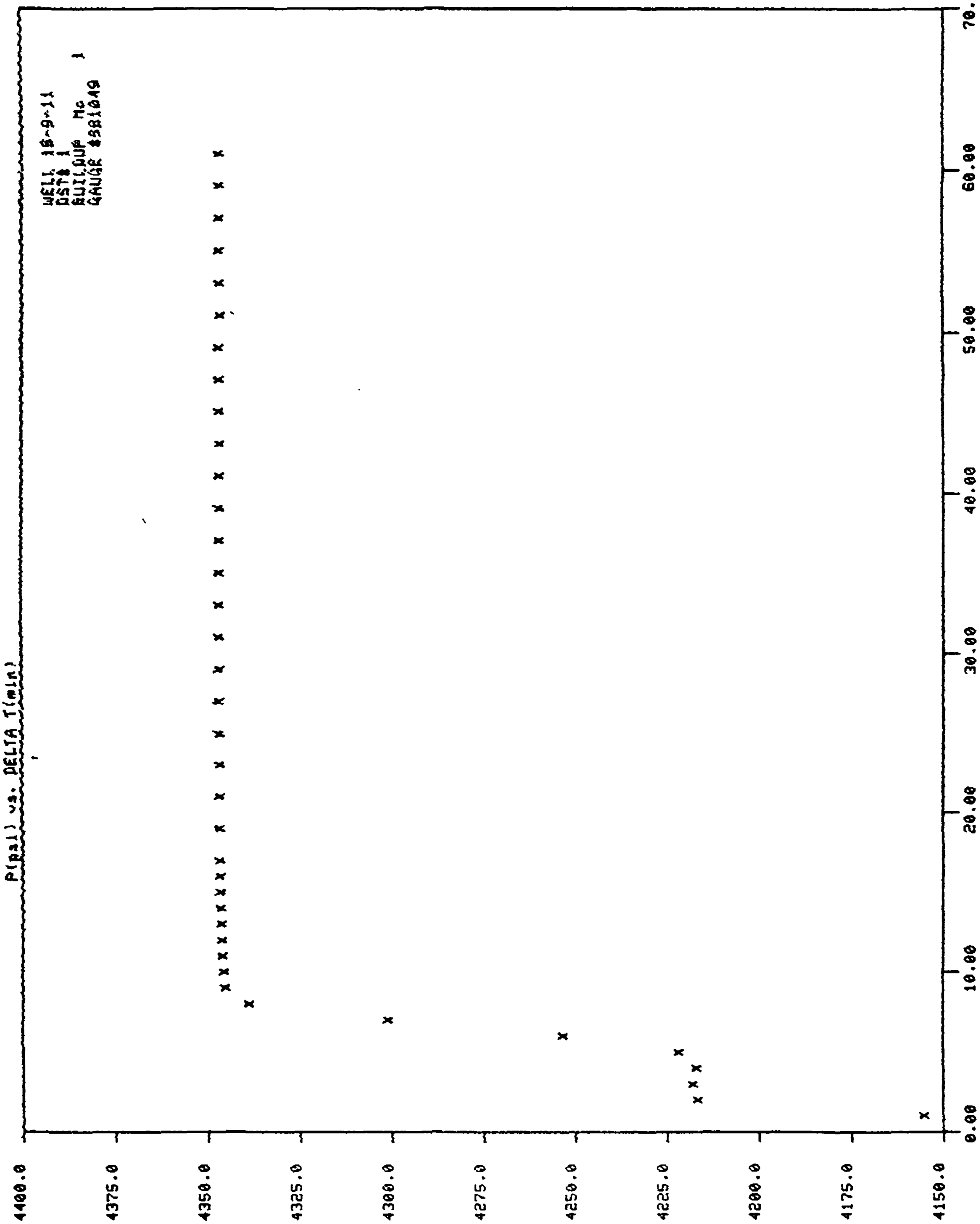

P(psi) vs. DELTA T(min)
WELL 18-9-11
DST# 1
BUILDUP Mc 1
GAUGE #581049
4400.0
4375.0
4350.0
4325.0
4300.0
4275.0
4250.0
4225.0
4200.0
4175.0
4150.0
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00

Fig. 2.3.

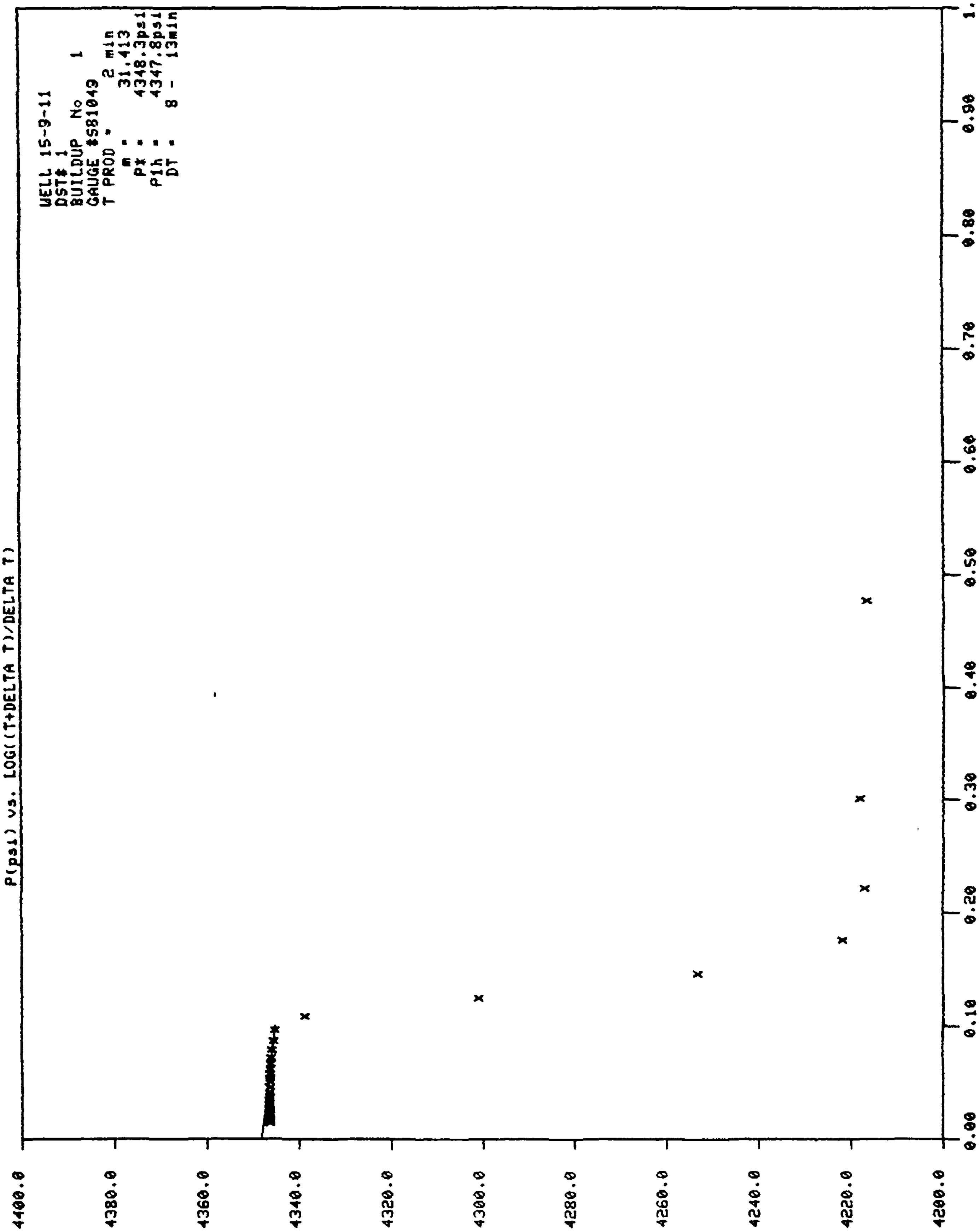

WELL 15-9-11
DST# 1
BUILDUP No 1
GAUGE #581049
T PROD = 2 min
m = 31.413
P* = 4348.3psi
P1h = 4347.8psi
DT = 8 - 13min
P(psi) vs. LOG((T+DELTA T)/DELTA T)
4400.0
4380.0
4360.0
4340.0
4320.0
4300.0
4280.0
4260.0
4240.0
4220.0
4200.0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

Fig. 2.4.

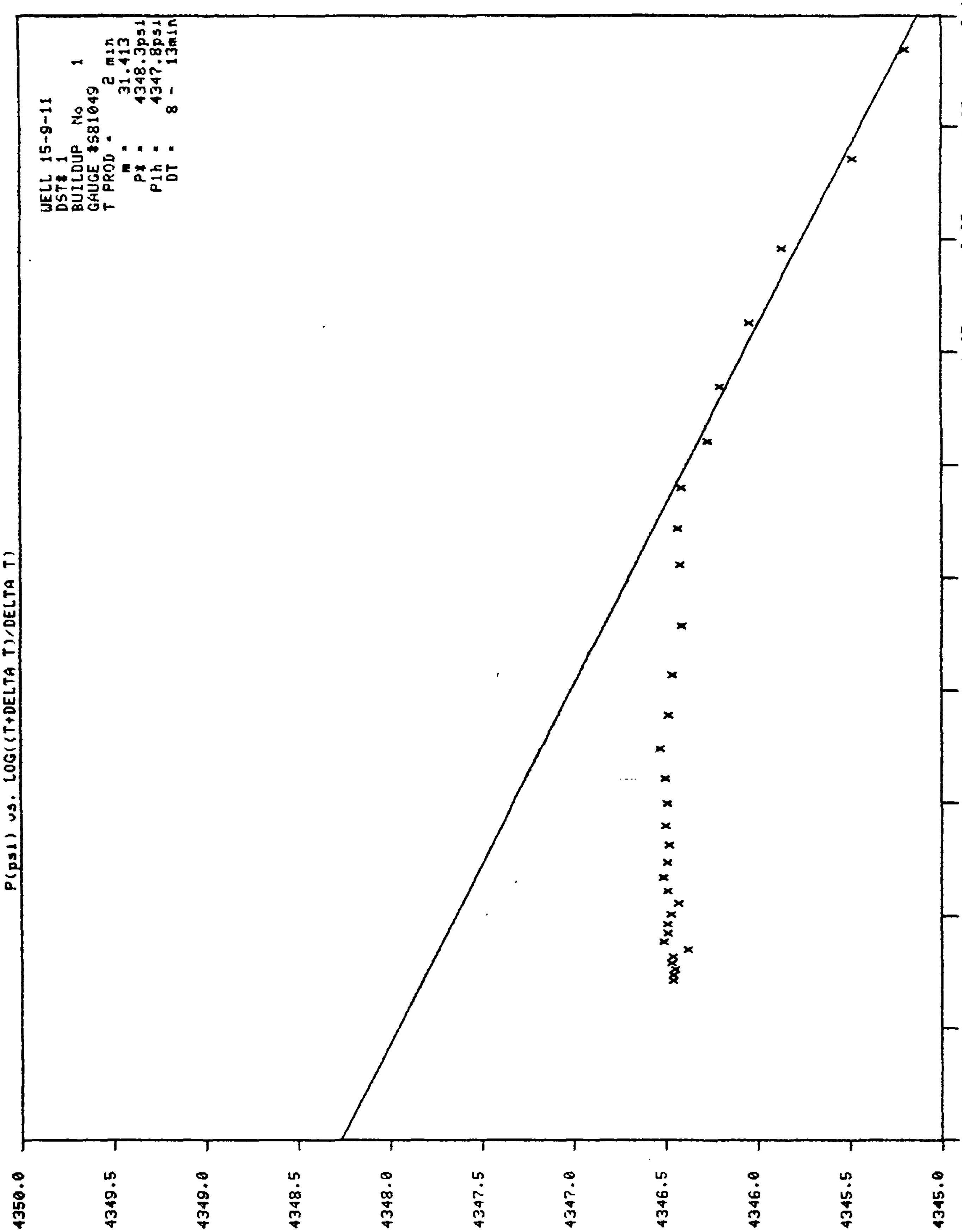
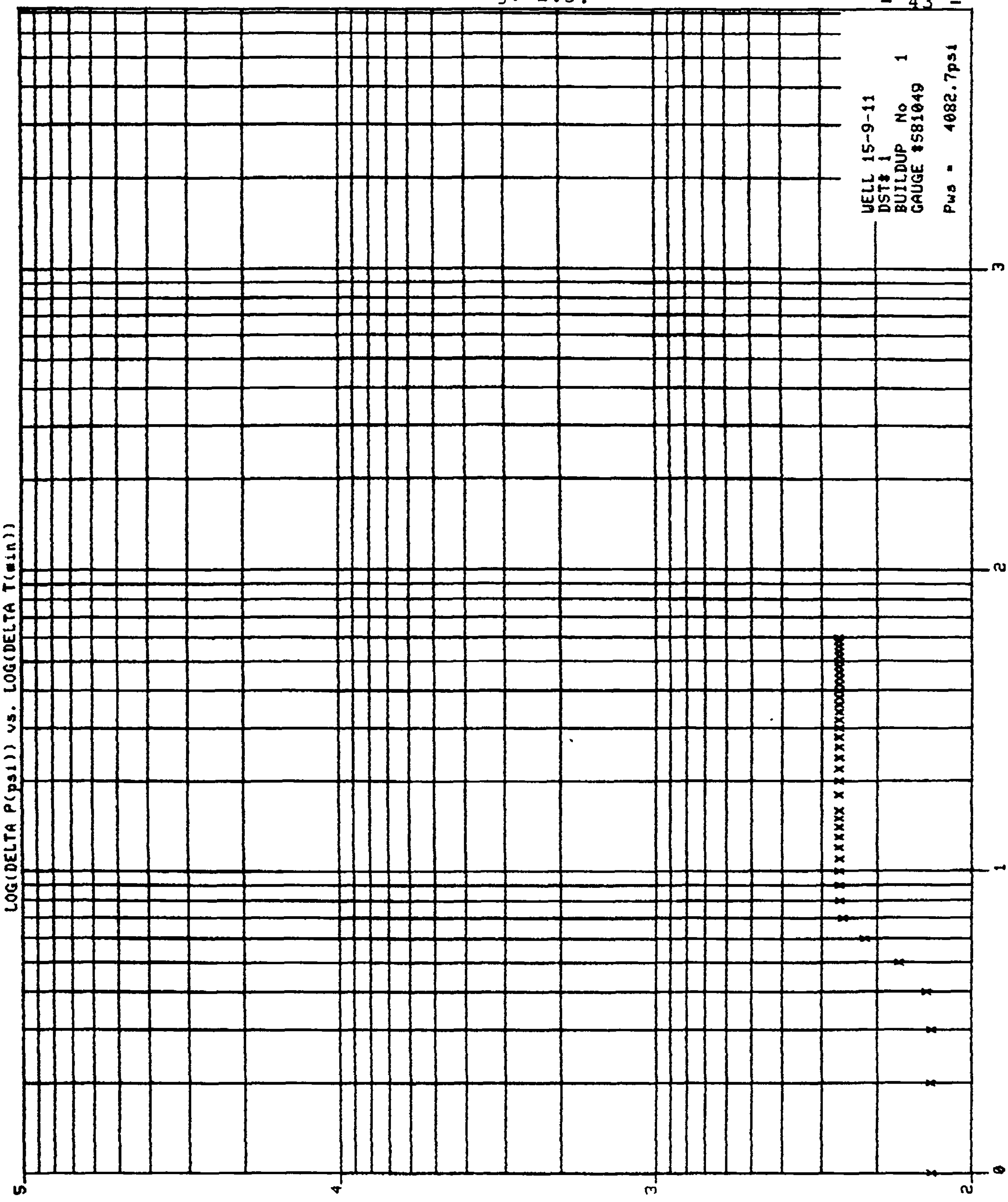

P(psi) vs. LOG((T+DELTA T)/DELTA T)
WELL 15-9-11
DST# 1
BUILDUP No 1
GAUGE #S81049
T PROD = 2 min
m = 31.413
P* = 4348.3psi
P1h = 4347.8psi
DT = 8 - 13min
4350.0
4349.5
4349.0
4348.5
4348.0
4347.5
4347.0
4346.5
4346.0
4345.5
4345.0
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10

Fig. 2.5.



WELL 15-9-11
DST# 1
BUILDUP No 1
GAUGE #581049
Pws = 4082.7psi
LOG(DELTA P(psi)) vs. LOG(DELTA T(min))
0
1
2
3
5
4
3
2

BRØNN 15-9-11 DST# 1
BUILDUP NUMMER 2
GAUGE SSDR 81049

NR.	TID	TRYKK
1	0.01	4204.230
2	0.02	4246.930
3	0.03	4285.070
4	0.04	4314.950
5	0.05	4337.690
6	0.06	4340.690
7	0.07	4340.820
8	0.08	4340.850
9	0.09	4340.900
10	0.10	4340.950
11	0.11	4340.980
12	0.12	4341.000
13	0.13	4341.030
14	0.14	4341.060
15	0.15	4341.090
16	0.16	4341.110
17	0.17	4341.120
18	0.18	4341.140
19	0.19	4341.160
20	0.20	4341.190
21	0.22	4341.260
22	0.24	4341.320
23	0.26	4341.360
24	0.28	4341.410
25	0.30	4341.470
26	0.32	4341.510
27	0.34	4341.560
28	0.36	4341.580
29	0.38	4341.590
30	0.40	4341.610
31	0.42	4341.650
32	0.44	4341.650
33	0.45	4341.920
34	0.46	4341.920
35	0.50	4341.920
36	0.55	4341.950
37	1.00	4341.970
38	1.10	4342.050
39	1.20	4342.120
40	1.30	4342.150
41	1.40	4342.170
42	1.50	4342.180
43	2.00	4342.250
44	2.10	4342.270
45	2.20	4342.250
46	2.30	4342.340
47	2.40	4342.370
48	2.42	4342.370
49	2.44	4342.370
50	2.46	4342.380
51	2.48	4342.380
52	2.50	4342.360
53	2.52	4342.390
54	2.54	4342.370
55	2.56	4342.390
56	2.58	4342.400
57	3.00	4342.380
58	3.10	4342.430
59	3.20	4342.480
60	3.30	4342.480
61	3.40	4342.510
62	3.50	4342.540
63	4.00	4342.550
64	4.10	4342.580
65	4.20	4342.570
66	4.30	4342.590
67	4.40	4342.630
68	4.50	4342.620
69	5.00	4342.650
70	5.10	4342.690
71	5.20	4342.700
72	5.30	4342.690
73	5.40	4342.730
74	5.50	4342.760
75	6.00	4342.740
76	6.10	4342.740
77	6.20	4342.780
78	6.30	4342.820
79	6.40	4342.790
80	6.50	4342.800
81	7.00	4342.820
82	7.10	4342.860
83	7.20	4342.880
84	7.30	4342.850
85	7.40	4342.840
86	7.50	4342.860
87	8.00	4342.890
88	8.10	4342.890
89	8.20	4342.910
90	8.30	4342.930
91	8.40	4342.950
92	8.50	4342.920
93	9.00	4342.910
94	9.10	4342.930
95	9.20	4342.950
96	9.30	4342.970
97	9.40	4342.970
98	9.50	4342.990
99	10.00	4342.990
100	10.10	4343.030
101	10.20	4343.030
102	10.30	4342.980
103	10.40	4342.970
104	10.50	4342.990
105	11.00	4342.990
106	11.10	4343.010
107	11.20	4343.030
108	11.30	4343.030
109	11.40	4343.050
110	11.50	4343.050
111	12.00	4343.050
112	12.10	4343.070
113	12.20	4343.070
114	12.30	4343.090
115	12.40	4343.090
116	12.50	4343.110
117	13.00	4343.110
118	13.10	4343.110
119	13.20	4343.080
120	13.40	4343.080
121	14.00	4343.070
122	14.20	4343.080
123	14.40	4343.080
124	15.00	4343.080
125	15.10	4343.100
126	15.20	4343.070
127	15.40	4343.020
128	16.00	4343.120
129	16.11	4343.160

Fig. 2.6.

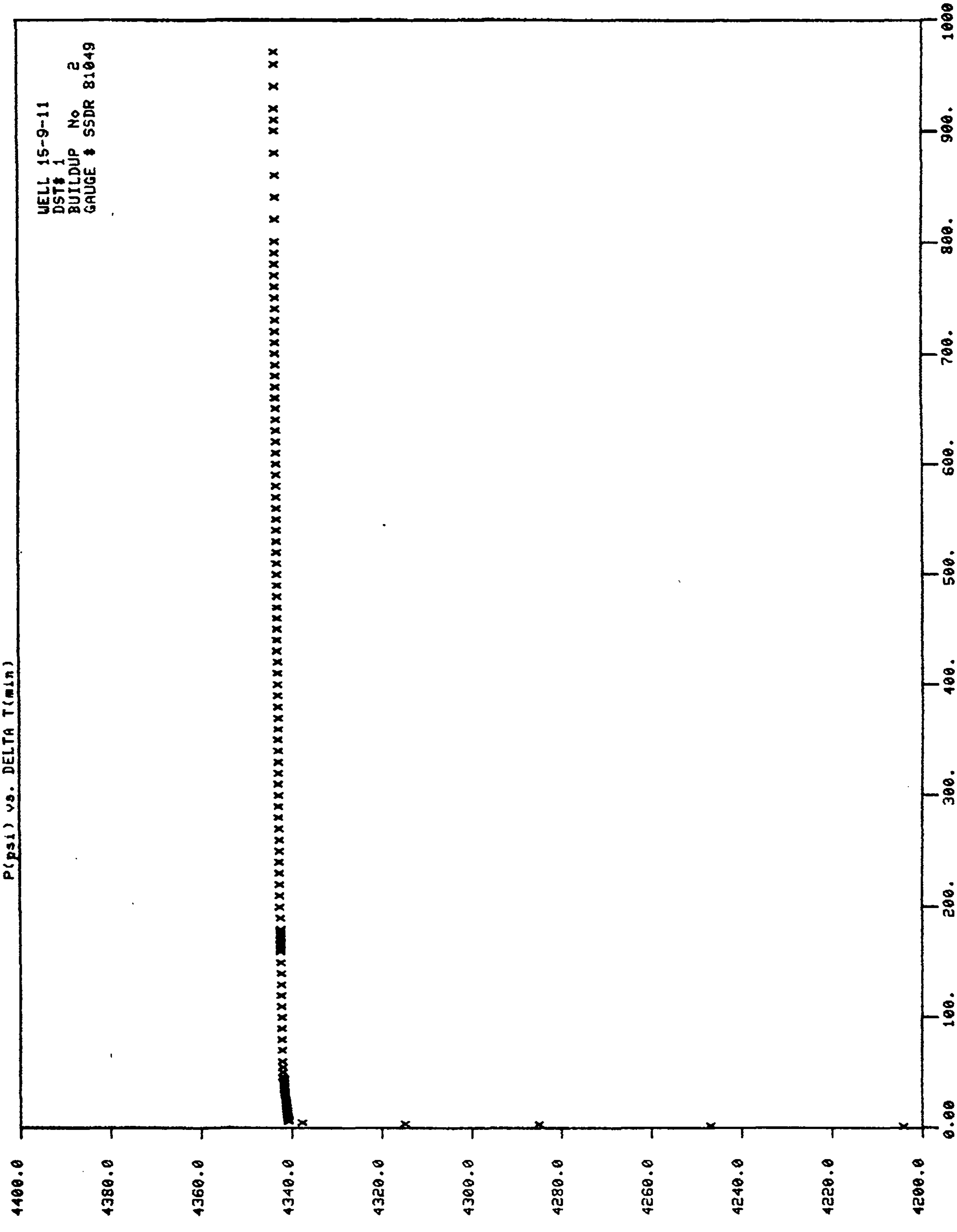

P(psi) vs. DELTA T(min)
WELL 15-9-11
DST# 1
BUILDUP No 2
GAUGE # SSDR 81049
0.00
100.
200.
300.
400.
500.
600.
700.
800.
900.
1000.
4400.0
4380.0
4360.0
4340.0
4320.0
4300.0
4280.0
4260.0
4240.0
4220.0
4200.0

Fig. 2.7.

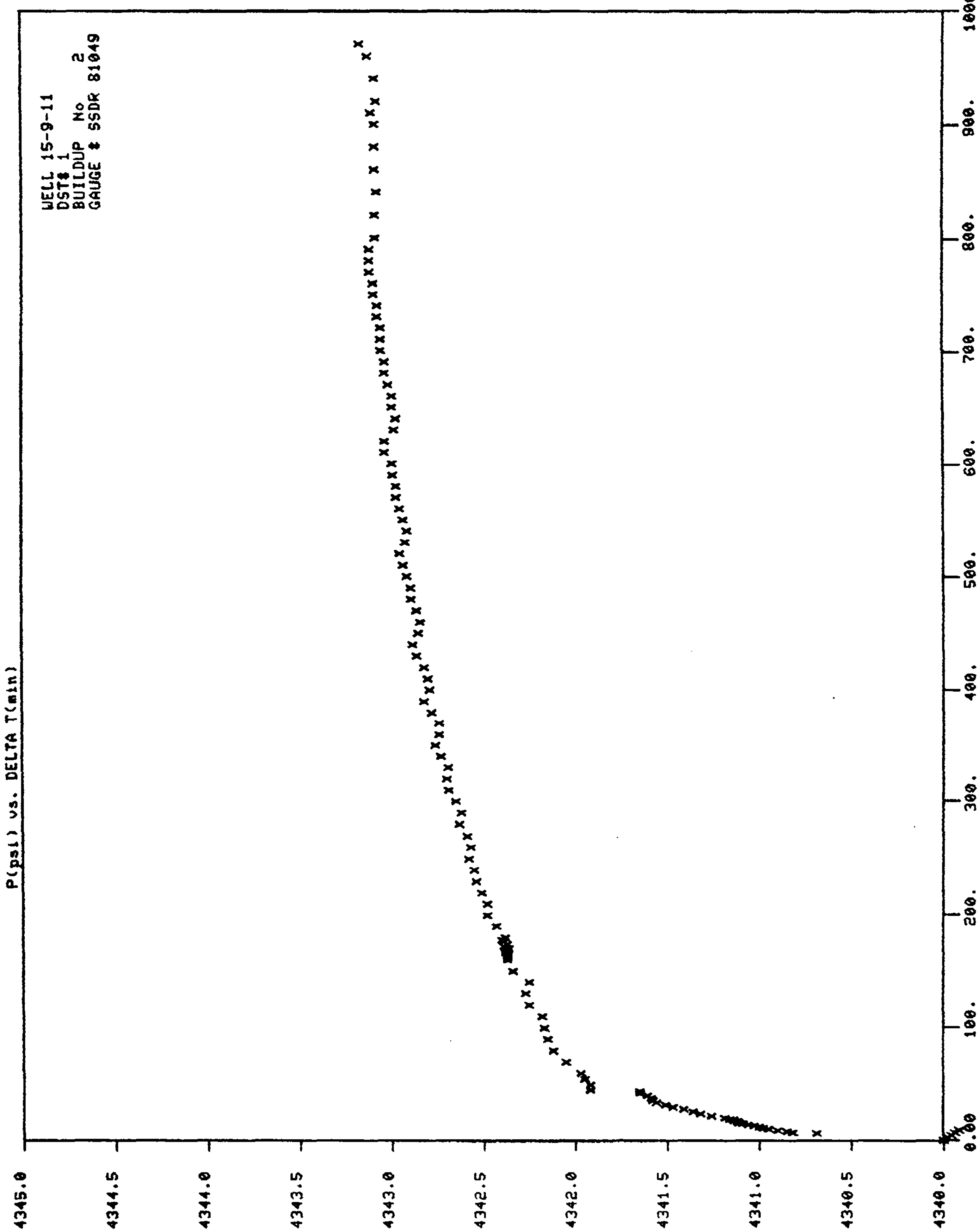
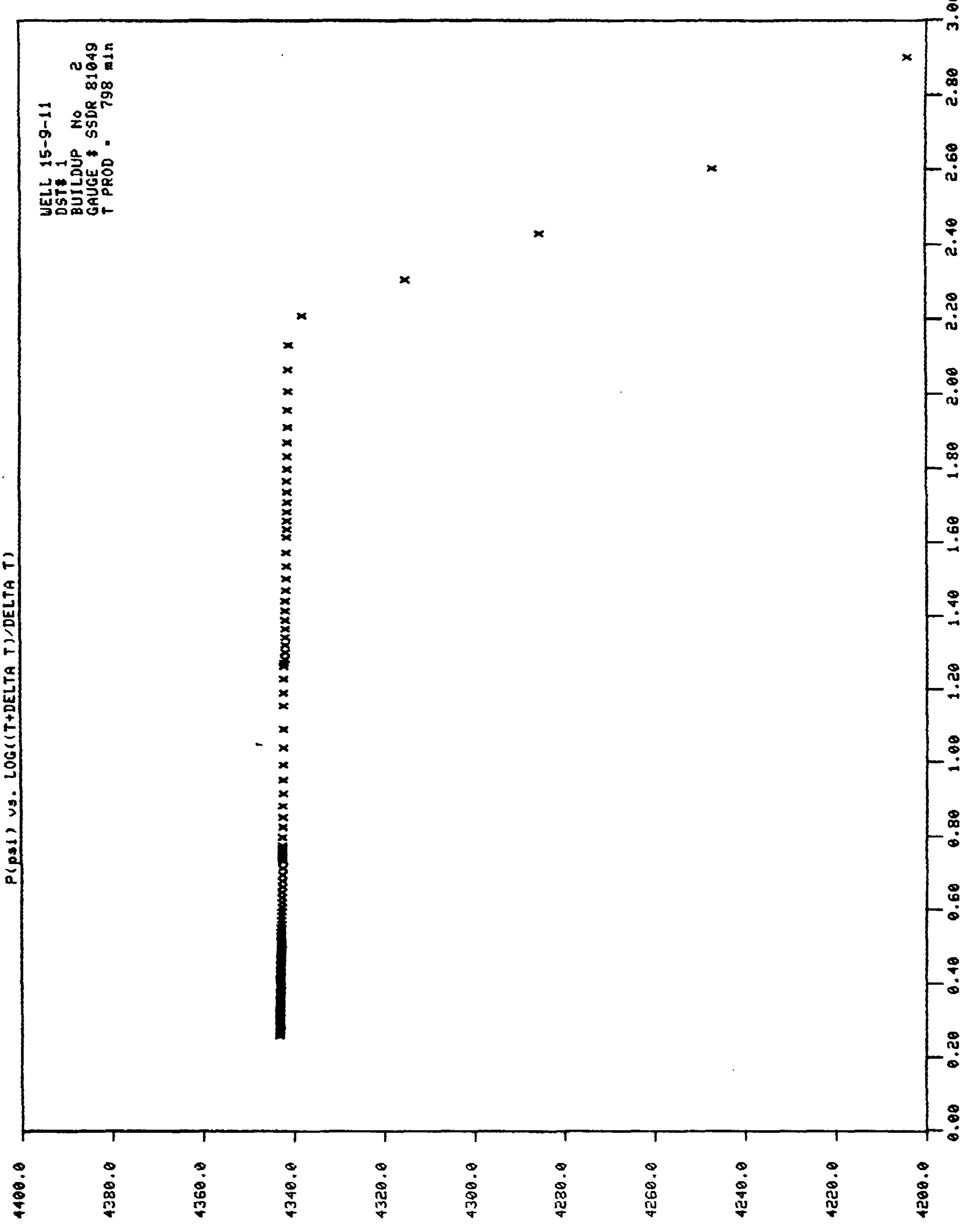

WELL 15-9-11
DST# 1
BUILDUP No 2
GAUGE # SSDR 81049
P(psi) vs. DELTA T(min)
4345.0
4344.5
4344.0
4343.5
4343.0
4342.5
4342.0
4341.5
4341.0
4340.5
4340.0
0.00
100.
200.
300.
400.
500.
600.
700.
800.
900.
1000.

Fig. 2.8.



WELL 15-9-11
DST# 1
BUILDUP No 2
GAUGE # SSDR 81049
T PROD = 798 min
P(psi) vs. LOG((T+DELTA T)/DELTA T)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
2.20
2.40
2.60
2.80
3.00
4400.0
4380.0
4360.0
4340.0
4320.0
4300.0
4280.0
4260.0
4240.0
4220.0
4200.0

Fig. 2.9.

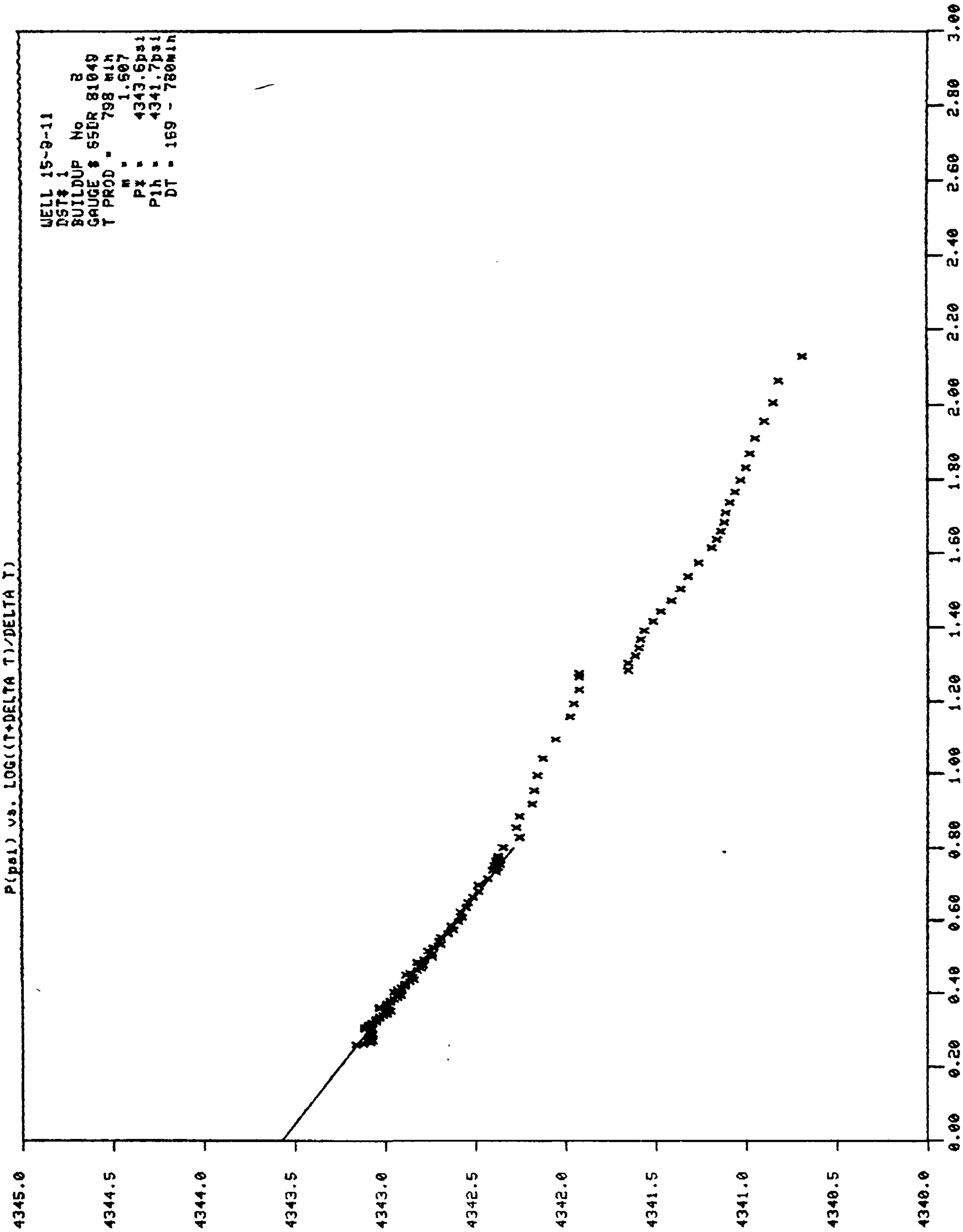
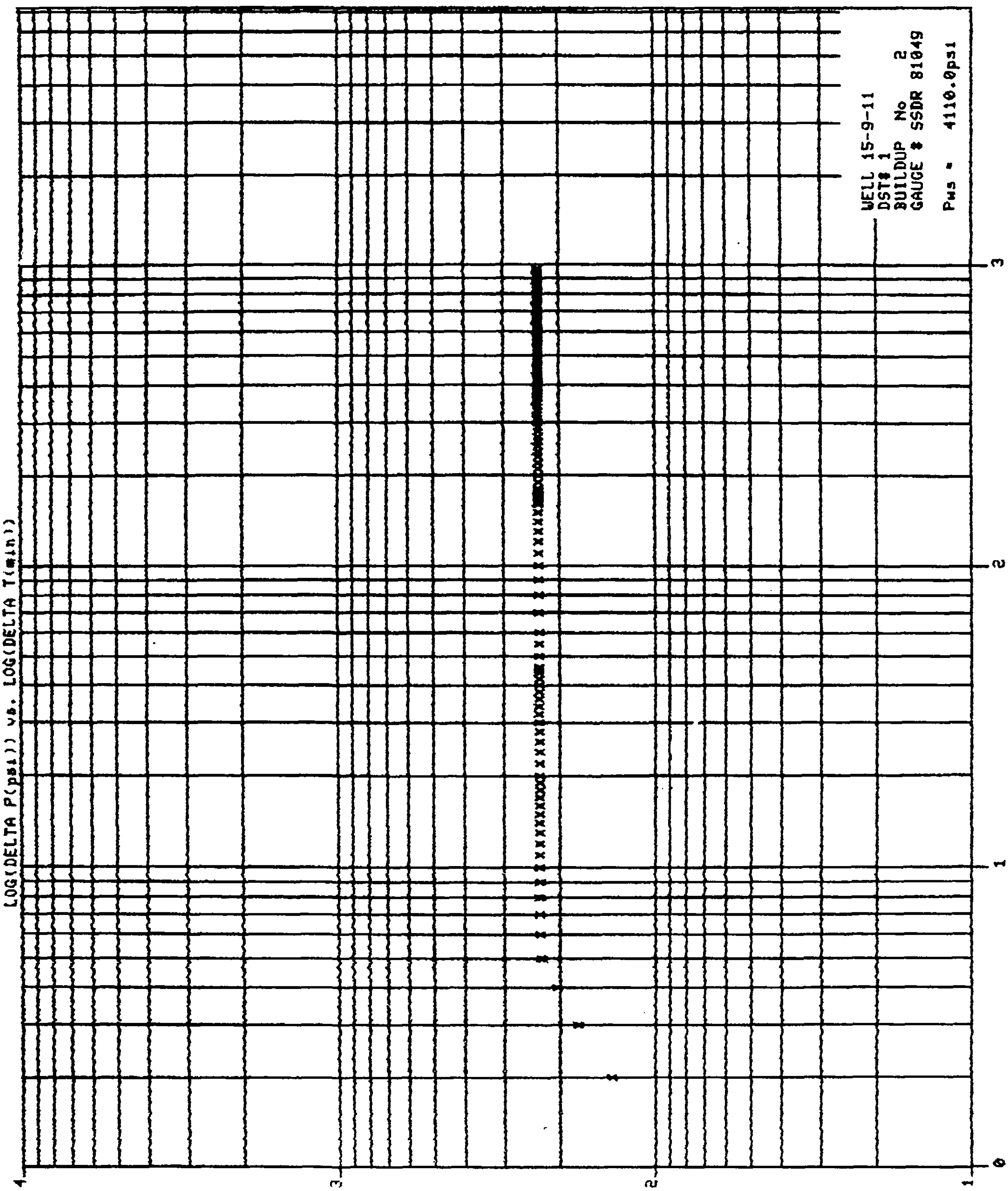

WELL 15-9-11
DST# 1
BUILDUP No 3
GAUGE # SSDR 81049
T PROD = 798 min
m = 1.607
P* = 4343.6psi
P1h = 4341.7psi
DT = 169 - 780min
P(psi) vs. LOG((T+DELTA T)/DELTA T)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
2.20
2.40
2.60
2.80
3.00
4345.0
4344.5
4344.0
4343.5
4343.0
4342.5
4342.0
4341.5
4341.0
4340.5
4340.0

Fig. 2.10.


LOG(DELTA P(psi)) vs. LOG(DELTA T(min))
WELL 15-9-11
DST# 1
BUILDUP No 2
GAUGE # SSDR 81049
Pws = 4110.0psi

APPENDIX 3

DST NO. 2

Content:

- Summary of DST no. 2.
- Lay out of test string
- Pressure recorders
- Diary of events
- Pressure, choke and flowdiagram
- Flow data
- Separator sampling
- Surface sampling
- Test analysis
- Water analysis

Figures:

- Listing of pressure data
- Sperry Sun: Pressure/Temp. vs. time plot
- P_{ws} vs Δt
- P_{ws} vs log $((t + \Delta t)/\Delta t)$
- Log ΔP vs log Δt

SUMMARY OF DST NO. 2.

Perforated interval: 2432 - 2440 m RKB

- Flow	600 min		
	25.4 mm (64/64")	choke:	10 min
	19.1 mm (48/64")	choke:	20 min
	11.1 mm (28/64")	choke:	121 min
	12.7 mm (32/64")	choke:	435 min
- Build up	441 min		

<u>Average flowrates:</u>

On 12.7 mm (32/64") choke:

- 233785 Sm^3/D (8272000 SCF/D) of gas
- 104 Sm^3/D (653 STB/D) of condensate
- 108 Sm^3/D (680 BPD) of water

Gravities:

- Gas: 0.72 sp.gr. rel. to air
- Condensate: 0.75 sp.gr (57.4^{o}API)
- Water: 1.042 g/cc

Separator conditions:

- Pressure: 11.07 bar (160.5 psia)
- Temperature: 17.2^{o}C (63^{o}F)

<u>Gauges:</u>

- Two Flopetrol SSDR, two Sperry Sun MRPG and two Sperry Sun MK III. One Sperry Sun MRPG erratic readings after five hours build up.

TEST STRING TALLY, ROSS RIG 15/9-11 DST NO. 2

All measurements to top of each item

	Equipment description	ID(")	OD(")	Length(m)	Depth(m)
	Otis SST w/x-over				
2	jnts 5" vam tbg 18 lbs/ft 1-80	4.25	5.56	20.02	- 6.31
1	pupnjt 5" vam tbg	4.25	5.56	4.53	13.71
1	x-over 5" vam box x 4-½" sa pin	4.25	5.51	0.40	18.245
1	Otis lubricator valve	2.99	13.88	1.62	18.64
1	x-over 4½" sa box x 5" vam pin (0-23)	4.25	5.51	0.41	20.26
1	jnt 5" vam tbg	4.25	5.56	10.32	20.67
1	jnt 5" vam tbg	4.25	5.56	9.65	30.99
2	stds 5" vam tbg	4.25	5.56	59.86	40.64
1	pupjnt 5" vam tbg	4.25	5.56	4.53	100.50
1	x-over 5 vam box x 4-½" 4 sa pin (f-24)	3.00	6.00	0.29	105.03
1	Flopetrol ez-tree	3.00	17.00	2.61	105.32
1	slickjnt 5" o.c. 4-½"-4 sa pin x pin (f-17)	3.00	5.00	2.95	107.93
1	Flopetrol fluted hanger	3.00	16.00	0.29	110.88
1	x-over 4-½"-4 pin x 5 vam pin (f-25)	3.00	6.00	0.31	111.17
1	pupnjt 5" vam tbg	4.25	5.56	1.22	111.48
2	jnts 5" vam tbg (no 44 and 45 from std no. 69)	4.25	5.56	19.61	112.70
68	stds 5" vam tbg	4.25	5.56	2001.92	132.31
1	x-over 5" vam box x 3-½" if pin	3.50	6.12	0.30	2134.23
1	slipjnt (open)	2.00	4.63	5.54	2134.53
1	slip jnt (closed)	2.00	4.65	4.01	2140.07
6	stds drill collars	2.25	4.75	171.08	2144.00
1	x-over 3-½" if box x 2-7/8 eue pin	2.50	4.75	0.20	2315.16
1	RTTS mech circ valve	2.44	4.87	0.84	2315.36
1	x-over 2-7/8" eue box x 3-½" if pin	2.62	4.75	0.20	2316.2
1	std drill collar	2.25	4.75	28.60	2316.4
1	slip jnt (closed)	2.00	4.63	4.01	2345.00
1	slip jnt (closed)	2.00	4.63	4.01	2349.01
1	std drill collar	2.25	4.75	28.61	2353.02
1	APR-M safety/circ valve	2.25	5.00	2.55	2381.63
1	dp-tester valve	2.25	5.00	1.46	2384.18

	Equipment description	ID(")	OD(")	Length(m)	Depth(m)
1	APR-N tester valve	2.25	5.00	3.86	2385.6
1	ful flo hydr. bypass	2.25	4.62	1.92	2389.5
1	big john jars	2.37	4.62	1.92	2391.42
1	x-over 3-½" if box x 4-½" if pin	3.00	6.12	0.40	2393.34
1	RTTS safety jnt	3.12	6.12	1.08	2393.74
1	RTTS packer (above)	3.75	8.25	0.98	2394.82
	RTTS packer (below)	3.75	8.25	0.80	2395.80
1	x-over 4-½" if x 3-½" fh	2.50	6.12	0.21	2396.60
1	x-over 3-½" fh x 2-7/8" eue	2.40	4.75	0.20	2396.81
1	perf. pupnjt 2-7/8" eue	2.44	2.88	3.54	2397.01
1	x-over 2-7/8" eue box x 2-3/8" eue pin	2.00	3.70	0.26	2400.55
1	collar 2-3/8" eue	-	2.88	0.13	2400.81
1	Otis xn-nipple 2-3/8" eue pin x pin	1.79	2.38	0.22	2400.94
1	x-over 2-3/8" eue box x 2-7/8" eue pin	2.00	3.70	0.26	2401.16
1	jnt 2-7/8" eue tbg	2.44	2.88	9.41	2401.42
1	pupnjt 2-7/8" eue	2.44	2.88	2.40	2410.83
	Flopetrol DST-hanger				
1	jnt 2-7/8" eue tbg	2.44	2.88	8.93	2413.23
1	perf. pupjnt 2-7/8" eue	2.44	2.88	2.05	2422.16
1	x-over 2-7/8" eue box x 3-1/8" eue pin	2.25	4.25	0.31	2424.21
1	Halliburton APBT carrier	-	3.00	1.51	2424.52
1	x-over 3-1/8" eue box x 2-7/8" eue pin	1.88	3.88	0.18	2426.03
1	bullplug w/cross 2-7/8" eue box	-	4.00	0.21	2426.21
					2426.42

WELL NO.: 15/9-11 DST NO.: 2 DATE: 7/12-81

WIRELINE NIPPLE OTIS XN-NIPPLE 2400.94m

SSDR

GAUGE TYPE AND NUMBER: Flopetrol SSDR no. 81048
DEPTH, PRESSURE ELEMENT: 2406.36 RANGE: 0 - 10 000 psi
MODE: 1 min. sampling DELAY: -
ACTUATED: time 04:41 date: 7.12.81
WILL RUN OUT: time 18:01 date: 10.12.81

Sperry Sun

GAUGE TYPE AND NUMBER: MRPG 0041
DEPTH, PRESSURE ELEMENT: 2409.76 RANGE: 6000 psi
MODE: 2 min DELAY: 8.5 hrs
ACTUATED: time: 04.58 date: 7.12.81
WILL RUN OUT: time: 21:00 date: 9.12.81

Sperry Sun

GAUGE TYPE AND NUMBER: MRPG III no. 1-12-1731
DEPTH, PRESSURE ELEMENT: 2412.28 m RANGE: 10 000 psi
MODE: 2 min DELAY: 8.5 hrs
ACTUATED: time: 04:54 date: 7.12.81
WILL RUN OUT: time: 21:00 date: 9.12.81

D.S.T. HANGER 2413.23 m

SSDR

GAUGE TYPE AND NUMBER: Flopetrol SSDR no. 81049
DEPTH, PRESSURE ELEMENT: 2417.07 m RANGE: 0 - 10 000 psi
MODE: 1 min DELAY: -
ACTUATED: time: 04:26 date: 7.12.81
WILL RUN OUT: time: 17:46 date: 10.12.81

Sperry Sun

GAUGE TYPE AND NUMBER: MRPG 0136
DEPTH, PRESSURE ELEMENT: 2420.88 m RANGE: 6000 psi
MODE: 2 min DELAY: -
ACTUATED: time: 05:01 date: 7.12.81
WILL RUN OUT: time: 13:00 date: 9.12.81

Sperry Sun

GAUGE TYPE AND NUMBER: MRPG III no. 1-9-1751
DEPTH, PRESSURE ELEMENT: 2423.50 m RANGE: 10 000 psi
MODE: 2 min DELAY: 8.5 hrs
ACTUATED: time: 04:55 date: 7.12.81
WILL RUN OUT: time: 21:00 date: 9.12.81

DIARY OF EVENTS	WELL No. 15/9-11	DST No. 2
	ZONE TESTED Heimdal	PERFS. 2432-2440m

DATE	TIME	OPERATIONS
071281		Perforation
	0330	Perforated 4sh/ft 2432 - 2440 m RKB. All shots fired.
		RIH w/teststring
	0430	Started running teststring.
	18:00	Held meeting with service people
081281	0037	Sat packer
		Flow
	0100	Opened APR-N valve
		13 psi increasing to 84 psi at wellhead
	0107	Opened on 64/64" adjustable choke 202 psi on WH
	0111	Changed to 48/64" adjustable choke
	0117	Changed to 48/64" fixed choke
	0121	Gas to surface. WHP = 1500 psi
		Backpressure 600 psi
	0130	Sand = 8%
	0137	Reduced to 28/64" adj. choke
	0145	Changed to 28/64" fixed choke
		WHP = 2000 psi. Backpressure = 400 psi. Sand = 0.4%
	0200	Sand = 0.5%. H_2O = 40%. CO_2 = 0.5%
	0338	Changed to 32/64" fixed choke
	0415	Sand = 0.1%. H_2O = 60%. WHP = 1994 psi. Backpressure = 700 psi
	0427	Flow through separator. 3" orifice
	0430	Sand = traces. H_2O = 65%. CO_2 = 0.5%
	0445	H_2O = 70%
	0500	H_2O = 75%. Sand = 0.5%. CO_2 = 0.1%
		Condensate gravity = 0.736 at 10.3 ^{o}C.
	0511	Stock tank: 35 bbls increase of H_2O in 44 mins
		1145 BPD of H_2O
	0521	WHP = 2030 psi

COMMENTS:

PE:

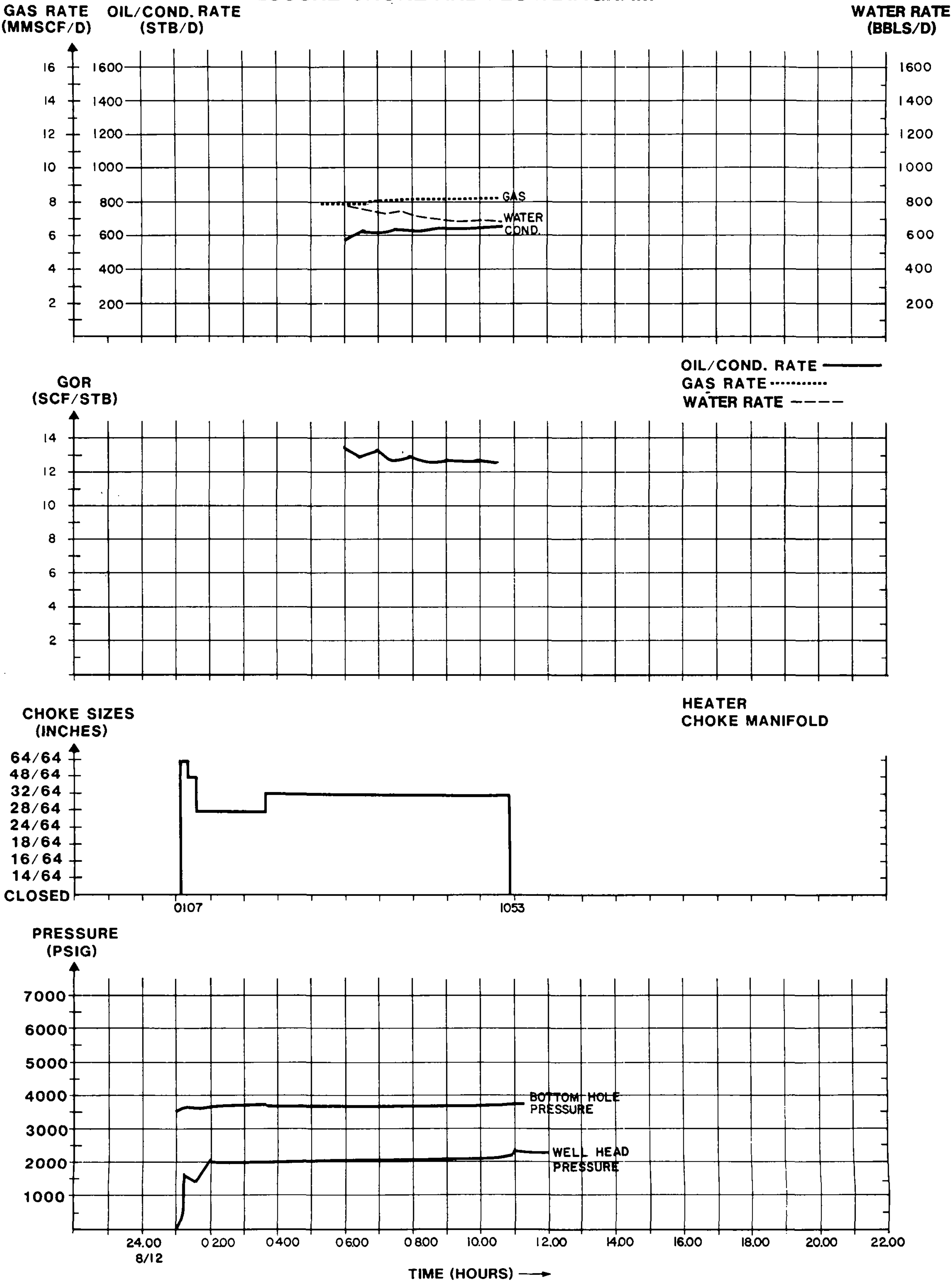
DIARY OF EVENTS		WELL No. 15/9-11 DST No. 2 ZONE TESTED Heimdal PERFS. 2432 - 2440m
DATE	TIME	OPERATIONS
081281	0645	Rates from separator:
		Gas = 7.9 MMSCFD. Condensate = 560 BPD. Water = 760 BPD
		Water meter factor = 0.98
	0915	WHP = 2095 psi. Stable last hour
	0930	Started taking PVT sample no. 1.
	1035	Finished PVT sample no. 1.
	1051	Leak in heater outlet.
		Tried to bypass heater, bypass valve stuck
	1053	Shut in well on choke manifold
	1100	Shut in APR-N valve
		Build-up
	1100	WHP = 2300 psig
		APR-N valve leaking
091281	0600	WHP stabilized on 2440 psig
	0800	WHP = 2440 psig
		Killing well
	0821	Bleed tubing through adj. choke to burner (48/64")
	0835	Pressure down to 1500 psig at manifold
	0836	Shut in well at choke manifold
	0839	WHP increased to 2000 psig
	0840	Bleed tubing through adj. choke to burner (48/64")
	0847	Wellhead pressure bled to 1390 psig
	0848	Shut in well at choke manifold. WHP build to 1600 psig
	1003	Started bullheading.

COMMENTS:

PE:

WELL NO : 15/9-11 ,DST NO.: 2

PRESSURE CHOKE AND FLOWDIAGRAM



FLOW DATA
15/9-11 DST no. 2. (2432 - 2440 m RKB)

Date/Time	Bottom hole Press. Psig	Bottom hole Temp. F	Well head Press. Psig	Well head Temp. F	Chokes Manifold	Chokes Heater 64. inc.	Separator data Press. Psig	Separator data Temp. F	Separator data Gas rat. mmscf/d	Separator data Oil rate stb/d	Separator data GOR scf/stb	Separator data Oil API	Separator data Gas S.G.	Separator data Water %	Separator data Water rate bbls/d	Liq. and gas analysis at goos neck Sedim. %	Liq. and gas analysis at goos neck Oil API	Liq. and gas analysis at goos neck Co2	Liq. and gas analysis at goos neck H2S
8.12.81																			
01:00	2660	171.7	13				OPEN APR-N VALVE												
01:07	3236	194.3	250		64/64	96/64	WELL OPEN ON 64/64" ADJ. CHOKE												
01:11	3249	196.4	1150		48/64	"	CHANGED TO 48/64" ADJ. CHOKE												
01:17	3384	196.4	1600		"	"	CHANGED TO 48/64" FIXED CHOKE												
01:21	3335	196.4	1600		"	"	GAS TO SURFACE												
01:37	3290	197.8	1550		28/64	"	REDUCED TO 28/64" CHOKE ADJ.												
01:45	3335	197.8	1800		"	"	CHANGED TO 28/64" FIXED CHOKE												
03:38	3424	198.5	2000	72	32/64	"	CHANGED TO 32/64" FIXED CHOKE										60.7		
04:12	3417	198.5			"	"	DIRECTED FLOW THROUGH HEATER										62.3		
04:27	3416	198.5			"	"	FLOW THROUGH SEPARATOR												
04:30	3417	198.5	2010	81	"	"								65		Trace			
04:45	3417	198.5	2015	82	"	"								70		Trace			
05:00	3416	199.2	2020	82	"	"								75		0.5			
05:15	3418	199.2	2030	82	"	"										0.5			
05:30	3418	199.2	2035	82	"	"	143	67	7.918				0.72			0.4		0.2	
06:00	3418	199.2	2040	81	"	"	140	67	7.960	586.6	13569	57.4	"	70	792.8	0.0	63.4	"	
06:30	3419	199.2	2065	82	"	"	140	65	7.960	612.01	13007	"	"		767.3	0.4	57.4	"	
07:00	3420	199.2	2070	82	"	"	140	65	8.066	600.17	13440	"	"		735.2	0.4		"	
07:30	3421	199.2	2080	86	"	"	140	65	8.095	638.01	12688	"	"		751.77	0.4	48.5	0	
08:00	3422	199.2	2085	86	"	"	140	65	8.095	628.43	12882	"	"		713.02	0.4		"	
08:30	3422	199.2	2090	84	"	"	140	65	8.095	639.68	12655	"	"		702.1	0.4		"	
09:00	3423	199.2	2095	86	"	"	144	65	8.202	641.28	12790	"	"		688.86	0.3		"	
09:30	3424	199.9	2095	86	"	"	144	65	8.202	643.66	12743	"	"		679.88	0.3		"	
10:00	3426	199.9	2100	84	"	"	146	63	8.272	650.36	12720	"	"		685.08	0.4		"	
10:30	3426	199.9	2110	86	"	"	146	63	8.272	655.76	12615	"	"		674.88	0.4		"	
10:50	3439	199.9					LEAK AT HEATER												
10:53	3477	199.9					WELL SHUT IN AT CHOKE MANIFOLD												
11:00	3507	199.9					WELL SHUT IN AT APR-N												

DST SUMMARY DATA

SHEET D: SEPARATOR AND BOTTOM HOLE SAMPLING

Well no.: 15/9-11 DST no.: 2 Date: 8.12.81

1. Separator samples

Bottle no.	Oil/Gas	Time	Oil rate	Gas rate
9209/100	Oil	09:30	647.01 bbls/d	8.237 MMSCFD
A-10915	Gas	09:30	"	"
A-4987	Gas	09:30	"	"

2. Bottom hole samples

Bottle no.	Sampling depth	Sampling presure	Opening pressure	Transfer BPP	True BPP (lab)
NONE					

SAMPLING

During flow:

- 1 x 20 l jerry-can of condensate from separator
- 6 x 1 l plastic bottles of water from separator

After shut-in:

- 1 drum of condensate from separator
- 1 x 10 l jerry-can of condensate from separator
- 2 x 20 l plastic-cans of water from separator

Note:

Few samples were taken during the flow because the well had to be shut-in too early as a result of leak in the heater-manifold.

TEST ANALYSIS

Input data, reservoir parameters:

Vapor volume equivalent:

Vcs = 160 M^3/m^3 (900 SCF/STB) at 10.10 bar (146 psig) and 0.749 sp.g. (57.4°API) on separator.

Last averaged rates on 12.7 mm (32/64") choke:

Qg = 233785 Sm^3 = 8272000 SCF/D
Qcond = 104 Sm^3/D = 653 STB/D
Qw = 108 Sm^3/D = 680 BPD
Qgeq = 233785 + 104 x 160 = 250425 Sm^3&D = 8860767 SCF/D
Teff = Tprod = 600 minutes

Reservoir temperature:	Tres = 87.2°C (189°F)
Specific gravity of gas:	γres = 0.927
Compressibility factor:	Z = 0.833
Viscosity of formation water:	μw = 0.370 cp
Viscosity of reservoir gas:	μg = 0.029 cp
Compressibility of reservoir gas:	Cg = 276.6 x 10^{-5} bar^{-1} (1.907 x 10^{-4} psi^{-1})
Compressibility of formation water:	Cw = 4.4 x 10^{-5} bar^{-1} (3.053 x 10^{-6} psi^{-1})
Compressibility of the formation:	Cf = 4.9 x 10^{-5} bar^{-1} (3.358 x 10^{-6} psi^{-1})
Gas formation volume factor:	Bg = 4.34 x 10^{-3} m^3/m^3 (7.72 x 10^{-4} RB/SCF)
Water saturation:	Sw = 80.1 %
Gas saturation:	Sg = 19.9 %
Porosity:	Ø = 24.4 %
Perforated height:	hp = 8 m (26.2 ft)
Formation height:	hf = 12 m (39.4 ft)
Wellbore radius:	rw = 0.155 m (0.51 ft)
	Nacl: 5.6 %

PVT data, viscosities and compressibilities are calculated parameters.

NaCl is measured on water samples in Statoil Lab.

Results:

The Sperry Sun MK III 2 gauge is used for the analysis.

Horner analysis:

P* = 244.20 bar (3541.8 psia)
P1hr = 244.06 bar(3539.8 psia)
m = 0.1329 bar/cycle (1.928 psi/cycle)
Pwfs = 236.8 bar (3434.5 psia)

Total compressibility: $Ct = 63.4 \times 10^{-5}$ bar^{-1}
(4.375×10^{-5} psi^{-1})

Effective gas permeability:

$$\left(\frac{K}{u}\right)_g \times h = \frac{162.6 \times (1000)\ (Qg - 0.001\ (QRs + Qw\ Rsw))\ Bg}{m}$$

$$= \underline{576298\ \frac{md\text{-}ft}{CP}} = \underline{175655\ \frac{md\text{-}m}{CP}}$$

$$Kg = \underline{424.5\ md}$$

Effective water permeability:

$$\left(\frac{K}{u}\right)_w \times h = \frac{162.6 \times Qw \times Bw}{m} = \underline{59069\ \frac{md\text{-}ft}{DP}} = \underline{18004\ \frac{md\text{-}m}{CP}}$$

$$Kw = \underline{555\ md}$$

For the permeability calculations, $h = h_f = 12$ m (39.4 ft) has been used.

Total mobility:

$$\left(\frac{K}{u}\right)_t = \left(\frac{K}{u}\right)_g + \left(\frac{K}{u}\right)_g = \underline{16138\ \frac{md}{CP}}$$

Total skin factor:

St = 55.3

Pressure drop due to skin:

Ps = 0.87 x m x St = 6.39 bar = 92.8 psi

$$PI\ (real) = \frac{Qg}{(P^*-Pwfs)} = 33850\ Sm^3/D/bar = 82579\ SCF/D/psi$$

$$PI\ (ideal) = \frac{Qg}{(P^*-Pwfs-\ Ps)} = 250490\ Sm^3/D/bar = 611087\ SCF/D/psi$$

Calculated initial reservoir pressures from the gauges used in the test.

Gauge	Depth (mRKB)	P* (psig)
Flopetrol SSDR 81048	2406.36	3525.2
Sperry Sun MRPG 0041	2409.76	3526.0
Sperry Sun MK III 2	2412.3	3527.3
Flopetrol SSDR 81049	2417.07	3527.3
Sperry Sum MRPG 0136	2420.88	3530.7
Sperry Sun MK III 1	2423.5	3536.0

These pressures have been used in the RFT-plot.

WATER ANALYSIS

Analysis of water from separator taken December 8th at 11:30 - 1230 hours.

The water was sampled after shut-in.

Table 1. Results of ion analysis of water sample.

Density at 20°C, g/cm^3	1.0420		
pH	6.69		
Total Dissolved solid, %	6.21		
Conductivity at 20°C, mmho/cm	80.0		
Ion concentration	(ppm)	emp	RSD %
Na^+	20633.	897.5	2
K^+	207.	5.3	1
Mg^{2+}	273	22.5	1
Ca^{2+}	2029	101.2	1.4
Ba^{2+}	64	0.9	1.5
Sr^{2+}	343	7.82	2
Fe^{n+}	40.5	-	2
Li^+	3.6	0.5	2
Zn^{2+}	0.24	0.07	8
Mn^{n+}	5.4	-	3
C_r^{n+}	9.3	1.3	4
Si^{n+}	<0.1	-	10
Cl^- including (Br^- and i)	35495	1001.0	1
P_2O_5	0	-	1
So_4^{2-}	15	0.4	1
Co_{3-}	0	0	1
HCo_3	403	6.6	1
Sum ion	5.95		0.9
Sum anion/cation		1008.0/1037.1	1/2
Defiency in cation		29.1	

DISCUSSION

Ion analysis

A Good balance between the anions and cations was obtained as illustrated in table 1. The small difference observed is within the experimental uncertainty. The consistency in the analysis is also demonstrated by the agreement between calculated numbers for total dissovled solids (TDS). The calculated value is based on the equivalent amount (Table 2) of pure NaCl solutions found in Handbook (1).

Furthermore, there is a good agreement between TDS calculated either from the results in table 1, from the Cl^- concentration, density or conductivity.

Table 2. Comparison of calculated and measured total dissolved solid data (%).

		RSD %
Residue after avaporation	6.21	1
Calculated from table 1	5.95	0.9
Calculated from Cl^- (Cl^- x 1.65)	5.86	1.0
Correlated from density	6.10	0.1
Correlated from conductivity	5.80	3
"Equivalent NaCl", from appendix 2	5.86	-

Comparison with mud filtrate

Unfortunately we have not been able to compare the water analysis with similar analysis on mudfiltrate.

The information we have on mudfiltrate is an extract from the mud report.

Table 3. Data for mud filtrate from mud report.

Ion	Concentration mg/l
Ca^{2+}	160
Cl^-	23000

It is seen that:

Cl^- sample > Cl^- filtrate
Ca^{2+} sample >> Ca^{2+} filtrate

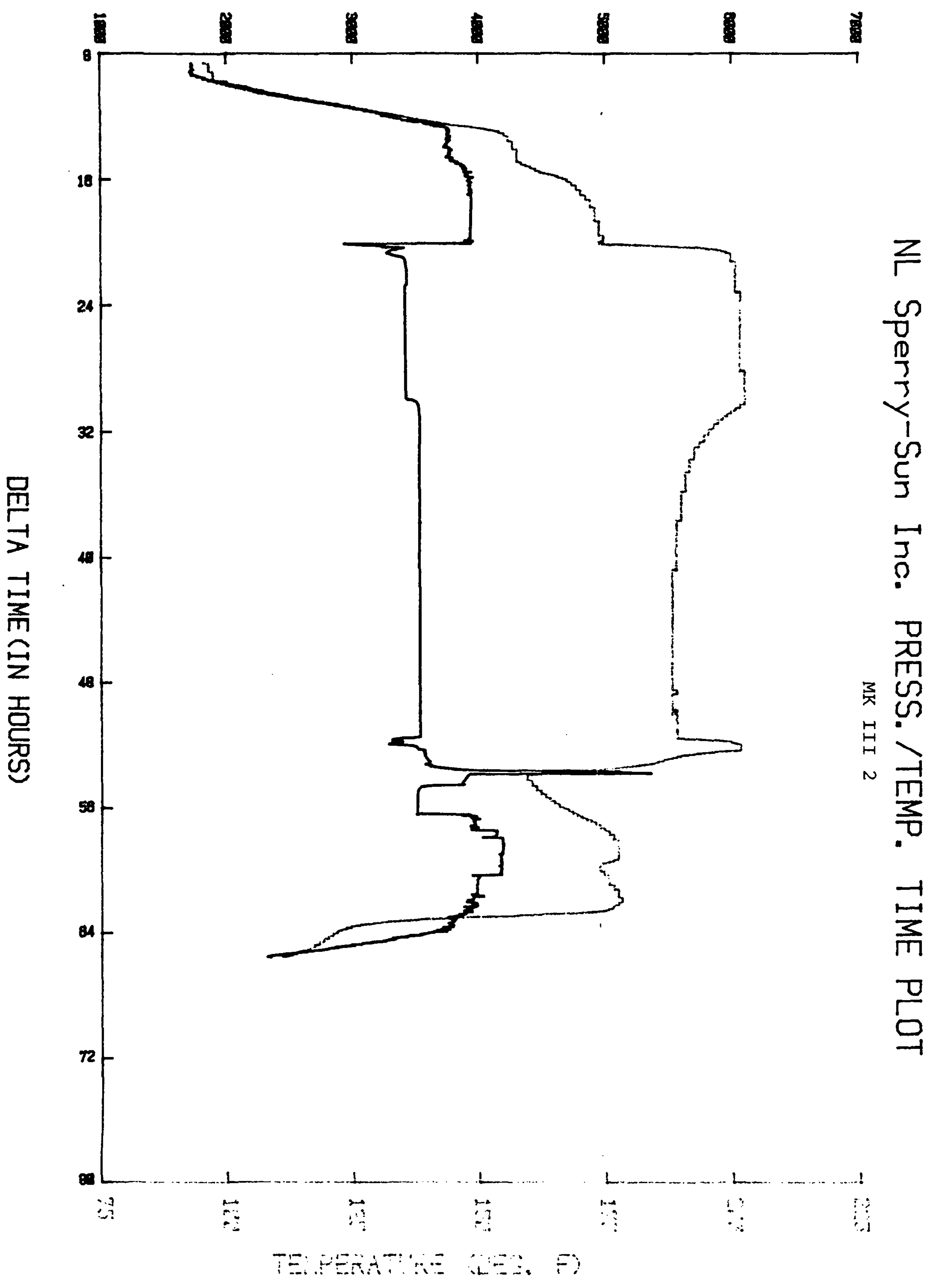
Table 1 Results from watersample taken at 0700 hours

Density at 20°C, g/cm³	1.0422
Conductivity at 20°C, m mho/cm	81.2
Ion	Concentration ppm.
Cl^-	35947

CONCLUSION

The water sample from 15/9-11 DST 2 contained no or a very low amount of mud filtrate and the water should therefore be representativ for the formation.

Fig. 3.1.


NL Sperry-Sun Inc. PRESS./TEMP. TIME PLOT
MK III 2
PRESSURE (PSIG)
1000
2000
3000
4000
5000
6000
7000
DELTA TIME (IN HOURS)
8
16
24
32
40
48
56
64
72
80

BRØNN 15-9-11   DST# 2
BUILDUP NUMMER 1
GAUGE SS MK III 2

NR.	TID	TRYKK
1	10.59	3501.700
2	11.01	3505.100
3	11.03	3509.000
4	11.05	3511.500
5	11.07	3513.200
6	11.09	3514.900
7	11.11	3516.400
8	11.13	3517.700
9	11.15	3518.100
10	11.17	3518.500
11	11.19	3519.400
12	11.21	3519.800
13	11.23	3520.200
14	11.25	3521.300
15	11.27	3521.700
16	11.29	3521.700
17	11.31	3521.700
18	11.33	3522.100
19	11.35	3522.800
20	11.37	3522.800
21	11.39	3523.200
22	11.41	3523.200
23	11.43	3523.200
24	11.45	3523.200
25	11.47	3523.800
26	11.49	3524.200
27	11.51	3524.200
28	11.53	3523.800
29	11.55	3524.200
30	11.57	3524.900
31	11.59	3524.900
32	12.01	3524.900
33	12.03	3524.900
34	12.05	3524.900
35	12.07	3524.400
36	12.09	3524.900
37	12.11	3525.500
38	12.13	3525.100
39	12.15	3525.500
40	12.19	3525.500
41	12.23	3525.100
42	12.27	3525.700
43	12.31	3525.700
44	12.35	3525.300
45	12.39	3525.700
46	12.43	3525.300
47	12.47	3525.900
48	12.51	3526.300
49	12.55	3525.900
50	12.59	3525.900
51	13.05	3525.900
52	13.15	3526.100
53	13.25	3526.100
54	13.35	3527.100
55	13.45	3526.300
56	13.55	3526.100
57	14.05	3526.500
58	14.15	3526.100
59	14.35	3526.100
60	14.55	3526.700
61	15.15	3525.800
62	15.45	3526.500
63	16.15	3526.500
64	16.45	3526.700
65	17.15	3526.700
66	17.45	3526.200
67	18.15	3526.200
68	18.45	3526.900
69	19.15	3526.900
70	19.45	3526.400
71	20.15	3526.400
72	20.45	3526.900
73	21.15	3526.400
74	21.45	3527.100
75	22.15	3527.100
76	22.45	3527.100
77	23.15	3526.600
78	0.01	3527.100
79	1.01	3527.100
80	2.01	3526.600
81	3.01	3526.600
82	4.01	3526.600
83	5.01	3527.100
84	6.01	3527.500
85	7.01	3526.900
86	8.01	3526.900
87	8.21	3526.900

Fig. 3.2.

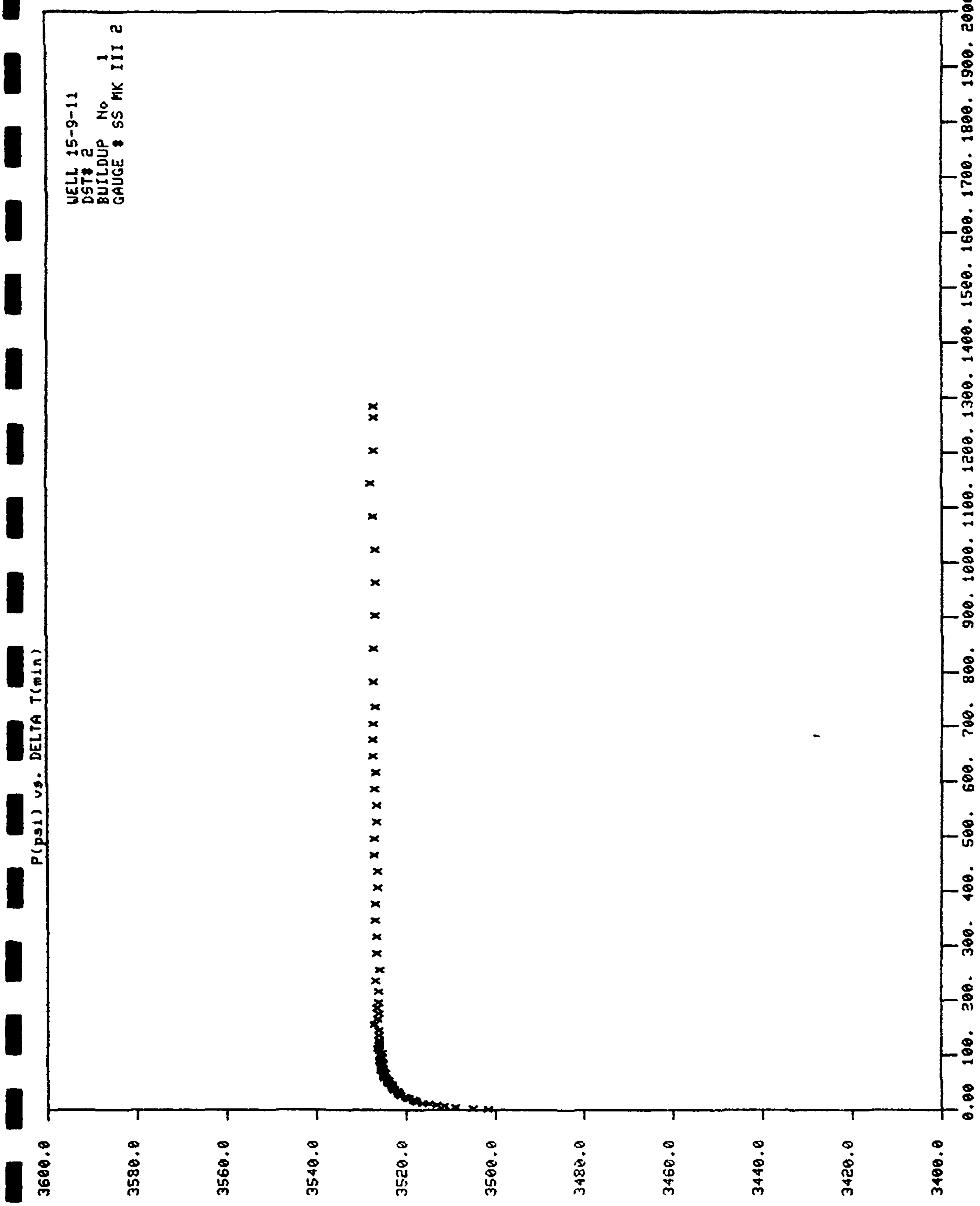

WELL 15-9-11
DST# 2
BUILDUP No 1
GAUGE # SS MK III 2
P(psi) vs. DELTA T(min)
0.00 100. 200. 300. 400. 500. 600. 700. 800. 900. 1000. 1100. 1200. 1300. 1400. 1500. 1600. 1700. 1800. 1900. 2000.
3600.0 3580.0 3560.0 3540.0 3520.0 3500.0 3480.0 3460.0 3440.0 3420.0 3400.0

Fig. 3.3.

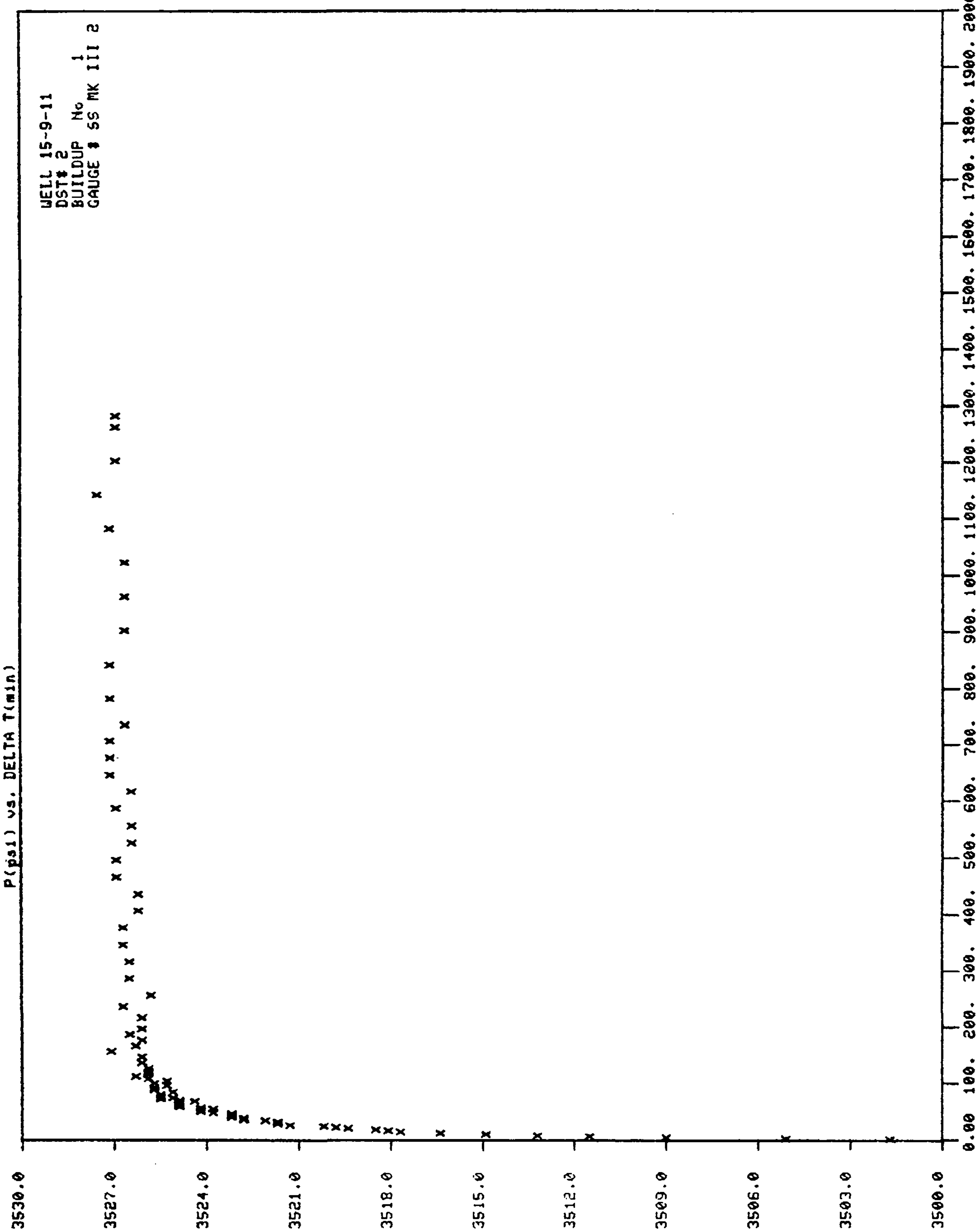

WELL 15-9-11
DST# 2
BUILDUP No 1
GAUGE # SS MK III 2
P(psi) vs. DELTA T(min)
0.00 100. 200. 300. 400. 500. 600. 700. 800. 900. 1000. 1100. 1200. 1300. 1400. 1500. 1600. 1700. 1800. 1900. 2000.
3530.0 3527.0 3524.0 3521.0 3518.0 3515.0 3512.0 3509.0 3506.0 3503.0 3500.0

Fig. 3.4.

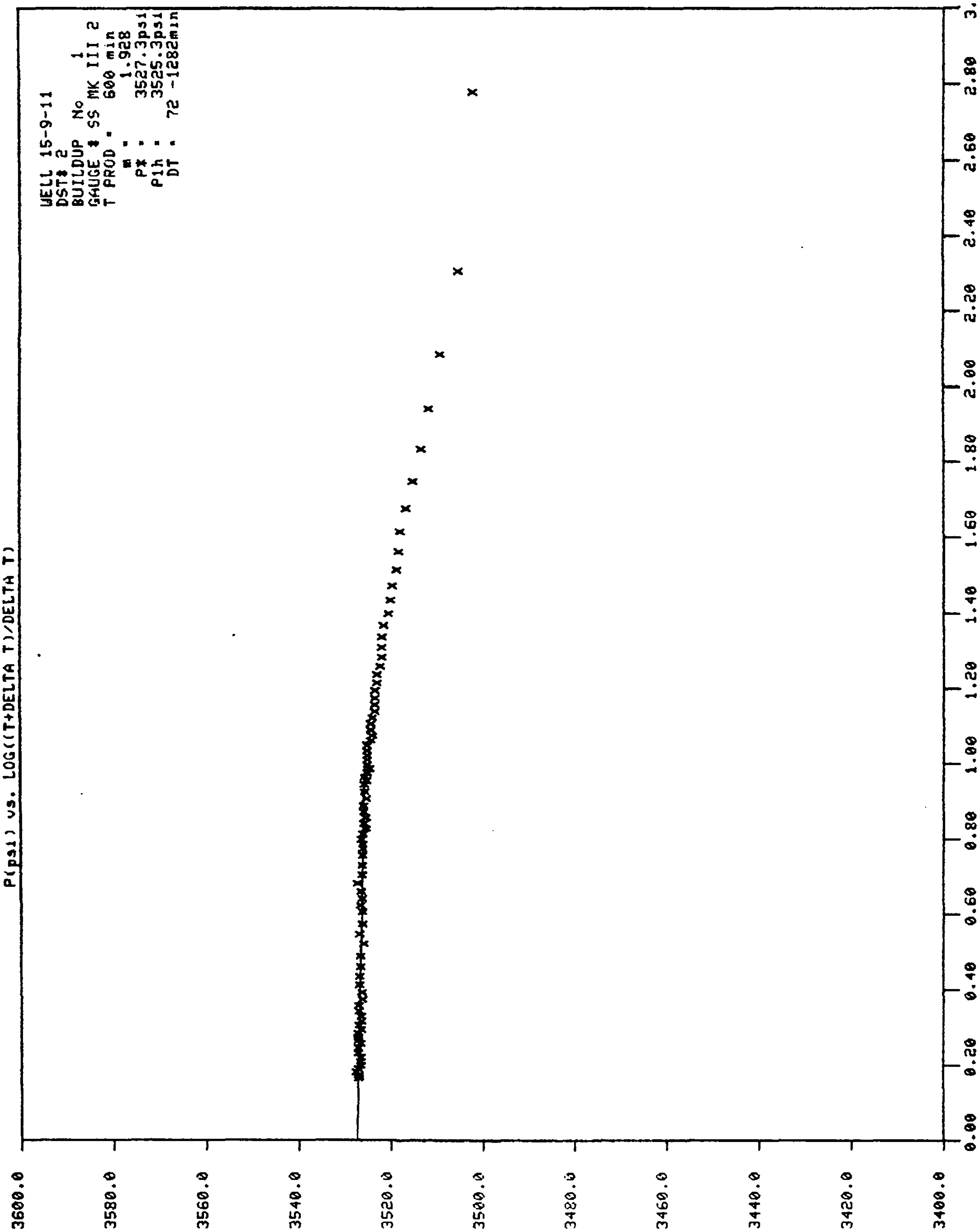

P(psi) vs. LOG((T+DELTA T)/DELTA T)
WELL 15-9-11
DST# 2
BUILDUP No 1
GAUGE # SS MK III 2
T PROD = 600 min
m = 1.928
P* = 3527.3psi
P1h = 3525.3psi
DT = 72 -1282min
3600.0
3580.0
3560.0
3540.0
3520.0
3500.0
3480.0
3460.0
3440.0
3420.0
3400.0
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
2.20
2.40
2.60
2.80
3.00

Fig. 3.5.

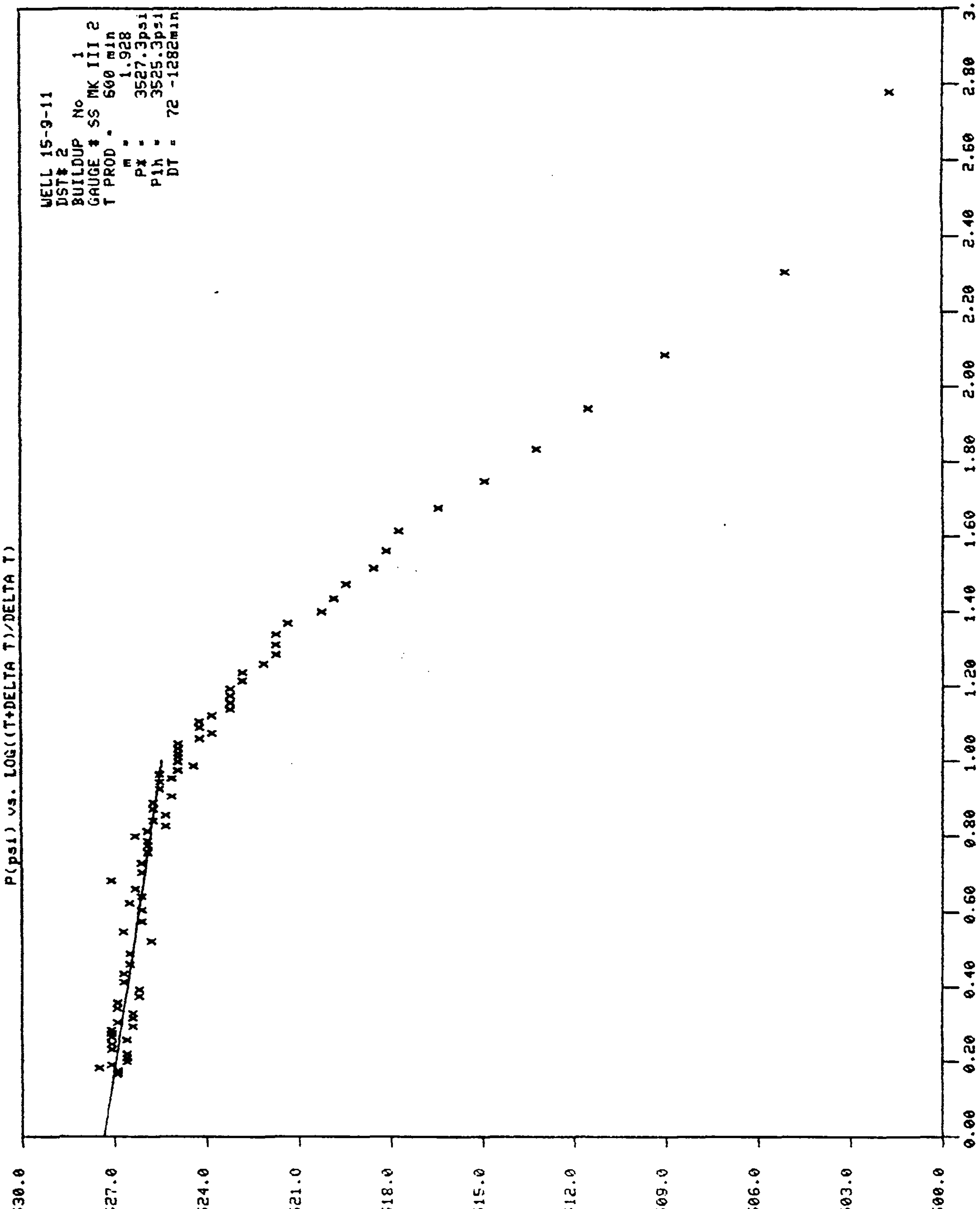
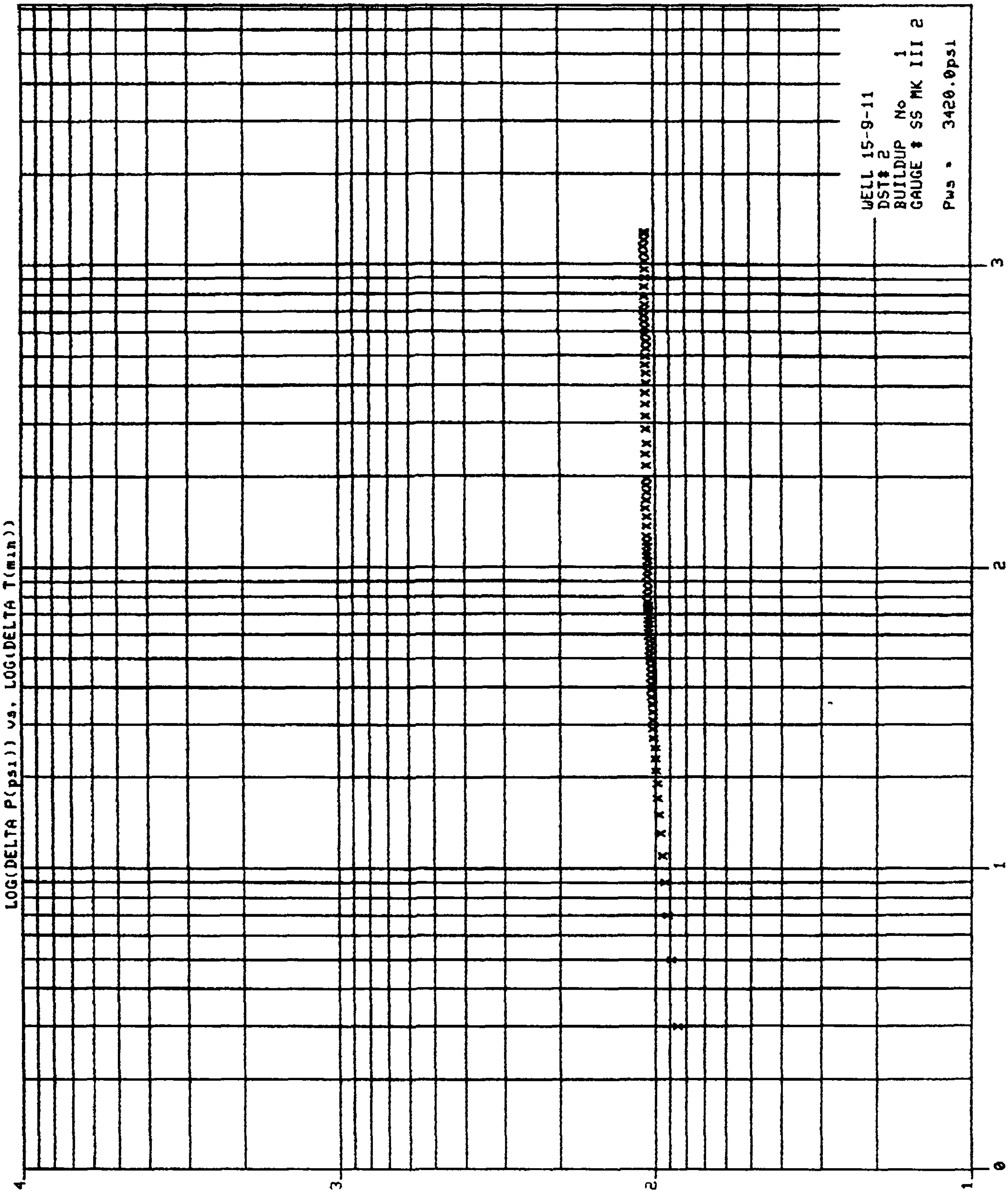

P(psi) vs. LOG((T+DELTA T)/DELTA T)
WELL 15-9-11
DST# 2
BUILDUP No 1
GAUGE # SS MK III 2
T PROD = 600 min
m = 1.928
P* = 3527.3psi
P1h = 3525.3psi
DT = 72 -1282min
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
2.20
2.40
2.60
2.80
3.00
3530.0
3527.0
3524.0
3521.0
3518.0
3515.0
3512.0
3509.0
3506.0
3503.0
3500.0

Fig. 3.6.


WELL 15-9-11
DST# 2
BUILDUP No 1
GAUGE # SS MK III 2
Pws = 3420.0psi
LOG(DELTA P(psi)) vs. LOG(DELTA T(min))
0
1
2
3
4
3
2
1

APPENDIX 4

DST NO. 3

Content:

- Summary of DST no. 3.
- Lay out of test string
- Pressure recorders
- Diary of events
- Pressure, choke and flowdiagram
- Flow data
- Separator sampling
- Surface sampling
- Test analysis

Figures:

	-	Flopetrol P, T vs. time
First flow	-	Listing of bottom hole pressure
	-	P_{ws} vs Δt
	-	P_{ws} vs log $((t + \Delta t)/\Delta t)$
	-	Log Δ P vs log Δt
Multirate flow	-	Listing of bottom hole pressures
	-	P vs. Δt
	-	P vs $\sum_{j=1}^{N} \frac{gi}{qn} \log \left(\frac{tn - tj-1 + \Delta t}{tn - tj + \Delta t} \right)$
	-	Log Δ P vs. log Δt

SUMMARY OF DST NO. 3.

Perforated interval: 2395 - 2415 m RKB.

- First flow

9.5 mm (24/64") choke:	6 minutes
12.7 mm (32/64") choke:	28 minutes
19.1 mm (48/64") choke:	971 minutes

- First build-up: 960 minutes

- Multiple flow

9.5 mm (24/64") choke:	3 minutes
14.3 mm (36/64") choke:	231 minutes
22.2 mm (56/65") choke:	243 minutes
31.8 mm (80/64") choke:	236 minutes

- Multiple build-up: 534 minutes

Flowrates:

19.1 mm (48/64") choke: 569.8 MSm^3/D
(20.16 MMSCF/D) of gas
266 Sm^3/D
(1671 STB/D) of condensate

14.3 mm (36/64") choke: 389.7 MSm^3/D
(13.79 MMSCF/D) of gas
187 Sm^3/D
(1179 STB/D) of condensate

22.2 mm (56/64") choke: 714.2 MSm^3/D
(25.27 MMSCF/D) of gas
288 Sm^3/D
(1811 STB/D) of condensate

31.8 mm (80/64") choke:	889.1 MSm^3/D
	(31.46 MMSCF/D) of gas
	435 Sm^3/D
	(2734 STB/D) of condensate

Gravities, first flow:

- Gas: 0.734 sp.gr
- Condensate: 0.75 sp.gr (57.2° API)

Separator conditions:

- Pressure: 36.54 bara (530 psia)
- Temperature: 33.3°C (92°F)

Gauges:

- Two Flopetrol SSDR gauges, two Sperry Sun MK III gauges and one Sperry Sun MRPG gauge were run. All OK. The SSDR gauge no. 81049 was used for the test analysis.

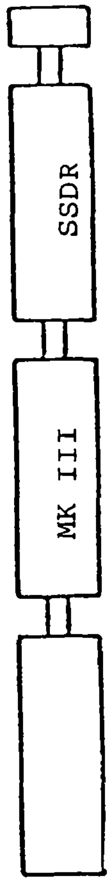
TEST STRING TALLY ROSS RIG 15/9-11 DST no. 3.

All measurements to top of each item

	EQUIPMENT DESCRIPTION	MIN ID(")	MAX OD(")	LENGTH (m)	DEPTH (m)
1	Otis STT w/X-lver 5" vam				- 6.31
2	Jnts. 5" vam tbg. 18 lbs/ft L-80	4.25	5.56	20.02	13.71
1	Pupjnt. 5" vam tbg	4.25	5.56	4.53	18.24
1	X-over 5" VAM box x 4½" SA pin	4.25	5.51	0.40	18.64
1	Otis lubricator valve	2.99	13.88	1.62	20.26
1	X-over 4½" SA box x 5" VAM pin 0-23	4.25	5.51.	0.41	20.67
1	Jnt. 5" VAM tbg	4.25	5.56	10.32	30.99
1	Jnt. 5" VAM tbg	4.25	5.56	9.65	40.64
2	Stds. 5" VAM tbg	4.25	5.56	59.86	100.50
1	Pupjnt. 5" VAM tbg	4.25	5.56	4.53	105.03
1	X-over 5" VAM box x 4½" SA pin F-24	3.00	6.00	0.29	105.32
1	Flopetrol EZ-tree	3.00	17.00	2.61	107.93
1	Slickjnt. 5" OD 4½" x 4 SA pin pin x	3.00	5.00	2.95	110.88
1	Flopetrol Fluted Hanger	3.00	16.00	0.29	111.17
1	X-over 4½"-4 SA pin x 5" VAM pin F-25	3.00	6.00	0.31	111.48
1	Pupjnt 5" VAM tbg	4.25	5.56	1.22	112.51
1	Jnt. 5" VAM tbg	4.25	5.56	9.81	122.51
1	Pupjnt. 5" VAM	4.25	5.56	3.00	125.51
67	STDS. 5" VAM tbg	4.25	5.56	1973.27	2098.7
1	X-over 5" VAM box x 3½" if pin	3.50	6.12	0.30	2099.08
1	Slipjnt. (open)	2.00	4.65	5.54	2104.62
1	Slipjnt. (closed)	2.00	4.63	4.01	2108.63
6	STDS drill collars	2.25	4.75	171.08	2279.71
1	X-over 3½" if box x 2 7/8" EUE pin	2.50	4.75	0.20	2279.91
1	RTTS mech. circ. valve	2.44	4.87	0.84	2280.73
2	X-over 2 7/8" EUE box x 3½" if pin	2.62	4.75	0.20	2280.95
2	STD drill collar	2.25	4.75	28.60	2309.55
1	Slipjnt (closed)	2.00	4.63	4.01	2313.56
1	Slipjnt (closed)	2.00	4.63	4.01	2317.57
1	STD drill collar	2.25	4.75	28.61	2346.18
1	APR-M safety/circ. valve	2.25	5.00	2.55	2348.73
1	DP-tester valve	2.25	5.00	1.46	2350.19
1	APR-N tester valve	2.25	5.00	3.86	2354.05

	EQUIPMENT DESCRIPTION	MIN ID(")	MAX OD(")	LENGTH (m)	DEPTH (m)
1	Ful flo hydr. bypass	2.25	4.62	1.92	2355.97
1	Big John Jars	2.37	4.62	1.92	2357.89
1	X-over 3½" if box x 4½" if pin	3.00	6.12	0.40	2358.29
1	RTTS safety joint	3.12	6.12	1.08	2359.37
1	RTTS packer (above)	3.75	8.25	0.98	2360.35
	RTTS packer (below)	3.75	9.25	0.80	2361.15
1	X-over 4½" if x 3½" Fh	2.50	6.12	0.21	2361.36
1	X-over 3½" Fh x 2 7/8" EUE	2.40	4.75	0.20	2361.56
1	Perf. pupjnt 2 7/8" EUE	2.44	2.88	3.54	2365.10
1	X-over 2 7/8" EUE box x 2 3/8" EUE pin	2.00	3.70	0.26	2365.36
1	Collar 2 3/8" EUE	-	2.88	0.13	2365.49
1	OTIS XN-nipple 2 3/8" EUE pin x pin	1.79	2.38	0.22	2365.71
1	X-over 2 3/8" EUE box x 2 7/8" EUE pin	2.00	3.70	0.26	2365.97
1	Jnt. 2 7/8" EUE tbg	2.44	2.88	9.41	2375.38
1	Pupjnt. 2 7/8" EUE	2.44	2.88	2.40	2377.78
1	Flopetrol DST-hanger				
1	Jnt. 2 7/8" EUE tbg	2.44	2.88	8.93	2386.71
1	Perf. pupjnt. 2 7/8" EUE	2.44	2.88	2.05	2388.76
1	X-over 2 7/8" EUE box x 3 1/8" m pin	2.25	4.25	0.31	2389.07
1	Halliburton APBT carrier	-	3.00	1.51	2390.58
1	X-over 3 1/8" 8n box x 2 7/8" EUE pin	1.88	3.88	0.18	2390.76
1	Bull plug w/cross x 2 7/8" EUE box	-	4.00	0.21	2390.97

WELL NO.: 15/9-11 DST NO.: 3 DATE: 12.12.81.

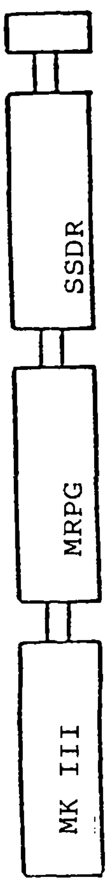


WIRELINE NIPPLE XN-nipple 2365.7 m

GAUGE TYPE AND NUMBER: SSDR no. 81049
DEPTH, PRESSURE ELEMENT: 2370.9m RANGE: 0 - 10000 psi
MODE: 1 min. sampling DELAY: No
ACTUATED: time 0503 date: 12.12.81.
WILL RUN OUT: time 1803 date: 15.12.81.

GAUGE TYPE AND NUMBER: MK III no. 3-10-1576
DEPTH, PRESSURE ELEMENT: 2373.95m RANGE: 0 - 10000 psi
MODE: 2 min. DELAY: 8 hrs.
ACTUATED: time: 0452 date: 12.12.81
WILL RUN OUT: time: 2204 date: 14.12.81.

GAUGE TYPE AND NUMBER:
DEPTH, PRESSURE ELEMENT: RANGE:
MODE: DELAY:
ACTUATED: time: date:
WILL RUN OUT: time: date:



D.S.T. HANGER 2377.7 m

GAUGE TYPE AND NUMBER: SSDR no. 81048
DEPTH, PRESSURE ELEMENT: 2382.5m RANGE: 0 - 10000 psi
MODE: 2 min. sampling DELAY: -
ACTUATED: time: 0430 date: 12.12.81.
WILL RUN OUT: time: 0400 date: 17.12.81.

GAUGE TYPE AND NUMBER: MRPG no. 41
DEPTH, PRESSURE ELEMENT: 2386.2 m RANGE: 0 - 6000 psi
MODE: 4 min DELAY: 8 hrs.
ACTUATED: time: 0431 date: 12.12.81.
WILL RUN OUT: time: 0623 date: 17.12.81.

GAUGE TYPE AND NUMBER: MK III no. 1-9.1751
DEPTH, PRESSURE ELEMENT: 2388.6 m RANGE: 0 - 1000 psi
MODE: 4 min DELAY: 8 hrs.
ACTUATED: time: 0433 date: 12.12.81.
WILL RUN OUT: time: 0625 date: 17.12.81.

DIARY OF EVENTS

WELL NO.: 15/9-11 DST NO.: 3

ZONE TESTED: Heimdal PERFS.: 2395 - 2415

DATE/TIME	OPERATIONS
11.12.81.	
23.45	PERFORATING
	Start rig up Schlumberger
12.12.81.	
00.35	RIH gun no. 1.
01.25	Gun fired. Interval: 2415.0 - 2405.0 m
02.00	POOH. All shots fired
02.40	RIH gun no. 2.
03.25	Gun fired. Interval: 2405.0 - 2395.0 m
04.10	POOH. All shots fired. Rigged down Schlumberger
	RIH W/TEST STRING
04.30	Start RIH w/test string
04.40	Installed 1 SSDR, 1 MRPG and 2 MARK III in DST hanger
05.20	Installed 1 SSDR, 1 MRK III in XN-nipple
13.12.81.	
09.02	Set packer. Discovered 13 bbl drop in riser level. Opened mastervalve. WHP increased from 11 - 780 psia. RTTS circulating valve open.
10.40	Recycled RTTS circ. valve. Checked for pressure communication to annulus. Valve closed.
11.15	Opened RTTS circ. valve, reversed mud into tubing. Dispalced mud back with 61 bbl water and 60 bbl diesel and 2 bbls of gel mud.
	FIRST FLOW
15.24	Opened APR-N valve. WHP = 370 psia
15.26	Opened choke manifold on 24/64" adjustable choke
15.28	WHP = 215 psia
15.30	Opened up to 32/64" adjustable choke
15.32	WHP = 70 psia

COMMENTS: WHP reached a minimum of 36 psia

DIARY OF EVENTS

WELL NO.:	15/9-11	DST NO.:	3
ZONE TESTED:	Heimdal	PERFS.:	2395 - 2415

DATE/TIME	OPERATIONS
13.12.81.	
15.40	WHP = 340 psia
15.50	Started injecting methanol. WHP = 895 psia
15.56	Gas to surface. WHP = 1420 psia
15.58	Opened to 48/64" adjustable choke. Mud to surface.
16.32	WHP = 1876 psia, BS&W: 8% mud, traces of water and sand
18.00	WHP = 1917 psia
20.00	WHP = 1957 psia, 5 - 6 % mud/water, 0.5% sand
20.40	Directed flow through heater
21.00	Directed flow through separator. Found relief valve leaking at 200 psi. Bypassed separator - repaired leak.
22.06	Directed flow through separator
22.40	WHP = 2000 psia, WHP = 108^{O}F
23.22	flow to stock tank to measure meter factor, f = 0.905
23.47	Bypassed tank
14.12.81.	
03.05	Started taking first set of PVT samples
04.00	Finished first set of PVT samples
06.10	Started taking second set of PVT samples
07.25	Finished second set of PVT samples
08.03	Bypassed separator. WHP = 1997 psia
08.05	Attempted to close APR-N. Negative. WHP = 1997 psia FIRST BUILD-UP
08.07	Closed choke manifold. Both Lynes probes plugged.
22.42	Closed fail safe valve. Rep. leak in needle valve for Lynes probe.

COMMENTS: All WHP from Lynes

DIARY OF EVENTS

WELL NO.: 15/9-11	DST NO.: 3
ZONE TESTED: Heimdal	PERFS.: 2395 - 2415

DATE/TIME	OPERATIONS
15.12.81.	
00.03	Opened fail safe valve. WHP = 2489 psia
	<u>SECOND FLOW</u>
00.05	Opened APR-N. WHP = 2489 psia
00.08	Opened on 24/64" adj. choke. Started injecting glycol
00.10	36/64" adj. choke
00.51	WHP = 2120, Went through heater
00.53	37&64" pos. choke
01.00	WHP = 2361 psi, indicating washed out adj. choke
01.15	Went through separator
01.20	WHP = 2364 psia. Downstream choke pressure = 850 psia. WHT = 80^{O}F
04.00	WHP = 2382 psia. WHT = 96^{O}F
04.01	Bypassed separator. Incr. to 56/64" adj. choke
04.09	56/64" pos. choke
04.30	WHP = 1887 psi. Went through separator
08.00	WHP = 1914 psi. Downstream choke pressure = 1110 psi, WHP = 116^{O}F
08.01	Bypassed separator
08.02	Bypassed heater
08.04	56/64" adj. choke. Slowly incr. to 80/65" adj. choke
08.07	80/64" pos. choke
08.27	WHP = 1455 psi
08.34	Went through separator
09.00	WHP = 1465 psi. Downstream choke pressure = 1130 psi, WHT = 116^{O}F

COMMENTS: All WHP from Lynes

DIARY OF EVENTS

WELL NO.: 15/9-11 DST NO.: 3

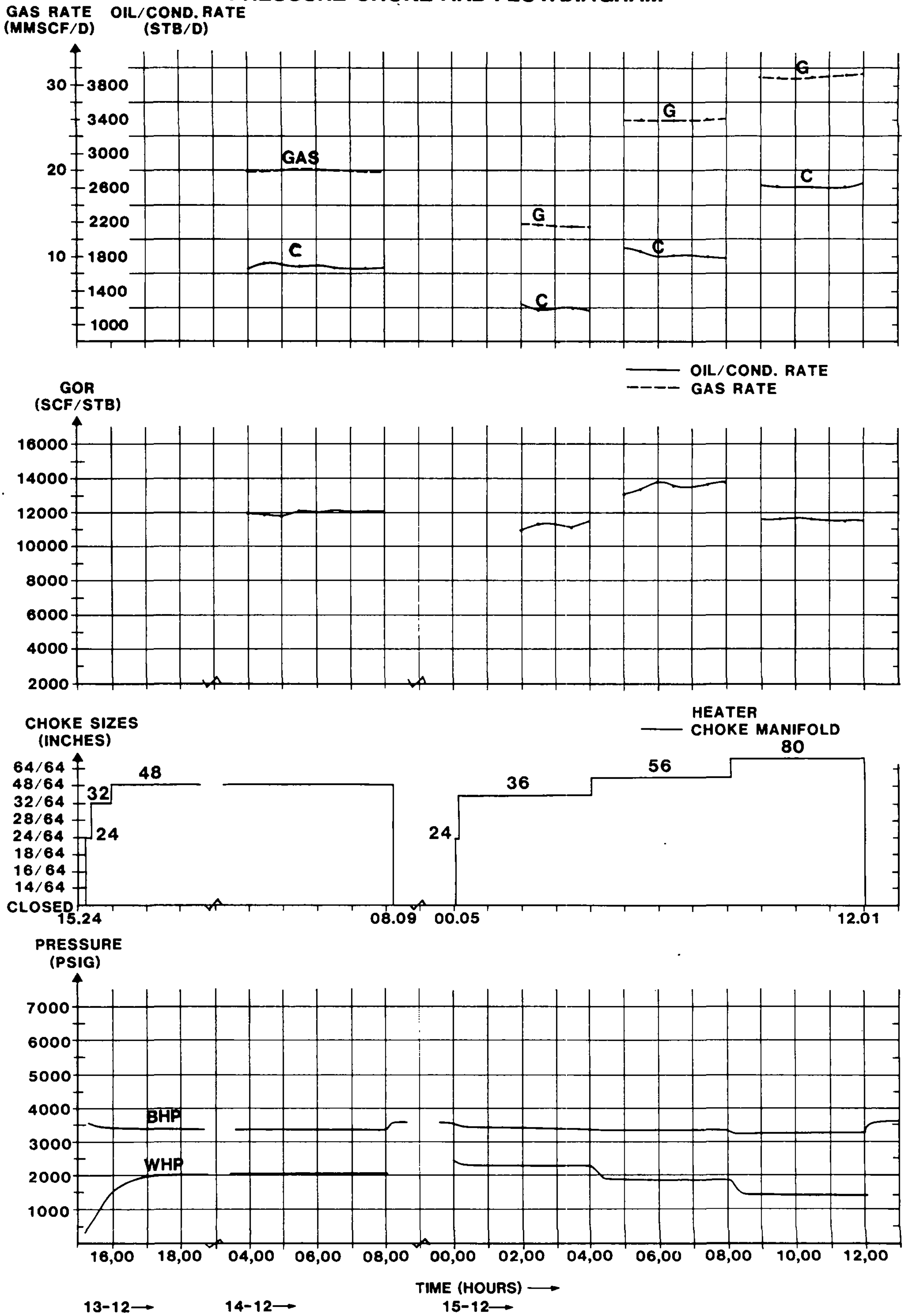
ZONE TESTED: Heimdal PERFS.: 2395 - 2415

DATE/TIME	OPERATIONS
15.12.81.	
10.00	Started PVT sampling
	Finished PVT sampling
12.00	WHP = 1482 psi. Downstream choke pressure = 1135 psi, WHT = 118^{o}F
12.00	Bypassed separator
	<u>FINAL BUILD-UP</u>
12.01	Closed choke manifold
12.02	Bled off ann. pres. to close APR-N when WHP = 2200 psi
	<u>KILLING WELL</u>
20.54	Started bullheading

COMMENTS: All WHP from Lynes

WELL NO : 15-9-11 DST NO.: 3

PRESSURE CHOKE AND FLOWDIAGRAM



FLOW DATA

SSDR LYNES

Date/Time	Bottom hole		Well head		Chokes		Separator data							W=water M=mud	Liq. and gas analysis at goos neck				
	Press. Psia	Temp. F	Press. Psia	Temp. F	Manifold	Heater 64. inc.	Press. Psig	Temp. F	Gas rat. mmscf/d	Oil rate stb/d	GOR scf/stb	Oil API	Gas S.G.	Water %	PH	Sedim. %	Oil API	Co2	H_2S
13.12.81.																			
1524	3551	173	370	56			APR-N valve opened												
1526	3505	"	325	"	24/64		Opened well to gas flare on 24/64" adjustable choke												
1530	3458	"	160	55	32/64		Opened choke to 32/64" adjustable choke												
1532	3463	"	70	"	"		Diesel to surface												
1550	3409	175	895	66	"		Started methanol injection												
1556	3401	177	1420	80	"		Gas to surface												
1558	3387	"	1470	84	48/64		Switched to 48/64" Fixed choke												
2040	3425	195			"		Flowing through heater												
2206	3428	"			"		Flowing through separator												
2230	3430	196	1975	108	"		515	86	20.138			57.2	.734	1.5w		0.1		0.1	0
2300	3429	"	1992	"	"		"	92	20.525	1746	11756	"	"	1.4w		0.1		0.1	0
2330	3430	"	1995	"	"		510	"	20.414	1724	11842	"	"	3.2w		0		0.1	0
2400	"	197	1997	"	"		-	-	20.128	1684	11950	"	"	7.5m				0.1	0
14.12.81.																			
0030	3431	"	"	109	"		505	92	20.216	1622	12463	"	"	0.8m				0.1	0
0100	"	"	"	"	"		"	94	20.254	1633	12402	"	"	0.8w				0.1	0
0130	3432	"	"	110	"		"	"	20.166	1687	11953	"	"	1.4w				0.1	0
0200	"	"	2000	"	"		"	92	20.216	1681	12026	"	"	2.9w				0.1	0
0230	"	"	2004	109	"		"	91	20.242	1666	12151	"	"	2.0w				0.1	0
0300	3433	"	2005	110	"		500	92	20.106	1654	12156	"	"	2.4w				0.1	0
0330	"	198	2004	"	"		"	90	20.684	1647	12559	"	"	1.0wm		Trace		0.1	0
0400	"	"	"	"	"		"	"	19.980	1660	12035	"	"	2.0wm		"		0.1	0
0430	3434	"	2000	"	"		"	89	20.094	1689	11899	"	"	1.2wm		"		0.1	0
0500	"	"	"	109	"		"	"	"	1691	11880	"	"	1.2wm	7.0	"		0.1	0
0530	"	"	"	"	"		495	"	20.158	1671	12065	"	"	0.7mw		"		Trace	0
0600	"	"	2002	"	"		"	"	"	1677	12018	"	"	0.85mw		"		0.1	0
0630	3435	"	2004	"	"		"	"	19.983	1651	12102	"	"	1.2wm		"		0.1	0
0700	"	"	2005	"	"		"	"	"	1660	12039	"	"		7.0				

SSDR LYNES

FLOW DATA

Date/Time	Bottom hole Press. Psia	Bottom hole Temp. F	Well head Press. Psia	Well head Temp. F	Chokes Manifold	Chokes Heater 64. inc.	Separator data Press. Psig	Separator data Temp. F	Separator data Gas rat. mmscf/d	Separator data Oil rate stb/d	Separator data GOR scf/stb	Separator data Oil API	Separator data Gas S.G.	W= water M= mud Water %	PH	Liq. and gas analysis at goos neck Sedim. %	Oil API	Co2	H_2S
14.12.81.																			
0730	3435	198	2007	109	48/64		495	89	19.806	1642	12065	57.2	.734	1.5mw		Trace		0.1	0
0800	"	199	"	"	"		"	"	20.158	1671	12064	"	"	2.8wm		"			
0803	3435	199			"		Bypassed separator												
0807	"	"	1997		"		Attempted to close APR												
0809	3483	"					Well shut in at choke manifold												
15.12.81.																			
0005	3521	186	2473				APR-N opened												
0008	3486	"			24/64		Well opened to gas flare on 24/64" adjustable choke												
0010	3470	"			36/64		Changed choke to 36/64" adjustable choke												
0053	3442	196			"		Changed to 36/64" fixed choke												
0115	3472	198	2352	88	"		Flowing through separator												
0130	"	199	"	90	"		465	67	13.730	-	-	-	-	0.35w		Trace			
0200	3473	"	2351	94	"		"	68	13.766	1236	11141		.734	1.3w		"			
0230	"	"	2355	91	"		460	72	13.770	1190	11575	56.5	"	1.5wm		0			
0300	"	"	2366	"	"		"	"	13.717	1192	11509	"	"	0.6w	7	Trace			
0330	"	"	"	92	"		"	73	13.699	1203	11388	"	"	2.0wm		"			
0400	"	"	2371	95	"		"	74	13.786	1179	11691	"	"						
0401	"	"			"		Bypassed separator												
0402	3462	"			"		Switched from positive to Adjustable choke 36/64"												
0405	3419	"			56/64		Increased adjustable choke to 56/64"												
0410	3393	"			"		Switched to 56/64" fixed choke												
0430	3411	"	1875	106	"		Flowing through separator												
0500	3412	"	"	112	"		530	94	24.955	1901	13125	-	-	1.3wm	7	Trace		Trace	0
0530	3413	"	1886	114	"		"	93	24.981	1871	13352	-	-	1.5w		"		"	"
0600	3414	"	1887	"	"		"	94	25.043	1789	13998	58	.734	1.0w	7	"			
0630	3415	"	1889	115	"		"	97	25.037	1845	13567	"	"	1.3wm		"		0	"
0700	3416	"	1893	116	"		"	"	25.124	1849	13591	"	"	0.6wm		0		"	"
0730	"	"	1900	117	"		"	"	"	1838	13670	"	"	0.6wm		Trace		"	"
0800	3417	"	"	118	"		"	98	25.266	1811	13949	"	"						

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FLOW DATA

SSDR LYNES

Date/Time	Bottom hole		Well head		Chokes		Separator data							W=water M=mud	Liq. and gas analysis at goos neck				
	Press. Psi a	Temp. F	Press. Psi a	Temp. F	Manifold	Heater 64. inc.	Press. Psi g	Temp. F	Gas rat. mmscf/d	Oil rate stb/d	GOR scf/stb	Oil API	Gas S.G.	Water %	PH	Sedim. %	Oil API	Co2	H_2S
15.12.81.																			
0801	3417	199			56/64		Bypassed separator, Bypass heater												
0805	3408	"			"		Switched to Adjustable 56/64"												
0807	3400	"			80/64		Increased adjustable choke to 80/64"												
0814	3375	"	1405	118	"		Switched to 80/64" positive choke												
0834	3386	"	1438	119	"		Flowing through separator												
0900	3389	"	1450	116	"		560	92	31.304	2640	11856	–	–						
0915	"	"	1452	118	"		555	"	31.149	2620	11891	60.5	–	2.6wm		Trace			
0930	3390	"	1452	"	"		"	"	"	2630	11843	"	.732	2.0w		"			
1000	3391	"	1455	"	"		"	"	31.252	2635	11862	"	"	1.3wm	6.5	"			
1030	3393	"	"	"	"		"	93	31.212	2651	11773	"	"	1.0wm		0		Trace	0
1100	3395	"	1457	"	"		"	"	31.314	2668	11701	"	"	1.5wm		0			
1130	3394	"	1465	117	"		"	92	31.456	2656	11843	"	"						
1200	3395	"	"	118	"		"	"	"	2734	11506	"	"						
1201	"	"	2165	119			Well shut in at choke manifold												

DST SUMMARY DATA

Well no. 15/9-11 DST no. 3 Date: 14-15/12-81

1. Separator samples

Bottle no.	Oil/gas	Time	Oil rate		Gas rate	
		14.12.81				
9214/328	Oil	03:10	1598	BOPD	20.684	MMSCFD
A12060	Gas	03:13	"	"	"	"
A12056	"	03:40	"	"	"	"
A10229	"	06:10	1602	"	19.983	"
13266/99	Oil	"	"	"	"	"
1911339	Gas	07:00	1610	"	"	"
		15.12.81				
9214/371	Oil	09:57	2360	BOPD	31.212	MMSCFD
A7327	Gas	10:00	"	"	"	"
A10033	"	10:35	2374	"	"	"

2. Bottom hole samples

None

OTHER SAMPLING

TYPE	SAMPLING POINT
1 Drum of condensate	Separator
6 x 1 liter bottles cond.	Goosneck
1 x 20 l. jerry can, cond.	Separator
Sample of mud filtrate	Mud pit
Sample of water	Separator

TEST ANALYSIS

Input data, reservoir parameters:

Reservoir pressure, P	: 242.83 bara (3522 psia)
Reservoir temperature, T	: $85.6^{o}C$ ($186^{o}F$)
Specific gravity of reservoir gas, γg	: 0.937
Compressibility factor, Z	: 0.828
Viscosity of reservoir gas, μg	: 0.029 cp
Gas formation volume factor, Bg	: $4.29 \times 10^{-3} m^3/m^3$
	: (7.64×10^{-4} RB/SCF)
Compressibility of reservoir gas, Cg	: 272×10^{-5} bar
	(18.75×10^{-5} psi^{-1})
Comp. of formation water, C_w	: 37.7×10^{-6} bar^{-1}
	(2.6×10^{-6} psi^{-1})
Compressibility of the formation, Cf	: 52.9×10^{-6} bar^{-1}
	(3.65×10^{-6} psi^{-1})
Water saturation, Sw	: 0.23
Hydrocarbon saturation, Sg	: 0.77
Porosity, Ø	: 0.20
Perforation height, hp	: 20 m (65.6 ft)
Formation height, ht	: 38 m (124.7 ft)
Wellbore radius, rw	: 0.155 m (0.51 ft)
Total compressibility, Ct	: 21.5×10^{-4} bar^{-1}
	(1.48×10^{-4} psi^{-1})

First flow period, 19.1 mm (48/64") choke:

- Vapour volume equivalent:
  Vcs = 192 m^3/m^3 (1080 SCF/STB) at
  0.75 sp.gr. (57.0^{o}API) and 35.16 bara
  (510 psia) on separator

- Flow rate
  $Qg = 20.16 \times 10^6$ SCF/D + 1080 SCF/STB x 1671 STB/D
  = 21.96 MMSCF/D (620.6 MSm^3/D)

- $t_{eff} = t_{prod}$ = 1005 minutes

Horner analysis, first build-up:

The Flopetrol SSDR no. 81049 is used for the analysis.

Results:

P^* = 242.85 bara (3522.2 psia)
P_{1hr} = 242.72 bara (3520.3 psia)
m = 0.1055 bar/cycle (1.530 psi/cycle)
P_{wfs} = 236.83 bara (3435.0 psia)

Permeability thickness:

$$kh = \frac{162.6\ Qg\ Bg\ ug}{m} = 15762 \text{ md m} = 51714 \text{ md ft}$$

The thickness of the zone which is contributing flow to the wellbore is assumed to be the formation height.

Permeability:

$h = h_t = 38$ m (124.7 ft) $\Rightarrow$ k = 415 md

Total skin factor : $S_t = 57.2$
Partial penetration skin factor : SP = 3.6

Pressure drop due to skin: $\Delta P_s = 5.25$ bar (76 psi)

Real productivity index:

$$PI = \frac{Qg}{P^* - P_{wfs}} = 103400 \text{ Sm}^3\text{/D/bar (251900 SCF/D/psi)}$$

Ideal productivity index:

$$PI = \frac{Qg}{P^* - P_{wfs} - P_s} = 827500 \text{ Sm}^3\text{/D/bar (1.96 MMSCF/D/psi)}$$

Input data, multirate flow

Vapour volume equivalents:

VCS_1 = 1050 SCF/STB at 56.5°API, 475 psia on separator

VCS_2 = 1100 SCF/STB at 58.0°API, 545 psia on separator

VCS_3 = 1150 SCF/STB at 60.5°API, 570 psia on separator

Flow rates on:

36/64" choke:

$Qg_1 = 13.79 \times 10^6$ SCF/D + 1179 STB/D x 1050 SCF/STB =
15.03×10^6 SCF/D (424800 Sm^3/D)

t_1 = 231 minutes

56/65" choke:

$Qg_2 = 25.27 \times 10^6$ SCF/D + 1811 STB/D x 1100 SCF/STB =
27.26×10^6 SCF/D (770400 Sm^3/D)

t_2 = 243 minutes

80/64" choke:

$Qg_3 = 31.46 \times 10^6$ SCF/D + 2734 STB/D x 1150 SCF/STB =
34.60×10^6 SCF/D (977900 Sm^3/D)

t_3 = 236 minutes

$$t_{eff} = \frac{Qg_1 \times t_1 + Qg_2 \times t_2 + Qg_3 \times t_3}{Q_3} = \underline{529 \text{ minutes}}$$

Multirate build-up analysis

Results:

P^* = 242.88 bara (3522.7 psia)

P_{1hr} = 242.63 bara (3519.1 psia)

m = 0.1610 bar/cycle (2.335 psi/cycle)

P_{wfs} = 234.05 bara (3394.6 psia)

Permeability thickness:

$$kh = \frac{162.6\ Qg_3 \times B_g \times u_g}{m} = 16270 \text{ md m } (53382 \text{ md/ft})$$

h = 38 m, formation height:

Permeability K = 428 md

Total skin factor = S_t = 54.2

Pressure drop due to skin: ΔP_s = 7.07 bar (102.5 psi)

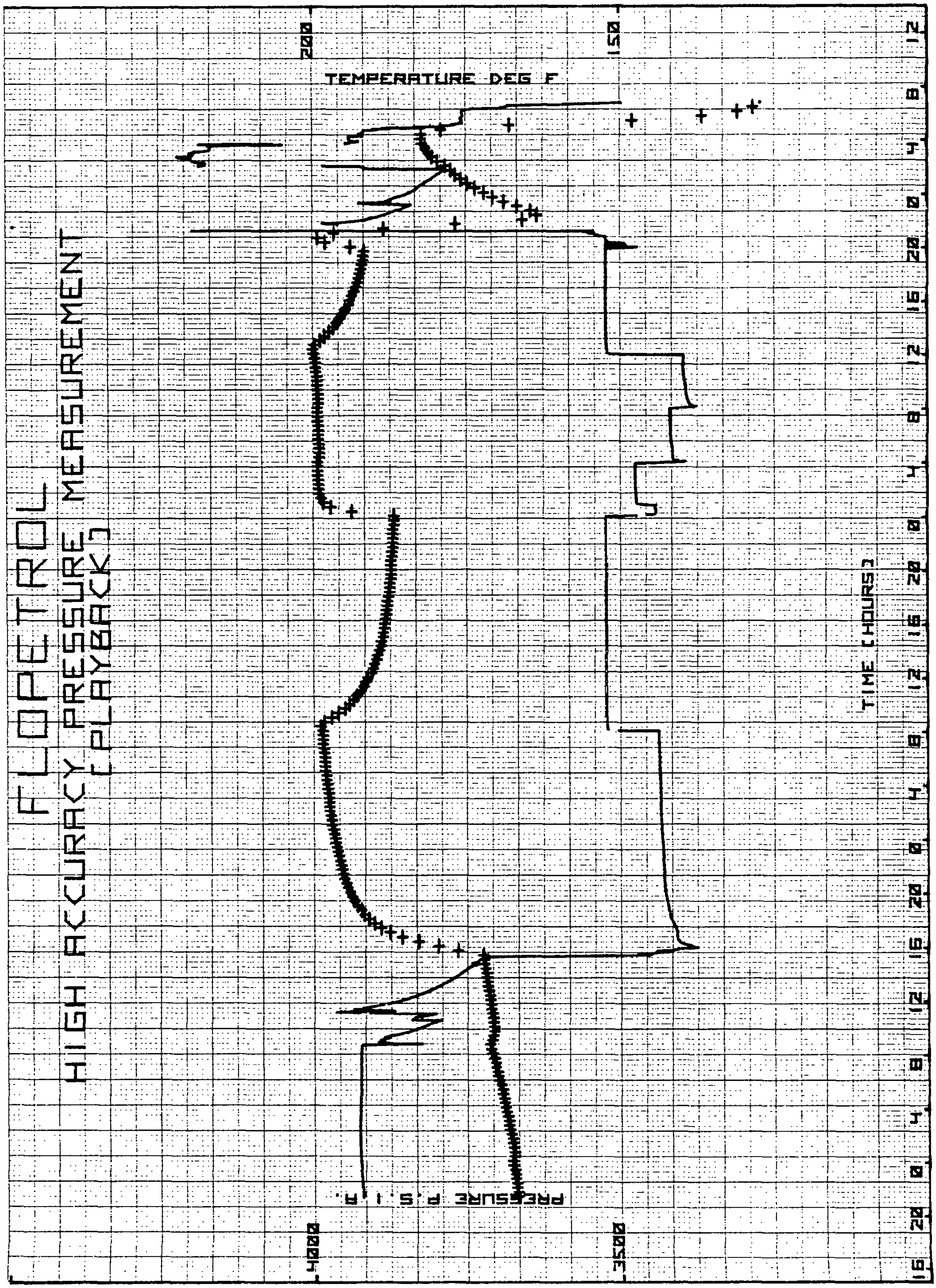
Real productivity index:

$$PI = \frac{Qg3}{P^* - Pwfs} = 111303 \ Sm^3/D/bar \ (270948 \ SCF/D/psi)$$

Ideal productivity index:

$$PI = \frac{Qg3}{P^* - Pwfs - \Delta Ps} = 564025 \ Sm^3/D/bar \ (1.37 \ MMSCF/D/psi)$$

Fig. 4.1.


FLOPETROL
HIGH ACCURACY PRESSURE MEASUREMENT
(PLAYBACK)
TEMPERATURE DEG F
200
150
PRESSURE P.S.I.A.
4000
3500
TIME (HOURS)

FIRST BUILD-UP

BRØNN 15-9-11 DST* 3
BUILDUP NUMMER 1
GAUGE SSDR 81049

NR.	TID	TRYKK
1	8.07	3435.000
2	8.08	3451.100
3	8.09	3484.400
4	8.10	3508.400
5	8.11	3516.500
6	8.12	3517.700
7	8.13	3518.200
8	8.14	3518.500
9	8.15	3518.700
10	8.16	3518.900
11	8.17	3519.000
12	8.18	3519.100
13	8.19	3519.200
14	8.20	3519.300
15	8.21	3519.300
16	8.22	3519.400
17	8.23	3519.400
18	8.24	3519.500
19	8.25	3519.500
20	8.26	3519.500
21	8.27	3519.600
22	8.28	3519.600
23	8.29	3519.600
24	8.30	3519.600
25	8.31	3519.700
26	8.32	3519.700
27	8.33	3519.700
28	8.34	3519.800
29	8.35	3519.800
30	8.36	3519.800
31	8.37	3519.800
32	8.38	3519.800
33	8.39	3519.900
34	8.40	3519.900
35	8.45	3520.000
36	8.50	3520.100
37	8.55	3520.100
38	9.00	3520.200
39	9.05	3520.200
40	9.10	3520.300
41	9.15	3520.300
42	9.20	3520.400
43	9.25	3520.400
44	9.30	3520.500
45	9.45	3520.600
46	10.00	3520.700
47	10.15	3520.800
48	10.30	3520.700
49	10.45	3520.800
50	11.00	3520.900
51	11.15	3521.000
52	11.30	3521.000
53	12.00	3520.800
54	12.30	3520.800
55	13.00	3520.700
56	13.30	3520.800
57	14.00	3520.800
58	14.30	3520.800
59	15.00	3520.800
60	16.00	3520.800
61	17.00	3520.800
62	18.00	3520.800
63	19.00	3520.800
64	20.00	3520.700
65	21.00	3521.000
66	22.00	3521.000
67	23.00	3521.000
68	0.00	3521.100
69	0.03	3521.100

GI TYPE EDITERING
0 = SLUTT
1 = LISTING
2 = SLETTING
3 = ADDERING
4 = ERSTATTING

Fig. 4.2.

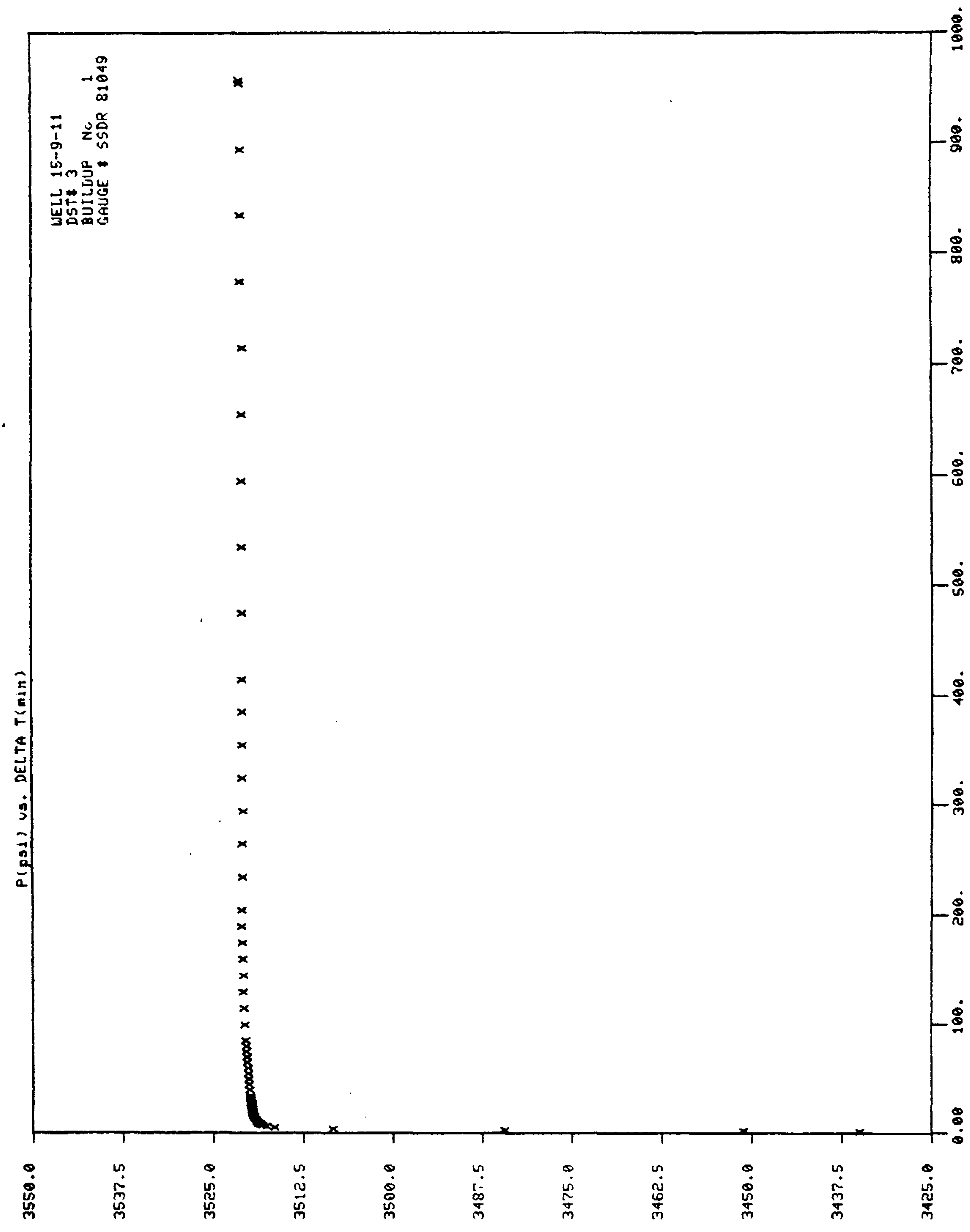
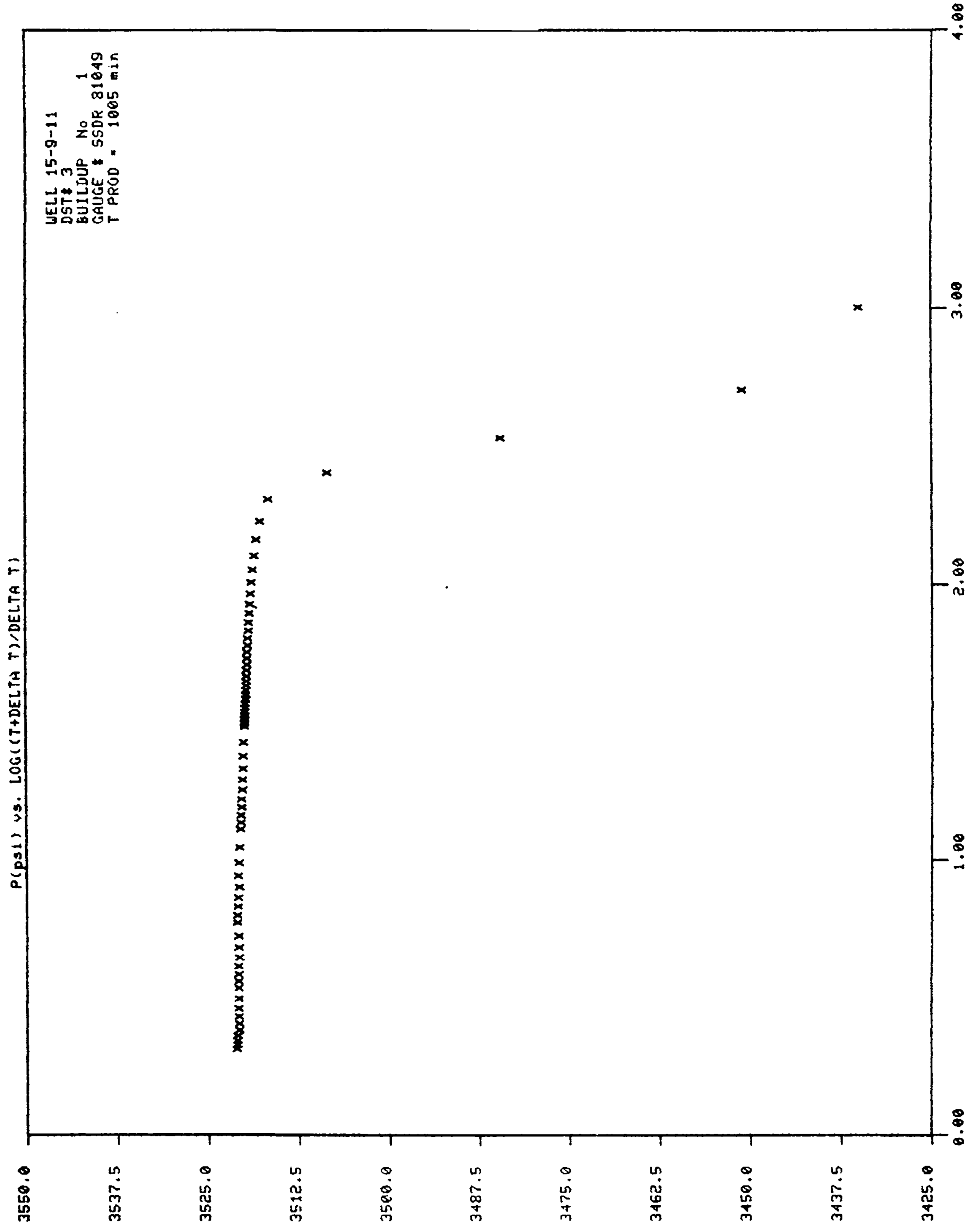

P(psi) vs. DELTA T(min)
WELL 15-9-11
DST# 3
BUILDUP No 1
GAUGE # SSDR 81049

Fig. 4.3.


P(psi) vs. LOG((T+DELTA T)/DELTA T)
WELL 15-9-11
DST# 3
BUILDUP No 1
GAUGE # SSDR 81049
T PROD = 1005 min
3550.0
3537.5
3525.0
3512.5
3500.0
3487.5
3475.0
3462.5
3450.0
3437.5
3425.0
0.00
1.00
2.00
3.00
4.00

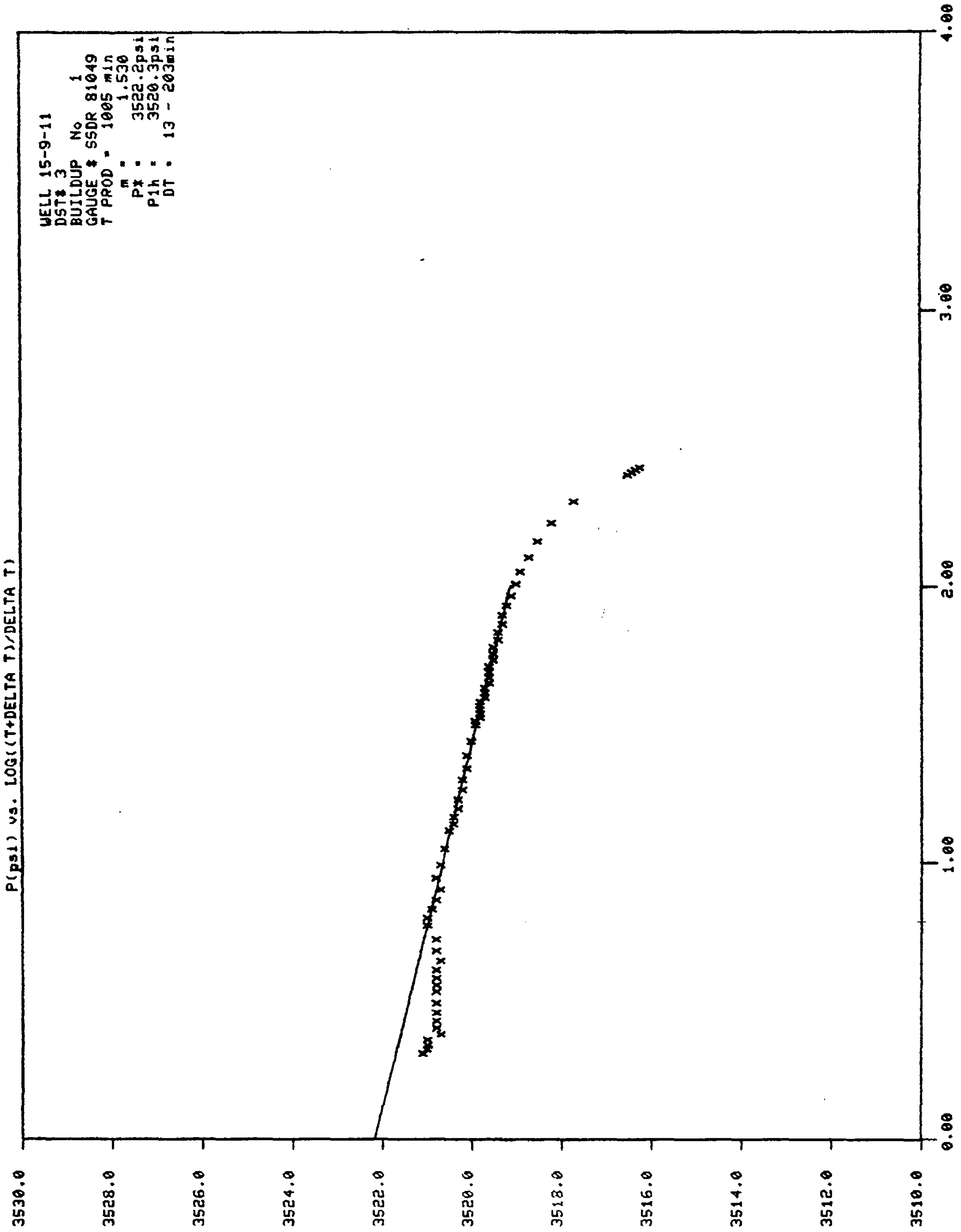
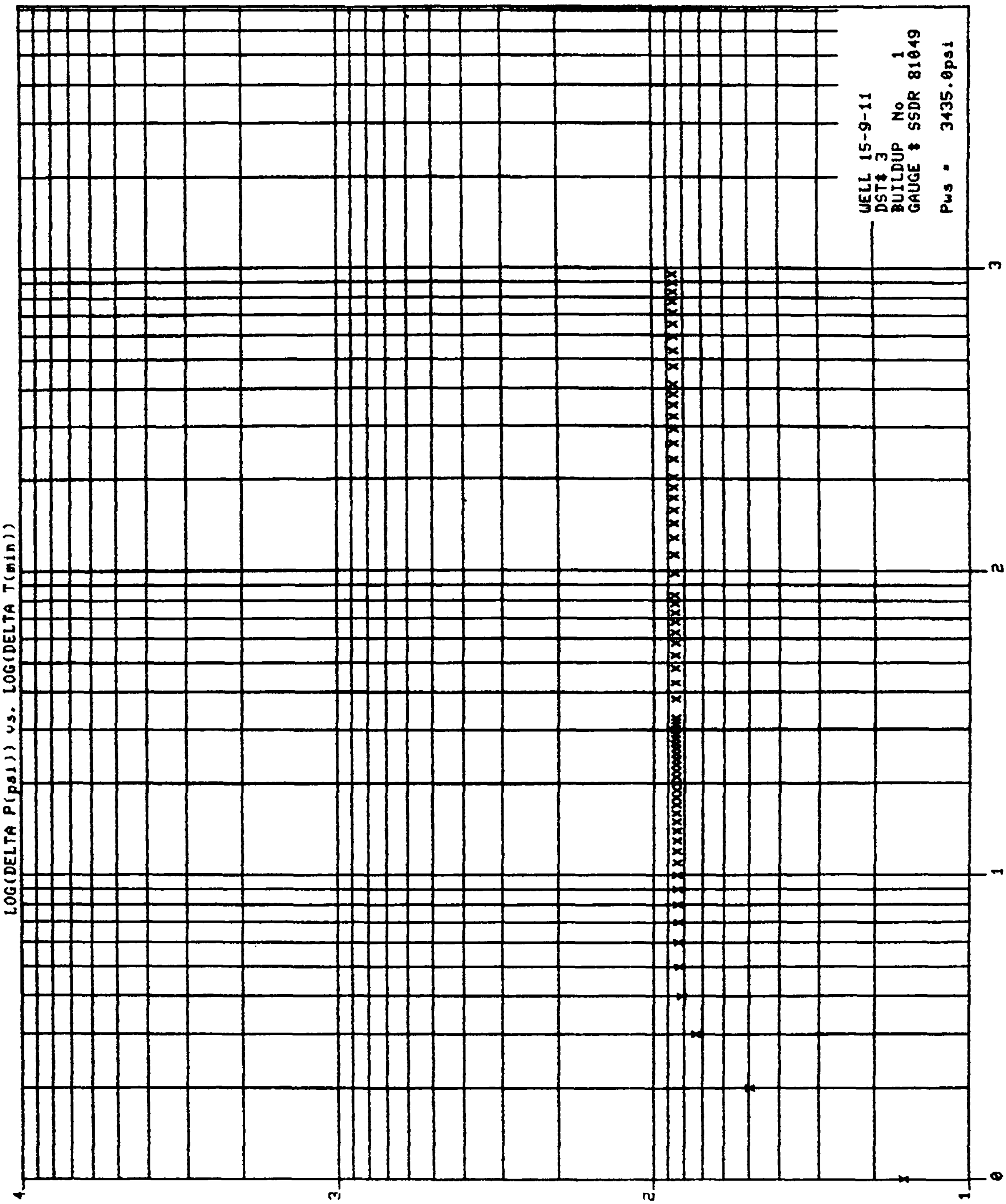

P(psi) vs. LOG((T+DELTA T)/DELTA T)
WELL 15-9-11
DST# 3
BUILDUP No. 1
GAUGE # SSDR 81049
T PROD = 1005 min
m = 1.530
PX = 3522.2psi
P1h = 3520.3psi
DT = 13 - 203min
0.00
1.00
2.00
3.00
4.00
3530.0
3528.0
3526.0
3524.0
3522.0
3520.0
3518.0
3516.0
3514.0
3512.0
3510.0

Fig. 4.5.


LOG(DELTA P(psi)) vs. LOG(DELTA T(min))
WELL 15-9-11
DST# 3
BUILDUP No 1
GAUGE # SSDR 81049
Pws = 3435.0psi
0
1
2
3
4
3
2
1

MULTIRATE BUILD-UP

BRØNN 15-9-11 DST# 3
BUILDUP NUMMER 2
GAUGE SSDR 81049

NR.	TID	TRYKK
1	1.00	3426.700
2	2.00	3469.890
3	3.00	3502.980
4	4.00	3514.080
5	5.00	3515.400
6	6.00	3516.020
7	7.00	3516.410
8	8.00	3516.680
9	9.00	3516.890
10	10.00	3517.080
11	11.00	3517.220
12	12.00	3517.360
13	13.00	3517.470
14	14.00	3517.560
15	15.00	3517.670
16	16.00	3517.740
17	17.00	3517.790
18	18.00	3517.860
19	19.00	3517.930
20	20.00	3518.000
21	22.00	3518.120
22	24.00	3518.190
23	26.00	3518.270
24	28.00	3518.320
25	30.00	3518.400
26	32.00	3518.470
27	34.00	3518.510
28	36.00	3518.580
29	38.00	3518.660
30	40.00	3518.680
31	45.00	3518.800
32	50.00	3518.900
33	55.00	3519.000
34	60.00	3519.120
35	65.00	3519.220
36	70.00	3519.280
37	75.00	3519.350
38	80.00	3519.420
39	85.00	3519.480
40	90.00	3519.540
41	95.00	3519.620
42	100.00	3519.660
43	105.00	3519.760
44	110.00	3519.800
45	115.00	3519.850
46	124.00	3519.910
47	134.00	3519.960
48	144.00	3519.980
49	154.00	3520.050
50	164.00	3520.060
51	174.00	3520.090
52	184.00	3520.040
53	194.00	3520.020
54	204.00	3519.970
55	214.00	3519.980
56	224.00	3520.000
57	234.00	3519.970
58	244.00	3519.970
59	254.00	3519.960
60	264.00	3519.960
61	274.00	3519.950
62	284.00	3519.970
63	294.00	3520.000
64	299.00	3519.960

GI TYPE EDITERING
0 = SLUTT
1 = LISTING
2 = SLETTING
3 = ADDERING
4 = ERSTATTING

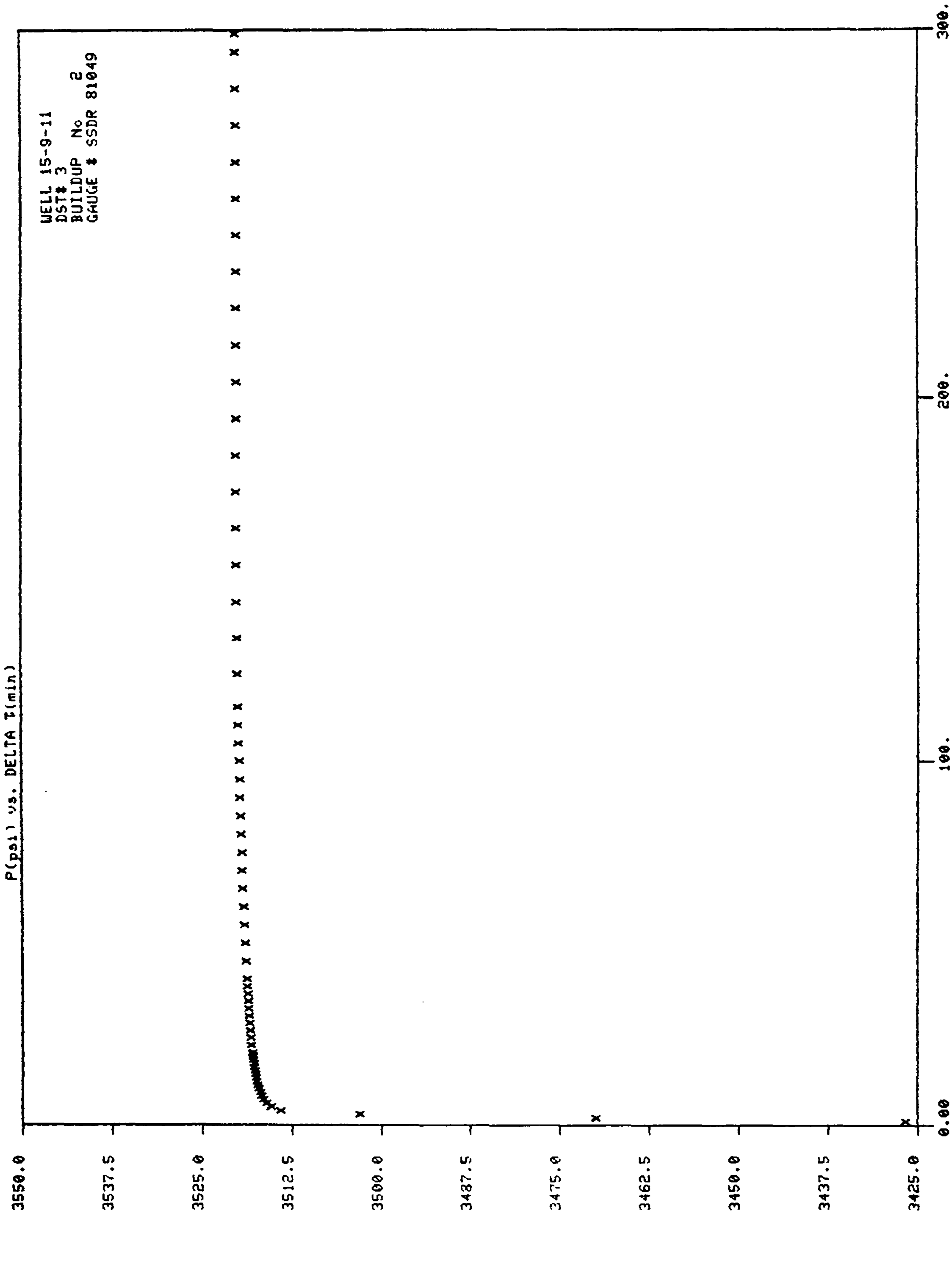
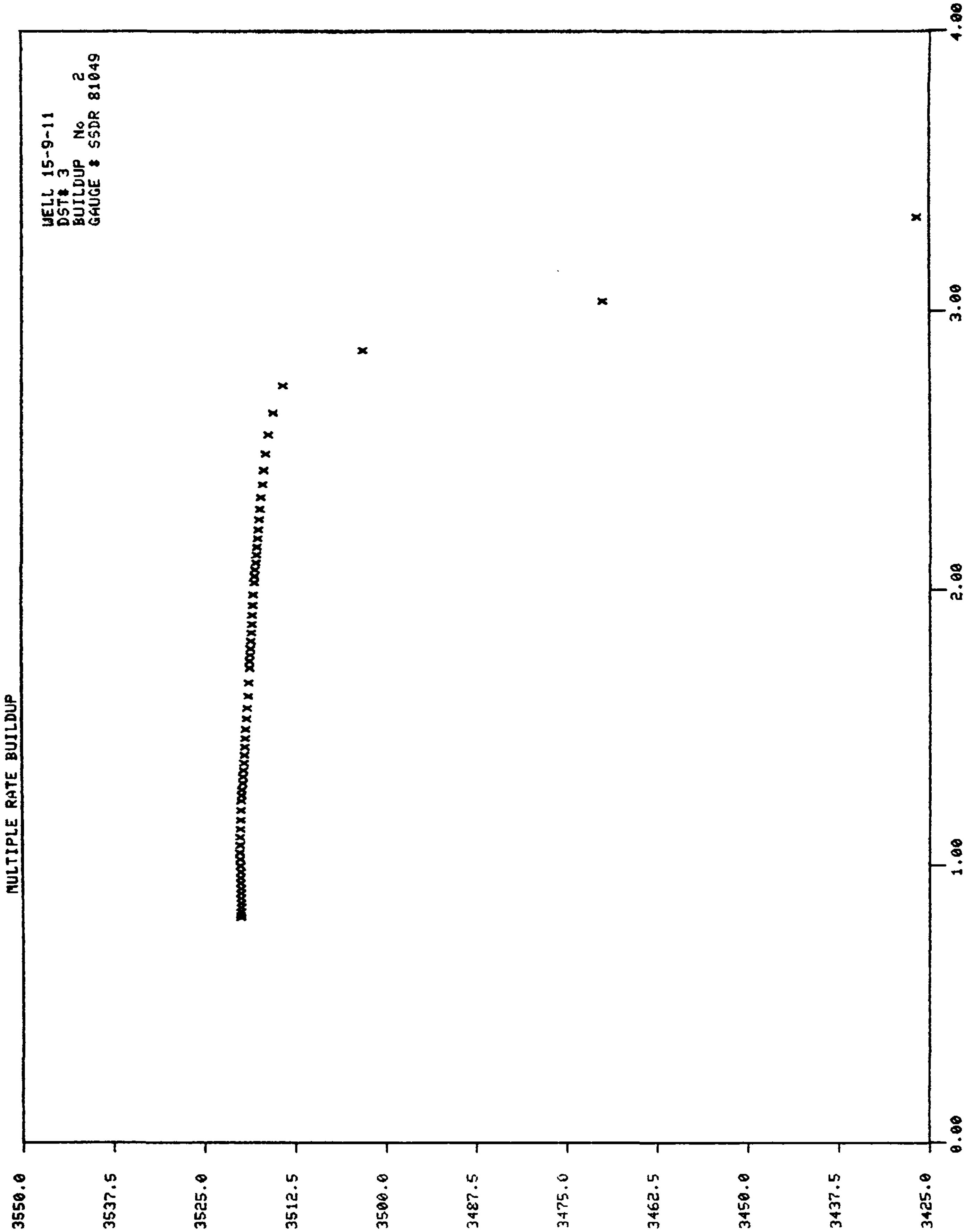

WELL 15-9-11
DST# 3
BUILDUP No 2
GAUGE # SSDR 81049
P(psi) vs. DELTA T(min)
0.00
100.
200.
300.
3550.0
3537.5
3525.0
3512.5
3500.0
3487.5
3475.0
3462.5
3450.0
3437.5
3425.0

Fig. 4.7.


MULTIPLE RATE BUILDUP
WELL 15-9-11
DST# 3
BUILDUP No 2
GAUGE # SSDR 81049
3550.0
3537.5
3525.0
3512.5
3500.0
3487.5
3475.0
3462.5
3450.0
3437.5
3425.0
0.00
1.00
2.00
3.00
4.00

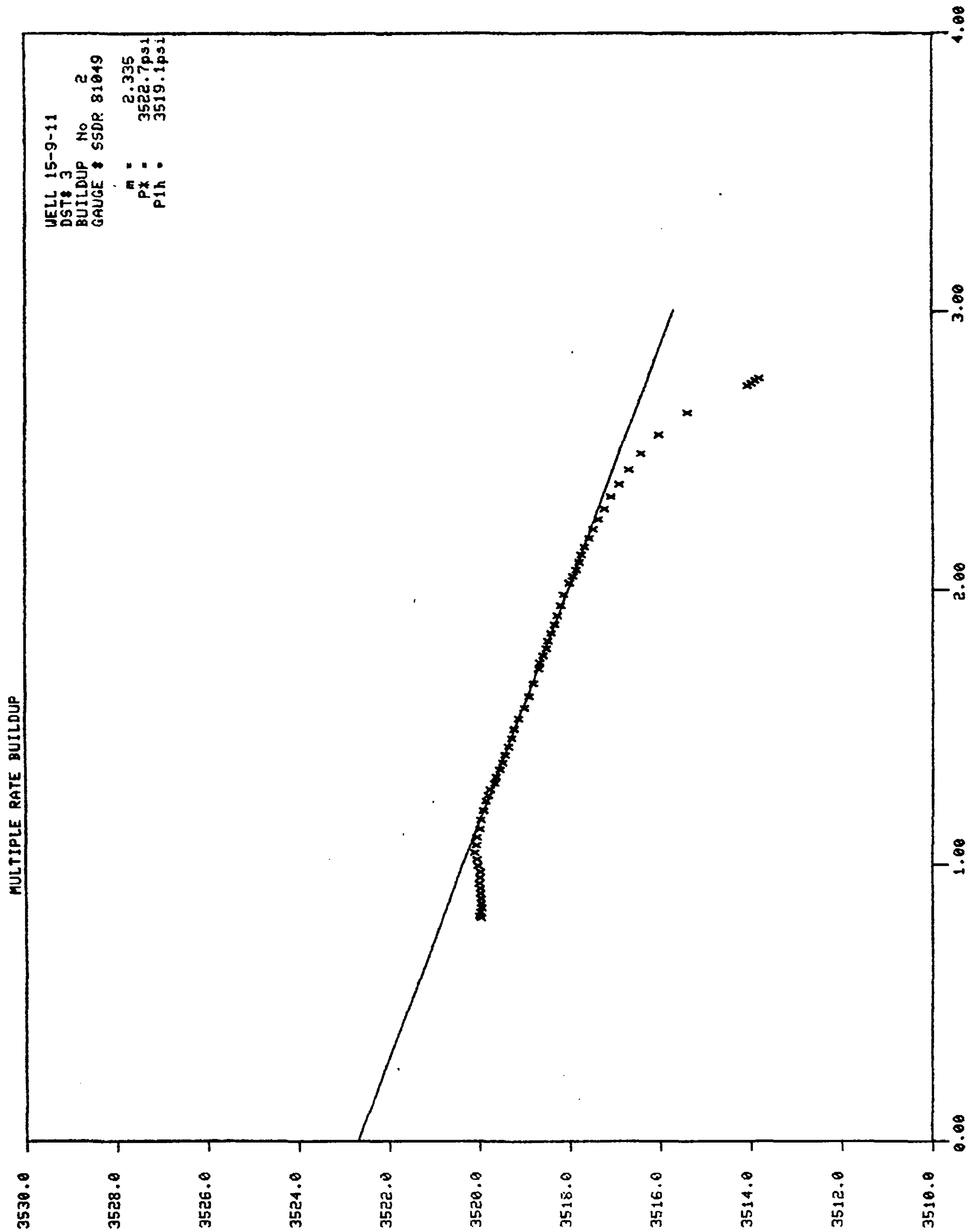
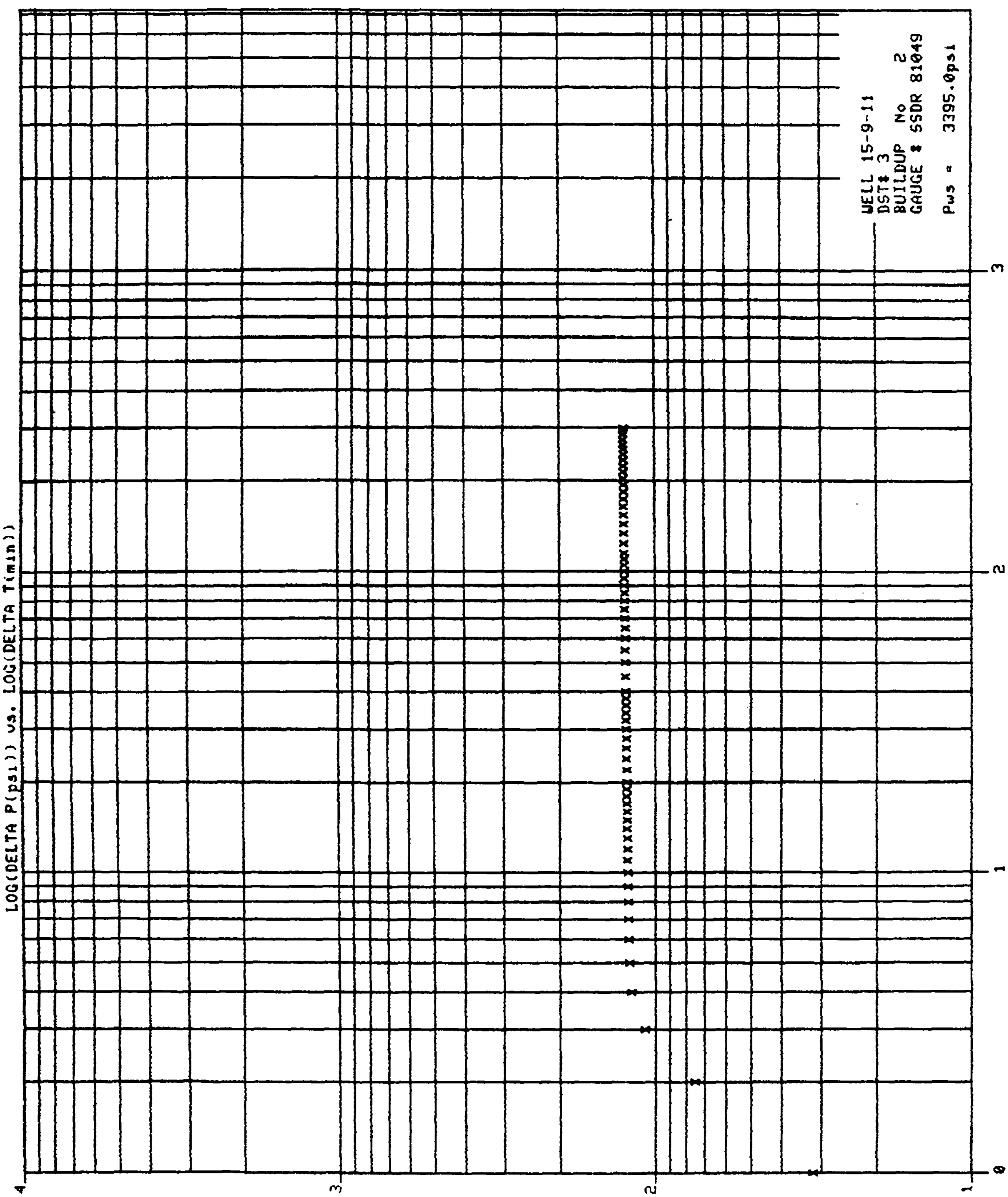

MULTIPLE RATE BUILDUP
WELL 15-9-11
DST# 3
BUILDUP No 2
GAUGE # SSDR 81049
m = 2.335
Px = 3522.7psi
P1h = 3519.1psi
0.00
1.00
2.00
3.00
4.00
3530.0
3528.0
3526.0
3524.0
3522.0
3520.0
3518.0
3516.0
3514.0
3512.0
3510.0

Fig. 4.9.


LOG(DELTA P(psi)) vs. LOG(DELTA T(min))
WELL 15-9-11
DST# 3
BUILDUP No 2
GAUGE # SSDR 81049
Pws = 3395.0psi
0
1
2
3
4
3
2
1