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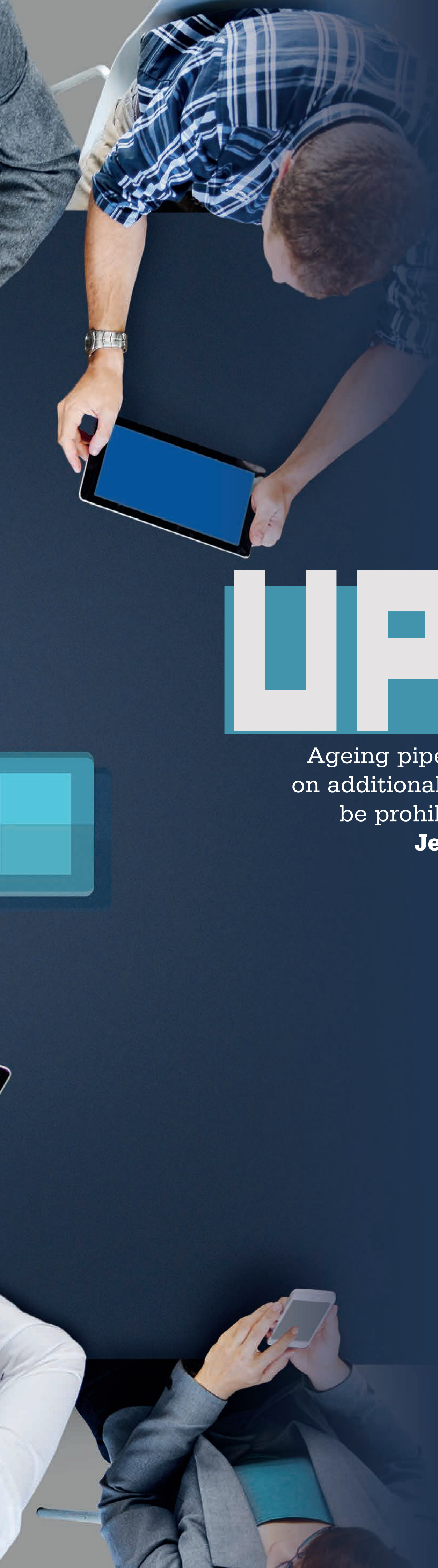

Sensing a wireless UPGRADE

Ageing pipeline monitoring systems often need to keep an eye on additional process parameters, but implementation costs can be prohibitive. Wireless sensors address this issue, explains **Jesse Dodge, Emerson Process Management, USA.**

Oil and gas pipeline companies often need to improve their monitoring systems to ensure efficiency, discover pending equipment problems and streamline operations. More flow, pressure, temperature, vibration and other instruments are frequently needed to improve monitoring of key parameters, but these can be difficult to add to an existing system.

The cost of adding wired instruments pose many costly problems, including the need for additional cable, power supplies, I/O devices and safety equipment. Legacy control and supervisory control and data acquisition (SCADA) systems may not be able to accommodate modern instrumentation because of either insufficient analog input points, or the inability to communicate via modern fieldbus protocols.

This article will look at the monitoring problems of oil and gas pipeline companies, and show how migrating to wireless sensors can make a pipeline company more profitable, increase equipment reliability and cut maintenance costs.

Accurate custody transfer saves money

Custody transfer, sometimes called fiscal metering, occurs when fluids or gases are exchanged between parties. Payment is usually made as a function of the amount of fluid or gas transferred, so accuracy is paramount because even a small error in measurement can add up fast.

Figure 1. A centralised pipeline monitoring system relies on data that sometimes is sent from thousands of miles away.

Figure 2. A wireless gateway can serve as backhaul or bridge to other gateways and collect data from many nearby wireless sensors, sending the data to a central computer.

For example, Pump Station 2 on the Alaska pipeline is designed to pump 60 000 gal./min. (227 m^3/min.) of oil. A measurement error as small as 0.1% can result in an inaccurate calculation of around 86 400 gal. in 24 hrs (330 m^3/d). This equates to approximately 2070 bpd of oil. At a spot price of US$44/bbl, that 0.1% error would equate to US$91 000/d. Over a year, the 0.1% error would amount to a difference of US$33 million. Note that the error could either be on the high side, benefiting the seller; or on the low side, to the buyer's benefit.

As with most automation components, there have been large changes in the instrumentation and related systems used for custody transfer. Flowmeters are smarter, and with modern electronics, software, firmware and connectivity, they can perform diagnostics and digitally communicate this and other information such as alarms and process variables.

Expert systems embedded in the diagnostics firmware inside the flowmeter or flow computer can identify troublesome and error-producing conditions like liquid fractions in a gas stream or entrained gas in a liquid flow, as well as pipeline deposit layer buildup.

Liquid fractions in a gas stream, for example, can help spot liquid condensate giveaway. Accumulated deposit layer buildup inside the pipe, especially inside the metering run itself, reduces the inside diameter of the pipe and can directly lead to large errors in measurement.

In many custody transfer installations, multiple meters are installed in a single header. This permits each flowmeter to be operated independently of any other meter, allows one meter to be used as a master meter, and gives the operator and maintenance technician the ability to isolate one flowmeter for repair and maintenance without shutting off flow.

Adding the necessary meters to a legacy system poses problems. In addition to the need for new wiring, cabling, power and safety, the advanced flowmeters provide a great deal of diagnostic data. Data demands require real time flow, diagnostic and status information to be acquired and transmitted at high speed to central computers for analysis, but many pipeline control and SCADA systems suffer from low bandwidth communication systems.

In addition, legacy control and SCADA systems at the pipeline may not be able to accommodate additional flowmeters in their I/O system, or they may not be able to process the advanced data stream because all they can handle is traditional 4-20 mA process signals. Wireless flowmeters avoid all these problems.

Wireless monitoring

Pipeline operations include wellheads, pumping stations, monitoring stations along the pipeline, custody transfer facilities and tank farms. Some of these facilities – such as wellheads and monitoring stations – are in remote locations, with no access to commercial electrical power. Instrumentation is powered by local generators or solar panels, leaving little capacity to add more wired transmitters.

Wireless sensors can be battery-powered, or equipped with energy harvesting devices, such as the Perpetua Power Puck (available through Emerson), which generates electricity from temperature differences. A heated pipeline can easily power wireless sensor energy harvesting devices.

Wireless sensors use a mesh network, where multiple transmitters send and re-send data to each other and to a central gateway. The gateways collect data from up to hundreds of wireless sensors, before sending it to a central computer for processing via a hardwired data link (Figure 1). This hardwired data link can be one of several popular protocols, such as EtherNet/IP, HART-IP or Modbus, ensuring compatibility with existing control and SCADA systems.

This system completely bypasses the local legacy control and SCADA I/O system, eliminating the need to accommodate additional I/O. Adding wireless sensors to a legacy system also eliminates the need to 'cut and gut' an existing infrastructure to adopt new fieldbus protocols.

Finally, the cost to install wireless sensors is much less than conventional wired 4-20 mA or fieldbus devices. There is no need to install wiring, conduit, cable, intrinsic safety devices, marshalling cabinets, I/O boards and power supplies.

How the data actually gets to the central computer depends on how close the wireless sensors are to the central system. In a custody transfer system, the wireless gateways can usually connect to a local control or SCADA system; in a tank farm, gateways (Figure 2) can transmit to each other, collecting data from hundreds of sensors spread out over a large area, with the closest one to the computer connecting via hardwiring.

If the gateway is too far from the computer for normal wireless transmission, then a longer distance antenna and transmitter can be installed. And if the facility is really remote, such as a pumping station or pipeline monitoring station, then cellular, RF or satellite communications can be used (Figure 3).

Legacy wireless systems had many limitations and concerns, such as the need to establish point-to-point links, the need for user configuration of the network, and concerns with security. Modern industrial wireless protocols, such as WirelessHART (IEC-62591), are self-organising and self-healing networks managed automatically by a gateway. Because the devices use a power module (battery) that can last for up to 10 years, there is no need install solar panels to power these devices.

With WirelessHART, all messages are encrypted using multiple AES-128 bit keys with support for key rotation. The use of direct-sequence spread spectrum (DSSS), time division multiple access (TDMA), frequency hopping, and no IP addresses on the wireless sensors helps increase the reliability and security of the network.

By taking advantage of mesh technology, which means that every device in the network is always a repeater, high gain antennas can be used in remote locations to increase the distances between the WirelessHART devices – and hence the network – to several kilometres.

There are also multiple options for locations where the use of repeaters is not possible. One is to use gateways connecting to a WirelessHART self-organising network with any host system via integrated Wi-Fi backhaul over several kilometres. Another possibility would be connecting the gateways to industrial hot spots that can reach tens of kilometres, or connecting to industrial cellular gateways to take advantage of available GSM or CDMA cellular coverage.

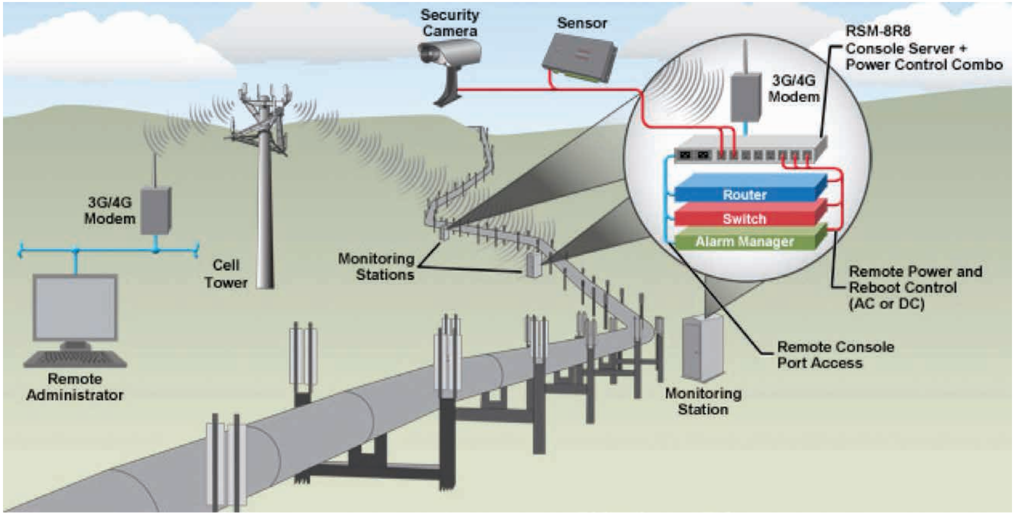

Figure 3. Monitoring stations along a thousand mile pipeline can have security cameras, leak detection monitors and other sensors. Data can be transmitted to the central computer via cellular communications or via RF or satellite.

Improving terminal operations

Oil and gas pipelines end at terminals and tank farms, where the fuel is transferred to tankers, barges, trains or trucks, or piped to a refinery or LNG plant. During its travel to the terminal, the fuel may have moved great distances, gone through many processing steps and had multiple owners as custody transfer occurred during its voyage.

Given the amount of money constantly in play as products move from pipeline transport to tank and back again, automating all or part of a terminal's operations will improve profitability, and help avoid incidents like the following:

- In December 2005, the Buncefield oil storage depot near London, England, was transferring unleaded gasoline from a supply pipeline into a storage tank. This very routine operation was being carried out in the pre-dawn hours of a Sunday. Operators filling the tank did not realise the two level sensors on the tank were both inoperative, nor were they paying close enough attention to realise the tank was reaching its limit. Pumping continued as the tank began to overflow, and leaks in the surrounding retaining bund allowed the gasoline to flow throughout the adjacent tanks. The resulting fire burned for five days and destroyed most of the 194 000 t facility.

- In January 2014, residents near Charleston, West Virginia (USA), noticed a strange odor from their drinking water and called local authorities. The odor was caused by 4-methylcyclohexylmethanol leaking from the Freedom Industries chemical storage facility near the Elk River; the source of the drinking water. The chemical, used to clean coal in nearby mining facilities, was leaking out of a 1 in. hole in the bottom of a 40 000 gal. tank. Approximately 7500 gals escaped, and much of it found its way through the facility's containment system to the nearby river where it affected the water supply of 300 000 local residents.

Figure 4. The geographically spread-out arrangement of most tank farms can make adding traditional wired instrumentation prohibitively expensive. Wireless sensors, such as this guided wave radar level device, can use WirelessHART to send information to the automation system.

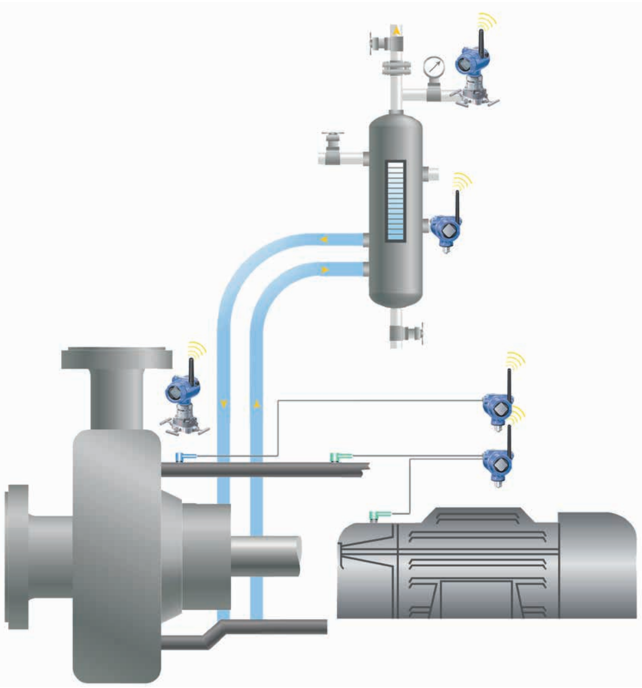

Figure 5. Pump monitoring diagram. A wide variety of parameters are typically measured on pumps used in pipelines, some of which are depicted in this diagram.

In both cases, proper use of wireless level and leak detection sensors would have prevented the incidents. Wireless sensors could have been installed on every tank in the farm and connected via a wireless mesh network, and the data could have been monitored.

Regulatory requirements for overfill prevention are increasing, which is driving upgrades of existing tank monitoring systems. However, the overfill prevention system needs to be independent from the tank gauging system; that is, the existing wiring and I/O cannot be used. Because of the cost of adding more wired instrumentation, a wireless solution is more attractive.

In addition to preventing disasters, wireless sensors can improve terminal management and operations (Figure 4). Terminal owners and managers want control of the business aspects of their operations, and these activities center on inventory tracking and handling speed of both product and information. Moving product through the facility is what generates income, and movements need to be measured very precisely. Sophisticated instrumentation keeps a close handle on product movement, down to proper compensation for changes in volume caused by temperature variations.

Tank management includes monitoring quality and quantity of contents, heating or cooling if necessary, blanketing for fire suppression, and corrosion monitoring to avoid leakage. A failed pump motor or a leaking valve can prevent a critical lineup from being implemented, delaying product movement or causing a spill or contamination. Valves not sealing fully can allow inventory loss, or products to mix and create contamination issues.

While specialised software – such as Emerson's SmartProcess terminal management solution (TMS) – can deal with all these situations, the software needs inputs from sensors and transmitters. Unfortunately, most terminals have only enough instrumentation installed to deal with normal operations, such as pumping fuel into tankers, filling storage tanks and so on. They are often unequipped to deal with more modern technologies such as vibration monitoring, pump seal monitoring and slot planning.

The same problems occur at terminals and tank farms when trying to install additional instrumentation as they do at wellheads, pumping stations and custody transfer facilities. The cost of installing wired instruments is prohibitive, and the legacy control systems may not be able to accommodate new transmitters. As noted, wireless sensors solve the problems at a fraction of the cost. Take pump monitoring for example, as discussed in the next section.

Wireless pump health monitoring

As reported in the February issue of *World Pipelines*, API Standard 682 recommends monitoring of pump seal systems. API Standard 682 Fourth Edition now indicates a preference for continuous measurements using level and pressure transmitters versus the prior practice of using simple on-off switches. Considering the hundreds or thousands of pumps that may be installed from wellheads to tank farms, these new regulations can pose a very expensive problem for pipeline companies.

Not only is the cost of installing the necessary sensors to monitor pressure, flow and level expensive, getting the data to a control or SCADA system poses even more problems. Pumps can be in remote or dangerous locations, local power may not exist, and the pump may not have any existing instrumentation. Therefore, equipping a pump with traditional wired instruments and installing an infrastructure to support the instrumentation wiring can be prohibitively expensive.

Wireless sensors (Figure 5) are increasingly used in pump monitoring systems because they are easier to install, simpler to maintain and much less costly to connect to control systems.

In addition to pressure, flow, level and temperature, wireless vibration sensors can be installed on a pump and its motor. These sensors are particularly critical given the remote location of many pump stations, and the correspondingly infrequent maintenance visits. If a technician does need to visit the site, the diagnostic information provided by the smart sensors to the control system will allow him or her to bring the needed tools and parts to complete a repair in one trip.

Monitoring equipment health goes far beyond pumps. Wireless sensors can also be used to monitor:

- Metering systems.
- Leak detection.
- Cathodic protection.
- Motors.
- Compressors.
- Rotating equipment.
- Flame detection.
- Gas detection.

Data from all these sensors can be acquired and transmitted by the same WirelessHART mesh network installed for monitoring custody transfer, tank farms or pumping stations. The data is sent to a central control or SCADA system, where specialty software programs can perform equipment diagnostics, maintenance management, power management, air quality reporting and similar functions.

Conclusion

Economic pressures are forcing pipeline companies to modernise their operations, improve efficiency, cut maintenance costs, and meet newer and tougher environmental regulations. Installing measurement devices is an important part of the solution, but traditional wired instruments may be too expensive and difficult to install on all of the pumps, motors, compressors, valves, manifolds and other equipment on a thousand mile pipeline.

Wireless sensors make it much easier to obtain the information needed, at about one-fifth the cost of installing comparable wired devices, and less than half the time. The return on investment can be seen in a matter of weeks, and there's no need to 'cut and gut' existing legacy control and SCADA systems.