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50 YEARS OF PRESSURE MEASUREMENT INNOVATION

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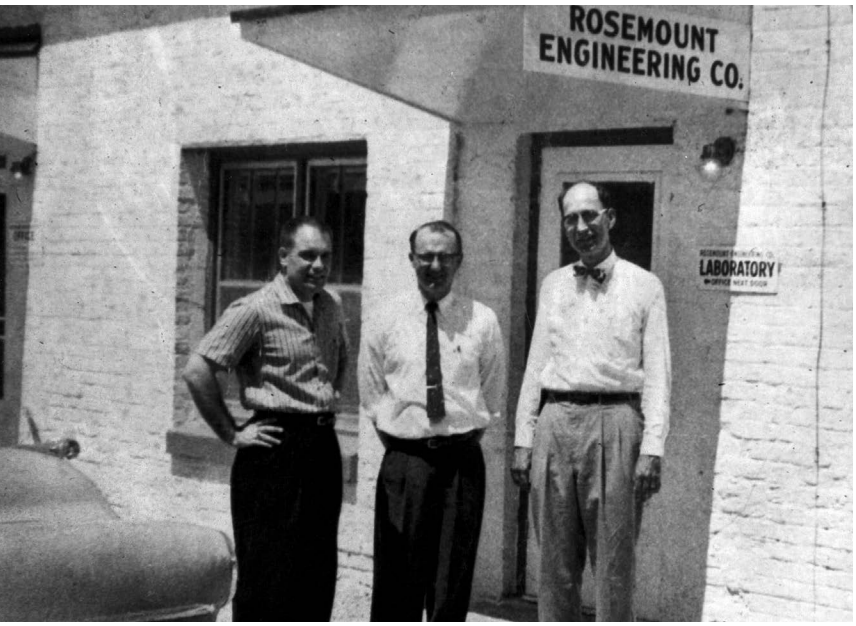
The pressure transmitter has long been the workhorse instrument of choice for the process industries. Like no other instrument, it offers unparalleled application flexibility and is as often used in flow and tank level applications. A steady stream of innovation has carried the pressure transmitter forward throughout the past several decades, following the transition from pneumatic to electronic to the digital age.

Rosemount Engineering Co. was there as the shift from pneumatic to electronic instrumentation gathered steam, introducing in 1969 the now iconic Rosemount™ 1151—the analog pressure transmitter that would set the performance standard for decades to come and pave the way for Rosemount Engineering Co. and eventual parent company Emerson to become a major force in the global process automation marketplace.

With the 50th anniversary of the Rosemount 1151's introduction approaching, Control*'s Vice President of Content Keith Larson caught up with Scott Nelson, Vice President and General Manager of Rosemount pressure products at Emerson Automation Solutions, to discuss the five decades of innovation that continue to make the company's pressure instrumentation offering as cutting edge and relevant today as the Rosemount 1151 was in 1969.*



Rosemount Engineering Company was incorporated in 1956 by Robert Keppel, Vernon Heath and Frank Werner.

Q When it was introduced back in 1969, the Rosemount 1151 represented a step change forward in terms of stability, reliability and accuracy—all in a more rugged yet modular, repairable package only one-third the size and weight of competitive offerings. What other innovations have continued to define Emerson's industry leading position in the pressure instrumentation space during the years since?

A The evolution of Emerson's Rosemount pressure instrumentation offering is

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entation innovation

really punctuated by the three generations—so far—of our flagship pressure transmitter. The Rosemount 1151, of course, marked our entry into the industrial space.

Pure and simple, it was a dramatically better and more capable transmitter than what had previously been available, and its success was the catalyst for Rosemount's transformation from a maker of specialized aerospace instrumentation to a process automation company.

If the Rosemount 1151 was about building a better analog instrument, our second-generation transmitter, the Rosemount 3051, debuted 20 years later and was firmly rooted in state-of-the-art digital technologies. Inside, a new, free-floating, micro-machined capacitive sensor came together with surface-mount electronics and custom ASIC circuitry to provide enhanced performance and increased functionality. The Rosemount 3051 was the first pressure product on the market to include a total performance specification that reflects operation in real-world conditions over a five-year time frame. It also supported a range of digital communication options, adding HART® communications to the 4-20mA analog signal and, in due time, Profibus, FOUNDATION Fieldbus and *Wireless*HART®. Miniaturization brought about a further 50 percent reduction in size and weight, and a new coplanar design allowed the integration of primary flow elements, instrument manifolds and diaphragm seal assemblies into complete, factory-assembled solutions.

Production of the Rosemount Model 1151 Pressure Transmitter.

The third-generation Rosemount 3051S added scalable intelligence and an architectural approach to the indus-

"We're leveraging onboard analytics to provide users with actionable insight into process conditions."

– Scott Nelson, VP & GM Rosemount Presssure Products, Emerson Automation Solutions

try's top-performing pressure transmitter. This platform for innovation has enabled many industry firsts since its introduction in 2001. The increased computational horsepower of the Rosemount 3051S, for example, allowed us to pioneer the multivariable transmitter: a single device that brings together pressure, differential pressure (DP) and temperature measurements to output real-time mass flow and energy readings.

Other industry firsts for the Rosemount 3051S include the Electronic Remote Sensor (ERS)™ System (pictured), which eliminated mechanical capillary and impulse lines for safer and higher performing DP level applications, as well as lower maintenance and installed costs. The Rosemount 3015S has also taken on higher level diagnostics, detecting anomalies not only in its own operation but in the integrity of its communication path, the health of the process itself and the performance of associated assets.

Q Your customers have certainly come to rely on the quality and reliability that comes with Emerson's Rosemount portfolio, but nowadays accuracy and stability of the primary measurement is only the cost of entry. Along what other dimensions has Emerson continued to innovate its pressure instrumentation offering?

A There are several driving forces behind our ongoing development efforts. While we continue to advance the state of the art in reliable and accurate measurement performance, we're striving to extend the reach, scope and applicability of our pressure instrumentation solutions while also making those solutions safer as well as easier to engineer, use and maintain.

On the digital front, we're leveraging onboard analytics to provide users with more actionable insight into their process conditions in a way that cannot be achieved via their control systems. Statistical analysis of process noise, for example, allows us to provide preconfigured diagnostics for specific issues or concerns such as valve

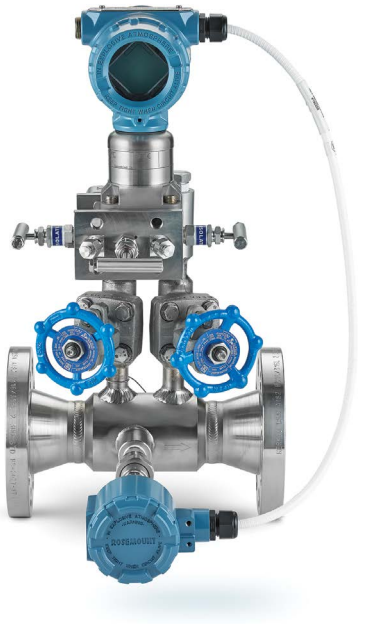
cavitation, column flooding, multi-phase flow conditions and plugged impulse lines. We're also ensuring loop integrity by monitoring and verifying the integrity of the device and its connection to the process and to the control system.

But not all of today's innovations are digital. Some of our latest innovations involve creating highly optimized and safety-centric solutions for very traditional applications like DP flow metering. Our new Rosemount 9295 Process Flow Meter (pictured) effectively eliminates the complexities and drawbacks of orifice plate installations in refining and chemical industries by replacing the whole installation with an all-welded spool design.

This pre-configured flow meter supports up to four individual flow transmitters for safety applications, is fully roddable, comes complete with true piping class isolation valves, and requires no straight pipe run beyond the meter body due to the use of the proven Conditioning Orifice technology. This is just one of a variety of application-based innovations that integrate traditionally separate components and bring much more flexibility, safety and capability to the picture.

We're also tackling increasingly extreme measurement conditions—both of the process and of the surrounding environment. These include differential pressures to 15,000 psi (1,030 bar) and gauge pressure measurements to 20,000 psi (1,375 bar). In terms of temperature, our transmitters are rated to -75°F (-60°C) on the low end and our new Thermal Range Expander accommodates process temps over 770°F (410°C).

Q Next year marks 50 years since Rosemount Engineering Co. moved from its roots in the aerospace market and into the industrial instrumentation space. As we look ahead, what can you tell us about what further innovations Emerson has in store for users of pressure instrumentation?



A We'll continue to adapt our pressure measurement technology to meet more diverse, industry-specific requirements. Subsea oil and gas applications, for example, pose pressures that can exceed 18,000 psi, and the end-user expectation is that instruments perform maintenance-free for up to 30 years. Downhole and aerospace also represent environmental and logistical extremes, requiring specialized packaging. On the other end of the spectrum, we're looking to extend Rosemount performance and reliability to the pharmaceutical industry's emerging single-use manufacturing technology.

In that same vein, miniaturization and industry's embrace of the Industrial Internet of Things will continue to drive the development of more types of economical sensors that will paint a richer picture of process conditions, while keeping people out of potentially hazardous areas.

We're also enhancing and expanding our wireless instrumentation capabilities. Faster update rates with extended battery life will broaden the spectrum of served applications including control and safety. With additional evolution in the underlying wireless technology, the most advanced instrumentation functionality will be available in wireless configurations. Other device interface technology will enable easier, faster and safer personnel interactions.

A half-century ago, Rosemount's groundbreaking pressure instrumentation technology set the pace for Emerson's industry-leading record of innovation in the automation business. And we expect to continue to expand that record into the next half-century. ■

Digital technology redefines scope of pressure measurement applications

The first applications of any new technology often do little to capitalize on its potentially transformative capabilities. Rather, new technology is first used to replicate its predecessor's functionality—only afterwards do new possibilities begin to emerge.

Such was the case with the earliest analog electronic pressure transmitters. An analog milliamp or low voltage circuit replaced the pneumatic signal, but the force-balance sensor mechanism of the previous generation pneumatic transmitter remained—complete with its drift-prone and maintenance-intensive moving parts.

Only when the entire sensor and communications package was reimagined from the ground up in 1969 did Rosemount Engineering Co. have the complete package of capacitive sensor and miniaturized electronics necessary to deliver the game-changing accuracy and stability performance of the Rosemount™ 1151 Pressure Transmitter.

The company had cut its teeth in the mission-critical U.S. space programs of the 1950s and 1960s, and well understood the importance of delivering unwavering reliability in tandem with accuracy. Then as now, the oil and gas majors played a leading role in the acceptance and adoption of new process automation technologies. And when one of them placed an order for 1,000 of the Rosemount 1151 transmitters in 1972, it was off to the races. Rosemount—and Emerson—haven't looked back since.

DIGITAL TECHNOLOGY TO THE FORE

Digital technologies—in the form of both on-board intelligence and bidirectional communica-

tions capability—were at the heart of Emerson's next generation pressure transmitter, the Rosemount 3051. The new free-floating sensor itself was micro-machined, and custom state-of-the-art surface-mount application-specific integrated circuits (ASICs) set the stage for a new burst of digital innovation starting in the mid-1980s.

While the Rosemount 3051 brought yet another level of operational stability and responsiveness to the company's pressure instrumentation offering, it also marked a significant expansion in transmitter functionality beyond an accurate, stable pressure measurement output.

In 1985, Emerson introduced its Smart Family of instruments, including pressure transmitters that communicated using the company's Highway Addressable Remote Transducer (HART®) protocol, which was soon released to industry as an open standard, now supported by the FieldComm Group.

The HART protocol allows pressure transmitters and other instruments to communicate with handheld devices and host control systems via a digital signal superimposed atop the transmitter's 4-20mA analog process variable signal. Ultimately, HART was complemented by the fully digital protocols of FOUNDATION Fieldbus, Profibus and *Wireless*HART®.

Most importantly, digital communications meant that the computational power now onboard the company's increasingly capable pressure transmitters was no longer stranded at the end of a one-way street. The first of this newly liberated information to be exchanged was device status and configuration settings, often only in the course

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Milestones in industrial

1964
Rosemount Engineering Co., founded in 1956 to supply instrumentation to the U.S. space program, files its first patents for non-aerospace applications of variable capacitance pressure sensors.

1969
The Rosemount Model 1151 Pressure Transmitter debuts to critical acclaim at the ISA Show in Houston. The new transmitter would set the process industry's performance, reliability and design standard for decades to come.

1971
Later to become a member of the Rosemount family, Dieterich Standard Inc. introduces the Annubar primary flow element, effectively eliminating the pressure drop penalty of many DP flow applications.

1967
Rosemount Engineering Co. introduces its first two-wire field transmitter (4-20mA). The temperature measurement device marks the company's entry into the industrial market.

1976
Emerson Electric acquires Rosemount, cornerstone for the new parent company's growth into a global powerhouse in the process automation market.

EMERSON.

1985
Smart Family of microprocessor-based HART® instrumentation is introduced; Emerson releases the HART protocol intellectual property as an open standard for digital communications between the field device and the control room.

1988
Emerson's second-generation pressure transmitter, the Rosemount 3051C, is introduced. Redesigned from the ground up, the light-weight device featured a new Coplanar™ design, a highly accurate free-floating capacitance sensor and miniaturized, microprocessor- based electronics. Also in 1988, the 1151 pressure transmitter is named to Fortune magazine's list of "100 Products that America Makes Best."

1983
Emerson ships its 500,000th Rosemount 1151 pressure transmitter.

1964 1967 1969 1971 1976 1983 1985 1988 1996

pressure measurement

1996
Emerson acquires Dieterich Standard and adds the maker of the Annubar primary flow element to its growing family of Rosemount measurement solutions.

2002
Seeking to simplify differential flow measurement applications, Emerson introduces the Rosemount 405P Compact Orifice Plate, a flange-mounted primary flow element that includes the orifice plate as well as integral impulse lines.

2003
Emerson further enhances traditional orifice plate measurement with the Rosemount 405C Compact Conditioning Orifice Plate. The four-hole design dramatically reduces upstream and downstream straight-pipe requirements.

2001
Emerson's third-generation pressure transmitter, the Rosemount 3051S Series of Instrumentation, adds scalable performance and intelligence through an architectural design approach to the industry's leading pressure transmitter offering. The Rosemount 3051S becomes a platform for innovation in pressure measurement that continues to this day.

2008
Family of *Wireless*HART®-capable instrumentation is introduced, including the Rosemount 3051S Pressure Transmitter. Wireless slashes the cost of incremental measurement points by eliminating the need for traditional wiring infrastructure.

2015
Emerson debuts the Rosemount Wireless Pressure Gauge, which replaces traditional gauges with a more robust design and increases personnel safety using *Wireless*HART® communications technology.

2001 — 2002 — 2003 — 2008 — 2011 — 2015 — 2018

2011
The Rosemount 3051S Electronic Remote Sensor (ERS)™ System effectively eliminates the maintenance headaches related to DP level measurement applications due to the use of wet and dry legs or reduced performance when using mechanical capillaries. The ERS System calculates DP level electronically via two pressure sensors connected via a standard cable.

2018
Emerson introduces the Rosemount 9295 Process Flow Meter, an all-welded differential pressure flow meter that uses Conditioning Orifice technology to increase installation flexibility by eliminating straight-pipe requirements and can be specified with multiple transmitters for redundancy in SIS applications.

Continued from p7
of commissioning and calibration tasks. But once unleashed, the ability of these early-day "edge" devices to perform self-diagnostics and complex calculations based on multiple sensor inputs began to blossom—and continues to do so.

ADVANCED MEASUREMENT CAPABILITIES

One of those advances was the Rosemount 3095 MultiVariable™ transmitter. In 1991, Emerson received funding from what was then the Gas Research Institute to develop "the world's most compact electronic flow measurement (EFM) device." The Rosemount 3095 included sensors for static pressure, differential pressure (DP), and temperature, and also calculated derived quantities such as a real-time, temperature-compensated mass flow rate. All of this functionality was available in a device that was the same size as the standard Rosemount 3051 Pressure Transmitter. It also paved the way for increasingly integrated pressure, flow and level solutions to come.

While many technological advances during the 1980s and 1990s continued to extend the scope and applicability of Emerson's pressure measurement solutions, the 2001 launch of the existing flagship transmitter, the Rosemount 3051S (pictured), set yet another performance benchmark for the process industry. With 0.025 percent accuracy, 200:1 rangeability and 15-year stability, the Rosemount 3051S was designed as a scalable innovation platform and has continued to allow ongoing developments in advanced intelligence and measurement.

The exceptional performance characteristics of the Rosemount 3051S made possible Emerson's Ultra offering due to superior dual-capacitance Saturn™ sensing technology, the hermetic SuperModule™ platform and advanced manufacturing techniques.

As a result, the Ultra Performance Class is warrantied for 15-year operational stability. Emerson built upon this foundation in 2005 with the release of its DP flow meter adaptation, Ultra for Flow, which optimizes performance over a wide flow turndown. Performance is specified as a percent of reading instead of the traditional percent of span. Ultra for Flow supports up to a 14:1 flow turndown, maintaining better than a ±0.5 percent of reading specification over the entire operating flow range.

BROADER SCOPE OF DIAGNOSTICS

The scope of the pressure transmitter's diagnostic capabilities also took a substantial step forward with the Rosemount 3051S. An expanded list of device health diagnostics now encompasses not only sensor and electronics, but safety certified diagnostics for enhanced Safety Instrumented Systems (SIS), diagnostic and event status logs, and customizable service alerts. Also included are loop integrity diagnostics, which use the qualities of the electrical signal to detect issues such as water in the instrument housing, corrosion and other wiring or power supply problems.

Perhaps most significant is the extension of pressure transmitter diagnostics from the device itself and associated wiring to issues with the process to which it's attached. Referred to as "Process Intelligence" by Emerson developers, this set of diagnostics is based on the real-time dynamics of the process variable itself. Patterns in variability are used to detect such diverse process issues as plugged impulse lines, flame instability, column flooding, pump cavitation, entrained air, process leaks and tank agitation loss.

This entirely new class of pre-configured diagnostics is delivering a range of business results such as reduced maintenance costs (by focusing on devices that actually need maintenance), improved product quality (by identifying process optimization opportunities), increased uptime (by preventing abnormal

Patterns in variability are used to detect such diverse process issues as plugged impulse lines, flame instability, column flooding, pump cavitation, entrained air, process leaks and tank agitation loss.

conditions), increased throughput (by running closer to constraints) and reduced waste and rework (by preventing process upsets).

WIRELESS EXTENDS MONITORING REACH

Wireless networking technology, notably via the *Wireless*HART protocol, has extended the applicability of pressure measurement solutions by making incremental monitoring points far easier and more affordable to install. With the completion of the specification in 2008, Emerson rolled out a full range of wireless pressure, DP, flow, level and multivariable solutions that can be added at 40-60 percent of the cost of traditional wired instruments.

Relatively new to Emerson's wireless lineup is the Rosemount Wireless Pressure Gauge, a one-to-one form-factor replacement for traditional pressure gauges, which are based on Bourdon Tube technology—an antiquated mechanical sensor invented in the 1800s. The Rosemount Wireless Pressure Gauge not only represents a 10-fold improvement in reliability, but it provides wireless transmission of the monitored pressure back into the control room. This reduces the need to send personnel out in the plant to monitor these stranded measurement points, which improves personnel safety.

Robust in design with multiple isolation barriers, the Rosemount Wireless Pressure Gauge can withstand overpressure or burst pressure up to 11,000 psi (758 bar). Meanwhile, local diagnostic indicators go far beyond simple pressure indication. One blinks green, yellow or red to warn of unsafe conditions, and another warns of an overpressure event, device malfunction or low battery.

Similarly, a broad range of digital technology enhancements to Emerson's Rosemount pressure measurement offering has provided a means to effectively communicate information to those who need it. A new breed of intuitive device dashboards, for example, are designed around users' tasks, with 63 percent of use cases discernable at a glance. They include instant insight into device and communications status, device readings, shortcuts to most common tasks and recommended actions to help with troubleshooting.

As important as digital technology has been to advancing the performance and capabilities of Emerson's pressure measurement solutions, there's also a case to be made for the role of mechanical innovation. That's the subject of the next article in this special report. Mechanical innovations include preassembled solutions that are safer for workers and the environment as well as easier to engineer and install. It also entails unique flow elements that perform better, save energy and reduce installation complexity. ■

Mechanical innovation opens pressure measurement horizons

As digital technologies continue to evolve at a fast and furious pace, it's sometimes easy to forget all the mechanical innovations Emerson has developed throughout the years to deliver pressure measurement solutions that today perform better than ever—yet are simultaneously easier to engineer, install and maintain.

Early success with the Rosemount™ 1151 Pressure Transmitter arose from a dogged focus on building the most accurate, rugged and stable sensor possible. But as sales of the Rosemount 1151 took off in the 1970s, the company's engineers took aim at a wider range of applications to drive the technology's broader use.

For example, differential pressure (DP) flow measurement across a traditional orifice plate primary flow element incurs significant pressure losses, which means wasted energy. Such applications also require long runs of straight pipe that complicate installation. And in both DP flow and level measurement applications, a laundry list of fittings, tubing, heat tracing and other components resulted in solutions that were complex to engineer, tricky to assemble in the field and susceptible to process leakage as well.

PRESSURE DROP WOES?

Emerson found a key answer to the pressure drop problem with the Annubar flow solution, an averaging pitot tube primary flow element first introduced in the early 1970s. The original Annubar consisted of a cylindrical probe inserted through the diameter of a pipe with openings along the length of both the upstream and downstream faces of the probe. The differential pressure between the upstream and downstream ports yields an accurate flow rate accounting—without incurring the high permanent energy loss penalty of other flow meter technologies.

Emerson acquired the Annubar primary element's original creator, Dieterich Standard, and has continued to innovate on the original. Now in its fifth-generation design (pictured),

today's Rosemount Annubar™ primary element includes an innovative upstream slot that provides for comprehensive averaging, while the sensor's T-shape creates large stagnation zones on the backside to reduce noise. Today's model also can be specified with an integral thermowell to derive fully compensated, real-time mass, volumetric and energy flow rates from a single pipe penetration. The product even can be hot-tapped for installation without shutting down the line and into lines up to 96 in. (2400 mm) in diameter.

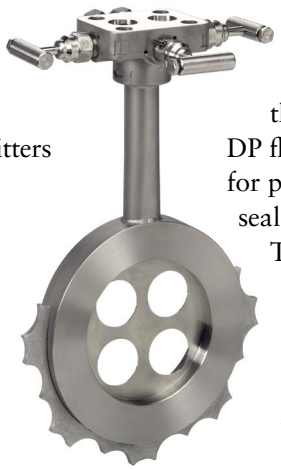
The Annubar primary element incurs one of the lowest permanent pressure losses of any flow device, including venturi, wedge, turbine, v-cone and orifice/nozzle flow meters. Lower pressure loss means reduced pumping/compression costs, increased capacity and lower capital costs commensurate with the purchase of a smaller compressor, pump or boiler. A lower pressure drop can also mean increased flow through existing lines and higher throughput for gravity-fed systems.

NO STRAIGHT PIPE? NO PROBLEM

Achieving a pressure-stable measurement that is truly representative of the entire flow profile across a pipe has always been a challenge. In order to achieve an accurate measurement the traditional orifice plate DP flow meter, which consists of a sharply cut circular hole in the center of a plate, also requires long lengths of straight pipe run both upstream and downstream in order to derive an accurate flow measurement. Such extra straight-pipe

requirements of 40 or more diameters add to the flow meter's installation expense and space requirements. Flow conditioners are sometimes used to provide a more uniform flow with less straight pipe, but the addition of another component (and potential leak points) adds to expense and installation complexity.

Turning their attention to this longstanding fluid mechanical challenge, Emerson engineers created the Conditioning Orifice—a plate with not one but four holes (pictured) that dramatically reduced the need for straight-pipe run by as much as 90 percent. Introduced in 2003, the Rosemount 1595 Conditioning Orifice Plate also provided a 30 percent improvement in accuracy and marked a key breakthrough in the broader application of DP transmitters for the measurement of flow.



FROM TRANSMITTER TO SOLUTION

Another essential way in which Emerson boosted the appeal of its pressure measurement solutions was through a concerted effort to reduce the complexity of their application. Now formalized throughout the company as Human-Centered Design (HCD) principles, the effort starts from a deep understanding of how its customers engineer, purchase, install and maintain its solutions in the field—and strives to identify innovative ways to reduce complexity throughout their lifecycle.

In the realm of DP flow and level measurement, the introduction of the Rosemount 3051 Pressure Transmitter with its unique patented Rosemount Coplanar™ connectivity platform allowed a smaller, lighter and easier installation, as well as a 50 percent reduction in potential leak points. It also paved the way for the factory shipment of complete measurement solutions, including the integration of primary elements for DP flow applications, instrument manifolds for pressure applications and diaphragm seal assemblies for DP level applications.

The Rosemount 405 Compact series of DP flow meters, for example, unify and ease the engineering and installation aspects of Annubar, Orifice and Conditioning Orifice primary element technologies.

A single seamless process for speci-

A single simple process for specification, ordering and installation of Rosemount 405 Compact series flow meters reduces risk and delivery time and can cut total acquisition costs by as much as 55 percent. Flow meters arrive fully assembled, factory leak-tested and ready to install.

fication, ordering and installation reduces risk and delivery time and can cut total acquisition costs by as much 55 percent. Flow meters arrive fully assembled, factory leak-tested and ready to install. The inclusion of an integral thermowell for temperature measurement minimizes pipe penetrations. The elimination of impulse lines reduces potential leak points by 80 perecent. And an integral centering mechanism for Compact solutions ensures the mechanism is properly installed in the pipe to within ANSI/API guidelines.

Similarly, in the realm of DP level measurement, Emerson's Electronic Remote Sensor (ERS)™ System calculates differential pressure electronically using two pressure sensors linked together with an electrical cable, rather than with mechanical components. This results in a system that provides faster response and eliminates the need for impulse and capillary lines, fittings, heat tracing and other external and potentially maintenance-intensive elements. Further, Tuned System™ assemblies eliminate excess capillary and oil volume—improving time response by 80 percent, and reducing temperature drift by 20 percent.

These are just a few highlights of Emerson's

first 50 years of mechanical innovation in the realm of industrial pressure measurement. Combine these with continued advances in sensor performance, digital analytics and wireless connectivity, and it's clear that Emerson's Rosemount pressure products are positioned to lead the process industry with instrument innovation for another 50 years. ■

Downtime for any reason is expensive. I need to stay two steps ahead of problems that could impact my productivity.

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Emerson's Rosemount™ 3051S Series of Instrumentation offers greater process control through advanced diagnostics, simplified connections and wireless communications. Learn more about improving productivity with pressure instrumentation.

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