BENEFITS OF IMPROVED PUMP OFF CONTROL FOR BEAM PUMPED PRODUCING WELLS

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ABSTRACT

For West Texas and Eastern New Mexico producing areas, analog pump off controllers are widely employed by numerous operators to optimize fluid recovery and reduce equipment failures for beam pumped producing wells. With the development of supervisory pump off control (SPOC) systems, pump off control technology can provide engineering and operations personnel with a more complete well surveillance package that includes diagnostic capabilities. In addition, SPOC system hardware configurations are deployed so that individual well site controllers send alarm signals, digitized dynamometer cards, and other pertinent operating data to a host computer when a lift equipment failure or anomalous operating condition occurs. Besides providing for an immediate response to an upset well condition, the stored data allows for more accurate determination for the problem source. Effective lift design modifications can then be accurately developed.

Amoco Production Company (Amoco) had implemented analog pump off controllers, to work in conjunction with a proprietary lease automation system, for the vast majority of beam pumped producing wells. With the availability of SPOC systems on a commercial scale, pilot testing was initiated to determine whether this enhanced technology could provide sufficient benefits to allow for pump off controller retrofit. In addition, experiences of other operators were reviewed to augment what developed to be favorable pilot test applications. Based upon this cumulative information, SPOC systems were implemented for non-automated producing properties and as upgrades for some key producing properties. Following implementation of SPOC systems for 671 wells that were previously equipped with analog pump off controllers, a post installations appraisal was completed to identify average economic benefits. Documented lift equipment failure reductions and fluid production increases were found to provide significant incentive to justify continued SPOC system proliferation.

INTRODUCTION

Beginning in the early 1970's, Amoco began experimenting with automation of oilfield production operations. Due to significant reserve holdings and the desire to maximize recoveries by minimizing producing fluid levels and equipment downtime, the West Texas and Eastern New Mexico producing areas were designated as priority areas for automation implementations. By early in the 1980's, the vast majority of production operations in these areas were automated. Pump off controller installations were a portion of an overall lease automation strategy that included automatic well testing, injection well monitoring and control, producing well monitoring, production and injection facility surveillance, and operator alarm notifications.

With this background of experience coupled with the desire to evaluate the profitability of the latest automation technologies, Amoco began exploring the benefits of SPOC system technology as a potential upgrade of existing analog pump off controllers. The analog pump off controllers in use could provide a "live action pumping card", through the use of a portable analyzer, to allow operations personnel to witness the producing well conditions and adjust set points for shut down of beam pumping equipment as wellbore fluids were pumped off. Pumping cards that could be recorded during equipment failures were not saved for future analysis, and pumping conditions were not transmitted to a central terminal. With SPOC systems, as depicted in Figure No. 1, live pumping conditions could be viewed at a centrally located terminal, dynamometer cards were saved for viewing following an equipment failure, diagnostic programs could be run to aid problem indentification, and treading packages could be used to monitor producing conditions and predict problems before they occur. It became evident that the SPOC systems provided superior capabilities as compared to the analog controllers in use. The resultant problem became one of defining what benefits could be derived from the improved capabilities provided with SPOC systems.

To begin addressing this problem, pilot testing was initiated for locations ranging in size from one to ten wells. The initial desire was to gain familiarity with the various systems commercially available. Advantages and disadvantages of each system s were documented as well as actual benefits perceived. In addition, tours of outside operated installations and vendor demonstrations/seminars were held to gain further knowledge on systems and operations. At the conclusion of this data gathering phase, the decision was made to proceed cautiously with SPOC system deployment. Initial justifications for these installations were estimated as up to a one percent production increase, a lift equipment failure frequency reduction of ten percent, and a power consumption savings of two percent. These benefits were based upon documented results in the Permian Basin area of West Texas by Shell Western E & P employees (see references 1, 2, and 4), and verified by pilot testing.

Following approximately one year of experience with SPOC systems for beam pumped producers that were previously equipped with analog pump off controllers, an appraisal was performed to identify average realized benefits. A total of 671 wells were involved in the Post Installations Analysis. These wells were distributed across eight distinct operating areas, and the appraisal was divided into two primary components. The first represented a statistical review of benefits obtained due to fluid production increases, energy consumption reductions, and equipment failure decreases. To accomplish the statistical evaluations, data was complied for previous operations using analog pump off controllers and compared to similar data following SPOC system deployments. The second component represented an operational review in which meetings were held with automation, operation, and supervisory personnel responsible for actual system use. These operations meetings were valuable in identifying other variables that may have impacted the statistical evaluation. In addition, the operational appraisal fostered employee input that will be used to optimize future system designs.

STATISTICAL APPRAISAL

Table No. 1 provides a summary of producing depths and type recovery mechanisms (primary or waterflood) employed in each of the eight operating areas. Table No. 2 provides a summary detailing that 546 of the 671 available wells for the survey were actually included in the detailed statistical review. A total of 125 beam pumped producers were removed from further study due to a change in the production well depth, revision in lift equipment type (such as conversion from beam pump to electric submersible pump), or shut in or abandonment of production operations. These wells were removed from the survey base to assure comparison of like operating conditions before and after SPOC system installations. Overall, 81 percent of the available wells remain in the statistical population analyzed.

Table No. 3 provides a summary of the failure date complied during this evaluation. Overall, downhole pump related failures decline by 20 percent from a before SPOC annual average of 495 to an after SPOC annual average of 396. Likewise, sucker rod related failures declined by five percent overall from a before SPOC annual average of 350 to an after SPOC annual average of 332. Surprisingly, over all workover frequency increased on average by 31 percent despite the fact that workover frequencies for leases in the West Texas and Eastern New Mexico producing areas had declined both in 1988 and 1989. Personnel in several locations credited improved data available with the SPOC systems as a primary tool to more readily identify the need for well stimulation or repair work. In addition, increased failure frequencies for areas B, E, and F were attributed primarily to left equipment fatigue. Recent budget restraints, due primarily to lower oil price realizations over the past few years have lead to more careful scrutinizing of the lift equipment replacements. Lifts equipment replacements have become more difficult to economically justify resulting in higher average equipment service lives in some ares during the past few year.

Increased failure frequencies can then occur. No attempt was made to adjust the failure data base to account for increased equipment service lives.

Table No. 4 provides fluid production and runtime data comparisons for the eight areas studied. This data was considered to be the most reliable data readily available from Amoco's central computing system for analysis of SPOC benefits. In addition to before and after comparisons of this data, an artificial parameter of barrels of fluid produced per hour of unit runtime was developed as a measure of electrical power consumption. The effort required to rigorously record and/or define actual power consumption on a well by well basis, for a population survey of this size, was considered to be too extensive for a task. This artificial parameter provided an acceptable indication of actual improvement in efficiency obtained. From the data contained in Table No. 4, an average fluid production increase of approximately ten percent was identified with an increase in average runtime of two percent, overall. Although these benefits are much greater than originally anticipated, the recommendation was made to justify further systems installations using a three percent production increase combined with the previously detailed fourteen percent decrease in equipment failure frequency. Electrical power consumption reductions are not recommended for inclusion in future justifications since power use actually increased, due to increased fluid production, despite the improvements in overall lifting efficiency noted.

As shown in Table 5, all of the eight areas surveyed experienced operational benefits of a magnitude sufficient to economically justify SPOC system deployment. On average, the benefits received would provide less than a one year pay out on the installation costs encountered. The capability to continuously monitor, control, and optimize beam pumping operations following SPOC system deployments provided the primary operational change that lead to these savings. However, it is noted that application of these systems services to increase the awareness and knowledge of lifting parameters amount operations personnel, and this also contributes to the level of benefits obtained.

OPERATIONAL APPRAISAL

To solicit comments on accurate performance, eleven separate meetings were held at field operations offices. These meetings were attended by operations, engineering, automation, and supervisory personnel with responsibility for SPOC system operation. At the time of these meetings, system manufactured by Automated Controls, Inc., Baker Lift Systems, and Delta X Corporation were in service. Preliminary discussions on statistical appraisals were completed to assure sufficient understanding of tabulated results. Comments generated during these discussions resulted in the following items being prioritized as principal operational concerns that materialized during SPOC systems deployment:

1. Communications Interface - Since SPOC central host computing systems were purchased in conjunction with individual wellsite controllers, difficulty was encountered linking host computer data to a separate Amoco automation computing system. Although the decision was made to deploy SPOC systems prior to completely resolving the linking issue, operations personnel were sometimes found to be searching for desired data contained within one of the two systems.
2. Organizational Impact - With enhanced trouble shooting and diagnostic capabilities, traditional roles of operations personnel shifted away from "checker" and more towards "well analyst" type functions. While this creates a more desirable and challenging position, some difficulty was encountered adjusting to the change operational mode.
3. Maintenance Concerns - The need for spare parts inventories was identified to assure minimal well downtime during controller of system repair. In addition, assignment of the maintenance function to appropriate personnel became a concern, as with most automation systems, to assure optimum system performance. Finally, a cost monitoring system was requested to document maintenance costs for inclusion in future economic and purchase analyses.
4. Vendor Service - Vendor support of the commerically available systems utilized appeared to impact the speed upon which operational personnel began obtaining projected benefits.
5. Further Training - Although initial training was provided, follow up training at three to six month intervals was deemed necessary to assure maximum use of trouble shooting and diagnostic capabilities.
6. Equipment Performance Monitoring - Documentation of component failures was considered a necessity to assure performance problems were corrected prior to significant costs being incurred for repair. In addition, adequate documentation assured that appropriate system design concerns could be addressed for future applications.

As with other automation tools, the operational appraisal demonstrated that sufficient training, experience, and support are required to assure realization of maximum benefits following SPOC system deployment.

CONCLUSION

The preceding analysis supports the following conclusions for future pump off control systems upgrades through application of SPOC system technology:

1. Production rates can be expected to increase by three percent, on average.
2. Lift equipment failure frequencies can be expected by fourteen percent, on average.
3. Although energy consumption efficiencies can be expected to improve, overall reduction can not be anticipated due to fluid production increases obtained, on average.
4. Operational impact of SPOC system deployments should be evaluated to ensure that full system benefits are obtained (the technology is of maximum value when fully, efficiently utilized).

Based upon these conclusions, Amoco will pursue future applications of SPOC system technology where these benefits provide sufficient economic incentive.

REFERENCES

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Table 1
SPOC Post Installation Analysis - Basic Field
Production Descriptions

AREA	APPROXIMATE PRODUCING DEPTH (FT.)	TYPE RECOVERY
A	6,500	WATERFLOOD
B	8,000	WATERFLOOD
C	5,000	WATERFLOOD
D	8,000-10,000	PRIMARY
E	6,700	WATERFLOOD
F	5,000-10,000	PRIMARY & WATERFLOOD
G	5,000	WATERFLOOD
H	8,200	WATERFLOOD

Table 2
SPOC Post Installation Analysis - SPOC
Population Surveyed

AREA	SPOC RETROFIT WELLS	SURVEY WELLS	PERCENT OF TOTAL
A	114	100	88
B	110	96	87
C	100	97	97
D	92	27	29
E	118	110	93
F	82	64	78
G	37	36	97
H	18	16	89
TOTALS	671	546	81

Table 3
SPOC Statistical Appraisal Failure Data Analysis

AREA	# OF WELLS	BEFORE SPOC # OF REPAIRS/YR			AFTER SPOC # OF REPAIRS/YR			DEVIATION %			COMMENTS
		PUMP	ROD	WO	PUMP	ROD	WO	PUMP	ROD	WO	
A	100	155	93	17	63	62	50	-59	-33	+194	ATTRIBUTE INCREASED WO ACTIVITY PARTIALLY TO DATA FROM SPOC SYSTEM
B	96	44	35	19	72	52	14	+64	+49	-26	RODS AND PUMPS INSTALLED AS PART OF LIFE REVISION PROGRAM, NOW FATIGUED
C	97	78	55	19	68	29	19	-13	-47	0	
D	27	27	26	5	24	9	9	-11	-65	+80	ATTRIBUTE FAILURE REDUCTION TO IMPROVED WELL CONTROL DUE TO DATA AVAILABLE WITH SPOC SYSTEM
E											
FIBERGLASS RODS	61	73	75	22	60	107	23	-18	+43	+5	ATTRIBUTE EXCESSIVE FIBERGLASS ROD FAILURE FREQUENCIES SINCE SPOC SYSTEM INSTALLATION TO RODS REMAINING IN SERVICE PAST FATIGUE LIMITS
STEEL RODS	49	59	30	13	42	26	17	-42	-13	+31	
F	64	36	18	13	47	31	7	+31	+72	-46	CORROSION INHIBITION PROGRAM CUT BACK END OF 1988. LIFT EQUIPMENT IN MANY OF THESE WELLS APPROACHING REPLACEMENT AGE.
G	36	8	1	7	6	6	12	-25	+500	+71	
H	16	15	17	0	14	10	0	-7	-41	0	
TOTALS	554	495	350	115	396	332	151	-20	-5	+31	

Table 4
SPOC Statistical Appraisal - Fluid Production and Runtime Data

AREA	BEFORE SPOC (AVG) BFPD	BEFORE SPOC (AVG) RUNTIME(HRS)	AFTER SPOC (AVG) BFPD	AFTER SPOC (AVG) RUNTIME(HRS)	PERCENT DEVIATION BFPD	PERCENT DEVIATION RUNTIME(HRS)	OIL CUT %	INCREMENTAL BOPD	BFPD/HR. RUN BEFORE SPOC	BFPD/HR. RUN AFTER SPOC	BFPD/HR. RUN DEVIATION %
A	210	16.4	235	16.8	11.9	2.4	14.2	3.6	12.8	14.0	9.4
B	111	14.8	120	14.3	8.1	-3.4	19.0	1.7	7.5	8.4	12.0
C	117	14.1	144	13.3	23.1	-5.7	23.9	6.5	8.3	10.8	30.1
D	110	17.0	111	16.5	0.9	-2.9	18.7	0.2	6.5	6.6	1.5
E											
FIBERGLASS RODS	288	18.7	285	19.1	-1.0	2.1	12.2	-0.4	15.4	14.9	-3.2
STEEL RODS	126	17.2	129	17.6	2.4	5.6	18.0	0.5	7.3	7.3	0
F	179	16.5	191	9.5	6.7	-42.4	18.0	2.2	10.8	20.1	86.1
G	333	18.0	399	19.5	19.8	8.3	5.1	3.4	18.5	20.5	10.8
H	168	20.9	154	17.7	-7.1	-15.3	14.3	-2.0	8.0	8.7	8.8

Table 5
SPOC Appraisal Summary - Incremental Benefit after
SPOC Installation - Actual Results vs.
Original Estimates

AREA	1.0% PRODUCTION INCREASE GREATER THAN	1.0% PRODUCTION INCREASE LESS THAN	2.0% ELECTRICAL SAVINGS GREATER THAN	2.0% ELECTRICAL SAVINGS EQUAL TO	2.0% ELECTRICAL SAVINGS LESS THAN	10% FAILURE REDUCTION GREATER THAN	10% FAILURE REDUCTION LESS THAN
A	X		X			X	
B	X		X				X
C	X				X	X	
D		X		X		X	
E	X				X		X
F	X			X		X	
G	X			X			X
H		X			X	X	

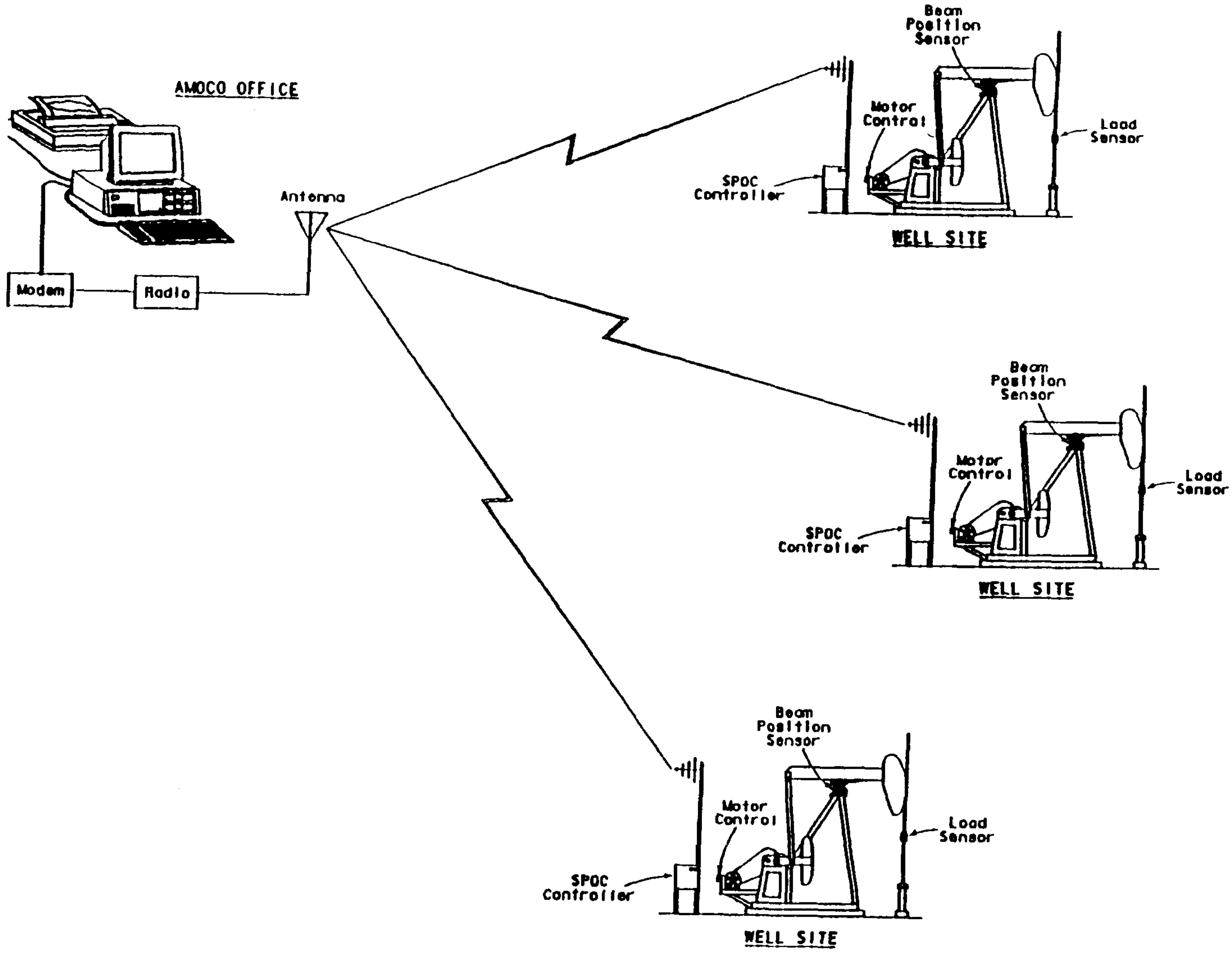

Figure 1 - Supervisory pump off control system configuration