REDUCING ELECTRICAL CONSUMPTION OF BEAM PUMPING UNITS BY PROPERLY COUNTERBALANCING USING PC SOFTWARE

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Abstract

With more and more emphasis on reducing expenses for beam units, most operators are examining all areas to try to cut costs. One of the biggest costs in beam unit operations is the associated electrical charges.

Examining the pumping units to determine and adjust to the optimum counterbalance will reduce the electrical bill. Several fields have been checked with a PC software program, which allows the operator to determine how far out of balance the units are and what it will take to properly balance them. Properly balanced pumping units will result in savings both in kilowatt hours demand and also in consumption, reducing the electrical costs.

Examples from several fields are discussed, including the actual power costs and the reduction in expenses that occurred.

Introduction

The first approach in determining if your wells require rebalancing or motor downsizing is to conduct a survey of the field. When the POWER software first became available, it was run on several individual wells to determine if either the unit was out of balance problem or if the motor was too large. This micro approach does not address any real potential cost savings unless a particular unit is way out of balance. The POWER program requires actual well data be gathered. The two probes are connected to the incoming electrical lines during two strokes of the pumping unit to gather information for interpretation. The actual time to measure these values is small, but all of the data is necessary to properly interpret the condition of the well. If the well is operated with a pump-off controller, you must determine the condition of the well for the majority of the run time, since it may vary widely from first coming on to just before pump-off.

The first small field surveyed consisted of 17 producing wells in the Waddell field, near Crane, Texas. Production depths range from 8700' to 9700' and all wells were equipped with beam pump units. This particular field also has a history of high gas-oil ratios, which has caused some lifting problems in the past. Incomplete pump fillage is not uncommon from this area, since in some cases, the tubing intake is located above the perforations.

Direction of pumping unit rotation was also checked with respect to which cost less electrically to run. In some cases changing the direction of rotation did help reduce the electrical costs and the rotation was permanently changed to take advantage of the savings. Some other work is being done right now to try to determine which tap on a high-slip motor is best and does direction of rotation make a difference in operations. Preliminary indications are to operate in the high-torque mode and rotate counterclockwise, unless rod overloading becomes a problem.

Table I lists the wells in the Waddell area and the resultant data gathered from the survey of the field. A meeting was held with the field personnel to present the results and to recommend moving counterbalance weights on 12 of the 17 wells. The estimated cost savings amounted to $168.00 per month based on the software predictions. The field personnel agreed to have this work done and we proceeded.

One advantage to the POWER software is that the measurements are made from the motor end of the pumping unit rather than the polished rod. The other software programs available on today's market require a dynamometer card be cut, the card interpreted and then to plug in the resultant data to the software programs to determine the best counterbalance for a particular well. Another plus to the POWER software is that it does not have to have a particular counterbalance weight library. A counterbalance dimension can be measured, the volume determined and the weight can be calculated/estimated from this information. The POWER software can then be run, and with this new information, the counterbalance weights can be moved further in or out.

To confirm the proposed work on the wells in the Waddell area, a dynamometer card was taken on each well prior to moving the counterbalance weights. This gave us confirming polished rod data as well as determining how complete the pump fillage was on each well during its pumping cycle. All of the wells were equipped with pump-off controllers (POC'S). The POWER software was also run again prior to moving any counterbalance weights, to assure us that each well did require changing the position of the weights.

Another advantage to the POWER software is that it allows the user to check the intermediate results while moving the counterbalance weights. Since the program only requires two strokes of the pumping unit, in many cases we would move one counterbalance weight, move the contractor's equipment away from the unit, start the unit up and measure again with the POWER program to determine/confirm the next required move was correct. This gives the operator much more confidence in moving the counterbalance weights, since you can tell during the middle of the work how successful each change is in obtaining a better balanced counterweight position. Figures 1-5 present the data from one of the wells in which the counterbalance weights were moved and POWER was run between each move.

After the counterbalance weights were moved to their final positions, a confirming POWER run was made, to again verify the initial survey. Table II presents the final data runs compared to the initial survey data. As you can see, most of these wells did show an improvement in balanced conditions.

The next step for the Waddell area was to gather actual billed electrical costs to operate the beam units prior to doing any counterbalance weight moving. This particular area has one electric meter, from which power is supplied both to the individual wells and also the water injection station. We had to back out the costs associated with the water station to determine how much electricity was being used by the pumping wells. Injection pump run time and horsepower usage was determined and a table was developed to reflect the electrical consumption prior to this work. Table III presents the data from both before the work was done as well as after. As you can see, the predicted savings of $168.00 per month was much less than our actual savings. This is probably due to the demand factor we are billed for as well as KW consumption. The KW demand was not included in the cost savings calculations. The KW demand factor was reduced about ten percent, and at $7.63 per KW demand, amounted to another $375.00 per month is savings. This together with the reduced KW consumption provided a quicker payout than initially calculated.

You will also note in Table III a three-month decrease in electrical costs and then an increase. This increase could not be accounted for with respect to anything different happening, so we elected to resurvey the field with the POWER software. Any changes could then be so noted.

The resurvey of the Waddell area was quite a surprise. We found several wells operating on "Manual Control" rather than with the POC. Because of this, obviously the electrical costs were higher, since the wells do not require continuous pumping. Some personnel changes have occurred during the increase in electrical costs and this probabaly led to the lack of communication between the lease operators and other field staff. There were also some POC electrical problems that were not immediately repaired and because of this, the POC's were not effective in controlling the operation of the wells.

While this work was being done, a question arose as to was there any "Rule of Thumb" for determining how far out of balance a unit would have to be to require action being taken based on potential cost savings. As best we can determine, for API 456 units and smaller, if the out of balance is less than ten percent of the unit rating, it is probably not worth moving the weights. For units more than ten percent out of balance (torque values), it will be worthwhile to reposition the weights. For API 640 units and larger, anything over 50,000 in-lbs is probably worth repositioning the weights. This "Rule of Thumb" is not firm, but should give the operator some guidelines on where to start moving weights around. This statment is based on some work done moving counterbalance weights when the units were less than 10 percent out of balance.

Second Phase

Because of the indicated success of the work in the Waddell field, the Parks field was selected to survey next. The Parks Fields contains about 90 producing wells, most of which are on a beam pump. This field also has a normal high gas-oil ratio. Table IV presents the results of the survey through the field, listing only wells requiring some rebalancing. Again a meeting was held with the field personnel to present the results of this survey, and they agreed to go ahead with moving counterbalance weights to reduce electrical costs.

At the north end of the Parks field we have a few wells with either individual meters or with a small number of wells tied to a single meter. The wells were rebalanced according to recommendations from the POWER software or another program and data was collected for the electrical bills in these smaller installations as well as the larger single field meter. The water injection station is also included in the larger master meter, so it was deducted from the base meter rate to try to determine any changes in power use in the field.

Table V presents the data for the main area in the Parks field and Table VI presents the single well data. As you can see, the single well data gets confusing, since any change at the well head (i.e. run time, downtime, pump-off-control resetting) affects the electrical readings for the month. Individual well problems are explained in the footnotes at the bottom of Table VI. These wells were also rebalanced using a different software program. At this time the results are inconclusive with respect to improvement. Future work with these wells is to resurvey the area with the POWER software to determine if any potential electrical cost savings are available.

One area of interest in this work is the measurement of the power factor for each well. Low power factors usually suggest room for improvement in the electrical design/installation and this was confirmed by our work. However, trying to create large improvements in the power factor is not easy. Even though we tried to optimize each well with the best electrical installation available (without completely changing out equipment), large improvements in the power factor was not always the case. Perhaps decreasing motor sizes on some of these wells will help improve the power factor.

Changing from the 440 volt taps to the 762 volt taps when available was tried on some high slip motors to determine any potential savings by going to this particular winding rather than the highest or lowest torque mode on the electric motor. The results of this effort may explain part of the increase in the electrical bill at Waddell, since after the work was done, we noticed an increased electric bill.

Future Work

Downsizing motors remains an interesting question. Most of the wells in West Texas were sized for larger than actual pumping conditions. "When the waterflood hits we have to be able to pump it off!" was a common statement years ago when selecting both motor size as well as pumping unit size. Consequently, there are many units in West Texas that are over designed both for lifting capacity and motor size.

We are in the process of evaluating the economics of downsizing motors, but as of this writing, do not have enough information to pass on to the reader. We are trying to carefully measure the pre-KWH consumption and KW demand prior to downsizing the motor, make the motor change and then carefully measure the results of this work. A well was selected in the Russell Ranch field to do this work. A multi-channel electrical meter was installed on the well prior to downsizing the motor, to determine the KWH per month, KW demand and power factor for this well. A 72-hp motor was on the well and the POWER software indicated a 30-hp motor would be sufficient to produce the well.

Once the results of this well are known, we plan to select a small group of candidate wells for motor downsizing and expand the effort to determine economics of a single motor change versus a group motor change.

Another question resulting from this work is the frequency of re-surveying the field with the POWER software. How dynamic is the particular field? Do you choose a certain increased electrical bill value to decide when to survey, or should you look at production changes. If you look at production changes, how big a change will require re-surveying? Or do you just go out and resurvey a field every X number of months, until sufficient information becomes available to allow the user to understand the dynamics of the field. None of these questions has been sufficiently answered in our opinion at this time. We have re-surveyed the Waddell field, approximately six months after the initial survey. The results of the re-survey indicated operational problems more so than changing downhole conditions. There were some downhole changes noticed, but the surface operational problems overwhelmed them.

A third area of further investigation is positioning of the counterbalance weights. Traditionally, most operators position the counterbalance weights to be equally balanced on the crank arms. However, during some of our work we noticed that by postioning the counterbalance weights in a certain direction of rotation, we could create a "slinging" effect. This slinging effect tends to generate power/electricity on part of the stroke and if there is detente credit for your electricity, there may be a savings available. This work is in its infancy, and we thus far have little information about it. It may have some potential savings

Conclusions

From the above we conclude:

A. The utilization of the POWER software can indeed reduce electrical costs.

Proper balancing of the pumping unit counterbalance weights has reduced the electrical operating costs in the fields we have examined thus far. Even though the torque values may increase, there is an overall savings, perhaps due to the unit being better balanced. Better balancing of the pumping unit adds to the longevity of the unit. The smoother operation of the pumping unit also decreases the possibility of damaging equipment because of overloading.

B. An additional savings is available when rebalancing counterweights due to a decrease in KW demand.

The KW demand portion of the electric bill can be a significant part. This was a pleasant surprise to us when we observed the ten percent reduction in KW demand. In the Crane area, this helped increase the cost savings of the monthly electrical bill, far exceeding our original cost savings estimates. KW demand should be closely examined to try to reduce it as much as possible.

C. Direction of rotation should be checked for each well, since there may be electrical savings available by changing direction.

Changing direction of rotation on pumping units is simple, and there may be cost savings available. We have also noticed in some cases a reduction of peak torque by changing rotation. The cost savings were not great, but the torque reduction in one direction was reduced and would better load the unit for torque in both directions. This will improve the life of the pumping unit.

D. There will not be a huge savings in electrical costs, but savings of up to ten percent have been observed on smaller fields from the data thus far gathered.

The POWER software will help to reduce electrical costs. However, it will not be a 25-percent savings, but more likely savings of up to 10-12 percent are available. For a small lease these costs may not be large. However, most small leases have higher per-kilowatt-hour charges and the wells would be worth examining to note any potential savings with the POWER software. For large fields, we have observed potential savings and are surveying all of our operations with the POWER software in West Texas.

We would like to thank Mobil E & P U.S. for permission to publish this paper. Thanks also are extended to Larry Logan and James Wolf of Mobil for conducting many of the surveys.

References

1. McCoy, J.N., Collier, F.B. and Podio, A.L., *Application of Real-Time Measurement of Motor Power to Determination of Beam Pump Efficiency*, Southwestern Petroleum Short Course, Lubbock, Texas, 1994.

2. McCoy, J.N., Podio, A.L., Jennings, J. and Drake B., *Motor Power, Current and Torque Analysis to Improve Efficiency of Beam Pumps*, Southwestern Short Course, Lubbock, Texas, 1993.

Table 1 - University Waddell Wells Requiring Counterweight Balancing

Well No.	Production (O/W)	Monthly Bill $	Out of Balance, M in-lbs.	Peak Torque, POWER ft-lbs	Avg. KW POWER Software	Move Weights
319	47/9	236.	124.	410	17.5	Remove weights
324	16/30	106.	82.	189.	2.9	Move all in 11.25"
323	18/26	472.	80	389.	25.2	Move out 25.125"
102	14/15	146.	75.	226.	8.3	Move weights out
321	70/48	791.	70.	379.	20.9	Move RJL in 38.25"
313	23/48	348.	66.	207.	9.7	Move wts in 13.375"
320	46/26	497.	54.	327.	13.8	Add heavier weights
422	94/101	443.	48	268.	13.3	Move in 8.5"
327	29/4	149	51	210.	8.6	Remove weights
605	40/13	176.	40.	179	10.4	Move out 2 weights
326	58/16	488.	36	450.	13.6	Move XJR in 9.5"
401	48/6	227.	38	243.	15.5	Move 2-2RO's in

Table 2 - University Waddell Lease POWER Software Measurements

Well #	POWER Software Electrical Costs $/month Before*	After	Change	Peak Torque Values Before*	After
319	236.	194.	-42.	301	306.
324	221.	188.	-33	139	143
323	770.	853.	+83.	388	429
102	146.	126.	-20	161.	191
321	753	781	+28	316	297
313	349	356.	+7	162.	173
320	595	605.	+10.	344	349
422	553	735	+182	368.	414
327	123	87	-36.	178	130
605	188	100.	-88	139	104
326	488	262	-226.	404	336
401	221	188	-33	216	196
			-168		

* The values reported here are from the resurvey of the field prior to moving weights

Table 3 - University Waddell Electrical Costs

Period	Days	KW Demand	KWH Used	Downtime, Days	Downtime KWH	KWH w/o Pump	Electric Bill, $	$w/o Pump	$/Day w/o Pump
27Dec93-25Jan94	26	549	314488	0	0	239291	15688.59	12068.43	431.02
25Jan94-23Feb94	28	576	310092	0	0	234895	16046.21	13898.37	496.37
23Feb94-25Mar94	28	559	347692	0	0	272495	16728.04	13165.93	470.21
25Mar94-26Apr94	31	547	321419	7	18799	256964	15849.78	12646.84	407.96
26Apr94-26May94	30	543	280191	21	56398	256021	14065.58	12351.67	411.72
26May94-27Jun94	31	497	323456	1.2	3134	243336	14528.61	11016.31	355.36
27Jun94-27Jul94	30	532	268726	0	0	188158	13559.94	9921.84	330.73
27Jul94-26Aug94	30	485	278387	0	0	197819	13222.59	9611.40	320.38
26Aug94-27Sep94	32	496	303930	0	0	217991	14031.25	10276.22	321.13
27Sep94-27Oct94	30	517	308138	0	0	227570	14412.61	10941.32	354.71
27Oct94-29Nov94	33	505	331089	0	0	269049	14846.52	12985.96	393.51

Note: Work was done in Mid May 1994, to rebalance the counterweights

Table 4 - Parks Field Wells Requiring Counter Balance Weight Adjustment

Well No	Out of Balance	Power, KWH	Peak Torque M-in lbs	Min Torque M-in lbs	Balanced M-in lbs
18-26	241" Out	10.1	324	20	177
25-5	212" Out	6.6	321	58	185
19-14	168" Out	6.4	384	132	224
19-17	125" Out	11.3	393	187	282
18-21	123" Out	8.7	459	216	341
23-15	114" In	17.2	197	420	307
16-14	109" In	7.5	213	391	290
19-18	108" Out	16.7	531	372	437
23-11	100" In	7.5	154	315	256
25-3	99" Out	11.0	243	73	160
MVB-1	87" Out	9.5	360	202	277
AB-10	86" Out	14.2	349	188	270
18-27	73" Out	7.0	171	79	123
ABH-4	70" In	11.4	188		113
14-18	69" Out	7.5	227	117	181
CBH-2	65" In	3.7	154		97
HSC-3	60" Out	10.1	192		136
23-21	59" In	14.5	103	214	160
26-18	47" Out	13.8	240	148	192
ABH-3	47" Out	8.5	257		218
RPA-1	41" Out	4.9	238	176	200
MVB-2	41" Out	3.4	188	131	155

Well No.	Out of Balance	Power, KWH	Peak Torque M-in lbs	Min Torque M-in lbs	Balanced M-in lbs
14-19	38" Out	9.3	98	156	135
18-13	35" Out	7.4	342	277	312
RPC-2	33" Out	7.7	212	151	184
26-A9*	18" In	6.0	158	189	175

*Change Rotation Only

Table 5 - Parks Field Electrical Costs

Billing Period	Days	KWH	Adjusted	$	$ Adjusted	$/Day
15Dec94-14Nov94	31	486449.	174825. *	14574.75	5244.75	169.19
14Nov94-13Oct94	32	478343.	195258.	14301.63	5838.21	182.44
13Oct94-14Sep94	29	420234.	187004.	12783.55	5684.92	196.03
14Sep94-12Aug94	33	471520.	232653.	13957.08	6886.53	208.68
12Aug94-14Jul94	29	412300.	225702.	12517.91	6861.34	236.60
14Jul94-13Jun94	31	459658.	260192.	13781.35	7805.76	251.80
13Jun94-12May94	32	447158.	241257.	13600.04	7334.21	229.19
12May94-13Apr94	29	425909.	239311.	13259.23	7442.57	256.64
13Apr94-14Mar94	30	439600.	246568.	13694.68	7692.92	256.43

* 1. Water Injection pumps (200 BHP) have been subtracted out
2. Five new wells were added to the field, beginning in August 1994 through November 1994
3. Work was done in late July to rebalance the counterweights

Table 6 - North Parks Field Area Electrical Costs

Billing Period	Days	KWH	Adjusted	$	$/Kilowatt	$ Day
15Dec94-14Nov94	31	17532.	19532. *	1348.94	0.0769	43.51
14Nov94-13Oct94	32	19655.	19655	1465.78	0.0746	45.81
13Oct94-14Sep94	29	18173	18173.	1366.75	0.0752	47.13
14Sep94-12Aug94	33	20509	20509	1420.49	0.0693	43.04
12Aug94-14Jul94	29	18891.	18891	1402.63	0.0742	48.37
14Jul94-13Jun94	31	19007	19007	1520.65	0.0800	49.05
13Jun94-12May94	32	21542.	21542.	1549.88	0.0719	48.43
12May94-13Apr94	29	16290	16290	1479.76	0.0908	51.03
13Apr94-14Mar94	30	16172.	16172.	1404.74	0.0869	46.82

* 1. The AB Harrington #2 well was shut in for two weeks in early December
2. Data summed is from wells where counterbalance weights were moved (5 wells adjusted, 7 were not)
3. Work was done in August 1994 to rebalance the counterwieghts

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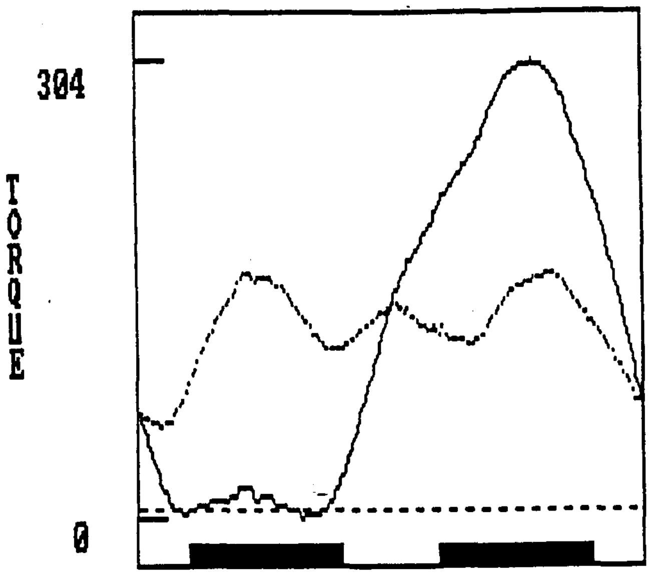


---- TORQUE ANALYSIS -------(T)

UPSTROKE PEAK	12
DOWNSTROKE PEAK	299
BALANCED PEAK	160

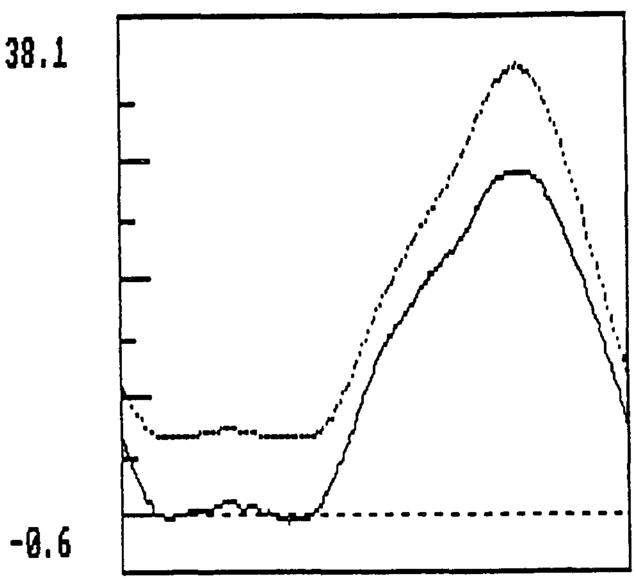
CB CHANGE FOR BALANCE
DECREASE 150

WEIGHT OF COUNTERWEIGHTS TO BE
MOVED, LBS 3180

FOR BALANCE:
MOVE COUNTERWEIGHTS IN INCHES 47

T = 84.5 * P * EFF / (SPM * SU)
EFF= MOTOR/REDUCER = 0.68
SPM= STROKES PER MIN = 6.90
SU= MIN. SPEED/AVG. SPEED = .80
P=POWER(KW) T=TORQUE(1000xINxLBS)
American Conventional
C-320-256-120 CW

WELL RP-28S DATE/TIME:03-22-1995 10:04



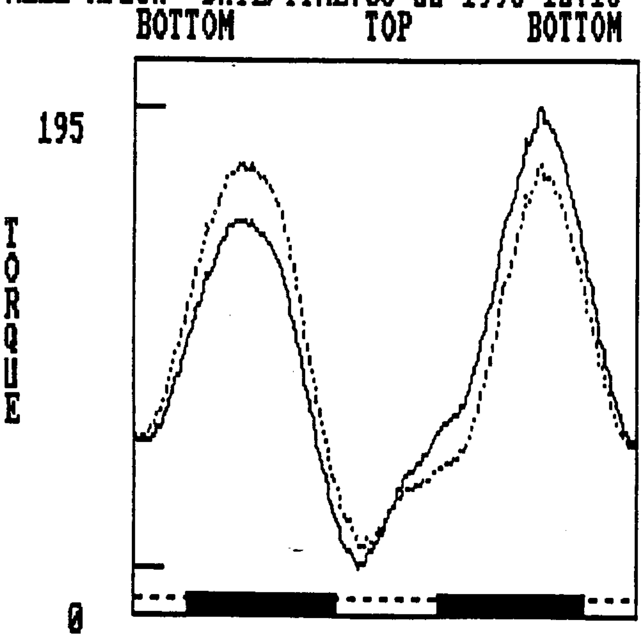
American Conventional
C-320-256-120 CW

POWER/CURRENT ANALYSIS

COST PER MONTH	
WITH GENERATION CREDIT..	$ 423
NO GENERATION CREDIT....	$ 424
COST PER BBL OF OIL.....	353¢
COST PER BBL OF LIQUID..	71¢
NAMEPLATE FL AMP RATING...	35
THERMAL AMPS..............	21
CLF.......................	1.360
RECOMMENDED MIN HP.(D)...	21.7
NAMEPLATE HP RATING......	40.0
INPUT HP (GROSS)........	15.8
INPUT HP (NET)..........	15.7
AVERAGE KVA.............	14.9
AVERAGE KW	
WITH GENERATION CREDIT.	11.7
NO GENERATION CREDIT...	11.8
AVERAGE POWER FACTOR....	57%
STROKES PER MIN.........	6.90
BOPD....................	4
BWPD....................	16

Figure 1

WELL RP28A DATE/TIME:03-22-1995 12:16



Balanced Torque
Actual Torque

---- TORQUE ANALYSIS -------(T)

UPSTROKE PEAK	151
DOWNSTROKE PEAK	195
BALANCED PEAK	173

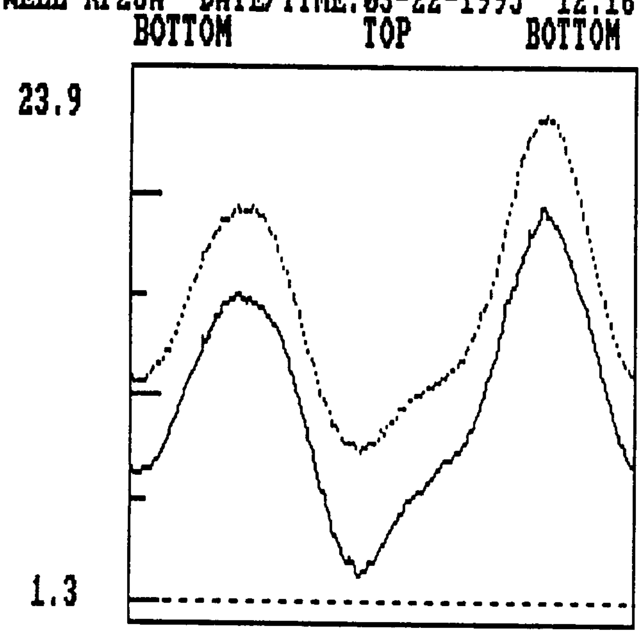
CB CHANGE FOR BALANCE
DECREASE 23

WEIGHT OF COUNTERWEIGHTS TO BE
MOVED, LBS 3180

FOR BALANCE:
MOVE COUNTERWEIGHTS IN INCHES 7

T = 84.5 * P * EFF / (SPM * SV)
EFF= MOTOR/REDUCER = 0.68
SPM= STROKES PER MIN = 7.14
SV= MIN. SPEED/AVG. SPEED = .80
P=POWER(KW) T=TORQUE(1000xINxLBS)
American Conventional
C-320-256-120 CW

WELL RP28A DATE/TIME:03-22-1995 12:16



Apparent Current (Amps)
Power (KW) JIM
American Conventional
C-320-256-120 CW

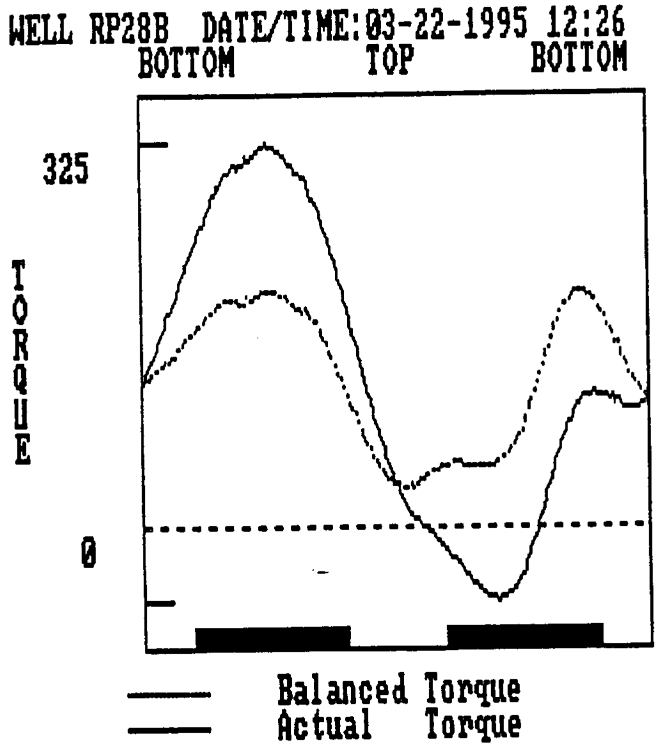
POWER/CURRENT ANALYSIS

COST PER MONTH
WITH GENERATION CREDIT.. $ 354
NO GENERATION CREDIT.... $ 354
COST PER BBL OF OIL..... 295¢
COST PER BBL OF LIQUID.. 59¢

NAMEPLATE FL AMP RATING... 35
THERMAL AMPS.............. 15
CLF....................... 1.117
RECOMMENDED MIN HP.(D)... 18.1
NAMEPLATE HP RATING...... 40.0
INPUT HP (GROSS)........ 13.2
INPUT HP (NET).......... 13.2

AVERAGE KVA............. 12.0
AVERAGE KW
WITH GENERATION CREDIT. 9.8
NO GENERATION CREDIT... 9.8
AVERAGE POWER FACTOR.... 77%
STROKES PER MIN......... 7.14
BOPD.................... 4
BWPD.................... 16

Figure 2



---- TORQUE ANALYSIS -------(T)

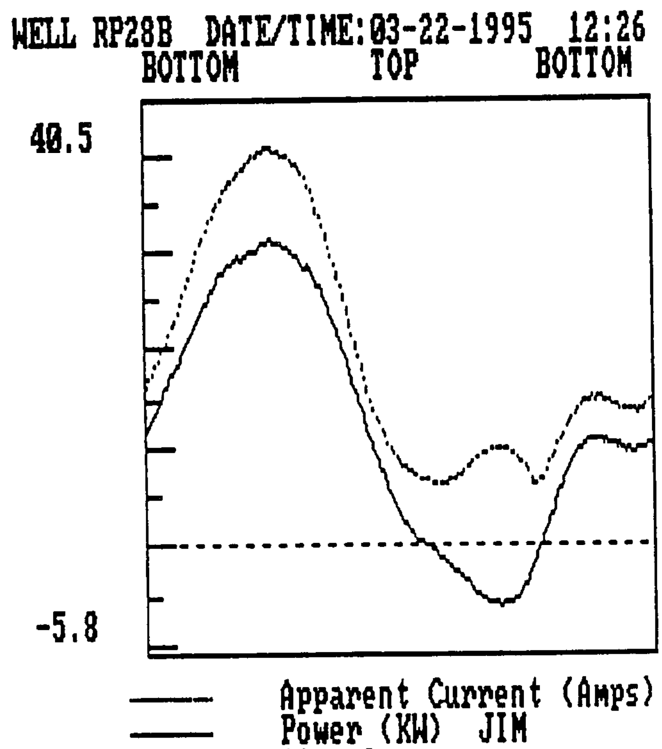
UPSTROKE PEAK	325
DOWNSTROKE PEAK	109
BALANCED PEAK	202

CB CHANGE FOR BALANCE
INCREASE 123

WEIGHT OF COUNTERWEIGHTS TO BE
MOVED, LBS 3180

FOR BALANCE:
MOVE COUNTERWEIGHTS OUT INCHES 39

T = 84.5 * P * EFF / (SPM * SU)
EFF= MOTOR/REDUCER = 0.68
SPM= STROKES PER MIN = 6.90
SU= MIN. SPEED/AVG. SPEED = .80
P=POWER(KW) T=TORQUE(1000xINxLBS)
American Conventional
C-320-256-120 CW



American Conventional
C-320-256-120 CW

POWER/CURRENT ANALYSIS

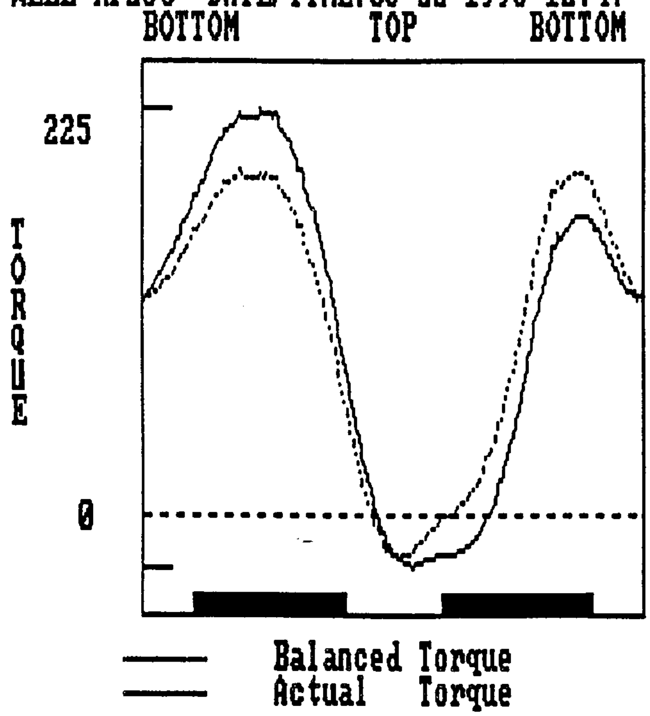
COST PER MONTH
WITH GENERATION CREDIT.. $ 440
NO GENERATION CREDIT.... $ 468
COST PER BBL OF OIL..... 390¢
COST PER BBL OF LIQUID.. 78¢

NAMEPLATE FL AMP RATING... 35
THERMAL AMPS.............. 23
CLF....................... 1.403
RECOMMENDED MIN HP.(D)... 24.0
NAMEPLATE HP RATING...... 40.0
INPUT HP (GROSS)........ 17.4
INPUT HP (NET).......... 16.4

AVERAGE KVA............. 16.2
AVERAGE KW
WITH GENERATION CREDIT. 12.2
NO GENERATION CREDIT... 13.0
AVERAGE POWER FACTOR.... 53%
STROKES PER MIN......... 6.90
BOPD.................... 4
BWPD.................... 16

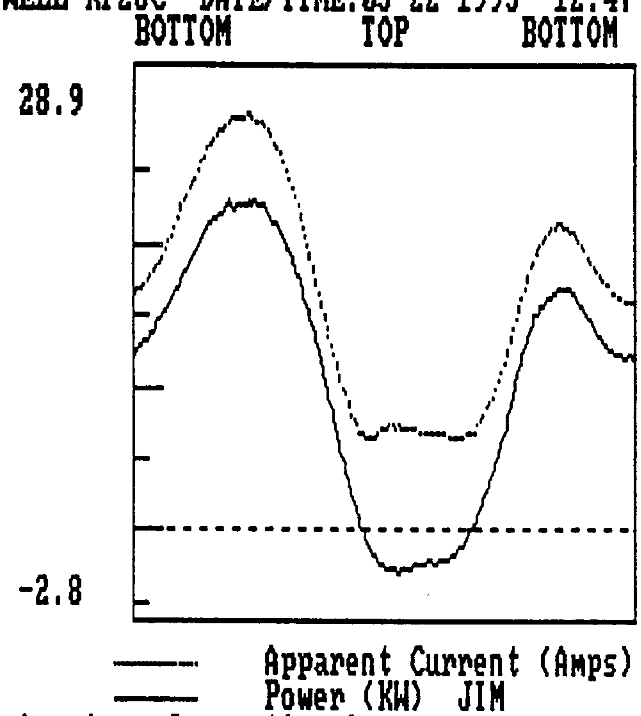
Figure 3

WELL RP28C DATE/TIME:03-22-1995 12:47




```
---- TORQUE ANALYSIS -------( T )
UPSTROKE PEAK                  224
DOWNSTROKE PEAK                165
BALANCED PEAK                  192

CB CHANGE FOR BALANCE
INCREASE                        36

WEIGHT OF COUNTERWEIGHTS TO BE
MOVED, LBS                    3180

FOR BALANCE:
MOVE COUNTERWEIGHTS OUT INCHES  11

T = 84.5 * P * EFF / (SPM * SV)
EFF= MOTOR/REDUCER   = 0.68
SPM= STROKES PER MIN =  7.32
SV= MIN. SPEED/AVG. SPEED = .80
P=POWER(KW) T=TORQUE(1000xINxLBS)
American Conventional
C-320-256-120  CW
```

WELL RP28C DATE/TIME:03-22-1995 12:47



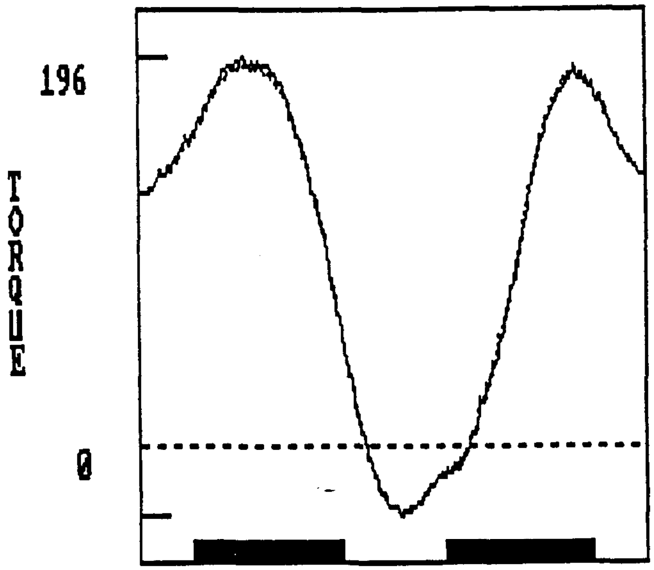
American Conventional
C-320-256-120 CW

```
        POWER/CURRENT ANALYSIS
COST PER MONTH
 WITH GENERATION CREDIT.. $ 387
 NO GENERATION CREDIT.... $ 402
COST PER BBL OF OIL.....   335¢
COST PER BBL OF LIQUID..    67¢

NAMEPLATE FL AMP RATING...    35
THERMAL AMPS.............     18
CLF...................... 1.283
RECOMMENDED MIN HP.(D)...  20.6
NAMEPLATE HP RATING......  40.0
INPUT HP (GROSS)........  15.0
INPUT HP (NET)..........  14.4

AVERAGE KVA.............  13.7
AVERAGE KW
 WITH GENERATION CREDIT.  10.8
 NO GENERATION CREDIT...  11.2
AVERAGE POWER FACTOR....   59%
STROKES PER MIN.........  7.32
BOPD....................     4
BWPD....................    16
```

Figure 4

WELL RP28D DATE/TIME:03-22-1995 13:04

BOTTOM TOP BOTTOM



—— Balanced Torque
—— Actual Torque

---- TORQUE ANALYSIS -------(T)

UPSTROKE PEAK	196
DOWNSTROKE PEAK	189
BALANCED PEAK	192

CB CHANGE FOR BALANCE
INCREASE 4

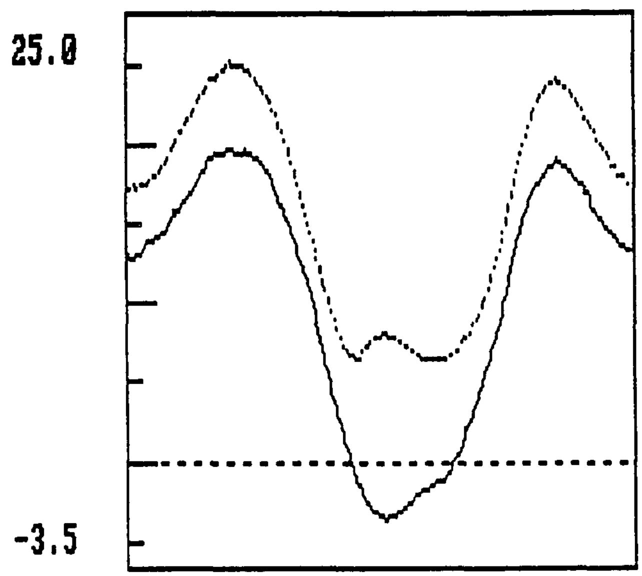
WEIGHT OF COUNTERWEIGHTS TO BE
MOVED, LBS 3180

FOR BALANCE:
MOVE COUNTERWEIGHTS OUT INCHES 1

T = 84.5 * P * EFF / (SPM * SV)
EFF= MOTOR/REDUCER = 0.68
SPM= STROKES PER MIN = 7.23
SV= MIN. SPEED/AVG. SPEED = .80
P=POWER(KW) T=TORQUE(1000xINxLBS)
American Conventional
C-320-256-120 CW

WELL RP28D DATE/TIME:03-22-1995 13:04

BOTTOM TOP BOTTOM



—— Apparent Current (Amps)
—— Power (KW) JIM

American Conventional
C-320-256-120 CW

POWER/CURRENT ANALYSIS

COST PER MONTH
WITH GENERATION CREDIT.. $ 376
NO GENERATION CREDIT.... $ 392
COST PER BBL OF OIL..... 327¢
COST PER BBL OF LIQUID.. 65¢

NAMEPLATE FL AMP RATING... 35
THERMAL AMPS............. 17
CLF...................... 1.261
RECOMMENDED MIN HP.(D)... 20.1
NAMEPLATE HP RATING...... 40.0
INPUT HP (GROSS)........ 14.6
INPUT HP (NET).......... 14.0

AVERAGE KVA............. 13.4
AVERAGE KW
WITH GENERATION CREDIT. 10.4
NO GENERATION CREDIT... 10.9
AVERAGE POWER FACTOR.... 60%
STROKES PER MIN......... 7.23
BOPD.................... 4
BWPD.................... 16

Figure 5