# CAN ELECTRICAL COSTS BE REDUCED?

by
R.E. Ott, M.D. Woods, L.J. Logan and J.R. Wolf
Mobil Exploration & Producing U.S.

## ABSTRACT

For the past few years there has been a lot of effort expended on examining potential electrical cost savings in the oil field. This paper presents efforts to examine the electrical savings in rod pumping operations by:

1. Motor changes and downsizing
2. Reversing the direction of rotation
3. Changing well operation run times and frequency
4. The effect of installing a down hole gas separator

All of these operational changes are inexpensive and the electrical cost savings compared to cost of making the changes are discussed.

## INTRODUCTION

Almost all of the operators in the U.S. have spent time and money to determine what sort of electrical cost reduction can be obtained in their operations. Electricity is the largest component in our expenses, and if a savings can be found, it directly effects our business. MEPUS has looked extensively at electrical cost reductions as well as conducted a thorough literature search to see what the others have also tried. Factors such as motor downsizing, direction of rotation, reducing run times and installing down hole separators have all been investigated as to their effect on electrical cost reduction.

None of these concepts are new. However, we were looking to confirm how these changes would effect our field operations and possible cost reductions. Previously presented papers have discussed the benefits of proper counterbalance of the pumping unit weights and their cost savings[1]. The 10-15 percent reduction in electrical expenses comes from a combination of reducing kilowatt hour (KWH) consumption as well as reducing the kilowatt demand.

## DISCUSSION

Motor changing has been presented several times in the literature, with some claims of success and others inconclusive. The most recent paper[2] indicated a change from Nema D to Nema B motors resulted in a "significant" savings. With this in mind, we decided to try to confirm a similar result by changing out a high-slip motor with a Nema B motor. Figures 1-3 present the fluid level data, dynamometer card data and a software program data to determine the power consumption that were taken prior to changing out the motor. A Sergeant Frame 405T high-slip motor had been installed when the well was first completed. A Reliance 30 HP Nema B was installed on the well and Figures 4-6 present the fluid level data, dynamometer card data and the software program to determine power data gathered afterward. Table I provides a comparison of the "before" and "after" data. As you can see, there is not a significant savings by changing out the motor size. This was unexpected, but not a complete surprise after reviewing the rest of the published literature on the subject.

Based on the results from this test as well as the other literature reports, we would not recommend switching from the existing motor type to a Nema B configuration. The amount of money saved (if any) is insignificant compared to the cost to change out the motor, sheave, etc. We may elect to try this test again on another well, but doubt it, since there are not significant advantages to doing this.

Motor downsizing has also been examined by several companies. The motor efficiency curves indicate a "sweet" spot to best run the motor and supposedly this will help the overall efficiency of the system as well as reduce electrical costs. Many of the wells in the Permian Basin have much larger motors than are required. This resulted by providing motors with sufficient HP to handle anticipated increasing production due to waterfolooding. However, in most cases the increase never did occur and the pumping units have oversized motors still on them. In an effort to determine what savings would occur by downsizing the motor to the correct HP, we cut a dynamometer card, shot the fluid level and ran the power consumption software prior to downsizing. These are presented as Figures 7-9. The 100 BHP Nema D motor was replaced with a 40 BHP Nema D, correctly matching the required HP as indicated by the software programs. After installing the 40 BHP electric motor, a dynamometer card, fluid level and power consumption software run was made, to determine the results. Figures 10-12 present the data gathered after the change. Table II presents the direct comparison. As you can observe, there was no cost savings. The amount of electricity consumed remained about the same. Actual measurements indicated that the amount of electricity consumed increased a small amount!

These results indicate that there appears to be no economy in downsizing, as long as you are not paying for connected BHP. If your electrical contract is set up where you pay for connected horsepower, it is probably worthwhile to downsize, based on the rates charged. If you are paying for only what horsepower you actually use, there does not appear to be a savings when you downsize.

Direction of rotation however, does appear to have merit in reducing electrical costs. One of our fields located near Midland, Texas was surveyed using the poewr consumption software program. Direction of rotation was changed on all of the wells, to determine what sort of potential savings could be obtained. Table III presents a summary of the data pertaining to direction of rotation, comparing direction of rotation to the estimated electrical costs. The old Rule of Thumb about running your pumping unit counter clockwise is not always the best electrical solution. Based on these results, most of our wells in the Permian Basin have been checked to determine which direction of rotation to obtain minimum electrical cost.

This does not say, however, that the one particular direction you run the unit will always be best. You must check the loading of the pumping unit with one of the software programs available. In some cases, changing unit rotation was less expensive electrically, but it did overload the unit. The limits of the pumping unit loading has to be considered before examining the potential electrical savings. Some of the pumping units will not stand more than 100 percent loading, and this has to be considered in your efforts to reduce the operating costs.

Another important item to watch is any change in production. If there is a production change of some significance, it will probably benefit you to rerun the software to determine any potential changes or savings that can be obtained by reversing the rotation. The time to rerun the software and then change rotation is minimal, and we have found that resurveying the field about every six months does point out wells where action can be taken to reduce the electrical costs.

Starting and stopping the motor is an area which we spent time investigating. Someone once told us that we should try to run our wells for longer periods of time, minimizing the number of starts and stops the unit made during the day. Supposedly we were told that the more often the well was started, the higher the electrical costs would be. Most of MEPUS's wells have pump-off controllers (POC's), which stop the well after detecting fluid pound. The well is set to rest for a period of time, to let the reservoir flow more fluid back into the wellbore and then the well is returned to production. We looked at two types of pumping operations. One was a regular pump-off controller that will shut down operations after detecting fluid pound for three consecutive strokes. The other well selected had a time-clock on it. Figure 13 shows the KWH consumption on a daily basis for the well with the first type of POC, both before and after changing the rest times for the well. As you can see, the electrical consumption did not increase. This was contrary to what we had been told earlier. The results from the second type of POC are presented as Figure 14. It too, showed less or about the same electrical consumption, even though the rest period was changed from 30 minutes to 15 minutes. Production stayed about the same in both wells. However, if you happen to have a reservoir that will contribute fluid to the wellbore more quickly than your current rest time, you should be able to increase production. This is an area that we plan to study further, since some of our reservoirs will contribute fluid into the wellbore faster than the current run times we have calculated.

Concurrent with this work, we looked at slowing the pumping units down even further than we had a couple of years ago. In an effort to reduce well failures, we slowed down pumping units, improved our corrosion program, redesigned the rod string and improved downhole pump metallurgy. All of these efforts enabled us to significantly reduce our well failures. In fact, we may have gone too far in doing so, since the amount of money spent may have not always been economic. With this in mind, we are examining at what level should the well failures be held to. What this number should be is still unknown at this time. However, one effort to hold the well failures down is to reduce the strokes per minute (SPM's) to a much slower level. Most of our wells pump in the range of 6-10 SPM. We looked at a couple of different fields to determine if we could reduce the SPM's down to the 2-5 SPM range.

This led to some interesting results. Most operators have several software programs to help them properly design their sucker rod strings, pump size and pumping unit speed. However, you must thoroughly check the computed results out, since operations in the 2-5 SPM range are not the usual design and some of the software programs do come up with some rather interesting results. We surveyed the group of wells in the two fields, cut dynamometer cards on these wells, shot fluid levels and again ran the power consumption software. Since all of these wells had American pumping units, we did not have to add gear box lubricators, which are required when using Lufkin pumping units.

Since one of the software programs did come up with some interesting answers/recommendations, we decided to contact Lufkin Industries, to ask them to recommend what HP motors to install on the redesign of the slower SPM rate. Figure 15 presents one of the sets of recommendations, Lufkin's, the power consumption software and a different software program. As you can see, there is a difference. We have not as yet made these changes, so we don't know which HP is the correct one at this time. We did note, however, that the electricity costs are predicted to increase, which is detrimental to what we were trying to do. Offsetting this is the possibility of better producing the reservoir, since we are attempting to keep the bottom hole pressure low to encourage more fluid flow into the wellbore, since there will be less fluid build up in the wellbore due to shut down/rest time. These results should be the subject of a future paper.

The last subject of this paper, downhole gas separators, has been presented previously at the Southwestern Short Course[3]. The discussion in this paper pertains to changing the run times and thus reducing the electrical costs.

Gas interference has a definite effect on the electrical costs. The more gas that has to pass through the tubing string the longer the unit has to run. Figures 16-18 illustrate a typical well with gas interference. The dynamometer card cut prior to installing a downhole gas separator shows poor pump fillage. This was confirmed by the fluid level and also the amount of time the unit had to run to produce its fluid (18 hours per day). After installing the downhole gas separator, the unit now runs approximately three hours per day and produces the same amount of liquid. The savings amounts to 15 hours per day less run time. This alone can offset the costs to install a downhole gas separator.

If you suspect gas interference in your well, it is definitely worth examining the best method to reduce or eliminate this problem. The cost savings of this particular well amounted to $469 per month, easily offsetting the cost of the downhole separator.

## SUMMARY

From the work conducted over the past year, it appears that there are very few ways to effectively reduce your electrical costs. Probably the best way to reduce your electrical costs is to make sure you have the best possible contract with the utility company. There are several different contracts available from the utility companies. Interruptible power service and staying off during peak hours are a couple of them that you should investigate for potential savings.

Of the four different types of cost savings discussed in this paper, only direction of rotation seems to offer any "quick hits" in reducing your electrical bill. The downhole gas separator will help improve your well operations and can reduce run time. This will reduce electrical costs and perhaps ease operating conditions at the tank batteries. Trying to downsize motors or starting and stopping your motors less do not appear to offer any electrical savings even though they have been touted as potential areas to reduce electrical costs.

## ACKNOWLEDGEMENTS

The authors would like to thank MEPUS management for allowing us to conduct these tests as well as permission to publish the results. Special thanks go to S.D. Bearden, L.G. Smith and R.W. Watkins for sponsoring this work.

## BIBLIOGRAPHY

1. Ott, R.E., Woods, M.D., McCoy, J.N., Podio, A.L., *Reducing Electrical Consumption of Beam Pumping Units by Properly Counterbalancing Using PC Software*, Southwestern Petroleum Short Course, Lubbock, Texas, 1995.
2. Ula, S., *Oil Field Electrical Efficiency Improvement and Cost Savings Results from Field Implementations*, Southwestern Petroleum Short Course, Lubbock, Texas, 1995.
3. Podio, A.L., McCoy, J.N., Woods, M.D., *A Decentralized, Continuous-Flow Gas Anchor*, Southwestern Petroleum Short Course, Lubbock, Texas, 1995.
4. McCoy, J.N., Ott, R.E., Podio, A.L., Collier, F.B., Becker, D., *Beam Pump Balancing Based on Motor Power Utilization*, SPE paper #29533, presented at Oklahoma City, 1995.

5. McCoy, J.N., Collier, F.B., Podio, A.L., *Application of Real-Time Measurement of Motor Power to Determination of Beam Pump Efficiency*, Southwestern Petroleum Short Course, Lubbock, Texas, 1994.
6. McCoy, J.N., Podio, A.L., Jennings, J., Drake, B., *Motor Power, Current and Torque Analysis to Improve Efficiency of Beam Pumps*, Southwestern Petroleum Short Course, Lubbock, Texas, 1993.
7. Takacs, G., *Modern Sucker Rod Pumping*, Pennwell Books, 1993.
8. Kilgore, J.J., Tripp, H.A., *Walking Beam Pumping Unit System Efficiency Measurements*, SPE 22788, presented at the 68th Annual Technical Conference and Exhibition, Dallas, Texas, October 1991.
9. Gault, R.H., *Designing an Energy Efficient Sucker Rod Pumping System*, Southwestern Petroleum Short Course, Lubbock, Texas, 1985.

Table I
Data from Changing Nema 'D' to Nema 'B' Motors
Parks Field

| Date | (1) Delta Hours | (2) Delta KWH | (3) Run Time, Hrs. | (4) KWH/Hrs | (3)x(4) |
|---|---|---|---|---|---|
| Nema 'D' Data | | | | | |
| 10 Nov | 49.283 | 26.688 | 34. | 0.542 | 9.21 |
| 11 Nov | 22.467 | 12.019 | 14.42 | 0.535 | 7.71 |
| 12 Nov | 25.467 | 12.437 | 14.42 | 0.488 | 7.04 |
| 13 Nov | 21.40 | 9.346 | 15.0 | 0.623 | 9.35 |
| | | | | Avg. = | 8.50 |
| Nema 'B' Data | | | | | |
| 17 Nov | 25.267 | 18.349 | 15.03 | 0.726 | 10.91 |
| 18 Nov | 25.217 | 18.557 | 14.38 | 0.736 | 10.58 |
| 19 Nov | 21.667 | 13.984 | 14.88 | 0.645 | 9.60 |
| 20 Nov | 24.283 | 18.326 | 14.77 | 0.755 | 11.14 |
| 21 Nov | 22.75 | 17.26 | 14.93 | 0.759 | 11.33 |
| | | | | Avg. = | 10.71 |

Table II
Results from Motor Downsizing (100 HP to 40 HP)
Russell Clear Fork Unit

| | 12July95 (100BHP) | 9August95 (60BHP) |
|---|---|---|
| Fluid Level, FOP | 175 | 642 |
| Run time, hrs/day | 24 | 24 |
| Recommended HP | 60 | 60.7 |
| Average KWH | 32.6 | 32.9 |
| System Efficiency, % | 57 | 63 |
| Cast, &/Month (Power) | 938 | 949 |

Table III

Existing

| Well # | Out of Balance K-in-lbs | Direction | Electrical costs \$/month |
|---|---|---|---|
| BS176 | 133 out | CW | 458 |
| NV296 | 22 out | CCW | 116 |
| NV281 | 78 in | CCW | 107 |
| NV282 | 16 out | CCW | 81 |
| NV267 | 48 in | CW | 344 |

Reverse Direction

| Well # | Out of Balance K-in-lbs | Direction | Electrical costs \$/month | Recommendations |
|---|---|---|---|---|
| BS176 | 66 out | CCW | 415 | Rev=\$43/month savings |
| NV296 | 79 out | CW | 73 | Rev to CW, save \$43/month |
| NV281 | 1 in | CW | 60 | Rev=\$47/month savings |
| NV282 | 52 out | CW | 46 | Rev=\$35/month savings |
| NV267 | 23 in | CCW | 310 | Rev to CCW, save \$34/month |

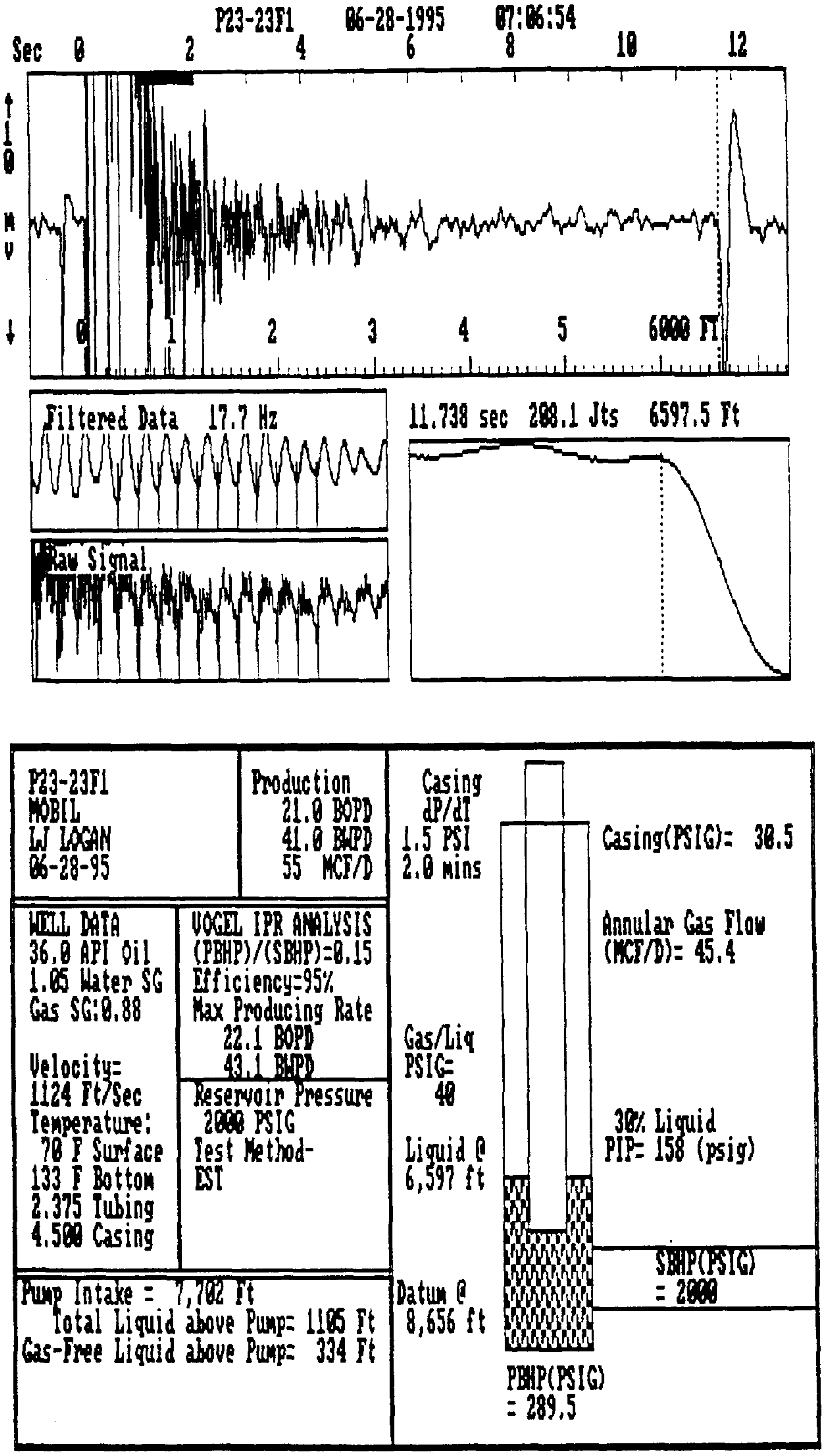

P23-23F1 06-28-1995 07:06:54
Sec 0 2 4 6 8 10 12
10 MV
0 1 2 3 4 5 6000 FT
Filtered Data 17.7 Hz
Raw Signal
11.738 sec 208.1 Jts 6597.5 Ft
P23-23F1
MOBIL
LJ LOGAN
06-28-95
Production
21.0 BOPD
41.0 BWPD
55 MCF/D
Casing
dP/dT
1.5 PSI
2.0 mins
Casing(PSIG)= 30.5
WELL DATA
36.0 API Oil
1.05 Water SG
Gas SG:0.88
Velocity=
1124 Ft/Sec
Temperature:
70 F Surface
133 F Bottom
2.375 Tubing
4.500 Casing
VOGEL IPR ANALYSIS
(PBHP)/(SBHP)=0.15
Efficiency=95%
Max Producing Rate
22.1 BOPD
43.1 BWPD
Reservoir Pressure
2000 PSIG
Test Method-
EST
Annular Gas Flow
(MCF/D)= 45.4
Gas/Liq
PSIG=
40
Liquid @
6,597 ft
30% Liquid
PIP= 158 (psig)
SBHP(PSIG)
= 2000
Pump Intake = 7,702 Ft
Total Liquid above Pump= 1105 Ft
Gas-Free Liquid above Pump= 334 Ft
Datum @
8,656 ft
PBHP(PSIG)
= 289.5

Figure 1

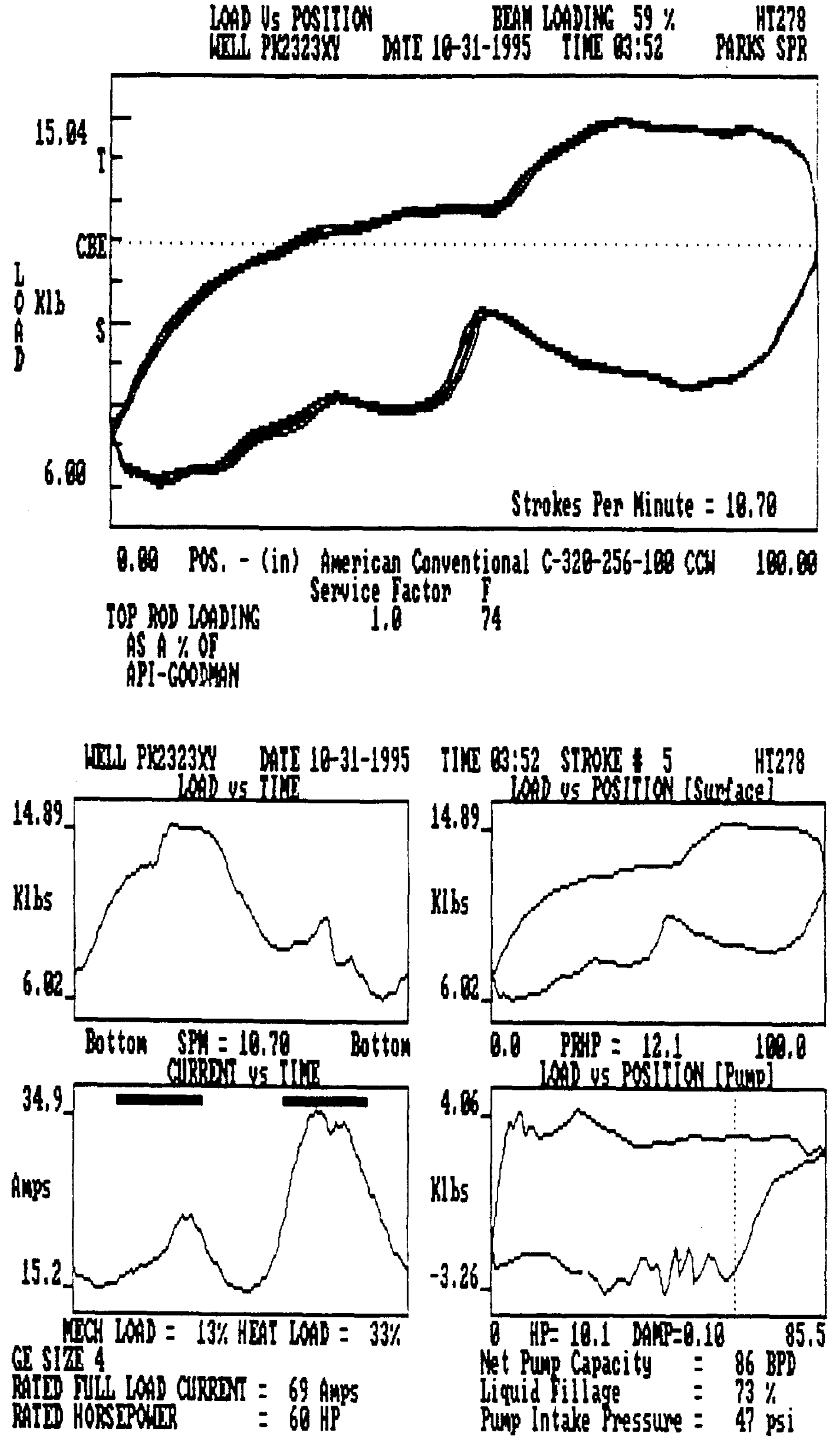
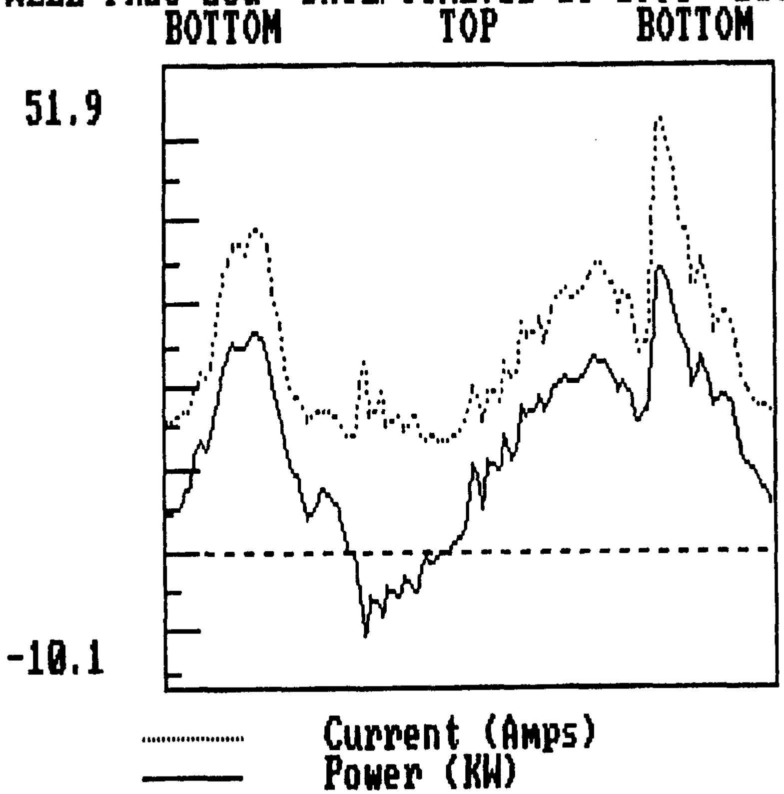

LOAD Vs POSITION
BEAM LOADING 59 %
HT278
WELL PK2323XY
DATE 10-31-1995
TIME 03:52
PARKS SPR
15.04
T
CBE
L
O
A
D
Klb
S
6.00
Strokes Per Minute = 10.70
0.00
POS. - (in)
American Conventional C-320-256-100 CCW
100.00
Service Factor F
TOP ROD LOADING
1.0
74
AS A % OF
API-GOODMAN
WELL PK2323XY
DATE 10-31-1995
TIME 03:52
STROKE # 5
HT278
LOAD vs TIME
14.89
Klbs
6.02
Bottom
SPM = 10.70
Bottom
LOAD vs POSITION [Surface]
14.89
Klbs
6.02
0.0
PRHP = 12.1
100.0
CURRENT vs TIME
34.9
Amps
15.2
MECH LOAD = 13% HEAT LOAD = 33%
LOAD vs POSITION [Pump]
4.06
Klbs
-3.26
0
HP= 10.1
DAMP=0.10
85.5
GE SIZE 4
RATED FULL LOAD CURRENT : 69 Amps
RATED HORSEPOWER : 60 HP
Net Pump Capacity : 86 BPD
Liquid Fillage : 73 %
Pump Intake Pressure : 47 psi

Figure 2

WELL PK23-23a DATE/TIME:11-13-1995 10:06



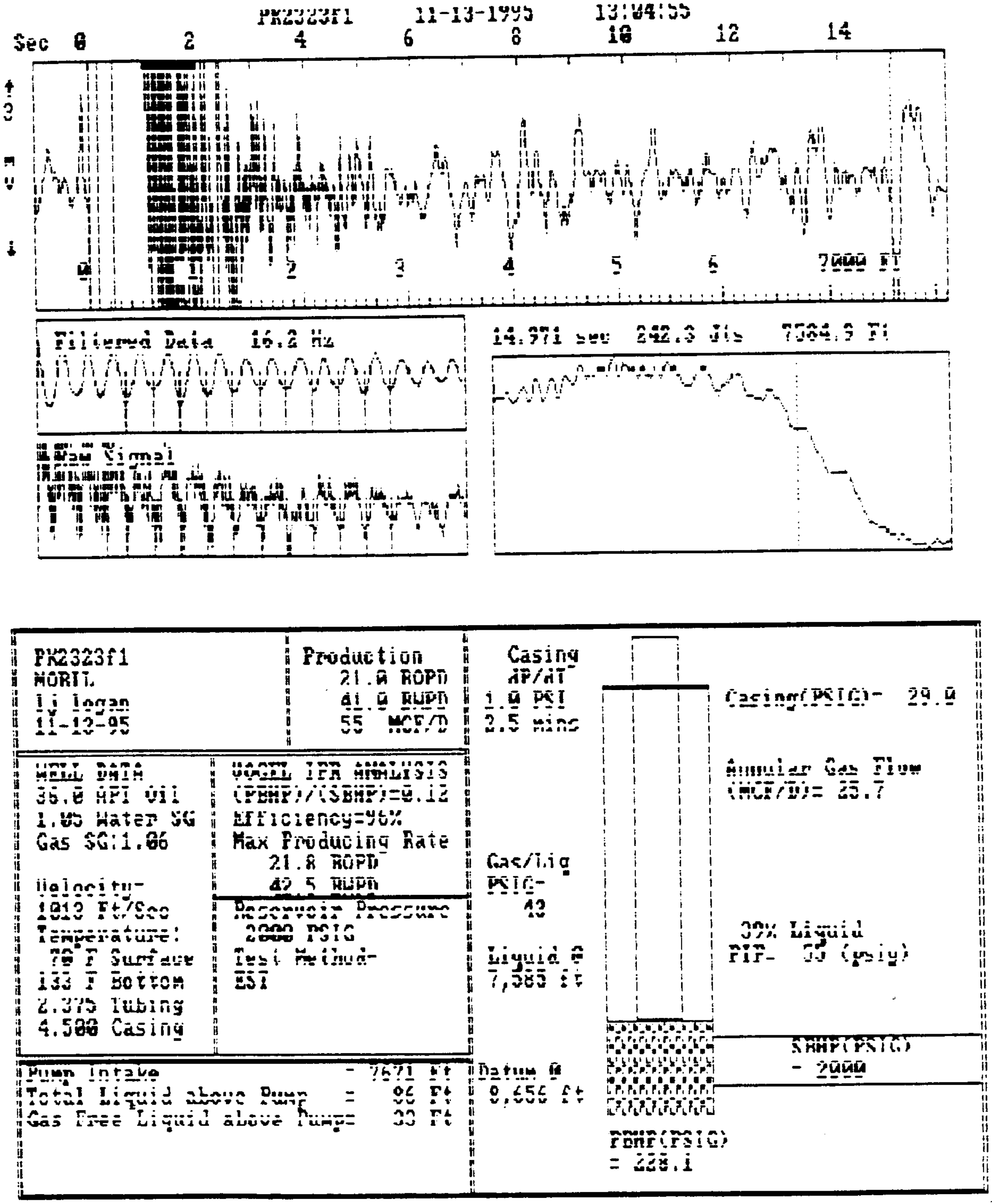

GE SIZE 4

POWER/CURRENT ANALYSIS

| | |
|---|---|
| COST PER MONTH RUN 12.0 HR/DAY | |
| WITH GENERATION CREDIT.. | \$ 139 |
| NO GENERATION CREDIT.... | \$ 146 |
| COST PER BBL OF OIL...... | 23¢ |
| COST PER BBL OF LIQUID.. | 8¢ |
| NAMEPLATE FL AMP RATING.... | 69 |
| THERMAL AMPS.............. | 27 |
| CLF...................... | 1.299 |
| RECOMMENDED MIN HP.(D)... | 24.1 |
| NAMEPLATE HP RATING...... | 60.0 |
| INPUT HP (GROSS)......... | 17.5 |
| INPUT HP (NET)........... | 16.7 |
| AVERAGE KVA.............. | 20.7 |
| AVERAGE KW | |
| WITH GENERATION CREDIT.. | 12.5 |
| NO GENERATION CREDIT.... | 13.1 |
| AVERAGE POWER FACTOR..... | 51% |
| STROKES PER MIN.......... | 11.01 |
| BOPD..................... | 21 |
| BWPD..................... | 41 |
| SYSTEM EFFICIENCY........ | 41% |

Hit [ENTER] to save SCREEN or type [N]o to not save:

Figure 3



PK2323F1 11-13-1995 13:04:55
Sec 0 2 4 6 8 10 12 14
2000 FT
Filtered Data 16.2 Hz
14.971 sec 242.3 Jts 7584.9 Ft
Raw Signal
PK2323f1
MOBIL
Li logan
11-12-95
Production
21.0 BOPD
41.0 BWPD
55 MCF/D
Casing
dP/dT
1.0 PSI
2.5 mins
Casing(PSIG)- 29.0
WELL DATA
36.0 API Oil
1.05 Water SG
Gas SG:1.06
Velocity-
1012 Ft/Sec
Temperature:
70 F Surface
133 F Bottom
2.375 Tubing
4.500 Casing
VOGEL IPR ANALYSIS
(PBHP)/(SBHP)=0.12
Efficiency=96%
Max Producing Rate
21.8 BOPD
42.5 BWPD
Reservoir Pressure
2000 PSIG
Test Method-
EST
Gas/Liq
PSIG-
42
Liquid @
7,585 ft
Annular Gas Flow
(MCF/D)= 25.7
39% Liquid
PIP- 55 (psig)
SBHP(PSIG)
- 2000
Pump Intake - 7671 Ft
Total Liquid above Pump = 96 Ft
Gas Free Liquid above Pump= 33 Ft
Datum @
8,656 ft
PBHP(PSIG)
= 228.1


Figure 4

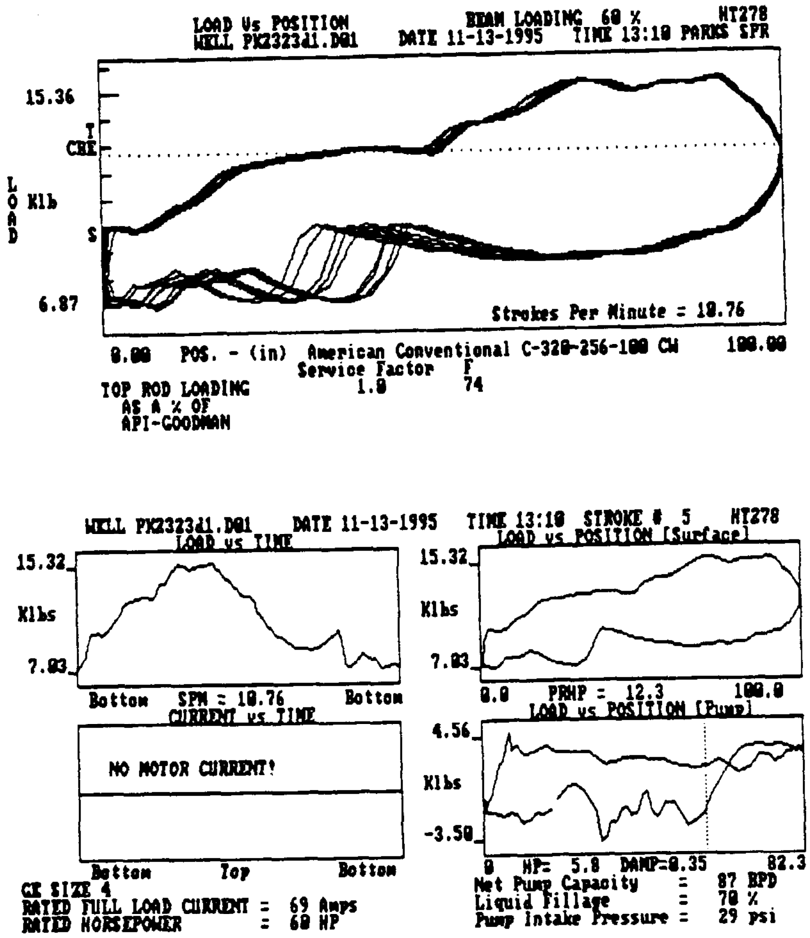
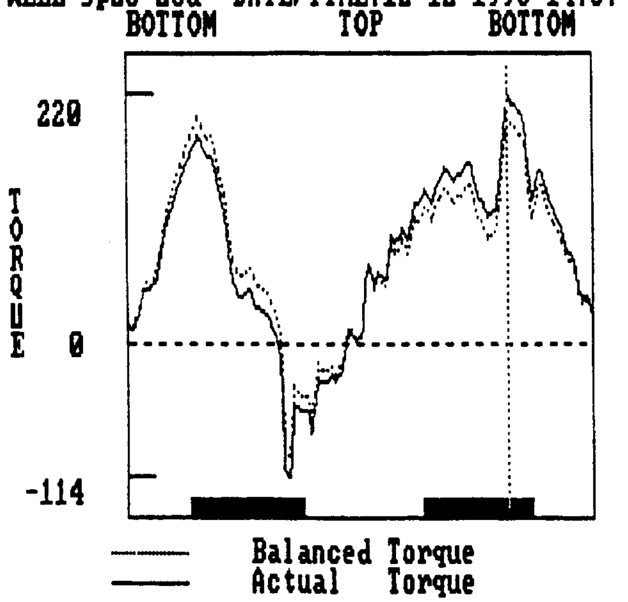

LOAD Vs POSITION
BEAM LOADING 68 %
HT278
WELL PK2323d1.D01
DATE 11-13-1995
TIME 13:10 PARKS SPR
15.36
CBE
LOAD Klb
6.87
Strokes Per Minute = 10.76
0.00 POS. - (in) American Conventional C-320-256-100 CW
100.00
Service Factor F
1.0 74
TOP ROD LOADING
AS A % OF
API-GOODMAN
WELL PK2323d1.D01 DATE 11-13-1995 TIME 13:10 STROKE # 5 HT278
LOAD vs TIME
15.32
Klbs
7.03
Bottom SPM = 10.76 Bottom
CURRENT vs TIME
NO MOTOR CURRENT!
Bottom Top Bottom
CE SIZE 4
RATED FULL LOAD CURRENT = 69 Amps
RATED HORSEPOWER = 60 HP
LOAD vs POSITION [Surface]
15.32
Klbs
7.03
0.0 PRHP = 12.3 100.0
LOAD vs POSITION [Pump]
4.56
Klbs
-3.50
0 HP= 5.8 DAMP=0.35 82.3
Net Pump Capacity = 87 BPD
Liquid Fillage = 70 %
Pump Intake Pressure = 29 psi

Figure 5

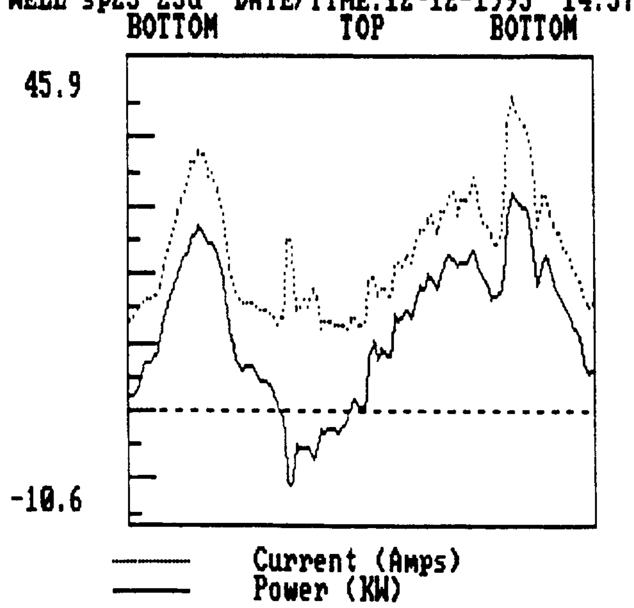
WELL sp23-23d DATE/TIME:12-12-1995 14:57




| ---- TORQUE ANALYSIS -------( T ) | |
|---|---|
| MEASURED UPSTROKE PEAK | 186 |
| MEASURED DOWNSTROKE PEAK | 220 |
| MARKER (← →) | 220 |
| ADJUSTED UPSTROKE PEAK | 201 |
| ADJUSTED DOWNSTROKE PEAK | 202 |
| CB CHANGE FOR ADJUSTED TORQUE DECREASE | 20 |
| WEIGHT OF COUNTERWEIGHTS TO BE MOVED, (LBS) | 3470 |
| FOR ADJUSTED TORQUE MOVE COUNTERWEIGHTS IN, (INCHES) | 6 |

T = 84.5 * P * EFF / (SPM * SV)
EFF= MOTOR/REDUCER = 0.80
SPM= STROKES PER MIN = 10.91
SV= MIN. SPEED/AVG. SPEED = 0.90
P=POWER(KW) T=TORQUE(1000xINxLBS)
American Conventional
C-320-256-100 CW
RELIANCE XE 30HP 35.8AMP FRAME 325T

WELL sp23-23d DATE/TIME:12-12-1995 14:57




RELIANCE XE 30HP 35.8AMP FRAME 325T

| POWER/CURRENT ANALYSIS | |
|---|---|
| COST PER MONTH RUN 13.5 HR/DAY | |
| KWH COST WITH GEN CREDIT | $ 153 |
| KWH COST NO GEN CREDIT. | $ 161 |
| DEMAND COST ............ | $ 108 |
| COST PER BBL OF OIL...... | 24¢ |
| COST PER BBL OF LIQUID.. | 7¢ |
| NAMEPLATE FL AMP RATING.... | 36 |
| THERMAL AMPS............... | 25 |
| CLF...................... | 1.309 |
| RECOMMENDED MIN HP.(D)... | 23.7 |
| NAMEPLATE HP RATING...... | 30.0 |
| INPUT HP (GROSS)......... | 17.2 |
| INPUT HP (NET).......... | 16.4 |
| DEMAND KW .............. | 13.5 |
| AVERAGE KVA............. | 19.5 |
| AVERAGE KW | |
| WITH GENERATION CREDIT.. | 12.2 |
| NO GENERATION CREDIT.... | 12.9 |
| AVERAGE POWER FACTOR..... | 52% |
| STROKES PER MIN......... | 10.91 |
| BOPD.................... | 23 |
| BWPD.................... | 54 |
| SYSTEM EFFICIENCY........ | 46% |

Figure 6

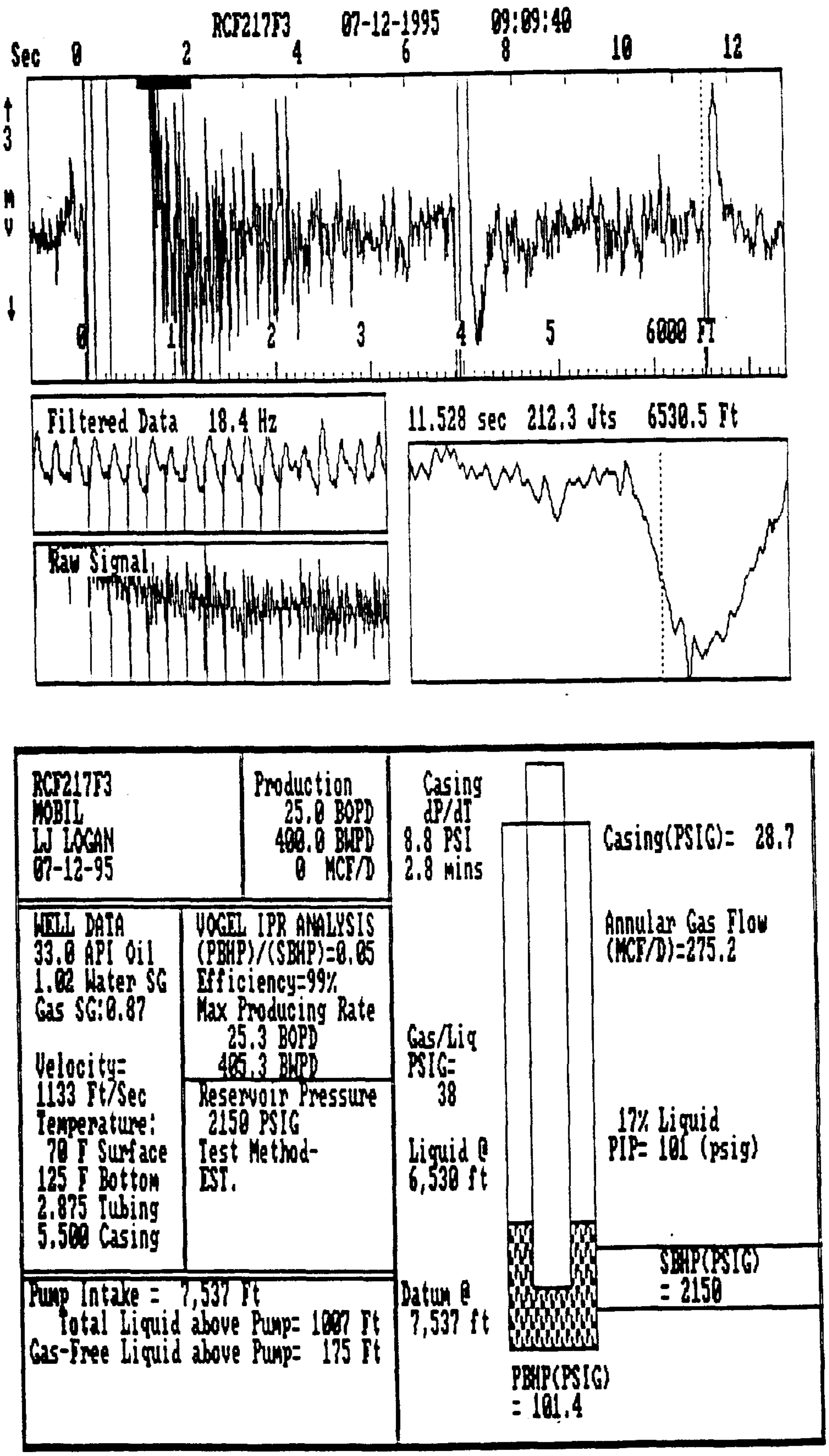
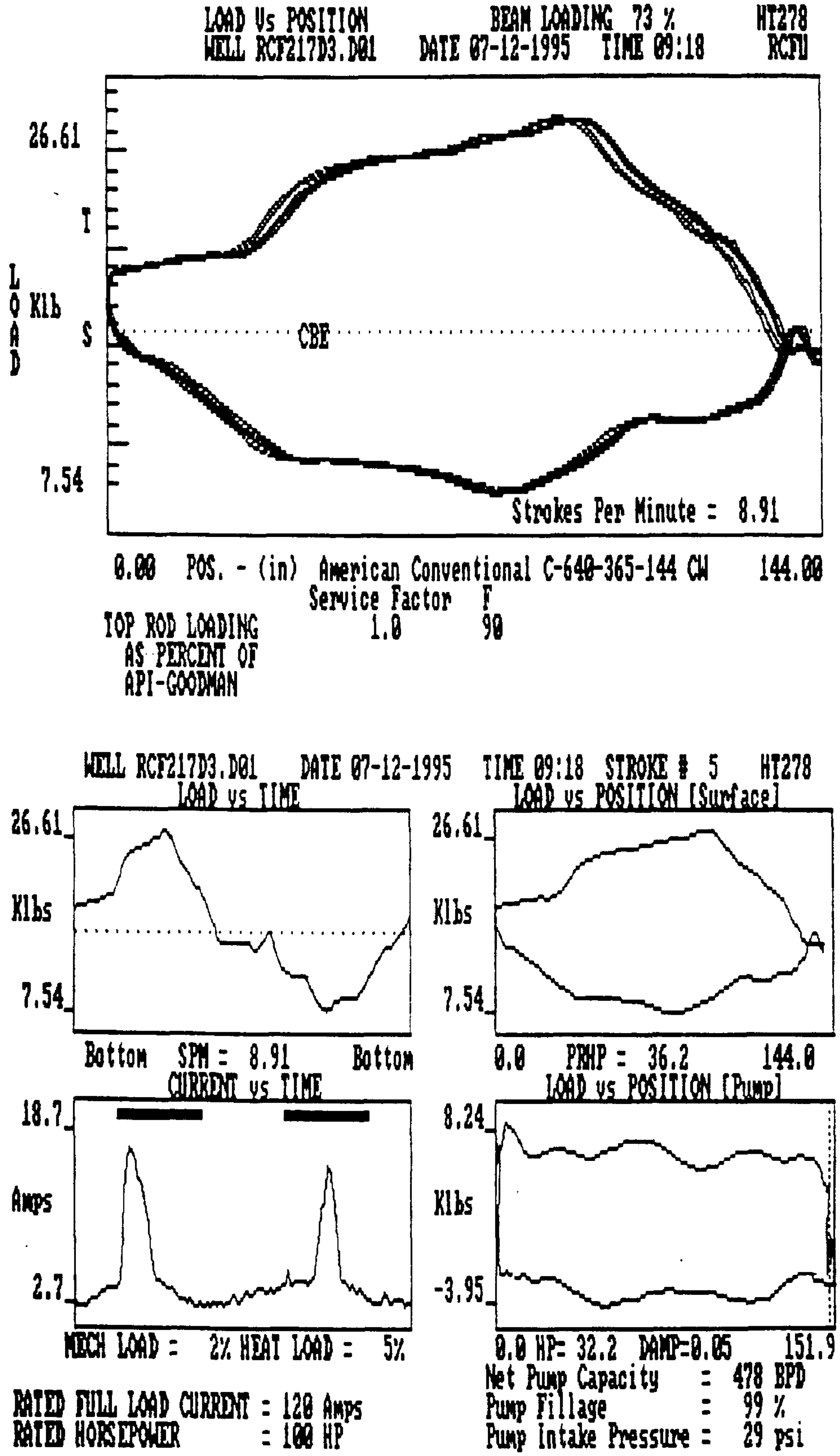

RCF217F3 07-12-1995 09:09:40
Sec 0 2 4 6 8 10 12
3 MV
0 1 2 3 4 5 6000 FT
Filtered Data 18.4 Hz
Raw Signal
11.528 sec 212.3 Jts 6530.5 Ft
RCF217F3
MOBIL
LJ LOGAN
07-12-95
Production
25.0 BOPD
400.0 BWPD
0 MCF/D
Casing
dP/dT
8.8 PSI
2.8 mins
Casing(PSIG)= 28.7
WELL DATA
33.0 API Oil
1.02 Water SG
Gas SG:0.87
Velocity=
1133 Ft/Sec
Temperature:
70 F Surface
125 F Bottom
2.875 Tubing
5.500 Casing
VOGEL IPR ANALYSIS
(PBHP)/(SBHP)=0.05
Efficiency=99%
Max Producing Rate
25.3 BOPD
405.3 BWPD
Reservoir Pressure
2150 PSIG
Test Method-
EST.
Annular Gas Flow
(MCF/D)=275.2
Gas/Liq
PSIG=
38
Liquid @
6,530 ft
17% Liquid
PIP= 101 (psig)
SBHP(PSIG)
= 2150
Pump Intake = 7,537 Ft
Total Liquid above Pump: 1007 Ft
Gas-Free Liquid above Pump: 175 Ft
Datum @
7,537 ft
PBHP(PSIG)
= 101.4

Figure 7

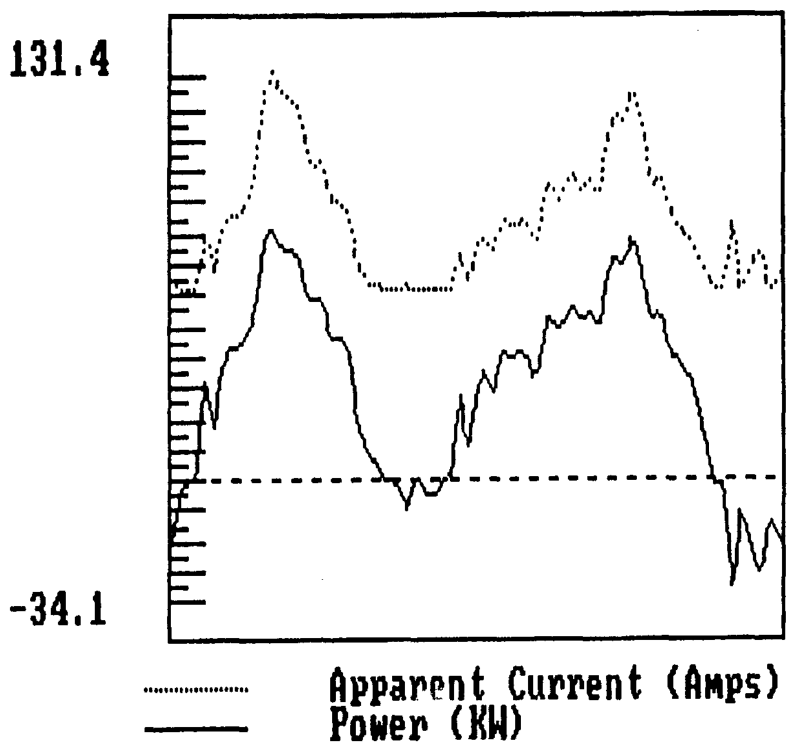


LOAD Vs POSITION
BEAM LOADING 73 %
HT278
WELL RCF217D3.D01
DATE 07-12-1995
TIME 09:18
RCFU
26.61
7.54
L O A D Klb
T
S
CBE
Strokes Per Minute = 8.91
0.00
POS. - (in)
American Conventional C-640-365-144 CW
144.00
Service Factor F
TOP ROD LOADING AS PERCENT OF API-GOODMAN
1.0 90
WELL RCF217D3.D01 DATE 07-12-1995 TIME 09:18 STROKE # 5 HT278
LOAD vs TIME
26.61
Klbs
7.54
Bottom SPM = 8.91 Bottom
LOAD vs POSITION [Surface]
26.61
Klbs
7.54
0.0 PRHP = 36.2 144.0
CURRENT vs TIME
18.7
Amps
2.7
MECH LOAD = 2% HEAT LOAD = 5%
LOAD vs POSITION [Pump]
8.24
Klbs
-3.95
0.0 HP= 32.2 DAMP=0.05 151.9
Net Pump Capacity = 478 BPD
Pump Fillage = 99 %
Pump Intake Pressure = 29 psi
RATED FULL LOAD CURRENT = 120 Amps
RATED HORSEPOWER = 100 HP


Figure 8

WELL RCF217D4 DATE/TIME:07-12-1995 09:49

BOTTOM TOP BOTTOM




POWER/CURRENT ANALYSIS

| | |
|---|---|
| COST PER MONTH RUN 24.0 HR/DAY | |
| WITH GENERATION CREDIT.. | $ 861 |
| NO GENERATION CREDIT.... | $ 938 |
| COST PER BBL OF OIL...... | 125¢ |
| COST PER BBL OF LIQUID.. | 7¢ |
| NAMEPLATE FL AMP RATING.... | 120 |
| THERMAL AMPS............... | 86 |
| CLF........................ | 1.419 |
| RECOMMENDED MIN HP.(D)... | 60.0 |
| NAMEPLATE HP RATING...... | 100.0 |
| INPUT HP (GROSS)......... | 43.6 |
| INPUT HP (NET)........... | 40.1 |
| AVERAGE KVA.............. | 69.9 |
| AVERAGE KW | |
| WITH GENERATION CREDIT.. | 29.9 |
| NO GENERATION CREDIT.... | 32.6 |
| AVERAGE POWER FACTOR..... | 36% |
| STROKES PER MIN.......... | 8.82 |
| BOPD..................... | 25 |
| BWPD..................... | 400 |
| SYSTEM EFFICIENCY........ | 57% |

Hit [ENTER] to save SCREEN or type [N]o to not save:

Figure 9

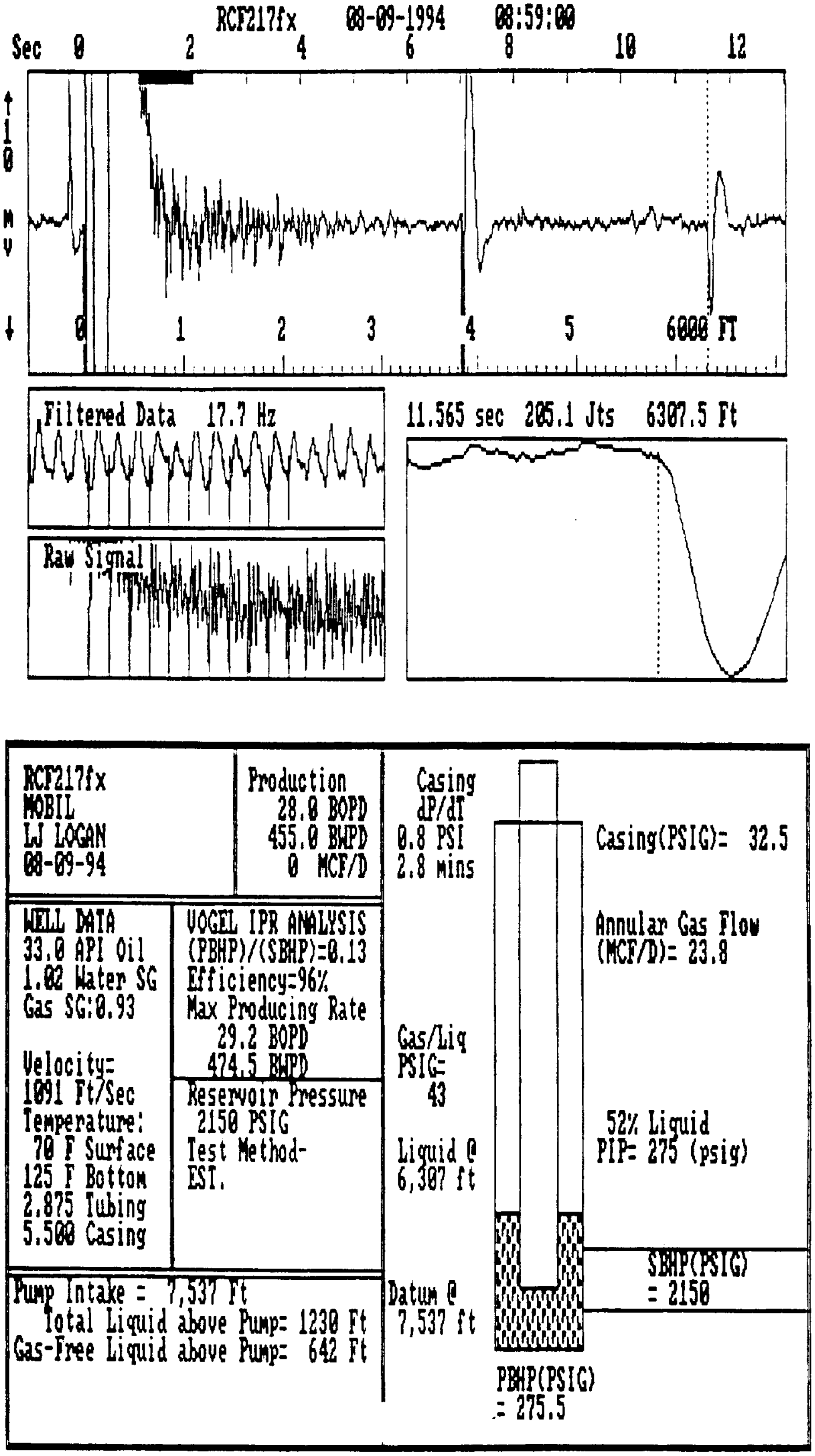

RCF217fx 08-09-1994 08:59:00
Sec 0 2 4 6 8 10 12
10 MV
0 1 2 3 4 5 6000 FT
Filtered Data 17.7 Hz
11.565 sec 205.1 Jts 6307.5 Ft
Raw Signal
RCF217fx
MOBIL
LJ LOGAN
08-09-94
Production
28.0 BOPD
455.0 BWPD
0 MCF/D
Casing
dP/dT
0.8 PSI
2.8 mins
Casing(PSIG)= 32.5
WELL DATA
33.0 API Oil
1.02 Water SG
Gas SG:0.93
Velocity=
1091 Ft/Sec
Temperature:
70 F Surface
125 F Bottom
2.875 Tubing
5.500 Casing
VOGEL IPR ANALYSIS
(PBHP)/(SBHP)=0.13
Efficiency=96%
Max Producing Rate
29.2 BOPD
474.5 BWPD
Reservoir Pressure
2150 PSIG
Test Method-
EST.
Annular Gas Flow
(MCF/D)= 23.8
Gas/Liq
PSIG=
43
Liquid @
6,307 ft
52% Liquid
PIP= 275 (psig)
SBHP(PSIG)
= 2150
Pump Intake = 7,537 Ft
Total Liquid above Pump= 1230 Ft
Gas-Free Liquid above Pump= 642 Ft
Datum @
7,537 ft
PBHP(PSIG)
= 275.5

Figure 10

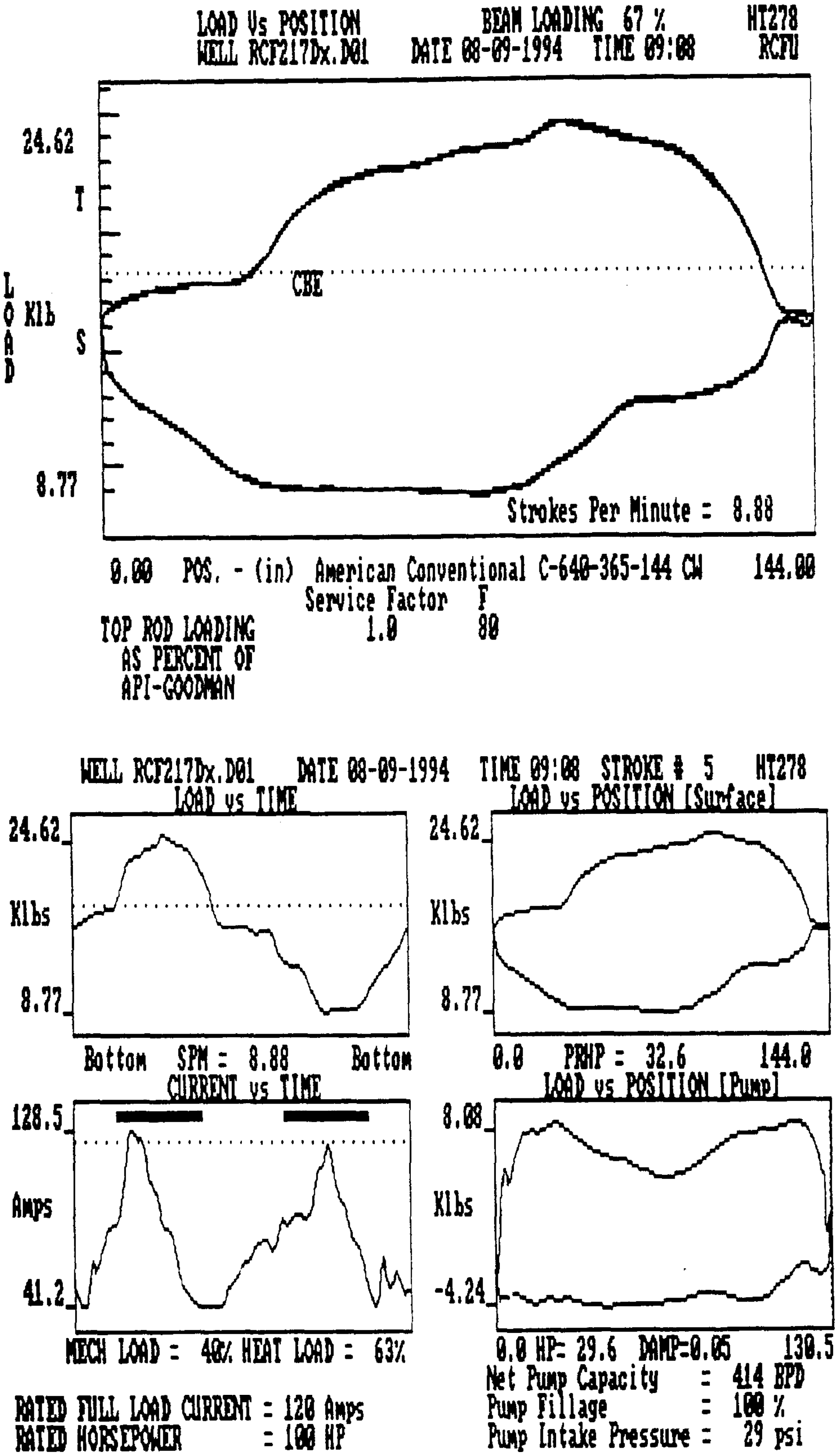
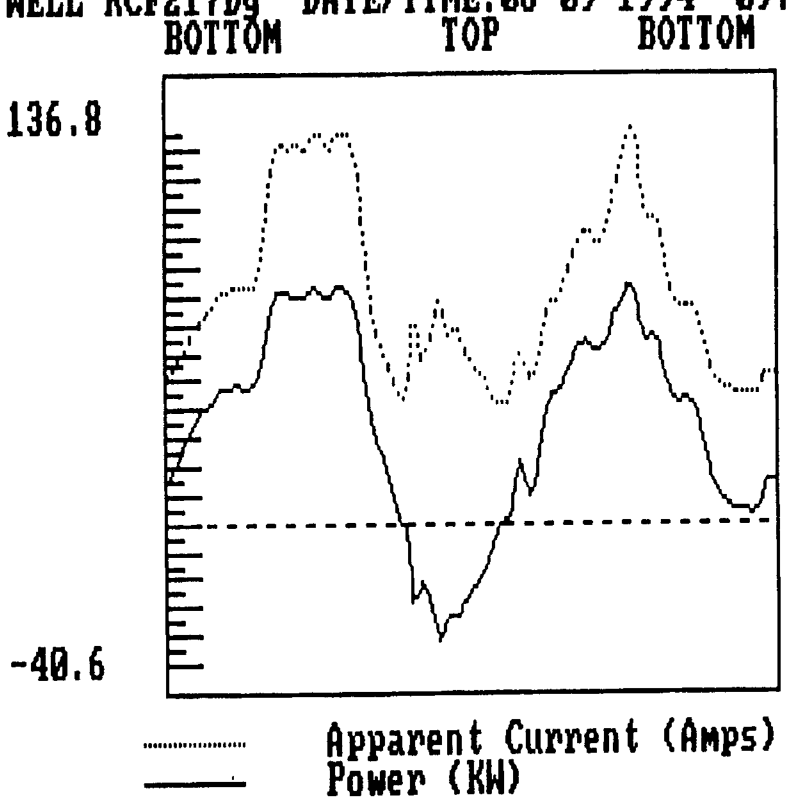

LOAD Vs POSITION
BEAM LOADING 67 %
HT278
WELL RCF217Dx.D01
DATE 08-09-1994
TIME 09:08
RCFU
24.62
T
LOAD Klb
S
CBE
8.77
Strokes Per Minute = 8.88
0.00
POS. - (in)
American Conventional C-640-365-144 CW
144.00
Service Factor F
TOP ROD LOADING AS PERCENT OF API-GOODMAN
1.0
80
WELL RCF217Dx.D01
DATE 08-09-1994
TIME 09:08
STROKE # 5
HT278
LOAD vs TIME
24.62
Klbs
8.77
Bottom
SPM = 8.88
Bottom
LOAD vs POSITION [Surface]
24.62
Klbs
8.77
0.0
PRHP = 32.6
144.0
CURRENT vs TIME
128.5
Amps
41.2
MECH LOAD = 40% HEAT LOAD = 63%
LOAD vs POSITION [Pump]
8.08
Klbs
-4.24
0.0 HP= 29.6 DAMP=0.05
130.5
Net Pump Capacity = 414 BPD
Pump Fillage = 100 %
Pump Intake Pressure = 29 psi
RATED FULL LOAD CURRENT = 120 Amps
RATED HORSEPOWER = 100 HP

Figure 11

WELL RCF217Dy DATE/TIME:08-09-1994 09:27




POWER/CURRENT ANALYSIS

| | |
|---|---|
| COST PER MONTH RUN 24.0 HR/DAY | |
| WITH GENERATION CREDIT.. | $ 990 |
| NO GENERATION CREDIT.... | $1100 |
| COST PER BBL OF OIL...... | 131¢ |
| COST PER BBL OF LIQUID.. | 8¢ |
| NAMEPLATE FL AMP RATING.... | 75 |
| THERMAL AMPS.............. | 87 |
| CLF....................... | 1.435 |
| RECOMMENDED MIN HP.(D)... | 70.4 |
| NAMEPLATE HP RATING...... | 60.0 |
| INPUT HP (GROSS)......... | 51.2 |
| INPUT HP (NET)........... | 46.1 |
| AVERAGE KVA.............. | 68.1 |
| AVERAGE KW | |
| WITH GENERATION CREDIT.. | 34.4 |
| NO GENERATION CREDIT.... | 38.2 |
| AVERAGE POWER FACTOR..... | 41% |
| STROKES PER MIN.......... | 8.89 |
| BOPD..................... | 28 |
| BWPD..................... | 455 |
| SYSTEM EFFICIENCY........ | 57% |

Hit [ENTER] to save SCREEN or type [N]o to not save:

Figure 12

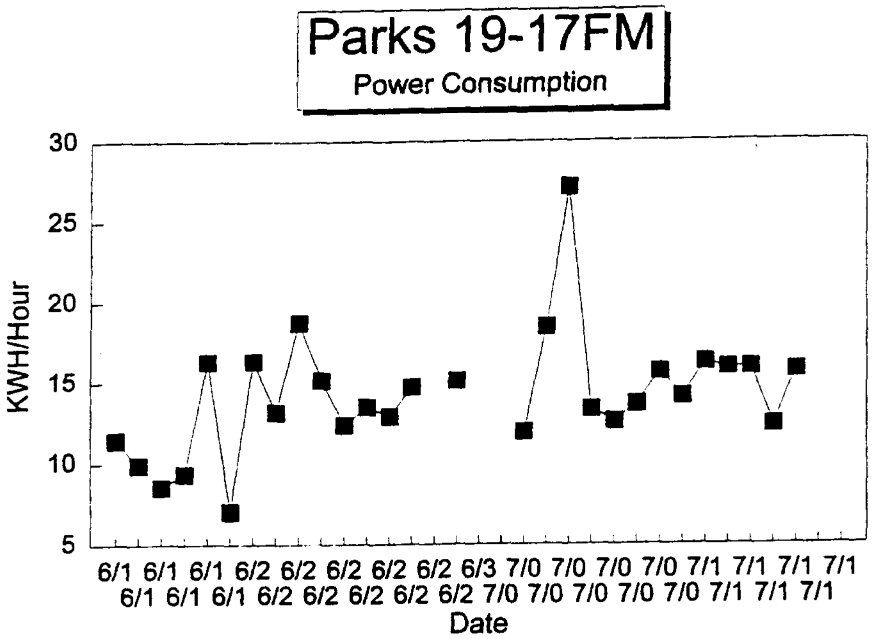



Figure 13

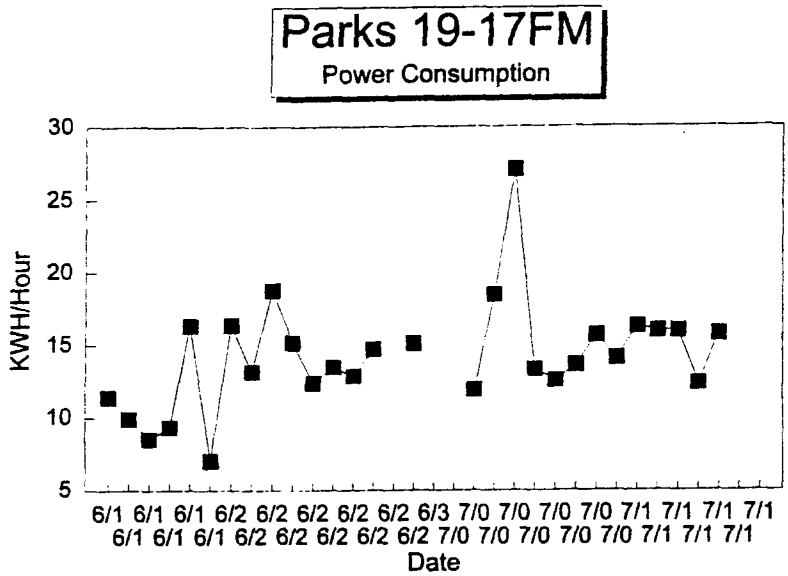



Figure 14

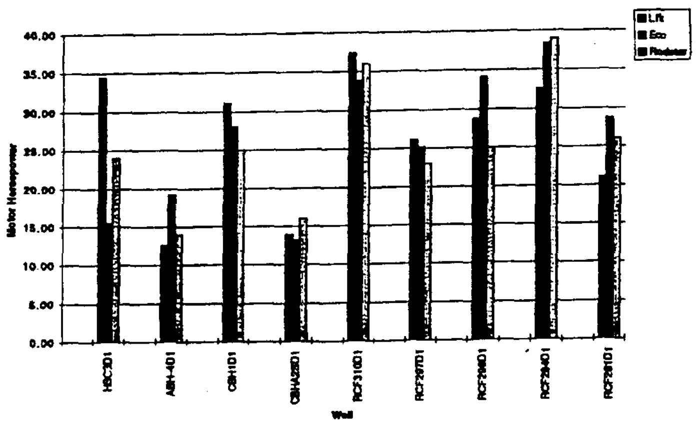



Figure 15

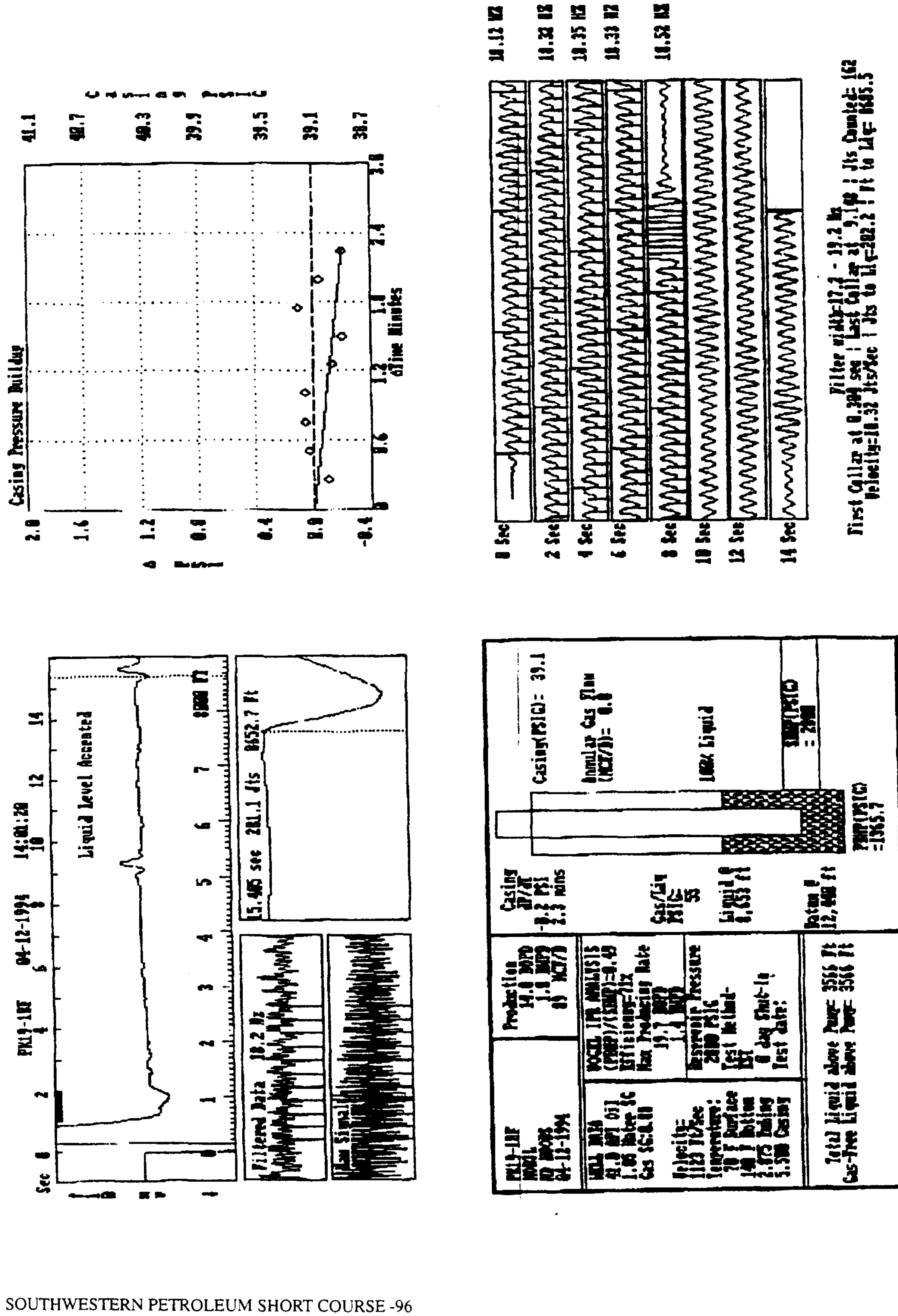


Figure 16

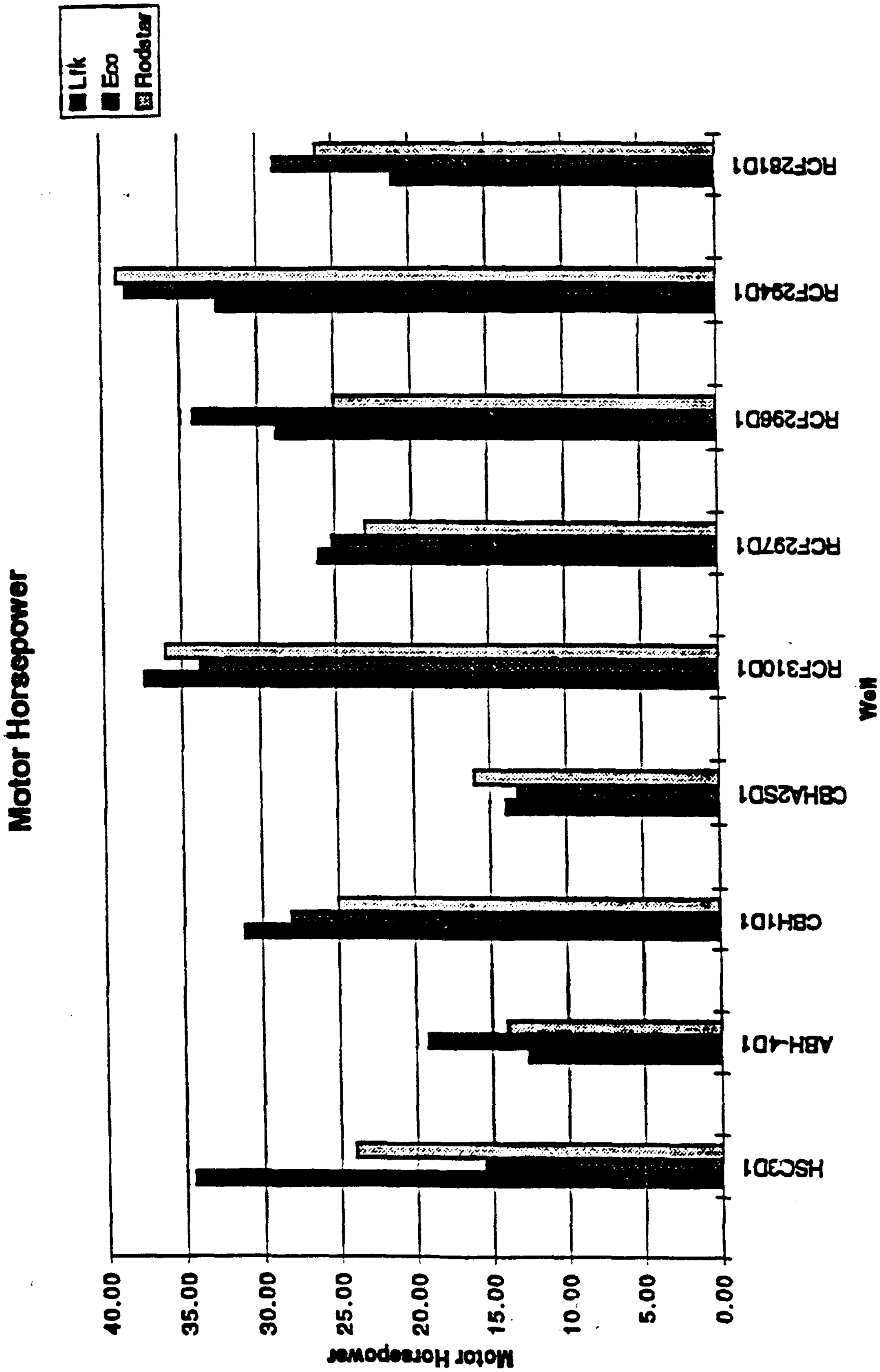
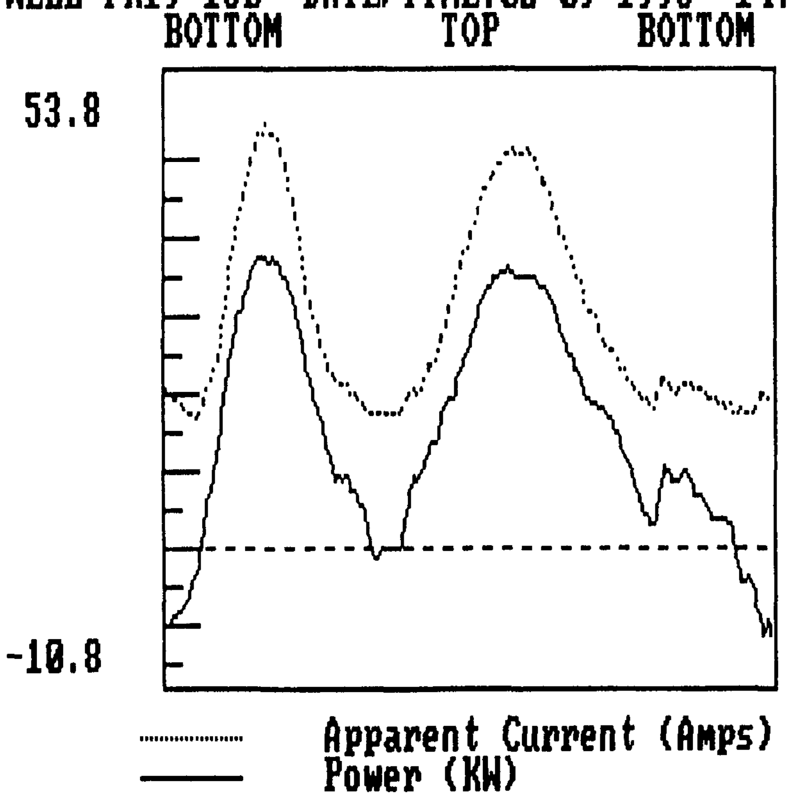

Motor Horsepower
Lfk
Eco
Rodstar
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Motor Horsepower
HSC3D1
ABH-4D1
CBH1D1
CBHA2SD1
RCF310D1
RCF297D1
RCF296D1
RCF294D1
RCF281D1
Well

Figure 17

WELL PK19-18B DATE/TIME:02-09-1995 14:50




RELIANCE dutymaster amps 95/74/50

Hit [ENTER] to save SCREEN or type [N]o to not save:

POWER/CURRENT ANALYSIS

| | |
|---|---|
| COST PER MONTH RUN 24.0 HR/DAY | |
| WITH GENERATION CREDIT.. | $ 536 |
| NO GENERATION CREDIT.... | $ 566 |
| COST PER BBL OF OIL...... | 135¢ |
| COST PER BBL OF LIQUID.. | 126¢ |
| NAMEPLATE FL AMP RATING.... | 95 |
| THERMAL AMPS.............. | 32 |
| CLF...................... | 1.369 |
| RECOMMENDED MIN HP.(D)... | 29.0 |
| NAMEPLATE HP RATING...... | 100.0 |
| INPUT HP (GROSS)......... | 21.1 |
| INPUT HP (NET)........... | 20.0 |
| AVERAGE KVA.............. | 24.5 |
| AVERAGE KW | |
| WITH GENERATION CREDIT.. | 14.9 |
| NO GENERATION CREDIT.... | 15.7 |
| AVERAGE POWER FACTOR..... | 49% |
| STROKES PER MIN.......... | 7.10 |
| BOPD..................... | 14 |
| BWPD..................... | 1 |
| SYSTEM EFFICIENCY........ | 6% |

Figure 18