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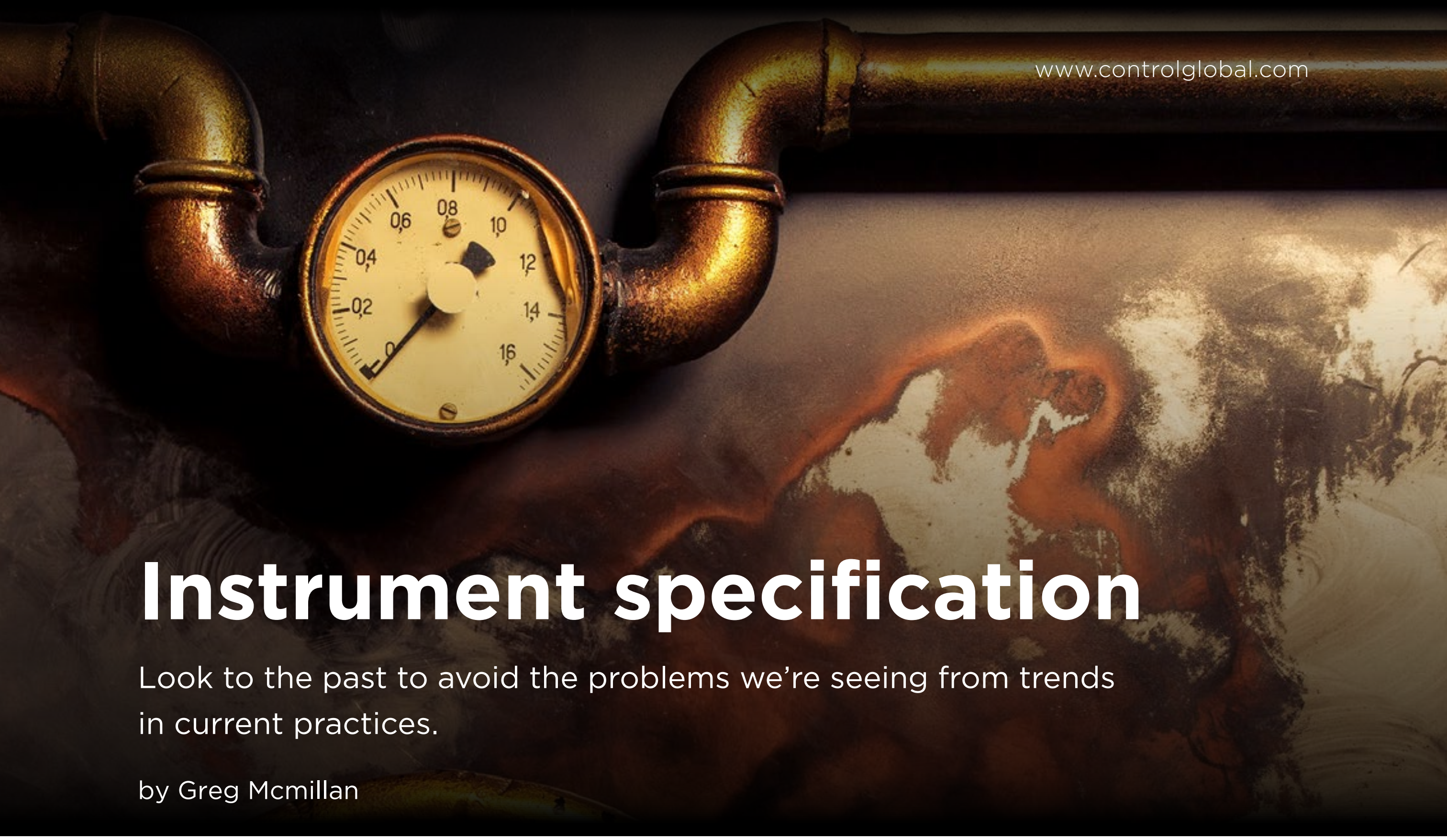


Instrument specification

Look to the past to avoid the problems we're seeing from trends in current practices.

by Greg Mcmillan

Instruments provide the view into the process and means of controlling it. If they're not telling the truth, we're in serious trouble. If you can't measure it, you can't control it. Mike Laspisa offers his insights as to where we are now and where we should be with instrumentation specification based on 37-plus years working in the instrumentation and control (I&C) discipline, including 32 years as a lead I&C engineer or manufacturing plant staff I&C engineer. I spent most the of the 1970s in instrument and electrical (I&E) design and construction, and to this day, the performance of instrumentation is foremost in my mind. Mike's goals are very similar to mine in terms of wanting to share our knowledge often learned the hard way to help automation engineers do what's best.

Mike, what were the original intents and methods for I&C specification from the late 1970s to the late 1980s?

Mike: Field device importance was held in high regard. Measurement and control device specification was a science, and could only be learned on the job. I&C engineers were considered an important asset by both the company and the client. Instrument engineers specified measurement devices, and selected and sized control valves, regulators and safety relief devices using process data, process and instrument diagrams (P&IDs), and pipe specs. A control valve outside sales engineer would review the engineer's selection and discuss difficult applications. Valve sizing calculations were always done by the engineer doing the valve specification.

Device selection took into account both application requirements and device cost. However, performance was the primary selection criteria. Process data was analyzed by the I&C engineer for each measurement and control application, including control valve sizing pressure drop, flow measurement turndown and multiple case studies, if applicable. Accuracy, advanced control strategies, ratio blending, batch addition resolution and many other requirements were discussed with process engineers during joint P&ID development.

However, mass flow measurement choices were limited (e.g., load cells, weigh belt, and volumetric flow with pressure and temperature compensation by remote electronics or computational module).

Greg: How would you describe our current situation?

Mike: Project bottom line focus has led to cost-effectiveness becoming almost more important than performance in instrumentation and control device selection. In addition, I&C device vendors are being asked to select/size field devices more often based solely on the data provided on a datasheet. A reduced budget for I&C specification work is now expected for projects and by some clients. Unfortunately, I&C device vendors are using a younger inside sales force that seems to rely mostly on software for quotations without the experience to ask the right questions or quote needed accessories.

Fast-track engineering has almost become the standard. This sometimes leads to preparing I&C device specifications without the necessary information to specify them completely. Also, process data is usually provided late, and is furnished incomplete or in partial installments. I&C engineer value or project early involvement is questioned by project management. Process or sometimes even project engineers think they can make the early decisions on required I&C devices, or assist the client in P&ID development.

Relying on vendors to select and/or size I&C devices has negatively impacted development of I&C specifying engineers. This has this led to I&C engineers not questioning process data and issuing incomplete datasheets. Reduced budgets and fast-track engineering have also compromised the datasheet checking process. The focus now appears to be more on checking tags against P&IDs rather than application information (sizing, materials of construction, end connections/rating, pipe specs, etc.) and the completeness of the critical process data required to support the sizing and selection of the device.

On the other hand, there are some bright technology developments that have made I&C device applications easier (and more forgiving), such as mass flowmeters, smart transmitters with wide rangeability, multivariable transmitters, radar level transmitters and digital valve positioners.

Greg: I&C engineers should ask process engineers what accuracy is required. In my experience, the accuracy they want is aggressive and was often not achievable until recently.

Mike, how does this history or commentary relate to instrument specification work at engineering, procurement and construction (EPC) firms?

Mike: When I was reviewing project work before I retired, I observed a number of specification deficiencies that included incomplete or incorrect datasheets. Calibrated ranges didn't always take into account the minimum, normal and maximum process requirements and sensor rangeability. I've seen datasheets where the vendor was to select the device size, model, trim, etc. from limited or possibly unintentionally skewed information (e.g., all globe valves with 5 psi valve drop for sizing, regulators using pilots where they weren't required, etc.) Some specific application requirements (e.g., magmeters missing ground straps/rings/ground electrodes; flow primary element selection not compatible with process pipe/duct; analytical probe connection requirements not considered during specification; level measurement selection not compatible or practical for application) were not specified correctly. Is this a checking issue, a philosophy issue (i.e., leave it up to the vendor whenever possible), or a misunderstanding of what is required?

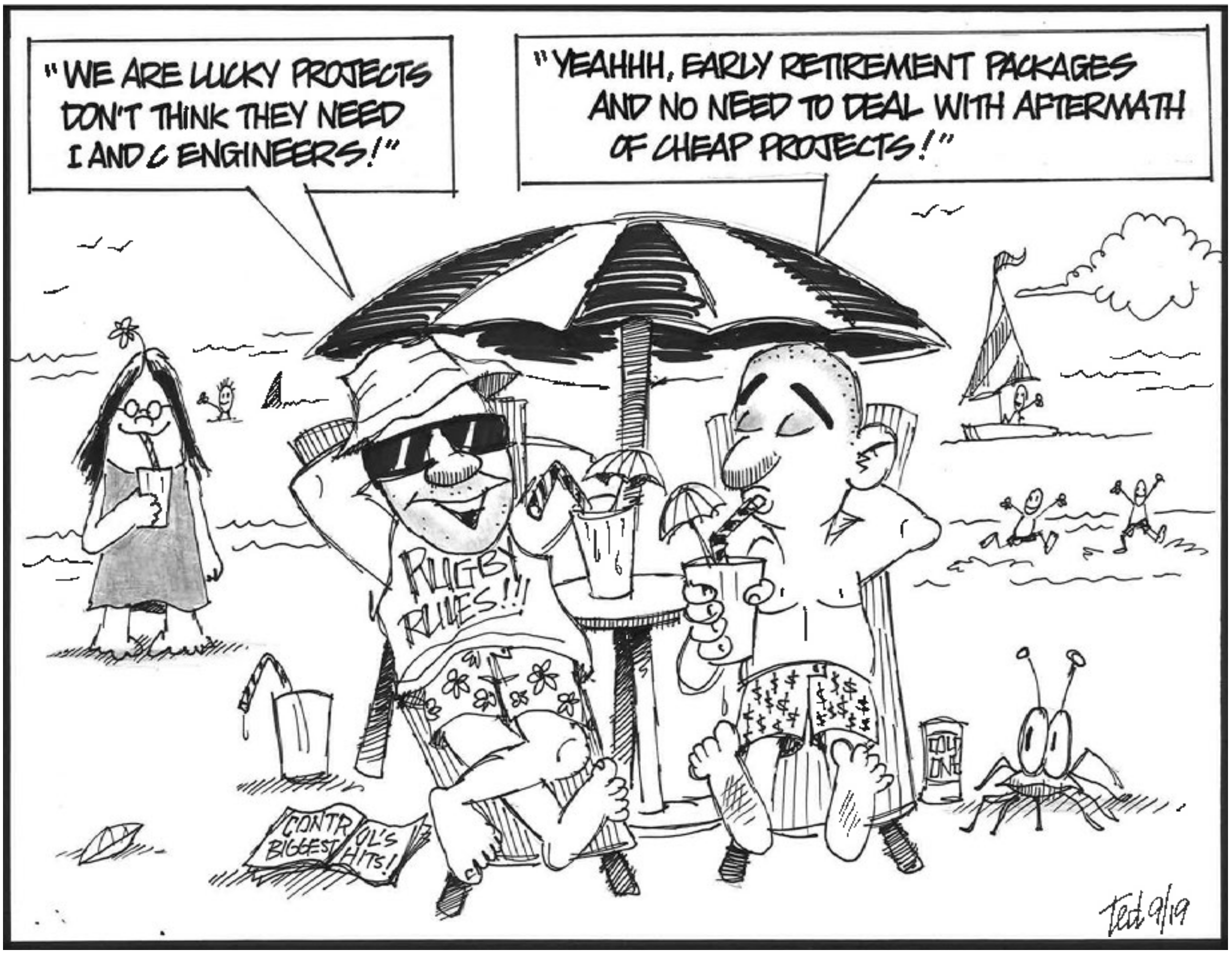
The interface with piping designers, including in-line installation detail preparation, is more after-the-fact than timely to the piping design effort. Packaged system instrumentation is a shared responsibility, but process design usually is in the lead. Historically, I&C does not get involved with the measurement requirements, only the hardware preferences, control system choices, and device signal levels.

Greg: We have to be especially careful to make sure packaged equipment suppliers use the latest and best technology consistent with plant standards.

Mike: The package instrumentation, control devices and control system (including the interface with the plant control system) must meet the equipment specification expectations/requirements (e.g., manufacturer or equal, type or series, and control system preference). There have been many examples where the plant standards or even preferred vendors were ignored to save money by accepting OEM devices well after the specification phase.

Greg: What's needed for a much better future in the specification of I&C devices?

Mike: Better use of appropriate instrumen-



tation and control device learning opportunities (courses, exhibitions, free vendor/manufacturer seminars, lunch-and-learns, asking a lot of intelligent questions and mentoring). Provide internal or external technical resources to discuss device-type applications during datasheet preparation. Develop the preferred role of vendors and I&C engineers in selection and sizing of I&C devices. Discuss the expectations for instrument process data analysis. Determine the critical data fields or notes for the different I&C devices. Datasheet checking must cover technical content as well as device checks against P&IDs for tag and service.

In addition, see the "Instrument Datasheet Preparation Flowchart" for the recommended approach to specifying instrumentation and control devices. Develop a standard naming convention for instrument package workbooks, worksheets and archiving. Discuss vessel connection responsibilities, requirements and impact on device specification. EPC firms need to get I&C engineers more involved in the packaged equipment system specification process and bid review. Process engineers commonly use vendors to create their package specifications, but they rarely have an I&C engineer involved in any conversations or meetings.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Taming temperature and pressure

Innovations in design, control and communications are making life easier in heating, cooling and pressure measurement applications.

by Jim Montague

Temperamental people are sometimes described as “blowing hot and cold,” and many process applications do the same. Handling and optimizing the changeability of temperature and pressure—if not outright volatility—is one of the cornerstone skills of the process control and automation field. However, along with their rookie counterparts, even longtime experts can appreciate many of today’s improved solutions for smoothing temperature and pressure fluctuations, along with supportive data processing and networking tools that allow wider access to information for better decisions.

“There are more divergent temperature and pressure applications these days, but users still want solid measurements that are easy to work with and don’t cost too much, especially as they add more points, gather more values, and improve communications,” says Keith Riley, national product manager for temperature and pressure at Endress+Hauser (www.us.endress.com). “There’s less resources and expertise to go around, so the goal isn’t so much collecting more or different measurements, but more about making life easier for existing processes.”

UNIFIED COOLING CONTROL

For instance, South Florida Distillers (www.southfloridadistillers.com) in Fort Lauderdale, Fla. recently helped 26° Brewing (www.26brewing.com) in Pompano Beach, Fla., implement an integrated, cold-side automation system for its 30-barrel brewery, including controls for precise temperature stabilization of seven tanks, expandable to 16 tanks. The controls include AutomationDirect's (www.automationdirect.com) Do-more PLC and C-more touchscreen HMI that perform process monitoring, process control, data acquisition and data logging for five conical, 930-gallon, stainless-steel, glycol-jacketed fermentation tanks, which are accompanied downstream by a brite tank for quick cooling and a cold-liquor tank (Figure 1).

"Though individual PID temperature controllers could have been used for each of the seven tanks, one Do-more controller was a better solution and less expensive," says Avi Aisenberg, CEO at South Florida Distillers. "The added value of the PLC is its remote viewing, process control and ease of training new users. This design also required less electrical work and will be less costly to expand."

KEEPING SUDS COMFY

Figure 1: Conical, jacketed, 30-barrel tanks are cooled during the fermentation process at 26° Brewing in Pompano Beach, Fla., by three glycol-filled bands controlled by AutomationDirect's Do-more PLC and C-more touchscreen HMI, which also control a brite tank and cold liquor tank downstream.

Source: South Florida Distillers and 26° Brewing

The temperature of each fermentation tank is controlled by a PID control algorithm running in the PLC, which includes two multipoint AC output modules to control 19 solenoid-actuated water valves. Seven resistance temperature detector (RTD) sensors are connected to PLC input modules to measure tank temperature using clean-in-place RTD probes. For each tank, a PID loop uses its tank's RTD sensor as the process variable input, and controls three ball valves via the PID controller output. These valves control flow of a glycol/water solution in each tank jacket. Each fermentation tank has three cooling zones, with cooling solution flow controlled by one valve per zone. The brite and cold liquor tanks each have two cooling zones and valves. A ramp/soak pattern can be programmed to last for days or weeks based on the beer being fermented.

The automation system's HMI has a custom-designed user interface that mimics product process flow. The controller and HMI are networked by an Ethernet switch and wireless access point, which provides network connections for local and remote access to the C-more touchscreen via iPad, iPhone and Android apps running on smartphone or tablet PCs. "This system adds makes interaction with the automation system more user-friendly and easier to setup than with multiple temperature controllers," adds Aisenberg. "The automation system provides data logging locally at the PLC, and remotely through the Ethernet switch, and a free app lets mobile devices remotely access the HMI. Once remote access is enabled at the HMI and the app is installed, duplicate screens from the HMI can be viewed and controlled remotely from the mobile device. All process data is periodically emailed to predefined users or when there's a high- or low-temperature alarm, deviation alarm or other condition."

TACKLING EXTREME SETTINGS, SAFELY

Not stopping at simplifying and combining control designs, many temperature and pressure solutions are also acquiring capabilities so they can serve in increasingly remote and harsh settings. To help users test cement used in oil drilling, for example, Fann Instrument Co. (www.fann.com) in Houston, Tex., has developed a standalone ultrasonic cement analyzer (UCA) to house its pressure and temperature sources, as well as its computer to control its sources and store recorded data. UCAs are used in field labs and drill sites to test cement slurry samples under simulated pressures and temperatures to determine initial sample curing rates. As a subsidiary of Halliburton (www.halliburton.com), Fann's traditional UCA used autoclaves connected to a common pressure source, while cement curing rate data is read back to a separate central computer. After evaluating several options, Fann selected National Instruments' (www.ni.com) CompactDAQ, which integrates connectivity and signal conditioning into a modular I/O device.

"Because of NI CompactDAQ's modularity, adding functions to our UCA for a custom machine is as simple as plugging in a new module," says Rick Bradshaw, formerly of Halliburton. "Our new UCA uses an embedded industrial PC, so NI CompactDAQ's standard USB connectivity eliminated the need for external controllers or interface cards. Also, by using National Instruments' LabView to create our software, we reduced our development time.

"Now, we can control the temperature, pressure and ramp profiles, and perform other tasks not possible on individual autoclaves. We can also take this standalone UCA into the field, directly to sites, while it would have been difficult to transport the whole system before. We've also potentially saved weeks on designing and building new hardware, and gained the flexibility to meet more customer-specific functions by adapting to a wider range of I/O requirements."

Scott Nelson, VP and GM of Rosemount Pressure Products at Emerson Process Management (www.emersonprocess.com), reports, "As our customers push the limits of their operations, we're being asked for more solutions that can withstand extreme environments and severe chemical conditions. As a result, six months ago, we introduced our Rosemount 3051S High Static DP pressure transmitter that can accurately measure differential pressure from 5 in.H2O to 150 psi on top of 15,000 psi line pressure. It's available with wired or wireless communications, and measures differential pressure (dP) and process temperature all in one."

To enhance personnel safety in these challenging applications, Nelson adds that Emerson also recently introduced its Rosemount Wireless Pressure Gauge (WPG). Unlike traditional pressure gauges that include a mechanical Bordon tube, WPG is based on Rosemount sensor technology that can handle 11,000-psi burst pressure, provide self-monitoring diagnostics and expand insight with WirelessHART. "We weren't in the pressure gauge industry before, but it's a need for our customers, so we're bringing our pressure transmitter technology into pressure gauge applications."

BETTER TOOLS + NETWORKS = BETTER DATA

Likewise, to enhance the safety of its boiler control system by generating remote updates, McKee Foods Corp. (www.mckeefoods.com) in Collegedale, Tenn., has implemented eWon's (https://ewon.biz) 2001 PSTN router and 4001 GSM/GPRS modem to notify maintenance personnel of current alarm conditions and let them shut down the boiler remotely, using land lines or cellular phones. This solution allowed the baker of Little Debbie snack cakes and other bakery products to comply with state regulations requiring any boiler systems to be monitored during operation by plant personnel, but now they no longer have to be onsite 24/7.

Consequently, the eWon rounter and modem communicate with the bakery's Allen-Bradley CompactLogix controller via EtherNet/IP networking to monitor alarms, including loss of communications, high-steam pressure and others. Connections between McKee's control system and its operators are enabled by eWon's Talk2M server, which creates a network tunnel and secure virtual private network (VPN) between sender and receiver.

When a critical alarm is detected, an SMS text message is sent to a preset list of cellphones and pagers, allowing operators to respond to the eWon units via cellphone or landline, and shut down the malfunctioning boiler. Staff can then go to the boiler, and begin diagnostics using eWon's data, including alarm history, events and historical datalogs to determine the failure source.

Similarly, because temperature readings are critical to the life sciences and their instruments need frequent calibration, Riley adds Endress+Hauser recently launched its iTherm QuickNeck thermometer extension neck with 1/4-turn quick release and IP69K protection. "Even aided by mobile devices, transmitters have to be unwired, opened, checked and wired, which takes about 30 minutes," says Riley. "QuickNeck's 1/4-turn gets the transmitter head and probe out of the thermowell and back in 10-15 minutes, which saves time and reduces the chance of an alarm, and lets the RTD continue measuring. Also, while a regular RTD can only handle 3-4-G vibrations, we have a new thin-film RTD that can withstand 60-G vibrations, so it doesn't need to be replaced as often." Thin-film RTDs also can provide 2-3-second response times, which are comparable to a thermocouple, rather than the traditional RTD response time of 12-15 seconds.

Unlike its foray into mechanically aided safety with the WPG, Emerson's Nelson explains that many temperature and pressure components are becoming more electronic and less mechanical because they're more efficient, cost effective, and save time for users. For example, he says Emerson's new Rosemount 3051S Electronic Remote Sensors (ERS) system eliminates mechanical impulse lines and the troubleshooting and maintenance they often require. Users also appreciate that ERS only takes one person less than two hours to install, while traditional mechanical devices can take two people six to eight hours to install.

"Previously, dP transmitters were connected to tanks with a mechanical system, which allowed outside ambient environmental changes to create instrument error," says Nelson. "Now, we put two pressure sensors on a tank that are connected electronically, which eliminates prior sources of errors and maintenance, and are five to 10 times more accurate."

Jim Montague is Control's executive editor

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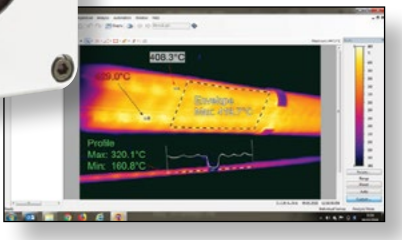

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Pressure and temperature ratings

Will a fail-closed valve open when the downstream pressure exceeds the upstream?

by Béla Lipták

Q: What is the difference between maximum allowable working pressure/temperature, maximum operating pressure/temperature, maximum allowable operating pressure/temperature, design pressure/temperature and storage pressure/temperature?

Mehdi Manouchehri

m.mnchri@yahoo.com

A: Following is an extract from "Guidelines on Dp, Op, Mop, Maop, Mawp, Psv Setpoints," available at several web sites. I hope it clarifies correctly:

Operating pressure (OP): This is the pressure at which the device/equipment/pressure vessel is operating under normal conditions. Simply put, you could say the general pressure conditions in the equipment on a regular basis.

Maximum operating pressure (MOP): The maximum operating pressure that the engineer considers will be encountered in the process operation, including a margin for any possible surges or fluctuations.

Design pressure (DP): Per ASME B31.3, this is the most severe and coincident condition, internal or external, due to the service that the equipment is likely to be subjected to, meaning the worst possible temperature and pressure case the fluid can exert on the vessel/

equipment. This is decided by the engineer based on the fluid service existing, and it also varies with the fluid. The engineer decides it based on previous experience and sound judgment.

Maximum allowable operating pressure (MAOP): MAOP is not to be confused with MOP. It's a definition mainly formulated for pressurized equipment such as cylinders or pressure vessels, but also applicable elsewhere. It's considered the maximum possible safe pressure that the walls of the equipment can withstand.

Maximum allowable working pressure (MAWP): This is defined as the maximum pressure experienced by the weakest point of the equipment before failure. Some mistakenly refer to it as design pressure, but simply put, it tells us the maximum pressure that the weakest point in the equipment can withstand before becoming unpredictable or failing (also referred to as design pressure of the weakest point, but not the general design pressure as such). An alternative and equally valid definition for pressure vessels is, it's the maximum permissible pressure at the highest point or top of the vessel in normal operating conditions at the coincident operating temperature for that pressure. MAWP is usually determined by the manufacturer of the equipment based on fabrication procedures, backward correlations, etc., and is usually stamped on the equipment.

The increasing order of the above values is: OP < MOP < DP < MAOP < MAWP. None of the other values are supposed to exceed the MAWP. The MAWP is usually about 10-25% above the operating pressure, but not always.

More information is at the links: www.ognition.com/1493/operating-design-and-maximum-operating-temperatures; webwormcpt.blogspot.com/2008/02/design-temperature-td-versus-maximum.html; and www.whatispiping.com/pressure-temperature-pressure-vessel-design.

Alex (Alejandro) Varga
vargaalex@yahoo.com

A: Maximum allowable working pressure is used for sizing relief valves. It's 10% above the pressure where the relief valve is actuated. Maximum operating pressure/temperature is the maximum operating condition. Maximum allowable operating pressure is the same as the maximum allowable working pressure.

Design pressure/temperature is the pressure/temperature at which equipment is designed to normally operate. There's also a maximum pressure, beyond which equipment integrity is compromised. There's also a spike it can tolerate for a few seconds.

Storage pressure/temperature is the pressure and temperature at which a product is stored.

Hiten A. Dalal, P.E.
hiten_dalal@kindermorgan.com

A: The maximum allowable working pressure/temperature (MAWP) is the pressure that the pipe and components will be subjected to before a protective function kicks in (e.g., 850 kPag for a 700 kPag gas pipeline. 850 kPag is the setpoint for the slam-shut valve that protects downstream equipment).

Maximum operating pressure/temperature: say the operating pressure range is 700-770 kPag (active rgulator is set at 700 kPag, monitor regulator is set at 750 kPag). Hence the maximimum operating pressure is 770 kPag.

Maximum allowable operating pressure/temperature: the maximum allowable operating pressure is determined and set by the end user. The manufacturer/supplier then selects equipment that will operate above this pressure, but incorporates protective functions to limit the operating pressure (see above).

Design pressure/temperature: Design pressure is the guaranteed safe pressure for the equipment (in this case, the pipe). Usually, the design pressure will be selected as 1,000 kPag to allow for thermal expansion, and the weep relief valve will be set at this pressure.

Storage pressure/temperature: Storage temperature is the maximum temperature at which the purchased equipment is stored in the warehouse. It could be, say, 50 °C during very hot summer when power is not available.

M. Binney
binney4family@internode.on.net

Q: Will a fail-closed (FC), double-acting valve open if downstream pressure exceeds upstream? We have one double-acting, air-actuated, FC angle valve installed where the upstream pressure is 70 kg/cm2 and downstream pressure is 14 kg/cm2. The control valve has one volume tank that’s feeding air from top of the actuator through an airlock valve to keep the valve closed in case the air supply to the positioner fails.

We planned an air filter/regulator (AFR) replacement job for the volume tank. The operator isolated the downstream isolation valve and said to start the job. The main air supply was isolated and the air drained from AFR of main air line to the positioner. The control valve remained in closed position. Then the volume tank air was drained, and as the pressure dropped to 1 kg/cm2, the angle valve (air fail to close) suddenly opened. The procedure was repeated and the valve opened again. I mention that all the tubing connections are OK, as was the and vent and air lock relay venting the air. After the AFR replacement job was completed and air was normalized, the control valve closed again. The downstream isolation valve was opened.

The next day, we tried the same thing to check the fail safe action of control valve, but this time the upstream isolation valve was isolated instead of the downstream isolation valve. When the main air was failed, the control valve remained in closed position and when the volume tank air was drained, the valve remained in the closed position.

Please confirm my thought that in the first case the control valve opened because the downstream isolation valve was closed, and back pressure forced the plug to open when the air pressure in the VT dropped to less than 1 kg/cm2 to zero.

I'm not finding this exact situation in any catalog or manual. The make of the angle valve is CCI-Drag.

Bhartendu Nayak

bhartendu.nayak@GMAIL.COM

A: The design of a CCI Drag valve is such that the process fluid pushes the valve plug toward the open position, as is the case with most control valves. This means, if all motive air is removed from both sides of the actuator, but the valve is left pressured with process fluid, the valve will open regardless of its failure mode. To be safe, you must close its upstream block valve and depressure the entire piping in which the valve is installed. That probably means closing the discharge block valve as well. That's why the valve has isolation valves and a low point drain in the piping (I hope!)

This practice must be followed when servicing any kind of valve. Don't depend on any claimed failure mode. It may be a nuisance to do all this work, but it's your neck that's on the line.

Walter Driedger.

walter@DRIEDGER.CA

A: On a double-acting-type actuator, fail safe mode, to maintain air pressure to the actuator was the responsibility of the pilot valves and air reservoir. In case of power and pressure system failure, the pilot valve will move to its failure position, so air from the reservoir flows to the actuator to maintain the valve in the closed position. If there's no pressure loss in this system (due to leaks on tube fitting, reservoir or failure of the pilot valve), the control valve will remain closed with no power and no pressure (failure of power and pressure system, e.g., plant blackout scenario).

On the control valve data sheet, check the maximum delta pressure (DP) in the closed-valve position. If the DP of the valve at those conditions did not exceed the maximum DP across the valve stated on valve data sheet, it's impossible to say that the control valve opened due to excessive upstream/downstream pressure.

In my experience, control valve manufacturers always ensure that their actuator has enough power to keep the valve at closed position at maximum delta pressure. I've suspected that disturbances of air supply of control valve (actuator) fail-safe system might cause the valve to suddenly open.

Budi Yuwonob

joewono@gmail.com

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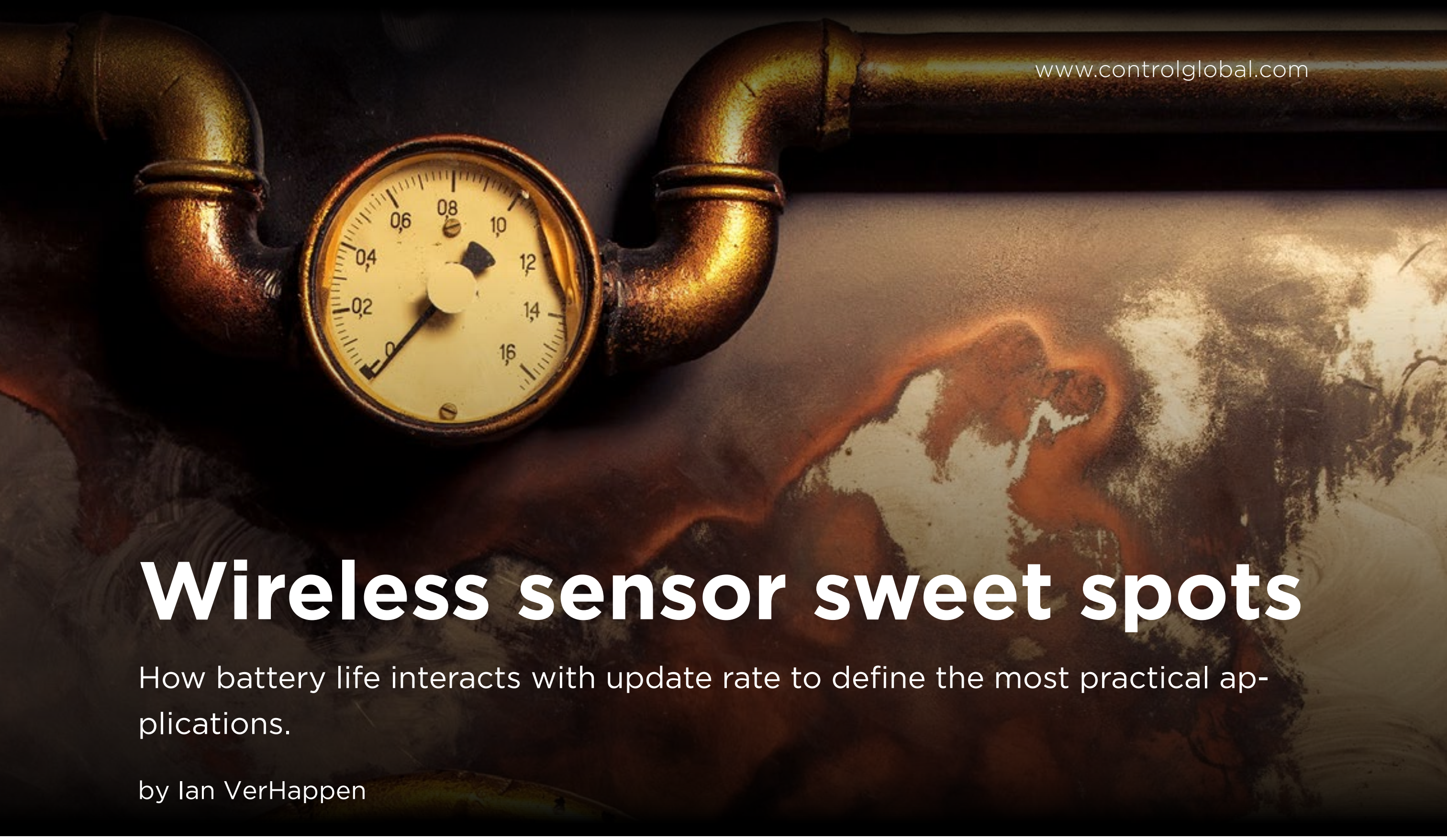


Wireless sensor sweet spots

How battery life interacts with update rate to define the most practical applications.

by Ian VerHappen

Though the majority of instrument and controls engineers have an electrical background (confirmed by the surprise people still have when I tell them I was trained as a chemical engineer and, like them, “fell” into this profession), we all need to remember that the reason we are installing all our sensors, control elements and control systems is to control and manage the process. The point of this message is that process dynamics need to be part of the design process.

With wired devices that are not power-constrained, the update rate is decided by the I/O card and controller. Battery-powered wireless devices, however, do need to manage their energy consumption, and the most common way of doing so is by configuration settings of the update rate.

Though update rates for wireless sensor networks (WSN), WirelessHART and ISA100.11a can be as short as 0.5 sec., as the update frequency is increased, there is an associated exponential decrease in battery life. As expected, the largest impact is at the faster update rates that might be required for closed-loop control. Longer update periods (beyond 60 sec.) are constrained by basic battery life physics more than the update rate, thus setting the limit on the slower-update-rate side of the equations.

So how do we balance the update rate and battery life? Basic control theory recommends that the update rate of the measurement shall be a minimum of three times faster than the process time constant. I personally prefer an update rate of six times the process time constant, if possible, because then I am sure to observe all stages of an oscillatory process. However, using the three-times-faster basis for a temperature loop (where measured temperature changes with a sensor inside a thermowell can be 16 sec. or longer, given how much time is required for heat to penetrate the thermowell and its mass), the required wireless update rate would be roughly 5 sec. Since WSN cycles increase by doubling each time, the closest approximation for this loop is a 4-sec. update rate.

Industry practice and experience also recommend the update rate should be four to 10 times faster than the time constant of the process for regulatory closed-loop control, so though it's at the low end, the 4 sec. update rate would also work in this example.

Another, non-process-related consideration in addition to battery life is the impact traffic may have on the network itself, and in particular, the access point or gateway. One WSN manufacturer recommends keeping update rates no faster than 4 sec. since doing so can impact the total number of wireless devices that can be put on a gateway. Therefore, the 4 sec. update rate for this example works well by meeting all three minimum criteria.

Temperature is one example of a slow process. Level measurement, especially in large tanks, is another. These sorts of measurements are well suited to wireless sensing because they can operate with slower update rates, and when you consider that large tanks and tank farms are widely distributed, not having to install cable infrastructure makes a lot of sense.

With today's computing power, the smart people working in our industry have developed a number of fancy tricks, such as custom P&ID algorithms for wireless networks that consider lag, other control algorithms (such as Smith Predictors, developed in 1957), or other math to compensate for the effects of delayed measurements. (Some would say mask rather than compensate, especially if they are used improperly by a person not understanding and applying first principles correctly.)

Despite all the advances we have made and continue to make with our control systems, it is always good to remember why we are implementing the application, as well as the underlying associated engineering principles, and basic laws of physics and chemistry that need to be followed.

Not everyone makes a good controls engineer, technician or practitioner, however, if you remember the basic laws of physics and chemistry, the chances of succeeding going up significantly.

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.

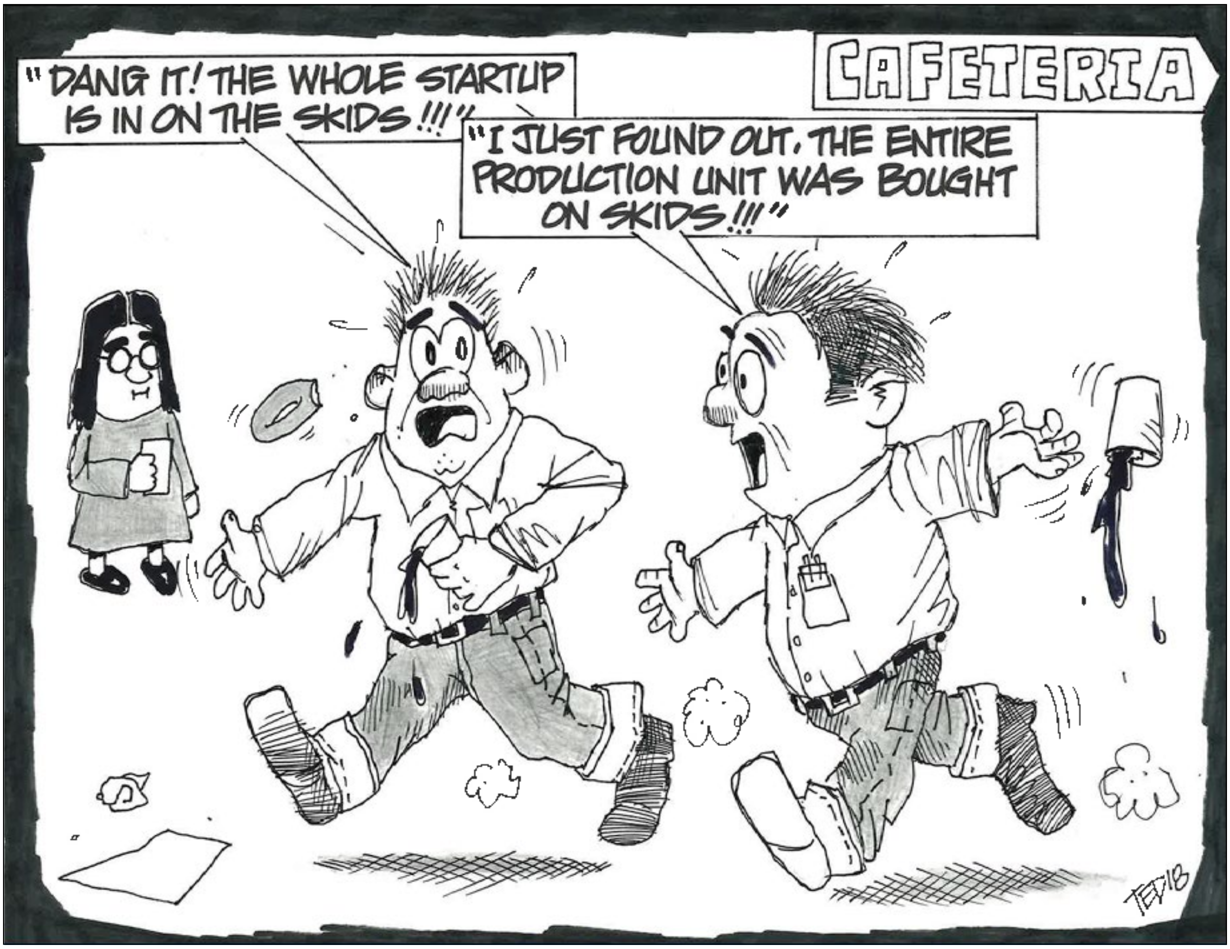
Hunter: It's very important that the tubing slope continuously from the process connection to the transmitter. Any high point along the way can trap vapors and cause an improper reading. Also, the transmitter connections usually branch off the main impulse run. This is done so if there are any solids 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 are 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.