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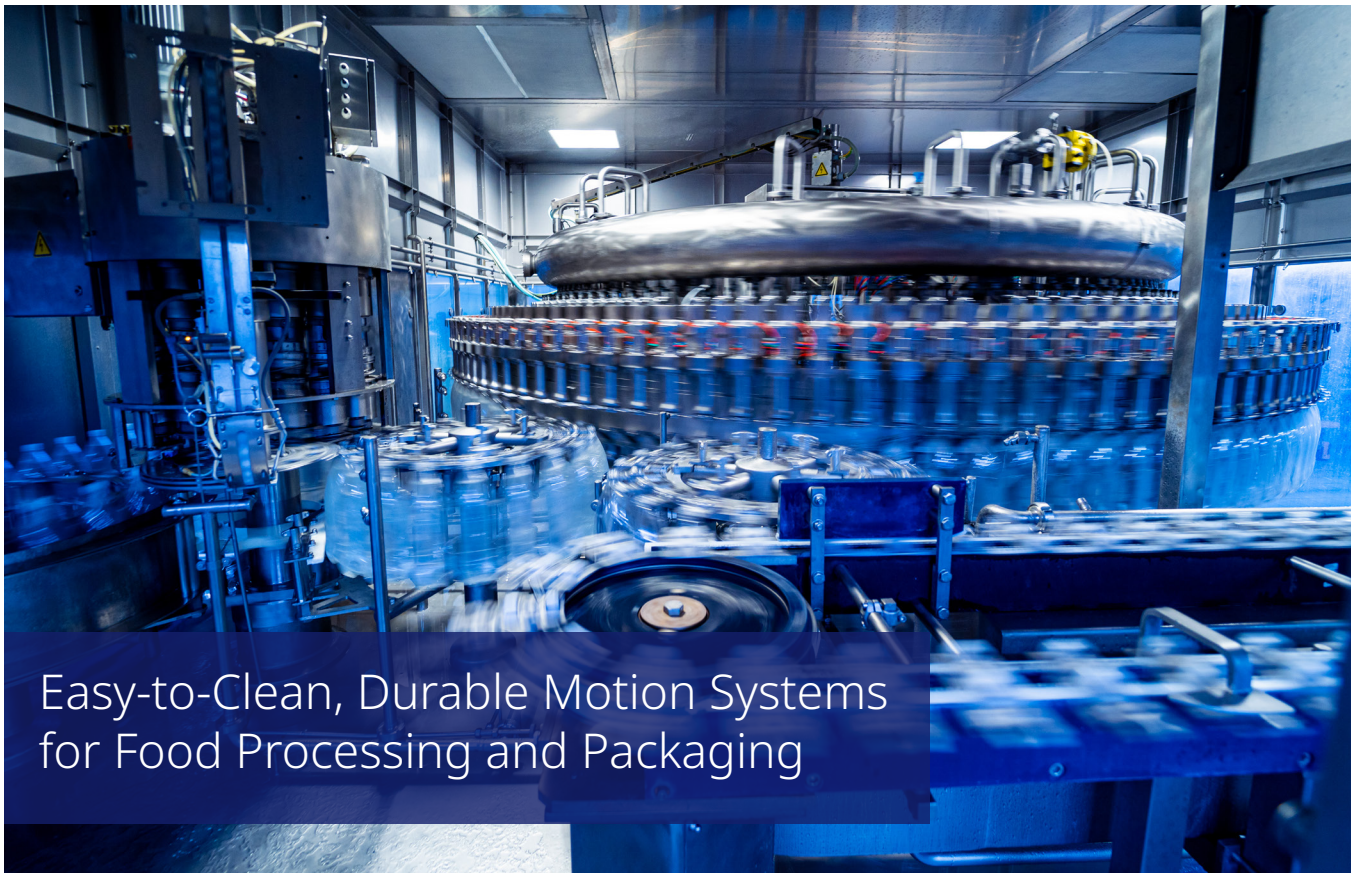
WHITE PAPER



Easy-to-Clean, Durable Motion Systems for Food Processing and Packaging

How can you satisfy public safety concerns and meet regulatory requirements while delivering a high-performance, cost-effective machine? Learn how to design equipment for simpler cleaning and greater durability to increase food processing and packaging productivity.

Ensuring a safe food supply presents significant challenges for the food processing and packaging industry. Food manufacturers need access to reliable equipment that can be operated in compliance with changing federal regulations and standards, all while remaining competitive in an increasingly demanding marketplace.

Machine components — such as instrumentation, motion controls, electrical motors and gearboxes — are important to food safety as they perform hundreds of critical tasks in direct-contact areas. While these components are generally developed to provide maximum performance in a compact, cost-effective package, increased durability or ease of cleaning have not always been considered integral parts of the design.

More stringent food safety regulations and the need to increase the overall effectiveness of food processing and packaging operations has changed all that.

This white paper discusses the limitations often found in the design of machine components for food processing and packaging, and proposes more robust alternative solutions. We will focus on instrumentation, motion control, electrical motor, gearbox and actuator designs, but the discussion also applies to the sensors and HMI instrumentation used in machines that operate in washdown environments.

Industry insights

Kollmorgen has taken steps to understand the unique challenges of food processing and packaging, and how the industry can best meet these challenges.

Manufacturers continue to struggle sourcing components and delivering machines that meet the unique demands of this market. Standard motion products were reported as nondurable in washdown environments, difficult to clean, and containing materials, such as toxic paint and cable jacketing, that are incompatible with use in the food product zone.

Products labeled as food grade fared slightly better. The paint was nontoxic, and motors had higher ingress protection ratings, but they were still difficult to clean and not significantly more reliable than standard motors.

Upgrades to stainless-steel or washdown-rated motors increased initial costs, and these alternatives were larger and heavier than standard equipment, often had significant restrictions on how they could be washed, and often failed in washdown environments even when adhering to difficult cleaning procedures as specified.

Another interesting finding was that rows of inoperable motors and gearboxes often sit idle on repair shelves, representing many thousands of dollars in material and repair costs and much higher costs in lost production time.

Our conclusion was clear: The food processing and packaging industry can gain significant value from the development of high-quality motion controls, electric motors and gearboxes featuring durable hygienic designs that can be easily cleaned without restriction or damage.

The effect of evolving food safety regulations and sanitary requirements on machine and equipment design

Undoubtedly, efficiently producing food products at high sanitary levels is the number-one priority of food processing and packaging companies. Integrity and commitment to social responsibility are the primary drivers for food safety, but manufacturers also need to minimize the risk of bad publicity and running afoul of newer and stricter government regulations.

The standards for acceptable levels of pathogens continue to change. An example can be seen in the evolving approach to the prevention of contamination by Listeria monocytogenes in ready-to-eat foods. While high standards have always existed in these areas, machine cleanability requirements continue to change.

At an American Meat Institute (AMI) workshop titled "Advanced Listeria Monocytogenes Intervention and Control Workshop," a group of 75 sanitation experts examined design changes for cleanability that were made by a couple of leading slicer and thermoformer machine manufacturers. The group reviewed both previous-generation and current machine designs. Their examination focused on product contact surfaces and noncontact adjacent areas, with a particular emphasis on eliminating niches and dead spots that could not be cleaned properly and inspected.

On the newer machines, sensitive equipment like instrumentation and motors that had been protected by enclosures/guards — creating potential dead spots — were moved into the open, where they could be cleaned during the normal sanitation procedure. The second session concluded with a demonstration of steam immersion cleaning, in which the entire machine was covered with a plastic tent and immersed in steam. Scrutiny of machine cleanability and new sanitation methods will continue to increase in the future.[1]

These activities are expanding outside of the ready-to-eat production environment. One example of increased scrutiny is the USDA guideline for controlling Campylobacter and Salmonella levels in fresh poultry. Issued in June, 2021, the guideline updates the 2015 standard that sought to reduce the levels of these pathogens significantly, with consumer groups demanding that the acceptable levels be pushed to zero.

According to the guideline, the Food Safety Inspection Service "has determined that contamination of poultry carcasses and parts by fecal material and enteric pathogens (including Campylobacter) is a hazard reasonably likely to occur (RLTO) in poultry slaughter establishments unless addressed in a sanitation SOP or other prerequisite program. For this reason, if an establishment relies on its sanitation SOP or other prerequisite program to address enteric pathogens, the establishment's HACCP [hazard analysis critical control point] system must identify why such sanitation SOP or other prerequisite program results in the enteric pathogens being not reasonably likely to occur."[2]

While product contact surfaces are aggressively cleaned in fresh poultry facilities, many times noncontact surfaces and adjacent areas are not considered. In a particularly severe Salmonella outbreak that sickened more than 634 people, hospitalizing 34%,[3] the USDA identified major causes as fecal material on carcasses, poor sanitary dressing practices, insanitary food contact surfaces, insanitary non-food contact surfaces, and direct product contamination.

Since then, resistance to antimicrobial drugs in Salmonella and other pathogens has become a major, escalating problem, making prevention through hygienic practices in the factory even more crucial. The CDC estimates that, in the U.S. alone, 216,000 infections and nearly 75 deaths per year result from drug-resistant Salmonella infections.[4] To minimize pathogen levels, equipment builders and food processors need to increase sanitation and improve scrutiny of noncontact surfaces and the general production environment.

Heightened awareness

Food safety and sanitation experts are increasingly being included in the machine procurement decision process along with engineering, operations, maintenance and purchasing staff. In the past, this level of scrutiny did not take place until the actual machine arrived on site, if at all. Now, through this collaborative decision making process, food safety and sanitation needs are being addressed in advance of the purchase so that hygienic requirements can be reliably met to prevent the need for significant modifications and minimize the risk of machine failures.

Designing machines that meet existing requirements, with the flexibility to meet future requirements, will be very important to machine builders and their customers going forward. Today's and tomorrow's machines must provide both hygienic cleanability (easy to inspect and clean) and durability (able to withstand evolving cleaning methods). Careful consideration of the components purchased for integration in these machines will be crucial for ensuring success.

Ingress protection ratings and washdown environments

Ingress protection ratings are defined in the international standard IEC 60529. The standard defines the protection provided against the intrusion of solid objects, dust and water into electrical enclosures. The commonly used rating consists of IP followed by two digits, for example, IP67. The first digit is the rating for solids or dust. The lowest dust rating that will be considered here is 6, which indicates a completely dust-tight enclosure. The second digit represents the degree of protection against liquid ingress as detailed in Figure 1.

IP second digit	Protection against	Effective against
0	Not protected	—
1	Dripping water	Vertically falling drops shall have no unsafe effect.
2	Dripping water when tilted at 15°	Vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle of 15° from its normal position.
3	Spraying water	Water falling as a spray at any angle up to 60° from the vertical shall have no harmful effect.
4	Splashing of water	Water splashing against the enclosure from any direction shall have no harmful effect.
5	Water jets	Water projected by a nozzle (6.3 mm) against the enclosure from any direction shall have no harmful effects.
6	Powerful water jets	Water projected in powerful jets (12.5 mm nozzle) against the enclosure from any direction shall have no harmful effects.
7	Immersion, up to 1 meter	Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1 m of submersion).
8	Immersion, 1 meter or more depth	The equipment is suitable for continuous immersion in water under conditions which the manufacturer shall specify. However, with certain types of equipment, it can mean that water can enter but only so that it produces no harmful effects.
9, 9K	Powerful high-temperature water jets	Protected against close-range high-pressure, high-temperature spray downs.

Figure 1: IP rating chart second digit: liquids.

Note: IP69 is defined in IEC 60529, while IP69K is defined in ISO 20653. The test protocols are similar, but not identical. While both ratings can be suitable in washdown environments, the IP69K rating was specifically developed for this purpose and is the highest rating a device can have. IP69K rated devices demonstrate protection against 14–16 liters of 80°C water per minute delivered with a force of 80–100 bar from a distance of 10–15 cm.

The IP ratings listed here all indicate some protection against water ingress and are useful in selecting products, but they are not based on adequate simulations of the washdown environments found in many food production facilities.

Day after day, machines in these settings are exposed to extreme temperature ranges created by refrigeration, volumes of hot or cold liquids used in sanitation, and heat produced by electric-powered equipment — especially motors. Additionally, caustic or basic cleaning solutions are sprayed onto equipment and left to soak, then removed with high-pressure wash.

All of these conditions can result in ingress that is not reflected by the IP rating tests. Moreover, these tests are only conducted over a time period of 2–30 minutes, depending on the IP rating that is being confirmed. Since these test times and conditions cannot accurately simulate actual manufacturing conditions, machine OEMs must think beyond the IP ratings and engineer machines using components designed for the specific environment where they will be used.

Figure 2: Kollmorgen's AKMH servo motor offers an IP69K rating and can endure daily high-pressure washdowns.

Motor considerations

With electric motors and the potential for contaminant ingress, a couple of issues are often overlooked or misunderstood. First, electric motors — like all electric devices — create heat. Under operation, the temperature of the motor increases; then, when powered off, the temperature decreases. This temperature cycle causes the small volume of air inside the motor housing to expand and contract.

When the air cools inside of the motor, it contracts, causing a pressure differential that can pull air and other fluids through the seals. This causes wear over time, increasing the likelihood that moisture and cleaning solutions will enter the motor, especially as it cools.

While it may seem logical to completely seal any device used in a washdown environment, an impervious seal is impossible to achieve since the motor shaft needs to turn. And without a method for equalizing internal pressure with the outside atmosphere, tighter seals only increase the pressure differential.

As a hot motor cools, the internal pressure can drop to 0.38 bar (5.5 psi) compared to a typical atmospheric pressure of 1 bar (14.5 psi) at sea level. This differential will inevitably pull air and contaminants past even the tightest seals, causing wear that will eventually lead to even greater ingress problems.

Moisture and chemicals inside the motor will ultimately cause failure of the bearings, winding insulation or the feedback device. To maximize the life of electrical devices used in washdown environments — avoiding frequent replacements and expensive downtime — some method is needed to negate this cycle of pressure-driven wear and contamination.

Kollmorgen has developed a vented connector and cable system to address this problem, equalizing pressure via a small vent tube that runs from the motor, inside the power/hybrid cable, to the electrical cabinet. With this system, temperature cycling has no effect on the internal pressure of the motor, which always remains equal to the outside atmospheric pressure.

A second issue to be considered is the cabling used in the washdown environment. The cable should be able to withstand the pH range of the cleaning solutions used. The cable jacket should be chosen to withstand direct pressure spray. Finally, the cable connectors should be designed to withstand the same chemicals and environment.

The main failure modes for servo motors used in washdown environments are ingress of moisture and cleaning solution into the motor, and the degradation and failure of cables and connectors. Careful selection of these components is important for maximizing the overall durability of your machines.

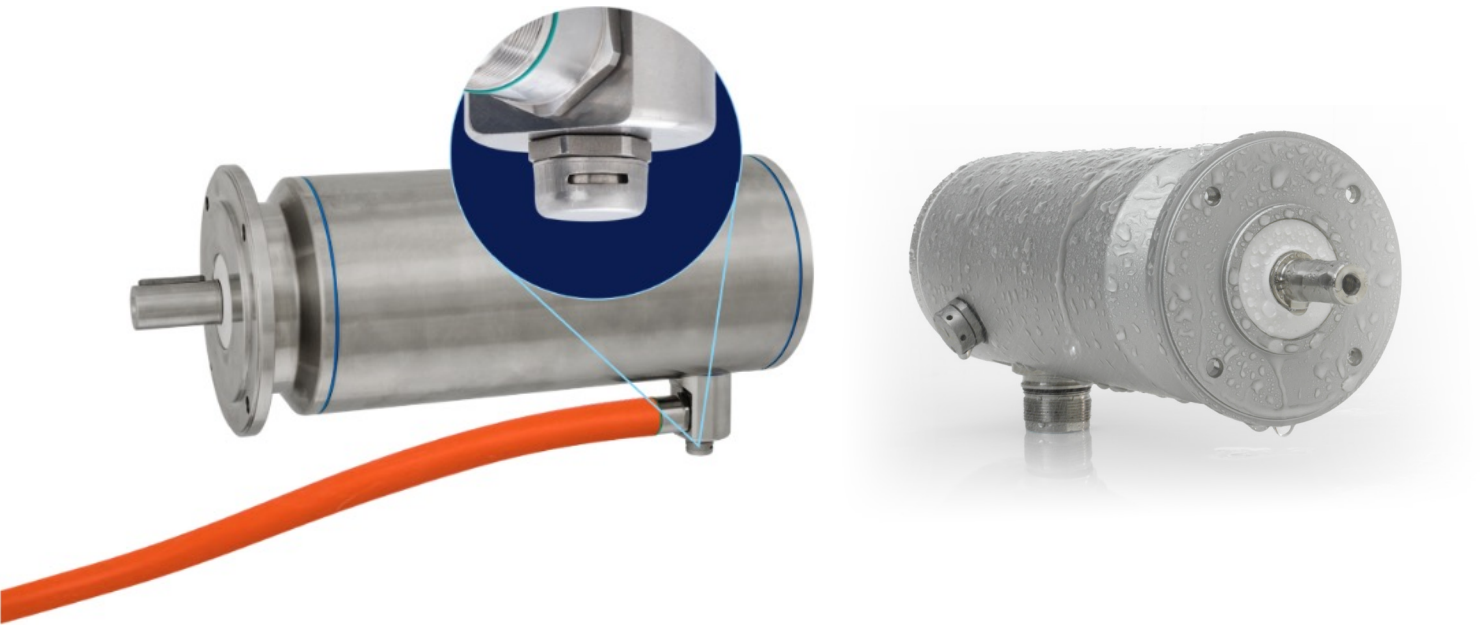


Figure 3: The AKMA & AKMH servo motors with IP69K washdown capabilities

Permanent and temporary covers, and their disadvantages

A common solution to the durability problems encountered when using electric servo motors in washdown environments is to craft permanent stainless steel guards/covers that protect the motors from cleaning solutions and water spray. There are a few drawbacks to this approach. The covers are expensive to fabricate and they add size and complexity to the machines.

Probably the biggest drawback is that the seal around the shaft exit eventually degrades and creates a dead spot for pathogen growth, or the seals fail completely and moisture ingress causes premature motor failure. Some cleaning regimens will require removal of covers and manual cleaning, which substantially increases cleaning time. Occasionally, contrary to instructions, cleaning crews remove the covers and spray motors that are not designed for direct washdown, often causing failures.

Another common solution is to use temporary covers or bags to protect motors during sanitation. There are a couple of issues with this approach. First, the bags or covers are inconvenient and time-consuming to install — sometimes leading cleaning crews to skip this essential step and wash down the motors directly, causing failure. Second, even when temporary covers are used correctly, motors must be cleaned manually. This significantly increases cleaning time, and the motors may not be cleaned as well if they are not included in the regular regimen, which could lead to future problems.

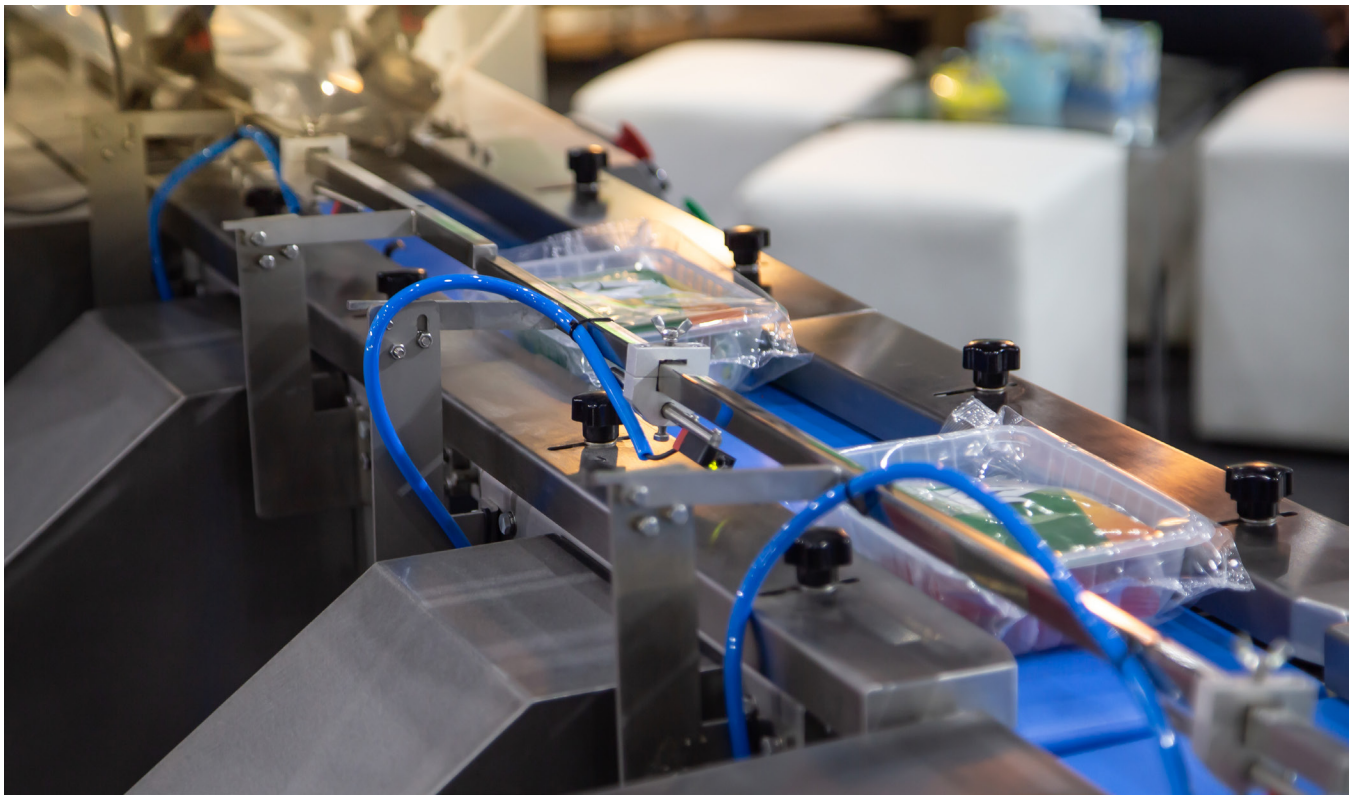
A better solution is to use electrical components, including motors, that are engineered to withstand a full washdown environment without restriction.

Cleanable to a microbiological level

In addition to being able to withstand washdown environments, components used in food processing and packaging areas should be cleanable at a microbiological level.

Generally, standard electrical motors and gearboxes, and even stainless steel products, have not been designed with this requirement in mind. Standard motors are typically painted, but these surfaces cannot be cleaned to a microbiological level because the finish is too rough and the paint itself inhibits cleaning. Many times, heat sinks are incorporated to enhance functionality, but heat sink fins make inspection and cleaning difficult. Other trouble areas that are difficult to clean and likely to harbor pathogens are fasteners, rough surfaces, metal-to-metal seams, nameplate areas and flat surfaces that allow liquids to puddle.

However, products are available that meet and exceed hygienic machine-design guidelines and are worthy of consideration for reasons of cleaning efficiency and food safety. The selection of a motor or gearbox that can be cleaned properly is just as important as the proper sizing of the equipment.



Choose your motion components wisely

Motion controls, electrical motors and gearboxes are integral to the development of highly effective and efficient machines in the food processing and packaging industry. The selection of electrical components for use in washdown environments has been limited in the past, leading to the use of components that were difficult to clean and prone to premature failure.

Manufacturers like Kollmorgen have developed high-grade components designed specifically to withstand these tough environments. (Top motors for use in food production and packaging environments are detailed in Figure 4.) Machine builders should seek out the latest selection of high-quality hygienic components for incorporation into their designs. Food processing and packaging manufacturers should make these components a requirement in their machine purchases.

The safety and quality of food products is at stake. But that's not all. Given the costs of cleaning equipment — and the extreme costs of downtime due to equipment failures — producers should be highly motivated to ensure that their machines are as easily cleanable and highly reliable as possible. Components designed specifically around the requirements of hygiene and durability in extreme washdown environments promise to make food processing and packaging operations more productive and profitable.

Kollmorgen offers a wide range of motors, cables and other motion products that meet these requirements, and we have extensive experience working with food and beverage machine OEMs to collaboratively engineer optimum motion solutions.

	AKMA	AKMH
		
Shaft Material	1.4404/316 stainless steel + chromium oxide inlay	
Hardware Material	No external hardware	No external hardware
Nameplate	Laser etched on rear cover	Laser etched
Housing Material & Coating	Round-frame 6082 aluminum anodized; satin gray	Round-frame, 1.4404/316 stainless steel; surface roughness < 0.8 µm per EHEDG requirement
Mounting Style	Flange	Flange or face
Ingress Protection (IP)	IP69K (static)	IP69K (static)
Shaft Seal	IP69K food-grade PTFE shaft seal	IP69K food-grade PTFE shaft seal
Typical Connectors	IP69K SS motor-mounted Hummel connectors	IP69K integrated motor cable; optional IP69K SS motor-mounted Hummel connectors
Application Examples	• Food and beverage, packaging: Cutting, packing, and filling where food contact is possible, or motor positioned laterally or below the food • Possible harsh locations, e.g. radar stations, wind turbines, offshore installations esp. where light weight is critical • Other: Pharmaceutical, medical laboratories	• Food and beverage, packaging: Cutting, packing, and filling where food contact is possible, or motor positioned laterally or below the food machines using exclusively stainless components • Machines which require BISSC, NSF, USDA, FDA compliance, and/or EHEDG design standards

Figure 4: Top motor products for use in food processing and packaging environments — contact Kollmorgen for more details.

Ready to move forward?

Contact Kollmorgen to discuss your needs and goals with a Kollmorgen expert for servo-driven applications.

1. Sutton, W., Notes taken from Advanced Listeria Monocytogenes Intervention and Control Workshop at the meeting of American Meat Institute, Kansas City, Missouri, October, 2014.
2. USDA, FSIS Guideline for Controlling Campylobacter in Raw Poultry, June 2021.
3. CDC, "Multistate Outbreak of Multidrug-Resistant Salmonella Heidelberg Infections Linked to Foster Farms Brand Chicken (Final Update)," July 31, 2014.
4. CDC Antibiotic/Antimicrobial Resistance (AR/AMR) 2020.

About Kollmorgen

Kollmorgen, a Regal Rexnord Brand, has more than 100 years of motion experience, proven in the industry's highest-performing, most reliable motors, drives, AGV control solutions and automation platforms. We deliver breakthrough solutions that are unmatched in performance, reliability and ease of use, giving machine builders an irrefutable marketplace advantage.

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