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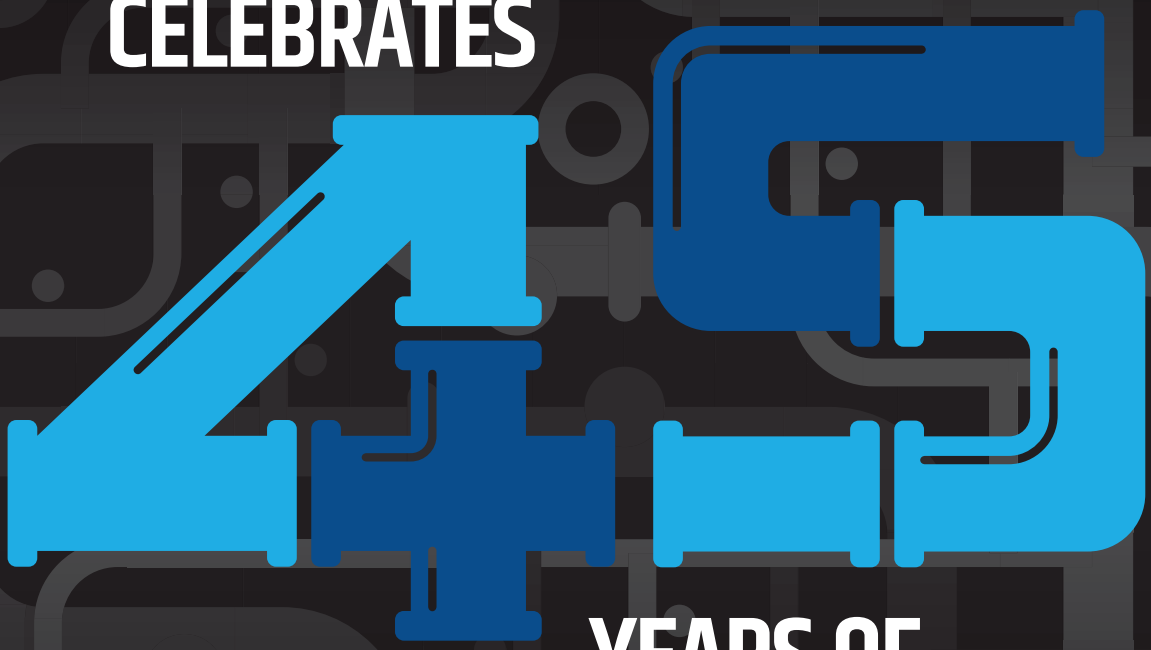

YEARS OF CORIOLIS LEADERSHIP

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Engineering for assurance

In 1977, Jim Smith invented the Coriolis meter and formed Micro Motion to bring the world's first direct mass meter to market. Since that time, the organization has engineered assurance into a broad range of industry-standard Coriolis solutions that offer reliable, accurate and long-lasting flow and density measurements that have proven vital to the success of its global customer base. With the 45th anniversary of that technology breakthrough approaching, Control *Editor-in-Chief Keith Larson caught up with Andy Dudiak, president, Flow Measurement, Emerson, to discuss the organization's continuing legacy of engineering expertise and customer-driven innovation.*

Q: What was it that really differentiated the first Coriolis mass meter from other measurement technologies?

A: The Coriolis meter was the first practical device to measure mass flow of liquids directly—it was completely unique at the time. All the other flow technologies available measure volumetric flow or velocity. You simply don't have the same understanding of what's going through the pipe.

Q: What industries first recognized the value that this new technology could bring to deliver?

A: Direct mass flow measurement was of specific interest to chemical companies because the stoichiometric relationships among reactants are based on mass. The first Micro Motion meters were sold into the chemical industry. Other early adopters included life sciences and food and beverage companies, which appreciated the extremely high accuracy over broad ranges obtainable with Coriolis technology. This meant that multiple ingredients and products could be batched through a single meter without recalibrating for different ranges. Also, the non-intrusive nature of the meter was a good fit for sanitary, clean-in-place applications.

The first oil and gas applications followed in Asia and Europe where they were accustomed to measuring hydrocarbons by mass rather than volume. But in the US, Coriolis technology didn't really start to take off in that sector until the 1990s, when the standards bodies started to recognize that a Coriolis meter reading could readily be converted into a highly accurate volumetric reading. We started to provide a volumetric output option for our meters, and applications grew from there.

Q: Micro Motion became part of the Emerson family back in 1984. What did that milestone represent for the organization?

A: First, becoming part of the larger Emerson organization meant an increase in available resources. Most notably, we were able to take the Micro Motion brand global. We saw a steady increase in product development investment that further kept our meters the leader of the pack. Also, that was when Gene Perkins came in as new president, and helped us transition from an entrepreneurial, technology-based company to one with more structured processes—including an adamant focus on the customer, on quality and on continuous improvement.

On top of that, Emerson brought in a very thorough, thoughtful process around planning for the future of the business. I give a lot of credit to Jim Smith from a

1977
Founding of Micro Motion and invention of the Coriolis meter by Jim Smith in Boulder, Colorado, USA

EMERSON™

1984
Micro Motion is acquired by Emerson, paving the way for continued innovation and rapid global expansion

yields Coriolis leadership

"An adamant focus on the customer, on quality and on continuous improvement are the foundation of everything we do."

— Andy Dudiak, President, Flow Measurement, Emerson

technology standpoint in the company's early days then Gene Perkins, who helped us really grow from there. In the years since, we've worked closely with Emerson's overall Automation Solutions business—from control systems to software and valves—and that alignment has led to continued growth.

Q: What technical innovation milestones have been key to the organization's continued success over the years?

A: From a technology perspective, the launch of the world's first dual-tube, D Series meter in 1983 eliminated a lot of the installation constraints of the earlier meters, which had to be stabilized by concrete anchors. With the D meter, the two tubes were able to reference each other, effectively cancelling out environmental effects such as vibrations from nearby equipment. This was a huge step forward in terms of installation flexibility.

The development of Smart Meter Verification in 2010 allowed customers to verify that their meters were working correctly without having to remove them from service. This was critical for increasing process uptime and satisfying calibration requirements around custody transfer applications. The release of the ELITE Series in 1992 leveraged advanced sensor and digital signal processing technology to set what has remained the benchmark for Coriolis meter performance, and in 2015 the release of the 5700 transmitter brought a new level of diagnostic capabilities to bear. Finally, as digital capabilities advanced, we pioneered Advance Phase Measurement, which allows us to measure both gas flows and the composition of multiphase mixtures. This capability continues to open new opportunities.

Q: What sorts of applications do you see as the next frontier?

A: We're working to make Coriolis technology a better fit outside its strongholds of the chemical and oil and gas markets. The food and beverage and life science industries are of interest, and our latest 1600 transmitter includes a compact, integral housing, Power-over-Ethernet connectivity and other features of importance to these industries. Sustainability is an important target area as well, and in addition to compressed and liquified natural gas applications, we've applied our refinery experience with high pressure hydrogen to create dispensing solutions for the emerging, hydrogen-powered vehicle marketplace.

In the years to come, you can be sure our new offerings will continue to be engineered for assurance as well as easy to use and fit-to-purpose for our customers' challenges. ■

2005
Acquisition by Emerson of Solartron Mobrey for complementary density, viscosity instrumentation

2020
Emerson breaks ground on $100 million Innovation Center and significant expansion of Boulder manufacturing capabilities

Sensor innovations push accuracy, application envelope

At their simplest, Coriolis meters operate by using a drive coil to make the tube through which mass flow is to be measured vibrate at a naturally resonant frequency. Filling the tube with a fluid causes the resonant frequency itself to shift in proportion to the density of the fluid. And, once flow begins, the Coriolis effect dictates a phase shift in the vibration that is proportional to the mass flow rate through the tube. The calculated mass flow measurement, then, is only as accurate as the reference to which these changes are compared is stable.

Make no mistake, the ability of the earliest Micro Motion meters to measure mass flow directly was a game changing innovation out of the box, but the company's A, B and C Series single-tube meters required that the meter be anchored on a grounded block of concrete to provide this stable point of reference—it was neither the easiest nor most flexible installation arrangement.

Introduced in 1983, the D Series' breakthrough innovation was a patented dual-tube design that split the flow between two tubes that vibrated with respect to one another, effectively canceling out many of the external factors that would otherwise have affected meter accuracy. The D meter—and its users—were liberated from those concrete anchors, resulting in Coriolis applications that were easier, more flexible and more accurate as well.

The success of the D Series meter demonstrated two interwoven throughlines of Emerson's longstanding leadership in the arena of Coriolis measurement: the drive to increase mass flow accuracy while simultaneously broadening the application envelope of the technology. The steady drumbeat of sensor innovations that led to the D Series meter only intensified after Emerson's acquisition the following year.

ELITE Series debuts

The balance of the 1980s saw Emerson's Coriolis presence and customer base expand across Europe and Asia, even as product development efforts continued. Line sizes increased, as more precise sensor electronics allowed the accurate characterization of two-phase flows. These and other advances culminated in the 1992 debut of the Micro Motion ELITE Coriolis meter, which became the preferred high-performance solution for critical applications such as custody transfer and multi-phase flow measurement.

The ELITE Series combined superior mass flow, density and volume measurement in a wide variety of line sizes and materials. To this day, its mass flow accuracy of 0.05% sets the standard for Coriolis meter performance. The ELITE Series meters were also designed to accommodate widely varying application

"You can certainly compensate for a lot of problems with software, but our philosophy is to design our products to minimize the effects of varying process conditions."

— Patrick Zimmer, Director of Product Marketing, Emerson

conditions from cryogenic conditions to high temperature and pressure extremes.

"With the ELITE Series, we made a product that is designed to handle the most challenging applications," says Patrick Zimmer, director of product marketing, Coriolis technology, Emerson. "You can certainly compensate for a lot of problems with software, but our philosophy is to design our products to minimize the effects of process conditions so they can handle nearly all process variations and conditions. Measuring two-phase flow, for example, is more effective with a lower resonant frequency. We looked at how the tubes themselves were structured to create a lower frequency sensor which in turn eliminated many of the performance effects generated by multiple phases going through the meter."

Process control workhorse

If the ELITE Series staked out the high-performance end of the Coriolis application space, the sweet spot for 1995's F Series introduction was intended as a practical replacement for competitive flow measurement technologies being used in process control applications. The F Series delivers 0.1% mass flow accuracy and is available in line sizes from 1/4 to 4 inches in 316L stainless steel or nickel alloy C22.

"The F Series is a compact, drainable product family that is still highly accurate and extremely reliable, but smaller in footprint," says Zimmer. "Its sister product is our H Series (for Hygienic) that was launched in 2002. That sensor is similarly compact, but features hygienic surface finishes for applications in the life sciences and food and beverage industries."

The straight tube revisited

By 1999, Coriolis technology had advanced considerably, and the time was right to revisit a straight, single-tube meter. A range of customer applications, especially in the food and beverage industry, dictate a straight, single tube rather than splitting the flow in two. This might be required due to cleaning with a mechanical device or to preserve product integrity during production. (Imagine a mixed flow of yogurt with whole raspberries.) Without the compensating effect of a second tube twisting in the opposite direction, Emerson engineers had to tackle varying temperatures and other effects head on.

They found their solution in the titanium from which the T Series takes its name. Titanium is far less sensitive to temperature changes than steel alloys. It retains a consistent stiffness, and doesn't expand or contract nearly as much as steel does in response to changing temperatures. "It's the same material used

1992
Even today, the ELITE Series remains the meter of choice for critical applications such as custody transfer and multiphase flow measurement

1995
The F Series is a compact, drainable workhorse meter designed to suit a broad range of process control applications

The Micro Motion ELITE High Capacity meter significantly expanded usage across oil and gas custody transfer applictions.

1999

Emerson returns to a single, straight-tube Coriolis meter with the T Series. A titanium flow tube helps minimize temperature effects

2005

Solartron Mobrey joins the Emerson family, expanding the company's density and viscosity measurement portfolio

"We now we have a device that can measure a little as a few drops an hour to 14-inch meters that measure 120,000 pounds per minute, and everything in-between."

— Amy E. Johnson, Vice President, Coriolis and Ultrasonic Meters, Emerson

to make aircraft turbine blades," says Zimmer, noting the similarly precise tolerances that turbine blade must maintain in the face of extreme temperature swings. Placing the flow tube down the center of a rigid outer case provides the necessary frame of reference for accurate mass flow measurement even when the process is quite hot and ambient conditions cold. "It's also a relatively compact meter," adds Zimmer, "which is well suited to food and beverage applications where space can be at a premium."

Viscosity, density portfolio additions

While much of Emerson's expanding footprint in Coriolis technology was through organic growth, the 2005 acquisition of Solartron Mobrey expanded the company's measurement portfolio with dedicated viscosity and density measurement technologies.

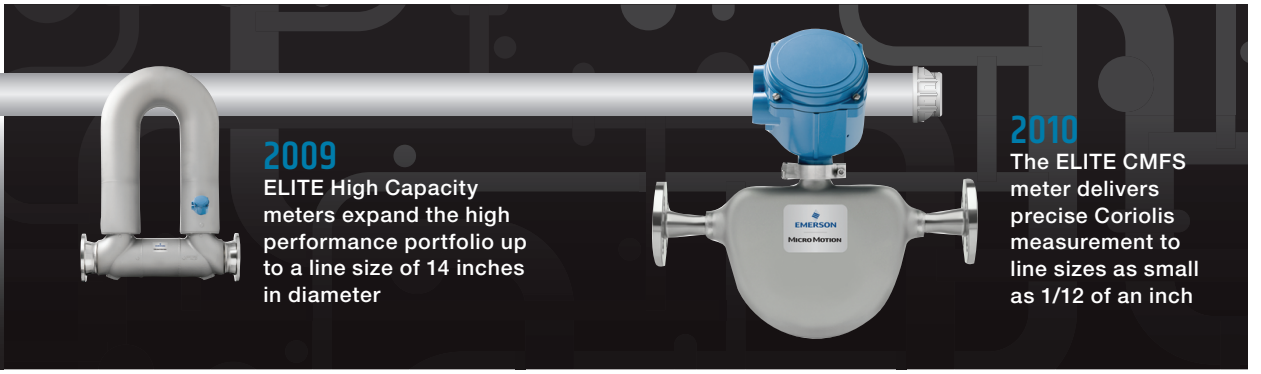
"Viscosity and density are often tightly correlated with final product quality—which is often at least as important as product quantity," notes Zimmer. Insertion-style gauges can accurately measure density and viscosity in open or closed tanks as well as in flow applications, thus representing important complement to the Coriolis meter's density measurement capabilities.

Key applications include the blending of multiple components to reach precise viscosity and/or density targets. "Consider a large ship that uses both light diesel and heavier, marine-grade fuels," Zimmer says. "The latter needs to be heated to a specific viscosity for optimal engine operation." Fermentation monitoring and control also benefits from insertion-style density instrumentation.

Pushing the extremes

At the end of the 2000s, Emerson again expanded the application range of its ELITE Series with both smaller and larger Coriolis meters. In 2009, the ELITE High Capacity meters became available for line sizes up to 14 inches in diameter. This significantly bolstered Emerson's Coriolis offering in the custody transfer arena, especially for customers in the oil and gas industry. At the other extreme, the ELITE CMFS meter introduced in 2010 extended line sizes downward to as little as 1/12 of an inch.

"Now we have a device that can measure a little as a few drops an hour to 14-inch meters that measure 120,000 pounds per minute, and everything in-between," says Amy Johnson, vice president, Coriolis and ultrasonic meters, Emerson. "This multi-variable device is pushing its application space and customers are using the information from the meter to drive step changes in their businesses." ■



Design, test investments boost Coriolis performance

In the 1800s, mathematician Gaspard-Gustave de Coriolis predicted the effect that the earth's rotation would have on a fluid in motion. But it was quite some time before Micro Motion founder Jim Smith figured out in 1977 how to empirically measure that effect and use it to calculate the fluid's mass flow rate. The earliest Coriolis meters were primitive by today's standard, relying on analog electronics—including the rotary optical encoder enshrined in the brand's original logo—to determine the vibrational frequencies and amplitudes necessary to calculate a meaningful mass flow rate.

But Micro Motion was formed just as digital tools began to revolutionize not only the speed and sensitivity of the Coriolis meter's electronic circuitry, but also the design of the vibrating tubes themselves. In pursuit of ever more accurate meters, finite element analysis (FEA) was used to model and study the mechanical aspects of the meters, even as computational fluid dynamics (CFD) was called on to simulate the fluid flows within.

"We were among the earliest users of FEA and CFD to figure out how fluid flows and structures interacted," says Mark Bell, vice president of engineering, Coriolis technology, Emerson. "Back then it was airplane manufacturers and Micro Motion," he says.

So began a sustained, user-driven campaign to push the accuracy and range of its meters to unprecedented levels—achieving the industry standard 0.05% of mass flow ratings embodied in the company's ELITE Series meters that debuted in 1992.

Proof of performance

But it wasn't just digital designs and simulations that made such performance possible. The organization simultaneously invested tens of millions of dollars in the sophisticated test facilities needed to validate those meters' performance. "We partnered with National Laboratories for guidance, and now have some 15 flow stands accredited by the International Organization for Standardization (ISO) to 0.01% accuracy," Bell says. "Today, our capabilities are more extensive than any national flow lab in the world."

Strategically located near customers across the Americas, Europe and Asia, these facilities serve both engineering and product development tasks—often across Emerson's flow measurement portfolio—as well as proving grounds for its customers' unique fluids and multiphase concoctions. "They're half engineering labs and half for specific customer applications," Bell explains. "On any given day we may be testing beer, toothpaste, fire retardant, or oil mixed with water." Custody transfer applications are particularly test-worthy, as billions of dollars of product may pass through a single Coriolis meter over the course of its lifetime.

1995
The Tecnologias de Flujo in Chihuahua, Mexico, is the first major manufacturing center for Coriolis technology outside the USA

2008
The Asia Flow Technology Center in Nanjing, China, provides an essential foothold in the Asian market for Emerson's Coriolis technologies

"We rely on proven engineering practices from design through test to ensure that a meter will not be a reliability concern, and that it will exceed performance expectations."

— Mark Bell, Vice President of Engineering, Coriolis Technology, Emerson

It's also extremely important to pair any given fluid with a sensor tube made of the appropriate alloy, to avoid corrosion, erosion or other effects that can pose safety or reliability risks. "We have a team of metallurgists on staff and use a range of stainless steels, exotic alloys and titanium, depending on the fluid in question. Our compatibility guidelines run into the hundreds of pages, and are based on our 45 years of experience with what metals can be used with what fluids." For example, titanium made be a super metal when it comes to many corrosive materials, Bell says, "but it doesn't do well with even dilute concentrations of bleach. It's important that we know that."

Pushing the envelope

"Our customers continue to ask for meters that can take higher operating temperatures and pressures; they're adjusting their processes to get higher efficiency or improved yields," Bell adds. So, new designs that push the traditional limits of Coriolis meters are rigorously tested using shaker tables, environmental chambers and burst chambers with over-pressurized meters to ensure they'll operate as promised. "If we say it's going to operate at 800 °F, it's going to operate at 800 °F—as one of our recently released meters does," Bell says. "We rely on proven engineering practices from design through test to ensure that a meter will not be a reliability concern, and that it will exceed performance expectations."

In the rare event that a Micro Motion meter does show signs of deteriorating performance—normally detected through the meter's onboard diagnostics before posing a safety concern—Emerson's labs are also equipped to get to the root cause of the problem. "All of our different locations have full sectioning capabilities, plus stereo and video scopes and scanning electron microscopes," Bell says. "We also have electron dispersive microscopes (EDMs) to examine any pitting mechanisms in great detail."

These labs are often co-located with the companies' service centers and key Coriolis manufacturing facilities in Boulder, Colorado (the original Micro Motion headquarters in the U.S.); Chihuahua, Mexico; Nanjing, China; and Cluj, Romania. And while most early Micro Motion meters were manufactured on demand, today they're assembled from regionally stocked sensor, transmitter and flange subassemblies to meet customers' specific requirements in a timely fashion. This local presence for final assembly and test also streamlines delivery of finished devices.

"Being physically close to our customers has always allowed us to better support their needs," Bell says. "And with today's supply chain issues and environment concerns, that proximity is more important than ever." ■

2014

To better serve Emerson's customers across Europe, the company opens a 200,000-sq. ft. Emerson Flow manufacturing center in Cluj, Romania

2020

Significantly bolstering product development and manufacturing capabilities in the U.S., Emerson expands Micro Motion'sheadquarters in Boulder, Colorado

Micro Motion expertise leads industry transformation

While digital technologies have helped to transform the physical design of Coriolis meters over the years, Emerson engineers were also amongst the earliest to embrace the potential of onboard intelligence to deliver higher instrument performance as well as extract meaningful information about the meter itself—and the process that it served.

Today we'd call it Industry 4.0 or the Industrial Internet of Things (IIoT), but as early as the year 2000, Emerson was shipping Coriolis meters with MVD (for multi-variable digital) technology that featured high-speed digital signal processing, faster response times and dramatically reduced signal noise. Further, the meters were already in line with the latest NAMUR Open Architecture visions of today, supplying both an analog measurement output for control purposes as well as a parallel Modbus communication path for all that non-control data.

"We've long focused on the diagnostic capabilities of our meters—delivering information, not just data, about our meters as well as insights into the process," says Tonya Wyatt, senior global product manager, Coriolis electronics, Emerson "It's important that we accurately measure mass flow, but our meters can also help diagnose cavitation, vaporization and other process issues," she says.

In 2005, MVD technology and other advanced transmitter features were repackaged for flexibility and convenience in the 2700, an integral-mount flow and density transmitter that offered a variety of I/O options.

Utmost confidence

Another focus area that has remained consistent over the years is using that secondary data to ensure "utmost confidence in your measurement," Wyatt adds. Despite the well-established reliability of Coriolis meters, they were often painted with the same "guilty until proven innocent" brush often used to first blame the instrument—and not a process problem—for any unusual readings.

"It's one thing to have a device tell you that there's a flow of 60 gallons a minute," Wyatt explains. "But if you don't know if the instrument is correct, if you don't know it's having issues, if you don't understand the health of it, then you can't have complete confidence in that measurement."

To address this situation in the context of Coriolis meters, Smart Meter Verification debuted in 2010, allowing end users to remotely initiate a diagnostic routine to verify that a Coriolis meter's unique vibration signature had remained unchanged. Since there are no intrusions or moving parts to deal with in a Coriolis meter application, successful Smart Meter Verification carries with it an extremely high assurance that the meter continues to operate as it did when installed or last calibrated. It can be initiated by an operator on demand, or scheduled to run

2004
Series 3000 transmitters combine measurement and control capabilities in one instrument, enabling a range of standalone applications such as for batch control

2005
Powered by MVD technology, the versatile, field-mounted 2700 transmitter brings a wide variety of I/O and application flexibilities to industry

"We've long focused on the diagnostic capabilities of our meters—delivering information, not just data, about our meters as well as insights into the process."

— Tonya Wyatt, Senior Global Product Manager, Coriolis Electronics, Emerson

at prescribed intervals with pass/fail status messages sent automatically upon completion.

The transparency afforded by Smart Meter Verification effectively elevates users' confidence in Micro Motion Coriolis meter reliability above that of most other instruments, allowing end-users unparalleled confidence in their meters' performance. The confidence afforded by Smart Meter Verification even allows organizations to increase the interval between meter calibrations, yielding process uptime and availability improvements.

Early to the Industrial IoT

Emerson's Micro Motion Coriolis meters again got a jumpstart on the Industrial IoT when the next-gen 5700 transmitter debuted in 2014. A transmitter of unprecedented digital capabilities, the 5700 even includes an onboard historian, automatically capturing a month's worth of 20 key process and diagnostic variables at one second intervals.

Data can be downloaded as a simple .CSV file for further diagnostic analysis using Micro Motion ProcessViz, a standalone software application that takes the raw historian data and renders it in an easy-to-follow graphical format to check for irregularities, including an audit trail of configuration changes. "Obviously, when things go wrong, it's always at 2 a.m. and nobody's there watching it," says Wyatt. "So that historian capability maintains a black-box recording of your process. Like after an airplane crash, you can go back and see just what happened."

The original 5700 release also added "zero verification," a 20-second diagnostic that, at the push of a button, checks whether the meter's current zero is within specifications, which can be especially important at low flow rates. If the instrument's zero is no longer within tolerance, the diagnostic will even check whether process conditions are quiet and stable enough to re-zero the meter without upsetting the process.

Emerson continues to add new features and functionality to the 5700 transmitter, and in 2021 added Wi-Fi connectivity. "This is exciting because some customers have meters in hard-to-reach locations or simply suffer from lousy weather," Wyatt says. "Wi-Fi now gives them the ability to interact with their device from the safety of the ground or comfort of their truck." It also means that users can download all that historian data without having to physically connect to the device.

In 2008, Emerson debuted the Micro Motion 2200S, the first Coriolis transmitter to be powered by a 4-20mA loop, which meant it was low power enough be deployed in hazardous areas using intrinsic safety methodologies. This breakthrough opened up new possibilities for Coriolis technology to replace other, less accurate flow measurement technologies because it could use existing piping configurations and wiring infrastructure. Fast-forward to

SMART METER VERIFICATION

2010

Smart Meter Verification brings an easy, straightforward way to remotely confirm the continued performance and integrity of Emerson Micro Motion Coriolis meters

2014

The 5700 field-mount transmitter adds a slew of new functionality, including "zero verification" and an onboard historian

2019, and the 4200 two-wire successor to the 2200S brought the capabilities of the 5700 transmitter to the two-wire realm.

Measuring multiphase flows

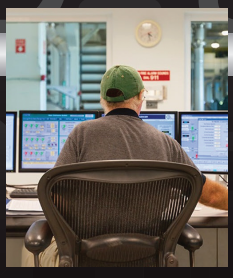
Perhaps the most dramatic advance that digital signal processing brought to Emerson's Micro Motion Coriolis family was the 2016 introduction of Advanced Phase Measurement, the ability to accurately measure multiphase flows. Previously, the presence of entrained gases had been detectable, but was used primarily as an alert to operators.

A digitally refined ability to understand the energy required to drive the sensor coil allowed Emerson engineers to get a better read on the relative mass flow rates of the liquid and the gas phases. Emerson's Tonya Wyatt likens the challenge to bouncing a basketball that's half filled with water. "It's going to bounce differently than if just filled with air, but it's not just the combined weight of the air and water—all the sloshing around takes energy, too."

"There are several dozen variables to consider in multiphase flow, including such subtleties as bubble size and surface tension," adds Patrick Zimmer, director of product marketing. "With Advanced Phase Measurement we can certainly measure gas and liquid flows, but also two immiscible liquids like oil and water, or even gas, oil and water together." Emerson has even built a three-phase flow lab at Emerson's Flow Measurement headquarters in Boulder, Colorado, where a broad range of applications have been validated for oil and gas customers as well as those in the food and beverage, dairy and other industries.

Micro Motion ProcessViz is a standalone software solution that takes Micro Motion transmitter raw historian data and displays it in an easy-to-use graphical format. It eliminates the need for technicians or engineers to engage in time-consuming data manipulations.

2016
Advanced Phase Measurement for the first time offers end users the ability to simultaneously measure the mass flowrates of each element in a multiphase flow



2017
Professional version of Smart Meter Verification adds compliance reporting and advanced diagnostics guidance

"The 1600 transmitter is a more compact, integral-mounted transmitter and is our first transmitter to feature hygienic finishes to complement our H Series hygienic sensors."

— Melissa Stiegler, Director, Food & Beverage Measurement Solutions, Emerson

Purpose fit for F&B, life sciences

Emerson has long made "simple yet targeted solutions" a key strategy in its product development processes, says Wyatt. "We ask, 'What problems are our customers trying to solve?'" she says, citing recent examples such as calibrating high-pressure hydrogen flows, and offering piece-wise linearization techniques to midstream oil and gas companies to increase custody transfer mass flow accuracy from 0.25% to 0.1%.

The most recent example of this strategy is the new Micro Motion 1600 transmitter set to debut in 2022. The 1600 transmitter is purpose-fit in both form factor and capabilities for the particular demands of the food & beverage and life sciences industries, says Melissa Stiegler, director, food & beverage measurement solutions, Emerson.

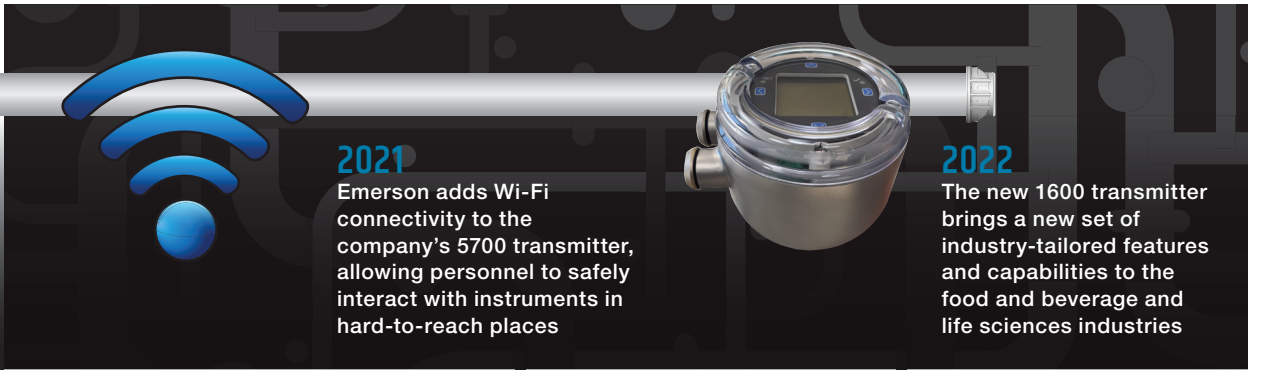
"The 1600 transmitter is a more compact, integral-mounted transmitter and is our first transmitter to feature hygienic finishes to complement our H Series hygienic sensors," Stiegler says. Also, since hazardous area classifications are seldom required in these industries, the device is powered and communicates via a four-wire, Power-over-Ethernet (PoE) network connection. "It features performance and capabilities that are of specific interest to these industries such as the onboard historian and Smart Meter Verification," Stiegler says. "It complements our 5700 transmitter and fills a specific market need."

Across the organization, Emerson recognizes the growing importance of digital tools to streamline engineering processes as well as to guide and inform its customers' operational decision-making. For example, the company's MyEmerson platform makes it easier for customers to quickly and accurately specify the correct instrument for their specific needs while also providing curated, device-specific information to help operational and maintenance personnel execute their work.

Advancing digital transformation

"We're also continuing to develop a range of tools to analyze instrument data and make it easy for our customers to understand what's going on in their processes and how their processes are changing over time," says Amy E. Johnson, vice president, Coriolis and ultrasonic meters, Emerson.

"Now that customers are upgrading their technology and communication protocols and the speed of data translation is getting better, customers are tapping into our meters because they are data machines," Johnson adds. "As a result, they are using the data to drive second order improvements to their facilities. They are operating more efficiently, with less down time and more safely." ■



Customer focus yields targeted Coriolis solutions

At its simplest, the chemical industry is centered on reacting one chemical with another to make yet a third. And as it turns out, mass is a much better indicator of proper reagent ratios than the volumes that traditional, pre-Coriolis flowmeters rely upon. So it was that the chemical industry was first to recognize the inherent value of mass flow measurement. Progressive chemical companies were first in line for the new meters back in 1977, and it was off to the races.

"Coriolis technology for the first time delivered a means of direct mass measurement," says Michael Machuca, marketing director, chemical measurement solutions, Emerson. "Our customers in the chemical industry really gravitated to that because they understood how a precise knowledge of molecular ratios is key to controlling chemical reactions." Coriolis measurements also gave chemical companies a better handle on mass balances across the plant, which in turn gave them a clearer understanding of overall plant efficiency and performance.

Other important chemical industry applications of Coriolis technology include custody transfer and batching of specialty chemical ingredients, where the meters' wide rangeability ensures highly accurate cumulative mass flow measurements even of multiple, different reagents. As in other industry verticals, the chemical industry embraced the inherent reliability of Coriolis meters to provide increased confidence in the validity of their meters' readings.

From chemicals to oil & gas

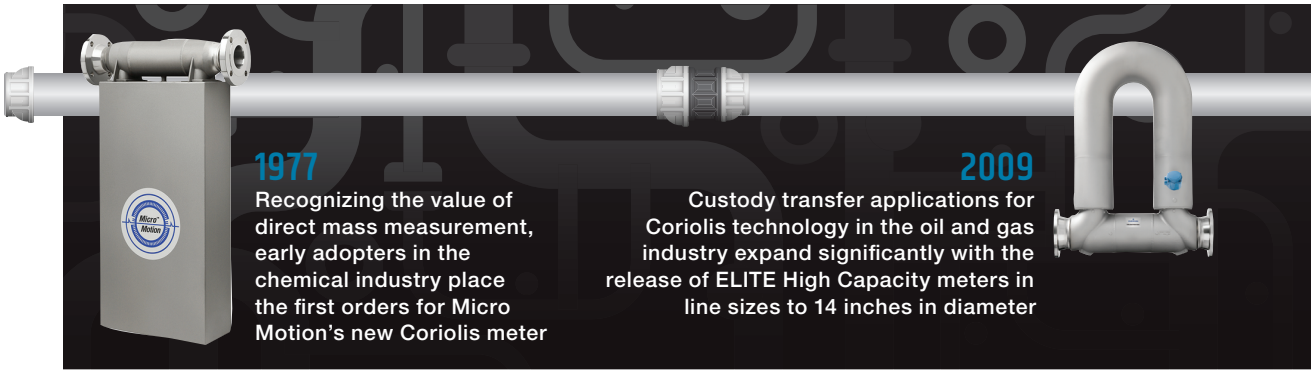
With a foothold in chemicals firmly established, continued innovations by Emerson's Coriolis engineers soon had customers in oil and gas turning to Coriolis technology as well. In this case, the earliest applications were in China and Russa, where energy companies were accustomed to selling products based on mass.

But demonstrated performance by Coriolis meters—together with computed volumetric outputs as a meter option—soon had API standards organizations in the US endorsing Coriolis as an acceptable alternative to traditional volumetric technologies for custody transfer.

Meanwhile, oil and gas processors continue to push their Coriolis meters to ever higher temperatures and pressures, as Emerson engineers responded to their increasing demands. They've also increased the size of their meters to as large as 14 inches in diameter, allowing Micro Motion Coriolis meters to satisfy all but the highest flow rate custody transfer applications.

A renewed focus on pharma, food & bev

For many of the same reasons that the chemical industry embraced Coriolis technology back in the 1970s, life sciences and food and beverage companies were also early adopters. In both arenas, product quality closely tracks accurate flow measurement, and the same ability to measure the flow rates of multiple substances over



"As we've increased the high pressure and temperature capabilities of our Coriolis meters, they've begun to migrate from midstream oil and gas custody transfer applications to inside the process-unit space of refineries."

— Meha Jha, Senior Marketing Manager, Refining Measurement Solutions, Emerson

wide ranges without recalibration or reconfiguration that appealed to specialty chemical makers was a key advantage in these sectors as well. The Coriolis meter is also well suited to clean-in-place processes.

Food and beverage manufacturers are particularly interested in maximizing production, and that means minimizing interruptions such as changeovers or unexpected equipment failures—both of which play to the Coriolis meter's strengths, says Melissa Stiegler, director, food & beverage measurement solutions, Emerson. "Sustainability is another issue of rising importance for food companies," Stiegler says. "So, reducing water and steam usage is another challenge we are focusing on."

With chemicals and oil and gas together accounting for some 80% of Emerson's Coriolis meter applications, the company clearly sees further growth potential in the food and pharma segments, and the company's new 1600 transmitter is designed to suit those industries' needs, with a fit-for-purpose combination of features and finishes.

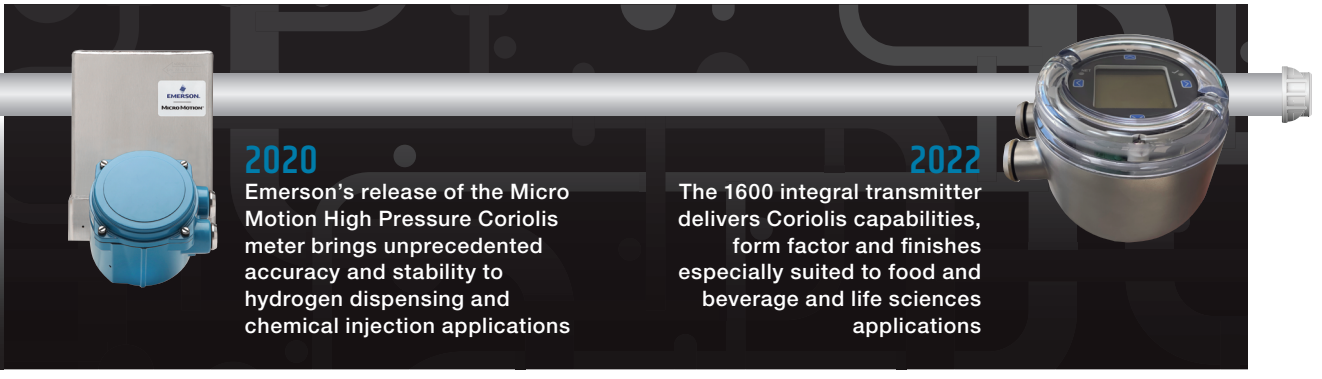
From refinery optimization to future energies

"As we've increased the high pressure and temperature capabilities of our Coriolis meters, they've begun to migrate from midstream oil and gas custody transfer applications to inside the process-unit space of refineries," notes Meha Jha, senior marketing manager, refining measurement solutions, Emerson.

Blending of crudes for consistent refinery operation is one key application for the company's Coriolis meters, as is the control of fuel gas ratios which are more readily optimized by mass ratio—leading to lower greenhouse gas emissions. They've been deployed to help optimize hydrogen production in refinery steam methane reforming hydrogen units. And their use has expanded beyond petroleum-based fuel production at refineries into the dispensing of alternative fuels like high-pressure hydrogen in commercial vehicle applications.

The Micro Motion High Pressure Coriolis meter features a gas mass flow accuracy rating of 0.5% at pressures up to 1,060 bar (15,375-psi). "It's the first meter approved for hydrogen dispensing in Europe," says Thomas Sautier, director of Coriolis product management, Emerson. "Coriolis meters in general have also played other sustainability roles beyond hydrogen into green diesel production and carbon capture."

And while this may not be an application that Micro Motion founder Jim Smith envisioned back in 1977, it's clear his inheritors are prepared to continue to reinvent what we know a Coriolis meter to be—for another half century at least. ■



We see

time traveling operators turning hindsight into foresight.

Micro Motion 5700 Transmitter

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Watch the informational video at
Emerson.com/WeSeeMicroMotion5700

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