IMPROVED FIELD MEASUREMENTS AID IN SUCKER ROD LIFT ANALYSIS

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Recently, AHC decided to update the technology in use to collect and analyze sucker rod load data. Data was being collected with Leuterts, Amerada Hess Corp. Portable Well Analyzer I (AHC PWA I) or AHC PWA II systems. Even though the Leuterts were easy to install, the data was difficult to analyze. The AHC PWA I is an older and obsolete digital dynamometer developed ten years ago. The AHC PWA II utilized load cells, but the electronics did not hold up. AHC approached Echometer Co. to develop a portable well analyzer system, utilizing modified Leutert heads.

Even though strain gauge load cells are more accurate than hydraulic systems, the decision was made to utilize existing Leutert dynamometers. The decision was based on the following factors.

1) Current needs called for a portable system. This excluded the option of permanently mounted load cells or similar systems.

2) Leutert dynamometers are easier to install on the polished rod than portable horse-shoe type load cells. These load cells require the rods to be "stacked out" on the stuffing box. This practice can cause damage to the stuffing box and/or polished rod and at times can be dangerous. The Leutert is installed by simply slipping the unit between the Leutert spacers, already installed on the polished rod, and pumping the system up.

3) The majority of AHC wells (+ 95%) already had Leutert spacers installed, precluding the associated cost of purchasing these spacers.

4) The installation of horse-shoe load cells on the polished rod raises the rods 3 to 5 inches depending on the brand of load cell used. This in turn raises the plunger in the barrel and changes the down hole conditions, resulting in analyzing data not exactly representative of actual conditions. The Leutert dynamometer only raises the rods 1/16 to 1/8 of an inch, resulting in data more representative of actual operating conditions.

The main concern with using a hydraulic system to measure varying loads were the inaccuracies, mainly those due to hysteresis. Hysteresis is defined as a lag of effect when the forces acting on a body are changed. When load is applied to the Leutert dynamometer and then released to a specific load, the measured load is higher than the actual load. This can result in erroneous minimum load readings, which can greatly affect rod stress and gear box calculations.

A series of tests were run to determine the amount of hysteresis found in various equipment used to measure polished rod loads and to see if the hysteresis could be reduced. The equipment in question is attached to a test stub and trapped between a hydraulic piston and a large nut. Pressure is then applied to the hydraulic piston by a hydraulic pump, the applied pressure is measured with a dead weight tester. The amount of pressure applied to the piston can then be converted to load if the area of the piston is known, ten inches square in this case. This load is then transferred to the trapped piece of equipment Output from the equipment being tested is recorded and compared to the applied pressure. To determine the amount of hysteresis in the equipment, load is applied at 5,000 pound increments, up to the load limit of the equipment in question, and then reduced by the same 5,000 pound increments. Transducer output is recorded from the equipment in question each time the load is changed. The percent hysteresis can be obtained be comparing the recorded transducer output going up to the recorded transducer output going down at each increment.

The first series of test were conducted to compare various equipment used to measure polished rod loads. The equipment tested were a standard Leutert dynamometer, the AHC PWA I, a modified Leutert (pressure transducer and modified load pistons), and an Echometer horse shoe load cell. Figure 1 shows the results from these tests. As you can see there is a great amount of difference between the equipment tested. The standard Leutert dynamometer resulted in the worse numbers. Later tests revealed other Leuterts exhibit better numbers, around seven percent, but still higher than desired. The AHC PWA I did not fair well either, mostly due to the fact the Leutert piston design was incorporated into the AHC head design. The modified Leutert (designated Echo on the plot) compared favorable to the horse-shoe load cell, which was used as the standard to attain.

The next series of test were conducted to determine what hydraulic fluid to use, if the modified pistons were better than the original pistons, and the affect of the pressure transducer versus the registration unit. Each modification was tested independently, only one item changed at a time to insure accurate results.

Two Leuterts (SN 1063 and 1121) were used for the hydraulic fluid comparison tests. Before each test the Leuterts were drained, cleaned and flushed three times to make sure no contamination of the fluids resulted. Each fluid was tested several times for repeatability purposes. During these test it was discovered some fluids give favorable results at first but deteriorated with time, probably due to shearing from the high pressures (7000 psi) put on the fluids. Figures 2 and 3 show the results of the oil comparison, averages of all tests ran. Leutert SN 1063 (Figure 2) had a pressure transducer and modified pistons while Leutert SN 1121 (Figure 3) had a pressure transducer and Leutert pistons. In both cases the Texaco Hydraulic 15 gave the best results. There are several other brands of hydraulic oils that can be used, but this test shows care must be given in the selection of the hydraulic fluid used.

The load pistons were then tested using the Texaco Hydraulic 15 fluid and Leutert SN 1063. Three basic piston designs were tested as follows. The original Leutert design which incorporates cup type seals, most likely the best seal technology at the time. These seals become tighter when pressure is increased. This makes for a good seal but increases the amount of hysteresis as load increases as can be seen in Figure 4. The first piston modification utilized o-ring seals and closely controlled tolerances. The results were favorable but repeatability was difficult to achieve. If the Leutert set for a period of time the o-rings would "seize" or "set", requiring a "break in" period before desirable results could be achieved. Finally a piston configuration utilizing Bal seals was tested. At first glance these seals look a lot like cup type seals. The differences include custom designed plastics to match pressures, fluids and metals; a spring to help hold the shape of the seal, a design that achieves minimal seal contact; and loser tolerances. Not only were the hysteresis affects reduced but the numbers proved to be very repeatable, even after setting for extended periods of time. Figure 4 shows the average results obtained with several Leuterts. The only change made between all tests were the pistons, everything else was held consistent.

Leutert SN 1121 was used to compare the results from replacing the registration unit with a pressure transducer. As before nothing else was changed. Figure 5 shows that the removal of the registration unit results in a large amount of hysteresis reduction. The registration unit has a small moving piston that reacts to pressure changes within the Leutert. This moving piston most likely contributes to the majority of the hysteresis affects. There is also a spring present and linkages which transfer the load differences to a stylus which traces on the attached drum. The registration unit not only contributes greatly to the hysteresis, but requires the highest amount of maintenance. By removing the registration unit load data is more accurate and maintenance problems are reduced drastically.

Figure 6 shows the average results from modifying 15 Leuterts. The hysteresis of the original Leutert equipment (registration unit and Leutert load pistons) versus modifications made (pressure transducer and Bal seal load pistons). As can be seen the hysteresis has been reduced dramatically, within 0.5 and 1.5% of the load cell. This small percent error can be justified by considering the ease of installation and less raising of the polished rod as mentioned earlier.

The polish rod load data is transferred to a PC via a analogue to digital converter. Acceleration data is also brought in, allowing for position analysis with less moving parts and calibration. The data is displayed in real time and can be analyzed quickly and accurately. At the same time power data is brought in from probes attached to power panel. This allows for electric usage calculations, surface efficiency calculations, and the option to balance the unit electrically.

By using a remote fire gas gun with pressure transducer, gas free fluid levels can be obtained easier than before. The system also comes with the pressure build-up software, which allows for static pressure calculations. This data is very important for analyzing inflow performance and to optimize lift designs.

The system also includes vibration probes. This will allow the technicians to trouble shoot unit and motor bearings, possibly averting catastrophic failures.

All of this equipment allows for improved measurements, allowing for better well optimization. The polished rod load data is far more accurate than before. This allows for better rod and unit maintenance. By keeping the rods, gear box and beam loaded properly failures can be reduced. We also have a better handle on our valve checks, the measured values are matching the theoretical values much closer. We can use this data as an indication of down hole problems.

The addition of power measurements has shown to have many benefits. With this data motors can be sized much closer, which in turn can reduce electrical costs (one of our highest operating costs). We can also better compare sucker rod lift cost efficiencies with other lift methods. This will help us in future lift installations. By looking at the surface efficiency, comparing horse power drawn by the motor to horse power at the polished rod, problems such as worn belts, sheaves and bearings can be found sooner. The vibration probes can then be used to find or confirm suspected problem areas. This not only increases system efficiency but can avoid some catastrophic failures.

The remote fire gas gun has improved our fluid level calculations. This is accomplished by having the ability to digital collect, store and analyze the data. This system has many more tools to analyze a difficult fluid level than the old strip charts. The addition of accurate short term pressure buildup data allows for better foam compensation. By accurately determining pressure increase with time the amount of gas flowing up the backside can be determined. This allows for "foam" compensation and gives us a gas free liquid level. The pump intake pressure calculated from the fluid level and down hole card is now coming in closer agreement than before, increasing our confidence level in the fluid levels we are obtaining. In some fields we are seeing a drastic difference in fluid level calculations in comparison with the old method. This improved fluid level data plus the capability to obtain static down hole pressures allows for better well management. Desired draw downs can be better confirmed, optimum production can be achieved, and well bore damage can be better accessed. The rod and pump designs can also be closer matched to well conditions.

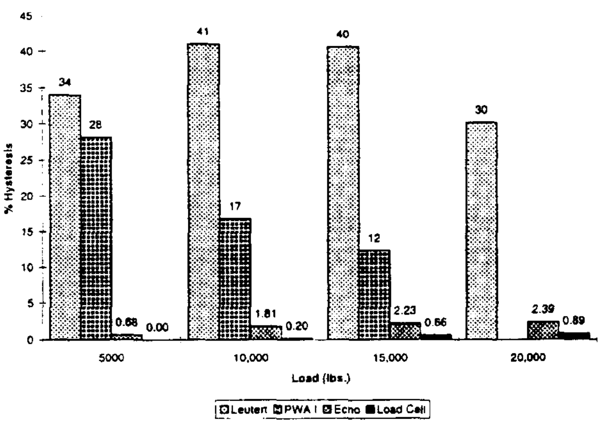

Figure 1 - Original Test

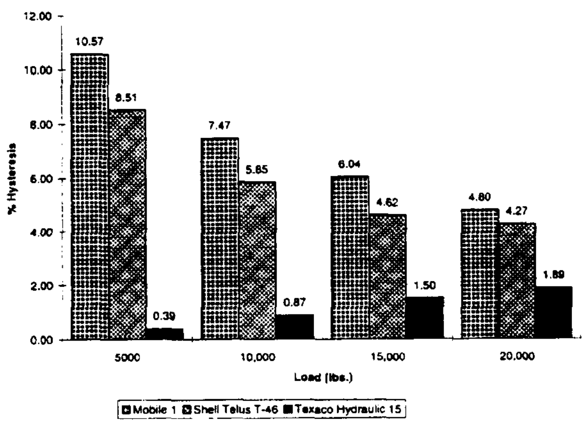

Figure 2 - Hydraulic Fluid Comparison

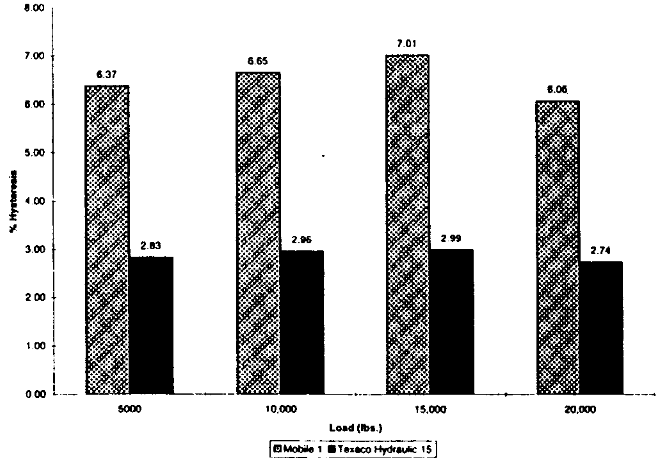

Figure 3 - Hydraulic Fluid Comparison

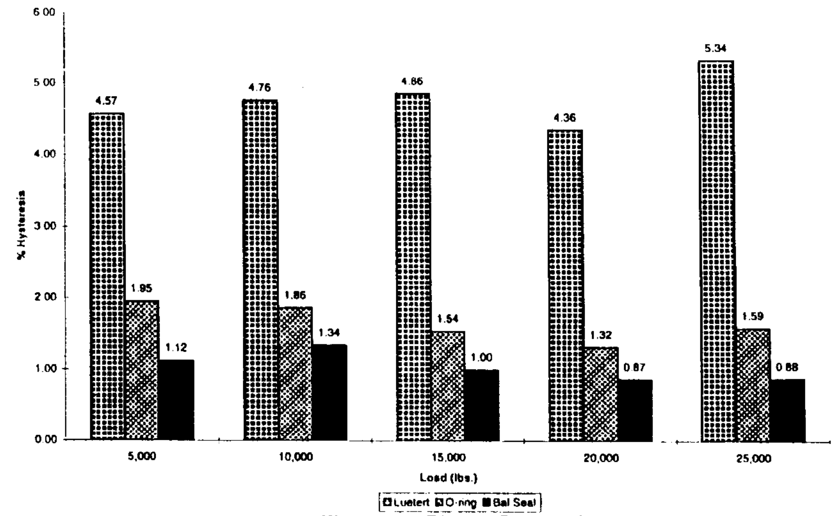

Figure 4 - Piston Comparison

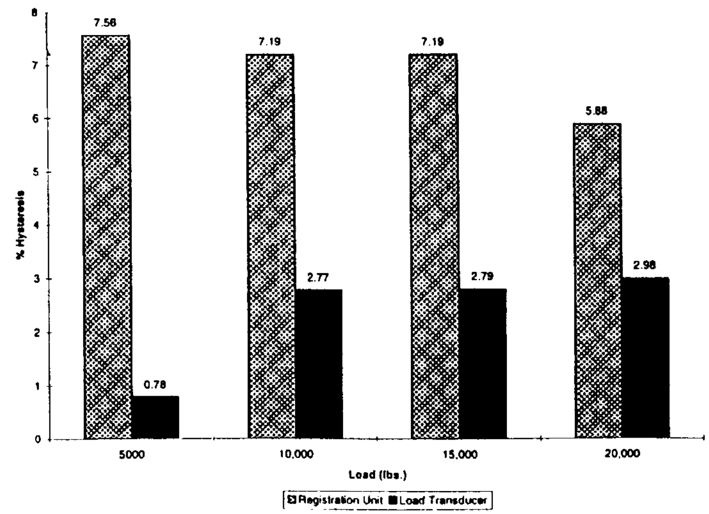

Figure 5 - Measurement Device Comparison

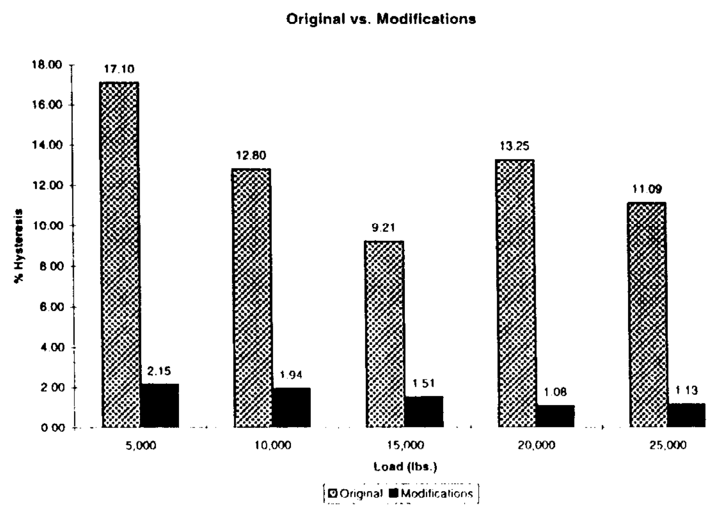

Figure 6 - Original vs. Modifications