White Paper

New Technology Innovations for Industrial Pressure Gauges

EMERSON
Process Management

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Advances in pressure gauge technology provide a number of advantages for use in demanding process plant applications.

Pressure is a key measurement in a host of process applications in industries such as chemical, refining, oil and gas, water/wastewater, power, pharmaceutical, food and beverage, and others. To gain process insight, local measurements of pressure have traditionally been made with bourdon tube pressure gauges (Figure 1-1). Local measurements are often viewed, read and recorded by plant personnel operating and maintaining nearby equipment.

Operation personnel use these manual pressure gauge readings as a critical component to run their plants. Readings are typically used by control room operators to verify correct process operation and make adjustments to optimize processes. Pressure gauges provide needed visibility into processes and equipment, and can be used along with other process measurements to drive peak performance and ensure safe operations. Pressure gauge readings also provide useful information to schedule and perform maintenance, often through manual data entry of readings into asset management systems.

New technologies are changing these traditional gauges by including utilization of digital electronics, new pressure sensing technology, and reduced mechanical components. In this white paper, bourdon tube pressure gauges will be compared to new gauge technology to illustrate the advantages and challenges inherent to each.

Bourdon tube pressure gauge challenges

While data gathered from pressure gauges continues to be critical for industrial facilities, bourdon tube technology presents application challenges in certain circumstances. Process operations with high pressures or pressure spikes, especially prevalent during startups or upsets, can cause havoc with these gauges, in the worst case causing them to leak or burst and possibly create safety issues. As processes become more caustic and harsh, bourdon tube pressure gauges degrade when the process fluids flow into the bourdon tube. With utilization of new piezo-resistive pressure sensor technology, the process can be isolated from direct contact with the sensor utilizing an isolator which curbs the effects of erosion and corrosion on the pressure gauge.

Also with bourdon tubes and other mechanical components in traditional gauges, the metal can fatigue and fail. This can lead to leaks, especially when processes have significant pulsations, as when installed directly downstream of a positive displacement (PD) pump. To combat these process pulsations, liquid-filled pressure gauges are sometimes used to dampen needle movements to reduce wear and

tear. This can reduce overuse of the needle gearing and subsequent premature failure of the needle assemblies, but adds costs. Filling the gauge with liquid can also cause problems as liquids solidify at low ambient temperatures, which can cause the gauge to break. Many installations also address this issue with a remote seal system, adding significant cost.

Figure 1-1. Bourdon Tube Pressure Gauge Application

Bourdon tube pressure gauges have been successfully used for decades, but have some limitations in demanding applications.

Another challenge is that bourdon tube pressure gauges can indicate incorrect readings with no clear indication of malfunction. To verify operation, a technician typically taps the gauge, for example with a wrench, to see if the needle bounces and springs back to an appropriate reading. This shows the gauge needle isn't stuck, but it doesn't provide verification that the gauge is working properly.

Getting the correct pressure reading information is also a challenge with traditional gauges. Many times key readings are gathered on an operator round, and then entered into an asset management or other data storage system manually. This step introduces the possibility of errors such as not transcribing the correct reading, or incorrect data entry into the system due to sloppy handwriting or incorrect keystrokes.

Digital technology addresses issues

Now that we've looked at some of the challenges when using bourdon tube pressure gauges, let's see how the new technologies compare.

Table 1-1. Technology Comparison

Challenges	Bourdon tube gauges	Technology enhancement
Pressure spikes	Limited capability to withstand overpressure spikes (up to 150% of scale)	Piezo-resistive pressure sensor can withstand up to **150 times** scale range and a burst rating up to 11,000 psi (758 bar)
Caustic/harsh processes	Caustic or erosive process enters the bourdon tube or requires a remote seal	Process isolator keeps process from contacting the sensor
Temperature range	Liquid fill gauges have limited ambient temperature capabilities	Piezo-resistive pressure sensors utilize wider temperature fill fluids

Table 1-1. Technology Comparison

Challenges	Bourdon tube gauges	Technology enhancement
Reliable readings	Physical damage of bent pins can show overpressure	Digital electronics and robust sensor can diagnose faults and withstand significant over-pressure plus deliver status indication
Expanded use for data	Gathering data requires manual labor and can introduce errors	Wireless communication can automate data gathering

Pressure spikes from pulsating processes

The piezo-resistive pressure sensor technology used in digital pressure gauges provides a wide range of stable pressure measurement under pulsating and other conditions including gage, absolute, compound and vacuum. Bourdon tube pressure ranges typically have a measurement range of 5 psi (0.34 bar) to 4 kpsi (276 bar) with an overpressure rating of only 125-150% of scale, providing a limited margin. Digital pressure gauges provide an overpressure rating of up to 150 times scale range, and a burst rating of up to 11,000 psi (758 bar). It also protects overpressure damage by limiting needle movement. This higher pressure protection extends the operating range in which pressure gauges can be applied and improves safety. Because the piezo-resistive pressure sensor technology used in digital pressure gauges reduces needle movement, the gauge can better withstand pulsating processes. In addition, since the sensor drives digital components, the gearing that often presents a problem in a bourdon tube gauge is eliminated. The digital gauge technology requires fewer moving mechanical parts and provides a much higher degree of durability and robustness which ensures a longer service life. Digital pressure gauges with piezo-resistive pressure sensor technology eliminate the need for a bourdon tube and remove the risk of tube fatigue which can cause the gauge to break due to process fluctuations. As a result of fewer parts, it is not prone to damage from pulsating processes. Also the piezo-resistive pressure sensor utilizes a process isolator.

Corrosion and erosion

The piezo-resistive pressure sensor technology found in digital pressure gauges allows the use of many different material types to protect from harsh process conditions. Bourdon tube gauges have limited choices for the tube materials which often are not optimal for today's tough processes. Materials for piezo-resistive pressure sensor technology can be robust stainless-steel, or alloy C-276 isolators which can significantly reduce corrosion and protect against harsh process conditions as compared to the bourdon tube technology found in bourdon tube pressure gauges. Dual layers of process isolation can also be provided with digital pressure gauges to protect against corrosive process fluids. This secondary layer of protection will typically prevent caustic process fluids from corroding the process wetted material, and diagnostics will indicate if this secondary protection has been compromised. For extremely caustic environments, a remote seal made from zirconium or other material can be utilized to significantly increase usable gauge life, thus adding a third layer of protection.

Wide temperature ranges

Because they employ a much more sophisticated sensing technology, digital pressure gauges can provide pressure readings over a much wider process temperature range. Bourdon tube pressure gauges with glycerin fill fluid may be rated from 20 to 150 °F (-7 to 65 °C) ambient and 20 to 200 °F (-7 to 93 °C) for the process fluid temperature, with temperatures above and below this level leading to inaccurate readings. Additional options with digital pressure gauges use a broad temperature range silicone or other sensor fill fluid, enabling accurate readings in ambient temperatures from -40 to 185 °F (-40 to 85 °C) , and for process fluid temperatures of -40 to 250 °F (-40 to 121 °C). Remote seal options are available to extend the process fluid temperature range up to 750 °F (400 °C), and a thermal range expander is available to extend the process fluid temperature range up to 1,100 °F (600 °C).

Accurate readings

Built-in diagnostics on digital pressure gauges can provide significant advantages to ensure accurate readings. Digital gauges can be provided with a local status indication, such as an LED indicator which glows green and blinks once per second when operating properly, glows amber to indicate low battery power, and glows red when maintenance is required. When the LED is glowing red, troubleshooting can be performed using a handheld HART® communicator.

One common gauge problem requiring diagnosis and troubleshooting is overpressure. With a bourdon tube pressure gauge, the gauge needle hits the stop pin when it experiences over pressure. If the overpressure is sufficient, the pin will bend the needle. This shows the gauge needs replacement, but isn't evident except upon close visual examination.

A digital pressure gauge uses a robust pressure sensing element to address overpressure issues. The pressure sensor provides significant overpressure protection of up to 150 times scale range, which eliminates many overpressure issues. And in the event of overpressure, the aforementioned LED provides indication of overpressure as the red LED will be on and blinking.

Easier installation

One additional item that may be helpful when ordering gauges is to have items like manifolds pre-assembled. This saves both time and labor by not needing to track down the correct components and then taking time to assemble them. Preassembling the manifold and gauge will deliver a leak-checked assembly for simplified installation and reduced installation time.

Presenting pressure data to plant personnel

*Wireless*HART® technology is available for digital pressure gauges, adding the ability to transmit a wireless communication of the pressure information (Figure 1-2).

Figure 1-2. Wireless Pressure Gauge

Wireless digital pressure gauges address many of the challenges of bourdon tube gauges, and also provide a wireless output of pressure reading.

Like a bourdon tube pressure gauge, a digital wireless pressure gauge measures pressure through a sensing element and displays it on a gauge. But a wireless pressure gauge also converts the sensing element output to a digital pressure reading and transmits this signal wirelessly, eliminating the need for signal wiring. Since it is battery powered, no wiring is needed for power. The wireless pressure gauge provides a number of advantages as explained below.

Summary of new gauge technology

- Gives local status indication to confirm proper operation
- Same gauge is used over a wide range of process pressures
- Can operate accurately over a much wider range of ambient and process fluid temperatures
- Higher overpressure durability
- Higher burst pressure rating for safety
- Requires less maintenance with improved sensor durability
- Remote seal is integral for process isolation for corrosive and erosive processes
- Automated data updates from the field of pressure reading and status via a *Wireless*HART network

The first advantage is the most important, namely the ability to transmit the local pressure reading to control, asset management and other systems via a wireless mesh network. The *Wireless*HART protocol provides reliable data transmission in

harsh process plant conditions. Data is transmitted from each node, such as a wireless pressure gauge, via a mesh network to a wireless Gateway (Figure 1-3).

Figure 1-3. *Wireless*HART Gateway

A single WirelessHART Gateway can collect information from many wireless digital pressure gauges and other WirelessHART instruments. The Gateway is hardwired into the control and monitoring system.

*Wireless*HART utilizes the mesh network to provide redundant paths of communication, as each node can receive and retransmit wireless information.

From the Gateway, the information gathered from wireless pressure gauges and other wireless sensors is sent to the plant's control and monitoring systems via hardwired links using industry standard protocols such as Modbus®, OPC or HART-IP™ across electrical connections such as RS-485 or Ethernet. These real-time pressure readings can be displayed to control room operators, allowing them to make better decisions regarding optimizing the process and pinpointing areas where attention is required. Asset management systems use these pressure readings for equipment optimization and predictive maintenance, allowing abnormal conditions to be detected before they cause shutdowns, damage equipment, or present a hazard to personnel. Asset management software can also use this information to monitor pump, compressor and other major equipment efficiency and proactively indicate when maintenance may be required.

When a bourdon tube pressure gauge is used instead of a wireless pressure gauge, all pressure readings must be read and recorded manually. This data must then be manually entered into various systems, which adds to the possibility of error. It also introduces delays because pressure readings could be entered into systems many hours or even days after readings are made, as opposed to within seconds with a wireless pressure gauge. Pressure readings are often stored for further analysis. Comparing pressure readings over long time periods can yield information regarding trends. Comparing pressure to other process information can show relationships and also indicate anomalies. Pervasive Sensing™ applications where information provided by wireless pressure gauges and other sensors identify areas for improved operational efficiencies and maintenance cost reductions, enable companies to leverage the Industrial Internet of things (IIOT) for their operations.

Stringent requirements drive gauge selection

The advantages over traditional bourdon tube options can make digital gauges a better choice in many demanding applications. In many cases, new features for gauges can provide safer installations and significantly more reliable pressure measurements. Continuous and remote visibility of pressure readings is often required during startup and process upsets. This allows control room operators to respond quickly and correctly to the rapidly changing process conditions often experienced during these events (Figure 1-4).

Figure 1-4. Control Room

Wireless digital pressure gauges permit control room personnel to view continuous pressure information, vital to the operation of many process plants.

Bourdon tube pressure gauges are a good choice in many non-demanding applications, but may not suffice when installed in tougher process applications and in harsh environments, particularly when the process media is corrosive or at high temperatures. These gauges can be supplied with a variety of options to handle some of these demands, but this often drives up the cost and even with all options included, bourdon tube pressure gauges are limited.

When reliable pressure measurements are needed in demanding applications, digital pressure gauges are often the wiser choice. This premier gauge provides the ability to give good information, operate safer, and also transmit the pressure reading via wireless communication.

For more information on Rosemount™ Wireless Pressure Gauges, see EmersonProcess.com/Rosemount-Wireless-Pressure-Gauge.

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