Smart instrumentation prepares organizations for the digital present and future

White Paper

Equipping facilities with smart instrumentation is vital for digitalization, and it eases installation, calibration, and ongoing operations and maintenance.

- Traditional analog instrumentation is limited to one-way, single-value process variable transmission via a wired instrument loop to a controller
- Smart instruments transmit multiple process values, calibration, and diagnostic data via two-way digital signals, with flexibility for multiple wired and wireless communication protocols
- Diagnostic data from smart instruments can be integrated into central plant systems to provide advance warning of instrument failure, or insight in the event of failure

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People for Process Automation

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As exemplified by the case studies below, smart instrumentation provides a host of process benefits as compared to their more limited predecessors.

Instrumentation selection for plant applications is a multi-step process requiring consideration of process type, industry standards, approvals, sizing and more. While vendor experts and online applicator tools can help specify the right instrument to meet process requirements, digital data capabilities are now another topic to contemplate.

In today's data-centric landscape, smart instrumentation provides a wealth of diagnostic and other information, enabling plant staff to get more from their instruments than simple 4-20mA process variable measurements. This information—transmitted via digital communication protocols—helps plant personnel improve plant efficiency and avoid unplanned shutdowns by empowering them to implement proactive maintenance and predictive monitoring.

Traditional instrumentation challenges

There are many factors that can interfere with the accuracy of a traditional instrument's analog output, and operators may not know whether the 4-20mA current signal processed by a programmable logic controller (PLC), distributed control system, asset management system or other host system is accurate. Each circuit scales a single process value as electrical current, omitting the ability to transmit secondary variables, such as temperature on a pressure instrument. Additionally, communication is one-way only, so there is no way to send commands from a controller to the instrument.

Traditional analog instrumentation also lacks diagnostic information, making it nearly impossible to foresee instrument failure. These failures can cause unplanned downtime and costly instrumentation repairs in the best cases, or catastrophic equipment damage and safety hazards in the worst. Bound by analog electronics, these instruments must be hardwired to a host system, limiting placement in hard-to-reach areas of a facility and especially in offsite remote locations.

Smart instrumentation prepares facilities for digitalization

By incorporating smart instrumentation into plant designs, facility operation and optimization become much more manageable tasks. These instruments incorporate digital communication protocols, sometimes in place of—and other times on top of—traditional analog communication protocols, greatly increasing capabilities and value.

For retrofitted and new applications where hardwiring transmitters back to a host system is convenient, instruments can use the two-way digital HART® communication protocol, which is superimposed on the analog current loop, to enable sending and receiving data with a calibration device or a host system. The exchanged data includes diagnostic, calibration, maintenance, process, and other information, greatly increasing configuration ease and operational process insights compared to traditional 4-20mA, analog-only instrumentation.

These HART-enabled instruments can transmit multiple process values to a controller via a single loop. This provides flexibility to continue using existing analog loops for real-time control, while making process and diagnostic data available via HART to make data driven decisions within a facility.

Additionally, data transmission is available via many fieldbus and ethernet-based protocols. These provide many of the same benefits as HART, but typically operate at much higher speeds, enabling inclusion of much more information.

Where wired implementations are impossible or inconvenient, wireless smart instruments provide solutions via 2.4 GHz radio wave protocols, notably WirelessHART™, WLAN, and Bluetooth®. Many smart instruments provide these connectivity options natively, while adapters can be added to provide this functionality for those that do not. These capabilities can be used to create a mesh network of sensors around a plant and in the field.

WirelessHART and Bluetooth instruments typically send and receive as much or more diagnostic and process data as their wired HART counterparts. While this data can provide immense benefits to a wide range of host systems and applications—such as maintenance management, asset information and health management, inventory control, and enterprise resource planning systems—many facilities do not take full advantage of what this data has to offer.

Automation systems regularly use flow, pressure, temperature, level and other process data to monitor and control processes, but they often discard status and diagnostic data. By not using this data, facilities miss out on opportunities to optimize, simplify, and safeguard their plant operations.

Figure 1: Endress+Hauser Promass F 300 mass flowmeters with Heartbeat Technology provide self-diagnostics and support in situ testing and verification.

When this data is ingested by intelligent plant analysis systems, facilities increase their ratio of proactive to reactive maintenance, thus reducing unplanned downtime, as well as equipment and human safety hazards. For example, instead of waiting to get an alert indicating a high-temperature condition, process data can be used to give an alert when conditions are detected that would lead to this type of issue.

When this diagnostic data is integrated into host systems, it can be analyzed to provide advance warning of instrument failure or troubleshooting insight in the event of failure. Because calibration and nameplate information are also internally stored in each instrument, tracking and managing assets is easier throughout plant lifecycles.

Let's look at five case studies where diagnostic data was effectively used in conjunction with multivariable process data to predict or identify failures, and to increase process efficiency.

Specialty chemicals — calibrate online

By replacing legacy flowmeters with smart instrumentation, a producer of specialty chemicals leveraged built-in self-diagnostics and in situ verification to reduce calibration costs and process disruptions. The producer's operation requires monitoring the flow of the individual components within a tank farm, and previously, the mass flowmeters used to make these measurements were manually calibrated each year. This was performed by pumping a defined quantity of product from a tank into a rail tank car and validating the weight. For each of the 19 mass flowmeters installed, plant personnel were required to take a tank offline, fill a rail tank car, weigh it, drain it, and often dispose of the product, amounting to planned downtime and waste. The exercise also carried operational risk for personnel executing the chemical transfers.

By installing Coriolis mass flowmeters with self-diagnostic technology (Figure 1), the producer eliminated the time-consuming and risky annual manual calibration, replacing it with in situ verification and documentation of each measurement point, without process interruption.

Additionally, the built-in self-diagnostics provide insight on instrumentation and process health, reducing manual diagnostic and maintenance effort, while increasing profit margins and personnel safety.

Life sciences — trust the temperature

In another retrofit, a pharmaceutical supplier replaced its steam-in-place (SIP) process temperature sensors with smart instrumentation to increase process accuracy and automate calibration. To maintain high quality and control risks in bioproduction, frequent instrumentation calibration is critical, but calibrating their old temperature sensors required great manual effort and frequent downtime. By upgrading to self-calibrating temperature sensors (Figure 2), the supplier eliminated these costs and roadblocks to production.

Figure 2: Endress+Hauser's self-calibrating iTHERM TrustSens temperature sensors eliminate manual calibration downtime by self-checking during every SIP operation, while providing precision accuracy.

Because processes are highly controlled in the life sciences industry, the supplier underwent validation over a period of four months, using a buffer tank in its bioprocess plant to prove instrumentation accuracy. The new sensors reliably performed automated inline self-calibration at 118°C (244°F) during each SIP process, reporting any deviations to the distributed control system via the HART protocol. The instrumentation upgrade greatly improved process accuracy, with the average deviation of 0.03°C (0.05° F) during validation outperforming the maximum permitted error of a standard Pt100 class AA sensor by a factor of ten.

Additionally, these new sensors provide the supplier with early detection of temperature drifts, straightforward visual monitoring via LED display, fully automated and traceable storage of the last 350 calibrations, and short calibration intervals. These functions reduced the risk of incorrect temperature measurements during SIP, directly preserving high production quality.

Nitrogen processes – multivariable accuracy

In the pursuit of a more cost-effective flow measurement technique, a nitrogen services company specializing in the hydraulic fracturing industry standardized on Coriolis flowmeters to accurately measure non-Newtonian fluids. Accurately measuring the flow of these fluids is difficult due to their viscosities, which fluctuate with changing shear rate. This same characteristic makes accurate measurement important because if equipment is not properly adjusted to current viscosity before pumping fluid and frac gel down a wellbore it can cause product, environmental or personnel harm.

The company's previous method of compensating for viscosity fluctuations involved a manual measuring process, and although workable, it required intense attention to detail. Operators obtained manual samples every 10 minutes and ran multiple tests to gauge the viscosity measurement and maintain exact product quality.

Because the Coriolis measuring principle operates independently of physical fluid properties—like viscosity and density—the new flowmeters provide reliable measurement regardless of process conditions, eliminating the need for manual testing (Figure 3).

The new flowmeter makes multivariable measurements including flow, temperature, density, and viscosity. The automatic collection of these data points by a single device freed up the company's operators to focus on other tasks because the control system now makes automatic corrections based on these process values. This provided improved control, accuracy, and quality, and it eliminated the need for multiple transmitters.

Additionally, the company can now view their process and instrument diagnostic data remotely via any device capable of hosting a web browser by using the flowmeters' built-in web servers. With less effort required to take manual samples and measurements, and more time to monitor operation, the company is making additional observations and preventing potential issues like leaks and spills.

Acrylics – automatically diagnose failure

A designer and manufacturer of acrylic-based products was experiencing a critical error with a flowmeter downstream of a reactor vessel. The instrument sporadically indicated zero flow through the pipeline, causing the process to shut down as a safety precaution. This false reading was eroding business continuity and profitability.

Figure 3: The Proline Promass I 300 Coriolis flowmeter by Endress+Hauser transmits multiple process values and instrument diagnostic data via HART, WirelessHART and Bluetooth.

After several manual efforts to troubleshoot the problem, the designer turned to the flowmeter's original equipment manufacturer (OEM) to examine the issue. By running an automated onboard diagnostics verification within minutes of arriving on site, the OEM's engineer determined the cause of flowmeter failure to be damaged empty pipe detection (Figure 4).

Further investigation of the installation and process indicated a better long-term solution was available, and the team replaced the unit with a flowmeter made to withstand higher temperatures. The insulation around the device was also adjusted to keep the electronics cooler.

Water treatment — select the right smart instruments for the job

Maintaining water safety and quality—while lowering energy consumption and meeting city, state, and national regulations—is challenging enough, but throwing unreliable measurements into the mix makes meeting these objectives nearly impossible for water and wastewater agencies. With reliable measurement, technicians can better control the process, make better decisions, implement predictive maintenance, and save both money and energy.

One wastewater treatment agency needed to measure flow to better control their process, but the required location for the flowmeter was a tight and restrictive space, with short pipe runs and sharp bends (Figure 5). This greatly limited their instrumentation options because typical electromagnetic flowmeters require a straight pipe run of multiple pipe diameters upstream of the meter, and one to two diameters downstream. Due to limited space in the facility, modifying the piping was not a viable choice. Other instrumentation options, like an electromagnetic reduced-bore flowmeter, create a pressure drop, resulting in higher energy costs and lower plant efficiency.

The agency estimated the flow coming through this section of pipe for years, but they were unable to obtain exact numbers. By installing an intelligent electromagnetic flowmeter, designed to measure flow independently of mounting location and profile without sacrificing pressure or efficiency, they were able to finally measure the flow through this pipeline accurately.

The agency easily installed the flowmeter without having to tear up or extend the pipe's run length, saving on installation costs. Knowing this flowrate helps them monitor for leaks in the system and initiate repairs more quickly, saving energy and reducing water waste.

Elsewhere in the facility, intelligent radar level transmitters help detect foam buildup in wetwells, automatically determining the ideal time to dose additives, and the optimal quantity (Figure 6).

Foam buildup occurs in wastewater plants when bacterial composition becomes destabilized, requiring expensive chemical

Figure 4: The Endress+Hauser SMT70 Field Xpert configurator tablet creates a mobile workstation in the field, and it can even be used in hazardous areas, enabling Heartbeat Technology and other diagnostic work without interrupting a process.

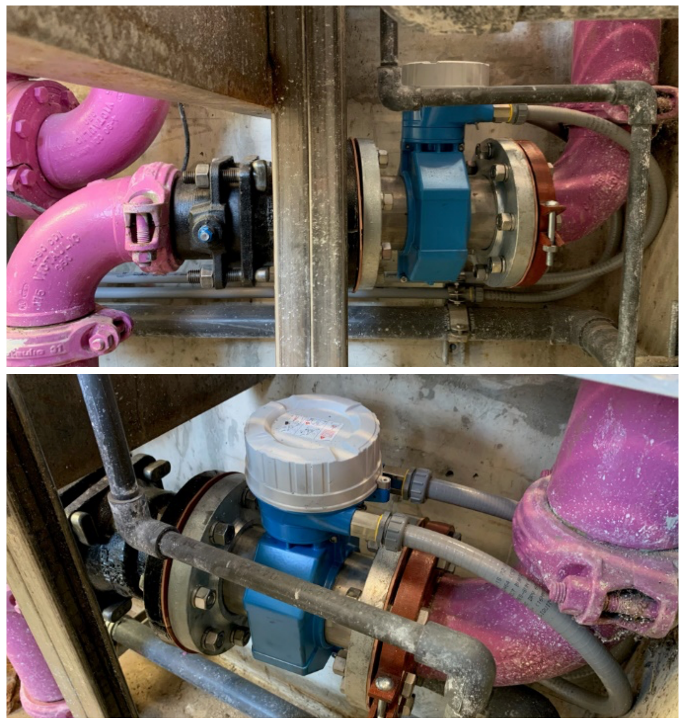

Figure 5: Endress+Hauser's Proline Promag W 400 enables flow measurement in tight spaces, regardless of pipe run length or bends.

Figure 6: The Micropilot FMR50 radar level sensor by Endress+Hauser can detect foam buildup in wetwells, and this can be used to automatically determine the ideal time and quantities to dose bacteria-stabilizing additives.

additives to manipulate concentrations. By intelligently dosing at just the required levels, the agency reduced additive usage by 30 percent, empowering them to efficiently control bacterial composition at a greatly reduced cost.

The present and future are digital

When looking to optimize plant processes, smart instrumentation provides indispensable data for host systems, which can be used to create operational and maintenance insights. This is done by utilizing two-way communication from smart instruments to host systems, providing multivariable process values and diagnostic information. These insights help improve process efficiency and assist in avoiding unplanned shutdowns by supporting proactive maintenance procedures.

Whether an organization is far along or just beginning to consider its digitalization journey, industry reliance on digital data and the industrial internet of things is only becoming more pronounced. By deploying smart instrumentation throughout their enterprises, companies are better prepared to continuously optimize their processes and remain competitive in the digital future.

All figures courtesy of Endress+Hauser

About the Author

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Resources

1. Smart transmitters enable smart sensors: isa.org/intech-home/2019/january-february/features/smart-transmitters-enable-smart-sensors
2. *InTech Focus*: Plant Asset Management: isa.org/intech-home/2021/april-2021/features/intech-focus-plant-asset-management
3. Digitize and optimize preventive maintenance for process instrumentation: isa.org/intech-home/2019/may-june/features/digitize-and-optimize-preventive-maintenance-for-p