Artificial lift is a process that allows oil and gas producers the ability to optimize well production while also minimizing overall maintenance and life cycle costs. Plunger lift control is a form of artificial lift used by natural gas producers who experience heavy downhole fluid loads. In many cases, when a gas well produces excessive fluid volumes, the natural gas pressure of the well is unable to overcome the weight of the fluid trapped inside the tubing. That means that the well is unable to produce the natural gas because, essentially, it is blocked by the fluids.

Artificial lift technologies and processes have become increasingly popular as instruments for optimizing oil and gas production. When the well is blocked, it is far from optimized, of course.

In instances where a well has been blocked by fluids, the common practice has been to manually shut in the well thus creating downhole pressure. The objective for this process simply is to build enough downhole pressure to lift, or produce the energy. To improve this process, producers also utilize a plunger, or a valve, to assist with lifting the fluid.

Incorporating the plunger is quite effective but not without its own risks. If the plunger is not used correctly — such as allowing excessive plunger travel speed — damage is likely to occur to at least the plunger equipment and maybe to other valuable assets. Of course, that has a direct negative impact on maintenance cost and potentially more.

Another factor in achieving optimal results in the manual plunger process is that the process must be managed by an experienced operator. In other words, the operator is tied up performing shut-in tasks when the person could be deployed doing more productive activities.

Technologies that combine artificial lift for plunger control and remote monitoring are keys to overall productivity and success. Of course, if there were enough technicians affordably available, remote monitoring would be less important in this equation. However, that scenario is simply not realistic.

By remotely monitoring a few critical data points, such as pressure, time, production volume, and line pressure, an operator can achieve maximum results at minimal cost and minimum risk for damage (see Figure 1).

The first two data points include both tubing and casing pressure. Understanding these respective pressures and how they correlate with one another allows an operator to determine fluid load. Once fluid load is determined, it is time to produce the energy. However, producing the well too quickly can potentially damage equipment while also minimizing flow time. The result is reduced daily revenues. Again, traditionally, this process was managed manually. In some cases, operators would be required to physically be deployed to monitor systems on a well location. The operators would monitor plunger arrival times while simultaneously monitoring production volumes. This data allowed the operator to understand the dynamic production characteristics of that particular well. With the data and the understanding, the operator developed a time-based program using a mechanical timer that would shut in the well to accumulate enough downhole pressure to subsequently produce the energy. The operator calculated the best use of a mechanical timer to set the time for the valve to be open and for it to be shut thus setting the production for the well. The timer is, of course, only time-dependent and not reactive to any changes that might occur as the well characteristics change.

The problem with this approach, though more valuable than doing nothing, is that, of course, wells change with time and use. What might have been the right formula on a new well may not be adequate for a one-year old well. It is even less likely that the program will be right over time since the production declines as the well ages.
The static nature and subsequent limitations of the mechanical timer lead to the desire for a “self optimizing” plunger application. The most desirable is a field-based, well site computer that can monitor flow rates and adjust the time cycle to increase production as the well characteristics change.

Automation electronics manufacturers have been focusing a great deal of their development efforts on the plunger lift control application during recent years. They have done so to support customers’ needs to automate this process – through the use of electronics – and also to improve the time-based shut in procedures while doing so remotely. To improve these manual procedures, manufacturers have created a series of algorithms that allow their electronics to self-optimize the plunger lift process. In other words, the controller or EFM (Electronic Flow Meter) learns and adapts to the changes in the well pressure. The algorithms utilize a collection of data points that include plunger arrival times (time), fluid load (tubing and casing pressure), after flow (volume and time) to make decisions. Based on these data points, along with high/low thresholds set by an operator, the remote terminal unit (RTU) or the programmable logic controller (PLC), or EFM can automatically self-adjust and determine when to produce – open the production valve – when to shut in – close the production valve – and, therefore, optimize the overall process for lifting heavy fluid loads while achieving each respective well’s maximum production efficiency.

This all contributes to the overall economics of a well during its life cycle. However, knowing that is true does not mean that the careful selection of equipment up-front can be ignored. One must also consider the up-front costs associated with the acquisition of plunger lift control technology as well as the deployment of this technology. Another variable, as always, is the estimated length of the equipments’ lifecycles. Cost factors that must be considered include:

1. Host software
2. RTU/PLC/EFM
3. Instruments
   a. Pressure Sensors
   b. Switch devices
   c. Automated valves
   d. Analyzers
4. Remote Communications
   a. RTU/PLC level
   b. Local
   c. Backhaul
5. Remote Power – Solar Applications
   a. Solar Panel
   b. Batteries
6. Communication Equipment
   a. Suitability for the application

b. Proper certifications
c. Power consumption
d. Customer support history
e. Generational compatibility

7. Installation
   a. Labor
   b. Equipment**
c. Time
d. Materials
   i. Cable
   ii. Conduit
   iii. Fittings
   iv. Valves
   v. Etc.

** Does not include plunger equipment

The cost of a plunger lift control automation package (installed) can run from $3,500 to $12,000. Whether that sounds like a lot or a little will depend upon the many decision practices that exist. Definitely what does sound like a lot are the increases achieved in well productivity from using plunger lift control. There are many documented cases from differing wells in different geographic areas that suggest a 12 percent to 35 percent increase in production is attainable as a result of implementing automated plunger lift control systems on wells that produce high volumes of fluid. Therefore, in many cases the system is relatively easy to justify by calculating the rapid return on investment (ROI).

Throw in the savings in on-going labor and equipment deployment by operating the plunger lift control remotely and the case becomes even stronger.

Some smaller may not calculate the staff resources necessary to attempt to optimize production manually as simply sunk costs because the labor and equipment (e.g. trucks) are required anyway. When opportunity costs for not deploying those resources for more productive purposes and, in large systems, the considerations are for producing hundreds or even thousands of wells then the costs can be staggering, if not prohibitive. Therefore, many operators are switching to new automated plunger systems. This monitoring and control functionality can be accomplished by hardwiring the instruments at the well head back to a control box, typically an electronic flow meter (EFM) or by deploying a new wireless radio technology know as Wireless IO (see Figure 2). There are several radio and instrumentation manufacturers that offer “Wireless IO” at differing levels of functionality, RF reliability, prices and many other variables.
So what is Wireless IO, or wireless monitoring and control? Wireless IO is a mechanism by which analogs (1-5 Volt inputs or 4 to 20 milliamp inputs), such as temperature and pressure, as well as discrete inputs (digital signals), such as valve control, and high level tank alarms, pulse counting, or other raw signals may be transmitted via radio to or from a central processing device (EFM, RTU, PLC) and to or from the sensor.

Specifically, on a plunger lift well the data transmitted includes, level, flow, pressure, temperature, plunger arrival, alarms and signals generated to final control of devices, such as valves.

Why do this wirelessly? There are several compelling reasons, but the most compelling is expense. The other factors are:

- **Fast installations:** Wireless can be running in 30 minutes versus several days with conventional wired methods.
- **Low cost:** On a single well site the cost of wireless can be lower than $2,000 to provide complete monitoring and control for a plunger lift automation.
- **Little repair:** A common source of irritation on well sites is the cut wire that was inadvertently severed when something was added later.
- **No trenching:** Trenching is slow, time-consuming and expensive with cost of $20 per foot common in many areas.
- **No Conduit:** Conduit again is slow and can take days to schedule a crew to do the install with costs running $20 per foot.
- **Redeployable:** Wireless is not a “sunk cost.” It is transportable. If the tank moves, take the radio with it. Even if the tank does not move when the well no longer is producing, the wireless equipment can be just as easily de-installed as it was installed. It then can be easily installed in a new location. Certainly, it is impractical to consider this action for buried wires.

These wireless systems save time and money on single well pad installations, but in recent years many operators have switched to “pad” wells using directional drilling techniques. These installations host multiple wells on one pad reducing the overall footprint of the wells allowing operators to share production facilities between multiple wells and, again, reducing the facilities cost per well head, and lowering the lifting costs per MCF of gas, or barrel of oil produced (see Figure 3). These new production techniques and new facilities designs also lend themselves easily to automated plunger and wireless control systems.

On the wireless control systems, instead of installing a RTU, EFM or PLC device at each well head you can use one RTU, EFM or PLC per pad. These RTUs or EFMs are capable of collecting custody transfer information from multiple wells as well as doing plunger lift applications on all of the wells. Some electronics manufacturers’ equipment can support as many as 20 wells with custody transfer gas measurement, plunger optimization and valve control to each of the wells with one EFM. Obviously, this concept plays well with the same strategy as using one well pad and one set of production equipment.
At the well head, the operators use a stand alone radio to read and transmit the casing pressure, tubing pressure, determine the plunger status, and to control the valve (open or closed). The radio does not provide any logic, or decision-making capability. The radio is merely the replacement for a wire between the EFM and the well head. The radio is constantly updating the EFM with well head information. Different manufactures use different update rates, but it is not uncommon to have information updates often as six times per second. This wireless IO radio is a fraction of the cost of a RTU or EFM and its only job is to act as the “Pony Express” and send the data back to the EFM where the mathematical algorithms are calculated to determine what needs to be done to optimize the production.

Case studies have shown that the cost savings is $3,000 to $5,000 per well head to install a radio instead of an EFM. On a directional drilling pad well that savings could be $45,000 per pad based on a savings of $3,000 per unit and 15 units. Of course, one EFM unit still is required.

In the Rocky Mountain area, pad wells are rapidly becoming the norm. Major producers in Colorado, Montana, Utah, New Mexico and Wyoming are standardizing on wireless automation of their well heads. Many operators are including the use of tank monitoring, flow rates, water meter monitoring, sump or pit monitoring and flare monitors as well as chemical injection monitoring. There almost is an endless list of data points that need to be collected AND collected wirelessly. Many of these “new wireless radios” have Modbus capability so they can theoretically bring thousands of data points back to the EFM or controller. While no well pad has thousands of points to be monitored, the idea of limitless data collection has intrigued producers to the point of constantly pushing the envelope. To support this push, the producers are constantly pushing radio manufacturers to constantly upgrade and expand their product offerings. Many of these manufacturers are now offering expandable “IO radios.” These products come with a base set of inputs and outputs and some offer the user the option of easily adding modules for an expanded IO count where needed. In addition to the “unlimited IO” capability of the wireless IO, this family of products also offers operators the ability to extend the distance they can bring signals from remote equipment into a central point (see Figure 4). Of course, running wire to remote instruments has limitations defined by physics. The furthest that wires can carry a signal is perhaps a few hundred feet without degradation of the quality and reliability of the signal and, thus, the data. Therefore, the usefulness of the information has physical limitations to overcome with wire only when implementing very expensive systems. With Wireless IO, an operator can carry temperatures, pressures and alarms from miles away back into the system.

Figure 4

For example, if an operator has a compressor site a couple of miles from a well pad, he can use Wireless IO to monitor the oil pressure, temperature and on/off status of the compressor. The radio also can transport near instantaneous signals to provide “Real Time” alarms back into the production office through the measurement equipment and polling host software.

The IO points monitored by an operator differ from company to company. The standards and levels of importance for certain variables seem to have differences from decision maker to decision maker. What each might consider are the perfect number of parameters automated and how the right parameters differ. No one seems to agree on what that optimal number or type of monitoring points must be in order to be the best.

One of the advantages of utilizing the Modbus version of the Wireless IO (see Figure 5) is that these radios are configurable to handle as many IO points as required or as few as are necessary. Every pad or well site can have different IO counts. Several Texas operators are monitoring as many as five analog inputs (casing pressure, tubing pressure, flow, etc.) and six digital inputs (plunger arrival, multiple chemical tanks, etc.) on each well head. Every producer seems to have found what they consider the “perfect” IO count. Since no one ever has the same idea of perfection, expandability and scalability are key to a successfully product selection. If there is one universal consistent idea among producers it is that they will always find more ways to utilize more data and the power of wireless communication from remote assets back to a central site. No one wants to be limited by or boxed into a fixed IO count.
Many of these Wireless IO radios are now capable of transmitting data 30+ miles with good line of site communication paths. Some offer clear line of site, perfect conditions range up to 60 miles. Of course, those conditions are difficult to achieve. However, a radio that offers that spec is more likely to easily achieve reliable communications over shorter distances when obstacles are introduced than are shorter range spec radios.

Another important criteria in selecting a wireless IO device is does it have a “Fail Safe” or default settings configuration. Fail Safe is an industry buzz word that means you can configure the device you are working with (In this case, the radio) to put the well into a pre-determined configuration in the event of a communication loss. Many wireless IO devices plan ahead for loss of signal. No device is immune to a loss of signal (not even wire), and it is important that the radio be able to support the fail safe conditions and make the changes to the situation as it is required and have been pre-planned for in the unlikely event of a signal loss. For example, if a wireless IO device that is being used to monitor tank levels loses a signal to the host (RTU), the user (you) should be able to choose what the “Fail Safe” condition will be. You can choose to have the valve close on loss of signal, thus preventing the possibility of overflowing a tank and having an EPA clean up (see Figure 6). In most cases, you will choose to have the valve close to insure that the tank does not overflow. The important issue is that you have a fail safe instituted and that it is user selectable.

When wireless IO was first introduced several years ago, many automation people were uncomfortable with allowing mission critical data to be handled in any way other than a hardwire connection. Today, with the advances in communications technology, the opinion has reversed for many. In fact, many industry automation executives feel safer with wireless connections than they do with wired connections because they can corrode, or be broken by mechanical devices. They certainly have become much more comfortable with the economics of wireless over wire especially when considering the proven reliability of wired systems let alone the portability.

In a relatively short period of time, gas measurement, plunger optimization, tank level monitoring, and custody transfer of both liquids and gas has drastically changed. Twenty years ago “Chart Recorders,” manual tank measurement with tape measures, and hand set timer clocks, were the normal tools of the trade for oil and gas production operations. In 2008, nearly 100,000 new wells in the U.S. and Canada were automated with electronic controls. The pace of change has increased every year, with electronics having overtaken manual devices by a 10 to 1 margin last year.
every 1,000 wells they automate just in installation costs. That data is certainly a powerful argument for today’s high-powered flow computers that can handle 16 to 20 wells and the new radio technology of “Wireless IO” at the well head.

As producers try to lower their lifting costs and “stay in the black” in normal times, let alone these tough economic times, using technology to reduce costs is part of making good business decisions. The trick, as always, is to pick the technologies that are proven to be effective. The technologies also have to be supported by companies that manufacture high-quality, low maintenance products with low failure rates and good tech support staffs. Also, it is important to pick companies with local support and technical expertise. Ideally, these companies will be in close proximity to your operations to help train your people or potentially provide system maintenance for your investment.

It is abundantly clear that technologies such as wireless IO save money, reduce labor costs and improve efficiencies. The old adage about change is, “The decision to change only happens when the pain of change is less than the pain of staying the same.” For most operators, that threshold has been crossed with wireless technology. Now the decisions have to be made on how to manage the pain of change and to minimize that pain. A few suggestions on how to have a positive experience while going through these changes are:

Never trust but verify. Always test and verify. New products claims sometimes have been exaggerated; a two-part evaluation of new equipment is prudent. First, ask the companies’ representatives to bench test the equipment in your facility. They should be able to validate that it will operate as advertised on the bench in your facilities. Second, ask for a field test. One of the important differentiating factors between manufactures of wireless equipment is how well does it work in the real world. The factors to consider in real world tests are:

- What is the range? In other words, how far can the radio reliably carry an accurate signal?
- Will it penetrate trees and foliage?
- How accurate are the readings when compared to the instrument that generates the signal (resolution)?
- How does the radio technology handle other radio traffic in the area? Some products fail when deployed in proximity to other radio signals.
- What is the power consumption of the radio? Some products are designed for in-plant operations and require significantly larger and more expensive batteries and solar panels to properly operate and need to extend the periods of power autonomy. These products can push your installation costs up by $500 per site or more over more efficient products.

The technology revolution continues to change the face of the oil and gas industry. Just as 3-D seismographic and directional drilling changed the drilling industry in recent years, the maturity and advent of powerful field computers and wireless technology is changing the production side of the business. The compelling reasons for the change are as we previously described and include important business criteria such as:

- Lower operating costs
- Lower production
- Lower completion costs

As has been the case throughout most of history, and is especially apparent today, oil and gas prices continue to show great volatility in 2009. The one consistent theme that operators agree on is finding and standardizing on cost-saving techniques. Success stories about how multi-well pad completions and wireless IO radios have saved operators money are becoming the norm in many of the new horizontally drilled shale plays around the U.S. Similar techniques are being used in the Barnett Shale, Marquis Shale, Fayetteville Shale, Bakkan, Piceance Creek and Wattenberg production areas.

By utilizing one EFM per pad and switching to wireless IO at the well head, one major production company in Colorado’s Denver Julesburg Basin claims they saved $4,000 per well. This producer plans to automate 3,500 wells over the next four years in the area around Greeley, Colorado. That’s the equivalent of saving $4 million for
Take the time to do a little research and product validation. It will make a huge difference in your experience. Taking time to talk to other industry “experts” such as your EFM manufacturer or local service provider, to see what their experiences have been with various products may save you time in getting to a small group of products you want to test before making your final decision. Ask about the service history of the product and the provider. Make sure that the service and support histories are consistent with the advertising and, especially, with your tolerance level for service calls.

If you have several wells you want to try going wireless on, ask those manufacturers on your “short list” to provide you with a pilot install to allow you to compare “apples to apples.” Do not consider any manufacturer who is not willing to do head-to-head comparisons with its competitors.

There are many good quality products available—all of which are designed for a wide range of applications. Finding the right product for you may have as much to do with the support as with the product itself.

One thing is certain. The world is changing and we are all adapting to keep up with those changes. Hopefully, you will find a group of vendors that share your excitement in making those changes. Having good partners will make it easy for everyone in your organization to make the transition. No one likes to change from the comfortable to the uncertain. Having experienced suppliers that help you and your staff make the “leap of faith” into new technology is important.