

**ePAC Flux Vector  
Rod Pump Controller  
Variable-Speed Control**

**Bakersfield Test Well Report  
October 01, 2001**



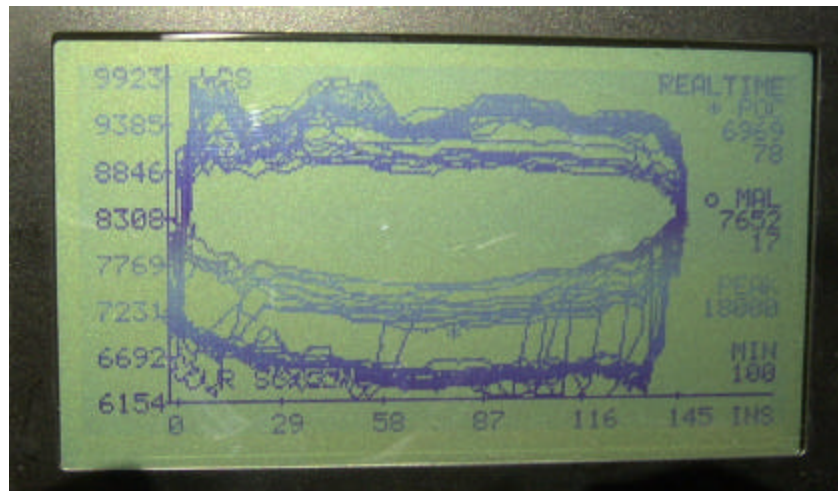
# ePAC TEST WELL BAKERSFIELD, CALIFORNIA

This paper documents the initial benefits of using the ePAC flux vector drive on an active well in California, USA. Benefits include the following:

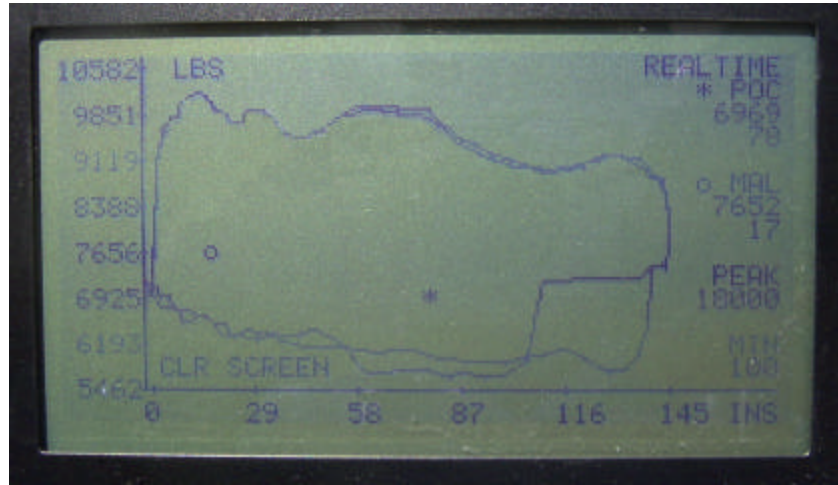
- Substantial power savings
- Reduced tubing and rod wear
- Rod and pump jack forces being dramatically reduced.
- Accurately balance the pump jack.

The ePAC Rod Pump variable speed drive was set up on a well in Bakersfield, California on September 25, 2001. This well was chosen to test all the software features and demonstrate the advantages of the ePAC drive. It is a horizontal steam injection well with the pump sitting at 85 degrees, with a Mark 2 Jack installed running off the line at 7.6 SPM. There was a Pump Off Controller (POC) on the well, which we left running. Due to sand infiltration, the POC was set to keep the well running during a pumped off condition. According to the dynamometer card generated by the POC, the well was running about 50% of the time in a pumped off condition. See Figure 1.

**(Figure 1) Dynamometer Multiple Trace Card Before Any Changes**



Following the setup, the well did not pump off. As the pump fill decreases below the target pump fill, the drive controls the speed to maintain optimum fill. The pump fill is calculated on each stroke. If the pump fill is greater than the target fill, the target fill is reset and the drive speeds up to accomplish the new target fill. Once the pump fill becomes less than the target fill, the drive slows down until target fill is accomplished. Thus the speed ramps up and down to maintain optimum production without pumping the well off. Minimum target fill was set at 60%. Minimum pump fill was set at 45%. As long as there is fluid in the well bore, the drive will slow down in order to never let the fill go below minimum pump fill. See Figure 2.

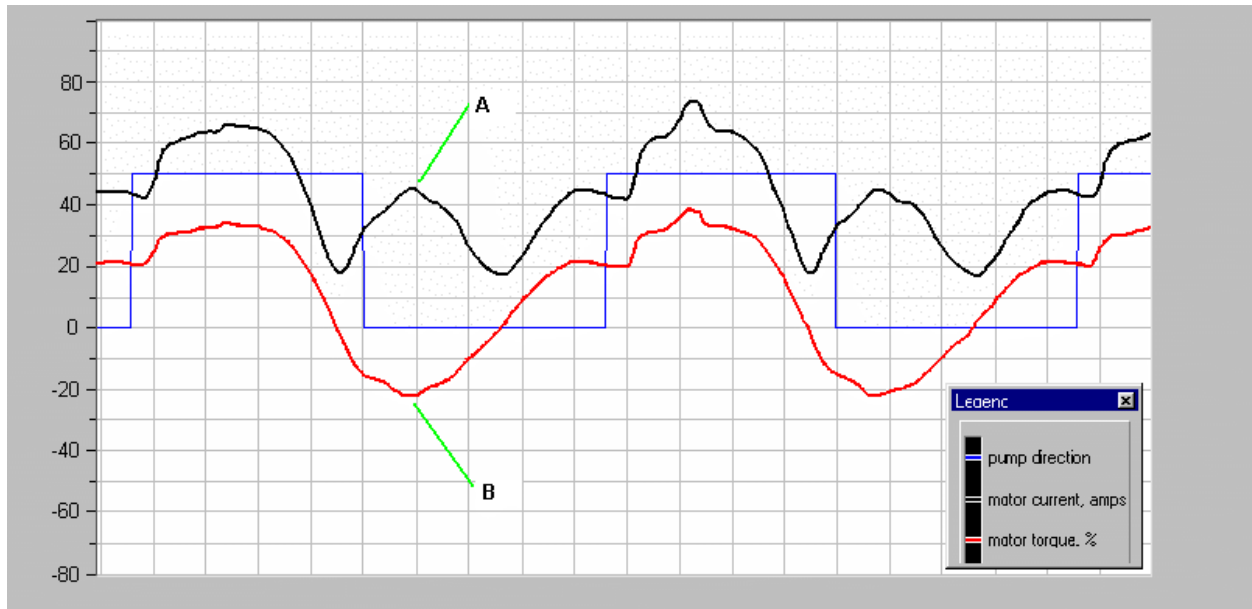
**(Figure 2) Dynamometer After Changes**

### ***Balancing The Pump Jack***

The standard method, throughout the industry, of balancing pump jacks is with an amp probe. Weights are adjusted until the mean amp reading is the same on both the up stroke and the down stroke. This method can be unreliable because if the load is overhauling the motor, as in an out of balance condition, an ammeter can not determine current being fed back down the power line. With the ePAC installed we were able, through charting the motor shaft torque, to determine that the jack was out of balance. On the up stroke, the torque on the motor shaft peaked at -33% with an amp reading of 38 amps, while on the down stroke the torque was 47% with an amp reading of 65 amps. During the up stroke the load was overhauling the motor because the jack was weight heavy and the 38 amps we were reading were in fact being generated by the motor and being fed back onto the power line out of phase. This condition dramatically reduces the power factor and the efficiency of the net work being done compared to the power consumed.

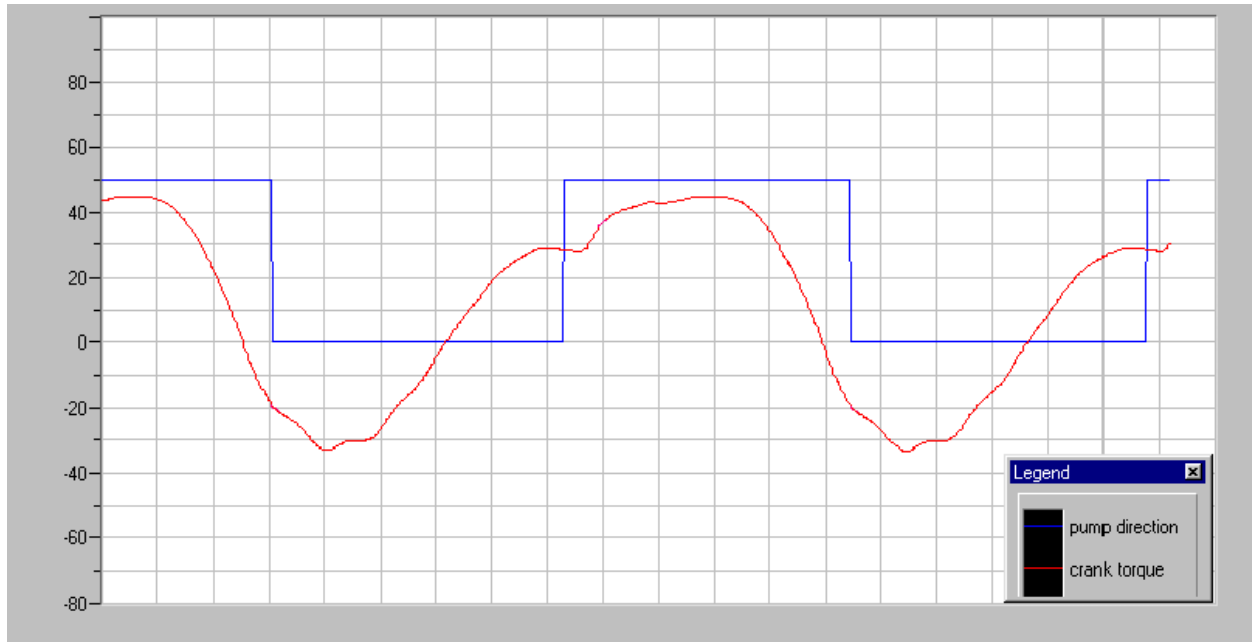
See Figure 3. Note points A and B. The current remains positive even though the torque goes negative (indicating an out of balance well) on the up stroke.

**(Figure 3) Motor Amps Compared To Motor Torque**

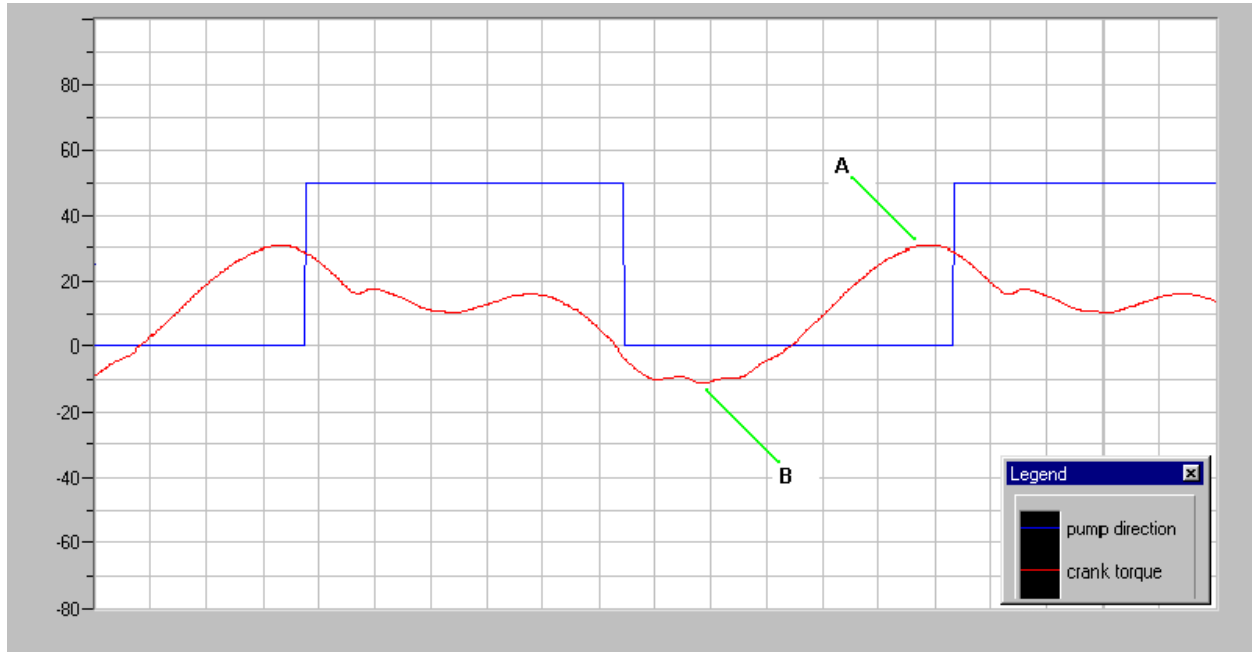


We calculated the out of balance condition and balanced the jack by removing weights. See figure 4 and figure 5.

**(Figure 4) Torque Chart Prior To Any Changes**



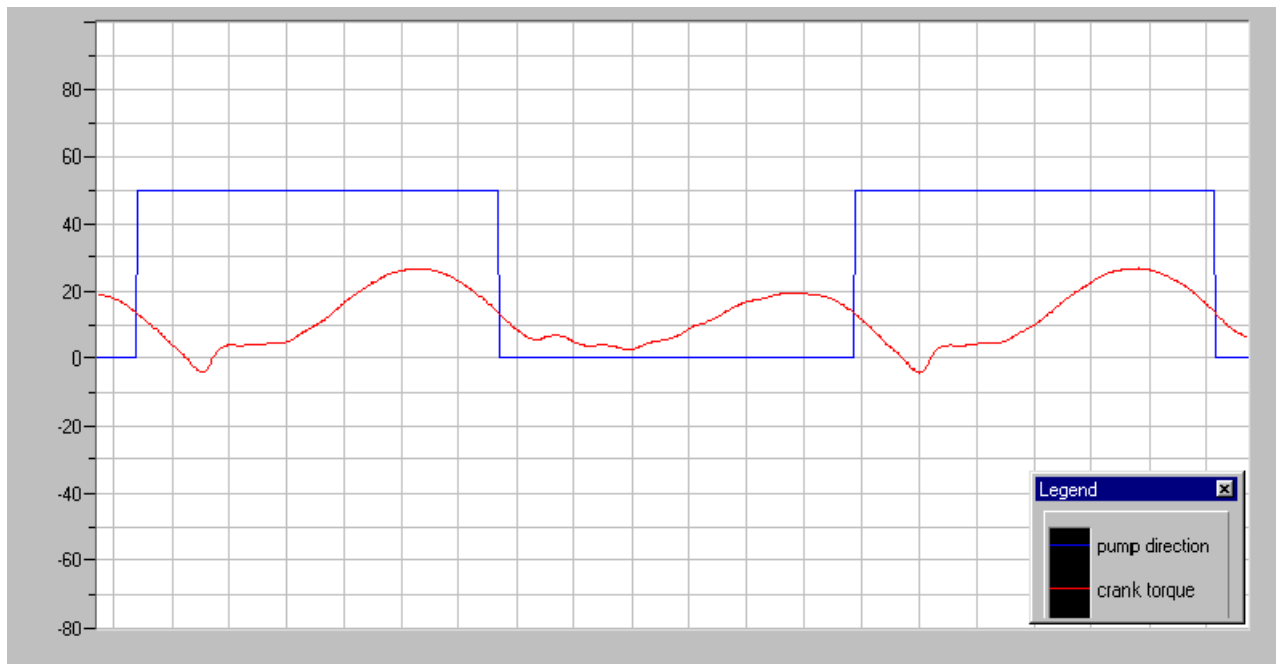
**(Figure 5) Torque Chart After Removing Weights**



Through studying the torque charts, we determined that one of the weights should have been on the trailing edge of the weight arm and not on the leading edge. See figure 5, points A and B. Compare figure 5 with figure 6. By making these two adjustments alone, we were able to reduce the amp draw from 65 peak amps to 28 peak amps.

We reduced the sheave ratio and under control of the software, slowed the well down from 7.6 SPM to an average 4.8 SPM while maintaining fluid output.

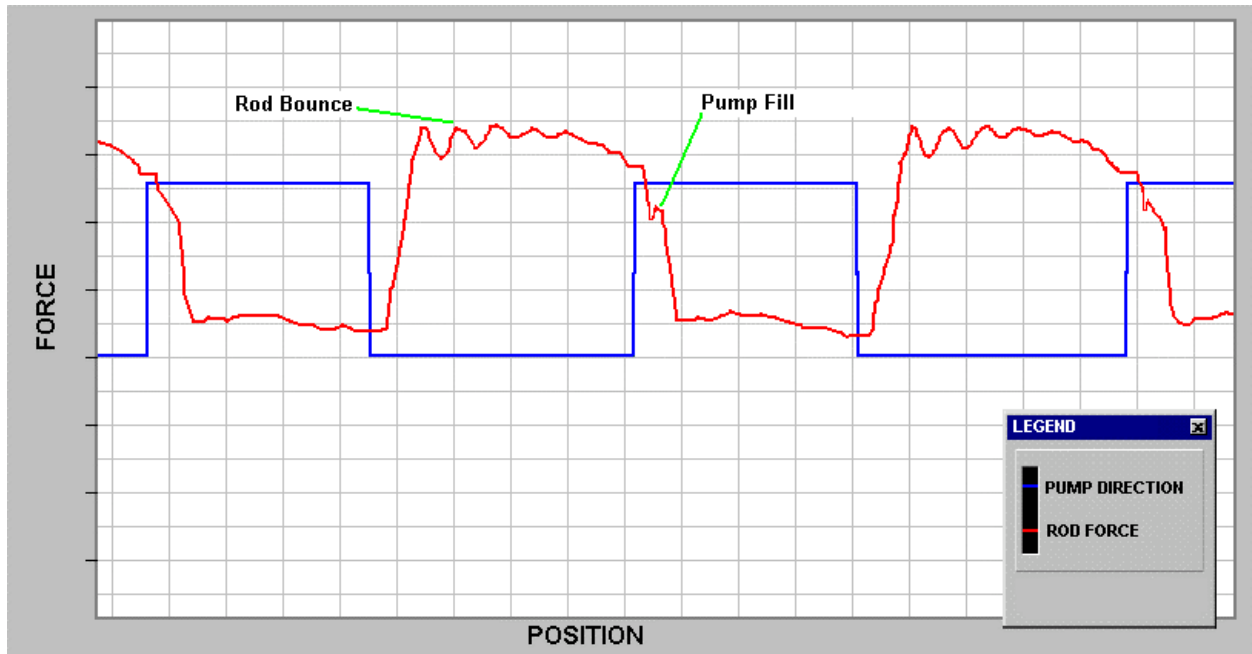
**(Figure 6) Torque Chart After Moving Weight To Trailing Edge**



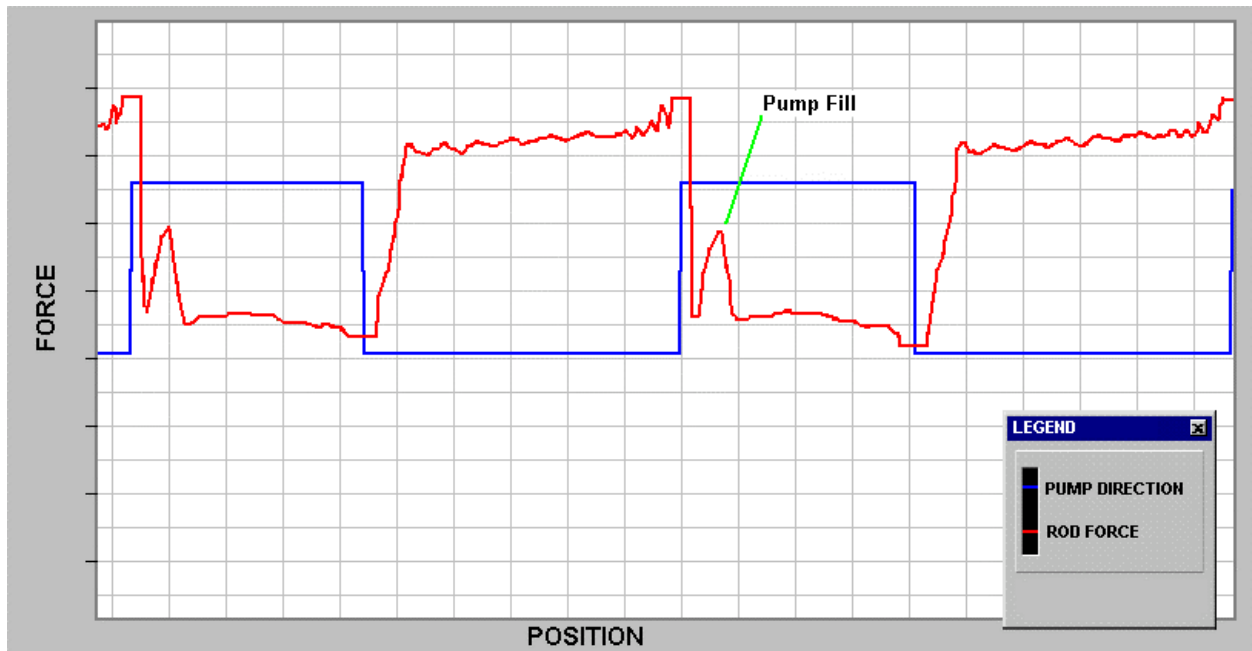
## Rod Force Control

Rod force control is a software routine that controls excessive spike forces on the rod string. The well is relatively shallow, and thus recoils on the rod at the top and bottom of the stroke is minimum. Figure 8 and Figure 9 show the forces on the rod with the routine disabled and enabled.

(Figure 7) Rod Force Chart Without Rod Force Control



(Figure 8) Rod Force Chart With Rod Force Software Enabled



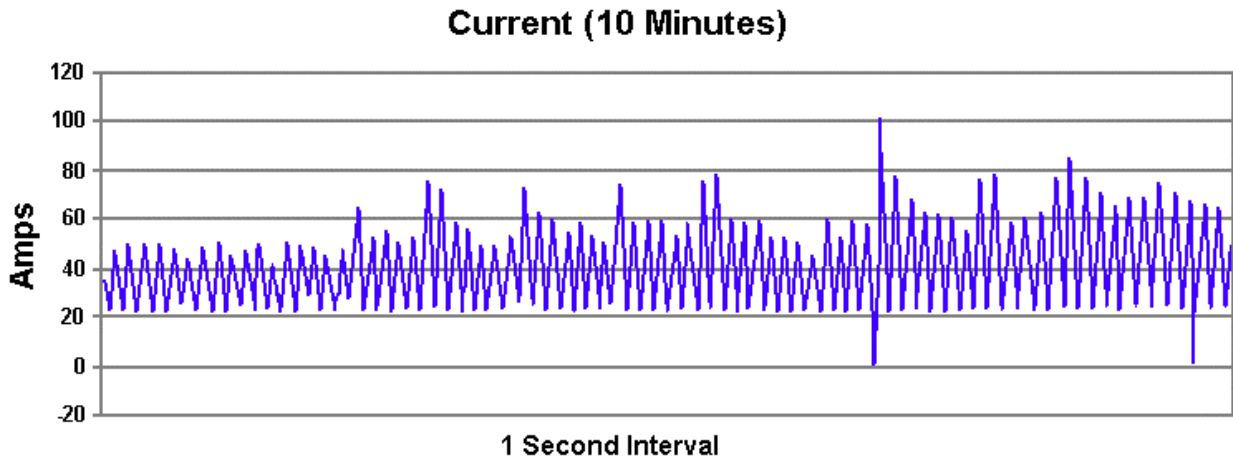
## Power Readings

The table below shows the power readings as determined by an independent company. These readings were taken the week previous to the changes and then the week following the changes.

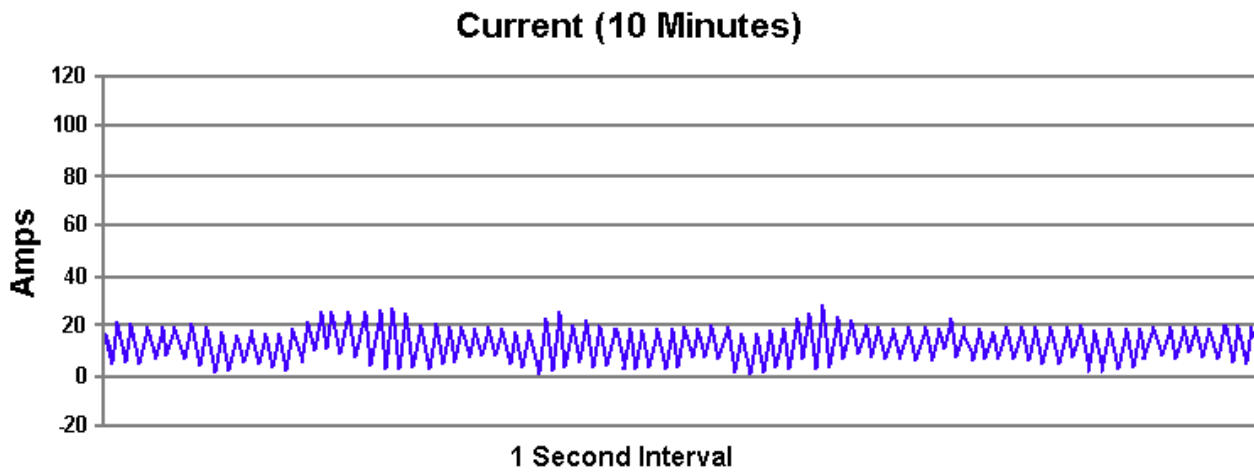
<b>Field Data Report Before Changes</b>		<b>Field Data Report After Changes</b>	
Voltage (V)	488	Voltage (V)	491
Average Power Factor (%)	-41.66	Power Factor (%)	-17.33
Maximum Current (A)	95.88	Maximum Current (A)	24.92
Average Current (A)	37.33	Average Current (A)	11.05
Total Demand (KW)	2.54	Total Demand (KW)	1.13
Total Real Power (KW)	15.35	Total Real Power (KW)	6.78
Total Reactive Power (KVAR)	20.60	Total Reactive Power (KVAR)	0.56
Total Apparent Power (KVA)	32.13	Total Apparent Power (KVA)	9.51

## Current Readings On The Motor

**(Figure 9) Amp Readings Before Changes**



**(Figure 10) Amp Readings After Changes**



## **Conclusion**

This project has successfully demonstrated the advantages of the ePAC drive with its associated pump fill and rod force software.

Optimization of the well can be achieved by controlling the fluid level in the well based on pump fill. Should the well pump off, the software detects dramatic decrease in pump fill. There is an option in the software to shut the well down similar to a POC. This option was left turned off.

Tubing and rod wear will be greatly reduced. Rod and jack forces are dramatically reduced. Since the calculated pump fill controls the down stroke speed, the shock load on the rod string caused by fluid pound is greatly reduced. Rod force control can eliminate excessive forces on the rod at any time the force may become too high, either positive or negative.

Power savings are substantial. The ePAC enables us to accurately balance the pump jack as demonstrated above. Because of the variable speed capabilities of the drive, we are able to sheave the jack so the sheave ratio does some of the work normally required of the motor. Due to the Flux Vector Drive technology, the initial start up current is 14.4 amps. This eliminates the line start momentary surge of about 325 Amps required to get the motor running under load.

### **Contact**

eProduction Solutions  
22001 North Park Dr.  
Kingwood, TX 77339  
Ph. (281) 348-1000  
epac@ep-solutions.com

