# USING PUMP-OFF CONTROLLERS (P.O.C.) TO THEIR FULLEST

Randy A. Gill and Roberto L. Soza, Exxon Company USA and
Russell E. Ott, A/L Solutions

## INTRODUCTION

Traditionally Pump Off Controllers (POC's) have been used to monitor wells for fluid pound. However, signals generated by properly maintained quantitative POC systems can be utilized for a variety of monitoring and production optimization activities. Typically the POC's used in quantitative analysis consist of a load measurement sensor, a position sensor and a control box to collect data. In addition, in centralized systems, a communications device (i.e. radio transmitter) is used to communicate to a modem equipped computer workstation.

This paper will discuss how data captured by POC systems can be utilized more extensively to manage field operations. Traditionally POC data, such as dynagraph cards, have been used to analyze for pump fillage, gas interference, and general artificial lift (A/L) performance by importing POC data into artificial lift analysis programs. However, properly calibrated POC's are being used to monitor fluid levels, minimize the occurrence of stuffing box leaks or flowline breaks due to excessive pressure, and monitoring paraffin buildup. In addition to load and position, data such as flowline pressures, vessel level in facilities, upstream and downstream pressures and rates on injection lines can be captured via the POC system. Submersible pump monitoring including amperage, flow rate and flowline pressures are also being monitored.

The subject POC system was installed in 1989 to monitor 600 wellbores producing from the Clearfork formation. The initial concept was to control pump off to reduce failure frequency and operating costs. The system was designed to use polished rod load cells and inclinometer position sensors. Hardware and software upgrades continue to be implemented as needed. However, the concept of using the system solely for pump off control has evolved to utilizing the system as a Production Optimization Center (P.O.C.) that serves as a hub for production operations processes.

## BASIC PHILOSOPHIES

Experience has shown that POC systems intended to evolve into a Production Operation Center require the following essential elements:

A dedicated systems operator
Training for any individual using the system
Databases to manage data
Preventative maintenance program

The brains of a POC system are provided by a system operator. The system operator must be a person dedicated to monitoring and interpreting the voluminous data being captured by the POC system. Requirements for this individual include a good understanding of A/L systems, A/L diagnostic capabilities, computer literacy, good interpersonal skills to communicate with operators and well service unit personnel.

A successful POC system also requires that individuals interacting with the system be trained both in software and hardware. For example, operators pull data such as dynagraph cards and A/L system capacity to make assessments as to whether the A/L system is operating efficiently. Reports such as those shown in Figures 1 and 2 are examples of data frequently used by operators. The POC system is not a system that has allowed jobs to be eliminated, but has changed how jobs are performed. It is a system that allows proactive measures to be taken instead of reacting to problems that have occurred. In addition, service company personnel working with or around POC system components need to be trained on how to handle POC components such as load cells and POC system cables.

Data from the POC system can be overwhelming. A process is needed to gather, file and retrieve data so that it can be utilized effectively. The use of computer databases, tracking of changes made to the A/L system and user customized reports such as those shown in Figures 3 and 4 are helpful in the management of POC data. By maintaining a log of the typical dynagraph card for each well, subsequent cards can be compared to the base case. Subtle changes in the dynagraph card due to equipment or reservoir performance changes can be identified. In addition, a log or database of "A/L events" are helpful in diagnosing well problems or equipment enhancements.

Maintenance for the POC system is an ongoing effort. Tolerance for POC system downtime should be kept to a minimum in order to effectively utilize the system and manpower. Current maintenance program requirements have focused on RTU motherboards damaged by lightning while maintenance on load cables and load cells is negligible.

## DAILY OPERATIONS

In order to maximize the effectiveness of the POC system, processes have been established to collect and utilize the enormous amount of data generated. Examples of this use in day to day operations are:

1. Well status
2. Trend reports
3. Populate dynagraph database
4. A/L equipment database
5. Management of daily activities
6. Environment
7. Safety

Status reports are used to provide an action list for POC system operators and operation techs. The status report details current well status such as wells operating within parameters, wells still operating but outside of parameters (alert) and an alarm list which are wells that have ceased to operate. The alarm group is the focus group for prioritizing daily activity. Environmental concerns, oil production and safety impact how a problem is prioritized. This allows for optimum use of manpower and resources.

Although the system is capable of a multitude of reports, four main reports are utilized on a daily basis. These reports include:

- Peak Polished Rod Load (PPRL)
- Minimum Polished Rod Load (MPRL)
- Percent Run Time
- PPRL Exception Report

All four reports are updated daily by the system and show the previous six months except the PPRL Exception Report, which is a daily report. The PPRL, MPRL and percent runtime plots are combined to help identify subtle changes such as leaking wellhead valves, casing check valves, tubing and casing leaks and injection response. The PPRL exception report helps identify failures such as pull rod parts, shear tool failures and tubing anchor failures that normally do not exceed the control limits set in the well's POC (Figures 5 and 6).

In addition, the POC system is used to populate a quantitative dynagraph database. This database is used as a reference file for analysis, design and fluid level calculations. For optimization, the POC system in use provides an electronic dynagraph file that can be taken into different software programs for quantitative analysis. With this data, the software programs provide accurate information about how the wells are performing. Rod loads, equipment loads, friction and efficiencies can be calculated to make sure that the components are not operating beyond their design limitations. Downhole pump efficiencies and problems can also be identified by the POC's. Furthermore, this reference file is also being used to populate Exxon's ALWORKS data management system.

An A/L Equipment Database is also maintained within the POC system. This allows customized report generation of all A/L equipment in the field including pumping units and downhole equipment. This database is updated daily by the POC system operator and is an important process in the management and optimization of production equipment.

Data from the POC system facilitates daily activities such as optimization and troubleshooting. Included in this effort is optimizing runtime/pump off control, utilization of A/L equipment and identification of mechanical problems such as late seating valves, dragging plungers, leaking pumps, and tubing leaks. However, more unconventional uses include identifying lack of water injection support, casing leaks, leaking wellhead equipment, bridles that are unstranding (Figure 7a and 7b) and Mark II units rotating backwards (Figure 8a and 8b). In addition, the POC system has proven valuable in identifying sections of the field that are down due to interruptible power or electrical storms. Instead of having to visit each location, the POC system is used to target problem areas.

In addition to A/L surveillance, the POC system is being used to improve safety and environmental performance. For example, by tightening the minimum polished rod load limit so that wells with plugged or frozen flowlines and/or closed valves, shut down before exceeding facility burst integrity. This is accomplished by setting the MPRLL to 1000 psi or less so that as the well pressures up, the MPRL dips below the MPRLL and shuts down the well. By utilizing this process, stuffing box and flowline leaks caused by winter freezing have been virtually eliminated. Figure 9 shows an example of a well pumping against a closed system.

Some additional environmental benefits are:

- Sensing of high level on tanks and/or production vessels which has allowed overflow pits to be eliminated.
- Remote field or area emergency shut downs.

Safety performance has been improved by being able to recognize pressurized systems before dispatching crews. The POC system is also used for remote startup after service jobs which allows us to remove personnel from potentially dangerous areas. In addition, the POC system has contributed to lowering the failure frequency which has resulted in reduced service jobs and therefore reduced the potential for injury.

## FUTURE OPPORTUNITIES

Most of the processes discussed above have dealt with rod pumping well management which is the traditional use of POC's. However, the POC system is starting to be used for more non-traditional management of field processes such as:

- Injection surveillance
- Submersible pump monitoring
- Facility surveillance
- Enhanced surveillance through Exxon's ALWORKS program

Injection wells and wells pumped with submersibles are currently being monitored for injection pressure and amperage respectively. Pressure or amperage is continuously monitored and is plotted once per day. Limits are set so that an alert is produced if these limits are exceeded. Future opportunities exist in monitoring tubing-casing annulus pressure, flow or no flow and tubing discharge pressure.

Facilities are currently monitored for vessel levels with the appropriate alarms. Additional opportunities have been identified in sub-battery flow rate, trunk line and header pressure monitoring. The emphasis being on changes that may indicate increased pressure due to restrictions or decreased pressure that would indicate potential leaks.

Integrating POC system capabilities with the ALWORKS program and eventually an "artificial intelligence" type rod pumping analysis program will extend the use of the POC system significantly.


## ACKNOWLEDGMENT

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| WELL # | STROKE LEN | STROKE SPEED | PUMP SIZE | PUMPING UNIT | REMARKS |
|---|---|---|---|---|---|
| FCU 03-23 | 100 | 7.32 | 1.50 | M320D-256-100 | |
| FCU 03-35 | 168 | 8.45 | 1.50 | M640D-305-168 | |
| FCU 03-37 | 168 | 8.22 | 1.50 | M640D-305-168 | |
| FCU 03-39 | 84 | 9.09 | 1.50 | M228D-256-100 | |
| FCU 04-21 | 120 | 6.74 | 1.50 | M456D-256-120 | |
| FCU 04-23 | 168 | 9.52 | 1.50 | M640D-305-168 | |
| FCU 04-25 | 64 | 7.36 | 1.50 | C-228-190-64 | |
| FCU 04-27 | 120 | 9.23 | 1.75 | M456D-304-120 | RT High |
| FCU 04-29 | 64 | 7.50 | 1.25 | C228-200-64 | |
| FCU 04-33 | 100 | 7.06 | 1.50 | M320D-256-100 | |
| FCU 04-35 | 168 | 7.06 | 1.50 | M640D-305-168 | |

Figure 1 - Stroke Length, Strokes Per Minute, Pump Size

| WELL # | STROKE LEN | STROKE SPEED | PUMP SIZE | PUMPING UNIT | AVG RUNTIME |
|---|---|---|---|---|---|
| DRGU 1707 | 144 | 10.34 | 1.50 | C640D-365-144 | 99 |
| FCU 05-35 | 130 | 10.08 | 2.00 | M640D-305-168 | 98 |
| FCU 06-37 | 130 | 10.91 | 2.00 | M640D-305-168 | 100 |
| FCU 06-41 | 130 | 9.30 | 1.75 | M640D-305-168 | 100 |
| FCU -8-25 | 130 | 11.11 | 1.75 | M640D-305-168 | 90 |
| FCU 08-31 | 130 | 10.91 | 1.75 | M640D-305-168 | 100 |
| FCU 08-35 | 112 | 10.53 | 1.75 | M456D-365-144 | 99 |
| FCU 09-19 | 130 | 9.30 | 1.75 | M640D-305-168 | 98 |
| FCU 09-87 | 120 | 10.62 | 2.00 | M456D-304-120 | 99 |
| FCU 10-27 | 128 | 9.84 | 1.75 | M456D-365-144 | 100 |
| FCU 10-33 | 130 | 25.53 | 1.75 | M640D-305-168 | 99 |

Figure 2- Artificial Lift Capacity Or Pumping Unit Size

| WELL # | FL DATE | DEPTH | FL | FAP | SL | SPM | %RT | CSG PR | TBG PR | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|
| FCU 66-29 | 3/28/96 | 6615 | 6559 | 56 | 149 | 8.3 | 91% | 84 | 83 | Fluid level only |
| FCU 66-37 | 10/27/94 | 6874 | 5932 | 942 | 130 | 9.7 | 100% | | 100 | Gas compression in pump |
| FCU 66-37 | 11/1/94 | 6874 | 5900 | 974 | 130 | 9.7 | 100% | | 101 | Fluid level only (A/L) |
| FCU 66-37 | 6/1/95 | 6874 | 5824 | 1050 | 130 | 9.7 | 100% | 120 | 119 | Slight gas compression in pump |
| FCU 66-37 | 1/11/96 | 6874 | 6008 | 866 | 130 | 9.7 | 100% | 97 | 98 | Gas compression in pump (Slight T.V. leak) |
| FCU 66-37 | 2/7/96 | 6769 | 5754 | 1015 | 130 | 9.6 | 100% | 71 | 102 | Fluid level only (FBG) |
| FCU 66-37 | 3/28/96 | 6769 | 6619 | 150 | 130 | 9.7 | 100% | 106 | 104 | Fluid level only |
| FCU 66-37 | 2/6/97 | 6769 | 6675 | 94 | 130 | 9.8 | 100% | 95 | 94 | Fluid level only |
| FCU 66-39 | 11/2/94 | 6151 | 6125 | 26 | 72 | 7.3 | 25% | | 110 | Fluid level only (CSB) |
| FCU 66-39 | 11/22/94 | 6151 | 6125 | 26 | 72 | 7.3 | 24% | | 107 | Fluid level only (CB) |

Figure 3 - Access Fluid Level Report

| WELL # | FAILURE |
|---|---|
| FCU 05-21 | Lost comm |
| FCU 12-25 | Pins |
| FCU 18-39 | Card drift |
| FCU 21-19 | Repl Batt |
| FCU 27-23 | 50k load cell? & pos prob comes and goes |
| FCU 28-23 | CLINO; Window <->; Time for MBD? |
| FCU 32-08 | Rats eat cable |
| FCU 50-31 | New install "ISMO" |
| FCU 59-29 | Repl ID cable "DD" |
| FCU 62-37 | Pins |

Figure 4 - POC Repair Report

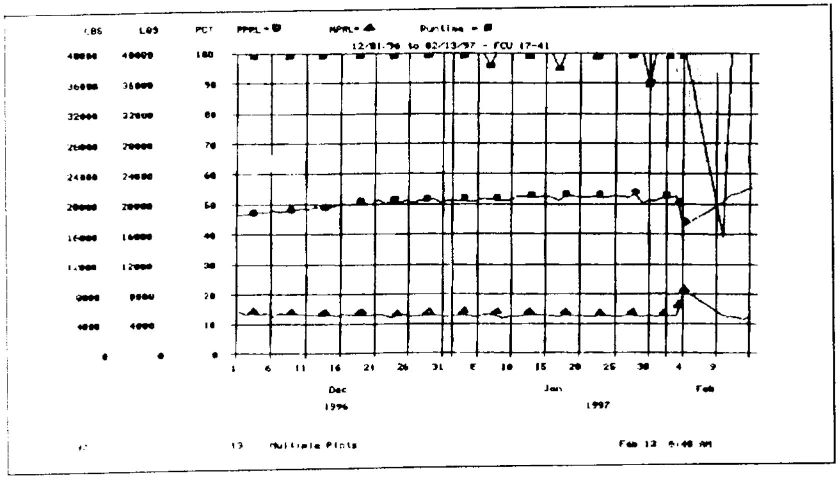


Figure 5 - Trend Report Of PPRL, MPRL, And Runtime

| WELL | CURRENT PPRL | DATE | PREVIOUS PPRL | DATE | PCT CHG |
|---|---|---|---|---|---|
| FCU 15-10 | 15720 | 02/06/97 | 17400 | 02/02/97 | 10 |
| FCU 18-39 | 20000 | 02/06/97 | 23880 | 02/05/97 | 13 |
| FCU 68-38 | 23520 | 02/06/97 | 19400 | 11/19/96 | -21 |
| FCU 23-35 | 15120 | 02/06/97 | 10800 | 02/05/97 | -40 |

Figure 6 - Exception Report

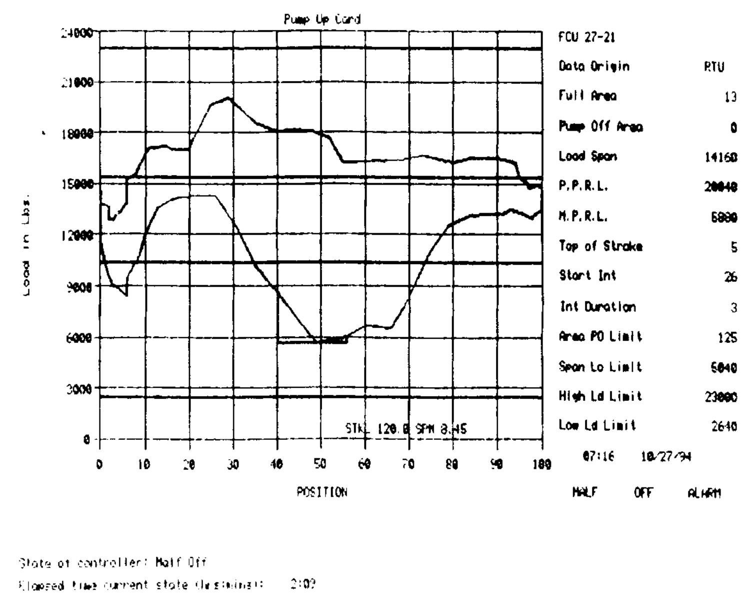


Figure 7 A - Unstranding Bridles

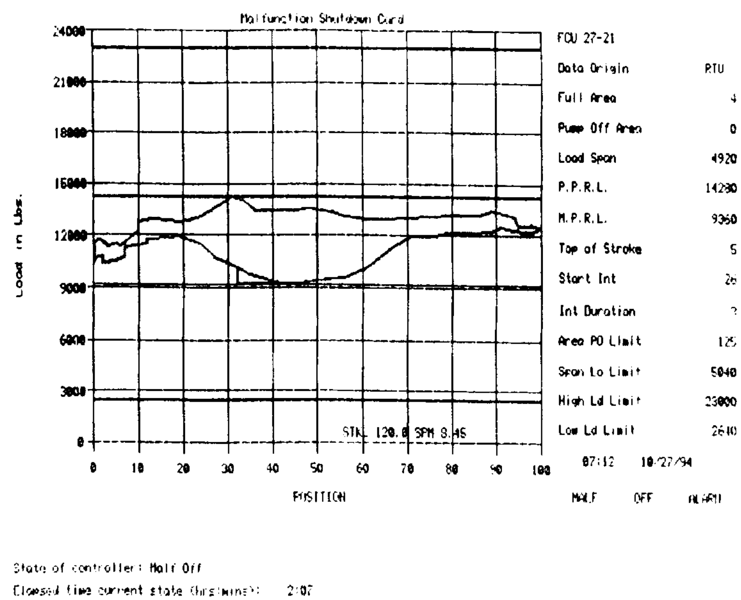


Figure 7B - Unstranding Bridles

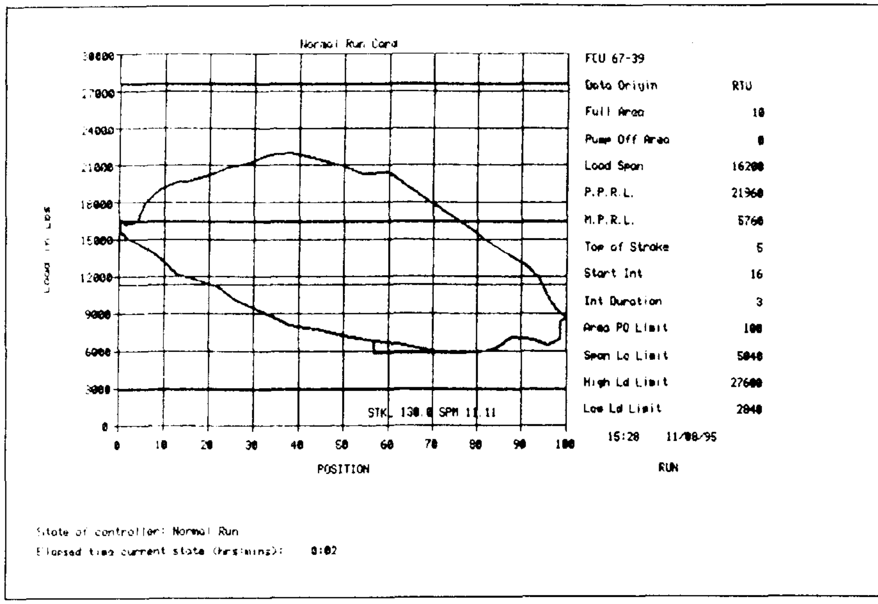


Figure 8A - Mark II Units - CW And CCW Rotation

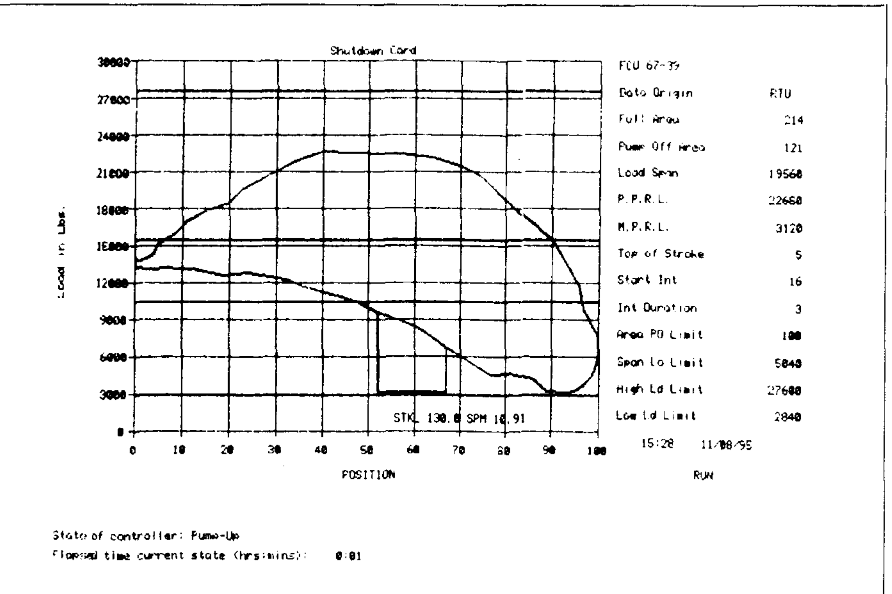


Figure 8A - Mark II Units - CW And CCW Rotation

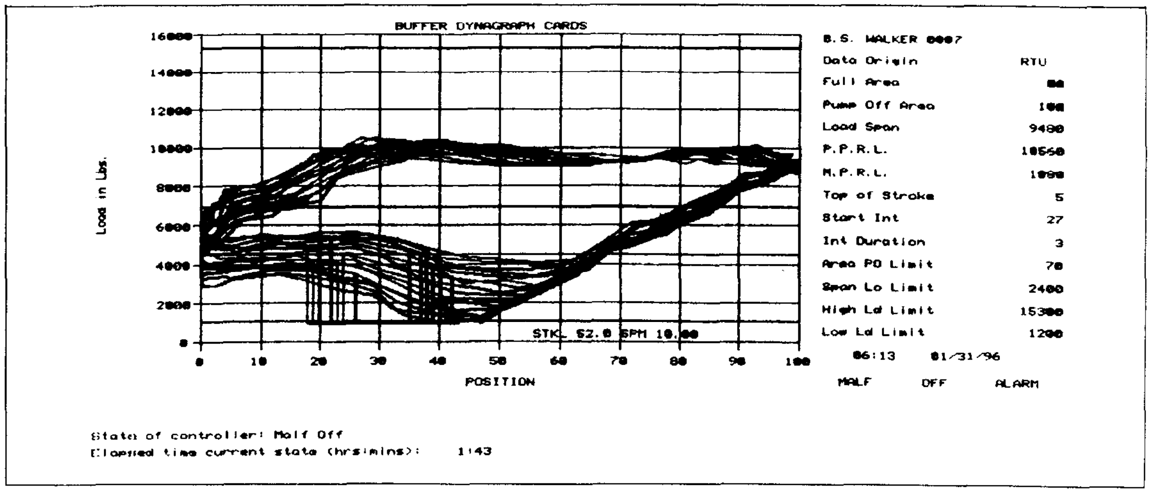


Figure 9 - Pumping Against Closed System