ANALYZING WELL CONDITIONS AND SUCCESSFULLY OPERATING ESP's BY UTILIZING INTEGRATED CONTROL SYSTEMS IN THE SACROC UNIT CO_2 FLOOD

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ABSTRACT

To operate an electric submersible pump (ESP) in a carbon dioxide (CO_2) flood successfully is a challenge that requires applying new engineering and operational resources. Extremely high gas-liquid ratios (GLR's), radically changing bottom hole pressures and changing fluid densities demand more than just conventional methods for operating and troubleshooting ESP's.

To mitigate these problems, we now use an integrated control system to troubleshoot well conditions where high concentrations of free CO_2 gas occur. Accurate bottom hole pressure, temperature and vibration information is collected to determine actual well conditions, decreasing the "guess work" previously required, thereby making decisions based on real data more effective in correcting problems.

This paper is a continuation of work efforts started in 2003, and discussed at last year's SWPSC.

REVIEW

As stated in the abstract, this year's paper is a continuation of a paper written last year addressing optimizing production and increasing run times by utilizing an integrated control system with a down hole sensor in the Kinder Morgan-operated SACROC Unit. Currently, the SACROC Unit is an active miscible CO_2 WAG flood that has many flowing / flumping wells that present many different challenges. One of which is operating flumping wells without excessive cycling. Another is determining the accuracy of the fluid level information collected each month. The 2004 paper was written with data collected from three installations that included bottom hole sensors.

INTRODUCTION

There are now 19 submersible pumping systems in SACROC that include down hole sensors with integrated control systems. We will review some of the data collected in 2004, from the installations and determine the effectiveness of their operation in high CO_2 applications.

This paper also includes a comparison of the pressure readings retrieved from the sensor to the fluid level shots taken with a model E fluid level gun and a comparison of the calculated GLR of the produced fluids and gases. Finally, the data is evaluated and conclusions are drawn for discussion and further analysis.

CURRENT INSTALLATION BEFORE AND AFTER SENSOR

Chart numbers 1 and 2 are the amperage charts before and after installation of the sensor in well no. 168-4. The before installation amp chart depicts erratic, idle amp shut downs resulting from extreme GLR's, an unprofitable production and potentially equipment damaging (cycling motor starts) scenario. The after chart depicts a continuous run even though the operating amperage is inconsistent; a scenario made possible by the controller and definitely more palatable to the operator.

As predicted in the previous paper, this submersible pumping system is able to continue to operate without excessive shut downs thus reducing the frequency for failure. Instead of relying of amperage level exclusively to protect the motor, the latest generation of controller includes evaluation of motor winding temperature and vibration as operating criteria. Temperature fluctuation is less over a wider range of bottom hole conditions than is amperage, hence, reducing the cycling normally seen. Under extreme conditions, vibration will dictate operations as the next example shows.

TROUBLESHOOTING

Figure 3 depicts data downloaded from the sensor and surface package installed on well no. 72A-5.

The data includes operating down hole pressure, motor temperature and vibration. This graph shows the system running, then repeatedly cycling from high temperature/vibration shutdown as the pump experiences gas interference and pump off conditions. It also shows a build-up and draw-down test that was performed (and is doable as a side benefit with accurate down hole sensing insitu). This information was utilized to help determine if there is an inflow performance concern with this well.

SENSOR VS. FLUID SHOT

As previously stated, determining the validity of the data collected from a fluid level shot in a CO_2 flood is difficult. In some cases, this data appears to vary with different CO_2 contents, GLR's, fluid rates, and oil cuts. Complete, accurate fluid level information or bottom hole pressures are invaluable in troubleshooting, sizing and maintaining wells. Without it, we sometimes cannot make an accurate determination of the problems we are experiencing. It is common for submersible pumps to operate in this particular CO_2 flood regardless of the composition of liquids and gases as long as adequate intake pressures are maintained. High GLR's ranging from 100 MCF/bbl to 10,000 MCF/bbl add to the complexity of this situation.

Monthly data consisting of production, including fluid types and rates, and calculated GLR's, oil and CO_2 cuts, and fluid level shots, and hourly sensor information, including pressure, motor and wellbore temperatures from the sensors are collected and analyzed. The information is then used in the troubleshooting of problem wells in various operating conditions.

The following represent examples of actual data from wells scattered throughout the active flood and equipped with down hole sensors, and the corresponding fluid level shots taken to illustrate what we have observed to date.

Figure 4 represents well no. 170-6. The fluid level shot and sensor pressure show a 1,300 psig difference while tracking each other. The GLR stays relatively constant and averages about 1,800 MCF/bbl.

Figure 5 represents well no. 225-6. This well has a low GLR for this field; however, it is located near the WAG periphery and consequently does not experience the brunt of the flood. The fluid level shot and sensor pressure still show a 750 psig difference while the GLR is falling to about 250 MCF/bbl.

Figure 6 represents well no. 124-6. There is a 1,600 psig difference between the fluid level shot and the sensor while the GLR rises to about 2,000 MCF/bbl.

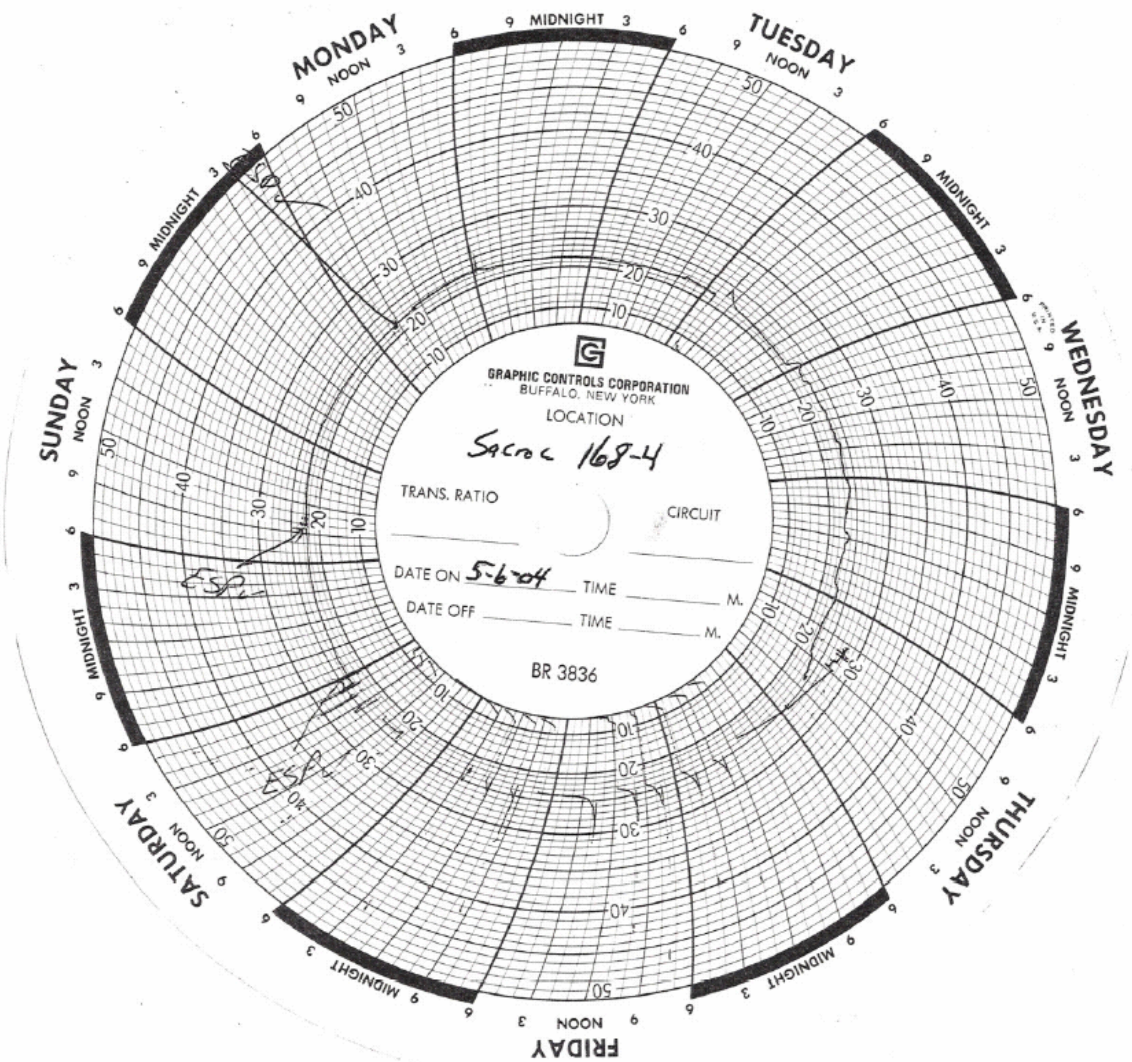
Figure 7 represents well no. 168-4. The two pressures maintain a 600 psig difference while the GLR fluctuates around 1,600 MCF/bbl.

Figures 4, 5, 6 and 7 show the calculated pump intake pressures from the fluid shot versus the sensor pressure versus GLR. The information collected shows a significant difference in all cases between the measured sensor and fluid level derived pressures, the fluid level being less across the board than the sensor pressure, regardless of GLR. The difference between the two pressures varies from 500 to 1,500 psig on average. This data suggests it may be detrimental to exclusively rely upon fluid level derived PIP's when attempting to troubleshoot a cycling well and determine true bottom hole conditions in this type of down hole environment.

SUMMARY

We conclude that electric submersible pumps can successfully operate in flowing/flumping wells when a down hole sensor is installed with a modern controller that is capable of controlling on more than just amperage range. The data retrieved is crucial in tracking, maintaining and troubleshooting these systems.

We intended to determine if there is consistency between the fluid level shot and the pressures retrieved from the down hole sensor. We were trying to determine at what GLR the fluid level shot and the sensor pressure begin to coincide. As of this writing, we have been unable to determine that they do in fact coincide and a significant difference in pressure is observed regardless of the GLR of the well. At this point, we question the accuracy, and thus, necessity of shooting fluid levels in the SACROC CO2 flood and other similar environments, and we will work to justify economically the installation of pressure sensors in the remaining ESP wells.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BUFFALO, NEW YORK
LOCATION
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TRANS. RATIO
CIRCUIT
DATE ON 5-6-04
TIME
M.
DATE OFF
TIME
M.
BR 3836
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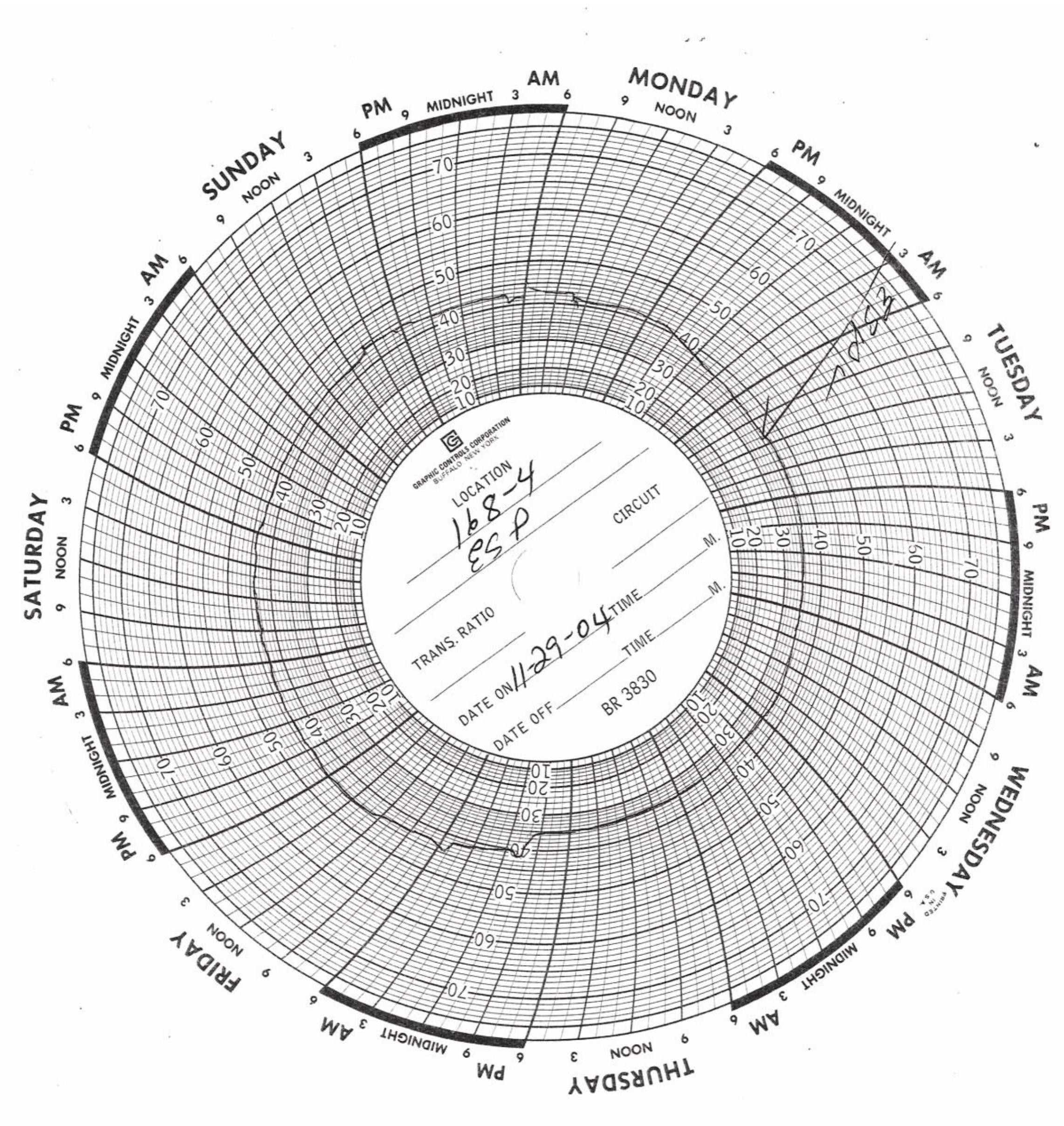
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
MIDNIGHT
NOON

Chart 1


MONDAY
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GRAPHIC CONTROLS CORPORATION
BUFFALO NEW YORK
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Chart 2

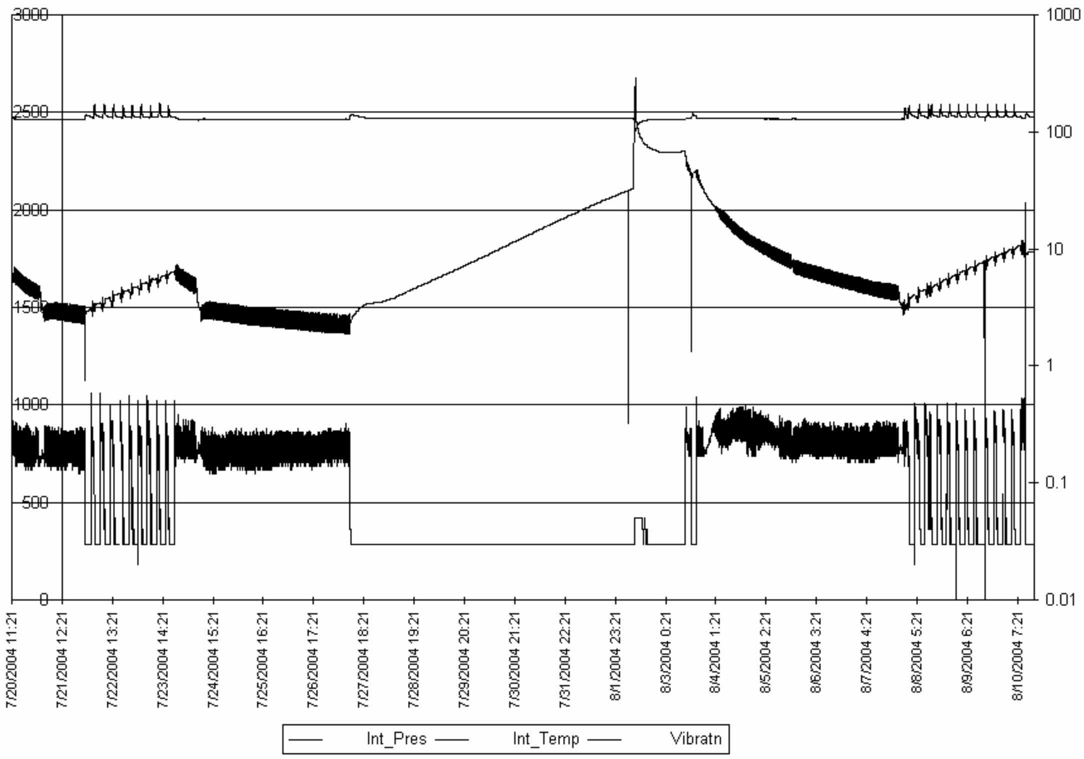
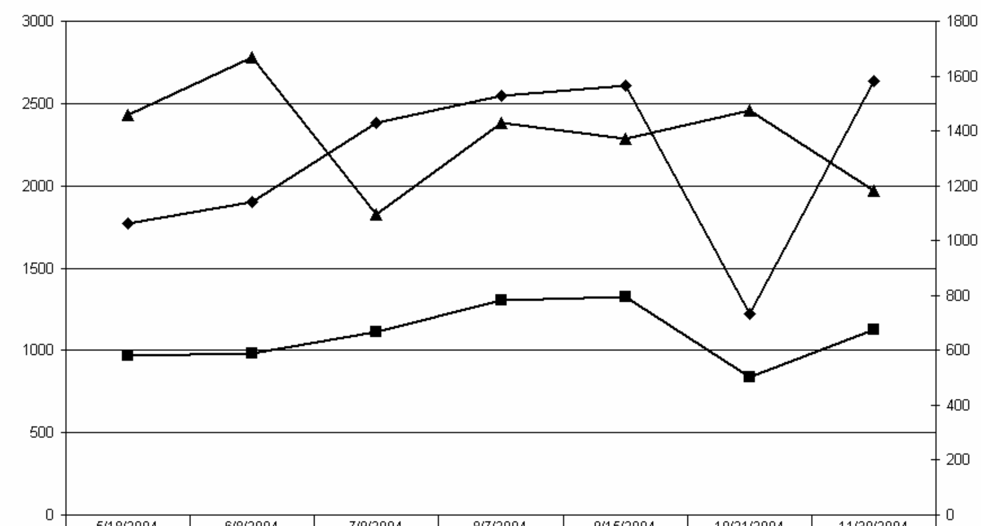


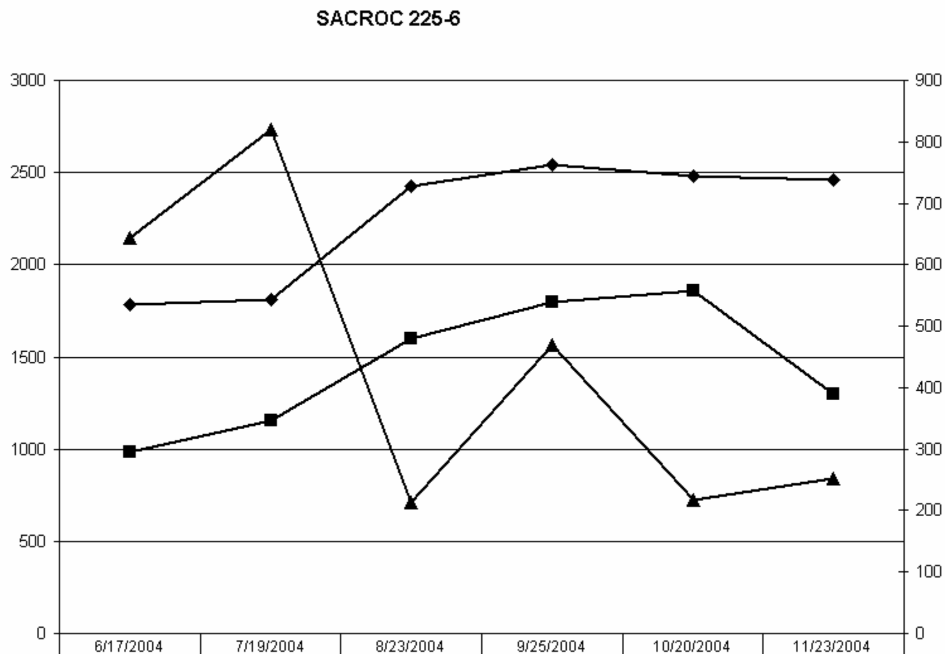
Figure 3

SACROC 170-6



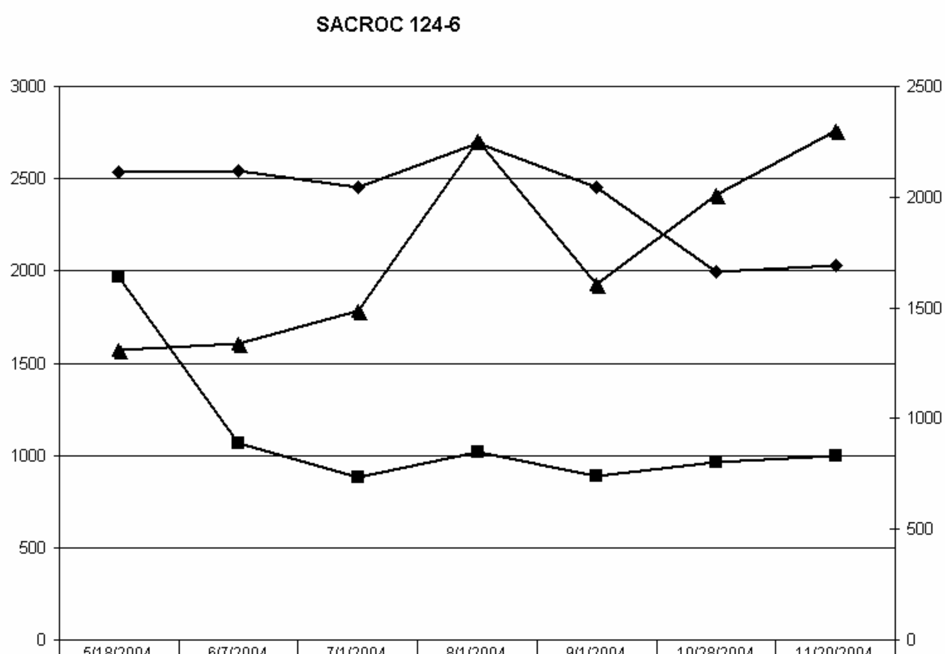
	5/18/2004	6/8/2004	7/9/2004	8/7/2004	9/15/2004	10/21/2004	11/30/2004
PIP (Shot)	970.4	982.5	1111	1307	1326	834.3	1123
Intake Pressure (Sensor)	1772.38	1903.94	2382	2545.36	2608.33	1224.3	2635.54
GLR	1458	1668	1096	1430	1370	1476	1181

Figure 4



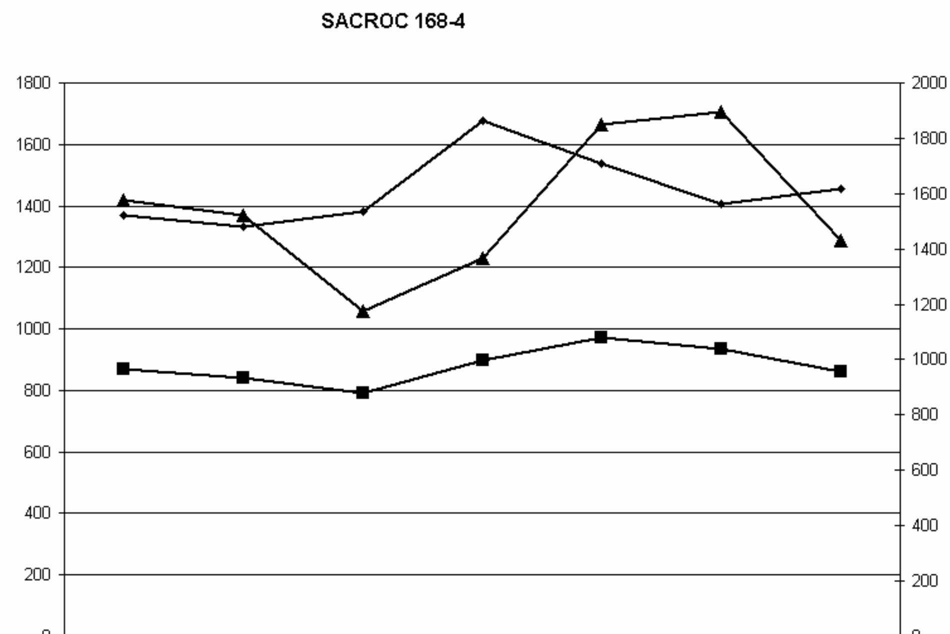
	6/17/2004	7/19/2004	8/23/2004	9/25/2004	10/20/2004	11/23/2004
PIP (Shot)	982.3	1158	1601	1794	1861.2	1300
Intake Pressure (Sensor)	1782.66	1809.52	2423.69	2539.68	2481.07	2461.54
GLR	644	820	213	470	217	252

Figure 5



	5/18/2004	6/7/2004	7/1/2004	8/1/2004	9/1/2004	10/28/2004	11/20/2004
PIP (Shot)	1965.5	1064.2	880	1016	885	966	1001
Intake Pressure (Sensor)	2538.5	2541.47	2453.52	2691.81	2453.48	1993	2027.67
GLR	1312	1341	1488	2256	1607	2011	2300

Figure 6



	5/18/2004	6/8/2004	7/9/2004	8/10/2004	9/15/2004	10/21/2004	11/30/2004
PIP (Shot)	867.9	841.6	790	897	970	936.3	863
Intake Pressure (Sensor)	1368.74	1332.11	1379.73	1675.21	1538.46	1406.59	1455
GLR	1577	1520	1175	1368	1848	1893	1429

Figure 7