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CALIBRATION UPDATE

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Digital Devices Need Calibration

Not Doing At Least a Reference Check on a Regular Basis is a Bad Idea

By Ian Verhappen, Contributing Editor

Many people are under the false impression that they don't have to calibrate their digital transmitter, in part because they don't have the facilities to do so with the accuracy possible at the factory. However, not doing at least a reference check on a regular basis, including at commissioning, is a bad idea. With today's smart instruments, doing such a check is easier than it ever was before.

An easy example of how to do this with the HART digital signal is to use the PV to verify the 4-20 mA reading at the zero, 50% and full-scale reading input to the transmitter. This will identify what, if any, errors exist along the analog signal circuit (D/A converter in field device, cable, A/D converter in I/O card). Other potential sources of error that can be identified this way include ground loop difference or losses due to cable resistance.

Even though digital devices are inherently more stable than their analog predecessors, their tolerances are much narrower than in the past. In addition, digitizing instruments have analog circuitry — process sensor (for example, capacitance cell, Wheatstone bridge, etc.), preamplifiers, buffers, etc., whose performance can change over time. Therefore, digital devices are not exempt from regular calibrations.

Not calibrating carries its own costs, for example, falsely passing or failing a quality specification. In discrete manufacturing, false passes can send inferior products to customers. False failures end up in the reject bin, ruining yields and prompting costly rework or discards. In process operations, the equivalent of a false failure is product giveaway because, to compensate and maintain the minimum specification, additional processing is often required.

Commerce depends on globally agreed upon standards of weights and measures. Only traceable calibration can ensure adherence to these standards, especially for custody-transfer measurements on which payment is based.

Contractual requirements may stipulate a regular calibration regimen where the penalty for non-compliance could be fines or loss of business.

Calibration can reveal an underlying problem that could evolve into a costly failure, thus preventing an expensive unplanned outage.

Being able to make effective use of this information requires a calibration management system to not only assist with the scheduling of the calibration procedure, but also in tracking the results of each calibration in one place, so any changes over time that might be part of a trend that may indicate a larger underlying problem can be identified early.

Only calibration can ensure adherence to globally agreed upon standards, especially for custody-transfer measurements on which payment is based.

The International Society for Pharmaceutical Engineering's (ISPE) Good Automated Manufacturing Practice (GAMP) guidelines for manufacturers and users of automated systems in the pharmaceutical industry rely heavily on the traceable documentation of a calibration management system.

Joint Committee for Guides in Metrology (JCGM) documents offer useful information on how to evaluate uncertainty in measurement data. "Evaluation of Measurement Data — Guide to the Expression of Uncertainty in Measurement" and "Evaluation of Measurement Data — An Introduction to the Guide to Expression of Uncertainty in Measurement and Related Documents" are two of the five documents available from the Bureau International de Poids et Mesures.

Another useful publication by the calibration tool company Beamex is the Ultimate Calibration Book on the hows and whys of calibration. This book can be downloaded here.

Calibration Can Be Condition-Based

Calibrating Industrial Devices Only as Needed Is the Better Method, and That Requires Automating the Calibration Process

By Dan Hebert, P.E.

Process plants abound with instruments, analyzers and control valves, all of which need calibration to ensure performance as designed. Many plants calibrate these devices at fixed intervals, but that's less than optimal for a number of reasons. First, it's expensive, as many devices can operate within parameters on extended calibration schedules.

Second, it can result in poor operating performance, as some critical instruments should be calibrated more frequently. Third, plant safety can be compromised if safety-related devices drift out of calibration between intervals.

Calibrating each device only as needed is the better method, and that requires automating the calibration process. Smart devices can provide information to an asset management system (AMS) or a calibration management system (CMS) over a digital data link. These systems use this information to determine optimal calibration intervals. They also send data to documenting calibrators, which are used to calibrate the devices. After calibration, these calibrators upload the "as left" condition of the device to the system.

Here's how it works in practice. "Our customer GlaxoSmithKline (GSK) has a pharmaceutical manufacturing plant in Cork, Ireland, with more than 4000 control loops with HART and Foundation fieldbus," says Laura Briggs, the product manager for asset optimization at Emerson Process Management.

Plant personnel were routinely calibrating instruments that did not need the same level of attention as devices that were critical to product quality or safety. To determine which instruments could be moved from the periodic schedule to on-demand calibration, they examined the diagnostics generated by every smart field device and digital valve positioner using Emerson's AMS Suite predictive maintenance software. They began monitoring a select group of less critical instruments, waiting for them to indicate that a change had taken place internally requiring attention. As time progressed, all of the smart devices were migrated to on-demand calibration.

Savings due to this procedure were 15 minutes cut from each calibration and more than 500 hours per week of manual data entry time."
– Laura Briggs

Streamlining regular calibration procedures is based on optimizing the plant's periodic calibration schedules using documenting calibrators and synchronizing instrument data between Beamex's CMX CMS and Emerson's AMS Suite. Calibration data on every instrument is stored and downloaded directly to a portable calibrator for use by a technician in the field. When the scheduled calibrations are completed, the results are uploaded for certification and documentation.

"Savings due to this paperless calibration procedure were 15 minutes cut from each calibration, 21,000 sheets of paper eliminated each year and more than 500 hours per week of manual data entry time eliminated, along with potential errors," notes Briggs.

GSK also extended the interval between calibrations to reduce the overall number of procedures done annually while remaining in compliance with corporate policy and government regulations. The company achieved this through an ongoing, computer-driven analysis of historical data to identify instruments that didn't need to be calibrated as often, resulting in an 8% reduction in scheduled calibration.

ISA Takes on Asset Management

ISA108 Intelligent Device Management committee finishes first document, "Concepts and Terminology"

By Ian Verhappen, P.Eng.

Asset management continues to be a critical but underused capability of modern control systems. Last year at this time, we talked about the different types of information available from modern microprocessor-based sensors. At that time I also mentioned the work being done by the ISA108 Intelligent Device Management committee. This committee is now close to completing its first document, ISA-dTR108.1-2015 "Part 1: Concepts and Terminology."

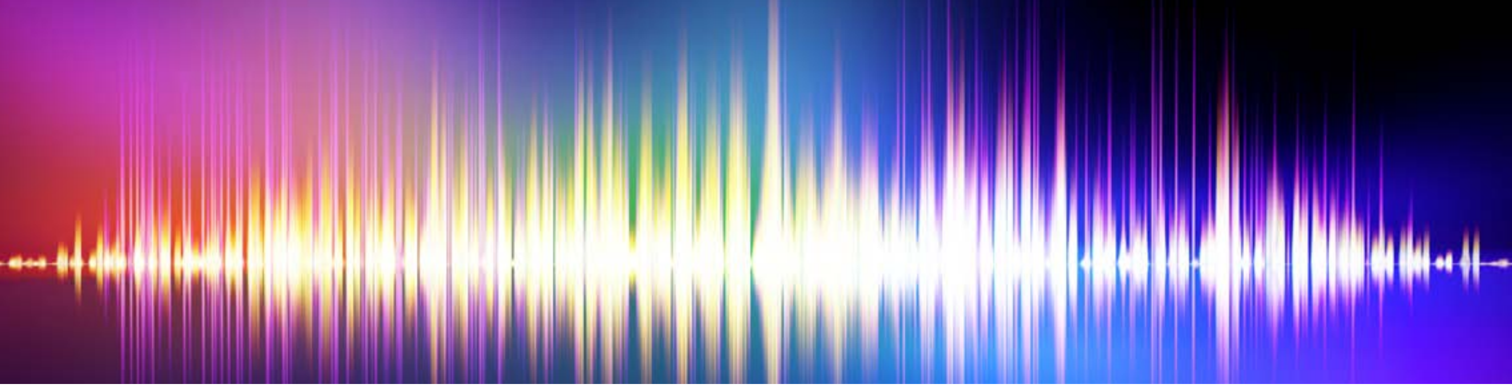
The purpose of ISA108 is to define standard templates of best practices and work processes for the implementation and use of diagnostic and other information provided by intelligent field devices in the process industries. This will be accomplished by preparing a series of documents that will describe the management structure and work process structure of intelligent device management (IDM) to provide a set of coordinated activities for an organization to optimize the value from intelligent devices.

Though hardware and software tools are necessary to support work processes and procedures, specification of the tools or implication of a particular asset management tool or set of tools is not a part of ISA108.

Committee work products will initially be a series of technical reports describing recommended work processes and implementation practices for systems that use information from intelligent field devices and the people who use them. As was done with the ISA99 cybersecurity standards, when the resulting technical reports have been in use for a period of time, they will be converted to standards as part of the normal maintenance activities. Each work process identified in the documents will have metrics and audit processes.

Because work processes change through a facility lifecycle, the resulting documents have to cover all lifecycle phases and transitions. The three-part document set will be based on the equipment lifecycle phase or by other means necessary to provide work processes with appropriate role definitions. The various parts of the standard series identified to date address the following aspects of IDM:

Part 1: Concepts and Terminology describes intelligent device management concepts and terminology necessary for in-depth understanding and effective communication. It gives an overview of the basic concepts of how intelligent devices can be managed and how this device management plays a larger role in the overall objectives of a facility throughout its lifecycle. The ultimate goal of Part 1 is to provide basic knowledge to understand the concept of intelligent device management so that end users can implement such a system.



A series of documents will describe a set of coordinated activities for an organization to optimize the value from intelligent devices.

Part 2.1: Configuration and Revision Management specifies multiple work processes related to configuration and revision of intelligent devices, including establishing an IDM program, engineering and setting of parameters, replacement and tracking, storing and updating related data in configuration databases, and auditing by documenting work processes for management of intelligent device configuration integrity, configuration adequacy and configuration congruency for a full facility lifecycle.

Configuration integrity refers to the application-oriented processes for establishing and maintaining design integrity, including processes for managing change. Configuration adequacy refers to device-oriented processes that provide assurance that necessary functions are properly and fully configured, and that undesired functions in the device are disabled. Configuration congruency processes assure that the multiple databases where intelligent device configuration data are stored all have the same data and that configuration changes propagate accurately and in adequate time.

Part 2.2: Diagnostics Utilization specifies multiple work processes related to diagnostics done by intelligent devices, including establishing an IDM program, training, maintenance of intelligent devices, scheduling of maintenance, audit and continuous improvement. The resulting document set will provide work processes for establishing, executing, auditing and continuous improvement of a program for diagnostics utilization at a facility. Execution of the resulting processes will focus on pre-start-up, operation and turnaround lifecycle phases.

Part 2.3: Procedure Management specifies multiple work processes not covered in other parts, including inspection and function testing of intelligent devices to assure that correct and appropriate manual and automated procedures are used for support of intelligent devices. Procedure management includes development, documentation and training as well as identification of necessary safety requirements, skills, and tools.

Part 2.4: Calibration Management addresses the program activities and work processes for managing calibration procedures. Inferential (analytical) and physical measurements, such as cover calibration checks, statistical analysis of calibration checks, decisions about calibration versus replacement, and actual calibration requirements, will be covered. Several classes of calibration may be needed, including calibration documentation and management for custody transfer, health, safety, and environmental, or regulatory reporting.

The last of the Part 2 documents is Part 2.5: Intelligent Valve Management, covering activities and work processes including on-line diagnostics and repair as well as off-line turnaround, diagnostics and repair processes, including in-line procedures and shop repair related to final control elements.

Part 3: Implementation Guide(s) provides guidance on implementation of intelligent device management and will be developed upon completion of the Part 2 documents.

Working groups have been identified for each of the Part 2 documents, and the first document has been submitted to the IEC as a new work item under SC65E. If you wish to get more involved in the direction and development of these documents, you can do so either directly through ISA or through your country's national standards body.

How to Calibrate Pressure Instruments

Hunter Vegas from Wunderlich Malec and Ned Espy and Roy Tomalino from Beamex present a two-part ISA webinar on the basics, crucial issues and best practices for successful pressure calibration.

By Jim Montague, executive editor, Control

As natural forces go, pressure is pretty straightforward. It involves less mysterious physics than electromagnetism, it's easier to observe than thermodynamics, and its calculations are simpler than often turbulent flows. However, there are still some important aspects of pressure that must be remembered to apply its technologies properly, and this is especially important when calibrating pressure-related devices.

To reacquaint users with pressure's crucial details, two 90-minute webinars were delivered recently by ISA and Beamex. The three presenters were Hunter Vegas, project engineering manager at Wunderlich-Malec, Ned Espy, technical director at Beamex and Roy Tomalino, professional services engineer at Beamex. They decided to do the webinar on pressure because a recent Beamex survey found that about 60% of applications in process plants use pressure.

The trio reported that calibration begins with the International System of Units (SI-Units), and that international, national, reference and working standards are essential for maintaining the agreed-upon building blocks of precise and accurate calibration, process measurements and efficient performance. "When we're talking about good measurement, we're really talking about good metrology practice and data with demonstrable pedigree that can show traceability back to international standards," says Espy. "And the reason we do calibration is to bring transmitters that were installed and have drifted back to their good-as-new condition."

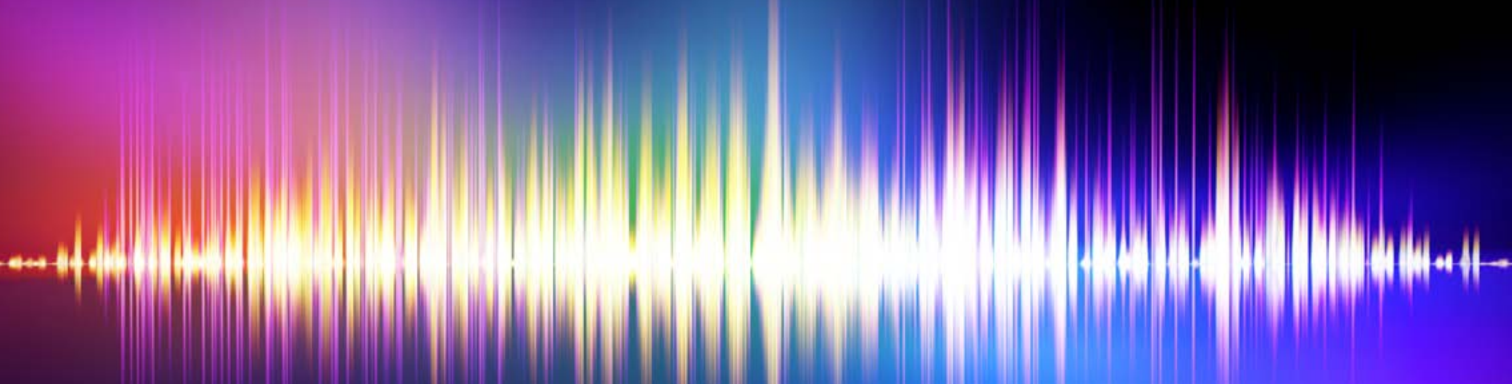
Basic Units and Scales

While pressure is defined as equaling force divided by unit area, Vegas reminded viewers that this simple equation can occur in some unexpected ways. For instance, if a large force is spread over a relatively large area, then the net local force is small, while a small force over a small area can have a high net local force. "Both sides of this equation need to be taken into account," says Vegas. "With tanks, a common myth is that the shape of a tank can affect the pressure at the bottom, but this is not true because 1 in. x 1 in. x 23 ft of water always weighs 10 lbs regardless of its shape, so the shape of a tank has no impact on the 10 psi pressure at its bottom. All that matters is the height of the liquid."

If this tank were filled with mercury, then this initial 10 psi would be multiplied by mercury's specific gravity (SG) of 13.6 to produce a pressure of 136 psi, and if a 1-psi blanket of nitrogen is added at the top to suppress fumes, then it would bring the bottom pressure up to 137 psi. "When calibrating a differential pressure (dP) transmitter that's reading pressure at the bottom, three things matter—height of the liquid, SG of the liquid and any pressure on top." Likewise, a 23-ft storage tank at 100% will read 276 inches of water column (in. wc), and a 10-in.wc nitrogen blanket will bring it up to 286 in.wc, until a compensation leg, bubbler or other device is added (Figure 1).

Espy adds that, while absolute pressure begins with zero in a vacuum and gauge pressure begins with zero at ambient barometric pressure (14.7 psi at sea level), dP happens in a closed system that looks at the difference between two pressure signals coming from a high leg and a low leg, and zero differential happens when those two legs are connected.

The primary pressure units are atmospheres, pounds per square inch (psi), Newtons per square meter (kPa), bars that are 0.01 kPa, in.wc, millimeters of mercury (mmHg, Torr) and inches of mercury (in.Hg). "People tend to get confused because there are so many units, and then ambient pressure is also affected by altitude, temperature, humidity and even



latitude," adds Vegas. "Depending how your scale is set, at sea level you may see any of these: 0 psig (gauge), 14.7 psia (absolute), 1 atmosphere, 30 in.Hg or 760 mmHg. Inches of water column are based on the weight of a 1-in. cube of water, and 27.7 in.wc equals 1 psi."

Vegas added it's also important to remember that, when using a standard orifice place in an air line, dP is multiplied by four when the flow is doubled, and dP is multiplied by nine when the flow is tripled. "Flow and dP have a squared relationship, so the dP's square root is needed to convert or relate to a given flow," adds Vegas. "This is usually done in the DCS, so if it's done in the field, you need to make sure the DCS doesn't do it again."

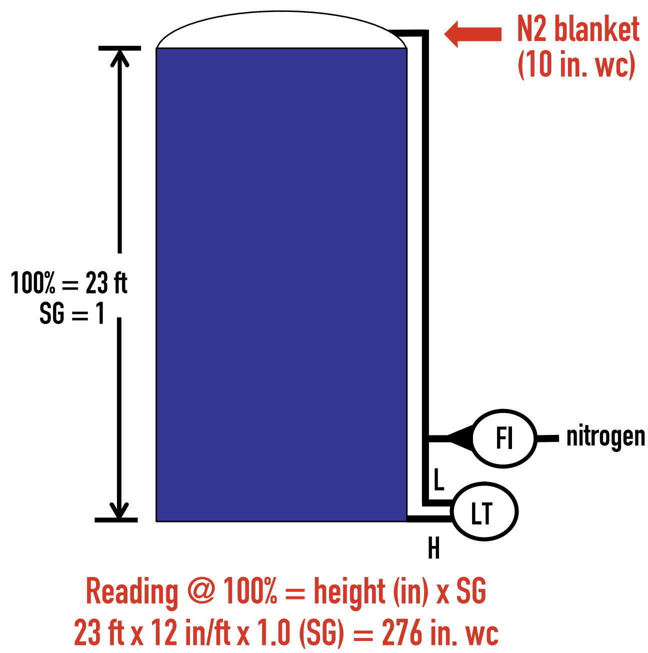
The Three Up-Down Test

Working in Colorado (at an ambient pressure of 12.3 psia), Tomalino first connected a Beamex MC6 documenting calibrator to the high side of a Siemens dP transmitter set up for 0-100 in.wc and a 4-20 mA output that provides a linear function of 4 mA at 0 in.wc, 12 mA at 50 in.wc and 20 mA at 100 in.wc, and has a 0.5% of span error tolerance. These levels correspond to zero, 50% and 100% of the transmitter's set operating pressure, and Tomalino used a connected, 300-psi air pressure pump with gradual venting to move the transmitter up through each level and back down through each in a three up-down test.

"The calibrator just needs to know what to expect," says Tomalino. "We first zero it for the atmospheric pressure, and only have a 3-scond delay while it looks for a stable signal and automatically grabs the test point."

Tomalino reports his first test failed because its 0.59% of span was outside the set 0.5% error tolerance. The MC6 calibrator's raw data and graph showed that most error during the test occurred on its high side, and he adds it's important to preserve this as-found data to aid trending efforts. "If you can gather 10 years of calibration data, you can see if a transmitter is drifting up or down, is rock solid, or needs adjustment every time," says Tomalino. "So don't erase a test, trim and then test again."

Because the dP transmitter has HART communications, Tomalino adds that screwdrivers and potentiometers can't



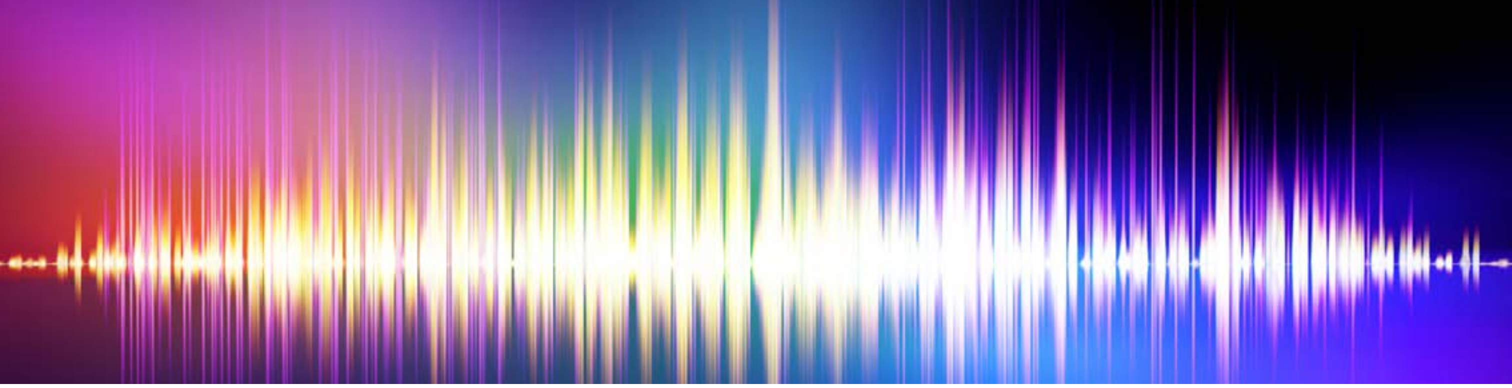
Credit: ISA, Beamex and Wunderlich Malec

DP CALIBRATION OF STORAGE TANKS

Figure 1: A 23-ft storage tank at 100% will read 276 inches of water column (in.wc), and a 10 in.wc nitrogen blanket will bring it up to 286 in.wc, until a compensation leg, bubbler or other device is added.

be used to adjust its zero and span. Instead, MC6's diagnostic service is opened, reminds the user to remove the transmitter from automatic control, adjusts its current and sensor trim to 100% at 100 in.wc, and allows it to stabilize. Next, the zero level is also typically trimmed, and when the transmitter is tested again it passes with a largest error of 0.128% of span, which documented as its as-left condition. Both as-found and as-left data sets are combined on the transmitter's calibration certificate.

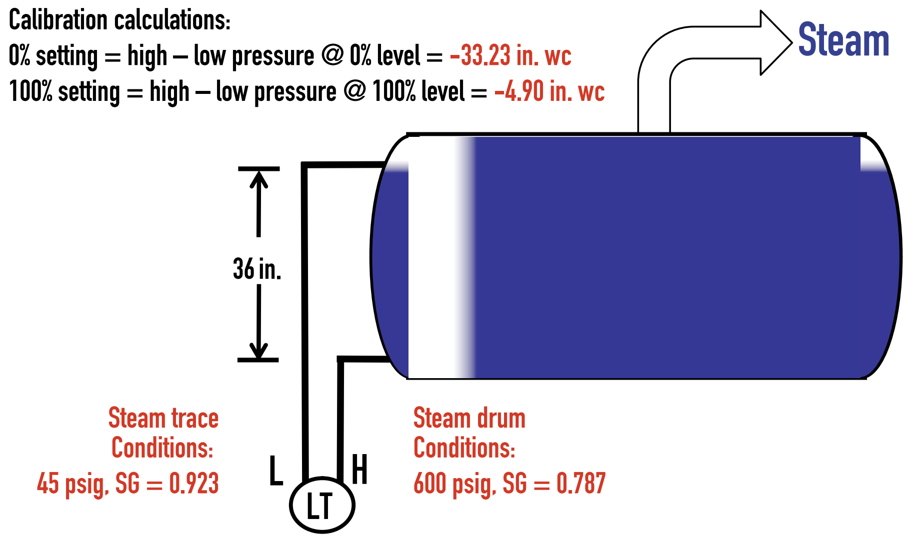
Vegas adds that initial zero levels must sometimes be adjusted to account for local conditions, such as a 10-psig air line with a connected pressure transmitter (PT) line that fills with water due to condensation and may add another 10 psig, or a 20-psig steam line at 400 °F that cooks its transmitter. In both cases, the PT line needs to be relocated, or the user must



account for the water's pressure by elevating its zero and 4 mA output up by 10 psig when calibrating its transmitter, and moving its 20 mA output from 30 lbs up to 40 lbs, so the DCS will read it as the originally intended 0-30 psi.

Tomalino demonstrated this procedure on a Rosemont 3051 PT set for 0-250 in.wc that equates to a 4-20 mA output, but needs to elevate its zero to account for a 10-in. wet leg, so it adjusts the transmitter to read 10-260 in.wc with 10 in.wc at the 4 mA output and 260 in.wc at the 20 mA output. "We begin with 10 in.wc, take it up to 135 in.wc and 260 in.wc at 100%, and go back down the same way," adds Tomalino. "However, if we forget to stop at 10 in.wc and vent all the pressure at the end, then the calibrator won't accept this as zero because it wasn't the input value. But we can't just go back to the 10 in.wc setpoint, so we must go up past it and then back down to it again."

This time, the calibration test failed because the 10-in. wet leg should have equated to 4 mA, but was only reading 3.9 mA. So it needed to be trimmed to zero, and was adjusted to a 0.006% of span error, which allowed it to pass the calibrator's test. All the as-found, adjustment and as-left data need to be documented and added to the calibration certificate too.



Credit: ISA, Beamex and Wunderlich Malec

CALIBRATION OF A STREAM DRUM LEVEL

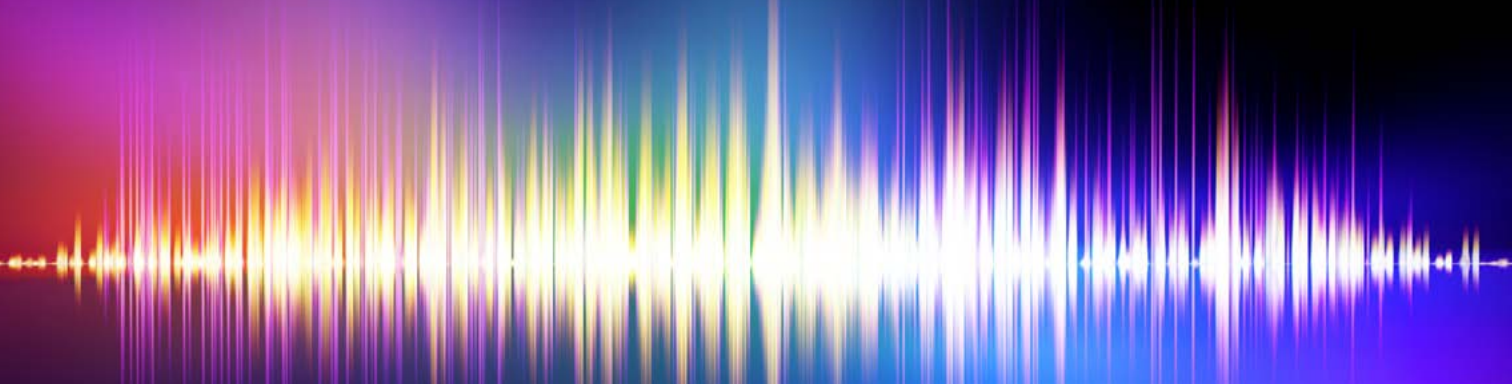
Figure 2: Water in a 36-in. steam drum at 600 psig will have a 0.787 SG, while a steam trace in its leg will be at 45 psig and 0.923 SG. Subtracting high-side from low-side readings results in a 0% level of -33.23 in.wc and 100% level of -4.9 in.wc.

Steam Drum Level

In the second webinar, Vegas stressed, "Steam drums bedevil many people because they need to know more than its tap-to-top height. You need the SG of the water or other liquids in the drum and its legs to calculate 0% and 100% levels." These readings can also be affected by temperature and pressure, so heat, steam and electric traces are used, and need to be left in place year round to help find problems. For example, water in a typical 36-in. steam drum at 600 psig will have a 0.787 SG, while a steam trace in its leg will be at 45 psig and 0.923 SG. Subtracting high-side from low-side readings results in a 0% level of -33.23 in.wc and 100% level of -4.9 in.wc (Figure 2).

Vegas explains that steam drum level calibration steps include:

- Making sure interlocks are bypassed or boiler is out of service because any steam drum level transmitters have low-high level trips, isolating the transmitter, but leaving steam trace active;
- Calculating steam drum level calibration, including the zero setting of -33.23 in.wc and the span setting of -4.9 in.wc;
- Setting the zero and span;
- Returning the transmitter to service; and
- Once steam trace is at temperature and boiler is at normal pressure, adjusting the zero if necessary to match sight glass or mechanical gauge.



Tomalino again used the MC6 to calibrate level transmitter steam drum and level transmitter capillary functions for a Rosemont 3051 transmitter with isolation manifold. He adjusted the transmitter fine-tuning to reach -33.22 in.wc, observe the mA output, automatically calibrated the transmitted, and check that it passed its test. "The calculate the needed calibration, you need to know the 4-20 mA signal, and then do high pressure minus low pressure to get the 4-20 mA point needed for calibration.

Diaphragm Seals

Vegas adds that the three main types of dP seal assemblies—pad type, pad type with single capillary and dual capillary seal—can all cause problems. Pads and seals directly measure pressure, but the diaphragms in them are easily damaged or installed incorrectly. Meanwhile, fluid-filled capillaries transfer process pressure to transmitters that aren't bolted onto their vessels, but their silicon-based oils or glycerin fluids can leak and cause process incompatibility; become viscous and slow their response due to low ambient or process temperature and pressure; or boil in low vacuums and high temperatures and ruin their applications.

"Process heat can cause liquids to expand and cause the readings on a transmitter to rise, but changing process temperatures will generate zero shift errors in the transmitter," explains Vegas. "Also, a larger seal will be more sensitive and able to read lower pressures, but it's also more prone to zero shifts due to process temperature variations. Similarly, wider capillary tubes respond faster, especially if fill fluid is viscous, but their higher volume results in more zero-shift issues from ambient temperatures."

In addition, single-seal capillary installations are subject to zero shifts due to changing process temperatures, and they only work on vented tanks, though they can work on pressurized tanks if the low leg is tubed up. They'll also likely need purges to keep out condensation.

Likewise, dual-seal capillary tubes can also create zero shifts due to ambient temperature changes, which may be offset if the capillaries are the same length. They also may be subject to zero shifts due to process temperature changes, unless both seals see the same process temperature.

"Seals are fragile and expensive, and need to be checked before they're bolted down, and you always need to be aware of ambient temperature," explains Espy. "It's also important to address up-front how testing and calibration will be performed to avoid big headaches. And venting at capillary seals is critical. Flush rings are useful for venting and applying calibration pressure, and this means the seal doesn't have to be unbolted." He adds that dP seal calibration steps should include:

- Isolate both seals from process using flush rings;
- Be sure both seals are at their normal position and elevation
- Vent both seals to atmosphere using flush rings; record the current 4 mA reading as found
- Apply span pressure on the high seal and record the current 20 mA reading as found;
- Vent both seals and adjust the transmitter to read 4 mA as left;
- Apply the span pressure to the high seal and adjust the 20mA point as left;
- Close vents and return the seals to service.

Tomalino adds that a tank with a 0-25 in.wc level range and 4-20 mA transmitter output may have a -28.46 in.wc to -3.46 in.wc pressure based on its process' SG, capillary fill fluid SG and a long capillary vertical distance to the low-side sensor, and all of these need to be compensated for in its calibration and trim.

"This kind of problem can be mind-bending for technicians, so you need to break it into chunks to conquer it," says Tomalino. "You need to test and pass the level transmitter and then test and pass the transmitter with the capillary. The lower trim pressure is closer to zero, so you capture the as-found data for the 0-5 mA input. The pressure calibration shows the pressure coming in and the current going out, so you do the lower, enter -3.46 in.wc, and send it over. Next, you do the upper, vertical pressure, and enter -28.46 in.wc. Then, you increase pressure, check for hysteresis, do an up-down test, see that it's passed, and store and save the results."

[Editor's note: This article is based on two webinars on Oct. 2, 2014, and Feb. 19, 2015, which were organized and hosted by the ISA and Beamex. They can be viewed at https://www.youtube.com/watch?v=2hgEmdxuAlM and https://www.youtube.com/watch?v=tmp0WDhNlCg.

Calibrating WirelessHART Transmitters

By Heikki Laurila

WirelessHART transmitters are becoming more popular. What are these transmitters and how do these differ from wired HART transmitters? Why do the WirelessHART transmitters need to be calibrated and how the calibration can be done? These and many other related issues are discussed in this article.

A Very Brief History of HART

The HART (Highway Addressable Remote Transducer) Protocol was developed in the mid-1980s by Rosemount Inc. for use with a range of smart measuring instruments. Originally proprietary, the protocol was soon published for free use and in 1990 the HART User Group was formed. In 1993, the registered trademark and all rights in the protocol were transferred to the HART Communication Foundation (HCF). The protocol remains open and free for all to use without royalties (Source: HCF).

HART is digital communication protocols that enable communication with a field device. With the communication, the settings can be read and written, measurement results can be read, diagnostic data can be received etc.

Wired HART Signal

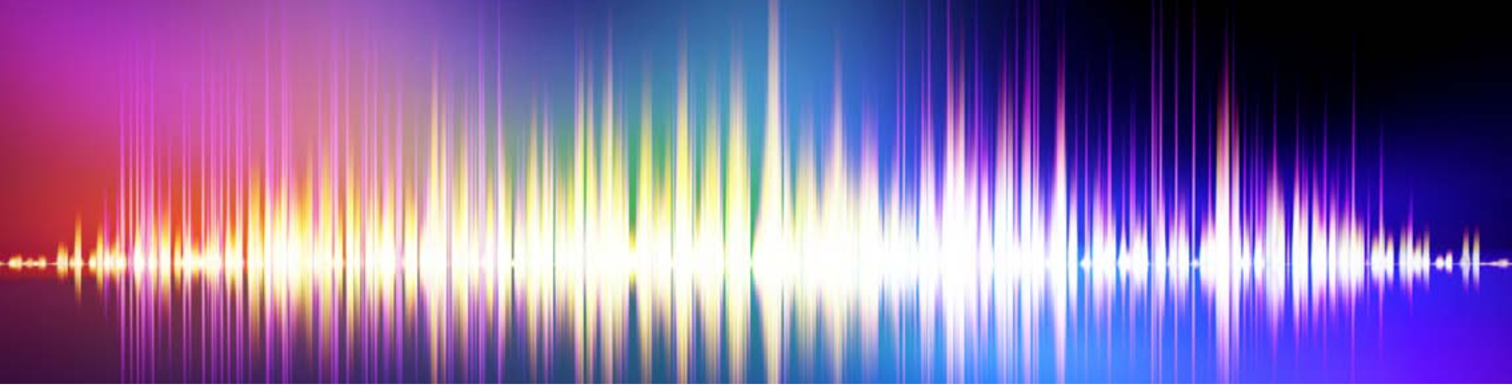
The wired HART Protocol uses Frequency Shift Keyed (FSK) digital communication signal superimposed on top of the standard 4-20mA analog signal. The wired HART transmitter is compatible with analog control systems.

*Wireless*HART

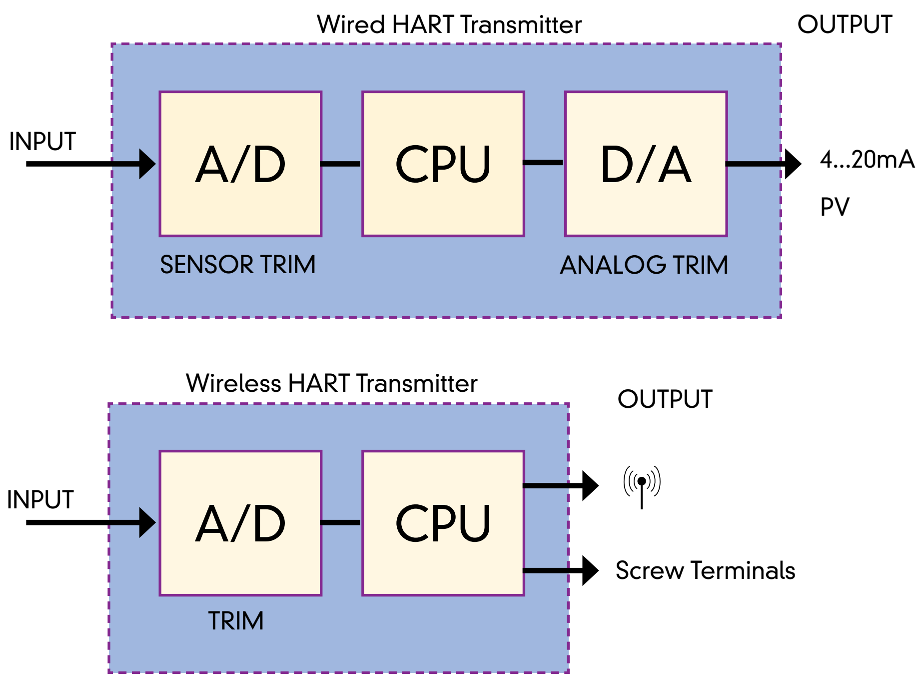
*Wireless*HART was approved and ratified by the HCF Board of Directors, and introduced to the market in September 2007, becoming the first officially released industrial wireless communication standard. The *Wireless*HART network uses IEEE 802.15.4 compatible radios operating in the 2.4GHz radio band. Each device in the mesh network can serve as a router for messages from other devices. The *Wireless*HART transmitter does not have any analog mA signal. It only has the digital signal which is available wirelessly, or via the screw terminal.

Since the transmitter is wireless and there are no cables, the operation power cannot be fed via cables, instead the transmitter needs a battery to power it up. The battery life and communication speed are inversely proportional. In order to save batteries, the majority of the time wireless transmitters are programmed not to communicate very often. The wireless signal can also be programmed to work faster. It is possible to use *Wireless*HART even on a control circuit. In practice, most often the *Wireless*HART transmitters are first used in monitoring applications, being slow in nature as well as in applications that are difficult to wire.

Any existing wired HART transmitter can also be made wireless by adding the wireless adapter available from many instrument manufacturers. If the control system is analog reading only the mA signal, an additional *Wire-*



*less*HART host system can be built to take care of all the additional information available from the HART devices. These can include information that is not available via the analog control system for example; advanced diagnostics and predictive maintenance.



A principled block diagram illustration of wired and wireless HART transmitter

HART Status and Future

Over 30 million HART devices are installed and in service worldwide, and the wired HART technology is the most widely used field communication protocol for intelligent process instrumentation. The HART share equals almost half of the intelligent transmitter installed base. Various studies estimate growth for HART also is the future. The new *Wireless*HART standard seems to be a new booster for the HART protocol. Data from studies predicts that *Wireless*Hart will grow exponentially over the next 10 years.

What Is Meant by "Calibration"

According to international standards, calibration is a comparison of the device under test against a traceable reference instrument (calibrator) and documentation of this comparison. Although formally calibration does not include any adjustments, in practice, adjustment is possible and often included in the process of calibration.

What is Meant by "Configuration"

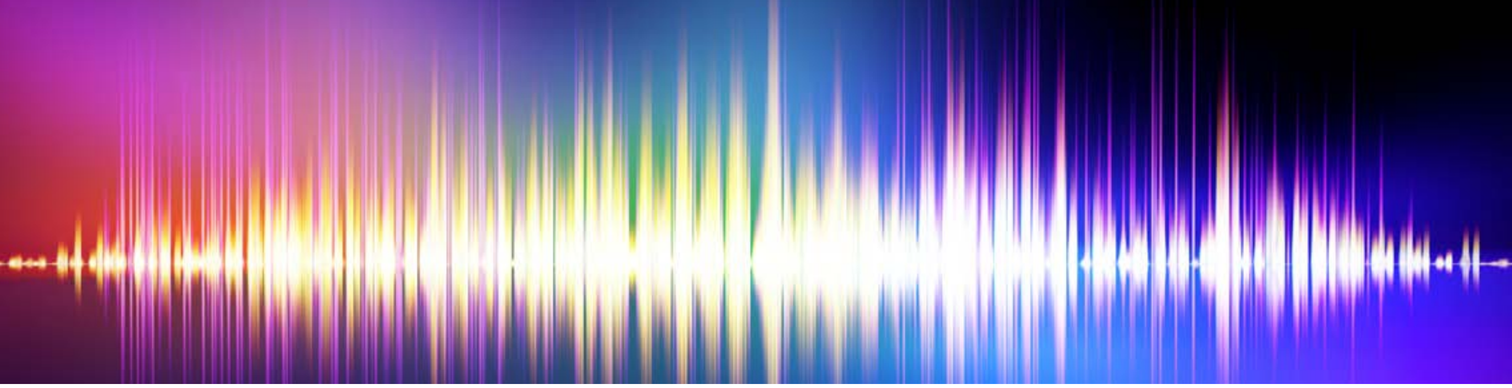
Configuration of a HART transmitter means changing the transmitter settings and parameters. The configuration is typically done with a HART communicator or with configuration software.

It is important to remember that although a communicator can be used for configuration, it cannot be used for metrological calibration. Configuring parameters of a HART transmitter with a communicator is not metrological calibration and it does not assure accuracy. For a real metrological calibration, a traceable reference standard (calibrator) is always needed.

How to Calibrate a Wired HART Transmitter

It is good to remember that a HART transmitter has two different outputs that can be used and calibrated; the analog mA output and the digital HART output. In most cases the analog output is still being used among customers.

In order to calibrate the analog output, generate or measure the transmitter input and at the same time measure the transmitter output. A dual functional calibrator being



able to handle transmitter input and output at the same time is needed, or alternatively two separate single-function calibrators. For example, if someone wants to generate a pressure input and measure that accurately with a calibrator and at the same time, measure the analog mA output with a mA meter.

If one wants to calibrate the digital HART output, the calibration process alters slightly. Obviously it is still needed to generate/measure the transmitter input the same way as for analog transmitter, using a calibrator. In order to see what the transmitter digital HART output is, some kind of HART communicator with the ability to show the digital HART signal is needed. A HART transmitter can have several digital variables depending on the transmitter type.

In the case of analog or digital output, one would step through the range of the transmitter in a few points and record the input and output signals to document the calibration.

How to Calibrate a *Wireless*HART Transmitter

First, it is good to remember that although the *Wireless*HART transmitter has a different output than the wired HART transmitter, the *Wireless*HART transmitter also needs to be calibrated. As the calibration verifies the transmitter accuracy, i.e. the relationship between the physical input and transmitter output, the need for calibration does not change the output being wireless or wired, digital or analog.

The input of a *Wireless*HART transmitter needs to be generated (or measured) the same way as the analog or wired HART transmitter, using a reference standard or a calibrator. The output of the transmitter needs to be read at the same time. A *Wireless*HART transmitter does not have any analog output; it has only a digital output. The digital output can be read in two different ways.

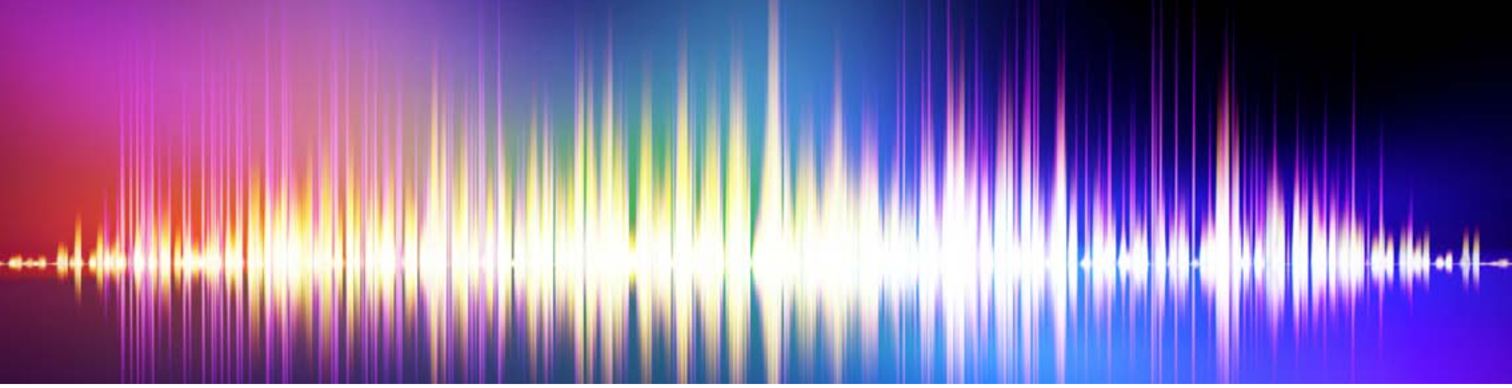
One way is to read the output signal wirelessly, but the wireless signal can be very slow. Depending on the transmitter configuration, it may be transmitting its output only once per minute. Anyhow, the wireless signal is not really suitable for calibration. For example, in the case of a pressure transmitter calibration, there can always be small leaks in the pressure connections or hoses, causing the input to change slightly constantly. If the output is read very seldom, there could be a significant uncertainty and error between the saved calibration input and output data. Also, if there is any need to trim (adjust) the transmitter, or make any other configurations, these cannot be done wirelessly.

All the *Wireless*HART transmitters also have screw terminals allowing a wired connection with the transmitter. While being connected via the screw terminals, the digital output can be read fast enough for calibration purposes and any configuration or methods, such as trim methods, are accessible. Therefore the *Wireless*HART transmitter should be calibrated with wired connection to the transmitter's screw terminals.

The input can be generated or measured with a reference calibrator. The output needs to be read with a HART communicator with the ability to read the transmitter via the screw terminals. As the *Wireless*HART transmitters are done according to HART7 standard protocol, a communicator able to support HART7 standard is needed. If there is a separate calibrator for the input and communicator for the output, the readings will need to be manually written down and the calibration documented. If there is a calibrator and communicator built in one device instead, the input and output can be handled simultaneously with the same device. If the device also is a documenting device, the calibration can be automatically documented in a paperless manner. If a wired HART transmitter needs to be trimmed, the sensor section (A/D conversion), as well as the analog (D/A conversion) section, will need to be trimmed. In case of a *Wireless*HART transmitter, there is no analog section, so it is enough to trim the sensor section.

Why Calibrate

A modern transmitter is advertised as being smart and very accurate. Sometimes people might say that there is no need for calibration at all, because the transmitters are so "smart." Why should the smart transmitters still be calibrated?



First of all, changing of the output protocol of a transmitter does not change the fundamental need for calibration.

There are numerous reasons to calibrate instruments initially and periodically. The main reasons are:

- Even the best instruments do drift during the time, especially when used in demanding process conditions.
- Regulatory requirements, such as quality systems, safety systems, environmental systems, standards, etc.
- Economic reasons, any measurement has direct economic effect.
- Safety reasons, employee safety as well as customer/patient safety.
- To achieve high and consistent product quality and to optimize processes.
- Environmental reasons.

The Beamex MC6 Field Calibrator and Communicator

The new Beamex MC6 is a device that combines a field communicator and a very accurate multifunctional process calibrator.

With the Beamex MC6, the smart transmitter's input can be generated/ measured at the same time as the digital output can be read. Both can be done simultaneously and the results can be automatically stored into the MC6 memory for later viewing or upload to calibration software.

For configuration of the smart transmitters, the MC6 includes a field communicator for HART, *Wireless*HART, FOUNDATION Fieldbus H1 and Profibus PA protocols. All required electronics are built-in, including power supply and required impedances for the protocols.

So the Beamex MC6 can be used both as a communicator for the configuration and as a calibrator for calibration of smart instruments with the supported protocols.

While a normal HART communicator can be used to configure and to read the HART digital output, it alone cannot be used for calibration or trimming of the transmitter. For that purpose, an additional calibrator is needed. Then one ends up having two separate devices without any automatic calibration procedure or documentation. Therefore a device, like the Beamex MC6, is superior for calibration of wired or wireless HART transmitters.

Example:

Let's take an example of calibrating an Emerson 648 *Wireless*HART temperature transmitter. The transmitter is configured for RTD measurement with sensor type Pt100 (Alpha385).

Disconnect the RTD sensor and connect the MC6 to simulate the RTD sensor. Connect the MC6's HART terminal to the transmitters screw terminals and configure the MC6 to read the Primary Variable (PV) of the transmitter, which is the digital output.

The range to be calibrated is 0°C to 100°C (32°F to 212°F). Configure the MC6 to step the input signal from 0 to 100 °C (32°F to 212°F) in 25% steps, stepping up and down. Then, configure the MC6 to wait 10 seconds in each step to allow the transmitter to stabilize. The transmitters damping should be naturally taken into account when deciding the calibration delay. In completing these steps, we have programmed the max allowed error tolerance to 0.5% of the full scale.

When the connections are complete, calibration can begin. The calibration will go through fully automatically stepping the required input steps, waiting the delay, and then going to next step. Once the calibration is completed, a dialog will appear, stating if the calibration was a pass or fail. Next, save the calibration into the MC6's memory. Later on, upload the calibration results to calibration management software to be saved in the database and possible printing of calibration certificate.

If the As-Found calibration failed, or we want to trim/adjust the transmitter, we can use the MC6's HART communication to run a trim method on the transmitter. While running the trim method, it is possible to simultaneously simulate the required accurate input with the MC6, so no other device is needed. Once the calibration method is completed, run another automatic calibration procedure to perform an As-Left calibration.

The above calibration example can be seen as live video at Beamex YouTube channel in this link.

Speedy Delivery of Calibration Data

Calibration is a complex procedure that takes time, and time is money. Here's how some facilities are saving both and also getting better data

By Jim Montague, executive editor, Control

Do you know what you're looking at? Are you really seeing what you think you're seeing? How can you be sure? How fast can you do it?

These are some of the unsettling questions that characterize the need for calibration in process control. The reason they're disturbing, of course, is that control, automation and manufacturing in general depend on functional certainties delivered fast, which enable operators and engineers to make decisions and complete all their tasks successfully and on time or better. So when information comes along that questions those absolutes and throws doubt on them, well, it can be pretty unnerving and drain time.

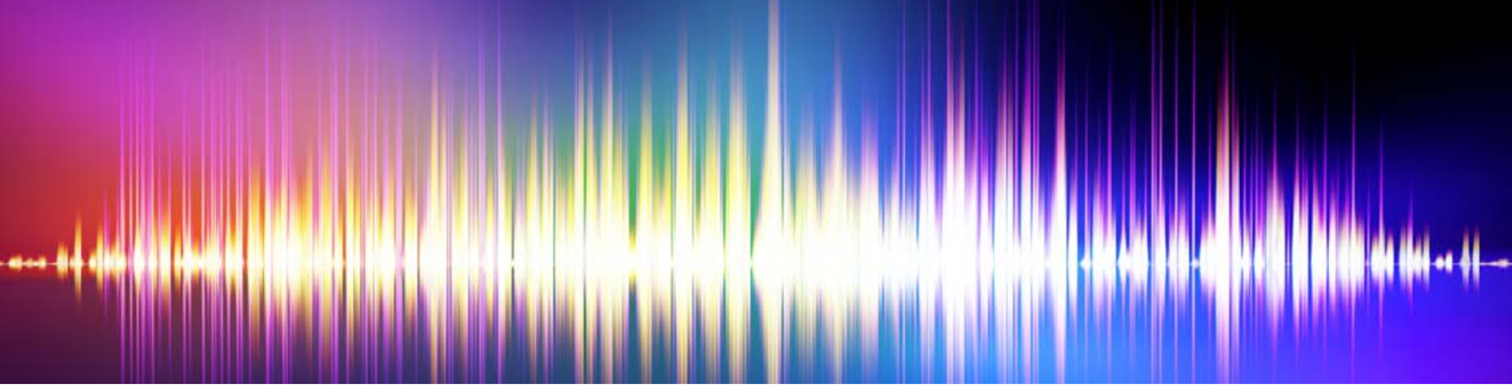
This is also the reason calibration is so crucial in the process control field—it restores accuracy to instruments and confidence and timeliness to users. However, the relativism that comes along with calibration can still be pretty spooky, which is why most users approach it with traditional caution. Fortunately, many calibration methods and tools are getting increasingly easier to use, so there's less need to worry and much better accuracy, improved optimization, speedier throughput and other benefits to be gained.

Consolidating Tasks

For instance, Cabot Microelectronics Corp. in Aurora, Illinois, is the world's leading supplier of slurries and polishing pads used to remove excess material from silicon wafers in the semiconductor production process, and master electrician Michael Schlegel and his colleagues use meters, calibrators and other devices to maintain and troubleshoot Cabot's mixers, blenders, shipping line conveyors and robots.

"I'm usually called on to look at anything electrical, so about 10 to 20% of my job is troubleshooting, and the rest is preventive or predictive maintenance and working on capital projects," says Schlegel. "I may jump from electrical to mechanical to pneumatics to plumbing, so I use a lot of Fluke (www.fluke.com) tools in the process, including the 725 process calibrators, 381 remote-displays, true RMS, an AC/DC clamp meter, and a Fluke 87 DMM that I have with me most of the time."

Schlegel reports that Cabot calibrates most of its pressure and temperature transmitters in-house, so he frequently uses his 725 calibrator. "I introduced it to Cabot not long after I got here because it's more adaptable to our business needs than what they had before," explains Schlegel. "The



previous calibrator had a lot of modules that would drift and had to be constantly calibrated, but the Fluke process calibrator is more efficient and easier to use. My 725 tells me everything about the process, and it covers RTDs, thermocouples and process loops. As a result, our calibration time dropped from about a month with the previous system to about four to five days with the Fluke 725."

Gaining Moments

Because calibrating instruments usually means taking them at least partially offline, it's often viewed as an unwelcome interruption in crucial processes. Conversely, any effort or capability that can shorten calibration time is more than welcome.

For example, British Sugar reports its plant in Wissington, U.K., is the world's largest beet sugar manufacturer, which processes more than 3 million tons during peak campaign periods and produces 420,000 tons of sugar per year—and can't waste time doing it (Figure 1).

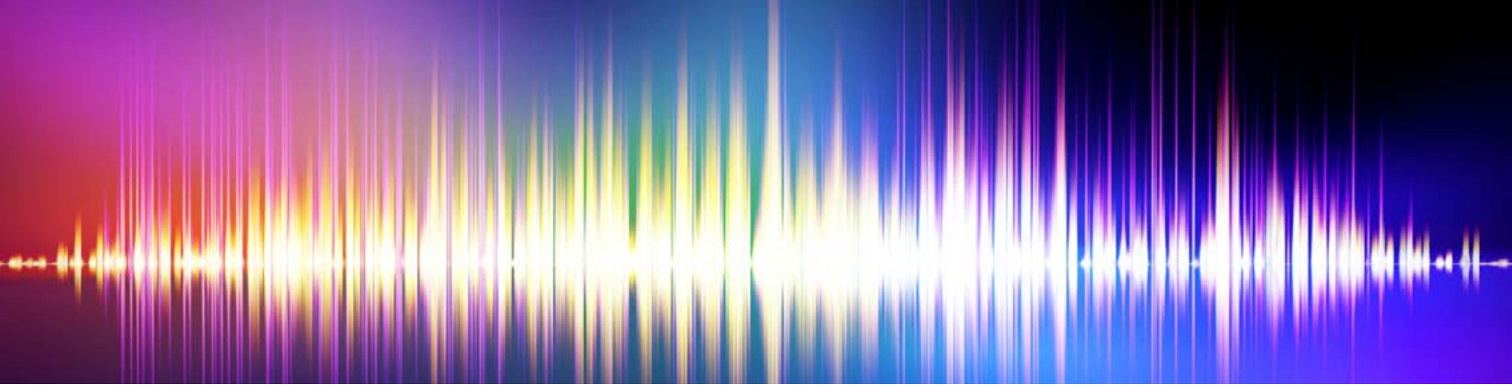
Because making sugar requires huge amounts of steam, the Wissington facility's combined heat and power (CHP) plant produces 500,000 megawatt/hours (MWh) of electricity annually, but it can only be shut down for maintenance for 10 days per year. During this period, all maintenance tasks have to be completed, including statutory and mandatory testing, repairs and inspections.

Photo Credit: Beamex and British Sugar

SWEET BEETS

Figure 1: British Sugar's Wissington plant and CHP facility used Beamex's MC5 calibrator and CMX calibration software to cut calibration times for 400 instruments in half.

The CHP plant includes a LM6000 gas turbine, waste heat recovery boiler, a 34-megavolt ampere (MVA) steam turbine, a water treatment plant, two small shell boilers and a back-up plant consisting of three water-tube boilers and a 20-MVA steam turbine. The plant supplies heat and power to the sugar operation and a bioethanol application, and even delivers waste heat and carbon dioxide to 46 acres of greenhouses on site producing 140 million tomatoes annually. The CHP plant also exports 45 MW of power back to



the U.K.'s National Grid, which is enough for a 120,000 residential consumers.

These varied operations enable British Sugar's Wissington plant to also annually manufacture 140,000 tons of animal feed, 6,000 tons of betaine, 55,000 tons of bio-ethanol, 120,000 tons of limex, 15,000 tons of tomatoes, 150,000 tons of topsoil, and 5,000 tons of stone that's cleaned and sold as aggregate. Finally, an associated carbon dioxide recovery and liquefaction plant recovers up to 70,000 tons of carbon dioxide per year from the bio-ethanol fermentation processes.

"It's essential that we all work together, so there's no interruption of steam supply to our clients," says Trevor Wolfe, EC&I engineer at British Sugar. "Any interruption to the steam supply would shut the sugar factory down, causing much inconvenience and expensive downtime, potentially destroying a multi-million pound tomato crop, and causing us financial penalties through loss of export revenue."

To avoid these disasters, British Sugar recently introduced a new boiler house standard that required all 400 of its operationally critical and safety instruments to be calibrated every year. These devices include a mix of temperature, pressure, flow, pH and conductivity transmitters, as well as associated pressure gauges and switches. Unfortunately, completing all these calibrations didn't look like it was going to be possible in the plant's 10-day window.

To reduce the time required for each calibration, Wolfe and his team adopted a MC5 multifunction calibrator and CMX calibration software from Beamex. This allowed them to perform more calibrations in the field, instead of taking instruments back to their workshop for calibration, and also minimized the risk of impulse line leaks. They also created a CMX calibration database that further reduced calibration time. The plant's instrument technicians also adopted the concept of combining a loop test with each calibration by working in pairs via radio.

"Less time is wasted with technicians returning to the shop to swap equipment because MC5 can carry out most calibrations with just the one calibrator" explains Wolfe. "Being able to download multiple jobs to MC5 also means a day's worth of calibrations can be given out at the start of a shift, so the instrument technicians can plan their day better. Using the Beamex setup helped us successfully halve the time needed to complete outage calibrations, and enabled us to comply with company standards without increasing labor costs."

Wolfe adds his team's solution has also been rolled out to the Wissington plant's bio-ethanol application, and CMX software is being used to automatically transfer work orders and other data to British Sugar's CMMS system. Their solution is also in the process of being implemented at the other British Sugar plants.

Diffusing Downtime

Schlegel adds that Cabot's improved calibration methods have also helped it minimize downtime. "We had a situation not long ago where the Fluke 381 amp meter helped us find a persistent intermittent problem that really had us theorizing," adds Schlegel. "One of our palletizer machines kept tripping out every three or four hours. We'd shut it down and take some ohm readings using the 87 DMM, but nothing showed up. So we reset the machine, and the main circuit breaker (MCB) would trip again later.

"Thinking that inrush current was probably the problem, we attached the 381 clamp meter to our MCB, closed the cabinet and moved away from the machine with the remote display. Then we ran the machine until it tripped and saw on the display that constant current wasn't the problem—it was the inrush current from a chattering master contactor. With the help of the 381's min/max feature to help identify a continual inrush current, it turned out that the problem was a loose connection on one of the terminals to the coil of the contactor. The contactor energized the hydraulic pump circuit, which helped us rule out the pump's solenoid circuitry. Without the 381, we wouldn't have been able to rule out the other possibilities so quickly because we were able to troubleshoot the machine with the main enclosure door closed, and not have to suit up in our category-rated electrical PPE gear."

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