

# CONTROL

PROMOTING EXCELLENCE IN PROCESS AUTOMATION • CONTROLGLOBAL.COM

## Pressure & Temperature Measurement, PART I



## TABLE OF CONTENTS

Prevent pressure transmitter problems . . . . .	4
Industry's most flexible solution for process temperature measurement . . . . .	9
Applications of valve position control . . . . .	12
When the heat is on, help your pressure transmitters keep their cool . . . . .	16
Manage the risks, reap the rewards . . . . .	20

## AD INDEX

ACROMAG . . . . .	3
Endress+Hauser . . . . .	8



# Dependable Value

## Expandable Remote I/O Modules for Ethernet



### New Expandable Ethernet Remote I/O Modules Offer Great Flexibility

Acromag's new BusWorks® NT Series remote I/O modules provide an Ethernet interface for analog, discrete, and temperature signals. These modules provide value with I/O expansion of up to 64 channels with a mix of signal types on a single IP address.

- Configurable over Ethernet with a web browser
- i2o® peer-to-peer or multicast communications
- Dual RJ45 ports enable daisy chain topology
- Modbus/TCP, Ethernet/IP, and Profinet protocols
- Conditional logic for rule-based I/O operation
- Thin 25mm housing with pluggable terminals
- Wide temperature operation (-40 to 70°C)

### You Get Personalized Support—Guaranteed

Doing business with Acromag means you can count on receiving dependable value when using our products. We guarantee to meet or exceed published product performance specifications and offer you exceptional personal service with a real person within one business day.

ISO9001  
AS9100



877-295-7066

**Acromag** <sup>®</sup>  
THE LEADER IN INDUSTRIAL I/O



Visit [Acromag.com/NT](http://Acromag.com/NT)  
**TO LEARN MORE**

Remote I/O Solutions You Can Depend On.

# Prevent pressure transmitter problems

Installation details make the difference in DP flow and level applications.

by Greg McMillan

**Greg:** You can't control something if you're not measuring it. There have been great advancements in measurement technology. Smart transmitters have increased accuracy an order of magnitude or more, and drift is so slow that calibration intervals can be significantly extended. However, a measurement is only as good as its installation. Not enough knowledge is published or presented on how to make sure the installation doesn't limit performance or create maintenance and reliability issues. Here, Hunter Vegas and I (co-founders of the ISA Mentor Program) offer what we think is important. The newest resource to our ISA Mentor Program, Daniel Warren, has stepped up to offer his personal experiences to help guide our group. Daniel has over 35 years of experience as a senior instrument and electrical design specialist in oil, gas, chemical, food, mining, utilities, water & wastewater, and various pulp & paper facilities, and is the owner of D.M.W Instrumentation Consulting Services Ltd.

The most common flow and level measurements often use differential pressure (DP) transmitters with two impulse lines for flow, and one impulse and an equalization line for level. Pressure drops are also measured by a DP with two impulse lines. Many pressures must also be measured and controlled. Gauge pressure transmitters vent the low side. Absolute pressure transmitters have the low side sealed with a full vacuum. Gauge and absolute pressure transmitters (PT) have a single impulse line. Consequently, a production unit can have thousands of impulse lines that are often the weakest link.

The DP and PT installation method and location should be designed to:

- Prevent a non-representative process variable at the transmitter,
- Prevent extraneous effects at the transmitter,
- Keep the fluid density, composition and phase the same to both sides of the DP transmitter,
- Minimize accumulation of solids and bubbles,
- Minimize plugging, coating, corrosion, and fouling of the impulse lines,
- Minimize time lag(s) from impulse lines to the transmitter,
- Maximize signal-to-noise ratio, and
- Enable calibration and maintenance of the transmitter.

The impulse and equalization lines, valves and manifolds, as well as the transmitter, must all have wetted surfaces, including gaskets, O-rings and seals, constructed of materials that can withstand the worst process scenario. This could include corrosion, temperature swings, sudden pressure and vacuum swings, mechanical impact (hammering), clean-out procedures, etc.

Let's first address measurement of gases. The goal is to ensure only gases enter the lines, and any liquid drains back into the process. The transmitter must be mounted above the process connections with a uniform slope of at least 1 foot of elevation change for every 10 feet of length, with a

greater slope being generally advantageous. For horizontal pipelines, the process connections should be at the top. For vertical pipelines, the process connections are on the same side as the transmitter. A vent at the DP transmitter may be useful for venting the accumulation of low-density gases (e.g., inerts) and for transmitter maintenance.

**Hunter:** Another potential problem with gas installations is gas condensation. If the boiling point of the gas at maximum operating pressures is less than ambient temperature, the gases can condense in the impulse line and cause intermittent negative pressure spikes. In this case, the process tubing must be heat-traced to eliminate this issue. Note that steam also can condense, but this case is handled differently. (See steam section below.)

**Daniel:** I've seen a number of cases where piping hasn't been installed adequately to ensure a sufficient slope for gravity drainage. I've also seen lines that are damaged and twisted when other mechanical components are installed as an afterthought. I have "blow-down" lines installed for gas venting when isolating and venting a transmitter. This also gives me a location to tie in a purge to blow any particulate, oils or condensate back into the process line.

**Greg:** When measuring liquids or steam, you need to ensure the lines are equal in length, and filled with liquid that has the

same density and no phase changes. The transmitter must be mounted below the process connections with a uniform slope of at least 1 foot in elevation for every 10 feet of length. Valves at the transmitter should enable flushing and draining the lines and transmitter.

Heat tracing must provide enough heat to prevent freezing on the coldest day with the coldest fluid, but doesn't overheat the lines and cause flashing (vaporization or boiling) of the fluid on the hottest day with the hottest fluid.

**Hunter:** It's very important that the tubing slope continuously from the process connection to the transmitter. Any high point along the way can trap vapors and cause an improper reading. Also, the transmitter connections usually branch off the main impulse run. This is done so if there are any solids in the impulse line, they'll drop into the line section above the blowdown valves and not impact the pressure measurement at the transmitter.

**Daniel:** The other thing to take into consideration is the liquid itself. The process conditions and product will make a difference in the materials and installation. As an example, what's used for water may not be suitable for liquid natural gas (LNG), diluent, chlorine, etc. Each of these requires certain materials for wetted parts (tubing, diaphragms, O-rings, gaskets, etc.), and it's

always best to confirm the requirements with the manufacturers' tables. The other thing to consider is the temperature and the specific gravity. The rangeability as well as the materials themselves may put a limitation on what can be used to accurately measure that particular process.

**Greg:** What more do we need to know about steam installations?

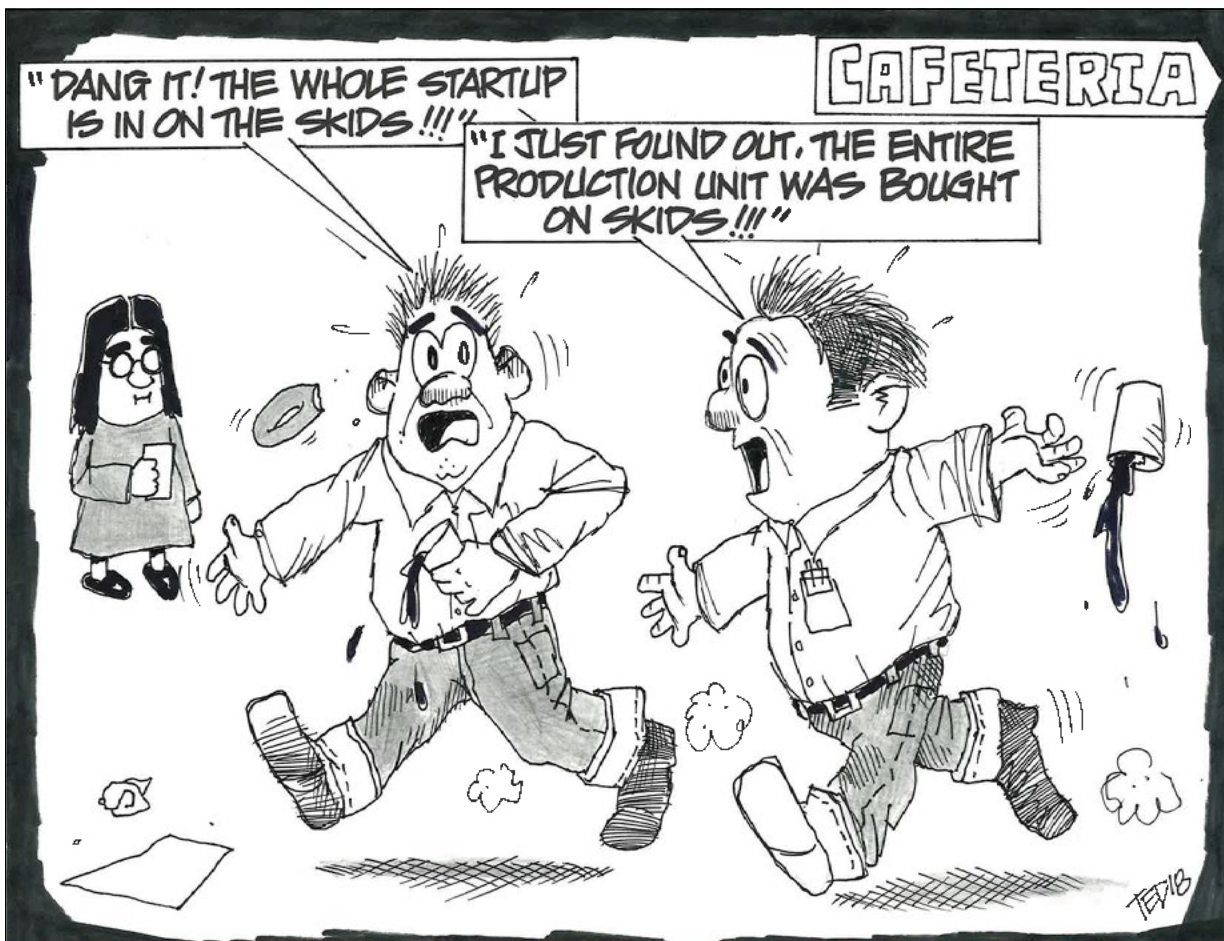
**Hunter:** One might consider steam a "gas" and mount the transmitter above the process line with a heat-traced line to avoid condensation. However, most transmitters cannot handle the process temperatures and will fail in short order. Therefore, a typical steam installation will mount the transmitter below the line, let the steam condense, and thus protect the transmitter from the high temperatures. As long as both legs are equally filled, the water in the line will not impact the DP reading, but it will cause an offset for a pressure transmitter that must be calibrated out. You also need to freeze-protect the impulse lines, and keep them warm enough to avoid freezing but cold enough to ensure the steam will condense.

**Daniel:** You don't have to wait for the steam to condense to fill the lines during commissioning. Distilled water can be used for this purpose. I've also used glycol to fill the lines when setting up transmitters in cold-climate locations. Seal pots are more of an old school practice. Their primary

use is to act as a barrier between a harmful process, such as a corrosive gas/liquid or steam, and transmitter.

The ability to calibrate and maintain the DP installation generally requires the vent/fill/flush and drain valves mentioned above, and a manifold or equivalent piping of impulse lines that enable the same pressure to be applied to both sides of the DP for zeroing. The valves in the lines and manifold must also allow the transmitter to be safely removed with no exposure to the process fluid.

**Daniel:** How you calibrate a transmitter also depends on how it was installed and the type (style) of transmitter. I've seen a number of skid-mounted transmitters (and older installations) that aren't properly installed (isolated) to allow for a zero and/or span adjustment. It's also easier to do a bench calibration as compared to a field calibration. A field calibration can be cumbersome, especially if you must have an assortment of tools and test equipment (air or nitrogen cylinders, hand pumps, etc.). Also, testing is limited when you're dealing with an older style of DP as compared to the smart versions.



We understand how leading-edge products and process improvements are critical in your business.

# INNOVATE + ACCELERATE

You are enabled to achieve a faster time to market, improve plant productivity and reduce risk.



## iTHERM TrustSens TM37x: The world's first self-calibrating compact thermometer



- Increases process safety with fully automated, fully traceable inline self-calibration
- Offers 100% compliance with automated audit-proof documentation
- Eliminates the risk of undetected non-conformities with Heartbeat Technology

Do you want to learn more?  
[www.us.endress.com/trustsens](http://www.us.endress.com/trustsens)

Endress+Hauser   
People for Process Automation

# Industry's most flexible solution for process temperature measurement

by Zachary Massa

NOBODY really wants to install a thermowell every time they need a process temperature measurement. Instead, wouldn't it be a lot easier, and safer, to just measure the temperature at the surface of the pipe and extrapolate the process temperature from there? Problem is, there's a lot of physics and calculations involved in that extrapolation. And because of those physics, not every application is well-suited to a non-invasive approach. The tricky part comes down to knowing which applications are which.

To gain a better understanding of the subtleties involved, Control caught up with Emerson's Zachary Massa, global product manager for the company's temperature transmitters portfolio. His responsibilities include the company's Rosemount X-well non-invasive technology, which has been successfully applied to thousands of applications throughout the process industries since it was introduced to the process industries five years ago.

**Q:** Using a "skin" temperature measurement as proxy for the process temperature within a metal pipe certainly predates the introduction of X-well technology. What was it about X-well that really changed the game starting in 2016?

**A:** In the past, skin temperature measurements couldn't be relied on as accurate predictors of process temperature due to the impact of the environment and heat loss. The physics of heat transfer through the pipe needed to be considered, and variations in ambient

**When combined with wireless connectivity, Rosemount X-well technology provides a proven, non-invasive process temperature measurement solution of unrivaled flexibility and ease of installation.**



conditions also had a significant impact on measurement accuracy. X-well technology first made it possible to model, in real-time, the physics of heat conduction through the pipe as well as compensate for variations in ambient temperature—and do all that within the transmitter itself.

X-well technology solutions are based on Emerson’s industry-leading Rosemount 3144P analog/HART and 648 wireless temperature transmitters. Notably, when intended for X-well use, the transmitter firmware comes factory configured with the pipe’s material of construction, diameter and schedule to accurately model heat flow from the process to the outer surface of the pipe. Meanwhile, the effects of changes in

ambient temperature are compensated for based on the temperature reading of a second, high-accuracy RTD within the transmitter housing.

Our combination of non-invasive process temperature sensing combined with wireless connectivity remains unique in the industry.

**Q:** With a global installed base that now numbers in the thousands, what sorts of applications have you found most suitable for X-well technology?

**A:** Applications suitable for X-well technology range from monitoring pipelines to small line-size applications. Obviating the need

for a thermowell is especially advantageous for pipes that require frequent cleaning, high velocity processes, slurries and heavy particulate fluids, clean-in-place processes, high viscosity fluids and harsh processes requiring exotic thermowell materials.

Retrofit or incremental temperature measurement applications are particularly attractive because no process penetration—or associated production interruption—is necessary. The value proposition of X-well technology in our wireless transmitters is even more compelling since you don't need to run cables either. This makes it particularly useful for diagnostically driven implementations.

The elimination of thermowells also eliminates associated leak points and long-term maintenance requirements. From an engineering perspective, wake frequency calculations are eliminated, as is time spent determining material compatibility, correct insertion length and thermowell profile—resulting in a 65% savings in engineering time and effort.

Further, Rosemount X-well technology can be installed with standard pipe-clamp procedures and ordinary hand tools and does not require a welder or pipefitter, resulting in a 70% savings in installation costs. In any installation, at least half an inch of insulation over the skin sensor should always be used to meet performance expectations (see photo).

We continue to invest in and improve on the technology's capabilities over time, but non-invasive methods in general aren't suitable for processes with rapidly changing conditions, such as safety loops, custody transfer or fast control applications. Low fluid velocities and non-metallic pipes are also unsuitable. That being said, there are far more applications for which X-well technology is suitable than there are applications for which it isn't.

**Q:** Say I'm an end user or system designer and want to gauge whether X-well technology is appropriate for a particular application. Are there tools available to help?

**A:** We can go a few steps further than simply determining whether X-well will work or not in a given application. Because we have a deep understanding of the underlying mathematics—as well as five years' experience and thousands of applications under our belt—we can provide a definitive specification around total probable error (TPE). Dynamic processes are a bit more complex, but we can also calculate an effect on temperature response rate relative to a thermowell.

In short, we have proven results and the methodology to set clear expectations around non-invasive temperature measurement performance—and we're prepared to meet them, too.

# Applications of valve position control

Among the simplest methods of optimization, VPC can do a lot of harm if misapplied

by Béla Lipták

**Q1:** At the last meeting of my ISA chapter, I was told that by using “valve position control,” I can design load-following optimization and save energy in many processes. I didn’t completely understand how it works. Could you please explain it? Thank you.

Z. Friedmann

solarh2cell@aol.com

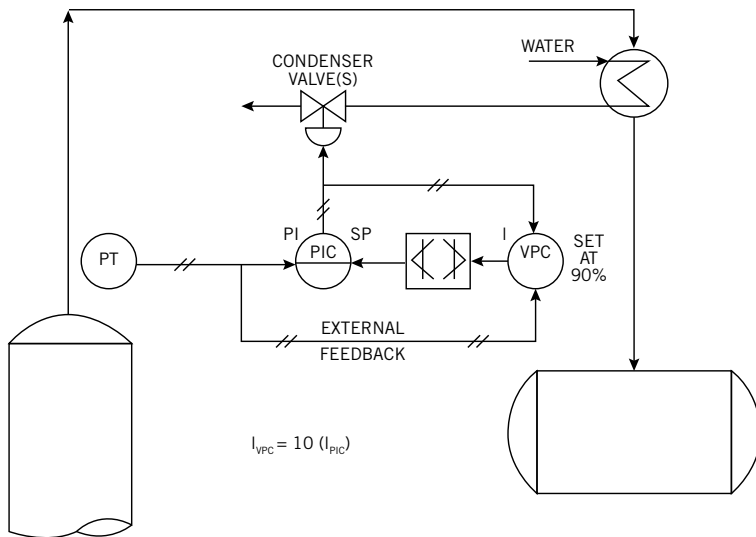
**A1:** This is a large topic. In my handbook, you’ll find more than 100 pages discussing it. You’re right that it can be a powerful tool to optimize operating capacity, efficiency or energy costs. Valve position control (VPC) can also be implemented in a couple hours, as it is one of the simplest methods of optimization, but it can also do a lot of harm if misapplied. Therefore, it’s essential to fully understand the nature and dynamics of the process that one intends to optimize with it. For this reason, it’s worth spending a couple of hours, sitting down with the process engineers and the operators, to gain a full understanding of the potential consequences of using it. Below, I’ll briefly describe a few common applications to illustrate the concept.

Distillation (Figure 1A): Using VPC to minimize the operating pressure of a total condenser system used in distillation applications reduces heat input, increases reboiler capacity and reduces reboiler fouling. VPC achieves this by continuously maximizing cooling by keeping the pressure control valve near its full opening, and thereby keeping the condenser fully loaded.

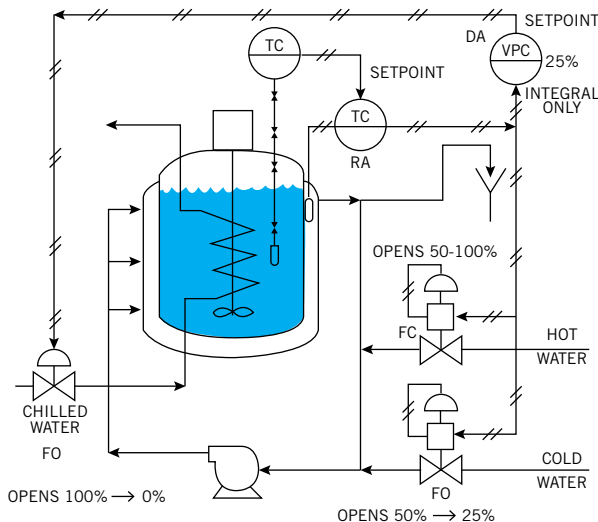
This being a cascade loop—where the slave should be 10 times faster than the master—proportional and integral (PI) actions are used in the controller (PIC) and

integral action only in the VPC. This integral is set for about 10 times the integral in the PIC. The external reset is provided to protect against reset windup, when

one of the limits that block the VPC output is reached. These limits are provided to keep the range within which the column pressure can be floated by the VPC within safe limits.



**VPC APPLIED TO A DISTILLATION TOWER CONTROL**  
**Figure 1A: Floating pressure control reduces energy consumption within limits.**



**VPC APPLIED TO REACTOR COOLANT CONTROL**  
**Figure 1B: In this reactor coolant application, the cost of cooling is minimized by minimizing the use of the more expensive coolant. (FO = fail open, DA= direct acting, RA= reverse acting)**

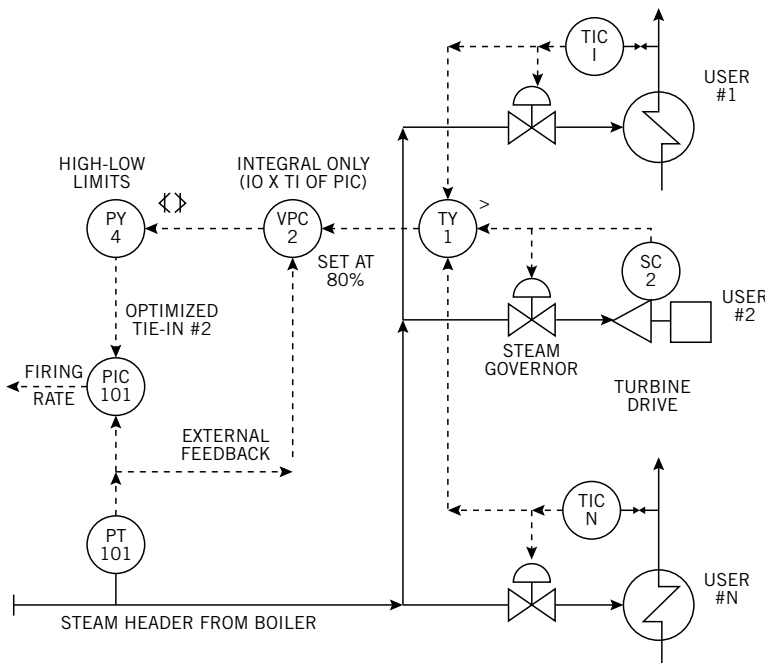
Reactor (Figure 1B): In the illustrated reactor control system, the VPC serves to minimize the cost of cooling by sending the chilled water to a separate chilled water coil only when the regular cooling water valve to the jacket is fully open. Here the VPC keeps the more expensive chilled water valve closed until the cooling capacity of the less expensive cold water is fully exhausted. The cascade temperature loop operates in a split-range fashion, so that at a temperature controller (TC) output of 0%, the cooling is maximum (both chilled and cooling water valves are fully open); at 25%, the chilled water valve is closed, but the regular cooling water valve is still fully open; at 50%, both cooling valves are closed and the heating valve just

starts to open; and finally at 100%, the reactor receives full heating through the full opening of the hot water valve. Naturally, one can overlap the transition points, which improves control, but does it at the cost of lowering energy efficiency. For smooth operation, the fact that there are three control valves should be transparent to the temperature controllers because the valve gains should be the same and their combined range should provide a straight line.

Boiler (Figure 1C): When a boiler serves several steam users, the VPC-2 (set at 80% or 90%) opens all user valves until the most open one is at a full opening setpoint. The VPC in turn reduces the setpoint of its cascade slave, the steam pressure controller (PIC). This cuts operating costs because it reduces the power consumption of the boiler feedwater pump, and increases turbine drive efficiencies by opening up their steam governors. In addition, the VPC protects

all users from running out of steam, moves all valves away from the near-closed and therefore unstable positions, and reduces maintenance and increases valve life by lowering their pressure drops. Otherwise, the control system is similar to all VPC systems, where a high selector sends the measurement of the opening of the most open valve to the VPC, which is an integral only controller (its integral setting is 10 times that of the PIC), plus has an external feedback against reset windup. The VPC output to the PIC setpoint is limited to a range to match the limitations of the controlled equipment.

Cooling towers (figure not shown): The energy consumption (cost of operation) of cooling towers can be minimized by keeping the most open user-inlet valve and the most open cooling-water-return valve nearly full open. This minimizes the cost of circulating water in the plant by



### VPC APPLIED TO BOILER CONTROL

**Figure 1C: Meeting steam demand of the plant with minimum steam pressure increases efficiency.**

minimizing the pressure drops through all the cooling water valves. The fan speeds are controlled by the required cooling water supply temperature of the plant in such a way that even the highest speed will be under the maximum.

Water balancing is controlled by measuring the total return flow, which becomes the setpoint for the flow-ratio controllers serving the three towers. The ratio setting of each controller can be set manually or automatically, and is based on the associated tower's capacities and fan status. Naturally, the total of the three ratio settings must always be 1.0.

The pumping costs associated with such a system will be minimized when the pressure drop through the three cooling tower supply valves is at a minimum. This is guaranteed by the VPC, which measures the opening of the most open valve and compares it to its setpoint, which is about 95%. As long as all valve openings are below 95%, the VPC increases all setpoints until the most open valve reaches 95% opening. This way, the return water distribution will be correct, plus both groups of valves (the user inlet and the tower inlet valves) will be operating at minimum pressure drop.

Béla Lipták

liptakbela@aol.com

# When the heat is on, help your pressure transmitters keep their cool

by Doug Greaves

IDEALLY, a pressure transmitter is installed with the sensing element as close to the process as possible. Short impulse lines allow for the fastest dynamic response. But many industrial processes run at elevated temperatures and heat transfer by radiant, conductive or ambient paths can damage a transmitter's wetted materials or, more commonly, shorten the life of its electronic components. So, when process temperatures climb above 220°F, it's time to consider protective solutions that increase transmitter life and preserve process uptime without sacrificing responsiveness.

To learn about the range of solutions designed to facilitate safe and accurate pressure measurement at high temperatures, Control sat down with Doug Greaves, U.S. product manager, temperature and pressure, ABB Measurement & Analytics.

**Q:** Since heat transfer depends on proximity to the heat source, isn't mounting the transmitter further away and using longer impulse lines a logical and easy first step?

**A:** Most standard transmitters like the ABB 266DSH DP (differential pressure) and 266HSH Gauge are connected to the process via impulse tubing. Thoughtfully planning the path of the tubing can be a cost-effective way to extend transmitter service life without special seals, gaskets or material considerations.

Follow these recommendations when planning for a high-temperature application:

- While some distance is recommended, keep in mind that too much distance can dampen dynamic response.
- Note that impulse lines act as cooling fins, effectively reducing temperatures 150 °F per foot in common ambient conditions.
- Each impulse line should lead to a dead end, meaning no leaky connections and tightly closed instrument manifold valves. Sustained flow of hot medium to the transmitter effectively negates any cooling advantage gained by distance.
- In most cases, if the pipe is insulated, the transmitter should not be.
- Generally recommended impulse line sizing for lengths up to 50-ft is 1/4 in. to 3/8 in. for water/steam/dry gas and 1/2 in. to 1 in. for wet gases/oil/viscous and dirty liquids. Beyond 50 feet, increase impulse line size to 1/2 in. and 1 in. to 2 in., respectively.
- When multiple impulse lines exist for the same measurement point (e.g., DP, redundant P), run lines together to maintain equivalent temperatures and try to keep each line the same overall length.
- In cryogenic applications, impulse lines work in the opposite direction, effectively warming process fluids before reaching the transmitter.

**Q:** When using impulse lines for differential pressure-based tank level measurement,

what are the considerations between dry leg and wet leg installations?

**A:** It really depends on the process medium. Does cooling the headspace gas never, sometimes or always result in condensate? If normal is “no” or “some,” a dry leg impulse line can likely do the job. If condensate is normally expected, use a wet leg impulse line instead, where the headspace impulse line is kept full of liquid to a fixed height. Both options, however, come with maintenance considerations. A dry leg will require a collection pot that’s periodically drained, while a wet leg will require liquid level to be maintained at a known height and protected from freezing by heat tracing or compatible antifreeze additions.

Steam is a specific case where wet legs are commonly used, with condensate expected between the transmitter and process. Sometimes condensate pots are used to make sure impulse line condensate isn’t boiled off during high demand loads, particularly with superheated steam.

Another typical application in power and steam generation is boiler drum level measurement. ABB 266CSH Multivariable with active level calculation can compensate for DP drum level due to both wet leg condensate density changes caused by temperature fluctuations as well as real-time water and steam densities in the boiler based on the measured static pressure and on-board steam tables.

Remote diaphragm seal pressure transmitters such as the ABB 266DRH (shown here with WirelessHART antenna) facilitate the responsive, accurate pressure measurement of high temperature streams without the safety or maintenance implications of traditional impulse lines.



**Q:** What about blockages in impulse lines?

**A:** In an ideal case, mount the transmitter to allow the impulse line a 10% slope back to the process. This will allow liquid to drain or gas to vent back to the main process line, depending on the defined normal condition.

Continuous purging is a time-tested method to keep lines clear, but maintenance and operating costs across a plant can be prohibitive. Alternatively, ABB 266 Series transmitters come standard with a Plugged Impulse Line Detection (PILD) feature that can be trained to the high-frequency signature of the normal background pressure, and signal a diagnostic alarm to the opera-

tor if it detects a change in the signature indicating a blockage.

**Q:** The cost of installing impulse lines—and keeping them clear—is certain to add up, and failure to do could be unsafe or cause a shutdown. Are there other options?

**A:** Remote seals, specifically all-welded seals, remove the wet/dry leg decision as well as the need to install and maintain impulse lines in high temperature applications. Consider an ABB 266 Series transmitter complete with S26 remote seals like a doctor with a stethoscope. The measurement is taken directly at the process and transmitted back to the sensor. In the

case of the remote seal, the pressure is conveyed through fill fluid. In high temperature processes, the key consideration is specifying a compatible fill fluid based on the highest temperature at the lowest pressure that will be encountered, such as during a cleaning cycle. Compare these conditions to the vapor pressure curve of the fill fluid to make sure it won't boil behind the sensing diaphragm.

ABB transmitters with remote seals can also be direct or remote mounted to the process. When remote capillaries are used, it's best to keep them as short as possible and of equal length to minimize response time. And because ABB seals are designed in-house, our experts can also engineer

custom solutions like cooling extenders, or use special materials for constructing the wetted elements.

In some colder ambient conditions, heat tracing on the capillaries and a heated enclosure may be necessary to maintain fast response times. Another option for improving the response times of hot processes in cold environments are "electronic" remote seals. In this configuration, which we call a Digital Diaphragm Seal, an 266HSH and 266HRH are electronically coupled to produce a DP output. Often used for level applications, this approach removes the need for lengthy capillary legs; response effects are eliminated, and larger tap-to-tap dimensions are possible.

# Manage the risks, reap the rewards

Adoption strategies for Ethernet-APL will hinge on where it brings greatest value to your operations. While more speed is always a good thing, implementation thresholds will vary, especially between brownfield units and new projects

Adoption strategies for Ethernet-APL will be very much intertwined with the value proposition it represents relative to current technologies. The grassroots unit or production facility is one extreme, where, given a clean design sheet and a critical mass of available Ethernet-APL devices, the simplicity and advantages of a unified high-speed network architecture that extends from field instruments to the cloud—yet preserves existing workforce familiarity with HART—is quite compelling.

But that greenfield plant design is still a ways off, given the lead time for instrumentation and system developers to bring the necessary solutions to market, not to mention the testing, trials and tire-kicking that end-user organizations will demand before betting a new plant on any new technology.

At 3M, for example, initial laboratory tests will be followed by pilot-plant implementations plus assurance testing that the technology passes the company's rigorous internal standards for intrinsically safe operation before Ethernet-APL will be approved for a production environment or for widespread use, according to Robert Sentz, senior engineering specialist.

Bottom line, while the ultimate value proposition of Ethernet-APL will be in a greenfield facility, progressive end-user organizations will meanwhile be looking for more isolated use cases

at brownfield facilities to test out and prove the new technology's worth. Testing is appropriate, but for Ethernet-APL to win on its own merits in a brownfield environment, "It's got to be a pretty specific use case that really needs that higher bandwidth or will benefit from the greater amount of power that can be delivered over APL," notes Peter Zornio, CTO Automation Solutions, Emerson. "It's a very simple rule: if you're not putting in new instruments, you're not going to broadly deploy APL," he adds.

### **THE NEED FOR SPEED**

Many of the most apparent use cases for HART-IP over Ethernet-APL derive from the increased availability of data that higher bandwidth affords. In a brownfield context, this is most relevant when adding complex new instruments that generate more data of diagnostic significance.

Real-time access to valve signature data from a valve controller, for example, can be used to diagnose a range of issues before they lead to unscheduled process downtime. The same can be said for Coriolis meters, magnetic flowmeters and radar level gauges (see sidebar). Process analyzers in particular will benefit from the order of magnitude increase in power made available to instruments by Ethernet-APL relative to 4-20mA, representing a less expensive installation than the power supply plus four-wire Ethernet connections that otherwise might have been needed.

But the larger context of increased secondary data bandwidth is the ability to collaborate more effectively, and to send that more nuanced secondary data more easily to the individuals—and applications—that can make effective use of it. Think of a diagnostic application that pulls some data from the instrument, some from the computerized maintenance management system (CMMS), some from a condition monitoring system and some from the distributed control system (DCS). A beleaguered engineer might spend all day manually pulling that data into a spreadsheet before even beginning to analyze its meaning. Or think of the roaming technician who can quickly access real-time HART device data through a tablet wirelessly connected to the plant's WiFi infrastructure—access that was previously available only back in the control room, didn't reflect real-time conditions, and even then, was accessible to the technician only via walkie-talkie or a physically connected, low-bandwidth handheld.

### **TRANSITIONAL ARCHITECTURES**

For most end users—especially in the US, where few greenfield facilities are expected to be built in the near term—their first experiences of Ethernet-APL will be in hybrid environments that also include 4-20mA HART devices. On the positive side, with the debut of fully configurable input/output (I/O) systems some 10 years ago, industry already is on its way to moving I/O from control room environments out into field junction boxes.

Configurable I/O has delivered substantial benefits of its own, helping to decouple hardware design from system software development and taking instrumentation and control system design off the critical path of project execution. It's also reduced costs and system footprint, eliminating traditional marshalling cabinets in many newer facilities. Like fieldbus before it, Ethernet-APL effectively distributes I/O even further, relocating the transition between analog sensor signals and the digital world of ones and zeroes into the field devices themselves.

From a practical perspective, this means that the remote junction box is where 4-20mA HART and Ethernet-APL are most likely to converge. That remote junction box could relatively easily include both configurable I/O as well as an Ethernet-APL switch—both of which speak HART-IP over Ethernet up into the control system architecture. Further, a potential mix of Ethernet-APL with traditional 4-20mA HART devices will likely entail a range of network infrastructure devices designed to accommodate the transitional hybrid architectures required.

While dual devices sharing an Ethernet connection in the same box are easy to imagine, hybrid approaches are also likely. Analog Devices, one of the suppliers of chipsets for Ethernet-APL as well as the multiplexers that extract HART data from 4-20mA loops, has envisioned a device with hybrid functionality. And for suppliers like

Emerson, which uses a physical module to characterize its remote I/O channels (rather than software), a new Ethernet-APL module under development will allow these new digital channels to coexist side-by-side with their 4-20mA HART counterparts.

In all three of these scenarios, a shared commitment to the HART ecosystem and data model will ease the industry's ultimate transition to Ethernet-APL as the standard physical layer for field instrument communications

## **GREENFIELD BENEFITS AWAIT**

In the not-too-distant future, a greenfield facility or new production unit offers the most fertile ground for Ethernet-APL technology, since the baseline will involve comparing proven Ethernet-APL plus HART-IP technologies with the 4-20mA plus HART status quo. A greenfield design need not weigh sunk costs against new benefits. Rather, a clean-sheet design will allow end users to realize the full benefits of a secure, unified digital infrastructure that reaches from field devices to enterprise systems and the cloud.

Having a critical mass of instrument types available that support Ethernet-APL will be critical for greenfield designs to succeed, believes Robert Resendez, control systems supervisor for the oil, gas and chemicals division of Bechtel. "I remember finding all the instruments we needed being a challenge in the early days of fieldbus," he says. "We try to give our customers one standard proto-

col throughout the plant design, and HART is pervasive. Everybody has HART—even some of the smaller PLC (programmable logic controller) manufacturers.”

From an architecture perspective, tomorrow’s Ethernet-APL systems won’t look all that different from the remote, configurable I/O systems that Bechtel advocates today, Resendez adds. Indeed, replacing remote enclosures filled with configurable I/O with remote enclosures filled with Ethernet-APL switches may even allow system designers more flexibility when it comes to how many devices can be connected through a remote enclosure of given dimensions.

In any case, the transition to Ethernet-APL spurs (out to individual instruments) should be a relatively straightforward adjustment from a design perspective. The addition of the APL trunk concept will allow for new distribution models in areas lacking infrastructure for power and communications. And when it comes to installing and commissioning this new breed of devices in a greenfield facility, users will really begin to benefit from the dramatic improvements in communications speed that the move to Ethernet-APL represents.

Dow has used “smart” instruments ever since they were first available, but only relatively lately begun to rely on continuous monitoring of its instruments’ HART data for predictive diagnostics applications, says

Jeff Konrad, technical solutions team leader in the realm of automation interfaces. “So, with Ethernet-APL, the first thing is faster data,” he says. “My first questions are during commissioning and startup. We know sometimes it’s hard to communicate via traditional HART—sometimes it’s slow, sometimes we have interruptions. So, if it helps during startup and commissioning there will be a real advantage.”

Jason Urso, chief technology officer for Honeywell Process Solutions, cautions that we as an industry really need to focus a bit less on how great it will be to get more data faster and instead figure out just what we’ll do with even more data once it arrives. “I’m a big advocate of APL,” he says, “and I think we’ve got to continue moving in that direction. But let’s also figure out what we’re going to do with all that data now that we’re collecting it.”

Urso also agrees that standardizing on HART-IP over Ethernet-APL will help instrument and system suppliers get to market more quickly with the product offerings that end users need to take advantage of this new field networking technology. “HART’s well known to us in part because it’s used extensively used by our customers,” he says. “They have the knowledge. They have the competence, the expertise and the track record. And I believe true benefits tend to be sustained for a longer period when you have that ecosystem of knowledge and existing tools that are proven in use.”

## 'BEST BET' USE CASES FOR ETHERNET-APL

While industry awaits the opportunity to deploy a critical mass of Ethernet-APL devices in a new plant or unit, we'll also be looking for opportunities to verify the benefits of the new technology when adding new instruments to an existing operation. These "best bet" use cases that can begin to bring value in the absence of a full architectural shift will be those instruments that will benefit most from the dramatically faster data rates or higher power that Ethernet-APL can deliver. Here, then, a roll call of top prospects.

**Digital valve controllers** are among the most promising use cases for Ethernet-APL plus HART-IP in part because there's so much HART data related to their operation that it's hard to gain an accurate picture of their operation in a timely fashion via traditional HART communications. That usually means a trip out into the field with a handheld communicator or PC, but "running a detailed valve analysis might still take 15 or 20 minutes to complete," notes Kurtis Jensen, valve instrumentation portfolio manager, Emerson. "But with HART-IP over Ethernet-APL, engineers and technicians will be able to see things that they hadn't before."

**Coriolis meters** are similarly complex and pack a lot of localized intelligence such as for remote verification that the meter's operating characteristics have remained unchanged since installation. With today's communication technologies, most users rely on a simple pass/fail command to transmit their verification status back to the control room, but the increased bandwidth of HART-IP over Ethernet-APL would allow personnel to dig into the raw data behind the test and determine the root cause—all from the

relative safety and comfort of the control room or even a remote service center.

**Magnetic flowmeters** also include sophisticated onboard diagnostics to verify the continued integrity of the tube, coil and electronics. Again, HART-IP over Ethernet-APL would allow a remote user the ability to dig into the raw data behind these pass/fail tests.

**Radar level gauges** are a third group of instruments whose sensors have a characteristic signature that can be used to verify proper operation or alert the operator to problems such as an antenna coating interfering with its proper operation. Such signatures consist of a large amount of data that cannot be efficiently communicated via traditional HART and would benefit from HART-IP over Ethernet-APL.

**Process analyzers** are a good candidate for Ethernet-APL because the new physical layer can deliver nearly 10 times the intrinsically safe power of a 4-20mA analog loop. So, one may be able to provide both power and high-speed communications over a single, two-wire Ethernet-APL connection rather than the power wiring plus four-wire Ethernet connection traditionally required.

**Multivariable measurements** are yet another promising use case for HART-IP over Ethernet-APL, making it easier to power and communicate HART diagnostics from multiple related instruments, such as the multiple sensors included in a temperature-compensated, differential-pressure flowmeter. It could also allow for one Ethernet-APL spur to connect with multiple temperature sensors, obviating the need for separate transmitters.