

Measurement Instrumentation Approaches for Improving Pet Food Manufacturing



EMERSON™

Pet food must appeal to the animal and owner at the same time, presenting producers with a complex challenge. Maintaining consistent, reliable, and profitable production depends on effective instrumentation and control.

It's safe to say that people like their pets and are willing to go to great lengths to make sure they eat well (Figure 1). A glance down the pet aisle of a local supermarket or pet supply store will show a range of selections, but how big a business is it, really? A report compiled by Market Data Forecast* and released in March 2023, estimates that the North America pet food market in 2021 was US\$29.03 billion and growing on pace to reach US\$34.76 billion by 2026. Dog food leads, with cats in second place, and birds in a distant third.

In this eBook, we'll examine how producers, large and small, can improve production of wet and dry pet food products through improved instrumentation and automation.



FIGURE 1
Pet foods take a wide variety of forms.

*North America Pet Food Market, Market Data Forecast 2023

Industry Trends



Industry Trends

The days of one-bag-fits-all pet food are long gone, replaced by countless options from large-scale and boutique producers for different ages, sizes, and digestive health needs. Brands advertise that their offerings include vitamins, specialized fatty acids, probiotics, and other elements common to human health-food products. To keep up with changes in demand, producers must stay on their toes, watching markets and the latest developments in pet nutrition.

At the same time, supply chain disruptions are hurting virtually every industry, and those using agricultural products are especially affected due to shifting global food markets. Conflicts in grain-producing areas around the world have sent ripples into all areas of food processing, including pet food, as grain is a direct ingredient for many recipes. Moreover, when grain for animal feed is more costly, meat prices increase, directly affecting another major ingredient.

Even for companies with stable supply chains, personnel retention at all levels is another challenge. All food processors compete for the same pool of qualified people who understand the requirements of this industry (Figure 2). Those with training and a background in instrumentation and automation are especially difficult to find and recruit.



FIGURE 2

Finding workers with the required skills and experience is an ongoing challenge for pet food producers.

Food processing, both actual manufacturing steps and cleaning operations, is equipment intensive. Mixers, cookers, extruders, and other processing equipment must be supplemented by clean-in-place (CIP) systems and a variety of plant utilities, especially steam and hot water. Loss of any of these can slow or halt production, making equipment reliability critical across all manufacturing assets.

Pet food manufacturing is regulated by the U.S. FDA under the Food Safety Modernization Act (FSMA) of 2011. FSMA requires that animal food facilities create and implement food safety plans (Figure 3), including assessments of food safety hazards—and design of steps to prevent, reduce, or eliminate those hazards. People working in these plants as process designers, managers, and operators must understand how these regulations affect day-to-day activities.

Food safety requirements affecting the pet food industry have become more critical since the spate of widely-publicized pet illnesses and deaths about 15 years ago due to imported products and ingredients contaminated with melamine.



FIGURE 3

Pet food processors are subject to inspections by local health authorities.



Pet Food Manufacturing Process

Pet Food Manufacturing Process

When combined, food for dogs and cats accounts for the vast bulk of pet food production, so they will be the main area we examine in this eBook. The two main product categories cover wet (canned) and dry (bagged kibble, dog biscuits, etc., hereafter referred to as kibble). For most pet owners, the choice is a matter of convenience. Suffice it to say, the two together account for most production and require somewhat different manufacturing approaches, particularly for packaging.

Both begin with the same basic ingredients, including various dry components, along with meat and meat byproducts that are generally unsuitable for human consumption. Alternatively, vegetarian formulations bring in non-meat options.

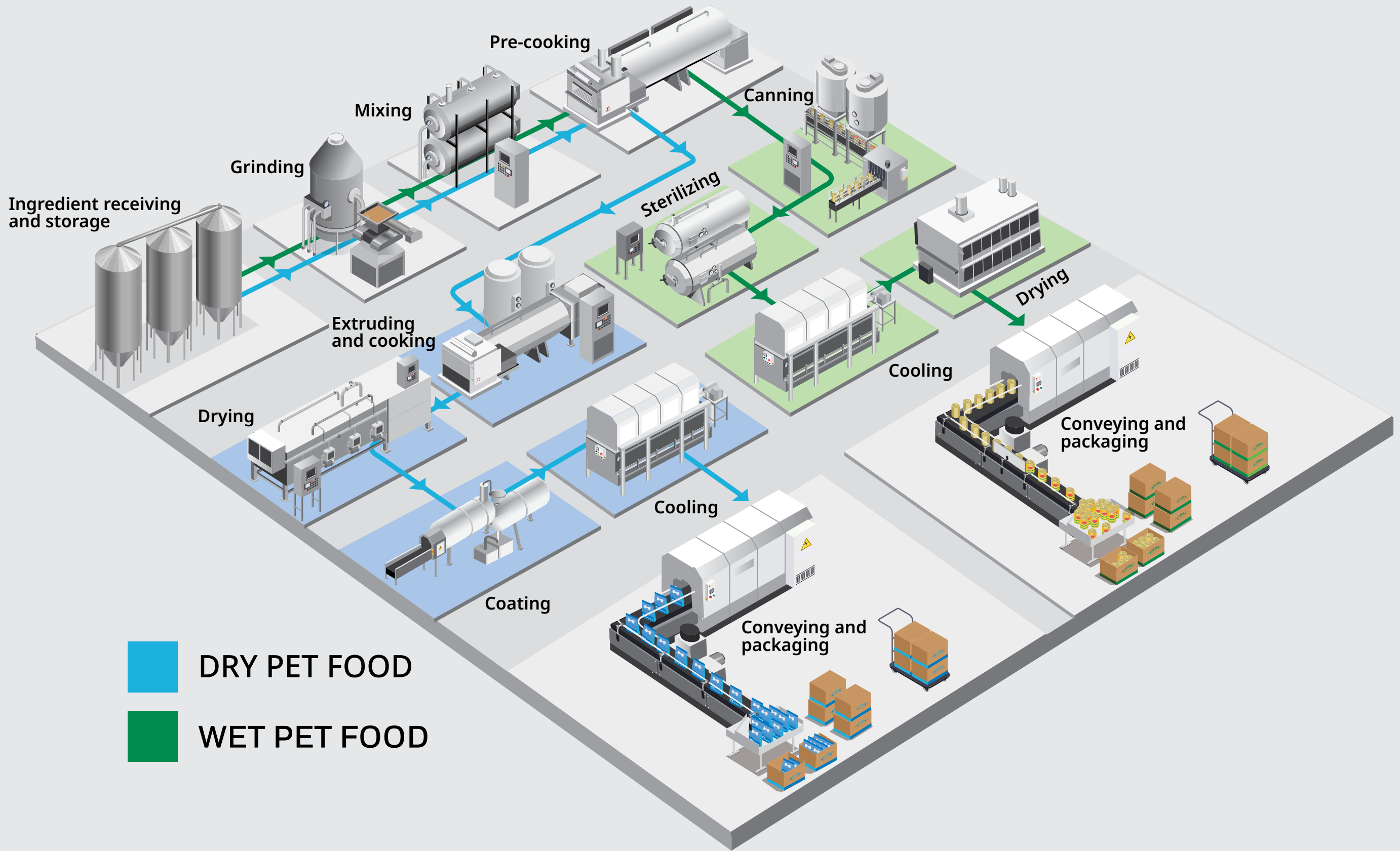
Initial manufacturing begins with wet and dry ingredients. Both are received and stored prior to the first processing steps. This typically involves grinding and cutting to reach the desired particle size, followed by the first mixing steps and cooking. Beyond this point, wet and dry products follow different paths.

With wet food, once this stage has been reached, the product is effectively finished and moves to the packaging process. Most of it is put in metal cans, but other options are also available, including plastic or metal trays and lids, pouches, and bags.



Dry food goes through additional processing steps, generally involving cooking and extruding so the product can be cut into specific kibble shapes prior to drying. These kibbles proceed to a tumbler mixer, where coatings are sprayed on to add flavors, colors, and binders to resist crumbling in the package. Kibble then goes to a conventional bagging process.

There is also a sub-category of soft dry food that is made into kibble but not dried completely. This offers the convenient handling of dry food, but it is easier for an animal to eat than the harder dry variety. Packaging for this type must retain moisture to avoid it drying out completely.



Manufacturing Challenges



Manufacturing Challenges

1 Maximizing production capacity — Manufacturing facilities are finite operations, and real-world budget constraints limit the amount of new equipment available. Therefore, to maintain and increase profitability, managers must find ways to get more from what is on hand. This means developing ways to shorten downtime between batches, speed up cleaning cycles, and reduce time consumed by manufacturing steps. For example, if it takes 35 minutes to bring a product batch up to a specified temperature, is there a way to apply heat more quickly to shorten that time without burning? Recipes and procedures must be frequently evaluated to determine if they are truly optimized.

2 Controlling production costs — These areas are similar to maximizing capacity, but also relate to ingredient and utility use. With virtually all costs rising, it is critical to control ingredient use to ensure product quality, but without waste and giveaways due to poor control loop performance. Similarly, use of plant utilities, especially steam, must be measured carefully to avoid waste.

3 Sustainability challenges — Manufacturers of all kinds are being challenged to improve their sustainability programs, mostly connected to emissions related to energy use. Since much of the energy used by food processors is natural gas to create steam and hot water, this utility deserves special attention. Water and compressed air use also figure into the picture.



4 Reliability and equipment efficiency — Any non-working manufacturing asset generates no income. These situations are obvious, but the less visible problem is the number of assets that are underutilized or not fully optimized. An asset working at 50% of its capacity probably needs maintenance attention. The challenge is to implement reliability and maintenance programs that take advantage of advanced diagnostic capabilities of sophisticated instrumentation to increase uptime. These instruments supply data able to indicate when problems are developing so action can be taken before there is an outright failure capable of causing a production outage.

A top-down photograph of a dog's head and front paws looking into a stainless steel bowl filled with dry kibble. The bowl sits on a wooden floor. The dog's fur is brown and white. The text 'Measurement Solutions for Pet Food Applications' is overlaid on a dark green background in the upper right corner.

Measurement Solutions for Pet Food Applications

Measurement Solutions for Pet Food Applications

Let's take a closer look at manufacturing processes and facility utilities, step-by-step, and how process instrumentation fits into the picture. We'll start with incoming ingredients, general cooking, and then the different ways wet and dry food are finished.

INGREDIENT RECEIVING AND STORAGE

Incoming ingredients, particularly those that make up the bulk of a recipe, are stored in silos or tanks. Monitoring level is critical, and the measurement solution must be appropriate for the product. Precise measurements are also important for effective inventory management of both dry and liquid ingredients.

For dry ingredients, such as grain and meal, top-mounted level instruments provide a continuous measurement. For this purpose, Emerson's Rosemount™ 5408 Non-Contacting Radar Level Transmitter (Figure 4) delivers accurate, reliable measurements. Its two-wire continuous wave technology deploys a continuous echo to maximize radar signal strength and produce a more robust and reliable measurement.

Where spot-level measurements are sufficient, or where overflow protection is required, Rosemount 2500 Series point level switches (Figure 5) provide flexible measurement of powders and grains. Four different technologies are available, so the best selection can be matched with the specific product.



FIGURE 4

Non-contacting radar level transmitters provide a continuous measurement and work well with solids and liquids.



FIGURE 5

Level switches provide point measurements, especially useful for warning when a storage tank is almost empty, or nearing capacity.

For liquid ingredients, many options are available to measure level from the bottom or top of a tank. Emerson's Rosemount 3051HT Hygienic Pressure Transmitter (Figure 6) is one such option, designed to be installed at the bottom of a tank for gauge and absolute measurements in pet food production. It uses standard sanitary fittings in conformance with 3-A, EHEDG, and ASME-BPE industry standards.

When it's better to measure from the top of a tank, Emerson's Rosemount 1408H Level Transmitter (Figure 7) provides accurate continuous level measurement, with accuracy of ± 2 mm. It uses standard sanitary fittings, and complies with 3-A, EHEDG, and ASME-BPE requirements. Since users might want to leave it in place during cleaning cycles, it can withstand normal CIP and steam-in-place (SIP) procedures.

Where a continuous reading is not necessary, or where tank-empty and overflow warnings are needed, Emerson's Rosemount 2120 Vibrating Fork Level Switch (Figure 8) is easy to install through a tank or vessel wall. It is certified for both sanitary and safety applications, and it can be configured with multiple output options depending on the application. Its reliability is very high since it has no moving parts, needs no calibration, and is unaffected by process conditions.



FIGURE 7

Top-mounting radar level transmitters designed in compliance with sanitary practices can be left in place during cleaning and sterilization cycles.



FIGURE 6

For liquid level measurements, adding a pressure transmitter at the bottom of a tank is an excellent way to get a continuous level reading.



FIGURE 8

When a level switch is mounted near the top of a tank, it can alert operators if a tank is being filled to the point of overflowing, or it can be mounted at the bottom to warn if a tank is almost empty.

GRINDING, MIXING, AND COOKING PROCESSES

Most recipes begin with an initial mixing and cooking step to combine and cook the main ingredients. The initial mix must be measured into the cooker in correct proportions and then heated to the required temperature.

Adding the ingredients in the correct amounts depends on effective flow meters, and for food processing, mass measurements are especially important. This calls for Emerson's Micro Motion™ Coriolis flow meters (Figure 9), known for their high accuracy and turn-down ratios.

For the main ingredients, inaccurate measurement is the primary challenge, which can be addressed by using Micro Motion ELITE Peak Performance Coriolis flow and density meters to provide accurate, repeatable flow measurement in these types of challenging environments and applications. Where hygienic configurations are necessary, Micro Motion H-Series meets the requirements for hygienic fittings and CIP/SIP capability.

Some liquid ingredients require an emulsifier to mix properly and prevent separation. Here again, Micro Motion Coriolis flow meters are an excellent choice.

Once ingredients are in the cooker, a radar level instrument can verify that the desired total volume has been achieved, which helps maximize production capacity. For this application, Emerson's Rosemount 3408 Non-Contacting Radar Level Transmitter (Figure 10) is often used, as this instrument offers smart diagnostics, along with easy configuration and maintenance.



FIGURE 9

Micro Motion Coriolis flow meters are available in a variety of sizes and configurations, but all share the same basic mass flow measuring capability.



FIGURE 10

A radar level transmitter on top of a cooker can verify that the correct volume is maintained throughout the process.

In most cooking applications, steam is the main heating mechanism because it provides very controllable heat, and many cookers have jackets designed for this very purpose. At the same time, steam is also very expensive, and in many facilities, is the largest energy consumer, so it can be a major source of waste if not handled correctly. This often happens when a facility doesn't measure steam use to the level of detail necessary. It is also important to monitor steam quality to ensure final product quality in cooking applications. To reduce steam cost, improve sustainability, and ensure quality, every major steam application must be measured precisely.

Measuring steam calls for specialized flow meters, and Emerson offers two options for this purpose. First, Rosemount 8800 and 8600 Series Vortex Flow Meters (Figure 11).

Rosemount 8800 Vortex Flow Meters are the most sophisticated and high-accuracy version, offering an integral temperature sensor, plus high reliability with a gasket-free, non-clog meter body. The unique design of Emerson's Rosemount 8800 features isolated sensors that eliminate the need to break process seals for flow and temperature sensor replacement.

Rosemount 8600 Utility Vortex Flow Meters are optimized for general purpose flow metering of clean fluids and steam flow. They offer high reliability and simple maintenance without any moving parts. In many facilities, Rosemount 8800 flow meters are used for high-volume steam lines near boilers, and Rosemount 8600 flow meters are used closer to individual steam-driven applications.

Where budget constraints are tight, Emerson's Rosemount 3051S MultiVariable™ Transmitter (Figure 12) can also provide insight into steam consumption at individual applications by monitoring day-to-day steam use.



FIGURE 11
Vortex flow meters work well for steam measurement and consumption analysis.



FIGURE 12
Multivariable transmitters offer fully compensated mass flow measurement to reduce variability and improve profitability.

Processing Wet Versus Dry Pet Food



Processing Wet Versus Dry Pet Food

Once a batch comes out of the cooker, this is the point where wet and dry products take different finishing and packaging paths. Let's look at them separately.

Wet food (Figure 13) typically goes to a canning or sealed tray line, followed by sterilizing and drying. These installations are normally built by specialist companies and system integrators with the necessary instrumentation for performance to basic specs. However, they can benefit from additional instrumentation outside of the normal offering to address the main issue, which is having the product/container leak after it has been shipped, which causes poor product quality, and may prevent retailers from selling the product.

First, canning lines generally require steam for heating sections. The steam feed to a canning line should be equipped with a Rosemount 8800 Series Vortex Flow Meter with its integral temperature sensor. This helps operators keep an eye on how much steam is being consumed for energy use analysis and to reach sustainability goals.



FIGURE 13

Wet food normally goes directly to a packaging line while it is still hot from the cooker.

Second, trays are filled with product and topped-off with an inert gas before being sealed to preserve product freshness. However, all packaging lines don't always monitor the final result, allowing leaking packages to spoil. Emerson's Rosemount CT4215 Packaging Leak Detection System (Figure 14) accurately tests 100% of food and beverage product packages that use modified-atmosphere packaging, going through the production lines to ensure seal integrity. This system measures up to 200 packs per minute, detects trace gases from defective packs, and instantly rejects them without disrupting production. It uses Emerson's patented quantum cascade laser technology, and it can be integrated with a conveyor mechanism to eject defective packages.

On the other hand, dry food (Figure 15) moves to a forming process, typically an extruder (kibble) or other molding approach (dog biscuits), to form the wet food into the desired final shape and proper size. Sized pieces move into a dryer stage, passing through ovens on a conveyor. These can be heated with steam, but gas-fired units are also common.

Monitoring the amount of natural gas used is critical to controlling costs, along with minimizing gas use and emissions for sustainability reasons.

Gas flow monitoring calls for appropriate technology, and Emerson offers two approaches. For large installations with a gas line of two inches or larger, the Rosemount 3051SFA Annubar™ Flow Meter (Figure 16) uses a patented, averaging pitot tube and integrated thermowell that allows its transmitter to deliver a volume or mass reading for natural gas flow.

For line sizes of ½ to 12 inches, the Rosemount 8800D Vortex Flow Meter is available in a variety of piping configurations. This technology is frequently recommended for steam, but also works well with compressed air and natural gas.



FIGURE 14 Emerson's Rosemount CT4215 Packaging Leak Detection System is able to detect minute amounts of gas leaking from a package, indicating an incomplete seal.



FIGURE 16 For large natural gas lines, a differential pressure flow meter using an Annubar minimizes pressure drop.



FIGURE 15 Dry food moves from the cooker to a forming stage prior to drying.

Dry food is often sprayed with various coatings after an initial drying process to add nutrients, flavors, and binders to minimize crumbling after packaging. Coating systems should be instrumented with flow meters and pressure transmitters to ensure the correct amount is being added. This improves product quality and reduces product waste, which can occur if inaccurate amounts of coating are spread on dry food. Coating is expensive, so it is important to make sure producers have the necessary instrumentation to use it efficiently.

For this application (Figure 17), Emerson's Micro Motion Coriolis sensor can be matched with a 1600 transmitter to monitor coating flow, and then transmit this data via a native Ethernet connection. Its Power over Ethernet (PoE) and data historian features capture data on process events, fluid quality, and measurement stability over long and short periods of time. This application also calls for a Rosemount 3051HT Hygienic Pressure Transmitter to ensure coatings are being delivered as needed.



FIGURE 17

Coating lines require careful control of both flow and pressure to ensure the food gets just the right amount of additive.

Utilities



Utilities

Food processing facilities use a range of utilities under the umbrella of “WAGES,” water, compressed air, natural gas, electricity, and steam. We should focus on two areas that are both costly and frequently under-instrumented: steam and CIP. Both are critical to operation and expensive to operate, and if not adequately instrumented, can waste energy and resources, reducing overall sustainability.

For food processing, steam is usually applied as a heating source, especially for cookers, but also for heating water. Creating steam is very expensive, and in most facilities, it flows from natural gas fired or electric boilers. Steam distribution calls for careful monitoring, since if not used properly, it simply reverts to water, losing all its energy. To control steam cost and improve sustainability, every major steam application must be measured precisely to characterize how it is being used and where savings can be made.

As discussed earlier in the cooking section, specialized flow meters are necessary for steam applications, and Emerson offers two options for this purpose. First, Rosemount 8800 and 8600 Series Vortex Flow Meters. The Rosemount 8800 is the more sophisticated and higher-accuracy version, often used for high-volume steam lines near boilers. The Rosemount 8600 Utility Vortex Flow Meter is optimized for general purpose flow metering of clean fluids and steam flow. It offers high reliability and simple maintenance without any moving parts, and it is often used closer to individual steam-driven applications.



The largest steam lines (2 inches and larger) can use Emerson's Rosemount 3051SFA Annubar Flow Meter with its patented, averaging pitot tube and integrated thermowell. This gives it the capability to deliver a volume or mass reading for steam flow.

Once steam has transferred its heat to a cooker or other application, it turns back into liquid water, typically referred to as condensate. This must be removed from live steam lines using a condensate separation device: a steam trap. The idea is simple, but the effect is complicated. If a steam trap doesn't remove condensate fast enough, it backs up into the steam passages which reduces heat transfer. If it allows steam to blow past, it wastes heat. If the steam trap is sized properly and uses an appropriate design for the application, its action should be automatic, provided it is functioning correctly. Unfortunately, where there is a mechanism, there is an opportunity for malfunction.

A steam trap can fail in one of two ways: it sticks open and releases steam, or it sticks closed and doesn't release anything. Inspectors on plant rounds search for malfunctioning units, but a technician has to get to wherever the steam trap is installed and make the evaluation. Unless manual rounds by a highly qualified and experienced technician happen regularly and frequently, one or many steam traps can malfunction for a long time.



Most steam traps, when working properly, open intermittently and discharge condensate in slugs. This creates noise, which transmits through the adjacent piping. A Rosemount 708 Wireless Acoustic Transmitter (Figure 18) mounted on the pipe adjacent to a steam trap can hear the cycling and send data via WirelessHART® to a central data collection and analysis platform, such as the Plantweb Insight™ Steam Trap Application, where operators can see how the steam traps are performing. Maintenance can determine precisely which steam traps need attention and plan activities appropriately.

CIP and SIP systems are normally built on skids, fixed or moveable, that contain all the required tanks, pumps, valves, and instrumentation. Most systems use combinations of steam, alkali, acid, and water wash steps, each forcing solutions through processing equipment. Mixers, storage tanks, piping, and so forth are all designed to be cleaned this way, following appropriate design standards. Most CIP skids have basic instrumentation, such as flow meters and pressure transmitters, but depending on how advanced the system is, more sophisticated instruments at strategic places may be desirable.

For example, Emerson's Rosemount 8721 and 8705 Magnetic Flow Meters (Figure 19) are highly accurate and well suited to CIP applications, outperforming many of the units installed

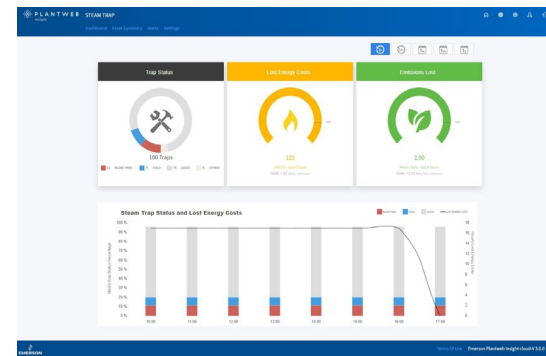


FIGURE 18 Mounting an acoustic transmitter on a pipe adjacent to a steam trap can determine if it is functioning properly, and the transmitter can report its results to the reliability team.



FIGURE 19 Solutions used with CIP systems tend to be very conductive, so they work well with magnetic flow meters.

originally on skids. Sensors start at ½ inch pipe size, with a fully-welded assembly for long and dependable service.

Cleaning and rinsing solution storage tanks often have rudimentary level measuring capabilities. These can benefit from Emerson’s Rosemount Non-Contacting Radar level instruments (Figure 20). The Rosemount 1208 Level Transmitter provides accurate level measurement for cleaning solutions and water. It uses continuous non-contacting technology in a compact polyvinylidene fluoride housing, so it helps ensure tanks are not pumped dry during cleaning cycles. Where a sanitary design is necessary, the Rosemount 1408H Level Transmitter provides the same accurate performance, but with a polished stainless-steel housing designed to match hygienic requirements in the food and beverage industry, and able to withstand CIP and SIP cleaning processes.

Many cleaning cycles use hot solutions, heated by steam. Depending on the size of the skid and how much solution it handles, the amount of steam can be significant. Some of the same flow meters used for cookers should also be applied here, including Emerson’s Rosemount 8800 and 8600 Series Vortex Flow Meters.

Verification of cleaning solution strength is also required for many cleaning procedures. Rosemount 400 Contacting Conductivity Sensors (Figure 21) accurately measure electrolytic conductivity of alkali, acid, and neutral cleaning solutions to verify that they have not lost their required concentration.



FIGURE 20
Radar level transmitters mounted on CIP solution storage tanks help manage solution usage.



FIGURE 21
Measuring conductivity of cleaning solutions helps verify their concentration, indicating if a solution needs to be replaced or replenished.

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