PUMP-OFF CONTROL FOR GAS ENGINE DRIVEN PUMPING UNITS

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Through cooperation of Amoco E & P Sector's Hackberry Field, D-Jax Corporation, Amoco Argentina, and Amoco's Tulsa Research Center, a new type of pump-off controller for a gas engine driven pumping unit has been developed. The processes of reducing well pump off and fluid pound for a gas engine driven beam pumping unit has been to reduce shieving, engine speed, and stroke length. The problems occurring with these types of solutions are numerous. There is still the possibility of well bore pump down or a gradual increase in well bore fluid level. Both of these results are tedious and time consuming. The stroke per minute timing will have need be changed whenever the fluid level changes high or low. Or, the high fluid above pump (FAP) will begin to reduce inflow from the formation due to hydrostatic pressure buildup in the casing.

Amoco and D-Jax have worked together to produce an automated Pump-Off Controller that can control the engine speed and pump-off with associated fluid pound of a pumping unit powered by a gas engine. The unit consists of the Well Tender Rev. E. Pump-Off Controller, a reed switch sensor assembly, a Murphy 12 vdc switching throttle servo, and a 12 vdc power source. The power source used was an engine mounted 12 vdc alternator connected to a 750 amphr. battery. Solar panels and wind generators combined with a battery or battery and alternator could be used.

The POC has four stages of operation. Upon startup, the unit is in *Down* mode (or slow mode). This mode slows the engine to the slow speed. It will stay in this mode for the preset amount of time. Once elapsed, the unit will change to *Pump-up* mode. This allows the pumping unit to settle at the faster normal run speed. Once the preset time for pump-up has elapsed, the unit will go into *Run* Mode. Once in run mode the unit will continue pumping at the normal (faster) run speed until the delta, or preset pumpoff speed (in milliseconds), is reached. The Unit accomplishes this by timing each stroke of the crank arm of the beam pump unit. The first three strokes are averaged for the sample stroke speed. The fourth stroke is used to compare the initial full pump speed to the averaged speed. If the averaged speed is faster than the stored full pump speed by the amount preset as delta, the unit will enter

Down mode. At this point the cycle repeats. If the POC does not receive a stroke signal from the sensor wand, the unit will switch to *SFail* mode at the down or run speed the unit was at when the failure occurred.. SFail mode will continue for a preset time and cycle in this mode until a signal from the sensor is received. When the unit receives a signal from the wand, it will continue in the mode it was in before the failure.

As the beam pump lowers the FAP (fluid above pump), the unit spm will increase. Using dynamometer and pump cards to set the delta, pump-off and fluid pound can be kept to a minimum. With the POC on the test well, the pump-off is kept to a maximum of 5% - 10%. With 6 hrs. of downtime after pump-off, the unit will pump for 1 1/2 hrs. - 2 hrs of normal runtime. Long term goals include downtime and runtime averages of 50% total time each. 60% - 40% would be allowable. While in down mode, the FAP rises to an adequate pumping level that eliminates fluid pound. Once the down mode time expires, the unit returns to the normal pumping speed and FAP begins to decrease due to pump down of the wellbore. As the pumpdown continues, the rod load decreases and unit speed increases. At this point, the cycle begins anew.

The following charts show the reduction of rod string and gearbox stress and load. The test well, State Lease #42 Well # 173, has a low inflow rate to the wellbore. Preliminary testing was done in January 1995 with a 48" bull shieve on the unit and a 10" shieve on the gas engine pto shaft. The well was pumped at a maximum of 7 spm with FAP initially at 100 ft above the pump. After 3 hrs. of operation, the pump fillage had decrease to 40% to 50% of the pump stroke due to the decrease in FAP. Chart 1 shows the dynamometer and pump card at this condition. The unit was slowed to 6 spm to allow FAP to rise. Chart 2 shows the dynamometer and pump for this condition. The POC unit was installed in February 1995. The unit was setup with 7 spm for the run mode speed and 6 spm for the down mode speed. The down mode time was set for 6 hrs and delta was set at 175 milliseconds. This produced an average run time of 1 1/2 to 2 hrs of normal pumping speed. The average pump off is 8% to 10%. Chart 3 shows the dynamometer and down hole pump card just as the unit goes from pump up mode to run mode. Chart 4 shows the cards just as the unit goes from run mode to down mode. Table 1 shows a comparison of the rod string and gearbox loading for each of the dynamometer card. Graphs one through three relate to Table 1. As you can see, gearbox peak torque increases, counterbalance decreases, and percentage of gearbox rating increases and the unit is converted to POC control. Higher gearbox rating percentages translate to higher efficiency. The table also shows the increase in rod string horsepower. This translates to increased efficiency. Initial production increases in oil and decreases in water have returned to levels produced before installation of the POC, but , with decreased rod stress and beam pump unit stress from fluid pound and pumpoff.

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Table 1

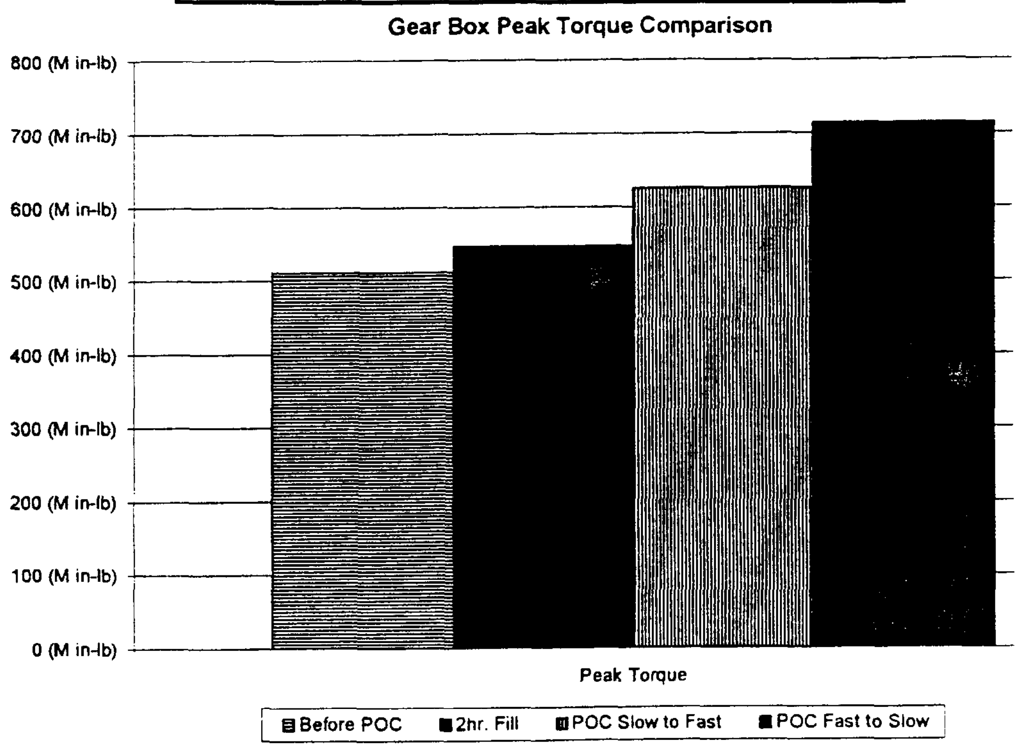
Unit Type: Lufkin FUA-912-427-192

Gear Box Analysis

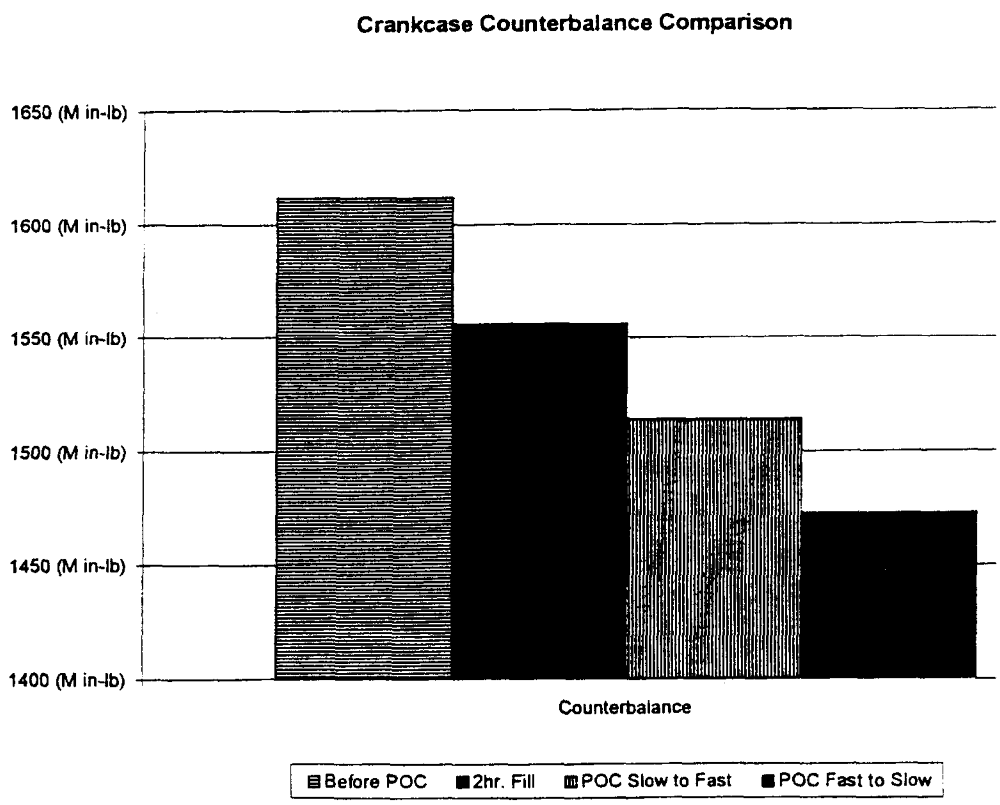
	Before POC	2hr. Fill	POC Slow to Fast	POC Fast to Slow
Peak Torque	512 (M in-lb)	548 (M in-lb)	627 (M in-lb)	714 (M in-lb)
Counterbalance	1612 (M in-lb)	1556 (M in-lb)	1514 (M in-lb)	1473 (M in-lb)
Gearbox Rating	56%	60%	69%	78%

Rod String Comparison
Rod Horsepower

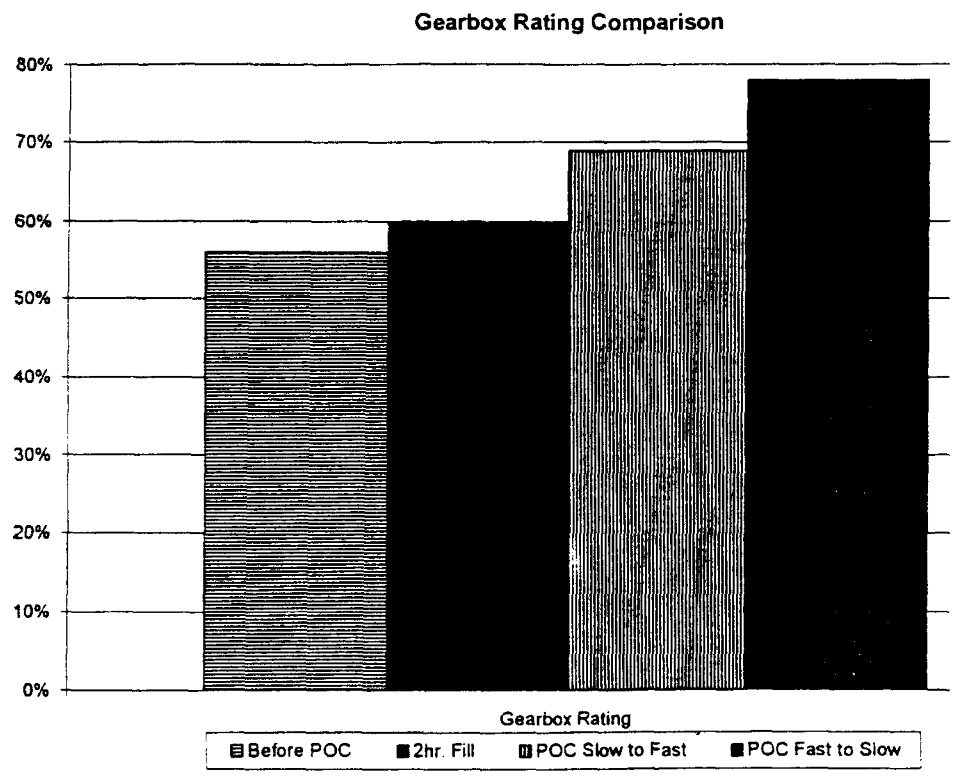
Depth	Before POC	2 hr. fill	POC Slow to Fast	POC Fast to Slow
0	16.96	15.5	17.8	21.5
2250	14.5	14.3	16.3	19.1
4600	12.3	13.2	14.9	17
9000	9.3	11.6	13	14



Graph 1

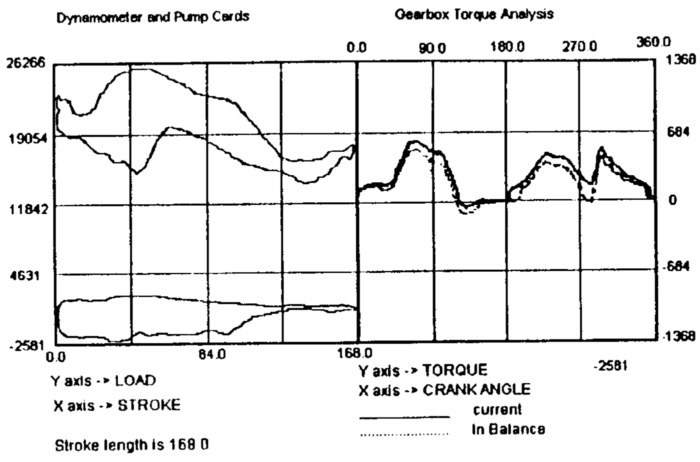


Graph 2



Graph 3

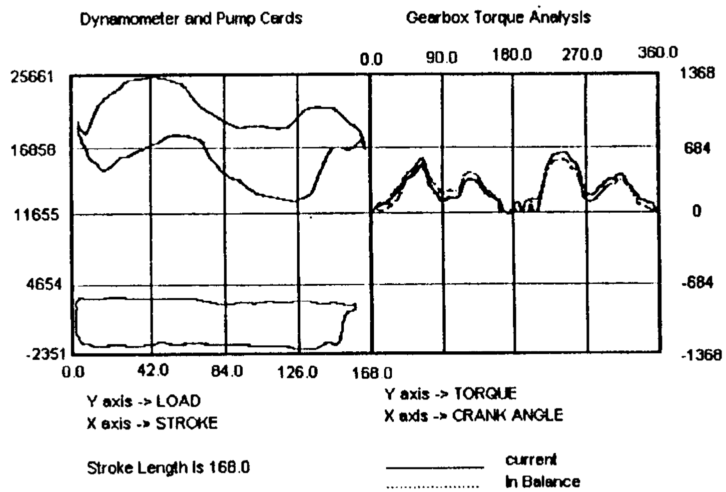
Chart 1



Peak Torque	Counterbalance	Gearbox Rating
512 (M in-lb)	1612 (M in-lb)	56%

Dynamometer Card for Test well before POC was installed

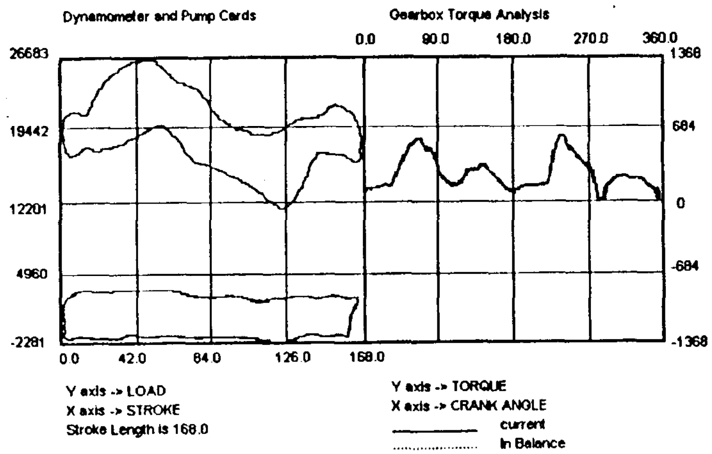
Chart 2



Peak Torque	Counterbalance	Gearbox Rating
548 (M in-lb)	1556 (M in-lb)	60%

Dynamometer Card for Test well after 2 hrs of shut-in

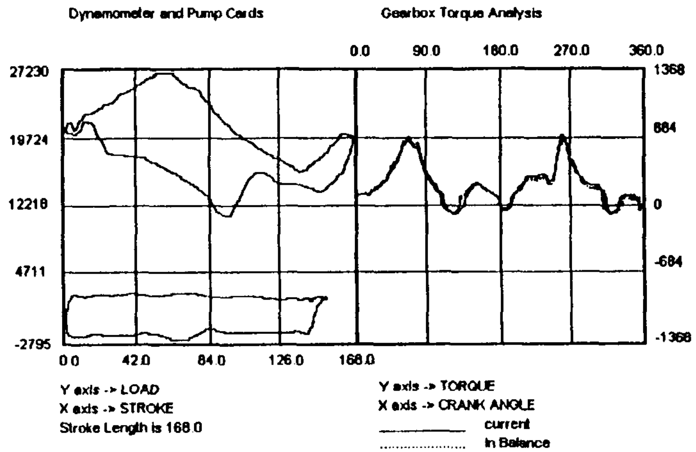
Chart 3



Peak Torque	Counterbalance	Gearbox Rating
627 (M in-lb)	1514 (M in-lb)	69%

Dynamometer card of test well. POC going from Down Mode to Run Mode

Chart 4



Peak Torque	Counterbalance	Gearbox Rating
714 (M in-lb)	1473 (M in-lb)	78%

Dynamometer card for test well. POC going from Run Mode to Down Mode