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THE STATE OF FOOD MANUFACTURING 2025

How Carbon Dioxide Capture Supports the Food Industry

Are Your Temps on Spec in Your Freezer and Cold Room?

Tips for Building Food Packaging Lines

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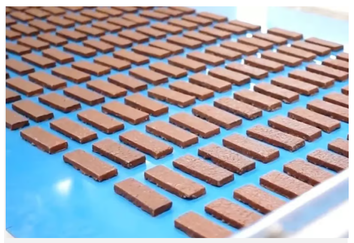

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What's Driving Change in Food Manufacturing?

AI, automation and consumer trends continue to drive change in food and beverage manufacturing, according to our 2025 State of Food Manufacturing survey.

IT'S A QUESTION WE AT FOOD ENGINEERING ASK ALL THE TIME, and it's not necessarily an easy one to answer:

What's driving change in food manufacturing?

There are all kinds of forces at play – whether it's external economic and technological forces or the internal need for continuous improvement.

Luckily, with our 46th State of Food Manufacturing survey, we have an opportunity to narrow down our scope. In partnership with research firm myCLEARopinion, we asked food and beverage professionals which trends they believe will shape manufacturing over the next five years.

Once again, artificial intelligence (AI) and automation integration topped this list. This year, 35% of survey respondents say AI and automation are a major trend, up from 27% in 2024.

As one respondent notes: "The use of AI assisted programs and processes will greatly revolutionize not only the food industries but most likely all industries. Its use is becoming more widespread and adaptation is rapidly increasing."

Another writes: "Artificial Intelligence will drastically change our operations for the better. Business plans include incorporating predictive maintenance, cobots, generative design algorithms, (and) better supply chain management initiatives within the next fiscal year."

Consumer demand is also an important driver, according to 19% of survey respondents. In their written responses, manufacturing professionals cite a shift to ready-to-eat and clean-label products.

Health and wellness follow as the third top trend, with 13% of respondents marking it. We saw how quickly the Covid-19 pandemic changed manufacturing protocols, ingredient availability, and even new product launches designed to boost immunity.

Over the last few years, we've also seen the rise of GLP-1 drugs for weight loss. Food manufacturers such as Nestlé and Conagra Brands have responded in kind, launching nutrient-dense products in small portions. We also can't forget about the recent push to phase out artificial dyes in favor of natural colorants. I imagine health and wellness will continue to shape how consumers — and by extension, manufacturers — think about food.

Cost control and regulatory compliance round out the top five. With the Trump administration's tariffs, alongside high interest rates and inflation, it's not a surprise that manufacturers are concerned about how to keep their costs down.

With rapidly evolving technology, consumer trends and economic environment, it's difficult to predict what's ahead, but whatever challenges come their way, I know food and beverage manufacturers will rise to meet them. **FE**

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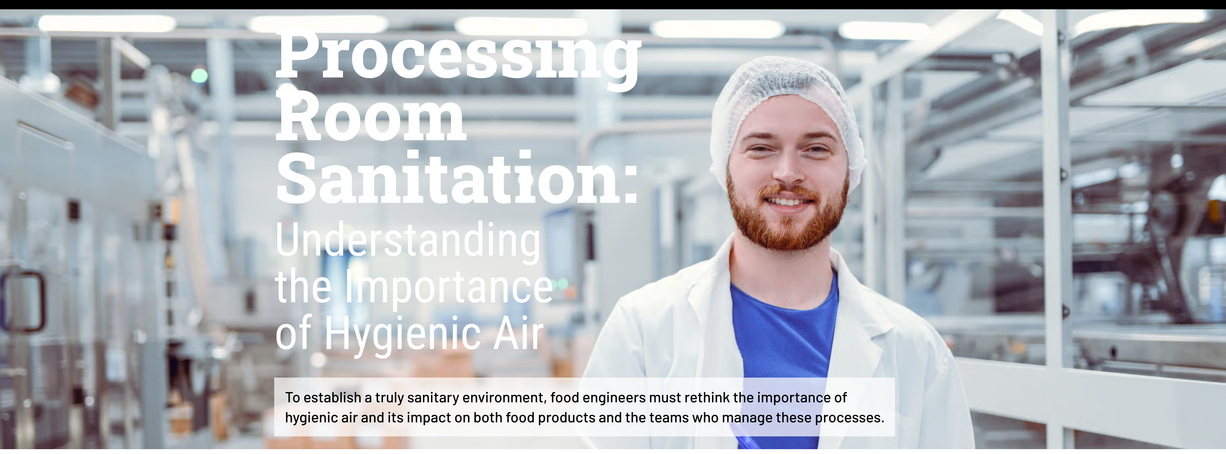

Processing Room Sanitation: Understanding the Importance of Hygienic Air

To establish a truly sanitary environment, food engineers must rethink the importance of hygienic air and its impact on both food products and the teams who manage these processes.

Photo courtesy: AleksandarGeorgiev / Getty Images

BY VICTORIA STEVENS SCHAUB, ACUAIR AND FPHE PRODUCT MANAGER, JOHNSON CONTROLS – FRICK INDUSTRIAL REFRIGERATION

Reliable and efficient processing room sanitation is the backbone of quality food production. Without the proper equipment in place, processing rooms can easily become susceptible to contamination requiring longer and more frequent wash-down intervals.

Maintaining superior food safety requires precise and consistent control of temperature, air filtration, air distribution and room pressurization. Many food manufacturers rely on ceiling-hung evaporators to maintain healthy processing room conditions after wash-downs. However, these systems are often limited to producing a recirculated stream of cold air. As a result, plant personnel are unable to control the humidity, airflow and filtration within the space – factors that can leave processing rooms susceptible to microbial growth and the spread of pathogens.

To establish a truly sanitary environment, food engineers must rethink the importance of hygienic air and its impact on both food products and the teams who manage these processes.

Risks From The Status Quo

It is recognized that temperature regulation after wash cycles is a critical component to maintaining a safe processing environment. However, managing humidity from temperature instabilities is also essential. Evaporators blast cold air to balance the inrush of heat produced during wash-down intervals, but this process provides little to no control over the direction of the airflow. As airborne water vapors settle, condensation can form — creating an environment for microbial activation and migration. In parallel, any contaminants within the room can easily become disrupted during the wash-down process. Without proper air filtration and room pressurization, these transient microbes are recirculated within the space and given access to migrate throughout the facility. Similarly, airborne particles can also enter the processing room from adjacent dirty rooms if each space is not adequately pressurized.

Air quality within the processing room also impacts the health and well-being of employees. Low-positioned ceiling-hung evaporators may blow cold air directly into employee workspaces, creating an environment that can be uncomfortable. Staff are also subject to poor indoor air quality (IAQ) from recirculated airflow that can potentially be contaminated with microbes and pathogens.

With traditional in-room cooling designs, it may seem nearly impossible to control air, but with the right equipment, processing rooms can be transformed into high-performing, healthy environments that support public and employee safety while preserving food quality.

Enhance Safety With Hygienic Air Systems

Hygienic air systems provide food engineers with a customizable solution to manage processing room sanitation. These purpose-built systems are engineered to meet the unique moisture and heat requirements of each processing room as it continuously flushes the space with dry, clean air and exhausts moisture and airborne contaminates.

During operation, fresh outside air is drawn into the hygienic air system and immediately conditioned to ensure fresh, clean air is introduced into the space. Filtration features a combination of either HEPA- or MERV-rated filters that can pair with ultraviolet lighting to sanitize airflow and support healthy IAQ for employees. The filtered air replaces any air that naturally escapes the process room to provide positive pressurization within the space to prevent cross-contamination from less hygienic rooms.

Hygienic air systems also provide humidity control by modulating between cooling and re-heat features that are designed to match the specific requirements of the space. Relative humidity levels are programmed within the system based on ideal processing conditions for each product, such as dairy or bread. Additionally, the system can automate operating levels in response to ambient conditions.

The equipment also manages air velocity to help ensure maximum coverage throughout the room and eliminate "dead spots" that may go untreated. Using a multi-directional stream, air sweeps across the ceiling to quickly dry surfaces and eliminate suspended condensation. This process also creates a more hospitable work environment for employees because air is not directly blown onto workstations.

Designing Processing Rooms For Maximum Uptime And Quality

Hygienic air systems are engineered to be roof-mounted outside of the building. This not only frees up space within the processing room; it also eliminates the need to sanitize the equipment itself. Each processing room must be equipped with a dedicated unit. This prevents cross-contamination and allows the transition from ceiling-hung evaporators to be scaled over time, if desired. Size, air volume, functionality and configuration of the equipment are determined by each processing room's unique requirements. For example, ready-to-eat (RTE) products may need enhanced filtration, whereas meat processing often requires stringent temperature control.

Like most building equipment, hygienic air system operation is maximized when integrated within a complete building automation system (BAS). Features such as real-time humidity sensing, automated reheat and economizer mode control can be enabled through the BAS to further optimize performance.

Sanitation is a necessary function within the processing room, but outdated practices reliant on ceiling-hung evaporators can create an environment that is susceptible to contamination. These high-risk conditions not only threaten public and employee health and well-being – they can also result in longer, more frequent wash cycles than are necessary. Specifying purpose-built hygienic air systems can alleviate these concerns by improving air distribution while delivering precise temperature and humidity control to enable faster dry times, maximized uptime and a longer-lasting clean environment.

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How Carbon Dioxide Capture And Liquefaction Supports Food Industry Revenue And Sustainability

More North American food and beverage producers are focusing on the capture and liquefaction of carbon dioxide from their waste processes to reduce costs, generate additional revenue and reduce greenhouse gas emissions.

Photo courtesy: Getty Images / Alter_photo

BY BENJAMIN BURFEIND, DIRECTOR OF PRODUCT MANAGEMENT, RENEWABLE GAS NAM, KANADEVIA INOVA USA, LLC, AND MANUELA HOELLINGER, MANAGER, MARKETING AND COMMUNICATIONS NAM, KANADEVIA INOVA USA, LLC

Converting to sustainable business practices is becoming more relevant for corporations in all sectors. A recent Kearney survey shows that 80% of buyers consider the environmental impacts of their purchases. Responding to this, companies continue to build sustainable practices into their operations, creating value for their customers and stakeholders.

For larger business operations, the integration of sustainability projects is more likely part of a broad strategy to optimize all facets of their business, from facility operations and process functions to manpower and distribution, while incorporating sustainable materials and procedures.

A crucial aspect of any sustainability initiative is minimizing a company's carbon footprint. As global demand for energy rises, so does the need for solutions to minimize the influence of carbon dioxide (CO_2) released from fossil fuels and other unsustainable sources into the environment. Food and beverage manufacturing operations, as significant consumers of energy and a source of carbon emissions in the global economy, need to play a contributing role in partnership with sustainability.

CO_2 CAPTURE AND LIQUEFACTION

While preventing carbon dioxide from being released into the atmosphere continues to be a key objective of sustainable practices, more recent decarbonization efforts have focused on CO_2 capture, with subsequent storage and/or reuse. Essentially, it involves capturing CO_2 from food and beverage manufacturing operations, then either sequestering CO_2 into deep underground storage, or converting it into reusable by-products.

Whether sequestering or repurposing CO_2, it first must be converted from a gaseous state to a fluid state to be transported and stored. The liquid state of carbon dioxide is typically between a temperature of -11°F (-24°C) and -18°F (-28°C), at a pressure between 206 – 261 PSI (g).

REPURPOSING LIQUEFIED CO_2

Solutions providing repurposed and renewable liquefied CO_2 are becoming increasingly important in numerous areas of application, enhancing circularity, decarbonization, improving supply security and reducing transportation costs. The fact that liquefied CO_2 is needed in food and beverage production and storage is increasingly directing attention onto this renewable by-product as a valuable commodity.

FOOD PRODUCTION AND PRESERVATION

The importance of pressurized CO_2 in the food industry cannot be understated. The food industry relies on this liquid gas for crop growth, refrigeration, preservation, storage and softening.

CROP GROWTH

CO_2 is used in agriculture to increase crop growth and photosynthesis and to minimize crop waste. Plants use CO_2, water, and sunlight to produce carbohydrates and oxygen through photosynthesis. Higher levels of CO_2 can improve the efficiency of photosynthesis, allowing plants to use light more effectively and produce more energy for growth.

This can also improve water conservation because carbon dioxide reduces the rate at which plants lose water through evaporation. Supplemental CO_2 in greenhouses can increase a crop's ideal temperature range, which can lead to higher production even in warmer temperatures.

FOOD PRESERVATION

The food supply chain uses many strategies to increase food production, extend fresh food availability and shelf-life, and reduce waste.

CO_2 is used in controlled storage atmospheres as a cooling agent to reduce food spoilage and extend the shelf life of fruits, vegetables, meats, seafood and other perishable products. It inhibits the growth of certain bacteria and molds, which are common causes of food spoilage. By

creating an environment that slows down the degradation process, CO_2 ensures that food products remain fresh for longer periods.

Fresh fruits and vegetables are alive and continue to respire even after harvest. Fruit respiration is necessary for ripening. However, it has a downside: It can negatively affect internal and external fruit quality attributes. The higher the respiration rate, the more perishable the

produce is, so high respiration rates result in less shelf-life. CO_2 technology in produce preservation is a leading post-harvest method to preserve food quality and extend yield from the farm to retailer's shelves. Carbon dioxide has three main functions in the post-harvest phases:

1. Reducing respiration rate
2. Reducing microbial and pest infestation
3. Cryogenic cooling

CO_2 is effective in the storage of frozen foods. It can be used in combination with other gases to create a protective atmosphere around frozen items, further inhibiting the growth of spoilage microorganisms. This technique retains the color, flavor and texture of frozen goods for a longer time by limiting the formation of ice particles.

In the baking and pastry industry, carbon dioxide is produced to help dough rise, resulting in baked goods like bread, cakes and pastries with a light, airy texture.

Food-grade CO_2 can be incorporated into food packaging to inhibit the growth of microorganisms. CO_2 is non-toxic, has a natural bacteriostatic power, and is a sustainable and eco-friendly solution to traditional preservation methods.

BEVERAGE PRODUCTION

SPIRITS DISTILLING

Fermentation creates CO_2. Rather than releasing it into the atmosphere, distillers can capture carbon dioxide as a byproduct, which can be sold on the market to soda or beer producers for carbonation, or to greenhouses to grow plants that will, in turn, sequester more carbon and store it as soil organic carbon (SOC).

BREWING

All beer leaves the brewer carbonated. This is accomplished in one of two ways – natural and forced carbonation. In both cases, beer and carbon dioxide are sealed in a container under pressure. The beer absorbs the CO_2, giving the beer its fizz.

One of the main ways breweries can control CO_2 emissions is to capture and reuse the gas produced during fermentation. During the brewing process, yeast converts sugar into alcohol and carbon dioxide. Capturing and reusing this carbon dioxide allows breweries to reuse the gas at various stages of production and for cleaning process equipment. By integrating such a closed-loop system, breweries can more efficiently utilize their resources while reducing CO_2 emissions.

SOFT DRINKS

Compressed CO_2 is used to carbonate soft drinks and add flavor, but it is also used to fill the packaging of the drinks to maintain the proper pressure and environment for the carbon dioxide to remain in the soda. The CO_2 used to carbonate soft drinks can come from a variety of industry sources.

DECAFFEINATION OF COFFEE AND TEA

Liquefied CO_2 has increasingly become an important commercial solvent due to its role in chemical extraction, in addition to its relatively low toxicity and environmental impact. It is used as a method to remove caffeine from coffee and tea. This process is chemical-free and natural, which does not damage the cell structure or components responsible for the aroma and taste.

The relatively low temperature of the process and the stability of CO_2 also allows compounds to be extracted with little damage or denaturing. The solubility of many extracted compounds in CO_2 varies with pressure, permitting selective extractions.

CO_2 LIQUEFACTION PROCESSES

Although variations exist in CO_2 liquefaction process technologies, one that stands out with high performance is the latest-generation technology from Hypro Engineers Pvt Ltd. (Hypro) in collaboration with Kanadevia Inova USA, LLC. The two companies have an exclusive agreement on providing their solutions to the American CO_2 markets.

Kanadevia Inova and Hypro offer integrated and standalone solutions, tailored for the respective industries, and ensuring the levels of CO_2 purity required by the food and beverage industry.

The fundamental process steps for CO_2 liquefaction with plants designed and manufactured by Hypro for Kanadevia Inova include the following:

- *Scrubbing:* The CO_2 gas is fed into a scrubber unit to wash and cool down the gas.
- *CO2 intermediate storage:* The carbon dioxide is being stored in a balloon after some trace contaminants are removed.
- *Cooling and two-stage compression with drying:* This process cools down the water-saturated feed gas, then separates the bulk water. The cooled gas is sent to a CO_2 compressor which increases the pressure to meet operating conditions.
- *Drying and absorption:* The remaining water and traces and other chemical components are removed from the CO_2 gas stream with interchangeable dryers. Depending on requirements, various absorbers and filters are installed downstream to remove further components.
- *Liquefaction:* The liquefaction process occurs through the condenser whereby the liquid CO_2 is cooled down to temperatures below -13°F (-25°C).
- *Optional rectifier and reboiler:* The dry CO_2 liquid passes through the rectifier and a reboiler,allowing for the non-condensable impurities to be passed through the vent stack and the liquid to be sent to storage tanks. A portion of the liquid CO_2 is then sent back to the condenser, improving the product quality as a part of a feedback loop.
- *Storage and loading for transport:* The liquefied CO_2 is stored in pressurized tanks for offtake and/or on-site applications. The CO_2 is then potentially further pressurized by means of additional compression and transformed into a supercritical state, then transported via a pipeline network. Another option is that the CO_2 from the storage tanks is transported via trucks, railway cars, or ships for non-sequestration use, typically food and beverage-production applications.

Kanadevia Inova's automated operations and controls dynamically adjust the processes to meet changes in feed gas composition and plant loads, achieving an output quality of 99.99% pure liquified CO_2. This supports maximized revenue return and heightened sustainability profiles for operations in multiple industries such as food production and preservation, spirits distilling and brewing.

ECONOMIC ADVANTAGES OF CO_2 LIQUEFACTION

In addition to the reduction of greenhouse gases released into the environment, CO_2 liquefaction pays off monetarily by providing additional revenue streams with the sale of CO_2 to other sectors of industry, or OPEX reduction by recirculating the captured and liquefied CO2 into the production process, hence making the system more self-sufficient.

Data from different industries vary and indicate that CO_2 can be captured on a larger scale with a capacity range of medium size systems producing 11,000-12,125 short tons or 10,000-30,000 metric tons per year, respectively, to even larger scale production facility that produce 82,650 to 165,350 short tons (75,000-150,000 metric tons) per annum. The value of the capture, and ultimately, liquefied CO_2 is contingent on whether it is sequestered, diverted into a depleted oil field (EOR – Enhanced Oil Recovery), sold directly into the food and beverage industry, or recirculated into the production process to minimize or completely remove the LCO$_2$ (liquified CO_2) transportation costs from the cost equation.

Additionally, the carbon credits from CO_2 liquefaction can be traded on the voluntary carbon market (VCM), both nationally and globally. For food and beverage manufacturers, CO_2 liquefaction presents a viable addition to further diversify a company's income portfolio. **FE**

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THE STATE OF FOOD MANUFACTURING 2025

While sales were largely down under dynamic economic and geopolitical conditions, some of the world's top food and beverage manufacturers experienced revenue growth.

Photo credit: Valerii Apetroaiei / Getty Images

BY ALYSE THOMPSON-RICHARDS

OVERALL, FOOD MANUFACTURERS CONTINUE TO INVEST in equipment and training despite rising material and labor costs.

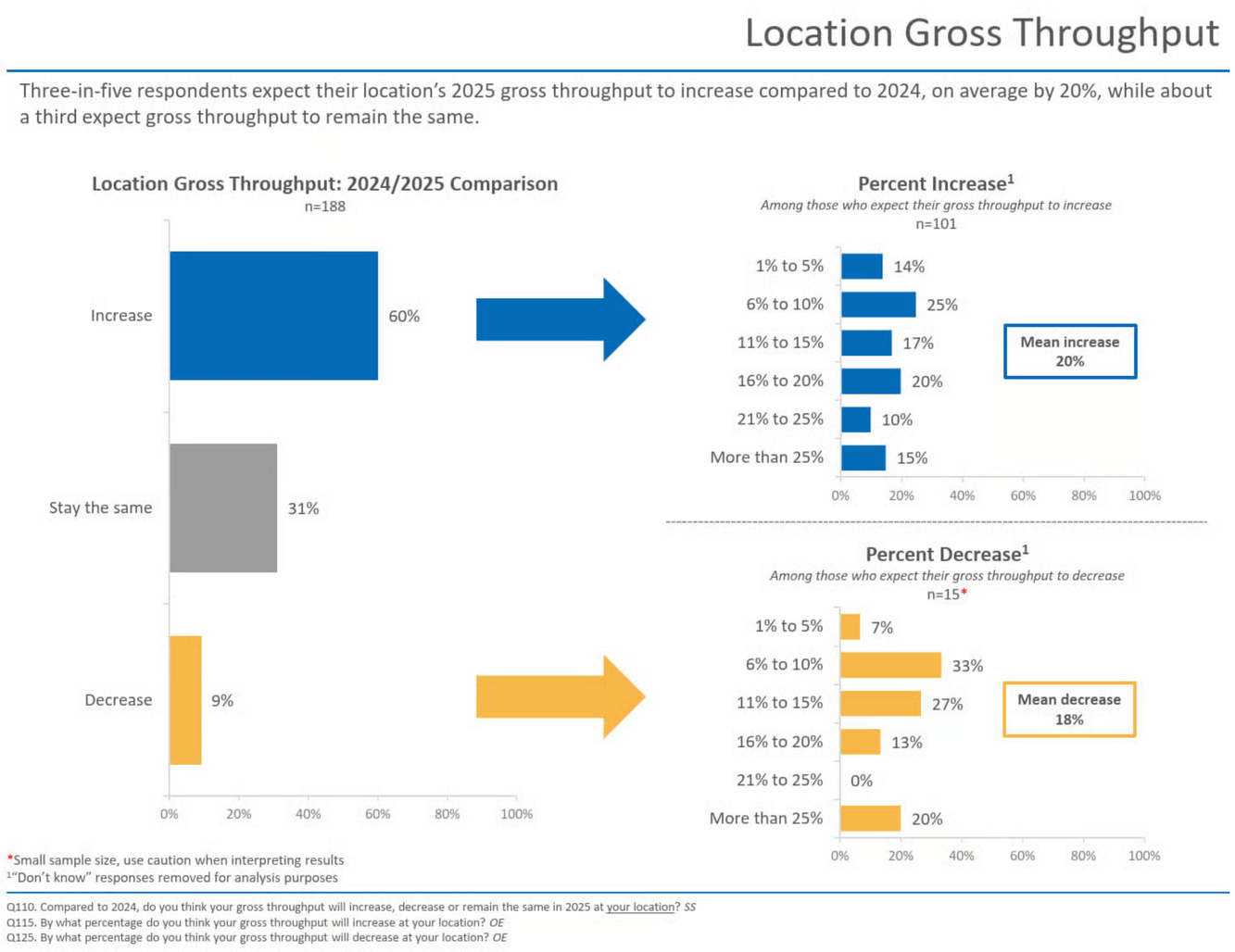
That's according to FOOD ENGINEERING's 46th State of Food Manufacturing survey, conducted annually in partnership with research firm myCLEARopinion Insights Hub. We asked food and beverage manufacturing professionals about operational improvements, equipment budgets, food safety implementation and more.

These insights, following our 48th Plant Construction Survey and our annual ranking of the Top 100 Food and Beverage Companies, offer a complete picture of manufacturers' priorities, concerns and experiences.

THROUGHPUT EXPECTATIONS

Similar to 2024, three in five (60%) food manufacturing professionals expect their location's throughput to increase in 2025 – by 20% on average. One quarter of respondents project their location's throughput will increase by 6% to 10%, while 17% expect an increase of 11% to 15%. Another quarter expect a throughput increase of more than 20%.

Manufacturers cite increased business or new customers (28%) and increased demand (23%) as reasons driving growth in throughput, but expanded product offerings, expanded operations and improved efficiency also made the list.



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While sales were largely down under dynamic economic and geopolitical conditions, some of the world's top food and beverage manufacturers experienced revenue growth.

Photo credit: Valerii Apetroaiei / Getty Images

BY ALYSE THOMPSON-RICHARDS

MEANWHILE, 1 IN 10 (9%) OF RESPONDENTS SAY their location will experience a reduction in gross throughput this year. One-third project a decrease of 6% to 10%, while another 27% expects throughput to drop by 11% to 15%. The average decrease is 18%.

Survey respondents who expect a decrease point to economic and market conditions, cost and pricing pressures, labor challenges, operational and production issues, and customer and sales impacts.

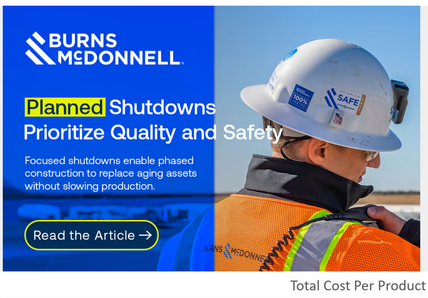
One executive cites workforce concerns: "We are unable to find labor and the only answer we have right now is to produce less product."

Another discusses shifting consumer demand in the face of economic pressures: "My products are not considered essential to consumers who are focused on basic items rather than 'treats.'"

COST PER PRODUCT

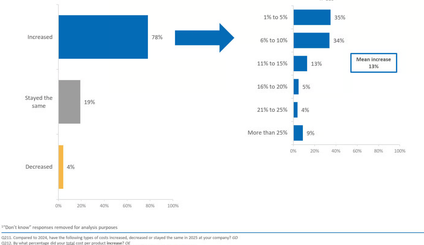
Overall, survey respondents say the cost of manufacturing products has increased in 2025. In fact, 78% say they're experiencing increases from 2024, while last year, 68% of manufacturing professionals said total cost per product increased from 2023.

Nearly 70% of this year's survey respondents say their company's total cost per product has increased up to 10%, while 13% say costs have jumped between 11% and 15%. The mean increase is 13%.



Total Cost Per Product

More than three-quarters of respondents indicate that their company's 2025 total cost per product has increased compared to 2024, on average by 13%.



[1]"Don't know" responses removed for analysis purposes

Q211. Compared to 2024, have the following types of costs increased, decreased or stayed the same in 2025 at your company? ☒

Q212. By what percentage did your total cost per product increase? OR

Q213. By what percentage did your total cost per product decrease? OR *Insufficient sample size for analysis*

Credit: Graphic courtesy of myCLERopinion

Looking at labor costs per product, 64% of surveyed manufacturing professionals say they're expecting an increase, while 32% expect them to remain the same. Most (42%) expect labor costs per project to grow 1% to 5%, while another third (33%) expect them to increase 6%-10%. On average, they expect labor cost per product to rise 11%.

The majority of food manufacturers (81%) also project material costs per product to rise in 2025. Nearly 40% expect an increase of 1% to 5%, while 29% expect material costs per product to grow by 6% to 10%. On average, survey respondents expect material costs per product to increase 11%.

Manufacturers cite several reasons for material cost increases, including rising ingredient costs (83%), growing raw material costs (75%) and increasing logistics and transportation costs (59%).

EQUIPMENT BUDGET

Some manufacturers say their budgets for production, packaging and process control equipment, as well as professional services, have increased this year. Specifically, 54% of survey respondents expect an increase, while 34% say their budgets will stay the same. Last year, exactly half (50%) expected an increase and 40% expected their budgets to remain the same.

Share of Budget for Equipment, Software, & Services

An average of 27% of companies' 2025 budgets are designated for the purchase of production, packaging, process control equipment, software, and professional services. Most designate less than $500,000 of this budget for plant equipment.

[1]"Don't know" responses removed for analysis purposes

Q160. What percentage of your location's 2025 budget is designated for the purchase of production, packaging, process control equipment, software and professional services? ☒

Q165. Of this spending, what dollar amount is specifically for plant equipment? ☒

Credit: Graphic courtesy of myCLERopinion

On average, manufacturers' equipment budgets have increased by 19%. However, 21% say their budgets increased by 1% to 5%, while 24% say their equipment budgets grew by 6% to 10%.

Proportionally, 21% of manufacturing professionals say one-quarter up to half of their budgets will go toward equipment purchases, while 19% say 6% to 10% of their budgets will cover equipment. On average, 27% of manufacturers' annual budgets will go toward equipment purchases. That compares to 25% in 2024.

However, the majority (56%) plan to spend less than $500,000. That's down from 60% in 2024. Meanwhile, one-third (33%) of manufacturing professionals expect to spend more than $1 million, with 9% expecting to spend $5 million or more.

FOOD SAFETY

With recent recalls connected to foodborne pathogens — and upcoming mandatory traceability requirements under the Food Safety Modernization Act (FSMA) — food safety is more important than ever.

Nearly half (48%) of surveyed manufacturing professionals say they've conducted safety-related training over the last year, compared to 46% in 2024. Additionally, 32% say they plan to purchase lab testing or analysis equipment or software, while 24% intend to purchase a food safety management system. These represent the top two categories of software and hardware purchases this year.

As for food safety methods in use, three-quarters (74%) of manufacturing professionals say they employ food allergen controls, representing the top method. Comprehensive staff training (72%) follows, as does lot-level traceability (64%) and food safety management system (63%). Rounding out the Top 5 is item-level traceability (53%).

Just over half (53%) say the rely on microbiological or chemical testing of raw materials and ingredients, while 40% say maintaining supply chain consistency is the most difficult preventative control to manage. Nearly a third of respondents (32%) said supply chain consistency was the most difficult preventative control to manage in 2024.

This year, manufacturing professionals also cite allergen controls and cross-contamination prevention (29%) and sanitation procedures (27%) as difficult to manage.

Notably, 22% of respondents say they have no difficulty managing preventative controls, which is up from 19% in 2024.

These insights represent only part of the information included in our study, which also covers methods for improving operations and productivity, workforce challenges and cybersecurity. The full study is available on the myCLERopinion Insights Hub. We'll also expand on these topics during our State of Food Manufacturing webinar, set for Oct. 15. **FE**

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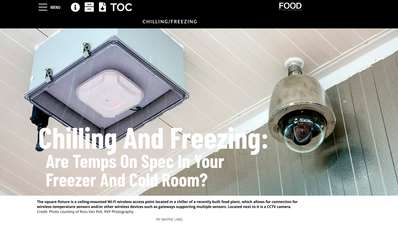


Chilling And Freezing:

Are Temps On Spec In Your Freezer And Cold Room?

The square fixture is a ceiling-mounted Wi-Fi wireless access point located in a chiller of a recently built food plant, which allows for connection for wireless temperature sensors and/or other wireless devices such as pallet tracking supporting multiple sensors. Located next to it is a CCTV camera. Credit: Photo courtesy of Rius Van Pel, RVP Photography

BY WAYNE LAIG

Recently, I attended a webinar put on by our sister publication, *Food Safety Magazine*. During the discussion, I was surprised to hear that many food companies are still relying on the old-fashioned clipboard and paper charts to record key temperatures in chillers and freezers. Unfortunately, this approach is prone to human blunders, and there's no quick and easy way to generate insights on temperature shifts.

With manual data recording, key temperatures may get missed entirely (either by distracted or new employees), and illegible scribbles won't get accurately transferred to an automated system, if it indeed exists. The lack of real-time critical temperature information in the plant or warehouse shouldn't, however, be an issue today because wireless temperature transmitters are affordable and can be placed in key remote locations — where a person may forget to check.

Why rely on humans to take temperature readings in chillers and freezers when networked wireless devices can "make the rounds" more efficiently and accurately? When discussing chillers, freezers and other cold storage, we mean that fresh refrigerants in previous articles, based on the webinar discussion, a look into the automated recording of temperatures in cold storage rooms seems worthwhile. [1], [2] Certainly, newly built cold storage warehouses and manufacturing structures have sophisticated wired and wireless systems for flexible and automated zoned temperature control. Older facilities — not so much.

AUTOMATED DATA COLLECTION OF TEMPERATURE EXCEEDS FDA REGULATIONS

FDA's regulations (21 CFR Part 117.93) don't specify specific warehousing and distribution chiller and freezer temperatures — they're performance based. It puts the onus on the operators to determine safe storage temperatures and maintain them. However, in referring to FDA's *Food Code 2022* (Chapter 3), a good benchmark is to use 41°F (5°C) for TFCS (Time/Temperature Control for Safety) for refrigerated foods. For frozen food, which is to be "maintained frozen," typically 0°F or -18°C is appropriate. Specifically, the Food Guide says, "A food that is labeled frozen and shipped frozen by a food processing plant shall be received frozen." There is a different requirement for raw eggs, which says that "Raw eggs shall be received in refrigerated equipment that maintains an ambient air temperature of 7°C (45°F) or less."

How often should temperatures be checked? For storage-only facilities (warehouses holding unexposed packaged refrigerated foods that require TFCS), FDA requires operators to:

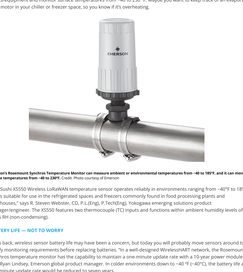
"Monitor the temperature controls with adequate frequency" to assure they're consistently performed (you set the frequency based on risk). (Legal Information Institute [2] (21 CFR 117.206)

Review monitoring & corrective-action records within seven days (or justify a longer timeframe in writing). (Legal Information Institute (21 CFR 117.206))

For processors, preventive-controls verification requires calibration/accuracy checks and timely record review, but still leaves monitoring frequency to the operator's hazard analysis/plan. (See 21 CFR 117.160. - Legal Information Institute.)

Part 117 doesn't specify a numeric tolerance for temperature sensors used in chillers and freezers. However, it does requires calibrating monitoring/verification instruments or checking them for accuracy per the operator's written procedures. As a reference, the *FDA Food Code* specifies temperature accuracy of ±3°F (±1°C) for food probes and ±3°F (±1.5°C) for ambient air/water devices — commonly adopted in industry QA specs, though not binding on processors under Part 117. [3]

Automation is allowed but not required. For warehouses, FDA explicitly allows either affirmative records (e.g., routine manual/automated logs) or exception records (typical of continuous automated systems that only log/alert on deviations). Part 117's verification framework supports either approach, as long as the operator monitors an adequate frequency, calibrates/checks accuracy, takes corrective actions and reviews records.



WHY AUTOMATE TEMPERATURE READINGS IN COLD STORAGE?

If you're not depending on a person to make designated temperature readings in cold storage (chillers and frozen food) areas, then you may have a wired system of temperature sensors in place, which when using an automated data collection system will be more reliable than any manual system.

However, the location of the wired sensors established 10 or 20 years ago may not meet your specific product application(s) today, especially if you make several different products requiring different chill-down timings or final temperature. It may not be easy to move the wiring to accommodate a sensor location change — and some of the sensors may be inoperative anyway due to broken wires and/or damage from forklifts or their cargo. Considering the inflexibility of wired systems and effort required in manual recording, wireless temperature and/or humidity sensors make sense for many reasons.

Wireless temperature sensors/transmitters make it easier to monitor product cool-downs in different areas of the freezer or chiller. With the ability of a wireless temperature transmitter to allow both an internal (ambient sensor) to check the overall unit (freezer/chiller) temperature plus accept a wired sensor input, an operator can monitor an internal (case, carton or product) temperature to verify the TFCS cool-down rate — even while checking various areas in the cooler. Being able to move ambient temperature sensors freely around the space lets operators check for temperature gradients in the cooler — or section off spaces with temperatures that better match certain products.

Wireless sensors substantially reduce the cost of temperature monitoring in highly regulated environments such as food processing and cold storage, says Ray Alengren, CEO of Swift Sensors. "Many of our largest clients are claiming a ten-fold reduction in annual costs by moving from their legacy wired systems to our modern wireless cloud-based monitoring system." Swift Sensors offers several types of wireless temperature and humidity sensors that can measure –100°C to +300°C and 5% to 95% RH.

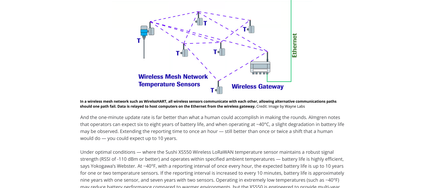
Most process control vendors offer wireless temperature transmitters that fit into wireless networks. According to Adam Edison, global product manager, Emerson's Rosemount Synchros temperature monitor can measure ambient/environmental temperatures from –40 to 185 °F. Additionally, when needed, this device can be mounted to assets/equipment and monitor surface temperatures from –40 to 230 °F. Maybe you want to keep track of an evaporator fan's motor in your chiller or freezer space, so you know if it's overheating.

Emerson's Rosemount Synchros Temperature Monitor can measure ambient or environmental temperatures from –40 to 185°F, and it can monitor surface temperatures from –40 to 230°F. Credit: Photo courtesy of Emerson

"The Sustiv X5550 Wireless LoRaWAN temperature sensor operates reliably in environments ranging from –40°F to 185°F and is suitable for use in the refrigerated spaces and freezers commonly found in food processing plants and warehouses," says R. Steven Webster, CO, P.Eng, P.Tech(Eng). Yokogawa emerging solutions product manager/engineer. The X5550 features two thermocouple (TC) inputs and functions within ambient humidity levels of 0 to 100% RH (non-condensing).

BATTERY LIFE — NOT TO WORRY

Years back, wireless sensor battery life may have been a concern, but today you will probably move sensors around to satisfy monitoring requirements before replacing batteries. "In a well-designed WirelessHART network, the Rosemount Synchros temperature monitor has the capability to maintain a sensor update rate with a 10-year power module life," says Ryan Lindsey, Emerson global product manager. In colder environments down to –40 °F / -40°C, the battery life at a one-minute update rate would be reduced to seven years.



In a wireless mesh network such as WirelessHART, all wireless sensors communicate with each other, allowing alternative communications paths should one path fail. Data is relayed to host computers via the Ethernet from the wireless gateway. Credit: Image by Wayne Laig

And the one-minute update rate is far better than what a human could accomplish in making the rounds. Alengren notes that operators can expect six to eight years of battery life, and when operating at –40°C, a slight degradation in battery life may be observed. Extending the reporting time to once an hour — still better than once or twice a shift that a human would do — you could expect up to 10 years.

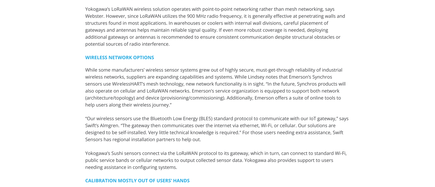
Under optimal conditions — where the Sustiv X5550 Wireless LoRaWAN temperature sensor maintains a robust signal strength (RSS) of –110 dBm or better) and operates within specified ambient temperatures — battery life is highly efficient, says Yokogawa's Webster. At –40°F, with a reporting interval of once every hour, the expected battery life is up to 10 years for one or two temperature sensors. If the reporting interval is increased to every 10 minutes, battery life is approximately nine years with one sensor, and seven years with two sensors. Operating in extremely low temperatures (such as –40°F) may reduce battery performance compared to warmer environments, but the X5550 is engineered to provide multi-year battery life even under these demanding conditions.

The Yokogawa X5550 Temperature Sushi Sensor operates on a scheduled transmission cycle, sending data at pre-configured intervals. For on-premise data logging, solutions such as GA10 Data Logging Software and Q Server Software are available. Credit: Photo courtesy of Yokogawa

WIRELESS RANGE — CHEAPER THAN COPPER WIRING

You can extend the range of your temperature sensing network through the use of wired gateways that receive data from wireless sensors or through wireless mesh networks — much like the power company uses the wireless meter on your house to connect to another — and another, until the data reaches a direct connection to the power company's gateway.

For Swift Sensors, the maximum sensors-to-gateway distance is 300 ft. line of sight and 150 ft. non line of sight, Alengren says. Concrete walls and metal enclosures will reduce the wireless communication distance. Additional gateways can be added in a facility with wireless interference to ensure all sensors are monitored. The sensors automatically connect to the closest gateway.



Swift Sensors' wireless ambient temperature and humidity sensors, left, mount conveniently and relay temperatures to a nearby gateway, which connects to the cloud via Ethernet. The Swift Sensors' wireless temperature/humidity transmitter features a probe that can be inserted into product packages or taped to product surfaces. Credit: Photo courtesy of Swift Sensors

The Rosemount Synchros temperature monitor includes native support for the a WirelessHART communication protocol, Edison says. Wireless/HART networks are self-organizing and self-healing 2.4 GHz ISM-band (Industrial, Scientific and Medical) networks that manage multiple communication paths for any given device. If an obstruction is introduced into the network, then data will continue to flow because the devices have other established paths through the mesh network. Each device can communicate up to 100 ft. to another device within the mesh network. The range can be increased and obstructions to the signal can be alleviated by using repeaters and/or other measurement devices within the network.

Yokogawa's LoRaWAN wireless solution operates with point-to-point networking rather than mesh networking, says Webster. However, since LoRaWAN utilizes the 900 MHz radio frequency, it is generally effective at penetrating walls and structures found in most applications. In warehouses or coolers with internal wall divisions, careful placement of gateways and antennas helps maintain reliable signal quality. If even more robust coverage is needed, deploying additional gateways or antennas is recommended to ensure consistent communication despite structural obstacles or potential sources of radio interference.

WIRELESS NETWORK OPTIONS

While some manufacturers' wireless sensor systems grew out of highly secure, must-get-through reliability of industrial wireless networks, suppliers are expanding capabilities and systems. While Lindsey notes that Emerson's Synchros sensors use WirelessHART's mesh technology, new network functionality is in sight. "In the future, Synchros products will also operate on cellular and LoRaWAN networks. Emerson's service organization is equipped to support both network (architecture/topology) and device (provisioning/commissioning). Additionally, Emerson offers a suite of online tools to help users along their wireless journey."

"Our wireless sensors use the Bluetooth Low Energy (BLES) standard protocol to communicate with our IoT gateway," says Swift's Alengren. "The gateway then communicates over the Internet via ethernet, Wi-Fi, or cellular. Our solutions are designed to be self-installed. Very little technical knowledge is required." For those users needing extra assistance, Swift Sensors has regional installation partners to help out.

Yokogawa's Sushi sensors connect via the LoRaWAN protocol to its gateway, which in turn, can connect to standard Wi-Fi, public service bands or cellular networks to output collected sensor data. Yokogawa also provides support to users needing assistance in configuring systems.

CALIBRATION MOSTLY OUT OF USERS' HANDS

Depending on the sensor, calibration is slowly becoming less of a task or no task at all for users, greatly simplifying operation and reducing lifecycle costs. "All of our temperature sensors can be calibrated in the factory, at an ISO 17025 calibration lab, or on-site at the customer's facility — all according to NIST standards," Alengren says. "The Swift Sensors Console includes a feature we call the VCalibration Wizard, which streamlines and simplifies the calibration process. Calibration frequency is set by the customer or the regulatory standard they follow. Annual calibration is the most common frequency we see."

More expensive industrial sensors may pay for themselves. Why? How about temperature sensors requiring no initial calibration, or literally, no calibration at all? Yokogawa X5550 Sushi temperature sensors are designed to operate without the need for initial calibration or ongoing recalibration. All accuracy specifications are detailed in the company's "General Specifications," according to the specific thermocouple type used. Edison says there is no calibration required for the lifespan of the Emerson Synchros sensors.

Wireless Sensor Range/Distance Considerations

According to Yokogawa's Webster, the maximum point-to-point range between the Sushi wireless sensor and its associated gateway — both operating at 900 MHz — depends on the installation environment:

- Clear Line of Sight: In open environments with unobstructed visibility (such as open fields, along rivers, or on offshore platforms), the typical communication distance can reach up to approximately four miles or greater.[1]
- Partial Obstructions (Outdoor/Industrial): In outdoor areas where direct line of sight cannot be fully maintained — such as tank farms or facilities with dense piping — the expected range is around 0.6 miles.
- Indoor or Heavily Structured Environments: For sensors installed indoors or in areas surrounded by structures, like within production facilities or heavily shielded locations, the effective range depends greatly on the specific installation and the placement of both sensors and gateways. To enhance connectivity in such environments, antennas can be installed at elevated locations, or supplemental repeaters/antennas can be deployed within the facility.

"Ed. Note: According to the radio path loss formula, with all things being equal (antenna gain, transmit power, receiver sensitivity), radius (i.e., wireless sensor) operating at 900 MHz (compared to devices operating at 2.4 GHz) will see an 8.5 dB signal improvement, relating to a coverage at 900 MHz roughly 2.7 times the distance possible at 2.4 GHz for an unobstructed outdoor terrain.

DATA LOGGING OPTIONS ABOUND

With today's digital systems, you get wireless and logging — and you get it. Lindsey describes Emerson's approach now and into the future: Synchros devices integrate into WirelessHART gateways that interface with existing host systems via a wired Ethernet connection using industrial standard protocols, including OPC, Modbus TCP/IP, Modbus RTU, and Ethernet/IP. An example of a host system is Emerson's MES software, such as DeltaV. In the future, cellular products will offer cloud storage functionality.

"Our Console is cloud-based and can be accessed from any desktop or mobile device," Alengren says. The Console displays analytics in real-time, sends event alerts and creates comprehensive reports. Data can be exported as a CSV or PDF file. And our platform can be seamlessly integrated into existing applications using our secure API.

Yokogawa offers a variety of data logging solutions for the Sushi wireless sensors, including both on-premise and cloud-based options, Webster says. For on-premise data logging, solutions such as GA10 Data Logging Software and Q Server Software are available. For cloud-based needs, Yokogawa provides a Wide Area Monitoring Solution (WAMS) and Oyesti Asset Health Insights (AHI). These platforms can integrate with HMIs, food safety management systems, MES software and other industrial applications, providing flexible options for local or remote data storage and analysis.

References:

[1] "Tech Update: Freezing & Cooling," FE, Nov. 23, 2022

[2] "Upgrade Chilling Equipment to Industrial Heat Pumps," FE, October 10, 2024

[3] *FDA Food Code 2022, Version 2022*, FDA Website download (8 JAN 2025)

NEXT ARTICLE

FOOD ENGINEERING

— WEBINAR —

OCTOBER 15, 2025
AT 2:00 PM EDT

DELVING INTO FOOD ENGINEERING'S 2025 STATE OF FOOD MANUFACTURING

FOOD ENGINEERING's 46th State of Food Manufacturing webinar breaks down the results of this year's survey of food and beverage manufacturers. Each year we partner with myCLEARopinion to poll the industry about staffing, automation, supply chain and more.

Last year's survey revealed manufacturers were investing in their production processes to improve revenue. Is that still the case? Join Ariane Claire, myCLEARopinion Insights Hub panel and research director, as we share what's affecting the food business and where companies are spending money, if at all.

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LEARNING OBJECTIVES:

- Explore how throughput and budgets have changed from last year
- Learn about trends that affect manufacturing operations
- Discover methods being used for food safety
- Understand changes in the workforce and retaining workers

SPEAKERS:

ARIANE CLAIRE
Panel & Research Director
myCLEARopinion Insights Hub

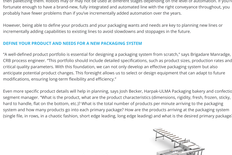
ALYSE THOMPSON-RICHARDS
Editor-in-Chief
Food Engineering

Made in Vev

PACKAGING, AUTOMATION

Tips for Building FOOD PACKAGING LINES

Setting up a new line or incrementally adding automation is easier when you know your product and expectations.



Bars are lined up for automatic feeding into a conveyor system leading to packaging in a pouch. Credit: Photo courtesy of Hayssen-ULMA/ BY BERNIE LIBS

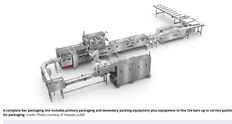
TYPICAL PACKAGING LINES HAVE THREE OR MORE SUCCESSIVE LEVELS OF PACKAGING: primary packaging, say, film wrapping a candy bar; secondary placing 12 wrapped candy bars in a case; and tertiary, placing 24 cases in a carton and then palletizing them. Robots may or may not be used at different stages depending on the level of automation. If you're fortunate enough to have a brand-new, fully integrated and automated line with the right conveyance throughout, you probably have fewer problems than if you've incrementally added automation over the years.

However, being able to define your products and your packaging wants and needs are key to planning new lines or incrementally adding capabilities to existing lines to avoid bottlenecks and stoppages in the future.

DEFINE YOUR PRODUCT AND NEEDS FOR A NEW PACKAGING SYSTEM

"A well-defined product portfolio is essential for designing a packaging system from scratch," says Brigalare Manraulge, CKB process engineer. "This portfolio should include detailed specifications, such as product sizes, production rates and variations, and packaging formats. This comprehensive data is only identified an effective packaging system but also anticipates potential product changes. This foresight allows us to select or design equipment that can adapt to future modifications, ensuring long-term flexibility and efficiency."

Even more specific product details will help in planning, says Josh Becker, Harpak-ULMA Packaging bakery and confection segment manager. "What is the product, what are the product characteristics (dimensions, rigidity, fresh, frozen, sticky, hard to handle, flat on the bottom, etc.)? What is the total number of products per minute arriving to the packaging system and how many products go into each primary package? How are the products arriving at the packaging system (single file, in rows, in a chaotic fashion, short edge leading, long edge leading) and what is the desired primary package?"



A complete fast packaging line includes primary packaging and secondary packing equipment plus equipment to line the bars up to correct position for packaging. Credit: Photo courtesy of Harpak-ULMA

Common Kinks and Hints to Primary Packaging Woes

Common kinks often depend on the operator and maintenance personnel, as well as their individual skill, training and teamwork. Many issues arise when new personnel are learning the equipment. Long-term or chronic issues are best resolved through collaboration between plant operations, the maintenance team, packaging OEM(s) and OEM(s) working together.

→ When core material components meet quality specifications, many persistent issues can be traced back to contamination sources within the packaging system. Identifying and controlling these sources is key to resolving recurring kinks.

→ Film tears and wrinkles lead to poor seals. Avoiding these requires regular film path alignment checks, auto tensioning systems, etc. Storage of film in the proper conditions can be overlooked. However, humidity can warp film rolls, which affect performance.

→ Poor seal integrity is another common kink. Keeping jaws clean, verifying temperature profile and seal pressure are easy fixes that can help maintain efficient operation. To avoid/minimize mis-threading, visual threading guides and SOPs for operators can help.

→ With horizontal flow wrappers, consistent flow and size of product is needed. If this cannot be guaranteed or it is not practical to improve the product or feed system, a product separation and rejection system can be added to improve performance of a wrapper. This rejected product can then be relied manually into the system so as to reduce overall waste.

→ Singulation of products from upstream processes, therefore, selecting the proper product distribution system for the type of product, size of product and zone is critical.

→ Film control and product control are the biggest "kinks" or areas to ensure are operating properly. As soon as film control/tension issues arise it causes a domino effect with misalignment of film registration, misalignment of code date on the package, etc. Product also needs to be fed properly and consistently to stay "on pitch" for the wrapper to be highly efficient.

Once you have that information you can determine the machinery type and possibly the total number of machines required for the production capacity, Becker adds. A good product specification spreadsheet with all the data information is essential, as well as pictures of the product and packaging material specifications. It is also good to know any future product sizes that should also be considered for this packaging line.

Some additional considerations include the following, according to Rick Graff, Gray AES principal packaging engineer:

- Sanitation requirements for the type of packaging operation (i.e. primary filling versus end-of-line pallet handling)
- Environment required for the product — temperature, humidity, washdown
- Required throughput rate of the overall system
- Range of sizes, speeds, patterns required

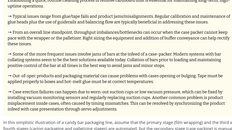
Is a buffer or redundancy needed — is this system directly linked to an upstream process that cannot stop if a packaging machine fails?

When planning and designing a packaging system from the ground up, especially when plenty of space is available, it's important to approach the process with a clear goal in mind and work backwards, says Nick Basham, regional sales manager for Magnum Systems, Controls Integration Business Unit (ICS Solutions) a CSW company. "We start by asking key questions about the who, what, where, why and how of the project. Consider who will operate and maintain the system, who will be affected by it and who your current and future customers are. Then, consider customer expectations for quality and type, management's needs for process visibility and potential opportunities for growth or diversification in the future. Many plants limit themselves by focusing on a single product or process. But adding packaging capabilities can unlock new revenue streams and industries."

Timing is another crucial factor — determine when the system needs to be operational, as projects can take anywhere from eight weeks to six months, depending on complexity and automation levels, Basham adds. Early planning and foresight are essential for staying on schedule and fulfilling delivery commitments. Additionally, consider the direction of the business and whether automation is a feasible option now or in the future. The "why" behind the project is perhaps the most important question: why is this investment being made, and will it benefit the business and its employees in the long run? Finally, address the "how" by assessing the financial impact, expected ROI, maintenance needs, desired level of automation and daily processing requirements to meet customer demand. By examining these factors comprehensively, you can design a packaging system that is efficient, adaptable and aligned with your business goals.

Finally, the opportunity to design a system from scratch provides a unique opportunity to take it right the first time, says Rahul Nehete, Gray AES vice president – packaging. "Often times, dollars drive decisions at a very early stage, however, in the lifecycle of the production line, this myopic view can cost multiple folds over in operational inefficiencies. Taking the initial phases of planning, deliberate planning based on long-term business objectives should drive the throughput goals, SKU variability and future expansion considerations. Design with flexibility in mind, which allows you to develop scalable layouts and allows you to account for new pack sizes or materials."

During the design phase, a deliberate emphasis on aligning packaging roles with processing capacity upstream and warehousing requirements downstream ensures seamless connectivity between production zones, Nehete adds. Another aspect worth consideration is the use of high-quality simulation models to run what-if scenarios that provide directional guidance instead of guessing the effects of changeovers, product variability, inefficiencies etc.



Incrementally Automating One Phase of a Packaging Line. Graphic by Wayne Labs.

Common Kinks in Secondary Packaging (Case Packing)

→ Cardboard dust is a significant source of contamination that can reduce uptime and overall equipment effectiveness. Establishing a quick, routine cleaning process to remove cardboard dust is essential for maintaining top-tier, high-uptime operations.

→ Typical issues range from glue/tape fails and product jams/misalignments. Regular calibration and maintenance of glue heads plus the use of guidelines and balancing flow are typically beneficial in addressing these issues.

→ Frozen ice overall line slowdown/stoppage. Throughput imbalances/bottlenecks can occur when the case former cannot keep pace with the wrapper or the palletizer. Right sizing the equipment and addition of buffer conveyance can help rectify these issues.

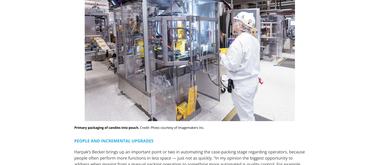
→ Some of the more frequent issues involve jamo of bars at the infeed of a case-packer. Modern systems with bar collating systems seem to be the best solution available for under-1000bpm of bars prior to loading and maintaining positive control of the bar at all times is the best way to avoid jams and minor stops.

→ Out-of-spec products and packaging material can cause problems with cases opening or bulging. Tape must be applied properly to boxes and hot-melt glue must be at correct temperature.

→ Case erection failures can happen due to worn-out suction cups or low vacuum pressure, which can be fixed by replacement and adjustment. Misaligned or improperly loaded blanks can also cause problems; proper alignment and reliable magazine loaded cases, often caused by timing simulation models. This can be resolved by synchronizing the product infeed with case presentation through servo adjustments.

In this simplistic illustration of a candy bar packaging line, assume that the primary stage (film wrapping) and the third and fourth stages (carton packaging and palletizing stages) are automated, but the secondary stage (case packing) is manual. What are the issues when the manufacturer wants to automate the case-packing stage — where humans now do the job?

Incremental integration requires careful planning, says CKB's Manraulge. "If the existing equipment has been well maintained and continues to meet throughput requirements, customer preferences and specific KI curve targets, it can often be integrated with newer subsystems. This is especially feasible when the component being replaced is a standalone unit and typically has some type of accumulation between it and adjacent systems."



The packaging engineer needs to fully understand the capabilities of the existing equipment in order to ensure that the new equipment will be well utilized, says Joe Bradley, director – packaging, Gray AES. It is important to understand individual equipment center rates and create an ideal "course" to optimize the efficiency of the overall packaging line. Each piece of equipment further away from the line bottleneck should typically be designed to be slightly (5-10%) faster than the equipment next closer to the bottleneck.

- Let's assume the following rates capability for existing equipment:
- (Primary) Wrapper – 340 bars/min (assume this is the bottleneck)
- (Secondary) Case packer – manual (12 bars/case) – 10 operators each pack 2 cases/min – 240 bars/min total
- (Tertiary) Cartoner – 1 cassettm (24 cases/min, 288 bars/min)
- Palletizer – 2 cassettm

In the system above, to specify the optimum new case packer, one should consider the "K-curve" of the existing system, Bradley says. In order to maximize the uptime of the bottleneck, the engineer should ensure that the case packer can run at least 5% 10% faster than the upstream wrapper. This would mean specifying a case packer that could run 21-22 cases/min.

For integration, the engineer should consider what is the overall line control being used? Is it a peer-to-peer system or supervisory system? What type of PLCs are being used. The engineer should attempt to use common platforms and hardware types where possible.

Control system compatibility is critical, Manraulge adds. Each subsystem has its own communication protocols and limitations, so early verification by experienced controls integration experts is essential. Ultimately, capital budgets and operating timelines will dictate how much of a packaging line is upgraded and replaced, and which components to prioritize.

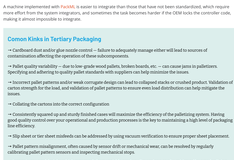
Primary packaging of candies into pouch. Credit: Photo courtesy of Imagemakers Inc.

PEOPLE AND INCREMENTAL UPGRADES

Harpak's Becker brings up an important point or two in automating the case-packing stage regarding operators, because people often perform more functions in less space — just not as quickly. "In my opinion the biggest opportunity to address when moving from a manual packing operation to something more automated is quality control. For example, you need to understand at the tables the operators were doing, such as evaluating primary/secondary packaging quality, confirming carton/case count etc. The manual operation is an often the last line of defense against incorrect product/packages are correct."

Becker adds: "When automating you need to consider what tools should be implemented, such as quality inspection systems (checkweighing, vision inspection for package quality — just to name a few). It is not that it is complicated, it is just something that is often forgotten you have to consider it. The other issue is sometimes the manual packing area takes up less space than an automated system. You could also automate in steps, such as first starting with automated case erectors, then moving to automated packing and finally automated product inspection. It doesn't have to be an all or nothing approach."

Magnum's Basham completely supports incrementally staging case packing. "We recommend incremental integration to address these challenges. Begin by introducing automation in phases, such as implementing semi-automatic casing, then conveyors, followed by automated infeed to the palletizer. Use integration gateways, like Ethernet-to-serial converters, and upgrade HMIs to connect older and modern control systems. Map out workflows to identify all handoff points, enabling the strategic addition of sensors, barcode scanners, or vision systems for verification. Standardize pack formats in the control software to prevent foreseeable mismatches and inconsistencies between legacy and modern devices. Finally, utilize simulation tools like EmulateD3 or Plant Simulation to validate speeds, layouts and buffer sizes before making physical changes, ensuring a smoother transition to a fully automated system."



Incoming packaging of pouches of candies into a case placed by delta-robots. Credit: Photo courtesy of Imagemakers Inc.

LINE INTEGRATION AND SYNCHRONIZATION

Your packaging system should always be designed to operate efficiently at a higher rate of speed than the delivery of the product from the upstream process, says Harpak's Becker. A rule of thumb in the past has been the 1-hour of your packaging operation should be 20% over the max of the upstream process before it. In some applications like baking and confectionary manufacturing plants, you need additional capacity on your packaging line to avoid stopping the upstream process because of downstream issues. Buffers can be a mix of product and/or empty packaging. Buffers need to be sized and be required, or larger buffering and accumulation systems may be a good idea. In baking, you want your accumulation system to be able to handle the full amount of product that would be in the baking process. A good packaging system has each unit operation integrated together so that the system can accommodate and divert product to the appropriate machine or buffer to avoid processing downtime.

All equipment and packaging sizes have their sweet spot, says CKB's Manraulge. The biggest improvement comes from having a data collection system that links speed with efficiency, making data visible and easy to understand. Many times, operators feel the equipment runs better but lack the data to support those observations. In some cases, the preference for a slower machine with fewer stops is the right choice, such as difficulty loading a component, leading operators to slow down the equipment to allow more time for that task.

From the controls standpoint, the simple interlocking mechanism between upstream and downstream machines may not always be enough, says Magnum's Gonzalez. To implement a more comprehensive integration, a centralized control system is required to handle the strategy of integration, adapting the speeds of each machine and the conveying system that transports products between the machines.

Because typically the integration is done with machines from different vendors, the standardization of the interface is extremely valuable. PackML is a standard whose adoption has been growing, making it easier to integrate not only to optimize the flow of products on the plant floor but also to integrate with MES and ERP systems.

A machine implemented with PackML is easier to integrate than those that have not been standardized, which require more effort from the system integrators, and sometimes the task becomes harder if the OEM locks the controller code, making it almost impossible to integrate.

Common Kinks in Tertiary Packaging

→ Cardboard dust and/or glue nozzle control – failure to adequately manage either will lead to sources of contamination affecting the operation of these subcomponents.

→ Pallet quality variability – due to low grade wood pallets, broken boards, etc. – can cause jams in palletizers. Specifying and adhering to quality pallet standards with suppliers can help minimize the issues.

→ Incorrect pallet patterns and/or weak corrugate design can lead to collapsed stacks or crushed product. Validation of system strength for the load, and validation of pallet patterns to ensure even load distribution can help mitigate the issues.

→ Collating the cartons into the correct configuration

→ Consistently squared-up and sturdy finished cases will maximize the efficiency of the palletizing system. Having good quality control over your operational and production processes is the key to maintaining a high level of packaging line efficiency.

→ Slip sheet or tier sheet misfeeds can be addressed by using vacuum verification to ensure proper sheet placement.

→ Pallet pattern misalignment, often caused by sensor drift or mechanical wear, can be resolved by regularly calibrating pallet pattern sensors and inspecting mechanical stops.

→ Inconsistent stack height, which may result from variable product dimensions, can be mitigated by standardizing incoming product tolerances or implementing checkweighers and vision inspection systems before palletizing.

METHODS TO IMPROVE OPERATION

"Harnessing the true potential of simulation and digital twins can help verify the throughput, changeover times and buffer strategy before actual installations," says Gray's Nehete. At the same time instead of starting at the initial design stage with simulation, keeping models updated with real-world production data can help with continuous improvement.

If possible, large projects including multiple packaging system operations should be modeled, simulated and analyzed with an FMEA (Failure Modes and Effect Analysis) to ensure all the possible impacts of line failures are addressed and accounted for, says Harpak's Becker. This will help you determine the amount of packaging operation redundancy and buffer for your system. That helps pre-project production, but during and after production it is best to create a PM plan to address all wear parts of equipment to avoid line downtime."

With installed systems, collection of data on individual equipment centers' performance (uptime, minor stops, breakdown time) is a great way to set priorities for improving efficiency, says Gray's Bradley. "Additionally, optimizing changeovers can be a significant improvement in uptime. Use a Pareto chart to determine which equipment centers have the most where changeover efficiency is not emphasized, and it is often one of the largest causes of downtime. In addition, efficiency of startups after changeovers is not always measured, and operator behaviors and frequent adjustments after a changeover are another large cause of downtime."

There is no substitute for observing problems in real-time or capturing video to analyze key transformation points, says CKB's Manraulge. "These recordings can be studied and sent to others for broader input. Having the right team leaders and maintenance personnel is essential. By 'right leaders' I'm referring to the DNA/Trustworthy, Tenacious and Humble leadership concept from the book Own the Gap. Plant leadership must provide a clear long-term vision that remains consistent year-over year."

To improve operations, it is crucial to implement preventative maintenance on a regular schedule, which can be integrated into the control system and guided by runtime and system efficiency metrics, says Magnum's Basham. "This proactive approach helps keep equipment in optimal condition, reducing downtime and boosting overall efficiency. Adding a step verification system within your batch management process is essential. This system ensures each step is accurately followed, guaranteeing consistency and reliability in the final product, which is vital for meeting quality standards. Together, these strategies lead to smoother operations and higher-quality results. FB

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BatchWright Frying System

Designed for kettle-style potato chips and other root-vegetable snacks, the BatchWright can produce up to 650 lbs. (295 kg) per hour while offering temperature control over the frying curve. Featuring filtration, hood-down operation and energy-efficient heating, this industrial fryer achieves product quality, improves production efficiencies and reduces operating costs. Compatible with both natural gas and propane, the BatchWright can be used in facilities with limited floor space or retrofit constraints.

WD-40

Specialist Food-Grade and Food-Processing Lubricant

The line extends the life of equipment and reduces downtime by providing products that make it easy to prep, clean, lubricate and protect. WD-40 Specialist Food-Grade Lubricant and Penetrant is a multi-use product that is safe on food-contact surfaces and is NSF H1-registered.

BÜHLER GROUP

OptiBake Wafer Oven

Engineered to boost quality, operational flexibility and efficiency, the OptiBake reduces energy consumption by 50% compared to conventional, gas-fired wafer-baking ovens. The solution is tailored for flat and hollow wafers, supporting customers in achieving operational excellence and sustainability in production. The OptiBake's induction-heating system uses electromagnetic fields to generate heat directly within the baking plates, dispensing with open flames and combustion. The result is a process that produces no direct emissions of carbon dioxide (CO_2), carbon monoxide (CO) or nitrogen oxides (NO_x).

CRC INDUSTRIES

CRC Food Grade Lubricants

Designed to enhance operational efficiency and safety, the new products aim to offer NSF-certified, innovative solutions to the food processing industry. They include:

- CRC Food Grade Bio-Based Power Lube is the first bio-based lubricant on the market matching the durable characteristics typically provided by a synthetic formula, only this formula is a readily biodegradable, vegetable oil-based lubricant. Formulated for extended service under extreme temperature conditions and treated with antioxidants, extreme pressure, anti-wear, and anti-corrosion additives and fortified with ceramic powder, it provides superior lubrication and protection for heavy machinery and equipment in food processing environments. As an additional safety feature, the Perma-Lock 2-Way Integrated Actuator is designed to prevent straw detachment from the can, reducing the risk of foreign object contamination.
- CRC Food Grade Bio-Based Power Lube Grease offers stability and resistance to water-washout, making it ideal for use in food processing applications where incidental food contact may occur. This readily biodegradable, vegetable oil-based grease is engineered to meet the extreme anti-wear characteristics of a synthetic formula in a biobased package. It extends equipment life and reduces maintenance costs while meeting the highest food safety standards.

JD MANUFACTURING, INC.

JD500CXI Automatic Batch Fryer

JDM has integrated Bison's Nautilair 12.3-inch High Energy Blower into its JD500CXI automatic batch fryer. This blower helped increase the fryer's output capacity and optimize energy use. The Nautilair blower fit within the existing fryer enclosure without altering its size and it integrated with JDM's 480V, 3-phase power setup. Additionally, the blower endures harsh conditions of a food production environment, including exposure to moisture, oil-contaminated air and aerosolized caustic substances. FE

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Manufacturing

REGULA

FDA, USDA Propose Amending SOI for Pasteurized Orange Juice

Photo courtesy of Getty Images Plus / Proformabooks

The FDA's proposed rule would reduce the minimum required Brix level – a measure of dissolved sugar content – in pasteurized orange juice from 10.5% to 10.

The U.S. Food and Drug Administration and the U.S. Department of Agriculture have proposed to update the standard of identity (SOI) for pasteurized orange juice.

This action would end a 60-year-old rule that causes reliance on foreign imports. The FDA expects this change is unlikely to affect the taste of pasteurized orange juice.

The FDA's proposed rule would reduce the minimum required Brix level – a measure of dissolved sugar content – in pasteurized orange juice from 10.5% to 10%, better reflecting the natural Brix level of American oranges. The rule change is estimated to save orange juice manufacturers more than $50 million per year and would reduce reliance on the use of imported oranges for "not from concentrate" pasteurized orange juice products in order to meet the required Brix level.

The Florida Citrus Processors Association Inc. and Florida Citrus Mutual Inc. jointly submitted a citizen petition on July 22, 2022 to amend the SOI. The current standard has become increasingly difficult for U.S. growers to meet due to severe weather and other factors. Despite producing quality fruit, many producers import high-Brix level orange juice from abroad to comply with this regulation.

This proposal is part of the FDA's broader effort to review more than 250 SOIs. The FDA will accept public comments through Nov. 4. **FE**

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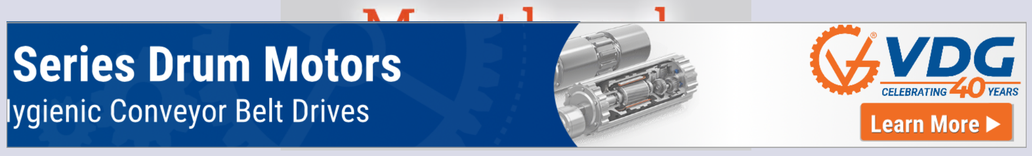

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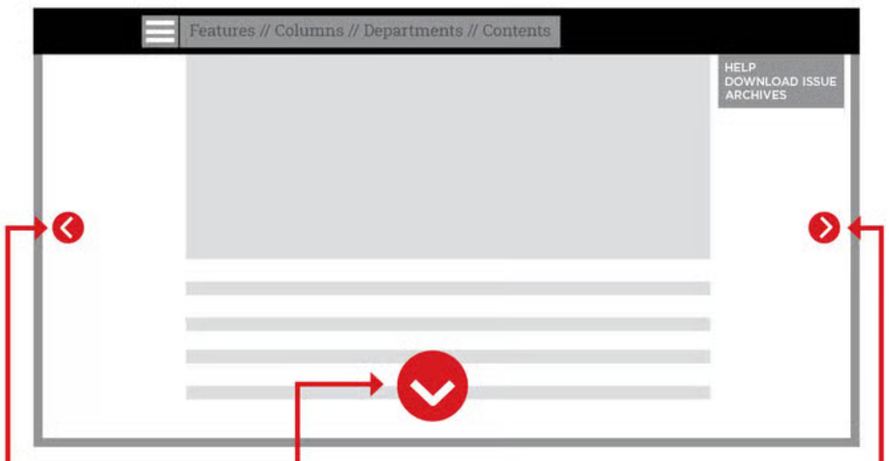

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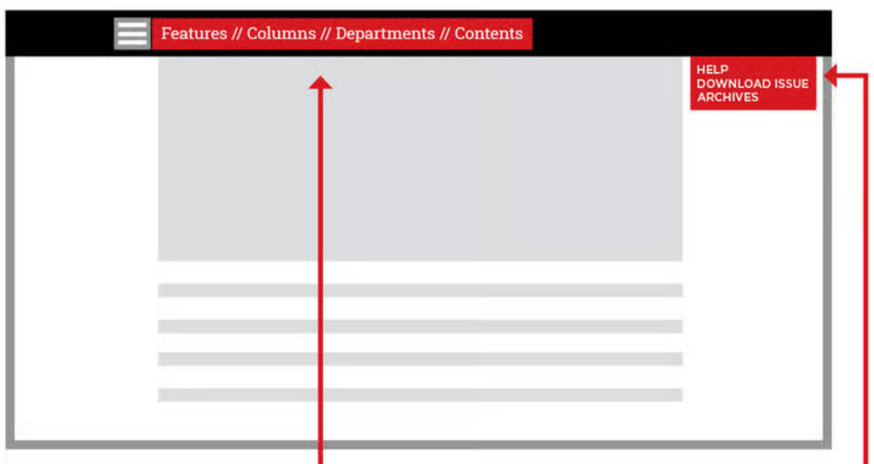

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