LEADERS
IN MACHINE DESIGN

2021
Machine Design®

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ABOUT ALTECH

Altech Corporation is an established United States supplier of components and devices used in industrial control, instrumentation, medical and automation applications. Altech provides a very broad line of products that meet UL and international standards and are RoHS and REACH compliant. Altech's commitment to continuous quality management has been recognized since 1999 when they were awarded ISO 9001 certification.

Altech provides a multitude of services for customers. This starts with its employees, where product managers provide technical support and partner with customers in design assistance, ensuring the best solution for the application. Next, an efficient customer service department ensures that customers are informed with complete order information. Depending on the product, the versatile assembly department provides manufacturing, value-added, or customization services to expedite delivery. Altech's marketing department has been highly recognized for its catalogs, advertising, and website designs, while the sales department motivates the sales organizations throughout North America, ensuring product information is current and complete.

SERVING AUTOMATION AND CONTROL INDUSTRIES SINCE 1984

Altech's products meet UL and international standards, and all are RoHS- and REACH-compliant. Altech's commitment to quality and continuous quality management had been recognized since May 27, 1999 when it was awarded the prestigious honor of ISO 9001 certification. Since then, Altech has successfully gone through the recertification process and complies with ISO 9001:2015.

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The Altech product line includes miniature circuit breakers, busbars, DC-UPS devices, digital panel meters, DIN rail terminal blocks, printed circuit board terminal blocks, contactors, industrial relays, motor disconnect switches, pin and sleeve devices, receptacles, foot switches, relay modules, safety relays, slimline relays, solid state relays, push buttons, and pilot lights.

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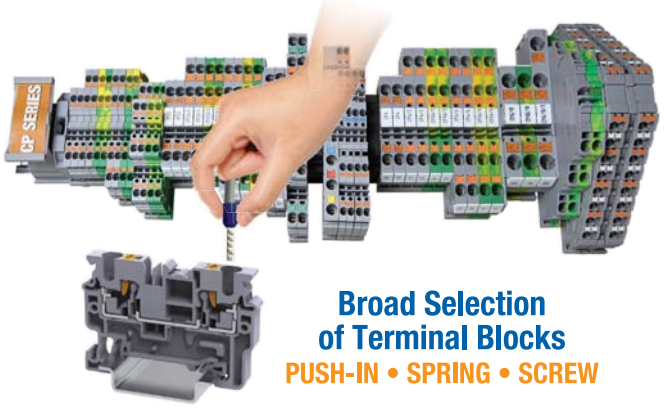
OUR POLICY

Altech Corp.'s Company Policy remains to provide adequately stocked quality products at competitive prices. Superior customer service and delivery are maintained through a quality management system and continuous process improvement and by performing these services with honesty and integrity. All Altech employees are regularly trained in quality management systems, and as a team are committed to achieving these goals.



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Editorial
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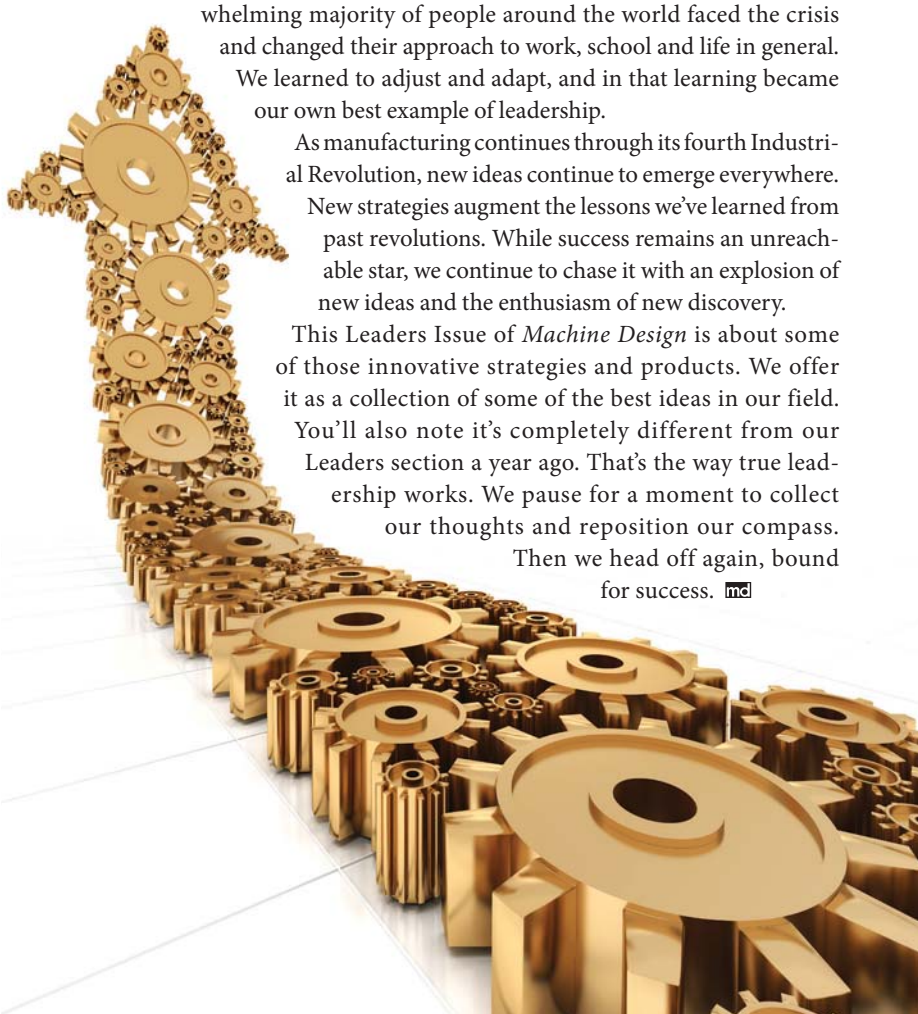
Leading Towards SUCCESS

There's an entire section in the library devoted to the subject of leadership. Rows of shelves and categories in your favorite bookstore or e-tailer offer dozens of tomes offering dozens of views on the subject of leadership. The funny thing about leadership is that it is associated with success, and that's simply not always the case.

Leadership in its most basic form is setting a direction and convincing people to join you in heading in that direction. The trouble is that leadership does not guarantee success; it's simply the first step in the process toward a desired outcome.

While leadership is linear, it's not usually a straight line. In fact, the willingness to adapt to the reality of the moment may be the truest test of leadership—and the truest warning about the potential for failure. Setting a course and taking a step are the first signs of leadership, but understanding that there always are new ideas, multiple choices and unexpected obstacles should also be part of the leadership process.

Our history books are filled with examples of leaders who started out with good intentions but who wound up coming short of their goal. They sometimes failed to plan, but more often, they failed to adapt. One of the big lessons of the past year—and perhaps its singular success—is that amid all the suffering in the pandemic, the overwhelming majority of people around the world faced the crisis and changed their approach to work, school and life in general. We learned to adjust and adapt, and in that learning became our own best example of leadership.

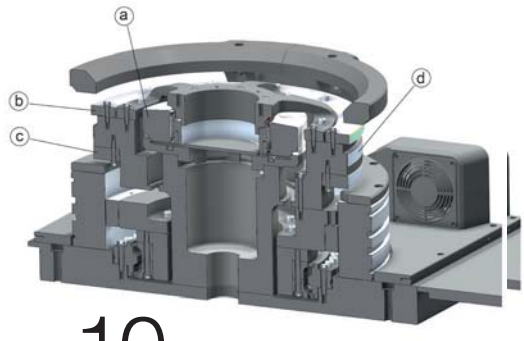


As manufacturing continues through its fourth Industrial Revolution, new ideas continue to emerge everywhere. New strategies augment the lessons we've learned from past revolutions. While success remains an unreachable star, we continue to chase it with an explosion of new ideas and the enthusiasm of new discovery.

This Leaders Issue of *Machine Design* is about some of those innovative strategies and products. We offer it as a collection of some of the best ideas in our field. You'll also note it's completely different from our Leaders section a year ago. That's the way true leadership works. We pause for a moment to collect our thoughts and reposition our compass. Then we head off again, bound for success. md

IN THIS ISSUE

FEATURES



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COLUMNS & DEPARTMENTS

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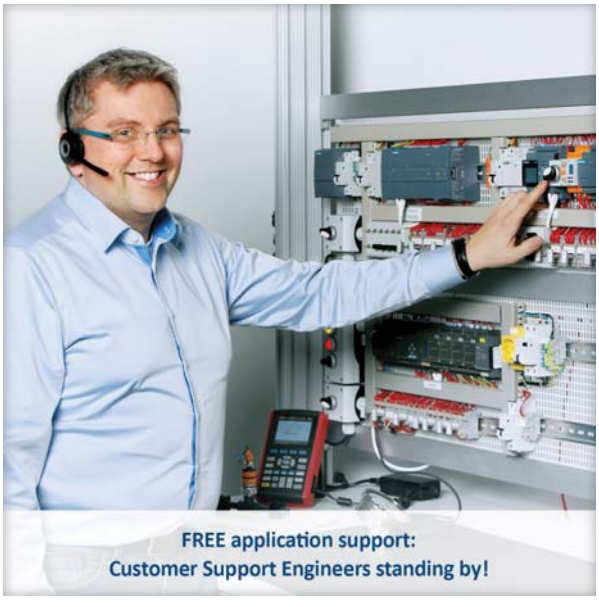

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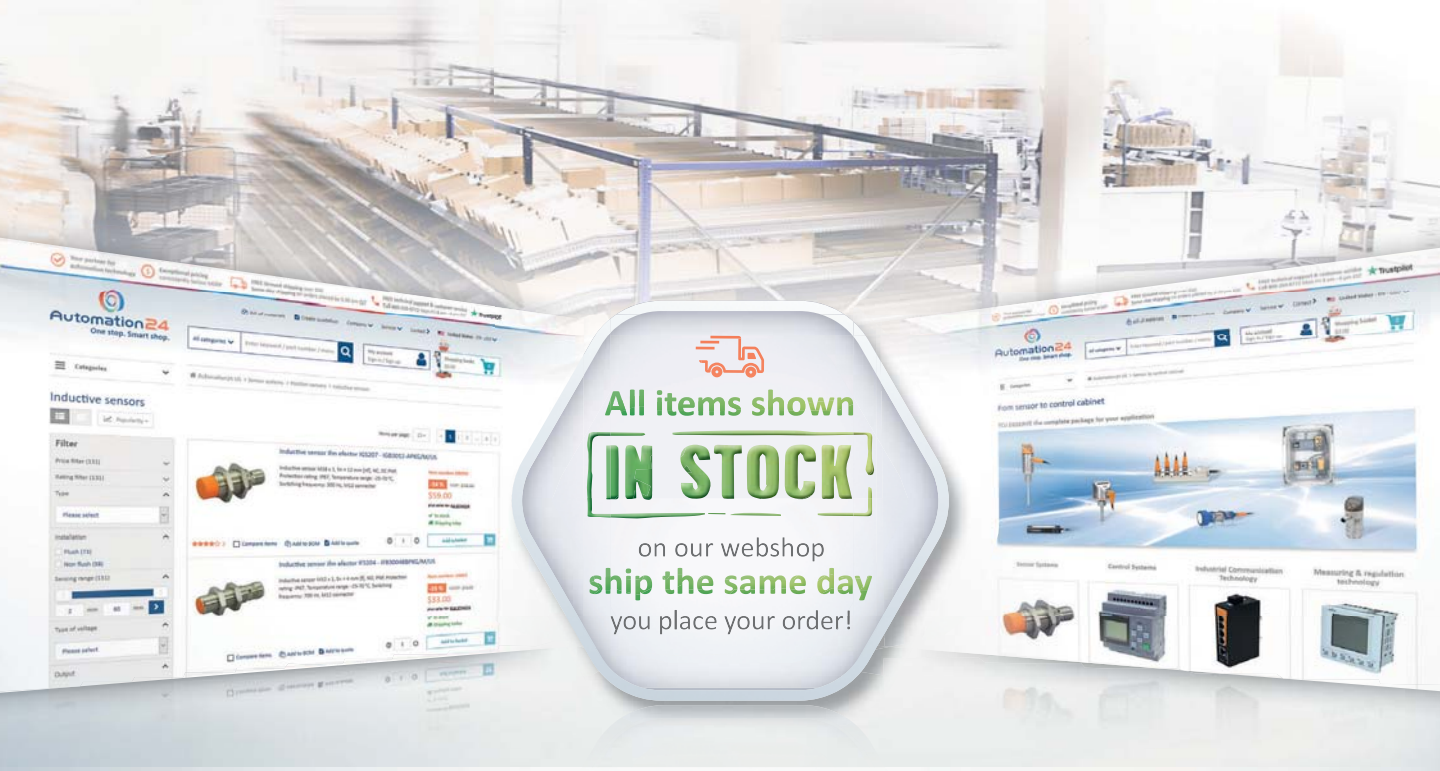

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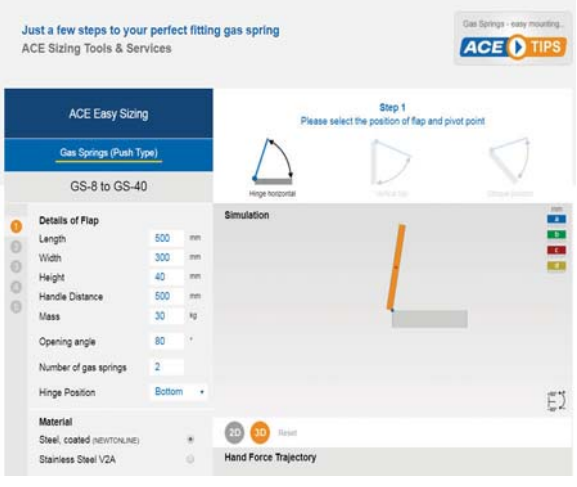

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TOM AYARS | Software Engineering Manager, Branson Ultrasonics, Emerson

Rethinking Data Security in Ultrasonic Welding and Manufacturing

Used in medical, electronic, automotive and consumer products manufacturing, these systems should meet industry data integrity standards.

Emerson's Branson GSX-E1 ultrasonic welder. *(Courtesy of Emerson)*

Digital technologies can help drive performance improvement throughout your operations, but without the right cybersecurity safeguards and approaches in place, your plant and enterprise could face the increased risk of a crippling cyberattack causing significant manufacturing downtime, a loss of consumer confidence in your product, or the loss of crucial quality or regulatory data.

Implementing a cybersecurity program begins with recognizing risks and responding by integrating essential, practical security solutions to ensure system security, data security and data integrity. Effective cybersecurity requires staying up-to-date on the latest threats, performing real-time asset inventory, improving threat-detection capabilities, ensuring equipment and devices have the latest defense measures, patching and updating systems, and enhancing incident response capabilities.

In addition, policies and procedures, workforce upskilling and periodic training are all key aspects of cybersecurity that should be deployed to protect critical systems by following a risk-based approach. Putting the basics in place gives you the flexibility to deploy more sophisticated measures as the need arises.

One critical area is the protection of vital manufacturing data. Consumer trust in manufactured products is built on accumulated experience and data that validate product performance, as well as the capability of a manufacturer to maintain consistent and controlled manufacturing processes that ensure repeatable, high-quality production.

For Emerson Assembly Technologies, these processes include the ultrasonic welding of plastics with traceability and digital controls, which are essential to the function of medical and drug delivery products and devices; food, beverage and snack products; computer products; automotive under-hood and interior components; and consumer electronics. All of these products are manufactured and used in the tens of millions every day, with each product reliant on the demonstrable quality, safety and consistency of the manufacturing processes that produce them.

With the ongoing digitalization of the manufacturing floor, manufacturing data is now an essential part of the "proof" that businesses, consumers and regulators demand to see when they consider the safety, value and performance of a product. Any threat to the consistency of the manufacturing process or the integrity of manufacturing data can represent a direct threat to product approval or market acceptance.

This is why data integrity is so important, yet equipment controls, industrial control systems and associated networks historically have not been designed with data integrity and security safeguards foremost in mind.

HOW TO COLLECT HIGH-INTEGRITY DATA

Virtually every product or service requires the support of high-integrity data, though the requirements and implications associated with that data vary. For example, because any inconsistency or error in producing approved medical products and drug delivery devices could threaten human health, the Food and Drug Administration (FDA) and other global regulators demand these products be uniquely traceable.

Traceability requirements, embodied in the FDA's Code of Federal Regulations (CFR) Title 21 Part 11, extend to all forms of manufacturing data: data that provides a complete audit trail, data that can trace finished devices by lot or individually, data about component

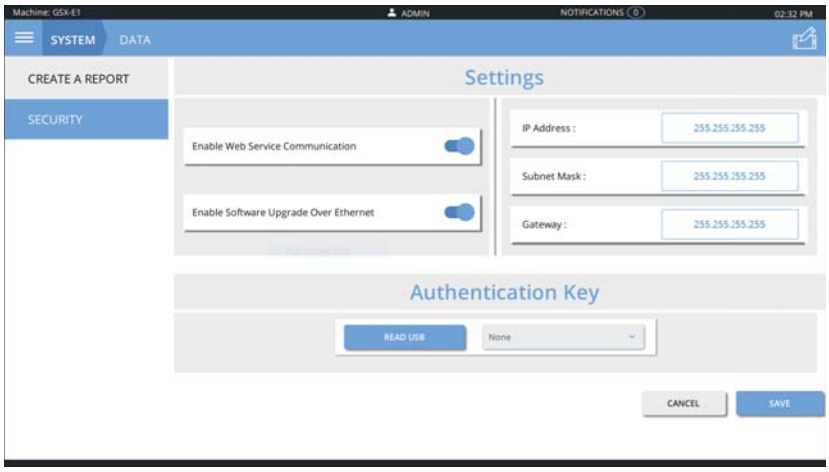
parts and data about the quality of individual ultrasonic welds—right down to the day, time and operator in charge.

To comply with this regulation, it is essential that the integrity of manufacturing data be safeguarded not only during its creation and storage, but also through features that limit access and assure complete, secure data transfer from the point of manufacture to remote global locations for use by corporate systems or global regulators.

While it is true that the suppliers and makers of electronics and automobiles do not face precisely the same type of manufacturing regulation as approved medical products, the quality and success of their operations demand essentially similar, high-integrity manufacturing data to ensure production efficiency, validate the quality and consistency of their products and ensure significant levels of product traceability to support everything from customer service to product warranties.

To ensure operational quality and success as well as the availability of secure, high-integrity manufacturing data from one important piece of many manufacturing processes, Emerson's software development team took a look at the security needs of automated ultrasonic welding systems. Ultrasonic welding systems play a major role in the manufacturing of a wide range of medical, electronic, automotive and consumer products and are vital to the production of personal protective equipment and a wide range of packaging for foods, beverages, snacks and other products.

To ensure that its newest ultrasonic welding platform, the BransonT GSX-E1, would not only meet the stringent FDA data-integrity requirements but also deliver the high quality and volume of secure production data demanded by other manufacturers, Emerson determined that this welding platform would be upgraded to provide security features modeled on those of typical "front-line" IT equipment—computers and servers connected directly to the internet.



Data transfer is secured with encryption technology. *(Courtesy of Emerson)*

The user management system of the Branson GSX-E1. *(Courtesy of Emerson)*

Through these software upgrades, the welding platform is capable of supporting 21 CFR Part 11 standards for data integrity, which include validating users for system security, storing data for up to 200,000 individual product welds, creating audit trails capable of identifying data manipulation and delivering data to meet FDA traceability requirements. The platform is also capable of meeting the most stringent demands of high-value, high-volume manufacturing processes worldwide.

A second and related upgrade to the ultrasonic welding platform gives it market-leading encryption technology that ensures the integrity and security of data transfers. After authenticating the identity of the data recipient, this technology assures secure data transfers from welders on the manufacturing floor to local or remote enterprise quality management systems, to customer systems or to regulatory bodies. The authentication process ensures that the data is coming from a reliable source (the welder) and that the welder is not sending data to an unidentified fraudulent attacker.

In short, improving the security and safeguarding the integrity of data generated and shared by vital manufacturing assets are critical responsibilities for every producer of capital equipment. md

Design Feature

NATHAN SERAFINO | Applications Engineer, Yxlon

NON-DESTRUCTIVE TESTING:

Should You Invest in a System or Service Partner?

NDT is an important part of quality control for the automotive, aerospace and electronics industries. Here is a breakdown of both investment options.

WHAT IS NON-DESTRUCTIVE TESTING?

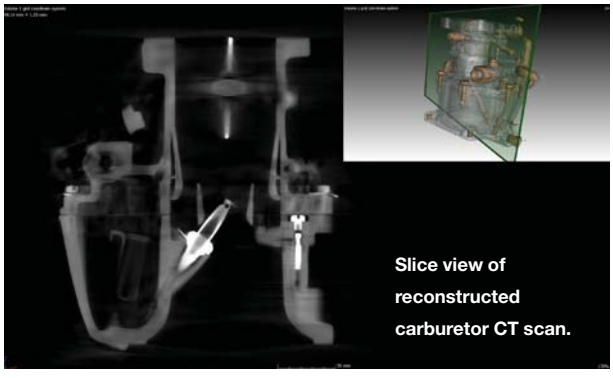
When manufacturing products for aerospace, automotive, electronics or a variety of other applications, testing or inspection in some form is critical to ensure that the products meet quality and regulatory standards as well as end-customer expectations. To certify that the structural and mechanical components will be able to function safely, reliably and cost-effectively for the mission-critical applications in these industries, the use of non-destructive testing (NDT) is ideal. NDT does not require that a part be altered or destroyed during inspection, which saves both time and money in evaluation, troubleshooting and research.

In addition to X-ray, other forms of non-destructive inspection include ultrasonic, visual and optical; magnetic-particle; penetrant; eddy-current; and low-coherence interferometry testing. In many cases digital radiography (DR) and computed tomography (CT) are the top choices for NDT because of their diverse range of applicability, ease-of-use and powerful visualization capabilities.

When choosing between DR and CT, it is important to understand the differences in capability between the techniques. DR offers a quick and effective way to visualize internal features and defects and make simple measurements of a sample by digitally displaying real-time, 2D projection X-ray images. CT expands on the X-ray technology by synthesizing 3D volumetric datasets to enable precise virtual cross-sectioning of the part. The resultant data provides superior contrast, advanced volumetric measurement capability and quantitative density characterization.

In order to produce an effective CT reconstruction, CT scanners collect a series of 2D X-ray images at predetermined rotational steps, usually through 360 deg. After the 2D projections are compiled, the system begins reconstruction and "tomograms" are created for each row of pixels on a digital X-ray detector. Tomograms are virtual slices through a 3D object composed of voxels (volumetric pixels). The reconstruction process then assigns each voxel a gray value that corresponds to the actual density of the of the object at that location. The higher or brighter the gray value, the denser the material.

The final CT dataset enables visualization of slices (virtual cross-sections) at any desired angle, allowing the operator to scroll through the part in any plane in real time. Additionally,



Slice view of reconstructed carburetor CT scan.

volume renderings are constructed automatically in the CT analysis software by assigning a color and opacity to each voxel that scales according to their gray value. These renderings of external and internal geometries of an object provide sophisticated and photorealistic visualization with adjustable shadows, transparency, camera angles, video creation and more.

CT scanning is widely used for a wide range of applications, including material analysis, defect recognition, failure analysis, statistical process control, metrology, assembly verification, image-based finite element analysis, reverse engineering and counterfeit detection. Many manufacturers also use CT to help fine-tune production parameters for die casting and additive manufacturing since it shows internal problems such as porosity, cracks, inclusions and foreign objects in blind cavities.

SYSTEM INVESTMENT vs. SERVICE PARTNERS

X-ray and CT systems can be a significant and worthwhile investment when integrated into traditional production lines, research and development labs, and quality control. Additionally, it is becoming more commonly used in-line or at-line in smart manufacturing facilities. However, if a facility does not need to inspect products regularly or volume of inspection is low, purchasing X-ray/CT systems may not be the right option. Alternatively, partnering with an inspection services provider may be a more efficient and cost-effective decision by leveraging the skills and expertise of knowledgeable NDT professionals.

Inspection service capabilities for common NDT applications in the automotive industry include visualization and quantification of porosity, shrinkage and inclusions, wall thickness measurements and detection of foreign objects in castings.

Additionally, identification of defects or missing wires in belt plies for tires and verification of air inclusions, shifts and distortions in the reinforcement plies are also common.

For the aerospace industry, a vast range of components can be effectively inspected by X-ray and CT inspection service providers, including turbine blades, flight hardware/sensors, welded components and more. In the electronics industry, solder quality, BGA inspections, wire bond defect detection, trace connectivity and visualization, and through-hole solder fill are all common inspection projects for inspection service providers.

WHAT TO LOOK FOR IN AN INSPECTION SERVICES PROVIDER

Inspection services providers can often offer more than simply generating 2D and 3D images by scanning your product or components. Service providers may also be able to offer:

- Support in development of specific solutions and testing procedures
- Fact-based recommendations and techniques tailored to meet your inspection goals
- Personal expert level support in data preparation, visualization and analysis
- Additional support during workload peaks or capacity bottlenecks
- Inspection of high-density and oversized items with high power linear accelerator X-ray systems
- Precise dimensional measurements for internal and external features and structures
- Workshops, seminars and training for your personnel

Inspection systems and inspection services vary greatly across manufacturers and service providers. However, a manufacturer of industrial X-ray systems that also offers inspection services has unparalleled depth of experience and capability by leveraging the optimal use of its own technologies. Once the decision to use inspection services has been made, there are a variety of items to consider when selecting which service provider to use.

First is capability. It may seem like a basic concept, but only consider a partner that can provide the specific set of capabilities that you need. Next is pricing. Compare prices from multiple service providers for the services that you need; do not hesitate to request quotes from multiple providers for the same project. Some companies even offer free quoting and feasibility tests.

Complete a trial project to evaluate the quality of image that each provider's equipment offers. Having scans conducted on the same sample by multiple providers can help you make a fair comparison of image and data quality. Along with the equipment they use, a service provider's personnel are also important to the quality of your inspection so investigate the level of training of the team members who will perform the scan. Most providers work within international standards such as ISO or ASTM. Many systems—regardless of manufacturer—use the same software to provide results, therefore the skill of the operator can truly differentiate one provider from another.

Remember to factor in shipping time if not already included in the quoted turnaround times from the providers. Service providers with multiple locations may be capable of performing scans more quickly and provide better shipping times due to flexibility of location. For companies with a global need for inspection services, using a global service provider is also a good decision.

Also, investigate the service provider's equipment. Some companies readily provide descriptions and details of their inspection systems to prospective customers. Generally, the newest systems will provide the highest resolution and produce the best images. Providers should update their equipment and software regularly.

WHAT TO EXPECT FROM THE INSPECTION PROCESS

The inspection service process is typically straightforward; however, some complicated projects may require additional steps in the process.

Before sending parts for a trial, the inspection service provider will need to know part dimensions, part materials and a brief description of the inspection needed and desired outcomes. If there are any specific requirements, such as visualizing porosity of 0.5 mm or greater, this information is provided in this step. Next, the provider will send a quote. If there is a question about whether the provider can meet your inspection goals or if the project is not easy to quote, the provider should offer a feasibility test.

Feasibility testing requires one representative test sample to be sent in order for the provider to demonstrate the level of data quality to expect for the entire project. Typically, they will provide images of a region of interest relevant to the inspection to give confidence in their capability.

Sample delivery, test execution and results delivery are the next steps, and this process varies from provider to provider. As an example of a typical process, when industrial X-ray inspection system manufacturer Yxlon's inspection services team receives a part, it takes about one to two weeks to deliver results for smaller projects. Data delivery options include sending files via FTP or, for large data sets, external hard drives may be provided. Yxlon can provide a free viewer for CT visualization, image stacks of the slices in JPEG or TIFF files, or slice projection/volume rendering movies.

The provider will then work with you to ship back the parts or dispose of the samples depending on your need. Inspection services can provide valuable data and insights for a range of product applications, and choosing to invest in an inspection system or partnering with an outside inspection service provider is the first step. md

HEIDENHAIN STAFF

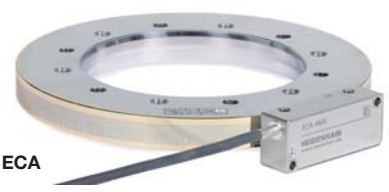
Evaluating Angle Encoders' Effects on Motors

Choosing the right encoder is critical for reliable, stable and accurate machining processes.

Why are there so many different angle encoders on the market? Why do they use different scanning and measuring methods? And which one should a designer choose?

To answer those questions, engineers at Heidenhain set up a torque motor commanded by a CNC controller hooked up to four different angle encoders to see how they differ. The four absolute angle encoders included a sealed optical encoder for rotary tables and swivel heads; a modular optical encoder with a steel scale drum for wide-axis rotary tables and swivel heads; a contamination-tolerant modular magnetic encoder; and a compact inductive scale-tape encoder.

The controller simulated positioning tasks for each angle encoder while technicians analyzed how signal quality affects dynamic performance and how the measuring principle affects accuracy. They also examined how using data from the motor, encoder and sensor could improve process reliability.



ECA

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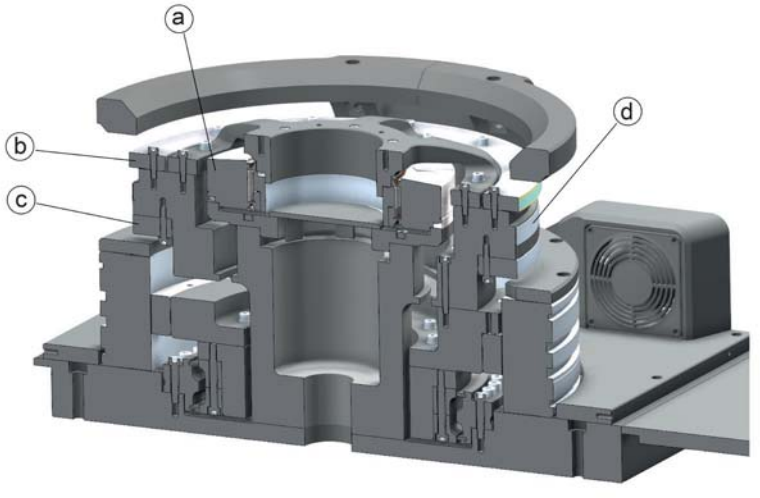
SIGNAL QUALITY

In direct drive motors, the encoder's signal quality plays a critical role in the amount of electrical current noise, which affects the motor's dynamic performance and possible power dissipation. The noise is a retroactive effect of interpolation errors and affects the dynamic performance of an axis. Interpolation errors, in turn, are rapid changes in the position value that cause errors in calculating the speed calculation. These errors lead to more current noise. To avoid instability in the drive system, the increase in noise must be counteracted by reducing the loop gain, which will in turn lower the motor's dynamic performance.

Noise also affects a motor's thermal behavior. Low noise levels translate into lower power dissipation and motor temperatures. High noise levels, on the other hand, increases the motor's power dissipation and significantly raise its temperature.

Comparing the noise from different encoders reveals their behavioral differences. Optical encoders cause low, steady noise, whereas magnetic and inductive encoders cause higher, much more heterogeneous noise, even with a low-pass filter. This makes optical encoders the best choice for getting the most out of a motor's performance potential and getting the best-surface quality.



This device was used to test and evaluate the different encoders using a TMB+ torque motor from ETEL. The cutaway shows the positions of the different absolute angle encoders: (a) a Heidenhain RCN 8311, a typical sealed encoder for rotary tables and swivel heads in high-accuracy machine tools; (b) a Heidenhain ECA 4410, a typical optical encoder with a steel scale drum for wide-axis rotary tables and swivel heads; (c) a Heidenhain ECM 2410 magnetic encoder; and (d) AMOS's WMxA 1010 inductive encoder, a scale-tape version that is compact and contamination-tolerant.

ACTUAL VERSUS DESIRED POSITION

Whether or not the actual position of a rotary table coincides with the desired position can be evaluated based on statistical measurement of positioning accuracy in accordance with ISO 230-2. This calls for five clockwise and five counterclockwise revolutions of the rotary table, with 12 measurements taken at 30-deg. steps over each revolution.

Key metrics for evaluating encoders are Parameter A (the bidirectional positional accuracy) and Parameter M (the range of the mean bidirectional positional deviation). Parameter A is comparable to the accuracy of an angle encoder and Parameter M to the graduation accuracy, each taking into account the error from the application.

To evaluate the contouring accuracy at a given maximum speed, the evaluation went beyond ISO 230-2 criteria and added dynamic accuracy of positioning (designated by the letter D). As in ISO 230-2, measurements are once again taken over five clockwise and five counterclockwise revolutions of the rotary table. This time, however, the measurements are taken at a scanning rate of 5 kHz and a speed of 20 rpm.

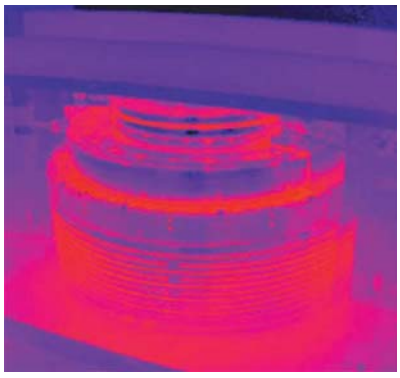
Measuring the dynamic positioning accuracy at the contouring accuracy uncovers high deviations for inductive angle encoders. (Contouring accuracy refers to the changes in accuracy measured at speed by comparing desired position to actual position.) The deviation is a byproduct of inductive scanning that causes accuracy to vary with speed. In contrast, optical encoders demonstrate hardly any deviation between desired and actual positions. The magnetic encoder showed mid-level performance without extreme deviation.

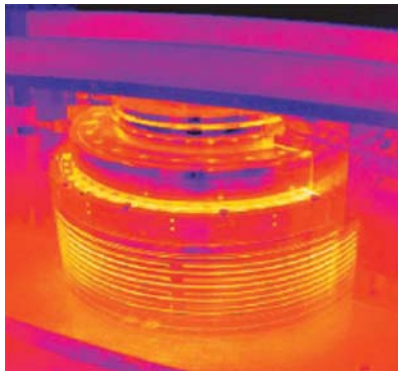
MOTOR PROTECTION

Torque motors provide high performance in a compact device. But overheating is a risk if current distribution in the windings becomes asymmetric during certain machining operations, causing a surge in temperature of a single winding. Sending sensor data on thermal behavior around the motor to the controller protects the motor, as well as increases the reliability and efficiency of machining processes.

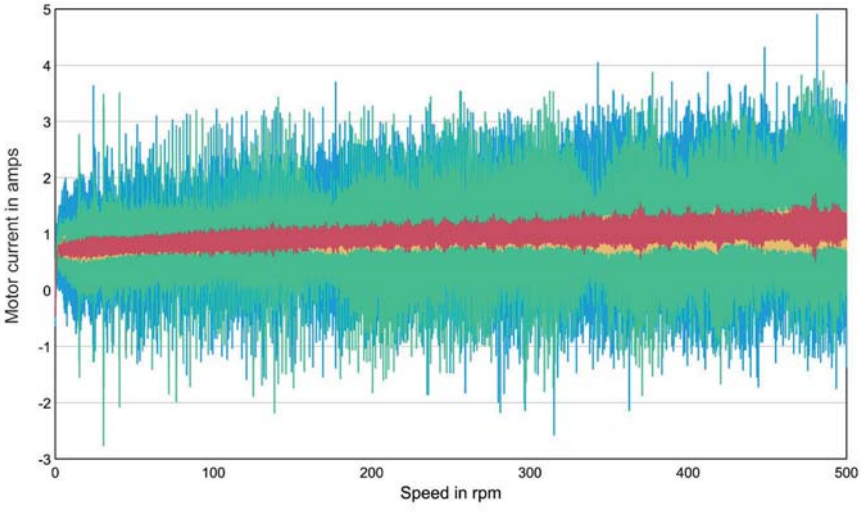
The sensor box used in the evaluation monitors all three motor windings, providing the temperature data for immediate use. The box is installed next to the motor and between the encoder and controller. If the motor's thermal model is already known, as is the case with the torque motor, the sensor box will rapidly detect sudden temperature rises, preventing damage to the motor windings and protecting the motor from overheating.

Choosing the right encoder and using the various data available from the machining process are important for reliability, stability and accuracy of machining processes. Knowing the characteristics of different encoders lets designers and developers choose the most suitable encoder for an application. After all, choosing the right encoder isn't just about dynamic performance and accuracy; designers and developers must also take design-related factors such as the shaft diameter and mounting into account, not to mention cost-effectiveness. md





The thermal image on the left shows the lower motor temperature for an optical angle encoder used for position control compared to the higher temperatures created by a non-optical encoder, as seen on the right.



	Type	Scanning	Line count	Resolution (in bits)	Max. speed in rpm	Applied TNC filter
	RCN 8311	Photoelectric	32768	29	1500	None
	ECA 4410	Photoelectric	25993	28	900	None
	ECM 2410	Magnetic	2600	25	4500	FIR=2
	WMxA 1010	Inductive	1024	24	520	FIR=2

This graph shows the noise levels generated by the four different encoders.

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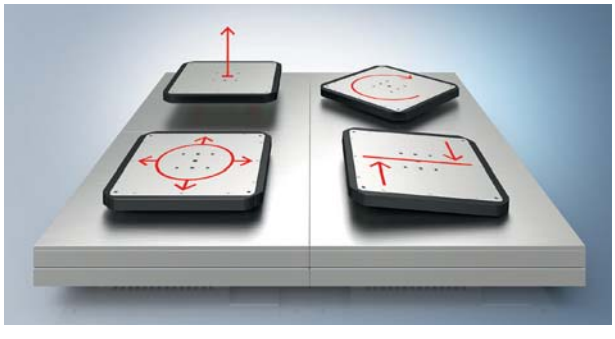
NEXT-STEP AUTOMATION TECHNOLOGY FROM BECKHOFF OFFERS UNRIVALED FLEXIBILITY AND THROUGHPUT

Beckhoff Automation is a global provider of open automation systems based on advanced PC Control technology. The "New Automation Technology" philosophy at Beckhoff represents universal and open automation solutions used in a wide spectrum of high-tech applications around the world. These applications range from control of machines and robots, to Internet of Things (IoT) systems, to category-defining mechatronics solutions and much more. The world headquarters of Beckhoff Automation is in Verl, Germany while the U.S. headquarters office is in Savage, Minn. (Minneapolis area).

The EtherCAT-enabled eXtended Transport System (XTS) offers paradigm-shifting capabilities for motion control and mechatronics by combining the advantages of proven rotary and linear motion principles into a new modular platform. With its compact and flexible design, the advanced mechatronic system can reduce machine footprint up to 50%. The XTS revolutionizes drive technology and promotes innovative, globally competitive machine concepts. XTS contains all functions necessary to support efficient integration for motion control applications in many industries. With attached mechanical guide rails, XTS motor modules feature directly integrated power electronics, EtherCAT communication and position measurement. An unlimited number of wireless XTS movers can be controlled with high dynamics at up to 4 m/s on extremely customizable paths.

Beckhoff expanded the XTS portfolio recently with new hardware and software enhancements. XTS Hygienic, a stainless steel, IP69K version, is ideal for wash-down production environments in packaging, pharma, food and beverage. In addition, new Track Management functionality allows individual movers to transfer between multiple XTS systems, enabling further customization, quality inspection, automatic defect ejection and more. These features, along with the system's high speeds, dynamics, small footprint, instant recipe changeovers and real-time integration with robotics, further revolutionize possibilities in machine design.

Another breakthrough in mechatronics technology, the XPlanar flying motion solution delivers unrivaled flexibility and throughput in part, product and package handling. The system uses planar motor tiles as a base to levitate passive movers that can fly at speeds of 4 m/s and acceleration up to 20 m/s^2. Path planning and collision avoidance software produce extremely efficient and maintenance-free motion control for complex assembly, packaging, inspection and material handling applications. Anti-sloshing functionality in TwinCAT 3 software optimizes XPlanar's transport capabilities in applications involving liquids, such as filling of beverages, cosmetics and other goods. XPlanar offers wear-free movement and the ability to cover planar motor tiles with stainless steel, glass or other hygienic surfaces.



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A revolution in linear transport systems: XTS

NEXTSTEP

The XTS advantage

- circulatory movement
- flexible modular system
- individually movable movers

User benefits

- reduced machine footprint
- software-based changeovers
- improved machine flexibility
- increased throughput
- shorter time to market

www.beckhoff.us/xts

Manufacturers around the world need to offer increasingly customized products – with machines that deliver reduced footprint and improved productivity. Available now in the U.S., the eXtended Transport System (XTS) from Beckhoff answers these machine design challenges and more. In combination with PC- and EtherCAT-based control technology, the XTS features a high level of design freedom for machine builders to develop game-changing concepts for product transport, handling and assembly. A stainless steel hygienic XTS version is ideal for use in the pharmaceutical and food industries.

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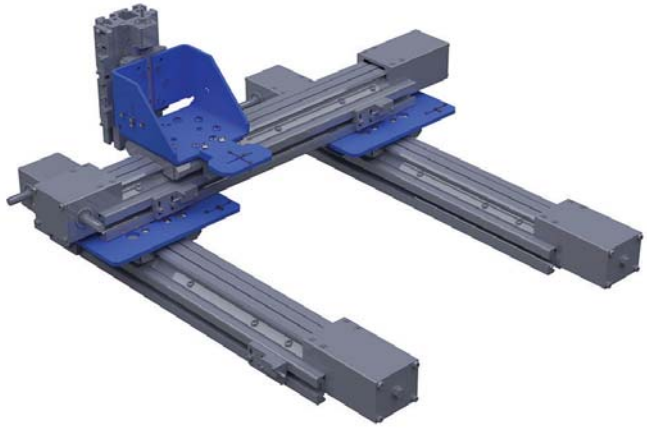

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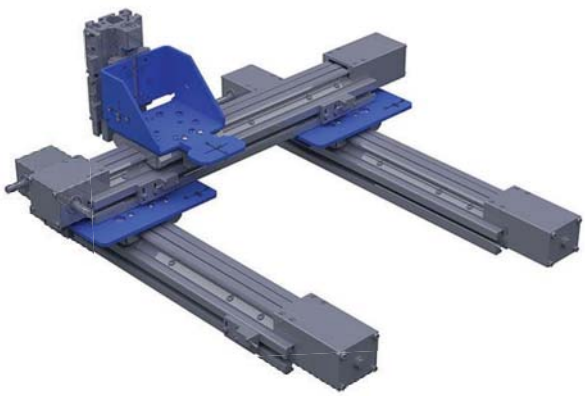

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TSUYUSHI AOMI | Chairman and CEO, Aomi Precision

ADVANCED MACHINING *for Hard-to-Make Parts*

When it comes to creating parts with small features, tight tolerances, complex geometries, and challenging materials or finishes, advanced machining could be the answer.

Advanced machining can solve many of the challenges of today's increasingly difficult-to-produce parts such as miniaturization, part complexity, strict tolerances, thin walls, material hardness and smoothing rough surfaces. Here are five examples of typical manufacturing hurdles engineers face and how advanced machining can overcome them.

Advanced machining can tun out small precision screws and other fasteners.

Machining can create thin walls and meet challenging surface finish requirements.

STRICT TOLERANCES

On a part with a tight hole entrance tolerance, the tool length, tool angle and thermal fluctuations during manufacturing can make it difficult to maintain that tolerance. Advanced microfabrication and high-speed rotary forming can create a miniature part to exact specifications, and the right tools and jigs will hold parts in place for a smooth surface finish.

Advanced machining tools, such as end mills with minimum diameters down to 0.01 mm, can efficiently and consistently perform milling, hole drilling and S0.5 (0.5-mm diameter) thread cutting—even for hole entrance tolerances of ±5 µm or less. These tools can also meet a thickness tolerance of 0.15 ± 0.01 millimeters and maintain a surface roughness profile of Ra 0.1 µm. These specifications are often too difficult for many manufacturers.

THIN WALLS

A conventional press may seem a good way to make miniature steel parts with thin walls, but it can generate heat and create residual material stresses. These make it difficult to make precise wall thicknesses without distorting the material and adding time and expense to the job. Despite these drawbacks you can still use a conventional press, but machining them offers precision and cost advantages.

Consider a round, cylindrical part like a stainless-steel motor housing. Such parts often call for wall thicknesses as small as 0.2 ± 0.05 mm. This specification is well within the capabilities of advanced machining, which can make walls as thin as 0.035 mm while maintaining precise geometric tolerances for roundness and concentricity.

COMPLEX SHAPES AND SURFACE ROUGHNESS

Demanding applications often call for stainless steel parts with both complex shapes and surface roughness challenges. Part with contoured surfaces in multiple axes need the latest machining technology. Stainless steel valves for fuel cell vehicles, for instance, must have scratch- and burr-free internal passages. This is

an ideal task for advanced machining's precision and quality finishes.

For example, advanced machining can create intricate parts with outside diameters smaller than Ø160 to strict geometric tolerances. It can also provide concentric groove machining and four-axis grinding, plus a range of surface finishes such as seal-surface and mirror-surface finishes.

TITANIUM AND SUPERALLOYS

For many part makers, machining titanium and superalloys such as Hastelloy poses problems. They are among the most difficult-to-cut materials, but are often used in critical applications where equipment manufacturers demand uncompromising accuracy and quality.

To process titanium or other hard-to-cut materials, companies should partner with a specialist that uses high-performance machine tools and understands machine tool technology and metallurgy. They will be aware of the latest chucking and cooling technologies, cutting speeds and cutting tools, and can assemble several parts and process them to get the specified surface roughness. Some, like Aomi Precision, have built databases of various processing requirements and conditions for hard-to-cut materials. This lets them quickly offer and then deliver the most suitable machining methods for parts.

If faced with a demanding part design, it can be easy to reflexively fall back on tried-and-true production methods. Satisfaction with conventional methods in the past can leave designers on the fence about whether to move onto advanced machining. And designers who only need a small batch of parts or just a prototype or two might think advanced machining is beyond the budget. But for many small, more-intricate and difficult-to-manufacture parts and prototypes, this could be a prime time for exploring and taking advantage of the capabilities and quick turnarounds of advanced machining.

Advanced machining can be a more attractive option than conventional production methods given that specialized machining companies have the technology, experience, and metallurgical knowledge to tackle many hard-to-make parts to exacting specifications. They also keep costs in check by making special tools in-house and eliminating costly third parties, so parts go from prototype to production and delivery faster. md

Advanced machining can accurately produce turned parts with thin, small features.

Complex parts can be machined out of titanium and other difficult-to-machine materials.

Complex parts such as these can be produced in a single up-to-date machining process.

DENIS GAGNON | CEO, Belt Technologies Inc.
ALAN WOSKY | President, Belt Technologies Inc.

Are **Metal Conveyor Belts** Right for Your Application?

Metal belts are durable, easy to clean and can be customized for most applications.

Conveyor belts date back to the end of the 18th Century, when they were hand-operated and made from leather belts and wooden beds. Over the years, technological advances have introduced new power sources such as steam and electricity, and new materials to belt design. Belt materials have included rubber, PVC, nylon, cotton, polyester and metal, among others.

Here's a look at metal belts, their features and benefits, advantages and disadvantages, and whether or not they're right for your engineering or design application.

Metal belts on conveyors are used in a wide range of high-end manufacturing applications such as robotics, food processing and solar panel production.

The high strength and low weight of stainless-steel belts let more of the conveyor's input horsepower be devoted to moving the product and not the belt. This boosts efficiency and reduces operating costs.

METAL BELTS 101

Here are some of the notable features of metal belts:

High strength-to-weight ratios. Stainless steel has a tensile strength ranging from of 180 to 300 KPSI, depending on the alloy and temper chosen. Relatively thin and light-weight belts can be designed to handle the stresses of almost any application. Accordingly, metal belts are strong contenders in countless applications where strength, light weight or both are needed during production. The high strength and low weight let more of the conveyor's input horsepower be devoted to moving the product and not the belt, which boosts efficiency and reduces operating expenses.

Customizable. Metal belts can be customized with perforation patterns, attachments and surface coating options.

One common customization option are perforations. They can be created on metal belts by mechanical and laser cutting, die-and-cut presses and rotary-pinned perforation rollers.

Vacuum perforations, for example, let air be pulled through holes in the conveyor by a vacuum plenum beneath it. This creates a suction force that firmly holds items and materials on the belt and in position and removes dust from the belt.

A SHORT HISTORY OF METAL BELTS

THE FIRST STEEL CONVEYOR SYSTEMS were invented and produced in 1901 and became widely used in food production. A little later in that century, Henry Ford popularized conveyors, incorporating them into his auto assembly lines. Rubber shortages during WWII led to the invention of synthetic conveyor belts.

Decades later, rapid growth in America's post-war economy led to the increased use of steel belts in manufacturing.

Early applications included productions for NASA and the tobacco industry.

Since that time, advancements led to the endless metal belt, a completely smooth surfaced belt with a single welded seam. Metal belt applications have also expanded into electronics, semiconductors, medical goods, food, packaging, robotics and printing.

Custom perforations vary by manufacturer. Endless metal belt maker Belt Technologies, Inc., for example, can perforate belts as thin as 0.002 in., as narrow as 0.040 in. and as wide as 36 in.

Vacuum perforated belts are used in clean rooms, solar panel production, electronics manufacturing, printing presses, packaging and pharmaceutical processing.

Metal belts can also be customized with coatings and surface treatments. Teflon, neoprene and silicon are the most common coatings. They can add nonstick qualities, improve lubricity, increase friction and change the belt surface's hardness (durometer).

The nonstick qualities of Teflon coating, for example, benefits food processors. And silicone helps ensure small components remain on the moving belt during manufacturing. Depending on the application method, surface coatings can be as thin as 0.0005 in.

Custom attachments can also be added to metal belts, often to secure product transport or control specific manufacturing stages, including sorting, separating and feeding. Applications of belt attachments include lead frame drives, timed parts nesting and high-speed packaging.

Materials. Designers have a range of metals to choose from, depending on the manufacturer. For example, belts can be made from an array of stainless steel alloys, as well as Inconel (a nickel-chromium-based superalloy), Invar (a nickel-iron alloy) and titanium alloys. Engineers can choose metals that give belts greater corrosion or temperature resistance or have higher tensile and yield strength.

> Unlike chain-link belts, metal belts are a single element, and don't generate any friction that calls for lubrication. This reduces maintenance while improving cleanliness and reliability.

Pitch accuracy. Metal belts can be fabricated with a pitch accuracy of +0.0005 in. (the gap between perforations, timing pins or other such features). This improves accuracy and repeatability, which is useful when designing indexing, positioning and processing equipment.

Lubrication. Unlike chain-link belts, metal belts are a single element, and don't generate any friction that calls for lubrication. This reduces maintenance while improving cleanliness and reliability.

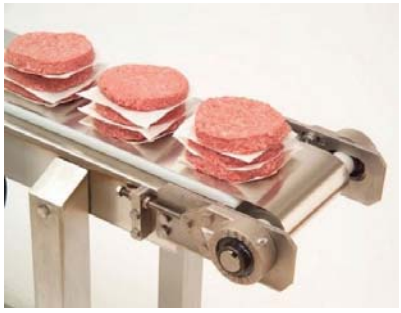
Non-stretchable. Compared to belts made with other materials, metal belts made with spring steels have a high modulus of elasticity. This makes them virtually non-stretchable and ideal in applications where high performance depends upon precision positioning.

Smooth operation. When non-metal belts transition from being flat to wrapped around a sprocket, it can cause pulsing motion in the drive chain, along with localized lowering and rising of the chain at the sprocket. Metal belts are free from this pulsation, so motion is smooth and matches the control system's motion profile.

Thermal conductivity. Metal belts are better at absorbing and transmitting energy in the form of heat, cold and electricity, which is often used in the manufacturing process. Many materials must be kept at specific temperatures as they move down the conveyor to improve finished product's quality and consistency. Stainless-steel belts with high thermal conductivity are well-suited for transporting food items that cook food as they move through production.

No static build-up. Because metal belts discharge static electricity, they're ideal for use in making electronic components such as integrated circuits and surface-mount devices.

Cleanliness. Unlike belts with teeth or grooves, or flat neoprene belts, metal belts don't generate dust or particulates that could spoil or corrupt food or phar-



Metal belts are a sound choice for the food processing industry. Stainless steel belts and conveyors have hygienic surfaces that are sanitary, easy to clean, and resist bacteria, rust, and corrosion. Most importantly, the stainless-steel designs meet and exceed FDA regulations and guidelines for food manufacturers.

Metal timing belts and drive tapes are like conveyor belts, but they work with specialized timing pulleys to ensure precise, cyclical movement of parts and products.

Perforated timing belts are best used for timing applications; they engage timing teeth on a pulley.

maceutical products. This also makes them well suited for clean rooms. Additionally, metal belts will survive being sterilized in an autoclave.

Unlike materials that call for the belts to be removed from the conveyor for regular cleaning, which interrupts production, metal belts can be cleaned in place.

Durability. Metal belts are inert and non-absorbent, so they resist humidity, corrosion and harsh chemicals. Stainless steel's nonporous surface resists damage, a benefit for applications where food bacteria or other germs could proliferate in grooves, marks or scratches.

Due to their resistance to extreme heat, metal belts won't melt or break during high-temperature processes, but they could see minimal warping. They also withstand temperature changes, making them good for bakery products, packaging and other high-temperature applications.

The alloy used in the belt determine the range of high temperatures it can withstand. One heat-treated stainless-steel alloy, for example, survives up to 800°F, while a type of Inconel handles up to 1,000°F.

Metal belts are inherently flame-resistant, a notable benefit for some food processors. In the 2000s, several such processors had their plastic conveyor belts catching fire. It caused millions of dollars in damages and, in some cases, closed the facilities.

Sustainability. Metal belts make less of an impact on the environment than plastic belts. Though all conveyor belts have a carbon footprint, plastic, made from petroleum, is tougher on the planet.

Cost-effectiveness. Due to their longer life and lower cleaning and maintenance requirements, metal belts can be the more cost-effective option over its lifespan.

METAL TIMING BELTS AND DRIVE TAPES

Metal timing belts and drive tapes are like conveyor belts and can be made from the same high-quality stainless steel. But they're designed to work with specialized timing pulleys to ensure precise, cyclical movement of parts and products.

Metal timing belts and drive tapes resist extreme temperatures and vacuums, letting them reliably perform tasks that require rapid acceleration, precise positioning and repetition. Their sanitary and easily cleaned surfaces make them ideal for use in clean room environments, as well.

Metal timing belts. Perforated timing belts for timing applications engage timing teeth on a pulley. They can also have tooth-like attachments that engage sockets in the pulley's outer circumference. In both cases, the timing elements ensure the pulley and belt are synchronized. The belt moves by frictional forces created between the belt and turning pulley.

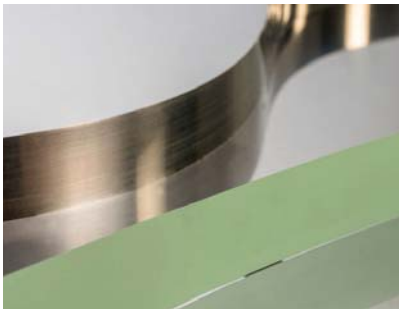
The ability to add timing attachments lets steel metal belts can be used for timing, positioning and indexing. The steel lets the timing belt resist impacts, corrosion, extreme temperatures and vacuum environments.

Because metal belts don't stretch, they can typically ensure a repeatability tolerance between 0.002 in. (0.051 mm) and 0.005 in. (0.127 mm). (Repeatability is the ability of a single pitch to return to its home position after several revolutions of the belt.) In a standard friction drive, the pulley moves slightly faster than the belt. Unchecked, this can lead to pitch accumulation or belt creep, which degrades accuracy.

Timing belts and timing pulleys control the effects of belt creep, making stainless steel an ideal way to maintaining accuracy when precision is a must.

Metal drive tapes. Although metal drive tapes ae made from the same stainless steel as metal belts, they're open-ended and anchored at each end. They are used when reliable and accurate motion profiles are needed, such as in XY plotting assemblies for 3D printers and robotic equipment.

Metal drive tapes are ideal for use in robots. Their low mass and high strength offer durability, along with quick acceleration and stopping. With



Metal belts can be customized with coatings and surface treatments including Teflon, neoprene and silicon. These coatings can add non-stick qualities, improve lubricity, increase friction or even change the belt surface's hardness.

Metal drive tapes are made from the same stainless steel as metal belts but are open-ended and anchored at each end.

other timing devices, motion loss and backlash of gears and timing belts can lead to inaccurate positioning and robot motion. Metal drive tapes can perform with near-zero backlash in various applications, including:

- LCDs
- Optical drives
- Carriage positioning
- Robotic arms
- Clean rooms

Metal drive tapes can be customized with a nearly unlimited selection of end attachments and/or perforation patterns. They can be found in robotic arm actuators, semiconductor and electronics packaging, industrial automation, medical and surgical applications, and animatronics and robotics for the entertainment industry.

Metal drive tapes can also be deployed with several belts with tight tolerances to increase a robot's operational lifespan and allows for repeatability when making mass batches of products.

DRAWBACKS OF METAL BELTS

Every conveyor belt system has its disadvantages. Fabric belts are prone to belt creep. Plastic mesh belts contain small parts that can break off and fall into and contaminate the production lines. Metal belts do well in these areas, but have their own drawbacks.

Timing belts and timing pulleys control the effects of belt creep, making stainless steel an ideal way to maintaining accuracy when precision is a must.

Though their durability, sanitary and ease-of-cleaning features means that metal belts will have a lower cost over the course of their lifetime, the initial cost of metal belts is often higher than other systems, which can be a challenge for some budgets.

Metal belts can also be deformed beyond repair if they suffer unexpected major impacts or are used improperly. Protecting metal belts from these scenarios lead to longer lifespans and higher production rates.

Certain perforations on metal belts can weaken the metal's structural integrity, which shortens the belt's lifespan and results in additional replacement cost and downtime. md

METAL BELTS AND FOOD PROCESSING

THE FOOD PROCESSING industry is vulnerable to product recalls, often due to bacterial contaminants that spread through poorly inspected products or because of contamination due to dirty processing equipment. A recall due to contamination can prove devastating, both financially and to a company's reputation.

Plastic and rubber belts are susceptible to fraying and generating particulates that can fall into the food. They are also prone to physical damage, including pits and cracks where chemicals, allergens or contagions can build up and fester. And plastic and rubber belts outgas (emit fumes), which can affect the food's flavor.

In comparison, solid stainless-steel belts and conveyors have hygienic surfaces that are more sanitary and do not affect food quality. Stainless steel resists rust and corrosion and can be cleaned easily and thoroughly with inexpensive chlorine, high-pressure steam or most other washing methods. Because metal belts contain fewer moving parts than mesh and other belts, there's a much lower chance that parts or particulates will break off the belt and contaminate the food supply.

Unlike plastic and rubber, steel does not absorb odors and its surface resists bacteria like salmonella and listeria that can cause cross-contamination.

Most importantly, the stainless-steel designs meet and exceed FDA regulations and guidelines for food manufacturers. From meats to frozen pizzas and ice cream, stainless steel metal belts are ideal for the cooking, freezing and handling of edible products. They have proven to be versatile, durable, and easy to design and manufacture for any food processing system requiring exceptional results.

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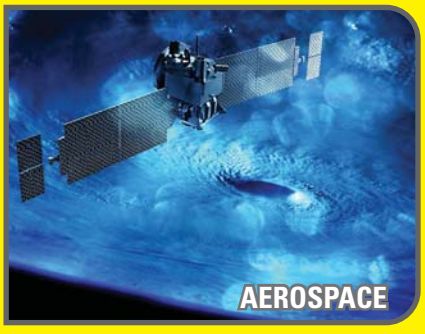

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SPECIAL REQUIREMENTS CALL FOR CUSTOM COUPLING SOLUTIONS

Figure 1 - The full range of food-processing relevant coupling models are available in stainless steel.

STANDARD OR SPECIAL DESIGN?

Design engineers seek the most efficient and reliable solutions to their applications. While often times, standard products are ideal, there are instances when an application challenge requires something other than a standard solution.

For these situations, DieQua offers custom designs that range from slight modifications to existing products, all the way to complete special designs - including Couplings.

DieQua's special design solutions are not limited to any industry, but are in fact necessary for certain specific industries like food, medical, or clean room environments. Special designs are available for all types of Couplings we offer - including Bellow Couplings, Elastomer Insert Couplings, Torque Limiters or Line Shafts.

Figure 2 - One specific example of food industry that utilizes couplings is filling machines that are for handling juice or milk.

FOOD GRADE APPLICATIONS

Most coupling selections are made using the basic available data, including the amount of torque to be transmitted, the type and amount of misalignment to compensate for, and the maximum overload torque that cannot be exceeded, and so on. Food grade applications have additional requirements, like anti-corrosion and wash-down surfaces.

They must withstand wash-down with caustic solutions and high-pressure water spray, extreme temperature fluctuations, etc. Often in these applications where a torque limiter is required, our standard design is simply not enough.

For this scenario in particular, the exterior components need to be protected from corrosion using materials like stainless steel or nickel plate. The body of the coupling needs to be sealed. This is to ensure that any high-pressure spray or cleaning agent does not enter the internal workings of the coupling, or that anything internal to the coupling can get into the environment where food is processed.

Figure 3 - Special design miniature coupling used for extreme temperatures due to high altitudes.

EXTREME ENVIRONMENTS

Often we are confronted with very extreme conditions and environmental requirements. For an aviation application, our customer wanted a coupling that needed to operate within a part of the aircraft that is subject to all the environmental and operational conditions which the aircraft is exposed to during flight.

The coupling needed to function in any weather condition, and would be subject to a very wide temperature range - from hot desert conditions to the extreme cold from flying at high altitude. This application presented a series of challenges. The coupling needed to be 100% reliable for the life of the aircraft.

Not only was the temperature range quite wide, the rate of change was also very rapid. Being an aircraft application, traceability of all components is a must, requiring a form of marking that was permanent and with many digits. Finally, the coupling needed to be mounted onto very small spline shafts. The resulting design, shown in figure 3 below, was a coupling made entirely of stainless steel. The bellow had an extended length and was laser-welded to the coupling hubs.

The required information identifying the coupling and all the traceability data was laser marked onto each hub, and a custom spline was broached into the coupling hubs. The screws used to fasten the coupling also had a special coating on the threads to ensure that, after they were tightened to the specified torque, they would never loosen from the normal use, or the rapid change in temperature during flight.

ENHANCING STANDARD PRODUCTS

Often times the solution is a modified or enhanced standard product. When a concept works reliably for an application, it can often times be slightly modified to meet specific needs that may not be common use for most customers. An example of this is a standard Elastomer Insert coupling used in an electronic assembly application. Often in these types of machines, everything needs to be grounded to avoid an electrostatic charge from building and possibly damaging the product being assembled. The elastomer insert typically used in our couplings is non-conductive. In other words, they will insulate or block the path of the built up electrostatic energy from reaching ground. The solution here was to make a conductive elastomer insert.

Figure 4 - Clockwise: Top Left: Metal Bellows Couplings, Elastomer Couplings, Torque Limiters and Line Shafts.

CHALLENGING REQUIREMENTS

These few examples show how the ever-growing needs of customers are the catalyst for an endless innovative approach to creating solutions with customized couplings. DieQua is able to work with design engineers to provide specific solutions to any type of application across many industries.

If you have a challenging or specific need where a standard off-the-shelf design is not enough, contact DieQua Corporation today and let's work together to create the design that will work for your specific application.

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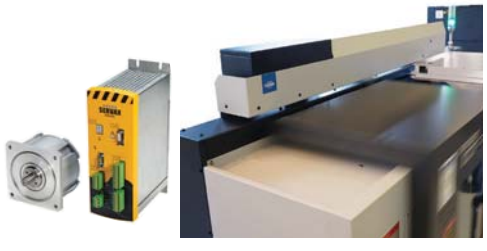

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THE DIFFERENCE BETWEEN:

Aluminum and Stainless Steel Pipe and Tubing

METAL PIPE AND TUBING are everywhere in automotive, aerospace, industrial, architectural, research, and medical applications. Aluminum and stainless steel are common pipe and tube materials, and each has attributes that make it the right choice for a given industry.

Choosing the Right Metal

When you're choosing a tubing material, the choices might seem overwhelming; both aluminum and stainless steel come in a variety of alloys and tempers, each with its own physical and mechanical properties. Each metal has general properties that are true for all its alloys.

One factor to take into consideration is the mechanical properties that are required for your application. In situations where strength is more important, you may choose stainless steel for its good strength-to-weight ratio and ability to gain significant strength from cold working. If you are focused on keeping components lightweight, aluminum may better suit your application. An aluminum part weighs one-third less than a stainless-steel part of the same dimensions.

A wide range of aluminum tubing sizes is available. Aluminum tubes are often chosen for their light weight, electrical and thermal conductivity, and corrosion resistance.

Another factor to consider is the corrosion resistance or heat resistance of metal tubing. In general, both stainless steel and aluminum offer corrosion protection, and the amount will vary depending upon the alloy chosen. The passivating oxide films that form on the surfaces of both metals help keep the metals from corroding.

One downside of passivation is that the oxide layer can inhibit electrical conduction. Consequently, stainless steels are not known for good electrical conductivity. Aluminum's high conductivity, along with thermal conductivity three times greater than that of steel, has led to its use in power transmission lines. If moving electricity or heat is important in your application, aluminum may be the better option.

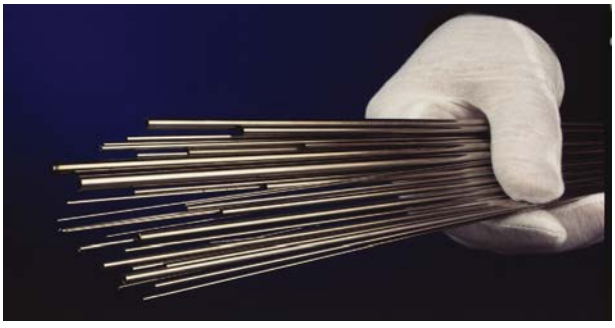
Regardless of whether your tube is intentionally conducting heat, you'll want to ensure it can handle the temperature of its operating environment. Stainless steels with high concentrations of chromium and nickel retain strength at high temperatures. On the opposite end of the spectrum, aluminum's tensile strength increases as temperature drops, and aluminum stays tougher at cold temperatures than many steels.

In summary, the main factors to consider when choosing what metal and alloy are best for your application are the mechanical properties, corrosion resistance, and heat resistance. Once you've chosen a category of metal that bests fits your application, you're ready to choose the exact alloy and temper you need.

Stainless Steel 101

For applications that lend themselves to stainless steel, you're sure to find a grade that works from the wide range of iron-carbon-chromium alloys covered by that term. The most common tube and pipe grades are T304 and T316, part of the 300 series of stainless steel alloys in which austenitic iron alloys with nickel in addition to the chromium and carbon.

T304 is considered the classic stainless-steel alloy. Also known as 18/8, it contains 18% chromium and



Stainless-steel tubing, noted for its good strength-to-weight ratio and high temperature performance, comes in a wide variety of sizes including hypodermics as small as 0.008 in. OD.

8% nickel. T316 is another familiar alloy, especially in food service and medical applications; it contains molybdenum for additional corrosion protection.

The properties of a given alloy depend greatly on its heat treatment and cold working history. To obtain a specific property or physical attribute for your tubing, check with a metallurgist or tubing specialist who can guide you to the right combination of alloy and processing for your application.

Tubing specialists can also advise you on tubing size and fabrication processes. Stainless-steel tubing comes in fractional and metric outer diameters (ODs) ranging from 1/16 to 8 in. for tubing and to as small as 0.008 in. for hypodermic applications. Fabrication can include bending, coiling, end forming, welding, and cutting.

Once you have the right stainless-steel tubing installed in your application, you might start to think about what to do with it at the end of its useful life. Although the alloying elements that go into stainless steel make it difficult to recycle, rest assured that about 50% of all new stainless steel is fabricated from melted down steel scrap.

Aluminum ABCs

The most common aluminum alloys used for tubing and pipe are 2024, 3003, 5052, 6061, and 7075. Their principal alloying elements of copper, manganese, magnesium, silicon, and zinc lend each alloy slightly different physical and mechanical attributes.

For instance, engineers specify alloys 2024, 6061, and 7075 for aircraft structures because of their high strength-to-weight ratios and good fatigue resistance. Untreated 2024 and 7075 are prone to corrosion, while 6061 is innately corrosion-resistant and easier to weld. 7075 provides higher strength with less weight, but costs more.

Alloy 3003 is good for applications that need corrosion resistance and high strength with less of an emphasis on ductility. And for applications that rely on many joints, you might choose highly weldable 5052.

STANDARD TUBING TOLERANCES FOR ASTM-A 269/A249/A213 (FRACTIONAL OR METRIC)		
Outside Diameter, Inches	**O.D. Inches**	**Wall**
Less than 3/32	±005	±15%
3/32 ≤ 3/16	±005	±15%
2/32 ≤ 1/2	±005	±15%
1/2 ≤ 1-1/2	±005	±10%
1-1/2 ≤ 3-1/2	±010	±10%
3-1/2 ≤ 5-1/2	±015	±10%
5-1/2 ≤ 8	±030	±10%

ALUMINUM TOLERANCES	
Outside Diameter, Inches	**Wall thickness**
.062-3″	.010-.250″

Both stainless steel and aluminum tubing come in a variety of outer diameters and wall thicknesses.

As with steel, alloy composition alone doesn't tell the whole story. The exact properties of a given aluminum alloy also depend on its temper or heat-treatment history. Temper O indicates the alloy is used as annealed, at its highest ductility and lowest strength. Tempers beginning with "T," like T3, T4, and T6 involve heat treatments. Cold working or aging steps often follow to strengthen the metal by toughening it on the grain or molecular level.

Once you've chosen the right aluminum alloy and temper for your application, your next steps will be specifying its size and any additional fabrication operations. Aluminum tubing ODs typically range from 0.062 in. to 3.00 in. with wall thicknesses from 0.010 in. to 0.250 in. Aluminum tubing suppliers can cut, bend, flare, and fabricate tube to your requirements.

After your aluminum tubing enjoys a long service life, you can plan to recycle it since it is made from 99.8% pure aluminum alloy. ■

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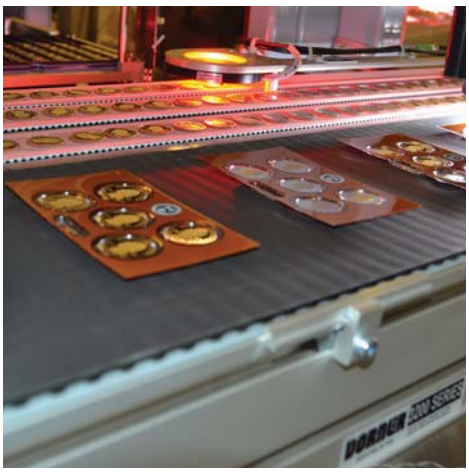

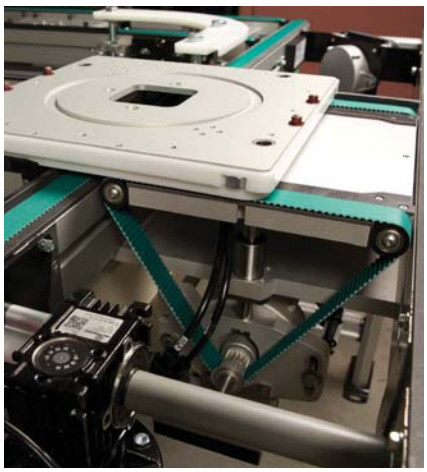

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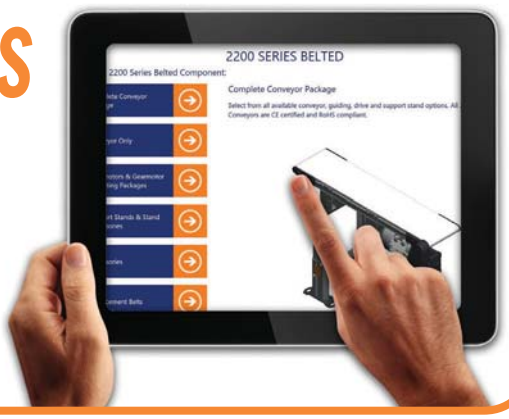

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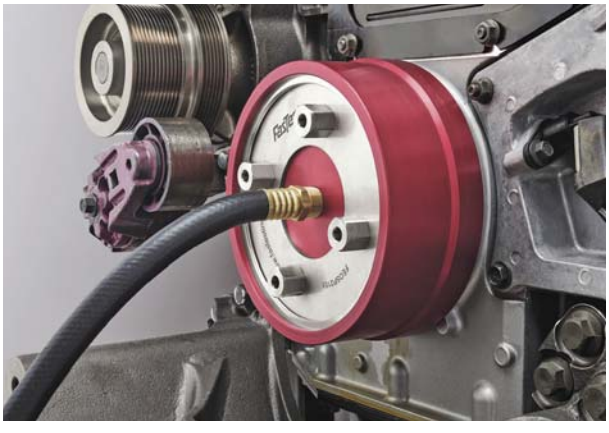

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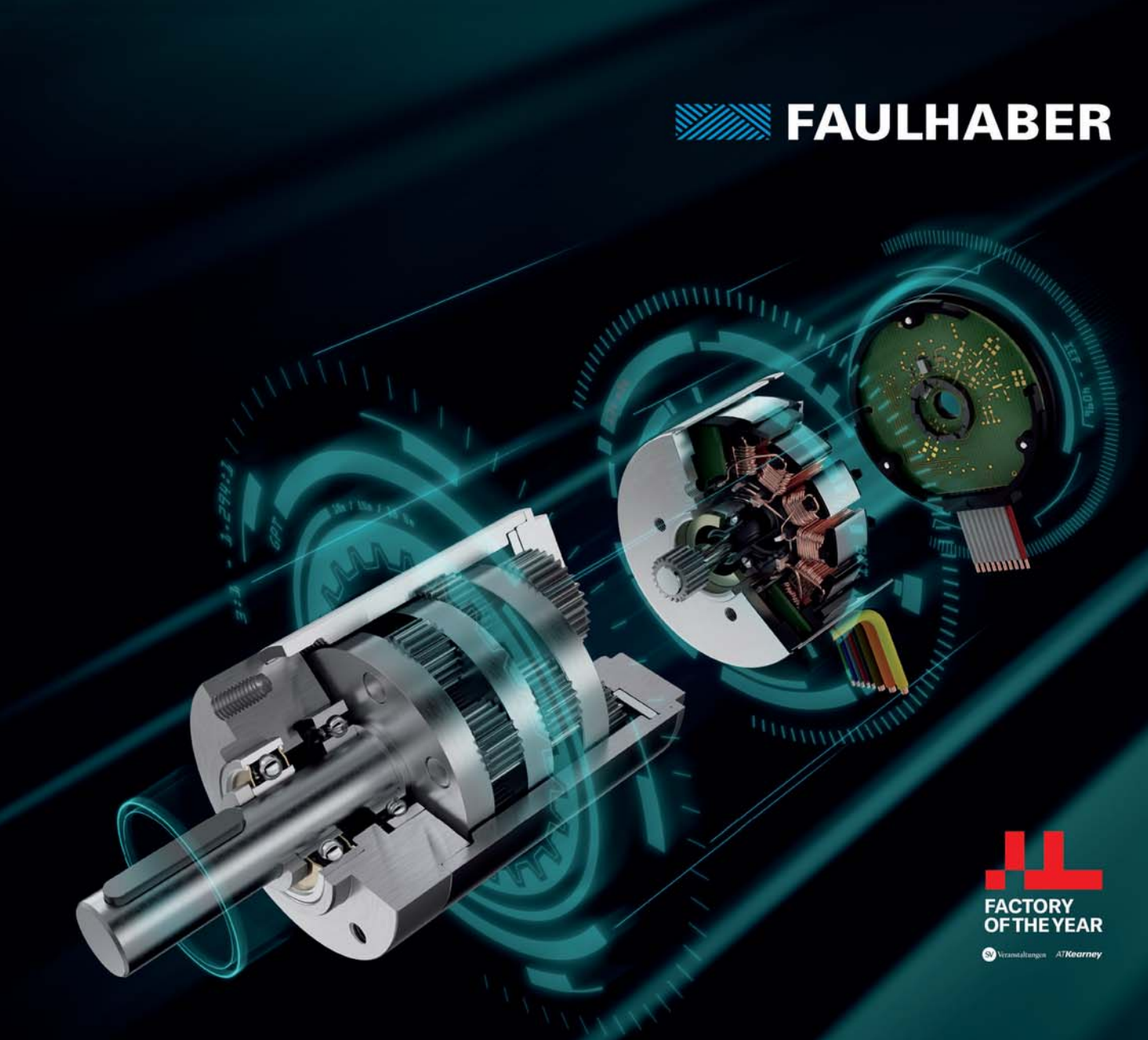

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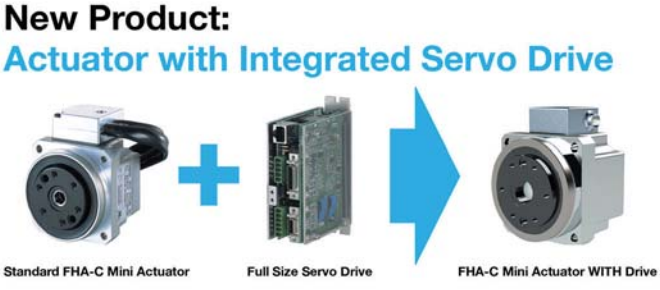

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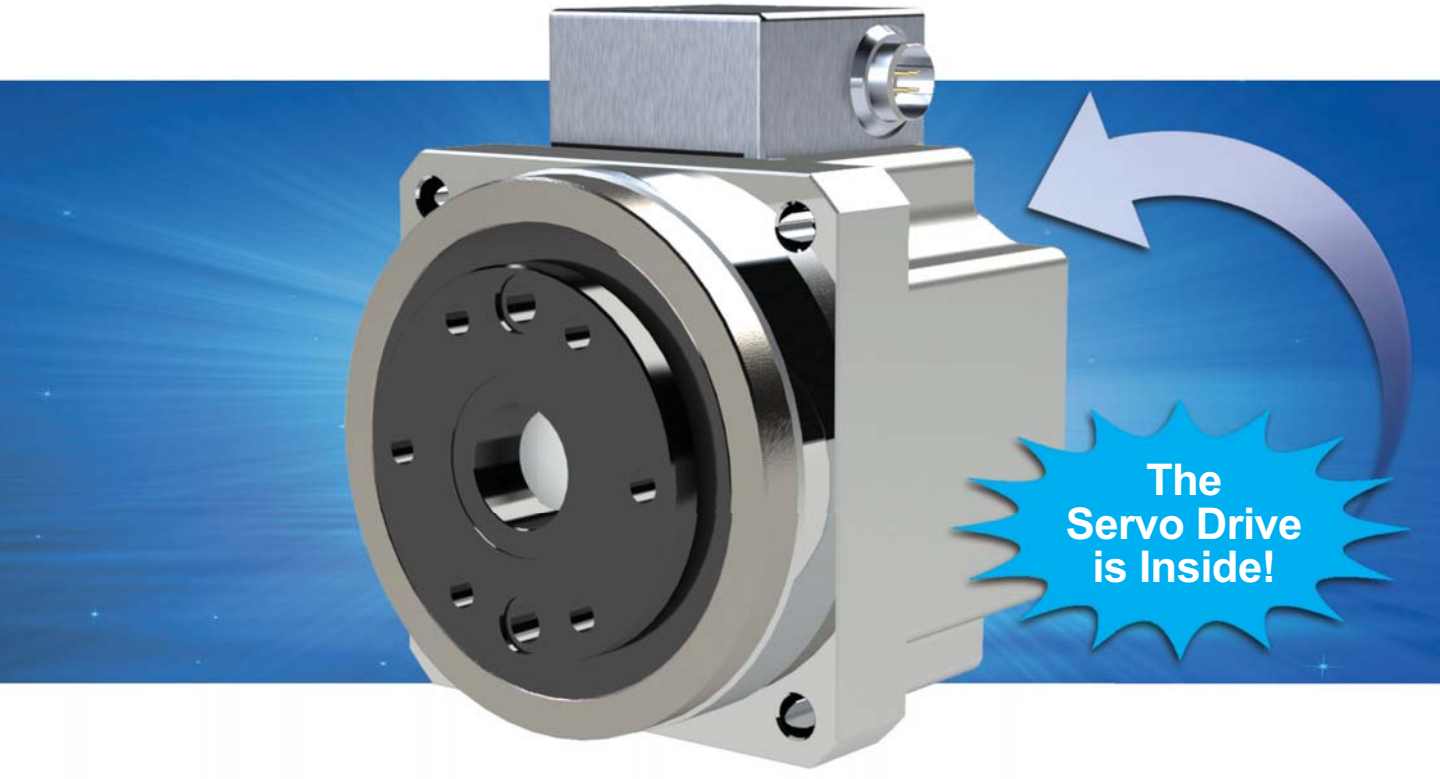

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Interpower Accessory Power Strips make it easier to connect globally. Product designers can design electrical equipment to be sold globally by simplifying power supply connections using an Accessory Power Strip with IEC 60320 components.

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The Accessory Power Strip allows different components to work together in one system. For example, instead of making four different systems to export to four different countries, use this one system and add a cord set with a country-specific plug. This allows the same system to be exported globally with cost-saving benefits.

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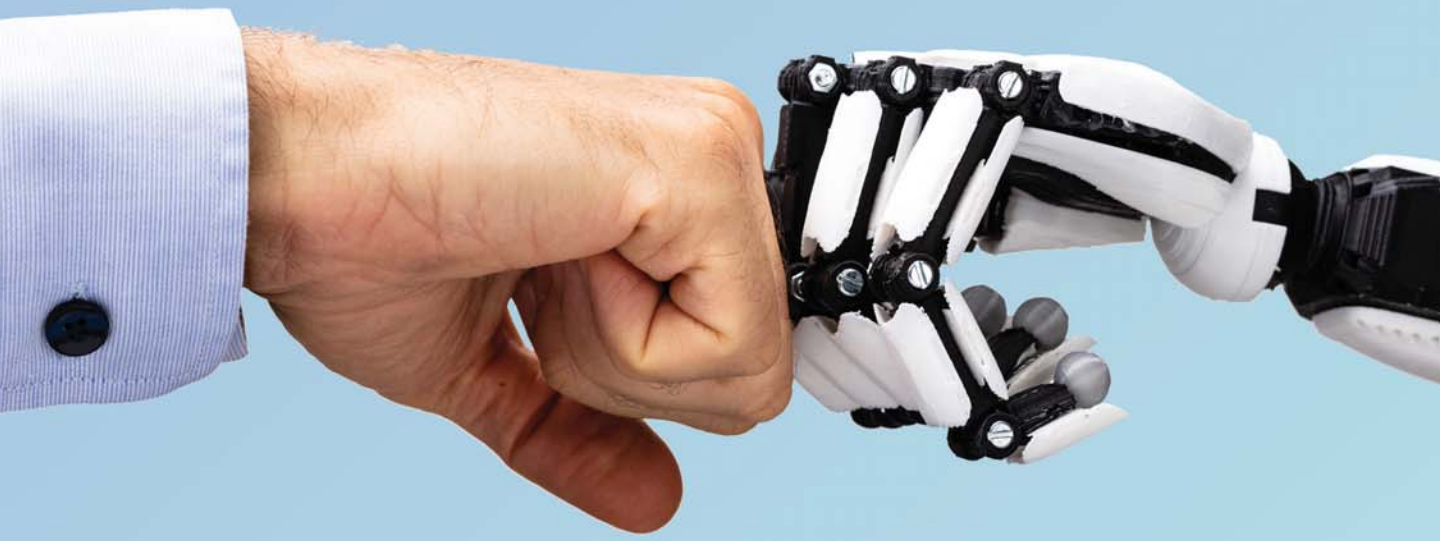

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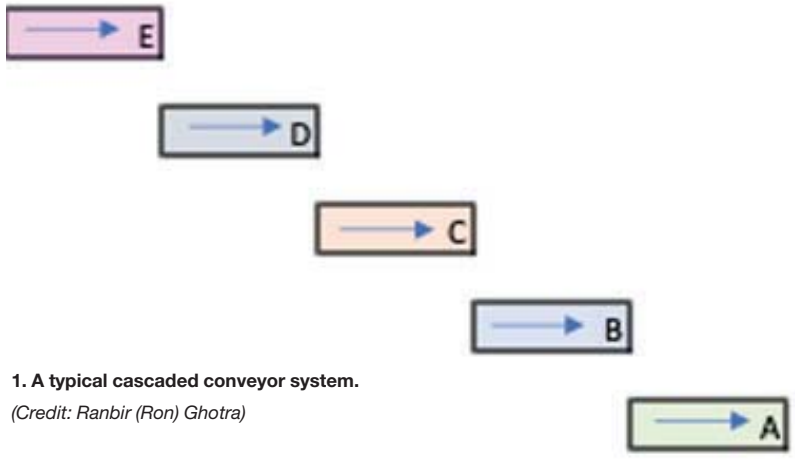
From transporting trays of food across your everyday cafeteria line to feeding coal into the world's supercritical thermal power plants, nearly every industry relies on cascaded conveyors. In the most complex environments, these systems work harmoniously in multiple cascaded systems to deliver material from point A to point B in a coordinated manner. In these instances, however, if one conveyor belt in the cascaded conveyors stops, the feeding conveyors automatically stop in order to avoid material pileups.

In these cascaded systems, the safety mechanism to turn off the drive powering the conveyors is similar to an emergency stop. This feature is very important when used in combination with preventative maintenance measures in the plant or process where these conveyors run continuously (24/7). The control and automation systems could range from a simple material handling system to a very complicated system designed to cater to multiple combinations of the conveyors.

For large material handling systems like those in thermal power plants, where the human machine interface is required to either manually or automatically select the paths, a distributed

control system or a programmable logic control (PLC) typically needs to be used.

However, in simple systems such as the conveyor system in a stone crusher quarry or a large cafeteria, only digital VFDs and sensors can be wired and programed to conduct the cascaded operation, as opposed to using a PLC. This approach offers benefits including lower engineering, commissioning and troubleshooting costs to implement a fully integrated cascaded conveyor system.



1. A typical cascaded conveyor system.
(Credit: Ranbir (Ron) Ghotra)

The most important aspect of any process is safety. All conveyor system safety sensors (such as pull cords or emergency stop buttons) should be verified for system readiness.

WHAT A SIMPLE CASCADED CONVEYOR SYSTEM LOOKS LIKE

A simple cascaded conveyor system will look like the one shown in *Fig. 1*. Certainly, along with the conveyors, there would be pull cords, zero speed switches, proximity sensors, photo sensors and vibration sensors. Diverter gates or flaps are also part of the conveyor system to divert the material on the conveyor to deliver it at the correct delivery point. An AC induction motor that is being controlled by a VFD is running each conveyor A through E.

In the non-digital age, all sensors were wired to a control contactor logic. Today's digital VFDs allow direct wiring of sensors to the VFDs, and in some more advanced systems these sensors can be wired directly to a PLC.

HOW A TYPICAL CONVEYOR SYSTEM OPERATES

The most important aspect of any process is safety. All conveyor system safety sensors (such as pull cords or emergency stop buttons) should be verified for system readiness. Then, the diverter gates at the entry and exit of the conveyor are set in the direction to set the conveying path for the system.

Depending on the number of installed sensors and the overall fidelity of the conveyor system, the start/stop command is given manually to each conveyor. Otherwise, the system can be given a system level start/stop command and then the sensors will start and stop the individual conveyors in the system.

After the cascaded conveyor system receives the "start" command, the conveyor that starts first will be the last to stop when the system stop command is issued. A visual of this logic can be portrayed using *Fig. 1* and is outlined in the steps below:

When the **start command** is issued, the conveyor system will follow the following start sequence:

1. The conveyor A is the first one to start;
2. Then conveyor B will start running after conveyor A has started running;
3. Then conveyor C will start running after conveyor B has started running;
4. Then conveyor D will start running after conveyor C has started running;
5. Then conveyor E is the last one to start.

When the **stop command** is issued, the conveyor system will follow the following stop sequence:

1. The first conveyor to stop is conveyor E;
2. Then conveyor D will stop after conveyor E has stopped;
3. Then conveyor C will stop after conveyor D has stopped;
4. Then conveyor B will stop after conveyor C has stopped;
5. Then conveyor A will be the last one to stop.

This same logic applies when any of the conveyor sensors in the cascaded path communicates an issue such as a motor fault. Therefore, if conveyor C trips on a fault, conveyors D and E will have to be stopped so that material does not pile up on stopped conveyor C. In a more complex system, users can choose to divert the material to a different path rather than stopping conveyors D and E.

As demonstrated in the model above, sensor integrity is critical for maintaining the effectiveness of cascaded conveyor systems. The most typical type of sensor found on conveyor belts is a

zero-speed switch. This solution provides true feedback regarding the status of the conveyor belt motion.

For example, these sensors should be effective in situations where an AC induction motor could be moving because the VFD is putting out voltage to the motor, but the conveyor belt/chain could be stopped because it is broken. In *Fig. 1*, if the zero-speed switch on conveyor C triggers, the motors on conveyors C, D and E should be stopped to prevent material pileup.

The implementation goal of zero-speed switch sensing controls is to ensure accurate sensing after the conveyor drive has started running at a certain frequency, but not until the conveyor drive has started moving. This is important, because if a sensor indicates zero-speed before the conveyor starts running, the conveyor would never start.

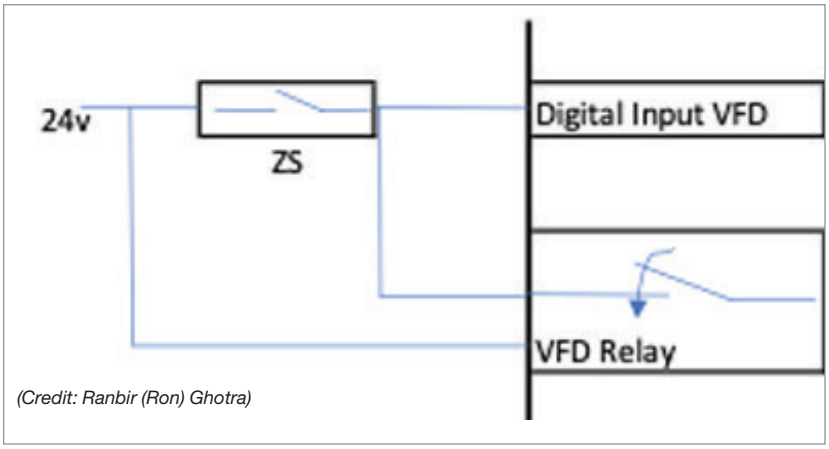
Before the digitalization of today's VFDs, PLCs were a must for implementing digital control for a simple cascaded conveyor system. Before PLCs, hardwired relay control was used. Following the advancement offered by VFD digital controls, most of the control functions required for a simple conveyor system *(as shown in Fig. 1)* can be achieved by integrating the sensors to the VFD and the interconnecting wiring between the VFDs.

This VFD-based approach can help improve return on investment, as it is able to achieve the same performance without the additional cost of integrating the VFDs and sensors and programing PLCs.

INTEGRATING A CONVEYOR SYSTEM USING DIGITAL VFDS

To demonstrate how to integrate a conveyor system using digital VFDs, let's again take a look at the system in *Fig. 1* on page 57.

Start command. Five VFDs, one for each conveyor motor in *Fig. 1*, is hardwired connected to each other on the control board of the VFD. Run feedback from conveyor A is wired to conveyor B, conveyor B is wired to conveyor C, Conveyor C is wired to conveyor D, and conveyor D is wired to conveyor E. The system start command is issued to conveyor A only and the run feedback signal wired between the conveyors start conveyor B; B starts C; C starts D; and D starts E. This is how the VFD controls start all five conveyors.



(Credit: Ranbir (Ron) Ghotra)

Conveying speed reference control. The main system speed reference input is only fed to conveyor A's VFD. Conveyors A, B, C and D's VFDs then feed the speed control signal upstream in cascaded conveyors—that is, A → B → C → D → E. Changing the speed reference to conveyor A subsequently changes the speed of the conveyors upstream feeding material into conveyor A.

Stop/fault command. Five VFDs, one for each conveyor motor in *Fig. 1*, are hardwired connected to each other on the control board of the VFD. The stop from conveyor E is wired to conveyor D, conveyor D is wired to conveyor C, conveyor C is wired to conveyor B, conveyor B is wired to conveyor A. The stop command is issued to conveyor E and the stop feedback to conveyor D stops conveyor D, D stops C, C stop feedback stops B, B stops A. This is how the VFD controls stops all five conveyors. Similar to a "stop" command, the fault on a conveyor follows the same stopping sequence, again achieved by VFD interconnection wiring.

Sensor interface. As the fidelity of the system increases, users add more and more sensors to the conveyor system. Let us start with the zero-speed switch. The switch from each conveyor is wired to its specific drive external fault. That is, if the switch triggers, it will fault the VFD it is wired to and the subsequent VFDs in the chain will stop due to stop logic. The simple way to bypass the zero-speed switch when the drive is not running is to use VFD relay to supervise the drive frequency to be above where the conveyor is already moving.

Once the supervising relay opens above the preset speed frequency setpoint, it starts to monitor the zero-speed input on the same channel where the supervision relay was connected for initial bypass of the zero-speed sensing. Again, simple control is achieved by using the VFD digital control without a PLC.

The pull cord of the conveyors can be wired in series to the STO of the drives. It's the safest mode to put an E-stop to the VFDs running motors. All of this is being achieved by VFDs only.

INCORPORATING OTHER CONTROL INTERLOCKS

Other interlocks, such as proximity sensors, can be connected to the VFDs for a more intelligent start and stop of the conveyors by sensing the material on belt. Instead of running the conveyors continuously and consuming power, the

Eaton PowerXL DG1Series Drives.

The single start/stop command to the sensor-based conveyor system helps implement an intelligent conveying system. All of the faults and the trips are interlocked in the cascaded conveyor system to prevent pileup of the material due to tripping of one conveyor in the path.

proximity sensor or the current sensor of the drive will sense the load travelling on the belt, and presence of a load sensed by the VFD will trigger a start command to the next VFD conveyor in the path.

Take the example of the system in *Fig. 1*: The smart sensing would be the sensor or the VFD algorithm sensing the load on conveyor E. As soon as the load on conveyor E increases above a preset level, the start command to conveyor D is given by VFD E, and so forth, until the last conveyor in the path starts. Similar logic applies to stopping of the conveyors. If the load falls below the threshold, there is an indication that the load is not being transported, so the VFD in the cascade path can be stopped automatically to save power.

Maintenance management. Sensors with vibration monitoring capabilities can be wired directly to the VFD to generate warning and fault the system to prevent damage. Sending the status of equipment health such as temperature, load or speed to the user using an IoT-based phone app, without the need for a full-blown automation system, eliminates the need of a high-fidelity HMI or SCADA.

As summarized previously, the single start/stop command to the sensor-based conveyor system helps implement an intelligent conveying system. All of the faults and the trips are interlocked in the cascaded conveyor system to prevent pileup of the material due to tripping of one conveyor in the path. At the same time, the VFDs are continuously monitoring the load current advising the user on whether to continuously run the conveyor, without wasting the power or shutting it down. As all VFDs are digital and enabled for the Internet of Things (IoT), all data is constantly being shared with the stakeholders who are managing the production and the commercial side of the business.

To draw an analogy, the IoT system helps maintenance and commercial teams run analytics in the same way QuickBooks serves the finance teams. This IoT-driven data analytics feature can help users optimize their processes by feeding digital data directly from sensors directly into a portal that is remotely viewable nearly anywhere.

In summary, the smart digital VFDs of today can very easily do the job of a small PLC while supporting IoT connection that allows users to monitor conveying systems remotely. This capability not only improves return on equipment and labor investments, but can also enhance overall business intelligence in terms of production, maintenance and safety management by providing the accurate, actionable data needed to improve processes. md

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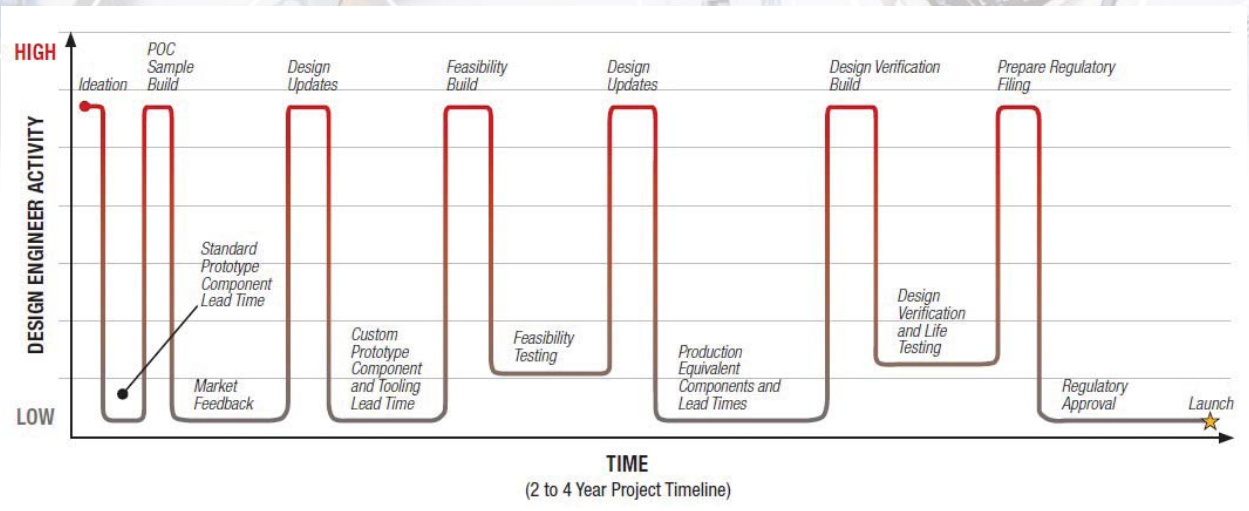
BRANDON STEINBERG | Senior Manager of Business and Strategy for Surgical Moto Solutions, Portescap

SUPPLIER COLLABORATION is Key to Developing Medical Devices

Companies reap the most benefits by using suppliers early in the design process.



Medical device companies are under extreme pressure to deliver new and improved products to the market ahead of the competition. While the overall process for a medical device takes years, most of that time is devoted to lead times for tooling and components, market feedback, life testing and seeking regulatory approvals. Engineers must often wait to update a design until these tasks are completed, leaving a tight window to complete their next deliverables before the deadline.

Immediately after management greenlights a project, engineers are expected to rapidly build proof-of-concept (POC) samples for internal review and market feedback, with speed prioritized over perfection. Weeks or months later, finance approves funding and marketing confirms the target specifications, at which point pressure is once again on the engineers to quickly turn out more durable and sophisticated prototypes for further testing. This "hurry-up-and-wait" cycle repeats itself through verification testing and regulatory approval.

Unfortunately, this time pressure often compromises the final product. To meet early stage deadlines, it is a common and accepted practice to design POC samples around readily available standard components with the intention of fine-tuning the design by using customized parts in the next round of prototyping. However, similar time pressure during subsequent iterations can make lead times for custom components prohibitive. As a result, concessions made on even the most rudimentary prototypes frequently survive to production, lowering product performance and increasing total costs.

Staying on track while delivering a high-quality design requires choosing supply partners that can help manage the evolution of a product as it goes from concept to launch. The suppliers must be able to quickly turn out standard prototypes for developing the product concept and also quickly customize parts for future iterations. The suppliers must be able to do all this at the right price and quality levels.

It is best to use one supplier throughout the process because it will learn more from testing the concept if its own products are used, and it can execute each stage while keeping the big picture in mind. If a supplier not viable for production must be chosen for the concept phase, it is critical to also work with a strategic supplier at the same time. An effective strategic supply partner can help engineering teams prepare to use the custom component by consulting on the concept and beginning work on customization at the same time.

The importance of supplier selection during early development stages is compounded by the fact that most medical devices cannot qualify several sources for critical components. As deadlines approach and issues arise, designers are forced to eliminate as many moving parts as possible.

Trying to get competing suppliers to meet the same specification and time-

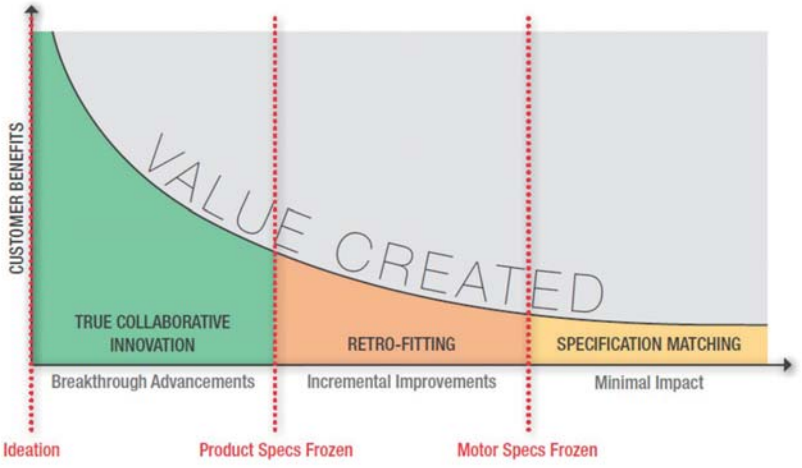
line is an added challenge that can rarely be supported. As a result, medical products are typically submitted for regulatory approval with only one supplier per component. Qualifying secondary suppliers after production has started rarely happens because it requires resubmission to regulators, a prospect generally rejected by management because it is too expensive, eats up too many resources and is too risky. And of course, qualifying two suppliers means double the development cost, and purchasing fewer products from two suppliers reduces volume pricing.

Given the difficulty in qualifying two suppliers and in switching suppliers at any point during the process, it is critical to choose strategic supply partners at the concept phase based on whether they can:

- Manufacture standard products designed for the POC prototype and shipment within a matter of days.
- Demonstrate the industry experience to anticipate and resolve common traps while contributing design suggestions for improvement.
- Supply design and manufacturing engineers and customer collaboration at all stages.
- Support building medical devices with its prototyping and product development capabilities.
- Provide facilities with good validation and change-control processes that regularly pass quality audits of leading medical device companies.
- Outline a clear plan to meet the target production price.
- Use a wide array of technology options that does not restrict product design.

To take full advantage of such a supplier's capabilities, the relationship must begin at the concept or even ideation stage. The right supply partner will be able to provide valuable insight to choose the best path from the outset. Just a few hours spent upfront with the supplier's experts can significantly reduce future design hours, cut overall development time by months and ultimately deliver a better, more valuable product to the market.

THE BENEFITS OF EARLY ENGAGEMENT



To illustrate the benefits of concept phase collaboration with a strategic supply partner, consider the following example of an engineering team selecting a supplier for the motor in a medical device. The team needs to have a proof of concept in three weeks, complete tests for regulatory submission in six months and be in high-volume production in two years. The POC clearly dictates an off-the-shelf motor, but the design team chooses a concept stage supplier it knows can also deliver the necessary custom version while meeting the price and quality level for production.

Within days or even hours of initial contact, the motor supplier calls to discuss the design's long-term goals. It recommends a standard motor that can be delivered within a week and is already tailored to the application based on the supplier's industry experience. Modifying standard products to meet common customization requests leads to POC builds that are closer to the final design criteria. This can avoid an extra iteration before finalizing the design freeze, potentially saving weeks or months of unnecessary engineering effort and thousands of dollars. Any remaining customizations needed—such as output shaft configurations, dialed-in windings and gear ratios—are planned during this initial discussion so the design team can account for differences during POC testing.

Once POC testing is complete, a strategic motor supplier can then provide custom prototypes in as little as four weeks when there is a development strategy that preemptively initiates design work and long lead time components or tooling. This leaves the device designer with ample time to complete design work, iterate on the motor design or resolve other issues before the six-month regulatory filing deadline. After testing is completed on each iteration of prototypes, the motor supplier sends its engineers to the customer's site for detailed design reviews of the motor and system.

When it comes time to move to production, it is assured that the motor supplier can execute the design. If engineering needs to switch suppliers at this time, it is unlikely a new supplier would meet the application's requirements without a design change that would derail regulatory approval.

In the end, successfully using a custom motor maximizes power and efficiency while eliminating extra components, therefore reducing costs, size and complexity. The total development time is also shortened, thanks to the seamless transition between motor iterations and eliminating surprises that could have rippled through the design. md

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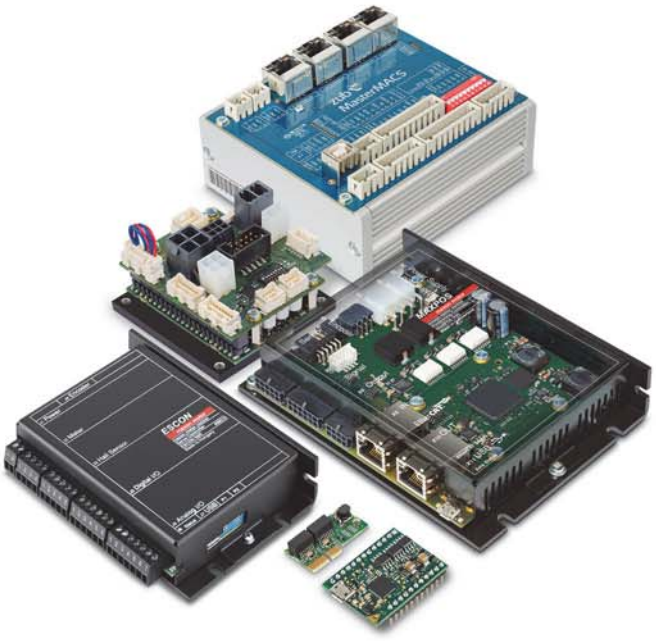

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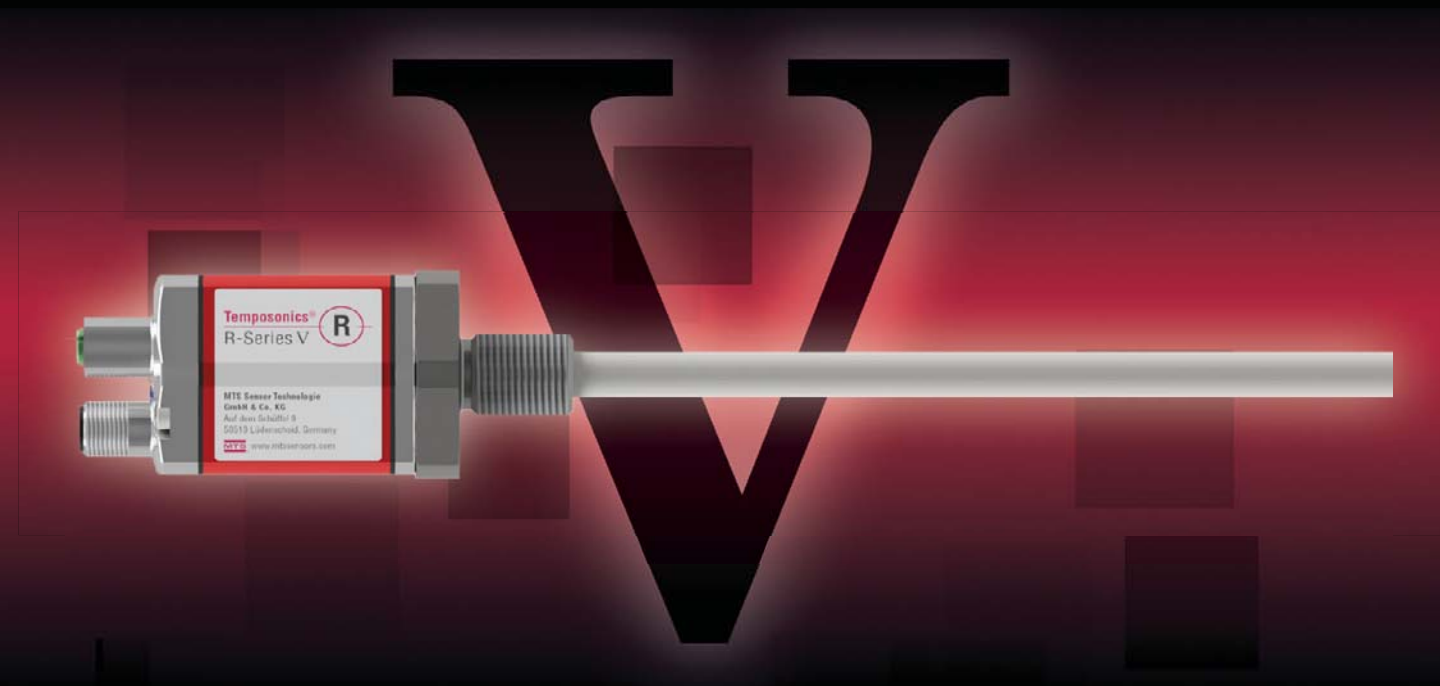

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Open- Versus Closed-Circuit Filtration for Hydraulics Performance

Selecting the appropriate filtration system contributes to longer service life.

Selecting the appropriate filtration system when designing a hydraulic circuit is critical for maintaining fluid cleanliness and preventing premature wear, both of which contribute to optimal system operation and service life.

Contamination of the hydraulic system can occur during assembly and during operation. Contamination can come in many forms, including water or other fluids, air, solid particles, or corrosive agents and heat.

Dirt is the greatest enemy of hydraulic systems, since it generates wear that results in shortened service life of components. The cleaner the system, the higher its service life expectancy. Therefore, it is imperative that only clean fluid enter the circuit. In addition, a filter capable of maintaining fluid cleanliness to ISO 4406 class 22/18/13 or better, under normal operating circumstances, is recommended.

Between open- and closed-circuit filtration designs, there are additional factors to consider:

CLOSED-CIRCUIT DESIGNS

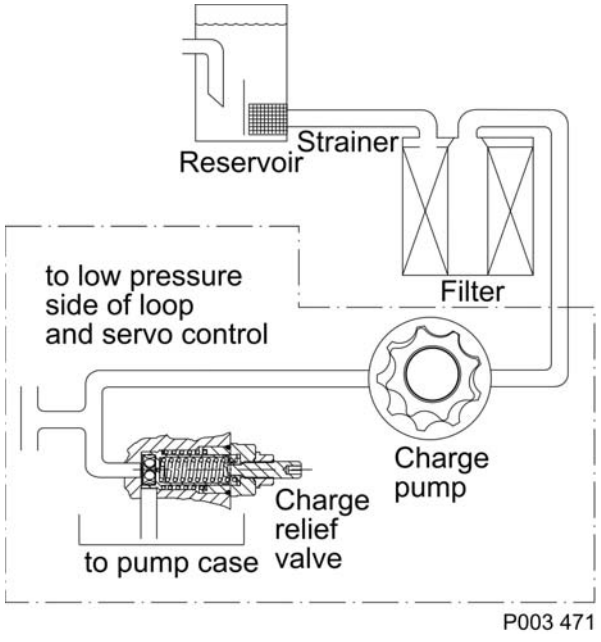
A closed-circuit filtration design will typically follow into either suction line filtration or charge pressure filtration (both partial- and full-flow).

In suction line filtration, a filter is placed in the circuit between the fluid reservoir and the inlet to the closed-circuit pump. Follow the manufacturer's recommendations for bypass versus non-bypass filter in the suction line. A vacuum gauge can be used to show when the inlet pressure exceeds the manufacturer's requirements. A contamination monitor will indicate when a filter change is needed, once a maximum vacuum level is reached.

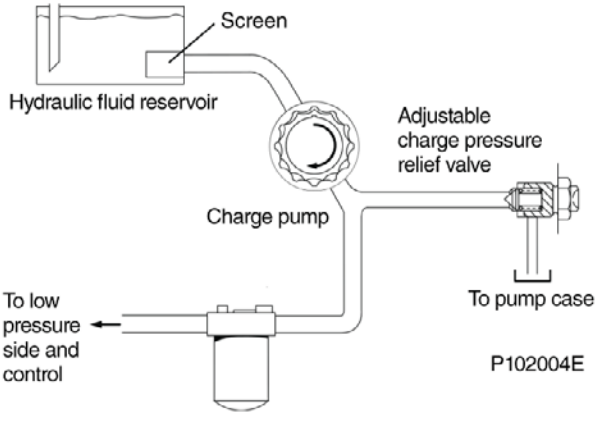
Examinations have revealed that a filter in the suction line with a $\beta_{35} - \beta_{45} = 75$ ($\beta_{10} \geq 2$) at a differential pressure of 0.25bar achieves the required cleanliness of 18/13 under normal operating conditions. In some applications even better cleanliness levels are achieved.

In charge pressure filtration, the filter is designed into the charge circuit of the closed-circuit pump. Placing the filter in the charge circuit can mitigate high inlet vacuum during cold start-up conditions. Fluid filtration is provided immediately ahead of a pump's control and the hydraulic loop.

Examinations here, too, have shown that filter elements with a $\beta_{15} - \beta_{20} = 75$ ($\beta_{10} \geq 10$) at the differential pressure occurring in the application are recommended. A strainer with a mesh of 100 µm – 125 µm must be used to protect the charge pump against course contamination. However, the actual filtering is done by the filter in the charge circuit.



The suction filter is placed in the circuit between the reservoir and the inlet to the charge pump. *(Credit: Danfoss)*



Partial flow charge filtration. *(Credit: Danfoss)*

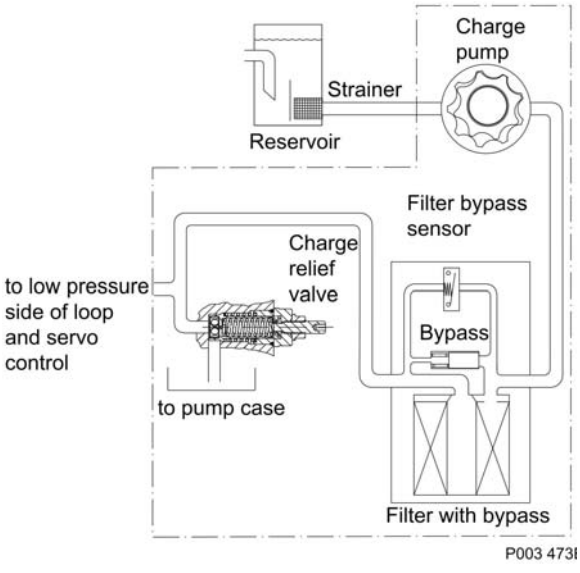
PARTIAL VERSUS FULL FLOW CHARGE FILTRATION

The charge pressure filtration design can be further broken down into either partial flow or full flow.

Partial flow filtration refers to the charge pressure relief valve located upstream of the filtration. A portion of the charge pump oil flows through the filter while the rest flows over the charge pressure relief valve back to the reservoir. Only the fluid needed by the closed-loop system and the pump control is filtered.

Carefully consider whether to use a non-bypass or bypass filter, as excessive pressure drops can occur that may lead to charge pump damage as well as contaminants being forced through the filter media. A "loop flushing" valve in the circuit increases the volume of "dirty" fluid being removed from the system and, consequently, increases the volume of fluid passing through the filter.

Full flow filtration has the charge pressure relief valve downstream of the filter element. All the charge pump flow is passed through the filter increasing the filter efficiency compared to suction filtration.

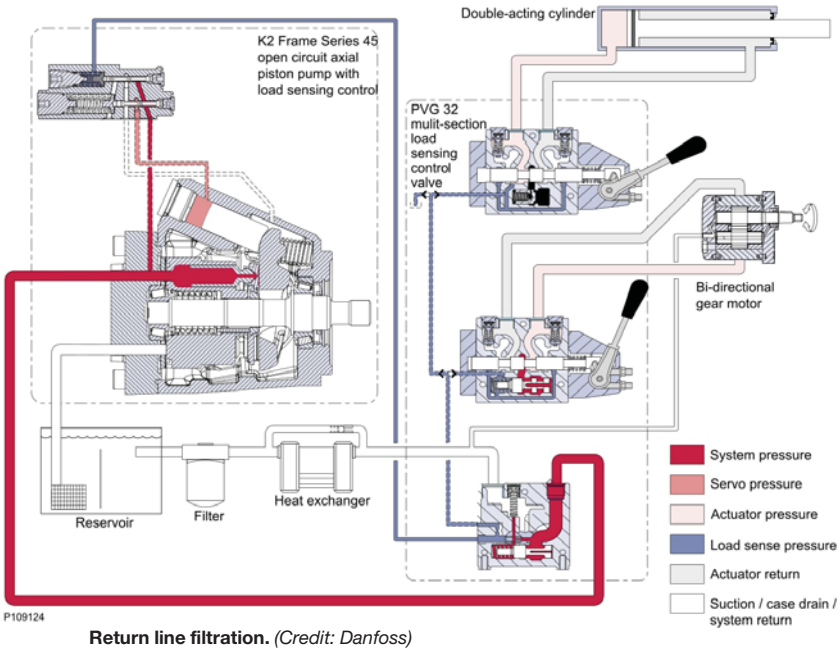


Integral charge pressure filtration, full flow. *(Credit: Danfoss)*

With full flow filtration, a bypass valve can prevent filter damage and contaminants from being forced through the filter media by high pressure differentials across the filter. Fluid will bypass the filter with a high pressure drop or cold start-up condition. Operating the system with an open bypass should be avoided, and a means of contamination indication is recommended.

OPEN-CIRCUIT DESIGNS

In contrast to closed-circuit hydraulic systems, suction filtration is not a recommended filtration method with open-circuit pumps. This is due to the potential for high inlet vacuum to occur. Instead, a screen is recommended in the reservoir covering the pump inlet. A 125 µm (150 mesh) screen protects the pump from course particle ingression.



Return line filtration. *(Credit: Danfoss)*

Return line filtration, with the filter in the return line to the reservoir, is often the preferred method in open-circuit systems. All the fluid in the system passes through the filter as it returns to the reservoir.

Factors to consider when specifying a return line filter system are:

- Cleanliness specification
- Contaminant ingression rates
- Flow capacity
- Desired maintenance interval

Typically, a filter with a $\beta_{10} \geq 10$ is adequate.

MAINTAINING A FILTRATION SYSTEM

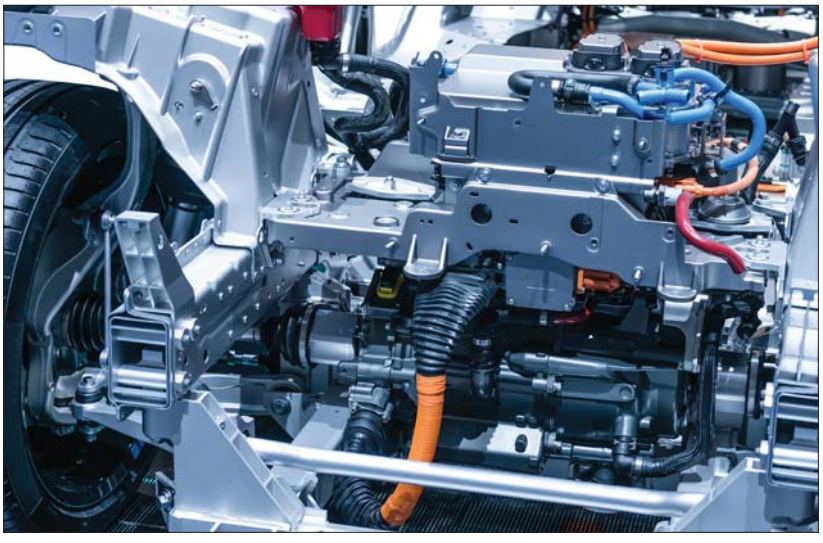
As this article serves only as a guideline, it is imperative to work closely with the filter manufacturer when selecting a filter. Every open- and closed-circuit hydraulic system is unique, and the filtration requirements and performance must be determined by test.

It is essential that monitoring of prototype systems and evaluation of components and performance throughout the test program be the final criteria for judging the adequacy of the filtration system. md

MARK CROSS | Commercial Sales Director, Ultraseal International

Eliminating Porosity in Die-Cast Parts Could Cut Weight in Electric Vehicles

Sealant impregnation eliminates porosity and makes parts fit for use in cars and trucks.



Vacuum impregnation seals leak paths and porosity in metal castings, sintered metal parts and electrical components—crucial for complex cooling systems that need to be pressure and fluid tight in hybrid and BEV vehicles.

According to *Automotive News* and a study by Boston Consulting Group, electrified vehicle sales (mild hybrid, full hybrid, plug-in hybrid and full battery-electric vehicles) are expected to surpass internal-combustion-engine (ICE) vehicle sales by 2030, taking 51% of the market, with battery-electric vehicle (BEV) and PHEV (plug-in hybrid electric vehicle) categories accounting for 25% of total vehicle sales. However, 82% of cars will still contain an ICE powertrain, with PHEVs, HEVs and mild hybrids all using internal combustion engines alongside their electric powertrain.

Automotive manufacturers are under pressure from many sides. On the consumer side, there is a sharp drop in confidence in diesel due to the introduction of clean air zones, some of which are already in force, and a ban on internal combustion engine vehicles in the UK by 2035.

Meanwhile, governments around the world are tightening up on automotive emission legislation. In Europe, there are increasingly stringent CO2 emission regulations. In China, efficiency is paramount, and the country's ever-stricter Corporate Average Fuel Consumption (CAFC) and New-Energy Vehicle (NEV) regulations are demanding it.

There's no doubt that significant advances have already been made in hybrid and BEV manufacturing. However, although these vehicles present a greener alternative when they are being driven, it is increasingly important that the engineering and manufacturing processes behind them are also environmentally sustainable.

VACUUM IMPREGNATION IN THE AUTO INDUSTRY

Vehicle weight affects battery use, and the lighter the better. So companies building hybrids and BEVs are exploring ways to reduce overall vehicle weight. Using of structural die-cast components can help, especially if manufacturers substitute heavier materials, such as steel, with lighter ones like aluminum. By manufacturing drive and powertrain components, such as electric motors, from die-cast aluminum, car makers can further reduce vehicle weight. In turn, battery range can be extended for BEVs and HEVs while reducing vehicle emissions for the latter as well.

However, porosity has long been an issue with die-cast components. Microscopic holes form within a part's body during the casting process, meaning the part may not be functionally sound and have leak paths.

In applications with requirements to be pressure- or fluid-tight—for example, in the complex cooling systems within hybrid and BEV drive system castings—this can be an especially critical issue. The move toward using increasingly thinner-walled castings for powertrain components to reduce component weight also brings with it an increased risk of porosity. This makes the role of vacuum impregnation even more vital to avoid scrapping complex and high value components, whether for hybrid, ICE or BEV powertrains.

Vacuum impregnation provides an OEM-approved method for sealing leak paths and porosity in metal castings, sintered metal parts and electrical components. Using specialist impregnation equipment, voids are filled with a liquid sealant under vacuum, which is then turned into a chemically and thermally resistant polymer by heating in a hot cure process. When it comes to hybrid and BEV manufacturing, vacuum impregnation can be used to effectively

seal die-cast and electronic parts against leakage or fluid ingress.

As well as improving the reliability of components, the process reduces scrappage and lowers defect rates, in turn reducing waste and costs from the manufacturing process.

VACUUM IMPREGNATION: OPERATIONAL CONSIDERATIONS

With modern supply chains under increased economic pressure, treating porosity has become even more important. Scrapping fully machined parts is expensive, especially given the work invested in them. However, if a machined part fails after it has been incorporated into a component such as an automotive compressor, the costs associated with scrapping it at that stage are significantly higher.

To meet this need, Ultraseal offers a range of equipment which can be incorporated into any production line, as well as both managed in-house and off-site impregnation services.

Modern front-loading impregnation systems give speed, control and significant health and safety advantages to users, as well as a smaller footprint and the lowest cost of ownership.

In situations where volume is a consideration, automated production equipment provides the benefit of significantly reduced production and labor costs and lower operator involvement. These fully automated systems combine fast, consistent cycle times with best-in-class sealing performance, ensuring a consistent output quality and health and safety improvements.

To maximize uptime and reduce the overall cost of ownership, Ultraseal's expert team can remotely monitor the performance and operating history of the equipment, helping to optimize processes and minimize unplanned downtime. Finally, those who don't have the need or space for a dedicated impregnation process in-house can tap into the company's global network of sites, which can manage the process from

Porosity is a recognized issue with die-cast components. Microscopic holes created within a part during casting may leave the part nonfunctional due to leaks.

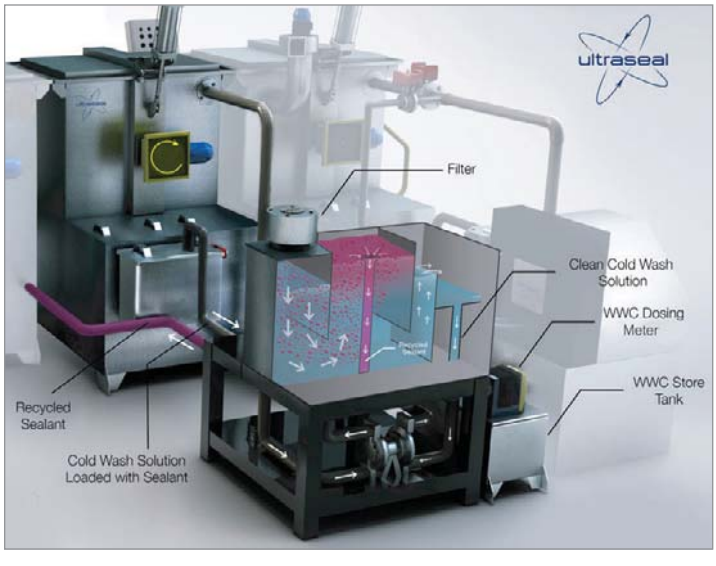
start to finish. Alternately, they can opt for a fully managed on-site service which provides a cost-effective, end-to-end, impregnation process management solution without investment in capital equipment or personnel.

In a traditional impregnation process, components are placed into an autoclave, where the component is immersed in sealant and a vacuum is used to draw the sealant into micro-porosities and leak paths. A cold wash module then removes excess sealant and a hot cure cycle exposes components to heat which polymerizes the sealant, changing it from a liquid state to solid polymer.

During the cold wash part of this process, up to 98% of the sealant used goes down the drain as waste. To overcome this expensive wastage and meet increasingly stringent environmental guidelines, Ultraseal offers a range of recyclable sealants. Instead of being washed down the drain, the sealant is collected from the wash tank and passed through a sealant recovery system for retrieval and reuse. In addition to significantly reducing sealant consumption, the process uses substantially less water and removes the need to change wash-water tanks, leading to a marked reduction in downtime while improving process efficiency.

Where customers have an incumbent supplier or have already invested in an impregnation solution, Ultraseal can convert existing systems to use Ultraseal's recycling sealants. This helps to meet environmental regulations and reduce wastage without the need for capital expenditure on completely new systems.

As the automotive manufacturing market evolves, established vehicle manufacturers are investing significantly in the electrification of their product ranges to future-proof their business and stay relevant in the marketplace. Incorporating vacuum impregnation into manufacturing processes can help the automotive industry to reduce scrap and material wastage, improve component life cycles and improve environmental performance. md



Impregnation sealants can be sent through a sealant recovery system, such as this one from Ultraseal, to retrieve and reuse them.

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Getting the right products and components at the right time has a direct impact on the health and wellbeing of patients. MW Life Sciences helps accelerate new product development, optimize performance, and increase speed to market.

The MW Life Sciences portfolio includes cases and trays, reusable and single-use surgical instruments, robotics, implantable components, drug delivery, orthopaedics, and other specialty medical devices. We provide expertise in the science of metal and plastic, design for manufacturability, prototyping, design transfer, and more to help ensure your product is both innovative and cost-effective.

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With decades of experience developing products and components for demanding healthcare applications, we know what it takes to get a new product to market. Our industry-leading engineering and production capabilities enable us to manufacture high-precision products to meet exacting standards while our concept-to-supply business model is designed to increase your profitability, reduce risk, and accelerate time to market.

No matter where you are in your process, our expertise in everything from design and development to compliance and launch logistics gives you the flexibility to partner with us at any phase of your project. We'll go the extra mile to help you achieve your objectives, bringing innovative new technology and solutions to the healthcare industry.

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Founded in 1898, New England Wire Technologies has been the premier supplier of custom wire and cable products for over 120 years. We currently serve a full range of industries including medical device and electronics, aerospace, defense, robotics and automation, power generation, and alternative energy to name just a few. Additionally, we have provided cabling and insulating services to the superconductor industry since the 1960's where our products are integrated into most of the major accelerator projects, ore separator magnets, NMR magnets, and superconducting magnetic energy storage (SMES) magnets.

OUR FACILITIES CONSIST of 400,000 square feet of manufacturing, quality/testing, tooling/machine fabrication, and office space. Manufacturing processes include wire drawing, plating, stranding, braiding, cabling, insulating, and extrusion services. We are an ISO9001:2015 registered company with over 400 employees operating three shifts, five days a week. Our sales and engineering staff assist engineers, scientists, and technical professionals in the design, development, and manufacture of the most technologically advanced wire and cable products in the industry.

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OUR SUBSIDIARY, New England Tubing Technologies, occupies a 14,000 square foot state-of-the-art facility adjacent to New England Wire manufacturing. Working directly with clients in the medical electronics and device industries, as well as with other custom industrial and commercial projects, we design and manufacture custom braid or spiral reinforced tubing, lined catheter shafts, multi-durometer and multi-lumen tubing, hybrid tubing configurations, as well as medical braid. Calling on the decades of advanced extrusion and wire-processing expertise of New England Wire, New England Tubing excels in thin-wall, tight tolerance tubing, reinforcing, bonding layers of thermoplastic to fluoropolymers, and braiding all types of round and flat wire.

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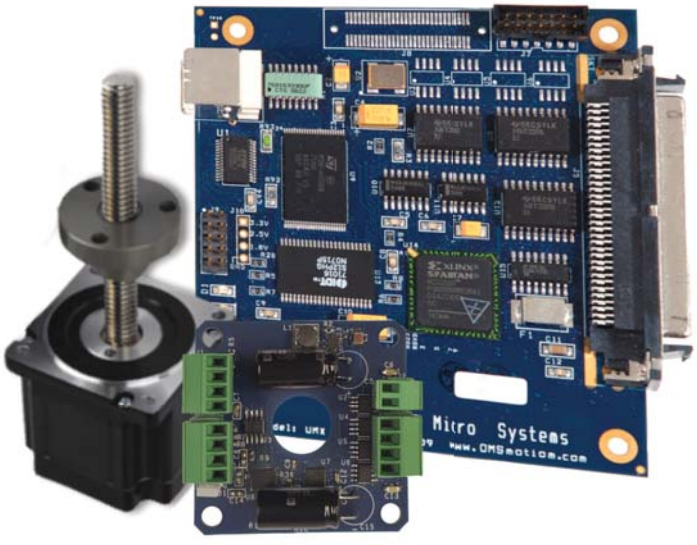
OMS MOTION (aka Oregon Micro Systems and Pro-Dex OMS) has been successfully producing motion control products and services for more than 35 years. Single axis integrated controls with drives as well as complete multi-axis controllers that can coordinate and synchronize up to 10-axes on a single controller.

Founded in the early 80's, OMS Motion evolved from patented technology that provides an advantage in the motion control industry. In the mid 90's, OMS was acquired by a publicly traded company which has a focus on the medical device markets. OMS continued the motion control business as a subsidiary, while supporting the medical device product development. In early 2017 OMS Motion separated from the public company, under the original leadership of the company's beginnings, and has regained its focus on motion control business.

OMS Motion produces superior motion control products that are functionally capable and intuitive to use. The controls accept simple ASCII character commands over communications on Ethernet, RS232, RS485, ModBus, VME, PCI bus and other. OMS controllers support stepper and servo motor control and have utilized incremental encoders, counting all 4-quadrants of the quadrature signal. Additionally, support for absolute encoders for SSI and BiSS are available for exceptional control of the systems. High resolution and speeds can be utilized to provide some extraordinary motion control. OMS controls also incorporate general purpose I/O that can be tightly coupled to the motion for precise applications. New products are being developed that cover other communication protocols, new functional features, integrated drives and amps and other features. Custom products based on the OMS architecture are also developed for specifically qualified applications.



Great effort has gone into the development of the controls and the functionality is ever continuously evolving as more and more unique applications utilize the controllers. OMS products are used in numerous markets worldwide, including semiconductor equipment, lab automation, life sciences, factory automation, large- and small-scale research facilities/projects, and others. OMS controllers are very versatile and capable.

OMS Motion is proud to be a small and nimble organization that can respond to customers' needs and focuses on the success of the customer. OMS has earned a strong reputation for reliable and quality motion control products and is trusted throughout the world. OMS Motion is a trusted name for quality motion control products and service.

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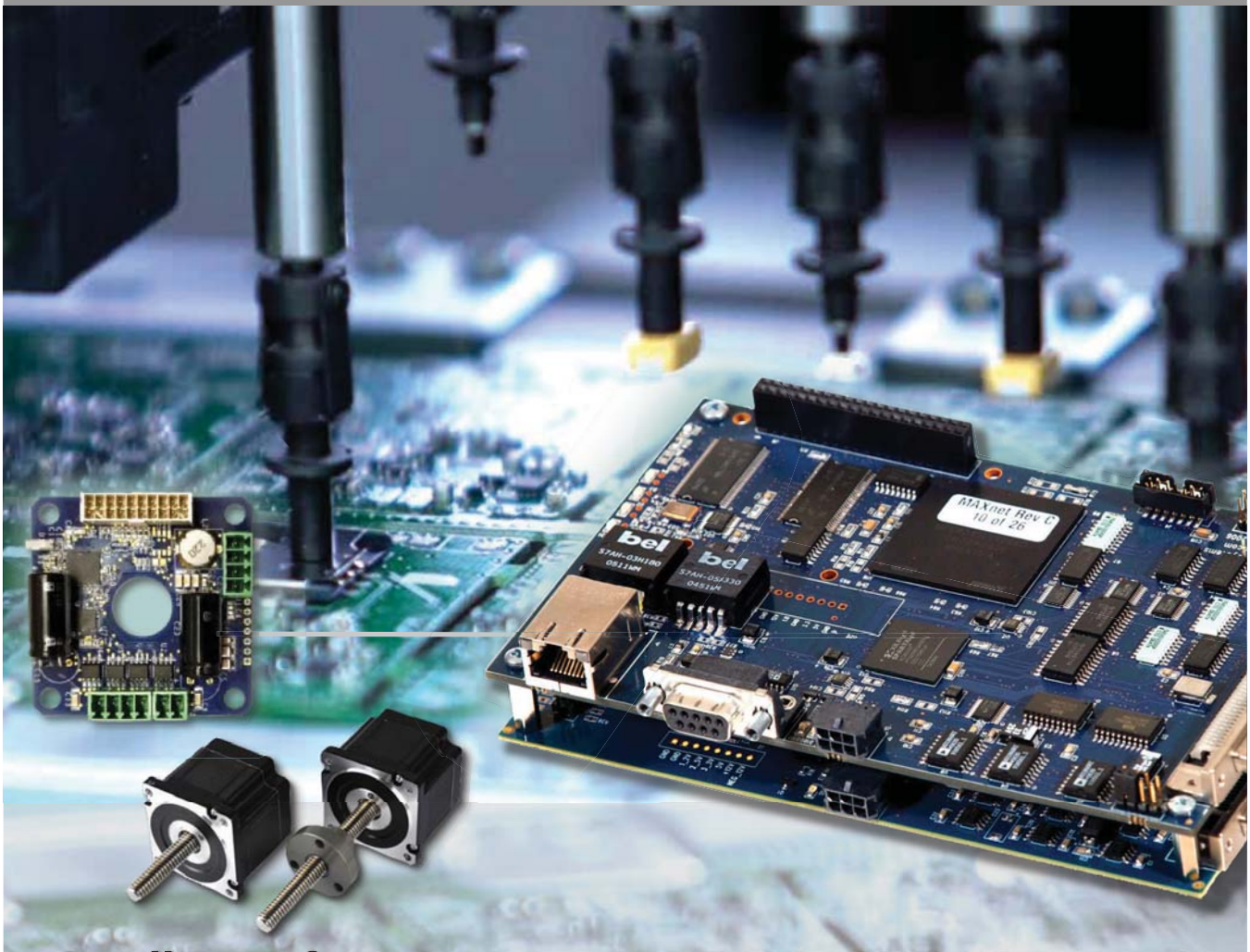

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To design its carbon fiber aerospace-grade submersible vehicles, Seattle-based OceanGate chose PTC's cloud-native Onshape product development platform that enables remote teams to easily collaborate in real time.

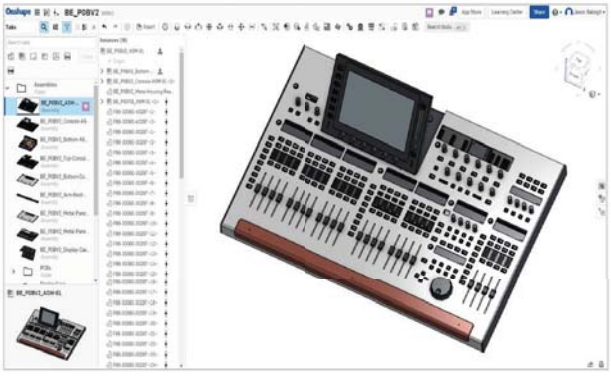
Onshape gives distributed product design teams the freedom and flexibility to simultaneously work together from any location on any computer, tablet or phone. Whenever one engineer makes a design change, everyone else on the team can instantly see it.

Onshape's SaaS platform eliminates the need for IT overhead such as software installation, licenses and upgrades. When engineers spend less time on administrative tasks, they have more freedom to innovate and take creative risks.

Hardware companies that are using Onshape to accelerate their time to market include:

- **Music Tribe** (Professional Audio Equipment) – "We design over 400 concurrent products and maintain close to 10,000 library items. It's important that we're able to keep track of each product and component in the pipeline," says Jason Blanco, Innovation Development Mechanics Leader. "Onshape has cut our design time in half with the help of automated version control and real-time data management."
- **OceanGate** (Submersibles for Ocean Exploration) – "The greatest part about Onshape is that I can always see everything that my team is doing. And I don't need to have a specific licensed computer, use a VPN, or have a separate PDM system. I can just quickly login online and see what they are working on," says Dan Scoville, Director of Engineering and Operations.
- **Delta Development** (Medical Rescue Equipment) – "It's such a liberation to not ever have to worry about what's on our server because it's all on Onshape's servers. Not having to worry about IT overhead has been a huge time-saver for us," says chief engineer Bill Barg.
- **Hirebotics** (Robotics/Automation) – "Having our product design tools in the cloud allows us to keep our IT costs down because we're not trying to run servers here. It keeps our hardware costs down because we don't have to buy elaborate engineering workstations. We're running everything on Macs," says COO Matthew Bush. "Our company likes to do things differently and think differently. We love Onshape's collaboration features and built-in PDM."

In addition, Onshape's flexibility to enable design teams to work remotely from anywhere can be leveraged as a recruiting advantage. Why limit your company's hiring pool to a 100-mile radius when you can now attract talent worldwide?



Music Tribe relies on Onshape's built-in version control to help its globally distributed mechanical engineering team better keep track of design iterations and speed up the product development process.

Speed Up Your Product Design

Onshape is the only Software-as-a-Service (SaaS) product development platform that combines powerful CAD tools with real-time data management, collaboration, and business analytics.

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PBC LINEAR IS A LEADER in the engineering, manufacturing, and assembly of a wide range of linear motion products, along with custom engineering services. Our core line of linear components includes bearings, shafting, rail assemblies, and cam roller sliders. Building on this strong foundation, we have created a sophisticated family of products that includes lead screws and motor lead screw assemblies, actuators, cartesian robotics, and mechatronics assemblies. In addition, we provide engineering services for companies interested in customizing their mechatronics assemblies.

The story of PBC Linear begins with an innovative and patented solution in bearing design, the Frelon®-lined plain bearing. That successful bearing design is now part of a larger family of products related to linear motion technologies, with many of them manufactured at our headquarters in Roscoe, Illinois USA. This central location in North America combined with over 200-thousand square feet of manufacturing space allows us to react quickly to dynamic market forces, helping to provide customers with a flexible and attentive partner. In addition, dedicated engineers at PBC Linear can work with industry professionals to produce prototypes, pilots, and small production runs, helping to bring customer ideas to market.

PBC Linear supplies components and linear motion systems to a variety of industry applications including packaging and distribution, medical devices and diagnostics, transportation and robotics, self-serve kiosks, and more. We match high-precision, low-maintenance products with the linear motion needs of our customers. For example, our patented Frelon-lined plain bearings are a perfect solution for many hazardous environments, including washdown applications. Where an appropriate amount of precision is needed, customers can look to a lead screw for tighter tolerances, or employ the practical precision of Redi-Rail over the standard profile rail. Together, these solutions combine to improve our customers' overall equipment effectiveness, a manufacturing metric commonly referred to OEE.

PBC Linear continues to gain success by employing smart, creative, and enthusiastic minds to help drive U.S. manufacturing forward. Our company's culture is a blend of midwestern work ethic paired with skilled technicians, knowledgeable service personnel, and a multi-disciplined group of trained engineers. Together, they form a full-service team that creates long-lasting and cost-efficient linear motion solutions. As our company grows, we continue to create opportunities for like-minded individuals that are committed to excellence and enthusiasm. Please contact PBC Linear to find out more about career possibilities at:

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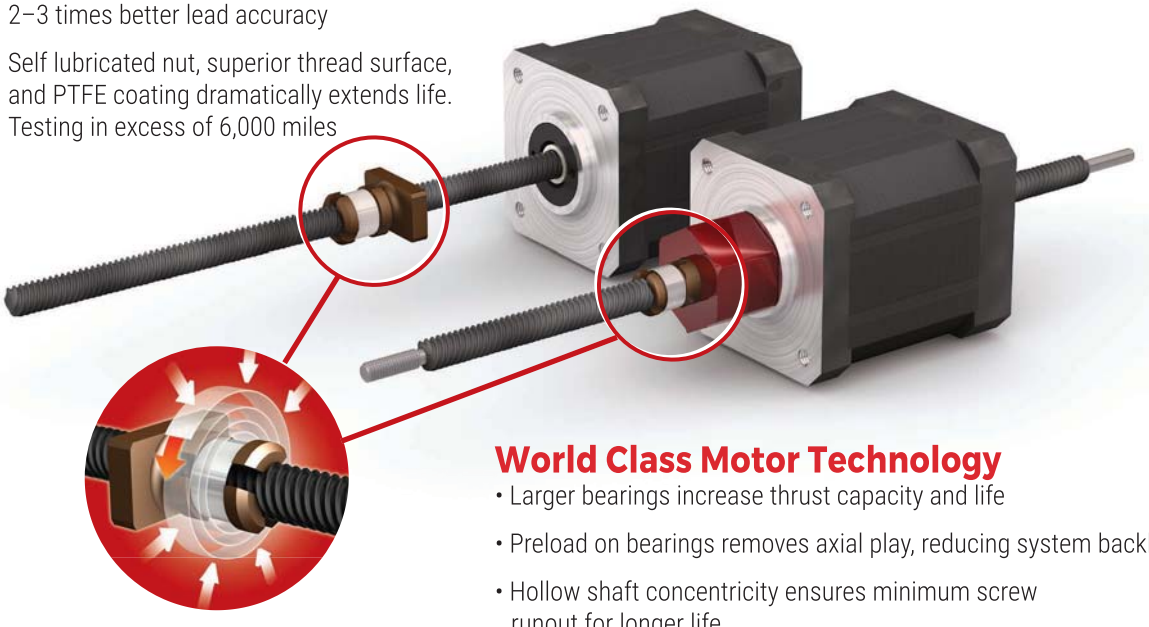

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PI PERFORMANCE AUTOMATION

Celebrating 50 successful years of enabling innovation as a multi-technology provider in 2020, PI manufactures world-class precision motion and automation systems including air bearings, hexapods, and piezo drives at locations in North America, Europe, and Asia. The privately held company, headquartered in Germany, employs more than 1300 people worldwide and provides global support to its customers who are leaders in high-tech industries and research fields.

PRODUCTS & MARKETS

PI's in-house engineered systems and components have enabled customers around the world to increase their productivity and technological advantage for 5 decades. With a large aggregate of standard precision motion products and proven methodologies, PI is in the position to quickly modify existing designs or provide a custom OEM solution to fit the exact requirements of your application from sensors and transducers to microscope auto-focus units, fast positioning stages to multi-axis automation systems.

Relying on our ever-evolving patent and technology portfolio, our products make the seemingly impossible possible and are trusted by experts for applications in:

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Examples of our products include Motion Controllers, Air Bearings, Hexapod Robots, XYZ Gantry Systems, Automated Photonics Alignment Systems, Fiber Positioners, Microscope Stages, Piezo Nanopositioning Stages, Precision Linear Translation Stages for Automation, Rotary Stages and Goniometers, Piezo Controllers, Piezo Actuators and Motors, Piezo Transducers and Components.

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PORTESCAP is a leading manufacturer of miniature motor technologies for performance-critical motion applications. Originated in Switzerland and driven by a passion for precision, customer-centric innovation, technical excellence and best-quality service, Portescap has become a recognized leading expert in miniature motors and precision motion control solutions. Building upon a tradition of manufacturing excellence, we leverage over 70 years of experience in motion solutions to put precise power in the smallest places. From medical devices to various industrial applications, our motors help save, improve and enhance lives.

At Portescap, we can help you choose the best motion technology for your application, including miniature dc motors (brush and brushless), miniature stepper motors, linear actuators, gearheads, and encoders. With motors ranging in diameter as small 8mm up to 85mm, as well as motors that can reach speeds up to 100,000 rpm, we can help you find the optimal solution. With maximum performance in a smaller package, our motors let you design compact machines and devices that are efficient, reliable, and easier and more comfortable to use.

Leveraging our miniature motor technologies and application know-how, we are able to serve a spectrum of motion control applications including :

- Medical devices & equipment
- Surgical hand tools
- Infusion systems
- Industrial power tools
- Clinical diagnostics equipment
- Robotics
- Aerospace & defense applications
- Automation equipment

Our global manufacturing footprint and application centers worldwide allow us to respond quickly to customer needs and to provide local support and collaboration. Whether you require unique modifications or a complete motor customization and assembly, our motion solutions can be tailored to your needs, including shaft cannulation, ground-up electromagnet design, mounting features, custom gear rations and more, to reduce assembly costs while providing a power-matched component.

We pride ourselves on offering dedicated resources for collaborative innovation to help provide you with breakthrough designs. Early collaboration is critical to developing a feasible solution that meets your needs, optimizes application performance and minimizes risks as they relate to product reliability, cost overruns and program schedule. Through a robust program-management and stage-gate process, we collaborate with you from the product design to commercialization to achieve the overall objectives of the project.

To learn more about what Portescap can do for your business, please visit our website at

www.portescap.com

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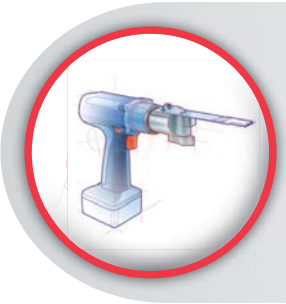

Surgical Motor Solutions

From standard offerings to fully customized solutions, Portescap offers a wide variety of sterilizable motion solutions for high performance surgical applications.

Mini Motors for Battery-Operated Power Tools

Portescap provides advanced motion solutions for industrial applications that maximize power and efficiency while improving the user experience.

Mini Motors for Robotic Applications

Portescap products drive performance, efficiency and precision of robotic applications while lowering the overall footprint of the motion system.

Precision Motors for Medical Infusion Systems

Portescap's high power density motors can reduce pump size, improve battery life, and lower cost of care with cost saving customizations.

Medical Motors

When you need to put the most power and precision in the smallest of spaces, you can depend on Portescap's high-powered miniature motors for medical applications.

THE LEE COMPANY

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Westbrook, CT 06498-0424

THE LEADERS IN MINIATURE FLUIDICS

Since its beginning in 1948, The Lee Company has pioneered the design and development of miniature fluid control components for aerospace hydraulic and fuel systems, medical and scientific instrumentation, downhole oil tools, machine tools, automotive, and other industries worldwide. Under the premise of economically solving problems where existing hardware is either not immediately available, or is too cumbersome, The Lee Company continues to redefine miniature fluidics by integrating new and more advanced technology into smaller packages.

The Lee Company story of innovation never ends. Ongoing research, design, and development helps us advance the technology behind our products to transform the most demanding challenges into deliverable solutions. This commitment to technology allows Lee to foster creativity and offer the best products and technical support available.

The Lee Company now employs over 1000 people and occupies over 1 million square feet of modern manufacturing space at three sites in Westbrook and Essex, CT. Sales offices are located throughout the USA and the company is represented worldwide by wholly owned subsidiaries, distributors and agents.

ELECTRO-FLUIDIC SYSTEMS DIVISION

THE ELECTRO-FLUIDIC SYSTEMS (EFS) Division produces high quality miniature solenoid valves (conventional and chemically inert models), high speed micro-dispense valves, atomizing and dispense nozzles, fixed and variable volume pumps, integrated fluidic manifolds, inert tubing and fluid control components, and custom engineered designs. These products are typically used in medical and scientific instrumentation, analytical and clinical chemistry, in vitro diagnostics, drug discovery and ink jet printing applications.

PRECISION MICROHYDRAULICS DIVISION

THE PRECISION MICROHYDRAULICS DIVISION supplies expansion plugs, high pressure solenoid valves, single and multi-orifice restrictors, nozzles, safety screens, check valves, relief valves, flow controls and shuttle valves to a wide range of industries. These include hydraulic and pneumatic applications on commercial and military aircraft, spacecraft, missiles, naval vessels, machine tools, downhole oil tools, power generation equipment, motorsports, etc.

Innovation in Miniature
LEE
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And because every one of our designs originates out of an application need, and is scrutinized with 100% testing and inspection, we're found in just about every mission-critical fluid control challenge you could imagine – from miles above the earth in satellite positioning systems, to miles below in downhole drilling. Plus many applications in between.

If you require precise fluid control, and absolute reliability, go with the experts. Contact The Lee Company.

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Pyramid Inc. is committed to continuous improvement — in processes, products and efficiency.

AN ISO 9001 CERTIFIED COMPANY

Pyramid Inc. is an ISO 9001 certified company located in Newton, Iowa. Pyramid was founded in 1967 and began manufacturing polyurethane drive belts in both round and flat cross sections under our registered trade name PYRATHANE.

At that time, polyurethane was a relatively new engineering plastic that had far superior wear characteristics to the widely used rubber.

While many of our belts are used in the conveyor industry, many also go into paper-handling equipment, small tools and appliances, medical devices and a variety of other applications.

A WORLD-WIDE PRESENCE

We have a world-wide customer base of over 1000 accounts — some who purchase daily, and some who buy just a few times a year.

Because Pyramid's reputation has been built on quality products, exceptional delivery and unmatched customer-care, our company continues to be the leader in the industry.

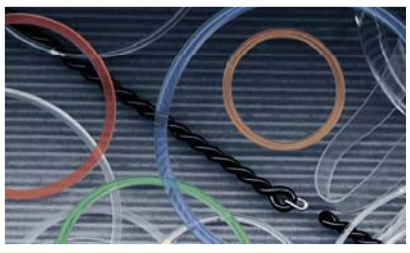
As an ISO 9001 certified company, we are committed to continuous improvement — in processes,products and efficiency. Pyramid manufactures drive belts of the finest polyurethane and pride ourselves on our exceptional customer service, competitive pricing and excellent lead times. Our staff of dedicated, trained employees truly care about product quality.

QUALITY SERVICE AND PRODUCTS

Whether you require only a small quantity for a specific project or thousands for an OEM application, we are here to serve you, and can provide prototype samples at little or no cost.

Pyramid's reputation for quality is well-known — in fact, we are so confident in the quality of our product, that our belts are covered by a lifetime warranty against manufacturing defects. It is this dedication to quality that will keep our company moving forward, not only as a world-wide supplier, but as a world-class supplier.

Visit **www.pyramidbelts.com** for more information, and if you want to deal with the best, please give us a call!



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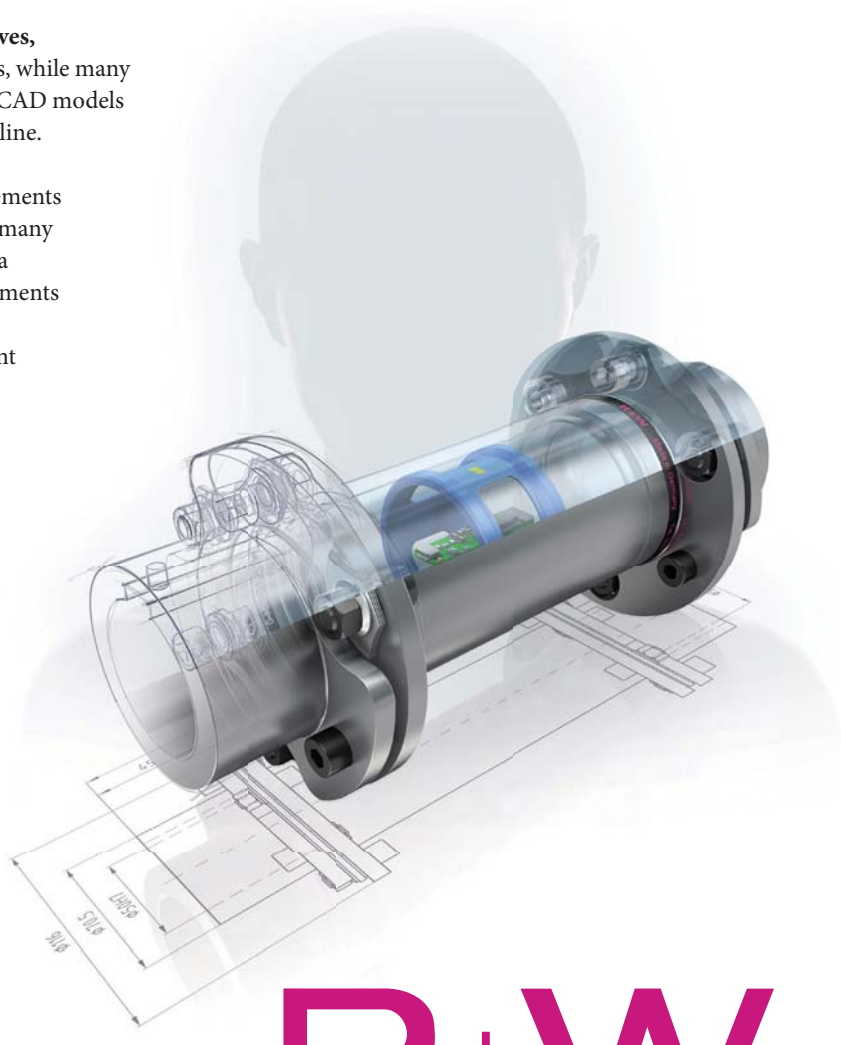
Whether for micro motors or 10 megawatt drives, couplings are customizable for most applications, while many standard models ship from stock. Configurable CAD models are available in a large number of file formats online.

With a philosophy of meeting customer requirements from concept to production, R+W has supplied many thousands of custom coupling designs, creating a wealth of knowledge about the technical requirements associated with a wide variety of industries and applications. Constant new product development takes place in house, in addition to intensive collaboration with universities and engineering firms, keeping R+W at the forefront of technical development and product innovation in its field. Over the past 30 years this has resulted in a position of market leadership for metal bellows couplings, and global availability for all of its precision couplings and torque limiters.



New for 2021 is the intelligent coupling series. This product line will integrate measurement electronics into R+W's existing coupling designs, offering users much better visibility and understanding of their drive system performance. Information such as speed, torque, and axial compression are streamed live to a proprietary app to provide useful real-time data. The integral battery allows for continuous usage of up to 5 days, with an inductive charging design still in the works for 2021. This coupling can also be integrated into customer's existing controls systems via a gateway converter, making installation and data management even easier. The future of couplings has arrived and is ready for Industry 4.0.

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SS2 Series

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SCHMERSAL - THE DNA OF SAFETY

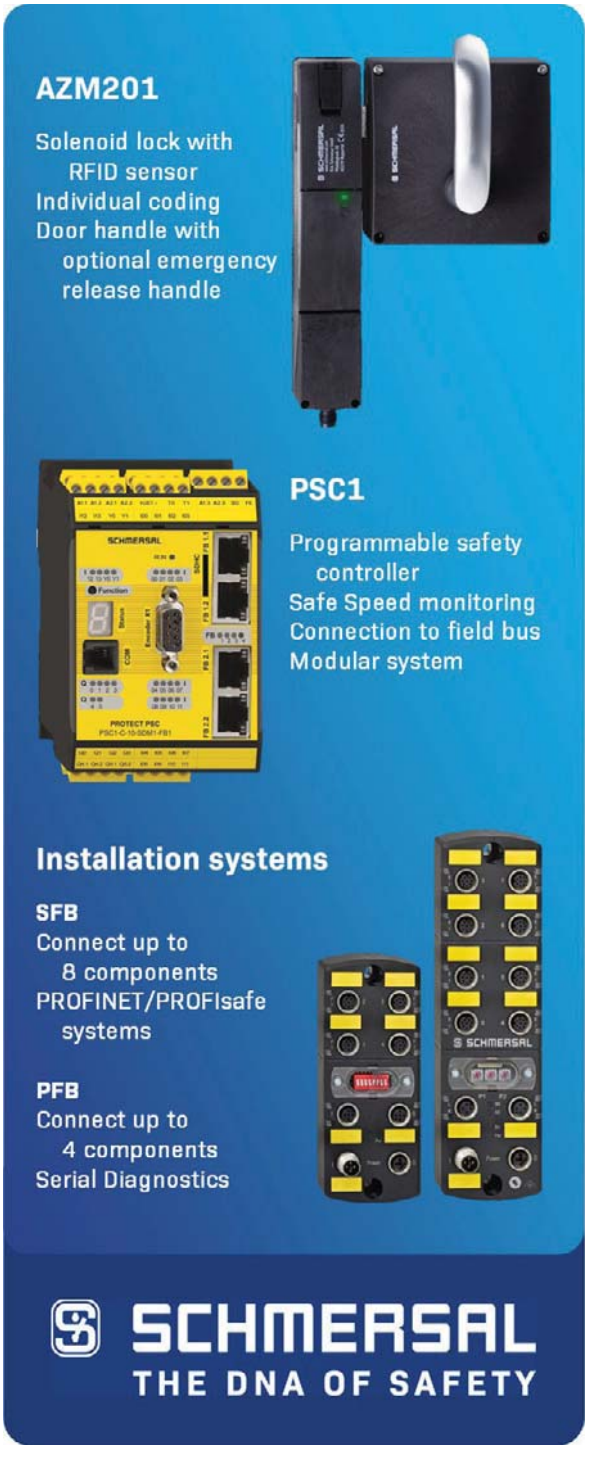
Machine safety is a complex topic. Companies are increasingly calling on qualified specialists for support. For Schmersal, safety is in our genes – our company is now managed by the third generation of the Schmersal family. But that's not the only reason machine safety is part of our DNA: 75 years of competence and expertise allows us to develop excellent safety solutions for individual plants, for machine builders, and operators.

Since 1945, Schmersal has been industry leader in the design and manufacture of machine safety products, industrial switches, position sensors, and control accessories for a wide variety of applications. As safety requirements have changed over the years, Schmersal products have evolved as well. We're constantly adding new innovations to our range of products, such as:

- Electronic safety switches utilizing RFID technology
- Programmable Safety Controllers
- Installation architecture options with plug-in connections
- Bluetooth interface integrated into Safety Light Curtains

Schmersal is your one-stop shop for developing safety solutions - combining the building blocks of safety rated components with control systems and software for customized and comprehensive safety systems.

Motivated by the vision of safe working environments and leveraging our vast experience in machine safety systems, Schmersal also offers machine builders and production facilities qualified services related to machine safety in support of our considerable range of safety products and system solutions. Through seminars and training, risk assessments, technical support, consultancy and integration program services we support safety engineers with first-hand specialist knowledge.



SCHMERSAL
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Schmersal Safety Light Curtains with Bluetooth interface

Schmersal SLC440 safety light curtains are now available with an integrated Bluetooth interface for data sharing with smartphones & tablets.

The SLC440 BLE uses the Bluetooth Low Energy system for secure data transmission, up to 5 meters. The data transmitted from the safety light curtains is accessible by the Schmersal **SLC Assist App**, available for Android and iOS smartphones and tablets.

The SLC440 offers many integrated functions including fixed blanking, floating blanking, fixed blanking with movable edge region, double reset, contactor control (EDM), automatic mode, re-start mode, and beam coding.

This unprecedented access to the operational data of the Safety Light Curtain has many advantages:

- The app serves as an installation alignment aid as it displays the signal strength of each beam.
- Real time monitoring of the active operation mode, the status of the OSSD outputs and the status of the protective field provides the information necessary to quickly resolve faults.
- The app can provide documentation on the light curtain, either emailed or saved to the smartphone or tablet.
- Additionally, you can see which functions have been enabled and their parameterized settings.

Contact us to learn more about this innovation in safety light curtains

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MADE IN GERMANY — QUALITY BY TRADITION, THE HEART OF SIKA

Founded in 1901, we invented the industrial thermometer. Today, we develop and manufacture a wide range of products for temperature, pressure, and flow measuring instruments. We also manufacture a full line of pressure and temperature calibration products. Your success is our goal by meeting your needs with precision German engineering. As your preferred supplier, we want you to benefit from our experience and worldwide network of subsidiaries and channel partners.

WE MEASURE UP

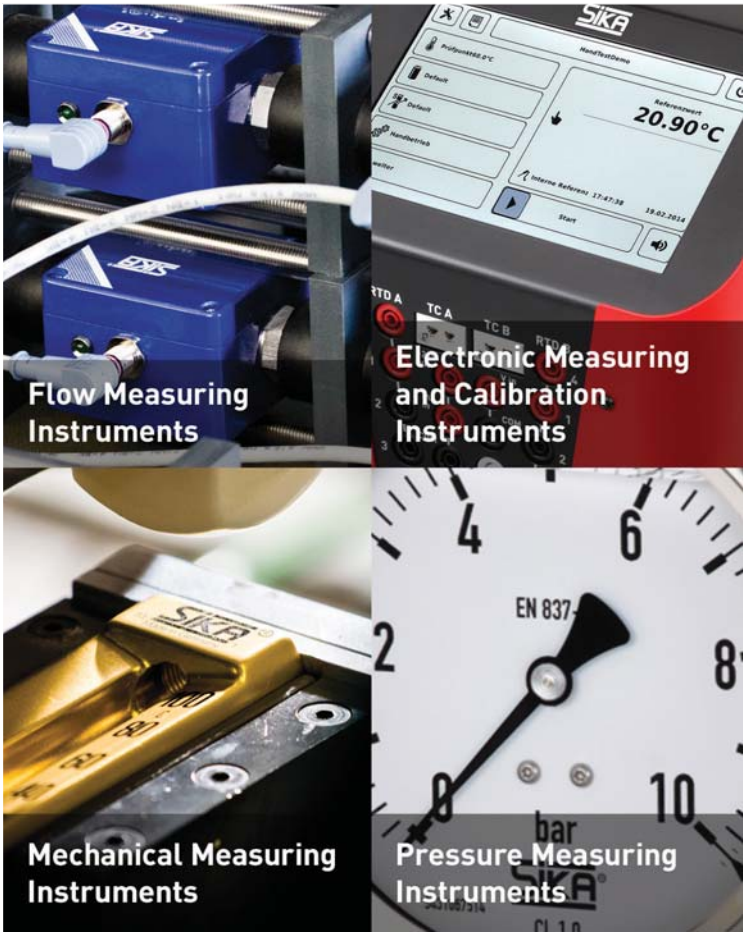
SIKA's produced over 15 million dial and digital thermometers including industrial thermometers, thermo-sensors, and digital reference sensors.

We replicate customer applications in our labs, test for service life, and extreme stress from thermal shocks and vibrations. It's a prerequisite to our commitment to quality and workmanship.

SIKA pressure products include bourdon tube, differential, diaphragm, and capsule element pressure gauges and sensors. We offer a variety of configurations for most industrial class applications.

50 years of international experience in flow measurement technology has evolved to the SIKA VVX32 and VVX40 vortex flow sensors — industrial flow meters with no moving parts. Built for the rigors of commercial and industrial applications while providing a reliable and accurate flow signal, not only for volume OEM manufactures but also for the system integrators.

Our calibration products include hydraulic and pneumatic pressure pumps and digital reference gauges. The integrated vacuum generation enables working in the vacuum range down to -950 mbar — available with different accuracies to meet the requirements of most applications.



The portable hydraulic and pneumatic pressure pumps from SIKA are a clever solution for testing, adjusting, and calibrating pressure gauges and sensors — commonly used in metrology labs and in the field.

We also offer a full line of multi-function temperature calibrators for marine, industrial, and laboratory grade environments providing fast and reliable calibration by simply changing between micro-bath, dry-block, infrared, and surface functions. Our laboratory grade calibrators offer the worlds fastest response times with stabilities to 0.05 C (0.09 F).

OUR HERITAGE

SIKA Dr. Siebert & Kuhn GmbH is based in Kaufungen Germany. Founded in 1901 by Dr. Carl Siebert and Albert Kuhn, is a fourth generation family owned and operated company.

Need Sensors for High-Flow Applications?

Our Vortex Flow Sensors are designed for higher flow applications such as large heat pumps, boilers and chillers, cooling systems, energy calculations, water stations and water treatment plants.

VVX32,40 FEATURES

- No moving parts
- Nominal diameters 1 ¼" and 1 ½"
- Multiple output signals
- Optional temperature sensor

Our new vortex flow sensors, the SIKA VVX32 and VVX40 are industrial flow meters with no moving parts. Built for the rigors of commercial and industrial applications while providing a reliable and accurate flow signal, not only for volume OEM manufactures but also for the system integrators. Multiple output signals available along with a variety of optional temperature sensors.

WE MEASURE...

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Bourdon tube, differential, diaphragm, and capsule element pressure gauges offer a wide range of pressure and accuracy options for most industrial applications.

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Over 15 million dial and digital thermometers produced with a high level of accuracy, installation and material options, robust design for long service life.

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Smalley stocks over 10,000 standard parts across 30 configurations and 400 sizes, ready for delivery. If a standard part doesn't meet your requirements, you'll work with our team of over 30 industry-specialized engineers to quickly create an economical custom part in the material of your choice, all without new tooling. Prototype or production volume, our No-Tooling-Charges™ manufacturing process meets the design flexibility your application, budget, and timeline requires.

While all of our manufacturing is produced in our U.S. based 300,000 ft^2 facility, our global network of offices, engineers, and distribution partners allows you to quickly receive parts and support from anywhere in the world. As an ISO 9001 and ISO 14001 company, we deliver quality products certified to IATF 16949, AS9100, and ISO 13485. Smalley's dedication to quality and manufacturing excellence has earned us multiple service and quality awards as well as the trust of OEMs worldwide.

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From everyday consumer products such as the smartwatch on your wrist to life-saving medical devices such as robotic surgical instruments, Smalley has helped tens of thousands of engineers and professionals create application-specific solutions across every industry.

Smalley has paved the way to become the world leader in rings and springs because of our personalized application-support, industry expertise, and customer-driven commitment.

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Standard or custom, we are dedicated to delivering the right part in the right material for all of your applications.

50% LESS SPACE

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MachineDesign

FAQs

Soft Magnetic Composites in Motor Applications

What are soft magnetic composites?

Soft magnetic composites (SMCs) are components made by applying powder metallurgy techniques to metal powders with magnetic properties. SMCs are generally made by compressing metal powder in a tool and following up with a heat treatment.

The metal powders that form the basis of SMCs consist of high-purity iron particles individually coated with an electrically insulating coating. One example is Somaloy from Höganäs AB (Sweden). The powder metallurgy process combines with the powder's specific properties to create parts with three-dimensional magnetic properties.

Where can they be used in motors?

SMCs have been used to improve the performance of claw pole motors that appear in applications like automobile alternators, consumer appliances, and printers. In these motors, SMCs form precisely shaped claws or inductors that fit these space-saving designs.

Linear tubular motors also use SMCs in their inner and outer stators in applications that call for precise and repeatable linear actuation. In these applications, they provide a broader spectrum of position control than pneumatic actuators.

In axial flux motors and yokeless axial motors, the magnetic flux paths are parallel to the motor axle as opposed to radial through the air gap between the rotor and the stator. These flat motors work well with the 3D flux paths made possible through SMCs. Designers are turning to these motors for their high power and torque densities and space-saving design that make them ideal for electric vehicles (EVs), pumps, fans, compressors, valve control, hoists, and power and wind generators.

How do SMCs improve magnetic performance?

The materials that make up SMCs, like Somaloy, aren't hindered by the two-dimensional flux paths that form in stacked magnets or sheet metal laminations. A 3D flux path creates high flux density and high magnetic permeability, allowing for a more compact motor design and simplified assembly.

The individual particles that form SMCs are coated with an electrically insulating material, so parts made from the powder have high resistivity. This keeps the bulk eddy current in the material low, so less energy is lost to heat. This effect is compounded at high operating frequencies, making them an ideal choice to minimize losses.

For example, Somaloy 700HR 3P, compressed to 7.52 g/cm3 density, has a resistivity of 600 μΩ-m and a permeability, μmax, of 770. Its magnetic flux density, B, is 1.57 T at a field strength, H, of 10,000 A/m. Under those conditions, the power loss is approximately 9.5 W/kg at 50 Hz.

How do SMCs improve physical design?

With SMCs, two aspects of three-dimensional design open up design options for motor engineers. First, the material's 3D flux capability lets designers think outside the box when shaping their motors' magnetic components.

Secondly, powder metal processing techniques make it easier to manufacture complex 3D parts. Like polymer injection molding and metal casting, powder metallurgy enables part consolidation for parts that are ultimately lighter and take up less space.

The Somaloy 700HR 3P material mentioned above, for example, has a transverse rupture strength (TRS) of 120 MPa. No change in strength is seen when testing the material at an elevated temperature of 150°C.

How do SMCs improve assembly?

In addition to giving designers more freedom to shape motor components to their specific applications, SMCs make motors easier to assemble. The laminated stacks of sheet metal stampings that are used in many motors are time-consuming to assemble. In addition,

each assembly must be checked to ensure it has the right number of layers in each stack to maintain uniform motor performance.

Components made from SMCs, on the other hand, permit error-proof assembly and optimize part geometry. SMCs let designers take advantage of the material's improved magnetic properties to save space. Some designers have used SMCs to take the winding step out of the assembly process by sliding pre-wound bobbins over the legs of the stator or other SMC object.

How are motor components created from SMCs?

The process of manufacturing motor components from SMCs is similar to other powder metallurgy processes. These processes always begin with precise blending of a variety of powders to achieve the desired properties. In the case of SMCs, the refined, coated-particle powder arrives pre-blended from the powder supplier.

The SMC powder is loaded into part-specific tools that ensure it is compacted to the desired shape. Compaction pressures and temperatures vary depending on the powders, geometries, and end properties desired. For SMCs, compaction pressures and temperatures vary to achieve densities as high as 7.57 g/cm3.

After molding, the "green" part needs to be heat treated to bond the individual metal particles together. Heat treatment temperatures can range from 530°C to 650°C depending on the material system used. Different heat treatment atmospheres—including air, steam, and nitrogen—can yield different results.

How can I learn more about SMCs?

More and more motor designers are considering the performance, form factor, and cost benefits of SMCs for magnetic motor components. However, the range of available materials and design options can be daunting. Look for material specs on the websites of material suppliers like Höganäs AB

Also consult with companies like Symmco that are experienced in powder metal manufacturing in general and with SMCs for motor components in particular. They have information about the manufacturing process, part options, and material selection on their websites. They also have engineers available to answer your questions about designing with SMCs.

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VISUMATIC — THE EXPERTS IN AUTOMATED FASTENING & JOINING TECHNOLOGY

Visumatic Industrial Products designs and builds automatic feeding and driving assembly equipment to install screws, nuts, bolts, push pins, rivets, and specialty fasteners. From robot end-of-arm tooling to vision-guided robots, engineered fastening is their only business and they've been at it for over 55 years. Their passion for fastening technology has allowed corporations with similar missions to become some of the most productive on the planet.

Hand-held screw feeding and driving systems are used in assembly production when volume is not sufficient to fully automate. They are designed to automatically deliver screws, nuts, or pins to the tooling tip, keeping the operator from having to reach for screws and manually place them onto the bit. The operator physically locates the driving position and initiates the drive cycle.

Machine-builder components are modular plug-and-work screw installers for machine builders to quickly integrate into an automatic assembly process. Visumatic's expertise in fastener automation provides machine integrators out of the box functionality to meet demanding build schedules. Systems are designed to interface with your equipment incorporating your bolt hole pattern. They include integral I/O contacts, cabling, and a suggested PLC code, all carefully planned and written for you. Single- or multi-spindle driver spindles for stationary or six-axis robot integration—their design seamlessly fits your process.

VIN-700 Pin Insertion System

VNR-800 Nut Driving System

Visumatic components are custom-engineered for your parts and your business. All designed, built, and extensively tested in-house. Each machine delivers longer life cycles, extreme durability, and pinpoint accuracy. Every system is backed by the strongest guarantee in the business and supported by a dedicated on-call customer service group working to ensure your line stays up and running.

Visumatic's breadth of expertise means you can rely on them to handle every fastening challenge your company faces—today and forever.

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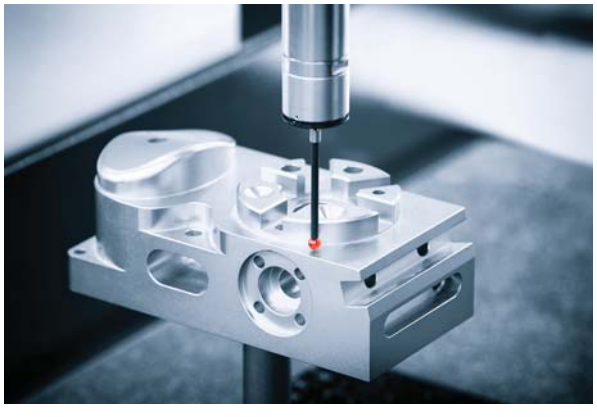
At Xometry, we created a proprietary software platform to enable product designers and engineers to instantly access the capacity of a network of manufacturing facilities. Our platform makes it possible for customers to receive instant pricing, expected lead times and manufacturability feedback in seconds. At the push of a button, the network is able to deliver high-quality parts at consistently fast lead times while offering very low prices.

We make it easy for all customers — from startups to Fortune 100 companies — to access manufacturing on demand by providing the most efficient way to source high-quality custom parts. We're dedicated to providing an innovative way for customers to easily work with a broad network of manufacturing facilities.

Xometry launched in 2014 and has grown rapidly, driven by the ease of our instant quoting platform, our manufacturing expertise, and our relentless devotion to helping customers with their project engineering needs. In 2018, Xometry acquired MakeTime, another leader in the manufacturing-on-demand space to create the single largest manufacturing partner network in the industry. In 2019, Xometry acquired Shift, Europe's largest CNC manufacturing network. Our partner network now spans the globe to support the needs of customers and to help drive the business of local machine shops and manufacturing facilities. Partners do not pay to sign up for our network. Our algorithm sends jobs to a list of carefully vetted facilities with matched capabilities. Xometry's Project Engineering team is always responsible for making sure the parts are done correctly and on time.

Our capabilities include **CNC Machining, Sheet Metal Fabrication, Direct Metal Laser Sintering (DMLS), Selective Laser Sintering (SLS), Fused Deposition Modeling (FDM), HP Multi Jet Fusion, PolyJet 3D, Die Casting, Binder Jetting, Urethane Casting, Finishing Services**, and **Injection Molding.** We can produce a wide range of quantities, from single-use prototypes to hundreds of thousands of molded parts. Some of our top customers include NASA, BMW, GE, Bosch, and Dell Technologies. We are ITAR registered and AS9100 and ISO 9001:2015 certified and all of the work we do is covered by the Xometry Quality Guarantee.

For more information about careers at Xometry, see our jobs page.



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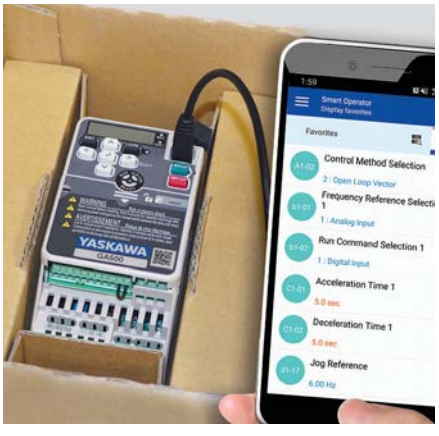

Experience is often the difference between solving a problem the right way and settling for "good enough." Yaskawa's global expertise is unmatched and unquestioned, with 100+ Years of manufacturing excellence, 15,000+ worldwide associates, 30 countries with sales, service, and manufacturing locations, and $4.0 billion in global sales per year. Since 1915, Yaskawa has produced 17 million servo axes, 27 million variable frequency drives and 405,000 robots.

We provide both standard products and tailor-made solutions, all backed by proven quality and reliability. We're also continuously working to save you money, time, energy and headaches, because we believe your machine can always run faster, smoother and more productively. It's about making the correct diagnoses, creating the right automation machinery, and implementing it in the best way possible.

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