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How to support condition monitoring with wireless instrumentation networks

When *Wireless*HART first hit the market in 2008, most of the native devices using it were process measurement instruments. A pervasive sensing approach using these wireless instruments is now being embraced as companies deploy wider Industrial Internet of Things (IIoT) solutions as part of larger digital transformation efforts. The following are seven practical examples.

Pump monitoring. Pumps are critical to any process involving liquids, as is evidenced by the number of installations with two, or even three, redundant units supporting a single application. Pumps are maintenance intensive, suffering a failure or some level of degraded operation once every 12 mos. on average. Maintenance is typically reactive, costing approximately 50% more than detecting and resolving a problem prior to failure.

While strategic pumps frequently have some existing monitoring equipment installed, there are many others that should also be monitored. Before the advent of wireless instruments and networks, this monitoring was often too expensive; however, pumps can now be equipped with sensors to detect problems early so that appropriate actions can be taken. Such wireless sensors include those designed to monitor:

- Vibration
- Bearing temperature
- Inlet/outlet pressure
- Strainer clogging
- Seal fluid pressure/level.

Devices using *Wireless*HART networks are available to perform all these functions. The approach used to monitor a given pump will depend on its size and configuration, but the range of sensors illustrated is typical. It is important to use a multi-measurement approach because the various sensor technologies tend to overlap, working together to help diagnose problems.

For example, increased vibration might be caused by shaft misalignment or bearing deterioration. If the bearing temperature and noise have not increased, then the technician doing the troubleshooting might verify alignment first, since it is consistent with the symptoms.

Heat exchangers. Getting the most efficiency out of a common shell-and-tube unit (**FIG. 1**) requires process measurements. The main operating parameters are defined by:

- Inlet and outlet temperatures for both the process and transfer fluids
- Differential pressure (DP) readings across the inlet and outlet of the process fluid
- Flowrate for the transfer fluid.

The following is a typical setup using *Wireless*HART instrumentation:

- Temperature transmitters capable of sending data from four sensors on one wireless signal, reporting each reading in turn. The host system

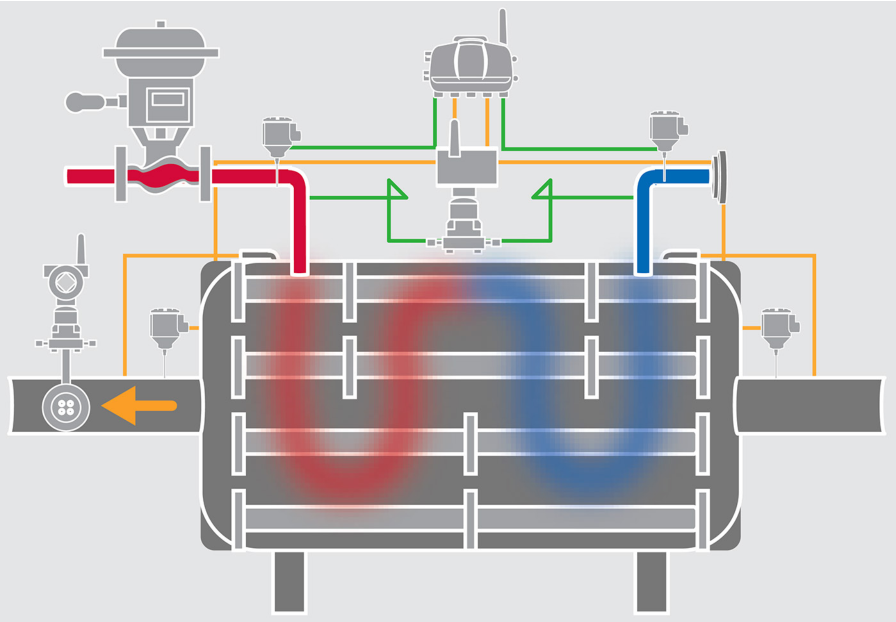

FIG. 1. A small group of strategic sensors can indicate both heat exchanger efficiency and condition.

updates each sensor reading individually. This covers all four temperature measurements.

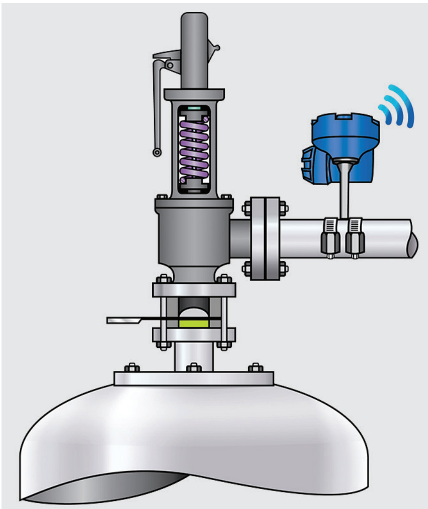

FIG. 2. An acoustic monitor mounted on the valve outlet can detect a full opening or slow leakage.

- The DP reading across the tubes uses a native *Wireless*HART DP transmitter.
- The flow meter for the transfer fluid can use a self-contained DP transmitter that is available with a native *Wireless*HART network.

When the temperature change and flowrate of both fluids are known, it is possible to determine how close the heat exchanger is running to its theoretical limit. If efficiency is low due to fouling, then information from the instruments can help determine which side of the tube wall is experiencing deposit formation. If there is a rise in the DP reading across the tubes unrelated to a change in flow, this suggests that the deposits are on the process side. A DP reading across the shell side is not recommended, since the internal free-passage flow is much larger. If there is enough depositing to cause a significant change on the shell side, this could cause a drastic loss of efficiency.

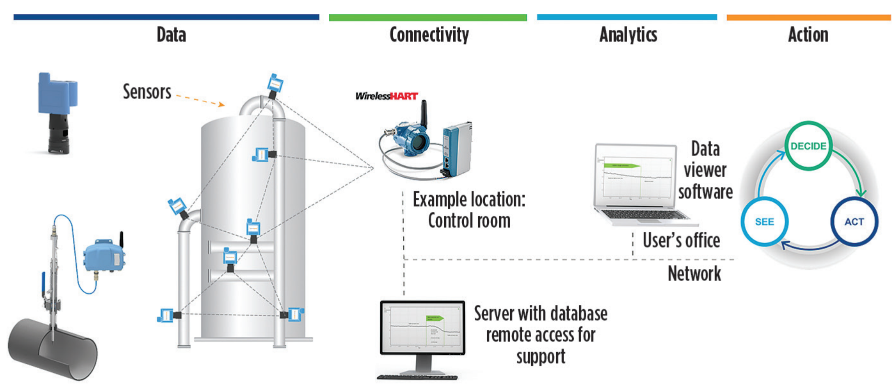

FIG. 3. Wall thickness sensors, combined with monitoring software, can provide data on real-time conditions and metal loss rates.

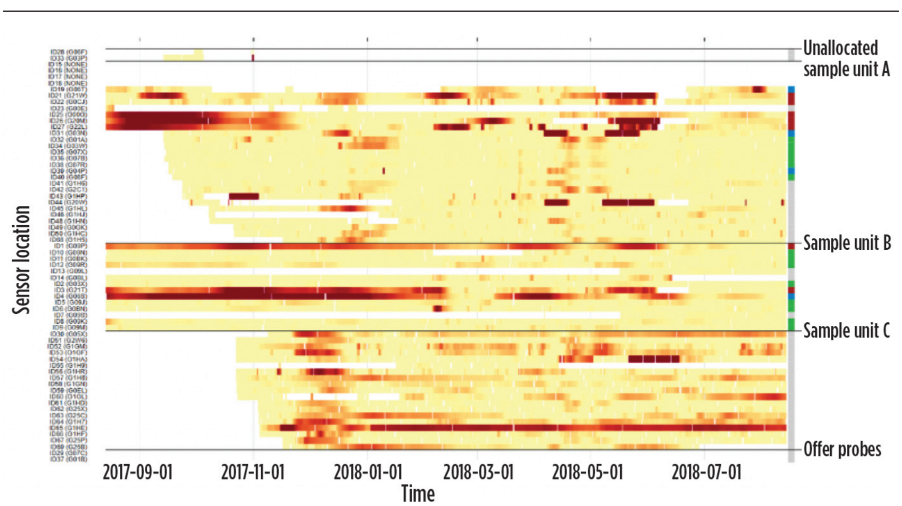

FIG. 4. Output from multiple sensors can be synchronized in time, using specialized software to provide a heat map of metal loss.

Pressure relief valves. Pressure relief valves (PRVs) have no built-in mechanism capable of reporting their condition or activity, so operators have little indication of their status. A PRV retains its seal by having a spring hold the stem against the seat. A fully closed valve is quiet because nothing is flowing through it. When the system pressure exceeds the setpoint, it opens, releasing the contents of the system—either liquid or gas (or both). This creates turbulence, generating noise that an acoustic monitor (**FIG. 2**) can hear and report to the automation system.

When pressure recedes, the valve should close again, and the noise should cease. Data from the acoustic monitor can report the time that the discharge began and ended, while indicating how serious the discharge was, based on sound amplitude.

The problem is getting the valve to reseal. Since overpressure incidents are often related to process upsets, particulates can be stirred up and blown out with the contents. Some can lodge in the valve seat, leaving it in a perpetually leaking state, which operators call "simmering." An acoustic monitor hears the simmering, so operators can tell if a given PRV has fully reseated itself after an incident. Maintenance can then decide when to address the issue.

With continuous monitoring, technicians can tell if a pressure release is underway or if a valve has not fully resealed itself. With prompt action, the overall effectiveness of the unit's safety system can be assured, while avoiding product loss and potential environmental consequences.

Steam traps. Steam traps are deployed throughout steam distribution systems to remove condensate. They are subject to mechanical problems, either failing open (resulting in a steam leak) or failing closed (causing condensate slugs to back up into steam lines).

Most plants monitor steam traps on manual rounds, where maintenance technicians look for signs of leaking, either visually or with handheld acoustic monitors. Condensate slugs are usually discovered when they damage equipment. Estimates suggest that 18% of the steam traps in a typical large refinery or petrochemical plant fail every year, each causing about $16,000 in extra fuel and steam costs.

By installing *Wireless*HART acoustic transmitters, plants can quickly identify steam traps that fail open or closed, and determine if they are leaking or working improperly.

These transmitters listen in ultrasonic ranges and can recognize sounds made by units in various states by using an algorithm to identify failure modes and conditions (such as "good," "blow through," "cold" or "inactive"), and can also send warnings of malfunctioning units.

Corrosion monitoring. Understanding the effects of corrosion requires monitoring pipe and vessel wall thickness to determine how much metal has been lost and when containment will be lost. The traditional monitoring approach involves technicians taking manual thickness measurements by using a handheld ultrasonic device.

A large plant may have several thousand locations scheduled for inspection at periodic intervals that can range from every few weeks in high-risk locations to once every 5 yr in other less-critical areas. Manual inspections incur costs for the technicians to gain access to the desired measurement location, which may involve erecting scaffolding and removing insulation, among other requirements.

Even if the inspections are performed fastidiously, manual methods are notoriously inconsistent, and no data is available between inspections. Variability of ±1 mm (.04 in.) is typical, but if a pipe wall is 5-mm (0.2-in.) thick, the engineer may lack confidence when trying to determine when that pipe will reach its retirement thickness. Achieving consistent, reliable readings requires a different method.

Permanently installed, ultrasonic sensors monitoring wall thickness (**FIG. 3**), and which are designed specifically to work in harsh environments, can send data on a *Wireless*HART network. The installation cost of ultrasonic sensors is low because they are non-intrusive and can be mounted nearly anywhere without any cabling.

These corrosion monitoring systems allow even small levels of corrosion or erosion to be detected. Advanced signal processing software, along with its data visualization and analysis features, makes data interpretation significantly easier and quicker. Data from multiple sensors can be visualized on a single screen as a corrosion heatmap (**FIG. 4**).

Safety showers and eyewash stations. Companies often call people their most valuable asset, so monitoring the condition of human beings is critical. Safety showers and eyewash stations are scattered throughout process units, but are typically unmonitored. A distressed worker reaching a station may have to call for help on the plant radio or hope to be spotted by a colleague. With a simple *Wireless*HART valve monitoring device (**FIG. 5**), however, any activation of a safety shower or eyewash station can immediately be reported, along with its location, to the control room and first responders. This monitoring also helps protect equipment, as a leak or spill might be in progress.

The water supply must be monitored for temperature and pressure. If piping feeding the shower systems is exposed to the sun, it can get hot. These systems should use lines with enough flow to avoid solar heating or should automatically dump water when necessary. Similarly, monitoring pressure confirms that an operator has not inadvertently closed a valve and rendered a station inoperative. This can be done with a *Wireless*HART DP transmitter or pressure gauge.

Location awareness. If plant managers want a mechanism to indicate who is in the plant and where each individual is at any given moment, using Wi-Fi for this application is expensive. *Wireless*HART networks can support location monitoring at a lower cost, using a different technology than what is used when adding new process instruments to the network.

Location triangulation functions operate with a device that is called an "anchor" (**FIG. 6**). These devices communicate with

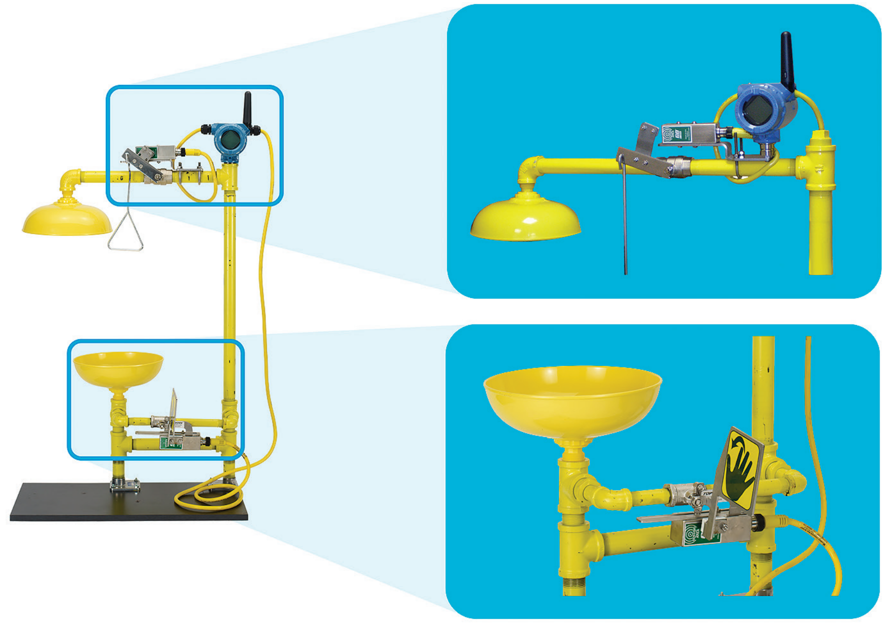

FIG. 5. Simple valve position indicators combined with a *Wireless*HART transmitter can warn the control room and first responders when a safety shower or eyewash station has been activated.

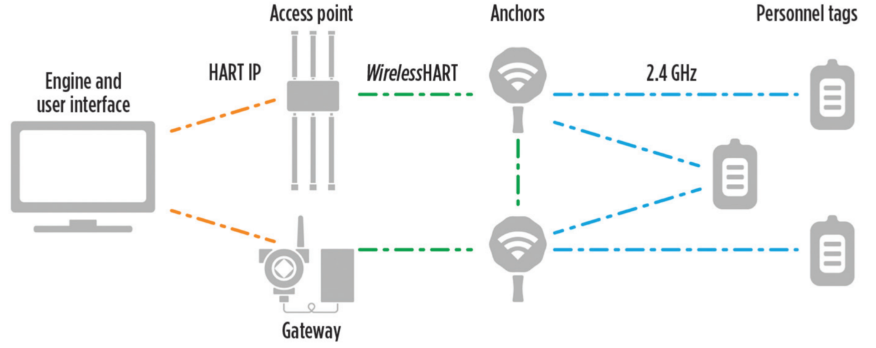

FIG. 6. Location anchors communicate with individual workers' tags, with each other and with the *Wireless*HART gateway.

each other and with the *Wireless*HART access points, in a manner similar to conventional *Wireless*HART instrument transmitters. Anchors communicate with the location tags worn by individual workers, providing the means to triangulate and determine where each tag/worker is located.

Location anchors are small, light and self-powered. Their Class 1/Division 1/Zone 0 rating allows them to be deployed throughout process plant environments. Rechargeable tags worn by each worker communicate with the anchors, and the anchors communicate with each other and with access points.

The *Wireless*HART approach is easily scalable to match head counts. It can also support the multi-level resolutions required for tall installations. This provides an exceptionally high level of flexibility to achieve the required coverage and overall worker safety.

Preconfigured software (**FIG. 7**) supports several useful functions, including:

- Geofencing indicates if individuals have moved into areas where they do not belong.
- Safety mustering lets first responders know which people have moved to the correct safe areas during a drill or an incident.
- Safety alerting allows a worker who is injured to hit a button on the tag to indicate an emergency in progress and the location.
- Social density can be monitored to ensure that large groups of workers are not gathered in a small area.

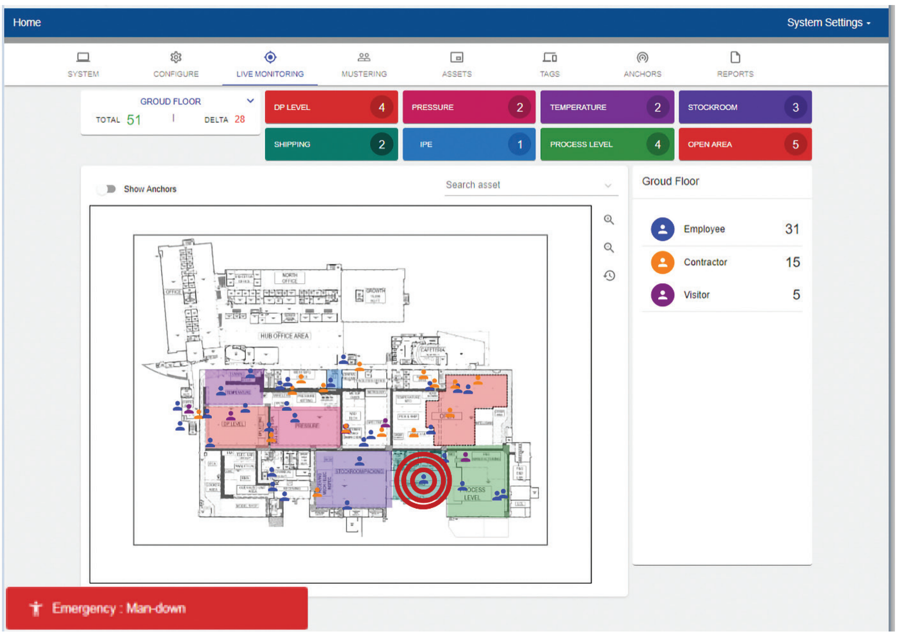

FIG. 7. Location monitoring platforms can indicate multiple functions, including emergency "worker down" situations.

FIG. 8. Preconfigured applications (such as the one shown[a]) make data management and analysis far easier and less expensive than in years past.

Sensors for monitoring. Sensors themselves do not ensure effective monitoring, as the data they provide must be collected and analyzed to be useful. Historically, this called for large-scale software installations, which made launching such a program a major undertaking and not cost effective for monitoring only a few items of equipment.

A new type of tool[a] has emerged (**FIG. 8**), drawing from concepts developed by the consumer electronics industry where sophisticated apps make user interactions simple. These are designed for specific functions, such as the seven just discussed.

Each application performs highly sophisticated analysis by focusing on their specific function, and includes preconfigured user interfaces and graphics, thus eliminating the need for custom software configurations. When provided with some basic values related to the equipment configuration and data from the wireless sensors, it becomes a simple matter to follow, record and analyze how the assets are performing.

*Wireless*HART sensors, whether used with existing control and monitoring systems or with new technical applications, provide the data required to improve process efficiency and safety. HP

NOTE

[a] Emerson's Plantweb Insight solution

ANDREW CURETON has been a Product Manager for Emerson's Pervasive Sensing applications for 4 yr and has been its go-to technical expert for the support of hundreds of wireless deployments in North America. His background includes quality engineering, computer networks and data analytics. Mr. Cureton earned a BS degree in industrial engineering from the University of Minnesota.