

# Applying wireless instrumentation to optimize oil and gas wells

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## Executive summary

The natural gas and oil industry is continually driven by cost-cutting measures and the need to gain more operational efficiencies and visibility to regulatory requirements. Wireless instrumentation systems provide highly accurate digital readings to the control system to assist in making control decisions at the well site. This paper summarizes a solution in which wireless instruments integrate with other conventional equipment to offer a rapidly deployable advanced well optimization system.

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# Executive summary

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# Introduction

The Natural Gas and Oil industry is continually driven by cost cutting measures and the need to gain more operational efficiencies and visibility to regulatory requirements.

Wireless instrumentation products provide cost-effective and easy to install alternatives to traditional, hardwired sensor sites. These rugged field units are designed for the majority of Oil & Gas applications and for installations ranging from general purpose to Class I Div 1 hazardous locations with extreme temperature and humidity ranges.

True wireless instrumentation is comprised of self-contained, self-powered field units providing process data to a centralized base radio through an unlicensed band, spread-spectrum, and frequency hopping wireless connection. Networks of up to 100 field units (900MHz version) can be created and polled by a single base radio using a secure, proprietary “Industrial Wireless” protocol, with a typical range between field unit and base radio of up to 3000ft (~1000m). With the capability to scale up to as many as 256 wireless instrumentation LANs, future expansion plans are easily accommodated.

Wireless Instrumentation eliminates complex, hardwired installations and makes it easy to deploy and monitor sensor networks across a wide range of applications.

Typical wireless instruments support industry standard Modbus protocol to ensure interoperability and compatibility with a wide range of Oil & Gas equipment from third party vendors such as but not limited to Schneider Electric, ABB, Emerson, Thermo, etc...

Wireless Instruments are available in a wide range of sensor and input configurations to fit many applications including pressure, temperature, level, acoustic, switch input and output, turbine meter and analog inputs.

# So why go wireless

The two primary motivations for choosing a wireless network over a wired approach are the flexibility and the cost-savings associated with eliminating cables and wires. The business case behind deploying wireless instrumentation is a compelling one. By eliminating cabling and trenching, you can dramatically reduce the cost of deployment by as much as 70%. Since true wireless instrumentation is battery powered, they are much easier to deploy in the field relative to their conventional counterparts. Wired systems can take days or weeks to properly install, scale, troubleshoot and commission. Wireless instruments require only the sensor to be installed in the process, saving hours or days and valuable resources. Other instruments can be added as needed with no additional cost other than the instrument itself.

Safety and compliance with environmental requirements are also major driving factors. In initial production, visibility to casing pressure is important to detect continuity of the formation during the frac process. During the initial flowback period, using wireless pressure sensors reduces the risk to personnel who would otherwise need to be in close proximity to a volatile and toxic well in order to read manual pressure gauges and to report on production readiness. During the flowback period, before a wired solution can be installed, wireless pressure sensors put the well analyst in touch with the well enabling remote trending and analysis. EPA regulations in many regions require the use of a Vapor Recovery Unit (VRU) to manage residual gases from separators and condensate tanks. An easy to install wireless temperature or switch input sensor can monitor the VRU and report on associated alarms.

## Wireless instrumentation is a different game

With a business case so strong and the return on investment so solid, why are some still reluctant to deploy wireless instrumentation in their facilities?

There are three main reasons:

### Reliability (tried and true?)

In industrial applications, reliability is a major concern. Wireless instrumentation must be as reliable as conventional wired units. Even in simple applications like remote monitoring, users come to expect a certain level of reliability and network availability. Wired systems are much easier to diagnose and trace because the medium, the wire, is physically there or could be damaged with water, well tenders, service rigs, welders, etc... Wireless, on the other hand, uses the invisible free space as a medium. Radio signals are subject to free space attenuation, where the signal loses strength at a rate proportional to the square of the distance traveled. Radio signals are subject to reflection as a result of structure, trees, water bodies and buildings. Furthermore, interference from nearby wireless systems such as cell towers adds more challenges.

RF design is getting better in addressing many of these issues. By designing highly sensitive radio receivers that hop frequencies many times a second to avoid noise, using the transmit power more efficiently and high gain antennas, engineers are able to establish highly reliable RF point-to-multipoint links.

## Adaptability

Wireless instrumentation networks are required to adapt to the existing environment. It is not practical to move a well head, compressor, tank or separator just to create a reliable wireless link; such as in 2.4GHz mesh applications. In long range SCADA networks, it would be much easier to locate a 30 foot tower in the field to allow for line-of-sight consideration. It might also be easier to increase the height of the tower to extend the range and avoid obstruction. Wireless instrumentation networks do not have that luxury. It is sometimes difficult to find a location for an access point or base radio that provides reliable communication with the wireless instruments. Relocating the access point or base radio to improve the RF link with one sensor could result in degrading the links with other sensors in the same network.

Adaptability can be addressed by using lower frequency bands, such as the license-free 900 MHz, which tend to provide better coverage, longer range and better propagation characteristics allowing the signal to penetrate obstacles. Also, high gain external antennas that can be mounted as high as possible on a structure allow access to hard-to-reach sensors which could be located at the bottom of a tank. Improved receive sensitivity of radios also plays a crucial role in ensuring network adaptability to various industrial environments.

## Integration

Today's gas production, processing plants and pipeline facilities have some level of wireless capability in place. Long range proprietary SCADA networks, backhaul point-to-point networks and local wireless area networks are some of the common systems deployed. Each of these networks is being used for a specific purpose such as control data transmission, high bandwidth communication and video surveillance. Engineers and operators are facing the challenge of integrating wireless instrumentation networks with other communication infrastructure available in the field. Managing and debugging dispersed wireless networks presents a new level of complexity to field operators that could deter them from adopting wireless instrumentation despite the exceptional savings.

The wireless integration dilemma is more apparent in SCADA systems. Since wireless instrumentation networks are supposed to tie into the same SCADA infrastructure available at the field site in order to relay valuable operating data to the SCADA host, having the ability to manage the complete infrastructure as one network becomes essential.

Moreover, having the ability to access hard-to-reach areas and gather new data points that were not economically viable before, gives the operator better visibility into the process and plant operations. However, this data has to end up somewhere in the system in order to be monitored, analyzed and leveraged. SCADA systems are normally designed to handle a certain number of data points or tags. Scaling up the system to handle additional data points and integrate them in trends and reports could be costly.

Despite the abundance of tools to capture, process and analyze data in the process control market, ensuring data integration is still a major problem.

## Addressing the wireless and data integration challenges

The financial benefits of using wireless for remote monitoring are compelling; yet, industry has been slow to adopt the technology. Security, reliability, integration, and power are all challenges that must be overcome before there is widespread adoption of wireless measurement systems.

A new breed of advanced wireless instrumentation base station radios or gateways is now emerging in the marketplace to address this need. This new generation of gateways integrates both a wireless instrumentation base radio and a long range industrial radio in the same device. The wireless instrumentation base radio has a Modbus data port, allowing an external Modbus Master to poll information from the base radio about its own status as well as the status and process values of its field units. It also has a diagnostics port, allowing the connection of the network management software for sensor configuration and diagnostics from the host. Both of these data streams are sent simultaneously through an advanced long range serial or Ethernet radio network. This is how it works in practice:

The wireless instrumentation base radio and all field units must have the RF Channel and Baud Rate set identically.

- Each field unit must then have its RF ID set to a unique value. This value will be used later for Modbus polling of the data.
- The base radio's Modbus serial port baud rate must be set to match that of the long range radio.
- The base radio's Device ID must be set. This value will be required later for Modbus polling of the system.

The integrated long range radio is configured as a remote device relaying information to a Master radio at the SCADA host. The two available serial ports on the radio are configured to tunnel Modbus polling and diagnostic data simultaneously to the wireless instrumentation base radio and host. This allows operators to manage and diagnose the wireless instrumentation network through the existing long range SCADA infrastructure. Live data and status information for all field units are displayed in a separate view or integrated in the SCADA host.

On the data integration front, modern SCADA host software offers a fully integrated environment that includes an integrated and scalable historian to handle more additional data without going through expensive and sometimes lengthy upgrades. Developing the SCADA screens based on templates allow engineers to add data points easily and rapidly in their systems.

# Applying wireless instrumentation to oil & gas applications for well optimization

One of the interesting attractions that makes working with the Oil and Gas industry so enjoyable is that the industry as a whole thrives on the development and implementation of new technologies to solve their challenging problems and improve operations. It is widely accepted now that innovations in directional drilling and multi-stage fracturing technology have secured the North American gas supply for many decades to come, due to the significant increases in production from shale gas wells and new frac technologies. Numerous articles have also been written that describe the logistics of dealing with the high volumes of sand, water, chemicals, horsepower and manpower to accomplish these multistage fracs for a given well. The industry has risen to the challenge and producers are being rewarded with significant return on their hard earned investment.

However, with new processes come new challenges, and in the case of shale gas wells and high volume fracs, what goes in the hole generally must come back out. Many shale producers are now faced with erosion of their piping and control valves at the well site as the produced gas carries the frac sand back through the piping at velocities high enough to cause damage. At the relatively high pressures that these large shale wells are capable of producing, a small pinhole leak in a pipe caused by erosion can rapidly escalate to a full scale rupture.

Once the leak occurs it is only a matter of time before a point gas detector at site, a routine site visit by operations, or the producer's worst nightmare – a passing land owner or other member of the public, detects the leak. As soon as the leak is detected the producer is obliged to shut in the well. While point gas detection is proven technology and an integral part of many shutdown systems, the gas still has to make it from the leak to the detector head in order for it to do its job. Unknown factors such as the wind direction at the time of the leak and relative location can cause the detector to be ineffective or slow to respond in outdoor environments.

## Solution

In response to the challenges, a new technology is coming to the fore front to help solve this leak detection problem. When gas leaks into the atmosphere from a pipe, the pressure differential and resulting high velocity flow create acoustic signatures in both the air and the solid material making up the pipes. While there is definitely a significant contribution of acoustic waves in the audible band of frequencies between 12 and 20 kHz, there are also measurable frequencies above the normal hearing band (Ultrasonic) that can be used to detect the presence of a leak.

For several years now wireless instrumentation manufacturers have been providing an Acoustic Monitor to provide release detection at pressure relief valves (PRV's) in process plants. When a PRV opens, there is typically a significant release of process gas or vapor, which produces acoustic waves. The monitor is physically attached directly to the piping near the PRV, and can be configured to send back either an analog signal proportional to the acoustic sound detected or an alarm signal when the acoustic value reaches a threshold limit. The status information is used by operations in determining the duration of the release and subsequently can be used to calculate a released volume for environmental reporting purposes.

Utilizing the Wireless Acoustic Monitor at a problem PRV will provide indication to the plant control or SCADA system of a stuck valve or overpressure situation. It will also alert operations to take appropriate action.

With this experience in acoustic monitoring, manufacturers have been working with a number of producers to apply the Acoustic Monitor technology as a leak detection device on their shale gas well site piping.

Testing has shown that the wireless acoustic monitor can detect acoustic waves generated by gas releases travelling through the piping at distances of tens of meters from the source. Strategic placement of the Acoustic Monitor on sections of piping close to the well head where pipe erosion has been experienced is expected to significantly reduce the response time in the event of a leak.

Unlike point gas detectors, which require routine calibration and have consumable sensors, greatly increasing their cost of ownership per point, the Acoustic Monitor requires no ongoing maintenance or calibration. Multiple points can be positioned on a site to cover any piping configuration with simple clamp-on, non-intrusive installation.

## Well optimization with wireless plunger lift

Recent advances in technology have enabled manufacturers to offer a completely wireless solution for Plunger Lift Control. A complete wireless Plunger Lift Solution consists of the following components: Tubing and Casing Pressure Transmitters and on selected wells a Braden Head Pressure, a Plunger Arrival Sensor and a switch output sensor to control a solenoid that shuts in a sales valve.

It has been the opening and closing of the sales valve through recent advancements in wireless technology that has opened the door to reduce the cost and time to deploy a plunger lift system. Legacy wireless systems were designed around one way communications. These systems only reported back to the base radio and SCADA System what the status was of the process. Each sensor pushes back to the base radio. Opening and closing of the sales valve requires the base radio to write to the switched sensor. This ability allows no cable to be buried and the ability to completely deploy a Plunger Lift Wireless Instrumentation solution in just minutes.

# Wireless vs. wired instrumentation – a case study

Consider the following cost comparison for a single well application.

Instrumentation	Wireless Solution	Wired Solution
Casing Pressure Transmitter	✓	✓
Tubing Pressure Transmitter	✓	✓
Separator Pressure Transmitter	✓	✓
Separator Temperature Transmitter	✓	✓
Separator Level Transmitter	✓	✓
Water Tank Dual Float Level Transmitter	✓	✓
Oil Tank Submersible Level Transmitter	✓	✓
Wireless Base Radio package	✓	N/A
Cabinet, terminal blocks, brackets, etc.	✓	✓
Conduit, wire, fittings, seal-offs, brackets, etc.	✓	✓
Installation Estimate with Contingency	✓	✓
<b>Total Cost</b>	<b>\$24,918 US</b>	<b>\$35,125 US</b>

## Additional benefits of wireless vs. wired

- Electrical Area Classification – Wireless Sensors are rated for Class 1 Div 1 areas thus they can go into any area whereas wired transmitters are of a mixture of Div 1 to Div 2 ratings and require barriers and seals.
- Warranty – Wireless solutions have up to three year warranty and the warranty is with one manufacturer whereas wired solutions have a one year warranty and have multiple manufacturers involved.
- Battery Life Expectancy – Pressure 5 years, Tank Level 10 years vs. Wired solution 3-7 years weather dependant
- Replacement Battery cost – (Total annualized) Wireless Solution \$41 US vs. Wired \$54 US
- Low Battery Warning – Wireless Yes vs. Wired Solution N/A
- Field Instrument Diagnostics from SCADA Host – Wireless Solution Yes vs. Wired Solution No
- Installation Costs associated with P&ID design, drawings, scaling and commissioning – Wireless Solution low cost vs. Wired Solution high cost
- Operational Risks due to Adverse Weather – Wireless Solution None (due to no Solar Panel) vs. Wired Solution Yes
- Work Over Rig Issues – Wireless Solution Low, easy removal of sensors vs. Wired Solution High, possible damage to instrumentation, conduit & wiring
- Cost Escalation Risk due to Inflation – Wireless Solution Low, relatively inflation proof vs. Wired Solution High, as metal prices and labor rates rise, so will installation costs
- Safety Risk – Wireless Solution Low, relatively little time spent on site vs. Wired Solution Moderate, more installation time on site has intrinsic dangers and risks
- Land Use Impact – Wireless Solution Low, fast installation vs. Wired Solution Moderate, long installation time creates land use conflict

# Conclusion

By leveraging tried and proven measurement methods combined with secure wireless technology and advanced power management techniques, producers can dramatically reduce their cost of deployment and operation, increase safety, improve environmental compliance with regulatory requirements and avoid hefty fines. Wireless Instrumentation Systems provide highly accurate digital readings to the control system to assist in making control decisions at the well site.

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