InTech FOCUS

An *InTech* ebook covering the fundamentals of automation

MAY 2022

Temperature & Pressure

Temperature Instruments Improve Operations

Instrumentation Best Practices

Sensor Integrity Ensures Temperature Measurement Accuracy

Streamlining Pressure Calibration

Introduction

Temperature, pressure, and measurements from process control instrumentation are key components for industrial asset health management and digital transformation. Determining why production unexpectedly stops mid-operation—or preemptively avoiding these stoppages—requires diagnostic data that can only come from the machines. Gathering that data has been a mainstay of industrial operations for a long time. Viewing, analyzing, and applying the lessons of that data either to maintenance or real-time operations is the ongoing challenge.

Experienced personnel who understand measurement instrumentation—its potential as well as the limits—can help temper expectations and ensure that digital transformation efforts are a success. Find out more in this edition of *InTech FOCUS* centered on temperature and pressure measurement.

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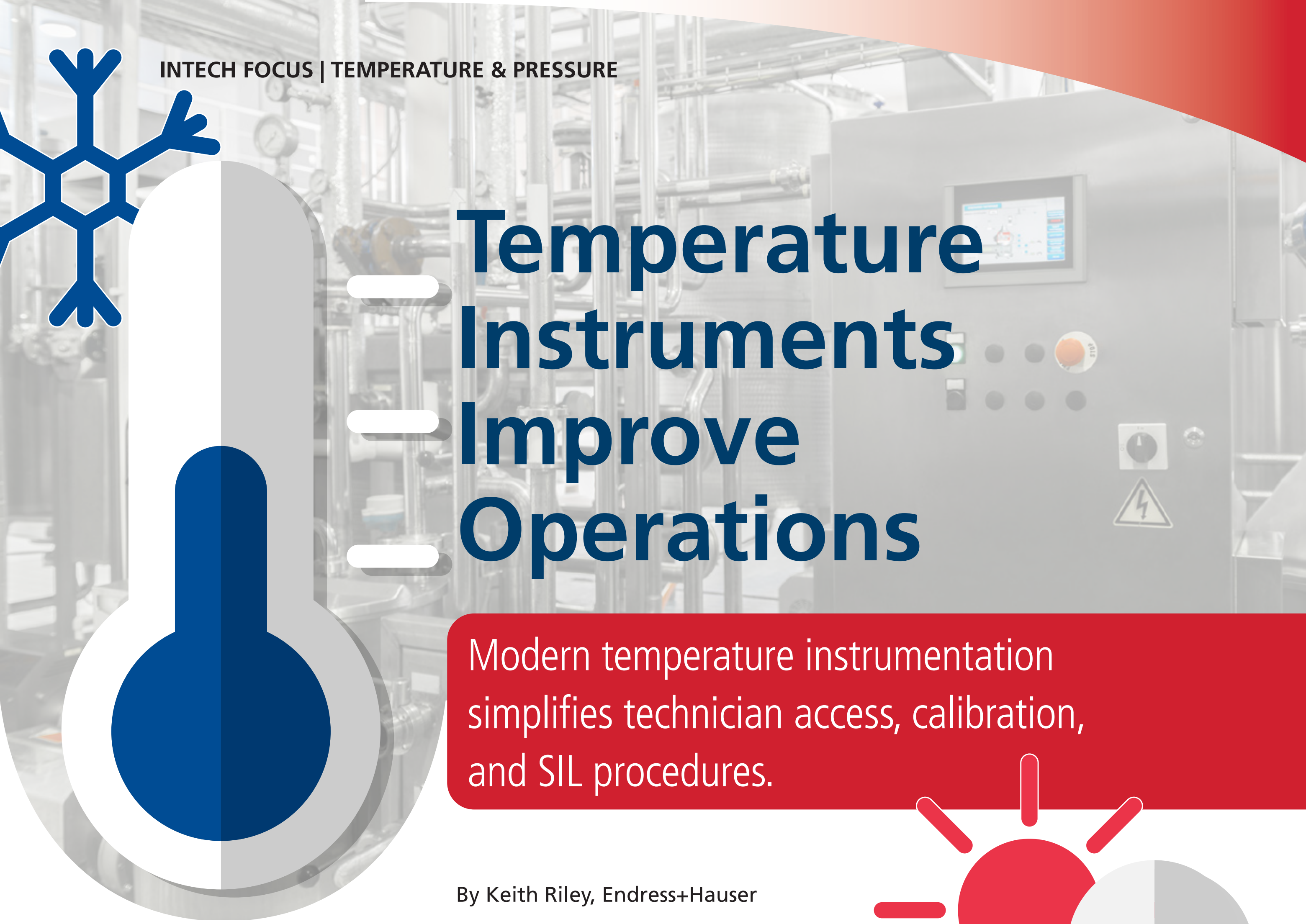
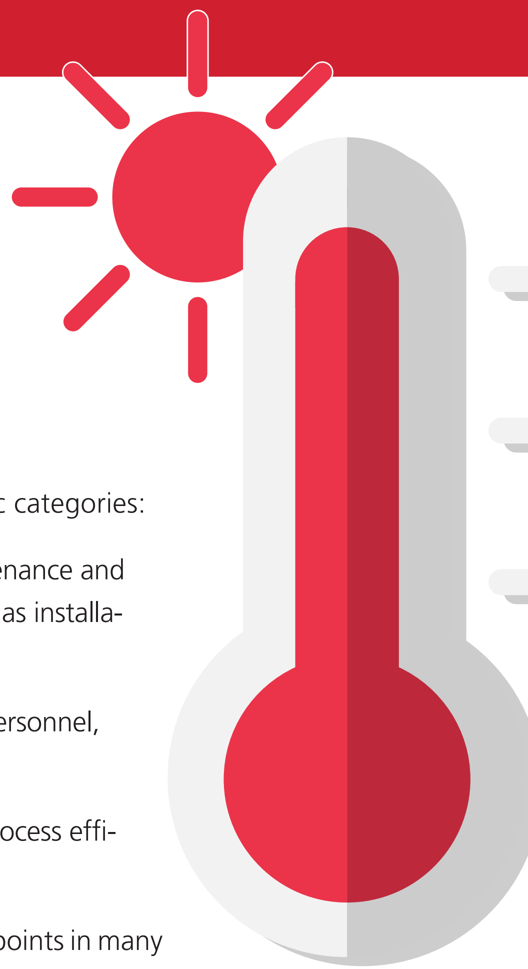


Temperature Instruments Improve Operations

Modern temperature instrumentation simplifies technician access, calibration, and SIL procedures.



By Keith Riley, Endress+Hauser

As temperature instrument technology has matured, there is less focus on the actual measured value and more on added value. Accuracy and stability are considered basic thresholds, and what process owners really want to know is how a temperature instrument can further improve the overall process.

For most process owners, added value falls into one of three basic categories:

1. **Simplicity.** For plants faced with continued attrition of onsite maintenance and service support, can the instrument assist with simplifying tasks such as installation, commissioning, calibration, and troubleshooting?
2. **Safety and risk reduction.** Will the instrument reduce the risk to personnel, property, or the process?
3. **Productivity and profitability.** How can the instrument improve process efficiency, reduce labor cost, and increase profitability?

Temperature, arguably the technology with the most measurement points in many process plants and facilities, presents a huge benefit potential in all three categories.

Simple access

The most time-consuming activities associated with any temperature instrument are commissioning, calibration, and service. Technicians on the plant floor need to access data in the instrument, such as status and diagnostic messages, to perform these services.

Most temperature instruments support a standard 4-20 mA HART communication protocol. While robust and well accepted, this two-way form of communication also requires specialized tools, such as a HART modem, software, and the correct device type manager (DTM) and device driver (DD), depending on the interface device employed. The technician goes to the instrument, plugs in the interface device, and performs the required maintenance tasks. The advent of wireless access to temperature transmitters changes all this. Many instrument vendors now offer Wi-Fi, WirelessHART, and Bluetooth connections to temperature transmitters.

For example, all a technician needs to interface with a Bluetooth-capable instrument is a smart device, such as a handheld computer, smartphone, or tablet, and the corresponding app. The technician can communicate securely with the device from distances of up to 40 feet away (figure 1). A technician can see the output of the device, as well as perform all the same commissioning and diagnostic functions normally associated with a HART modem and DTM.

The ability to access a temperature instrument from a distance means that the technician doesn't need to climb scaffolding or ladders to reach instruments installed on tops of tanks or in otherwise inaccessible locations. This increases technician safety and reduces the amount of time needed to perform maintenance tasks.

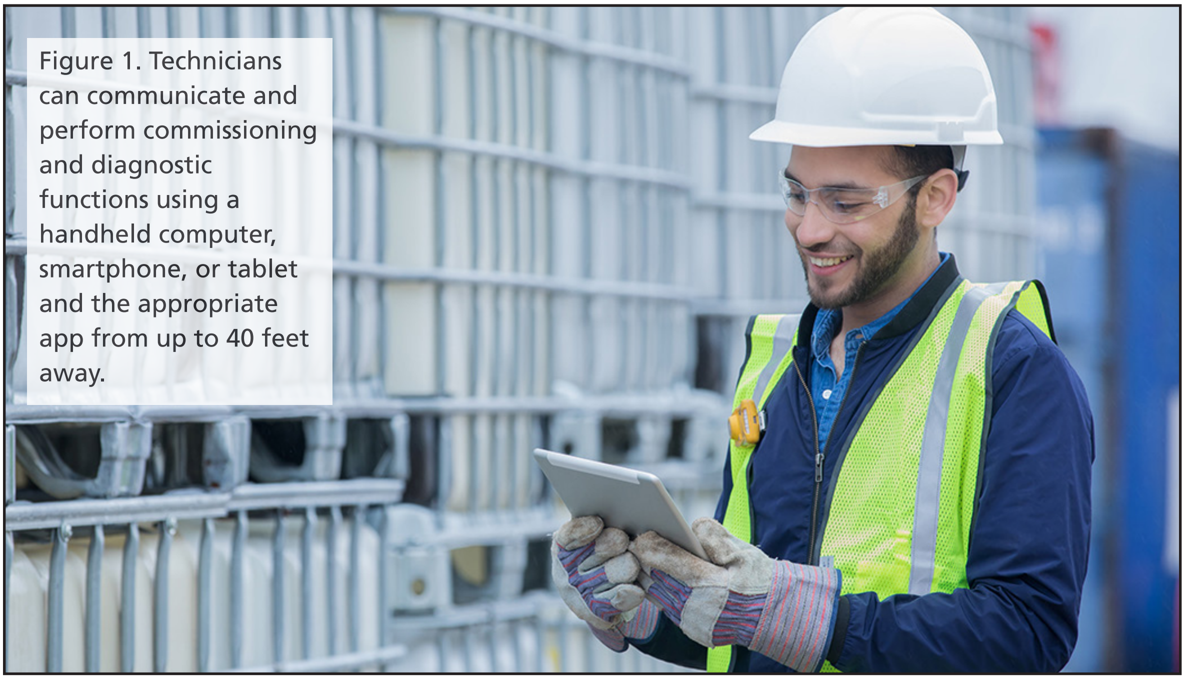


Figure 1. Technicians can communicate and perform commissioning and diagnostic functions using a handheld computer, smartphone, or tablet and the appropriate app from up to 40 feet away.

Calibration and diagnostics

In certain critical temperature measurements, temperature instrument calibration can be required every six to 12 months. Calibration is necessary to detect measurement drift and to permit adjustment or replacement of the instrument. The exact timing of calibrations is determined via a risk/cost analysis. A more frequent calibration cycle reduces risk to the facility but, conversely, increases cost.

Figure 2. Some resistance temperature detectors (RTDs) automatically perform an in-situ calibration once a predetermined set of conditions are met.

Some resistance temperature detectors (RTDs) (figure 2) automatically perform an in-situ calibration once a predetermined set of conditions is met. This occurs with no interruption in the process or measurement signal. The two conditions required are a process temperature that has met or exceeded 253 degrees F (123 degrees C) followed by a controlled cooling cycle to below 244 degrees F (118 degrees C). This most commonly occurs during a steam-in-place sterilization or some other type of aseptic process.

Once these conditions are met, the RTD's integrated transmitter automatically compares the measured value against an embedded traceable reference. Any deviation is identified, and if it exceeds the customer-specified tolerance, a notification occurs. The safety or metrology department can then determine if adjustment or replacement of the existing RTD is needed.

This in-situ calibration eliminates the need to periodically remove the instrument's sensor from the process, take it to a calibration lab, and reinstall it, thus saving time and money. Due to the popularity of this feature, instrument vendors are looking to develop additional temperature thresholds. Temperature sensors and transmitters also are becoming available with advanced diagnostics to simplify the job of maintenance technicians. Some temperature transmitters (figure 3), for example, have a two-channel function that detects drift between sensor 1 and sensor 2, detects a broken sensor, detects corrosion on the sensors, and provides automatic sensor backup if one sensor fails.

Figure 3. Some temperature transmitters have a two-channel function that can detect drift between sensor 1 and sensor 2, a broken sensor, and corrosion on the sensors, as well as provide automatic sensor backup if one sensor fails.

When the temperature transmitter detects a problem, it sends a standard NAMUR NE017 diagnostic message to the control system via its 4-20 mA HART, Profibus, or Foundation Fieldbus interface. When the maintenance technician accesses the temperature transmitter from a tablet or computer, all diagnostic messages and data are available.

Safety and risk reduction

Temperature is a critical measurement in a safety instrumented system (SIS). As parity among instrument vendors regarding safety integrity level (SIL) certification has been achieved, the more significant risk is human error associated with commissioning and proof testing.

The typical commissioning of a SIL-rated device in a SIS involves setting the SIL relevant parameters (SRPs) in conjunction with an instrument-specific SIL checklist developed by the safety engineer. Since a technician may need to enter six to eight values, there is ample opportunity for errors due to inexperience or interruptions. Also, during proof testing, the correct instrument-specific SIL checklist must be located, and then each of the SRPs must be confirmed.

New SIL-capable temperature transmitters have eliminated much of the risk inherent with this process. Transmitters designated as SIL capable (figure 4) are factory programmed with SRPs. While field customization is still possible, the amount of human interaction and setting adjustments is minimized. These same transmitters can produce and store the SIL checklist. Upgraded DTMs permit the safety engineer to access this information directly from the transmitter and print a PDF on demand, reducing lost or duplicated paperwork. Checksum is a unique numeric code generated by the transmitter based on which SRPs are used.

Figure 4. Transmitters designated as SIL capable are factory programmed with SRPs.

During a proof test cycle, a manual review of the six to eight SRPs is required. But a simple comparison of the current checksum value currently stored in the instrument against the last stored SIL checklist will confirm if any SRPs have been altered. If the checksum numbers match, no changes have occurred, and the technician can safely and efficiently proceed with the balance of the proof test. A 96 percent proof test coverage can typically be performed in approximately 10 minutes with a SIL-capable instrument, compared to 20 to 30 minutes for instruments without this capability. It will vary depending on the experience and efficiency of the technician.

Productivity and profitability

Temperature instruments need to be calibrated, which can be a time-consuming procedure that might require the process to be shut down, thus adversely affecting productivity. In most cases, calibration requires the following sequence:

- Disconnect the loop wiring.
- Remove the sensor/transmitter.
- Transport the sensor to a calibration lab.
- Reconnect loop wiring in the calibration lab.
- Insert the sensor into the reference for calibration.
- Reverse the steps to place the sensor/transmitter back in service.

Typically, this process takes a minimum of 30 minutes per instrument and adds additional risk to the process, including damage to wiring from connecting and disconnecting the leads, possible damage to the RTD or thermocouple (T/C) sensor when it's transported to and from a calibration lab, and the possibility of miswiring the leads during reconnection.

A quick disconnect feature (figure 5) can reduce calibration and downtime by two-thirds while reducing risk by eliminating the need to remove leads from the transmitter. This also makes it much more practical to perform calibration at the measurement point using a mobile reference. The time saved with easier instrument access (i.e., no scaffolding or ladders involved in reaching instrumentation) combined with time savings from self-calibrating sensors, SIL-capable transmitters, and quick-disconnect sensors can add up to considerable labor savings. In a plant with 1,000 or more temperature instruments, the labor savings can amount to several hundred thousand dollars per year, with additional savings achieved by reducing risk and increasing uptime.

Figure 5. A quick disconnect feature can reduce calibration and downtime while reducing risk by eliminating the need to remove leads from the transmitter.

Achieving savings

While it seems a monumental task to upgrade a plant with 1,000 or more temperature instruments, such a project may not be as big as it appears, due to the following factors:

- Any temperature instruments that have been replaced in the past few years may already have some or all of the necessary technical capabilities built in. Just because a plant isn't using all of the advantages of a SIL-capable instrument or Bluetooth communications doesn't mean the features aren't there.
- Instrument vendors have been preparing for remote access for quite a while. One of the biggest steps has been installing barcodes, QR codes, RFID labels, or other identification on instruments so a technician can identify them remotely.
- Instrument vendors have been aware of commissioning, calibration, and SIL testing problems for years, and have been developing devices, software, and technology to deal with these and other issues.
- All of the data needed to integrate a temperature instrument into a new commissioning and calibration program, such as DDs, DTMs, and SRPs, should be available on each instrument vendor's website.
- Even if a plant has temperature instruments from multiple vendors, this doesn't pose a problem for modern software tools. For example, a particular tablet PC tool (figure 1) has more than 2,700 pre-installed device and communication drivers, allowing it to work with many different instruments from a wide variety of vendors. In addition to this software protocol support, connectivity options include USB, Ethernet, HDMI, Wi-Fi, and Bluetooth, allowing local or remote connection to most instruments.

The best way to determine the next steps in an upgrade project is to perform a plant-wide installed base analysis of temperature instruments to identify what's installed, check to see if the installed instruments have the appropriate technology, and determine what needs to be done. Any major instrument vendor can assist with this type of project.

All images courtesy of Endress+Hauser.

ABOUT THE AUTHOR

Keith Riley is the national product manager for level and pressure at Endress+Hauser USA. He has been with the company since April 2008. Prior to this, he was a product manager and regional sales manager with L.J. Star Inc., as well as a product manager for Penberthy (Tyco Valves). He has more than 20 years of sales, marketing, and instrumentation experience in the process industries.

Pressure and Temperature Instrumentation Best Practices

These fundamental steps help extract data and additional value from pressure and temperature instrumentation.

By Nicholas Meyer, Yokogawa Corporation of America

When examining facilities and processes, users often see many opportunities for improved operation and efficiencies. They also might wonder how to better prepare their process for the next level of performance the future will inevitably require.

Fortunately, many locations are better prepared than they realize to seize opportunities for improvement and that the task of future proofing is already done. The information many locations need could be hiding in plain sight. Stranded instrumentation data sits waiting to be used, connections among systems need waking up, and data connectivity and analysis tools reside within reach or are simple to add.

Data is closer than you think

Begin by looking at temperature and pressure instruments for data that could lead to efficiencies and savings. For example, some advanced temperature transmitters (figure 1) provide additional information apart from the process temperature variables. They contribute diagnostic alerts that can be included in an ecosystem of insight, providing immediate benefit as they alert maintenance teams if the device, the sensor, or even the process needs attention.

In addition, a particular advanced digital sensor offers more than a single process measurement. The sensor simultaneously measures pressure and differential pressure, both of which can be accessed if one looks beyond the limiting factor of the 4-20 mA signal. The sensor data is abundant enough for algorithms or artificial intelligence (AI) to detect adverse process conditions such as pump cavitation or plugged impulse lines.

Figure 1. Some advanced pressure transmitters (figure 1) provide additional information apart from the process variables.

Data also can be found in devices that have been untouched for a while. Some field instruments are so reliable that they become "set and forget." In some cases, that is the most economical solution, but realize that such an approach could leave value on the table. These forgotten devices may be the superstars of digital transformation efforts.

After reviewing the data the current devices provide, think about how that data can be best used. When eventually adding instrumentation, first consider how robust and reliable the devices are so they continue to give value for a long time. It is also imperative to measure their sophistication—the data they gather—so information continues to be harvested for future opportunities.

Tap into stranded data

Tapping into data collected by devices is important to the goal of process improvements. Standards such as HART communications and FDT technology can simplify the job.

Communication standards.

Communication protocols enable device interoperability, which means an array of devices from multiple suppliers can be used in a single facility often without the added expense of translating that data for each system using it. To help future-proof installations, look for devices that communicate using an open standard protocol (figure 2). It is acceptable to have more than one standard in a given facility because many tools support multiple protocols. However, using too many different standards will place a greater burden on instrument and maintenance technicians.

Methods or mechanics.

The mechanics required to tap into data range from straightforward to complex. Once the data is unlocked, the information can deliver benefits throughout the organization. Accessing stranded data is linked to one of three primary methods:

1. **Native:** When native communications are used, a simple license or software checkbox in the control system or data collector can begin the process of gathering information from field instruments. Though some system vendors charge an additional software license fee, this is usually trivial next to the simplicity of accessing the data.

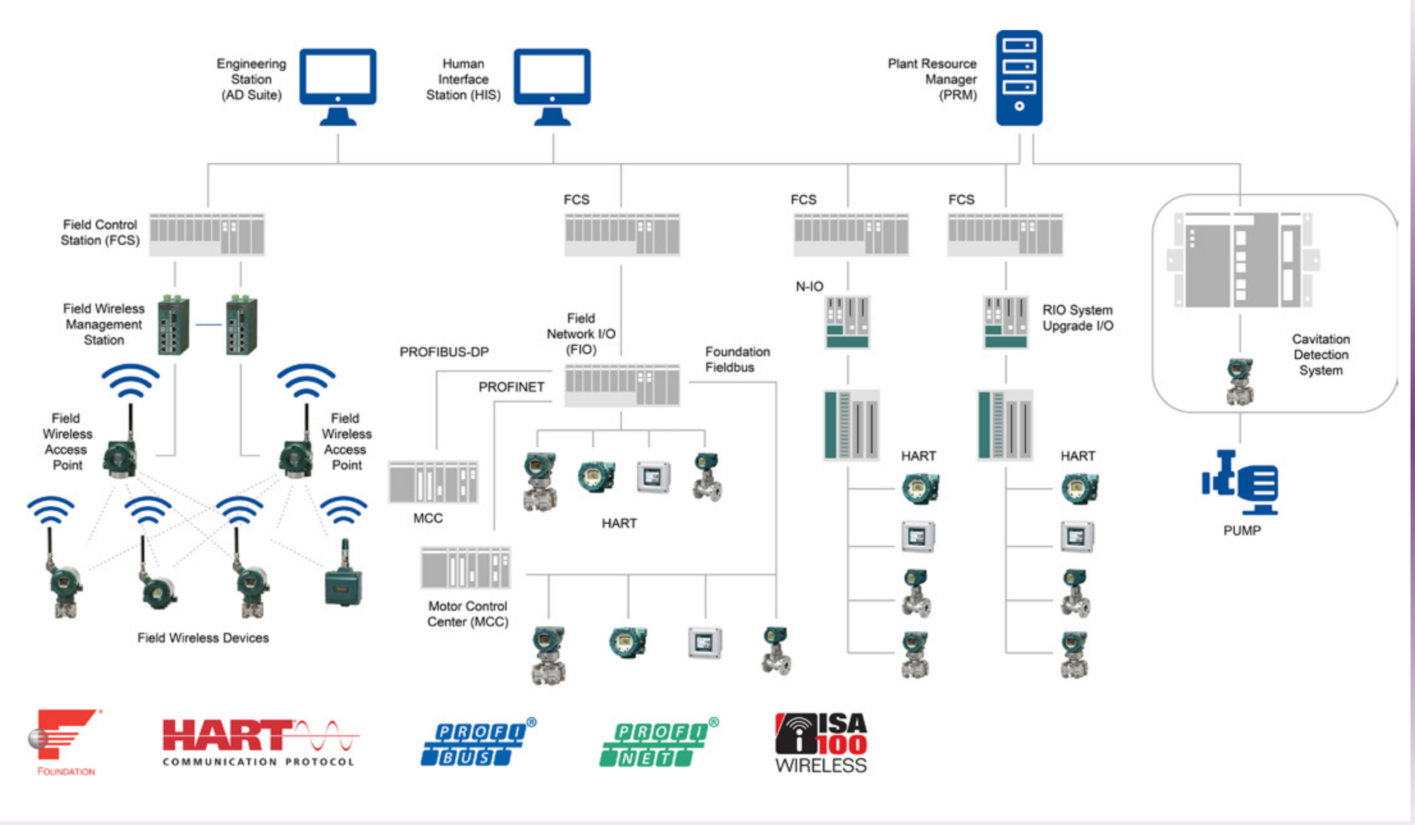


Figure 2. Communication standards simplify device data integration.

2. **Software:** Data sharing sometimes requires users to add a software plugin to the system. These may be provided by the automation supplier or developed by a third-party software company. Older systems may require a custom solution, while newer systems rely more on standard protocols. FDT technology, for example, is an open standard for the integration of industrial automation networks and devices. Device suppliers provide a device type manager (DTM), which functions as a device driver to interpret information from the device.

3. **Hardware:** The third way to access data involves incorporating hardware such as gateways, multiplexers, or other edge devices. While the additional hardware and maintenance cost more, there are increased benefits to this approach. Dedicated hardware channels may provide faster communications than a native host system channel, which must prioritize control and safety data over asset performance and health.

Standard reduces data overload.

Once the gates have been opened, a wealth of information is made available. Sometimes the amount of existing data can be overwhelming. Look to NAMUR NE107 for assistance. NE107 is a way to structure data into categories based on severity and simplify how data is delivered (figure 3). NE107 helps users better understand an issue's severity and helps users prepare appropriate responses.

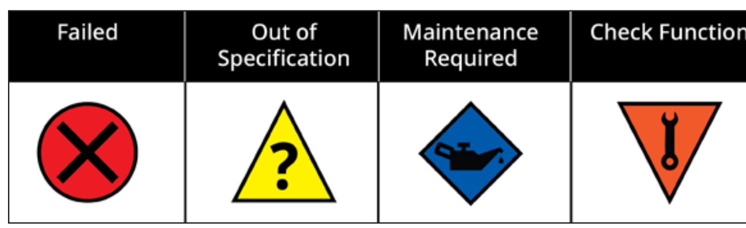


Figure 3. Four categories from NE107 that simplify data organization.

An asset management system will be able to display alarms in the appropriate category, enabling technicians to recognize the severity of device alerts and take the necessary corrective actions.

Due to innovations, many pressure and temperature devices—some possibly already in place—sort the data into NE107 categories: check function, maintenance required, out of spec, and failure. When used correctly, this information can improve operations and maintenance by helping technicians prioritize troubleshooting and repair work.

Put data to work

Once the data and the connections are set, plans can be created to put everything to work. Consider the facility's improvement goals and what data could move the team toward them. For example, digital diagnostics helps technicians troubleshoot existing issues. Predictive warnings provide early indications of impending failures so maintenance can be planned before excess loss is realized. This type of data can reduce maintenance costs while improving plant availability and safety.

As data is being put into action, additional instrumentation and maintenance insights can help teams move from preventive to predictive maintenance. This means that device alerts will automatically report when a device needs attention. Technicians will no longer need to be sent out on monthly routes just to check device health.

For example, to promote continued reliable process operation and accuracy, users of certain advanced temperature sensors can set threshold and frequency limits to trigger an alarm status. This alarm can be used to estimate the remaining life of the sensor, allowing users to plan when maintenance would be most effective.

"These forgotten devices may be the superstars of digital transformation efforts."

If using certain advanced multivariable sensors, users can put data to work in detecting line blockages. The fluctuations of differential and static pressure, and the capsule and ambient temperature signals are continuously monitored. Statistical calculations and comparison to reference conditions can show impulse line blockage.

Raw data from these devices also is more valuable than ever. In the past, case studies and failure analysis would guide software teams to develop algorithms allowing smart pressure and temperature transmitters to detect a specific issue or failure mode. Now artificial intelligence and machine learning (AI/ML) can replace these specific algorithms and begin detecting a wider range of potential conditions that may affect the process.

Note that users can choose from a wide variety of tools, from basic to high-end, that can help gather and analyze data. Open, enterprise level asset management software for both automation and production assets can contribute to improving the quality of maintenance plans and optimizing maintenance costs throughout the plant lifecycle.

Imagine the changes, plan the route

As users discover the data and tools they already have—or make a few adjustments to obtain—they must think about the opportunities that await. As they plan their actions, they must look for robust instrumentation and tools that deliver performance today and continue to perform well into the future. Data is only accessible from a device that continues to operate reliably and communicates with the right protocols.

All images courtesy of Yokogawa Corporation of America.

ABOUT THE AUTHOR

Nicholas Meyer is the chemical industry marketing manager at Yokogawa Corporation of America with 20 years of process industry experience, including applications engineering, product line management, marketing, and product development. He holds a degree in Chemical Engineering from the University of Minnesota.

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Sensor Integrity Ensures Temperature Measurement Accuracy

Whether measuring or controlling temperature, it begins with the sensor. Better sensors make better process measurements.

By Gary Prentice, Moore Industries

Although not every temperature application is a high-accuracy mea¬surement, best practices can be applied to eliminate sensor drift at the start of an installation. This helps users achieve optimal results while avoiding downtime or troubleshooting that might result from future drift during operation.

Several factors influence temperature system accuracy: individual sensor accuracy, extension wire, and measuring devices. When embarking on a project involving temperature measurement or control, consider these basic rules of thumb:

- The same techniques used to achieve accuracy also result in curbing measure¬ment drift.
- Specifying the appropriate sensor will keep drift to a minimum.
- Selecting the appropriate transmitter will keep drift from occurring.
- Using 4-wire RTDs will eliminate the possibility of measurement drift. (Even if using direct-wired 3-wire RTDs, solutions exist to minimize lead wire drift.)

- Reduction in drift means fewer calibrations/verifications, which translates to lowered operating expense.
- Thermocouple extension wire decays over time, causing measurement error, in the form of drift, and requiring replacement.
- Many of the considerations above have trivial impact on the initial purchase price and offer very significant impact on cost of ownership.

The most common temperature sensors acceptable for temperature measurement and control include thermocouples, resistance temperature detectors (RTDs), thermistors, and semiconductor-based sensors. Only T/Cs, RTDs, and remote input/output (I/O) are discussed here.

Thermocouples

Thermocouples (T/Cs) are the most common temperature measurement sensors used in the U.S. for process control. T/C use is a proven technology in industry. They are rugged, relatively inexpensive, and easy to use.

When metals of different composition come into contact, they form a junction that produces a voltage in the millivolt range. If the temperature to which this junction of dissimilar metals is exposed changes, there will be a corresponding change in the millivoltage produced by the junction.

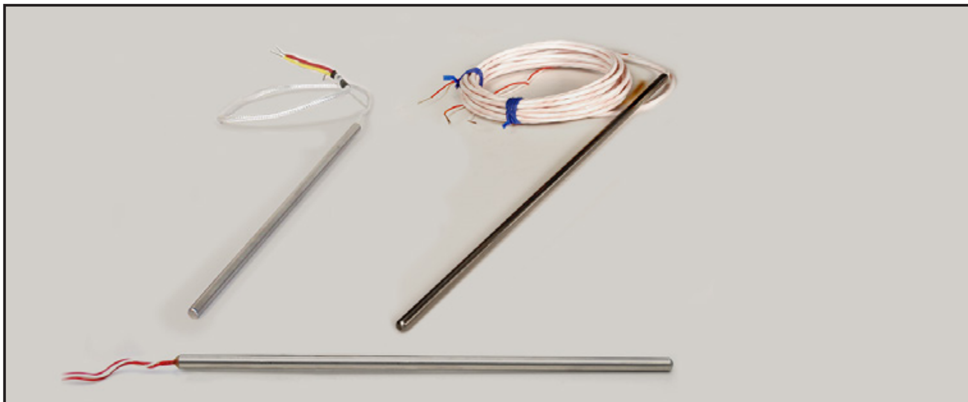


Figure 1. Solid sheath RTD or thermocouple temperature sensors.

Thermocouple types

Theoretically, any two different types of conductive material could be used to make a thermocouple. However, only a few combinations are used. The criteria for the material combinations chosen for use in thermocouples include the magnitude of their relative Seebeck coefficient, chemical stability, metallurgical stability, strength, ductility, and cost.

There are eight standard thermocouple types established in the U.S. The American National Standards Institute (ANSI) assigned letter designations to these eight types: T, J, K, E, N, S, R, and B (Table 1). The designations are based on the voltage versus temperature relationship for these thermocouples. The designations are not based on their compositions. T/Cs built to the ASTM E230 standard are more accurate. The ASTM E320 standard governs thermocouple accuracy.

Type	Composition	Color Code (U.S. only)	Polarity	Magnetic?	Temperature Range
T	Copper	Blue	+	No	-270°C to 400°C (-454°F to 752°F)
	Constantan	Red	-	No	
J	Iron	White	+	Yes	-210°C to 1,200°C (-346°F to 2,192°F)
	Constantan	Red	-	No	
K	Chromel	Yellow	+	No	-270°C to 1,372°C (-454°F to 2,500°F)
	Alumel	Red	-	Yes	
E	Chromel	Violet	+	No	-270°C to 1,000°C (-454°F to 1,832°F)
	Constantan	Red	-	No	
N	Nicrosil	Orange	+	No	-270°C to 1,300°C (-454°F to 2,372°F)
	Nisil	Red	-	No	
S	Platinum-rhodium (90%-10%)	Black	+	No	-50°C to 1,768°C (-58°F to 3,214°F)
	Platinum	Red	-	No	
R	Platinum-rhodium (87%-13%)	Black	+	No	-50°C to 1,768°C (-58°F to 3,214°F)
	Platinum	Red	-	No	
B	Platinum-rhodium (70%-30%)	Gray	+	No	0°C to 1,820 °C (32°F to 3,308°F)
	Platinum-rhodium (94%-6%)	Red	-	No	

Table 1. ANSI standard thermocouple types along with their compositions, color coding, polarity, magnetic properties, and temperature ranges.

T/C sensor accuracy

Thermocouple sensors built to the ASTM E230 standard are more accurate. The ASTM E320 standard governs thermocouple accuracy, as shown below in Table 2.

Sensor	Accuracy spec, greater of:	149°C/300°F	316°C/600°F	482°C/900°F	649°C/1,200°F
Type E	0°C to 870°C: ±1.7°C or ±0.005 * | t |	±1.7°C/3.0°F	±1.7°C/3.0°F	± 2.4°C/4.3°F	± 3.2°C/5.8°F
Type J	0°C to 760°C: ±2.2°C or ±0.0075 * | t |	± 2.2°C/4.0°F	± 2.4°C/4.3°F	± 3.6°C/6.5°F	± 4.9°C/8.8°F
Type K	0°C to 1260°C: ±2.2°C or ±0.0075 * | t |	± 2.2°C/4.0°F	± 2.4°C/4.3°F	± 3.6°C/6.5°F	± 4.9°C/8.8°F
Type T	0°C to 370°C: ±1.0°C or ±0.0075 * | t |	± 1.1°C/2.0°F	± 2.4°C/4.3°F		

Table 2. Temperature sensor accuracy.

Premium/special grade thermocouple wire

Thermocouples can be constructed with premium- or special-grade wire that cuts uncertainty in half. The premium/special designation indi¬cates that this wire has a higher purity alloy mix. Even with premium/special grade T/C, Moore Industries recommends using RTDs instead of T/Cs whenever possible, as their accuracy, repeatability, and stability are superior to those of T/Cs.

Sensor special tolerance	Accuracy spec, greater of:	482°C/900°F
Type E	0°C to 870°C: ±1.0°C or ±0.004 * | t |	± 1.9°C/3.5°F
Type J	0°C to 760°C: ±1.1°C or ±0.004 * | t |	± 1.9°C/3.5°F
Type K	0°C to 1260°C: ±1.1°C or ±0.004 * | t |	± 1.9°C/3.5°F
Type T	0°C to 370°C: ±0.5°C or ±0.004 * | t |	

Table 3. Uncertainty is cut in half by using premium-grade sensors.

In comparing the accuracy data between Table 3 and Table 2, notice that the uncertainty is cut in half by using premium-grade sensors. If T/Cs must be used, premium grade offers greater stability at a negligible cost difference. The problem consistently seen in thermocouples is wire contami¬nation. As contamination occurs, error gradually increases to a point necessitating sensor replacement.

T/C extension wire characteristics

Anytime T/C extension wire is connected to a T/C, it introduces more un¬certainty to the measurement (Table 4). If T/C extension wire will be exposed to temperatures outside the specified ranges, consider using actual thermocouple wire instead.

Extension wire	Temperature range	Standard error
EX	0 to 200°C, 32 to 400°F	±1.7°C/±3.0°F
JX	0 to 200°C, 32 to 400°F	±2.2°C/±4.0°F
KX	0 to 200°C, 32 to 400°F	±2.2°C/±4.0°F
TX	-60 to 100°C, -75 to 200°F	±1.0°C/±1.8°F

Table 4. When T/C extension wire is connected to a T/C, it introduces uncertainty into the measurement.

In addition to uncertainty, T/C extension wire is susceptible to radio-frequency interference (RFI) and electromagnetic interference (EMI). Extension wire for J and K thermocouple types adds another ±2.2°C (±4.0°F) uncertainty when wire is clean and uncontaminated. Also, T/C extension wire tends to behave as an antenna for RFI and EMI. Use best practices to keep disruptive noise out of these low-level mV signals. T/C extension wire will degrade to the point of replacement; replacing it with more extension wire perpetuates the T/C extension wire replacement loop. However, premium-grade T/C extension wire cuts the potential error in half and should be selected.

If extension wire is stressed by being exposed to temperatures outside the limits shown in Table 3, uncertainty will grow. Premium-grade extension wire still allows the possibility of error once metals become contaminated by airborne influences. It is recommended that T/C extension wire be eliminated as close to the T/C as possible by installing either temperature transmitters or remote I/O.

Options for eliminating T/C extension wire

Options exist that allow the elimination of T/C extension wire, thereby taking a step in ensuring reliable measurements. Among the options are temperature trans¬mitters, which can pose cost considerations, and remote I/O.

Temperature transmitters, remote I/O, and temperature concentrator modules eliminate expensive T/C and RTD extension wire and other point-to-point wires by sending temperature measurements, process monitoring, and control signals between the field and control room on one digital communication link. Related technologies, such as temperature concentrator modules (TCMs) and temperature transmitter/signal converters, have programmable inputs configurable for RTD, T/C, Ohms, mV or potentiometer, and current or voltage, depending on the specific module type. Outputs would often support HART, PROFIBUS PA, FOUNDATION Fieldbus, MODBUS RTU, etc.

Typical characteristics of state-of-the-art remote I/O include:

- Minimum hazardous area certification of Class 1, Div. 2/Zone 2
- Ambient temperature specs -40 to 85°C (-40 to 185°F)
- Each input configured, calibrated, and custom-trimmed individually, as with temperature transmitters
- A 20-bit input resolution and input accuracy equivalent to that of temperature transmitters
- 500 Vrms isolation in all directions
- Sensor and I/O diagnostics
- Serial, Ethernet, or wireless communication capability supporting open protocols such as MODBUS RTU, MODBUS/TCP, PROFINET, and EtherNet IP

Figure 2: Complete temperature assemblies using the WORM flexible sensor and an infinite combination of materials and components.

Resistance temperature detectors

RTD wire is a pure material, typically platinum, nickel, or copper. The material has an accurate resistance/temperature relationship, which is used to provide an indication of temperature. RTD elements are normally housed in stainless steel protective probes insulated and isolated from protective sheath with magnesium oxide.

Common RTD sensing elements constructed of platinum, copper, or nickel have a repeatable resistance versus temperature relationship (R versus T) and operating temperature range. The R versus T relationship is defined as the amount of resistance change of the sensor per degree of temperature change. The relative change in resistance (temperature coefficient of resistance) varies only slightly over the useful range of the sensor.

Premium- and special-grade RTD sensors

Moore Industries thermally ages all of its RTDs to minimize drift once they get into the field. The RTDs are temperature cycled for 1,000 hours at 0° and 600°C, and will maintain accuracy for more than five years. Typically, only Class A sensors are thermally aged. Just as it is recommended that you use premium-grade T/C wire for thermo¬couple measurements, it is also suggested that you upgrade to Class A RTD sensors, which cuts uncertainty in half.

Sensor trimming for high accuracy

When a particular application demands the highest accuracy possible, Moore recommends ordering a temperature measurement system with bath calibration. A Class A RTD sensor is calibrated in a bath to calibrate it to the transmitter or remote I/O measuring device. This process eliminates the final "as-built" offset error that exists in every sensor. You then receive a NIST-traceable calibration report that indicates the combined sensor and temperature transmitter uncertainty, which is typically better than ±0.01°F.

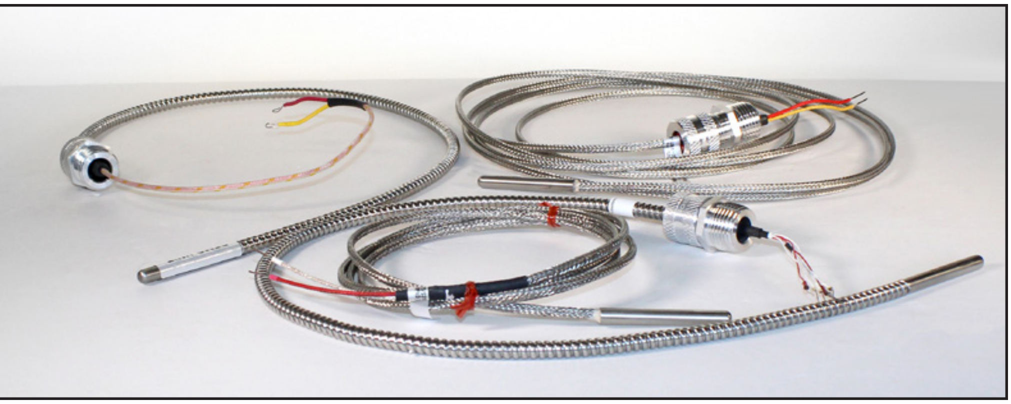
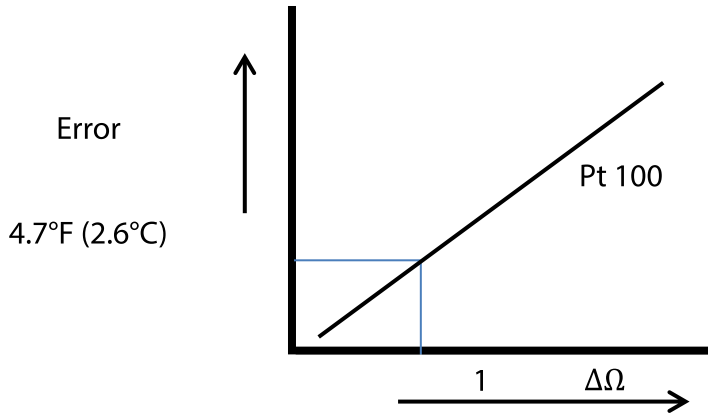


Figure 3. The WORM RTD or thermocouple temperature flexible sensors with flex armor or stainless-steel braid covering the insulating jacket.

Effects of RTD extension wire on accuracy

The 1,000 Ω platinum RTD "secret." If you must stay with 3-wire RTDs and you have long leads back to the DCS, consider replacing 100 Ω Pt RTDs with 1,000 Ω Pt RTDs. When this is done, the error caused by the resistance imbalance in the lead wire is reduced by a factor of 10.



RTD	0°F	300°F	Span	1Ω Error
100 Ω PT	93 Ω	156.9 Ω	63.9 Ω	1.565%
1,000 Ω PT	930 Ω	1,569.0 Ω	639.0 Ω	0.156%

Figure 4. By replacing 100 Ω Pt RTDs with 1,000 Ω Pt RTDs, the error caused by the resistance imbalance in the lead wire is reduced by a factor of 10

Sensor selection summary

To optimize measurement performance and minimize long-term maintenance expenses, use the following guide for sensor selection:

- Use an RTD when measuring in ranges between -40°C and 850°C (-40°F and 1562°F).
- For temperatures as low as -200°C (-328°F), use a wire-wound RTD.
- Best practice is to use 4-wire and Class A RTDs.
- Make sure sensors are temperature cycled and "aged" for long-term stability.
- When applying RTDs below 0°C and above 600°C, know the process conditions to optimize the build: temperature range, cycling, pressure, flow, media, vibration, and surrounding environmental conditions (chemicals/atmosphere).
- When highest accuracy is needed, use sensor trimming.
- If using 3-wire RTDs with long wire runs, and using 4-wire RTDs is not possible, replace the 3-wire RTDs with 1,000 Ω platinum RTDs.

- For temperatures above 850°C (1,562°F), use thermocouples.
- If using thermocouples, use premium-grade thermocouples and extension wire.
- Make sure long thermocouple extension wire is noise protected.
- Replace contaminated T/C extension wire with remote I/O.

Final thoughts

All temperature measurements, whether used for temperature indication or process control, begin with the sensor. Thermocouples and RTDs are the most common temperature sensors used in industrial applications. Temperature transmitters, remote I/O, and temperature concentrator modules eliminate expensive T/C and RTD extension wire and other point-to-point wires by sending temperature measurements, process monitoring, and control signals between the field and control room on a digital communication link.

Refer to Moore Industries Temperature Reference Guidebook for more information.

ABOUT THE AUTHOR

Gary Prentice is vice president of sales at Moore Industries. He manages all of the company's sales activities and responsibilities, including direct sales management of Moore Industries' international offices located in the United Kingdom, Belgium, The Netherlands, China, and Australia.

Streamlining Pressure Calibration for Quality & Productivity

By Bill Lydon, Automation.com

New instrument is introduced to systemize, streamline, and enhance the efficiency of the pressure calibration process.

Pressure measurements are often critical to the quality and efficiency of process control systems. Proper pressure instrument calibration requires the coordination of several factors to ensure precise accuracy. Improving this pressure calibration process can really boost an instrumentation team's productivity and overall production. Fluke has produced a new product that is designed to help these professionals streamline calibration. I sat down with product marketing manager Jim Shields, who walked me through the new Fluke 729 Automatic Pressure Calibrator product.

The four common calibration issues

As a 25-year industry veteran, Shields understands instrumentation and calibration. He described the four most common issues that today's process technicians encounter when performing pressure calibrations.

1. **Slow leaks.** A leaking pressure source makes it difficult to maintain a stable pressure at calibration points long enough to take an accurate reading. Slow leaks can require technicians to constantly finetune and adjust pressure applied from a pump, making it difficult for the system to settle for several seconds or even minutes, the recommended procedure, at the desired pressure setpoint for a more accurate and repeatable test result.

2. **Documenting pressure calibration requires multiple tools.** Documenting pressure calibration results is important to maintain accurate critical instrument records, but the number of steps associated with documenting the procedure, and the number of tools required for the average pressure calibration, can make the task immensely more difficult. For example, a typical pressure calibration could require a pressure calibrator, pressure module, or gauge for measuring pressure, a pump to generate pressure, and multiple hoses and fittings between the devices, including the connections to the pressure transmitter itself.

3. **Manually generating and controlling the pressure for each test point.** Pressure calibrations in process manufacturing environments rarely require testing to occur at a single test point. In fact, a typical pressure calibration can require anywhere from three to 11 pressure test points. Trying to adjust and finetune system pressure for these specific points can be difficult and time-consuming. Each individual point requires technicians to increase or decrease pressure by either pumping the system up or releasing pressure, and then to finetune the pressure using the fine adjust vernier of the test pump. This process can be simplified by spending extra time carefully matching the selected hand pump to the pressure range of the transmitter being tested. For example, some portable pneumatic pumps have pressure ranges that go up to 600 psi (40 bar), but it can be difficult to accurately increase pressure beyond 400 psi (28 bar). There are, however, newer portable pumps that can be pumped and adjusted to more than 1,000 psi (69 bar) if the primary calibration need is more than 400 psi (28 bar).

"A typical pressure calibration can require anywhere from three to 11 pressure test points."

4. **Achieving repeatability when calibrating a pressure switch.** Calibrating a pressure switch can be a time-consuming task. Repeatability is key to success. Achieving repeatability requires the user to apply slow changes in pressure to the switch as it approaches its defined setpoint or reset point. Not only do users need to determine where the switch sets, but they also need to make sure that the vernier or fine adjustment mechanism of the test pump has the capability of varying pressure up to the setpoint and back to the switch reset point. Since these adjustments are manual, achieving repeatable measurements of the set/reset points can be difficult. With practice, technicians can gain the experience to get the fine adjustment of the pump within range of the setpoint and reset point pressure with more regularity. This process can be further simplified by selecting a pump with a wide fine adjustment range, allowing users to more accurately make adjustments to meet measurement requirements.

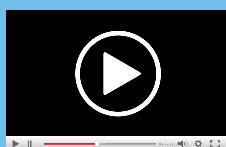
Systematizing pressure calibration

Shields further explained how Fluke has designed the new 729 Automatic Pressure Calibrator (figure 1) to systemize, streamline, and enhance the efficiency of the process based on customer feedback and the company's engineering know-how. The 729 has an internal electric pump that provides automatic pressure generation and regulation in a portable package. The 729 allows users to type in a target pressure, and the calibrator will automatically pump to the desired setpoint. Then, internal fine adjustment control automatically stabilizes the pressure at the requested value. The Fluke 729 also can automatically test multiple pressure test points and document the results. The processor in the 729 makes it an automatic test instrument based on the defined procedure. Built-in HART communication capabilities enable HART transmitter mA adjustments, light HART configuration, and the ability to adjust to applied 0 percent and 100 percent values. Calibration management software helps to manage instrumentation records, create scheduled tests, generate reports, and manage calibration data.

Figure 1. Fluke 729 provides a big productivity boost for pressure calibration.

A Tool to Enhance Process Productivity

The integration and simplification of the process using an instrument such as the Fluke 729 Automatic Pressure Calibrator provides the kind of tool that increases productivity and is a prime example of the type of technology that younger professionals can expect to work with in the processes of the future.



https://www.youtube.com/watch?v=KyBN1zcgie0

ABOUT THE AUTHOR

Bill Lydon brings more than 10 years of writing and editing expertise to Automation.com, plus more than 25 years of experience designing and applying technology in the automation and controls industry. Lydon started his career as a designer of computer-based machine tool controls; in other positions, he applied programmable logic controllers (PLCs) and process control technology. In addition to working at various large companies (e.g., Sundstrand, Johnson Controls, and Wago), Lydon served a two-year stint as part of a five-person task group, where he designed controls, automation systems, and software for chiller and boiler plant optimization. He was also a product manager for a multimillion-dollar controls and automation product line and president of an industrial control software company.