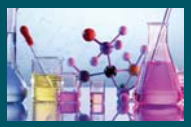

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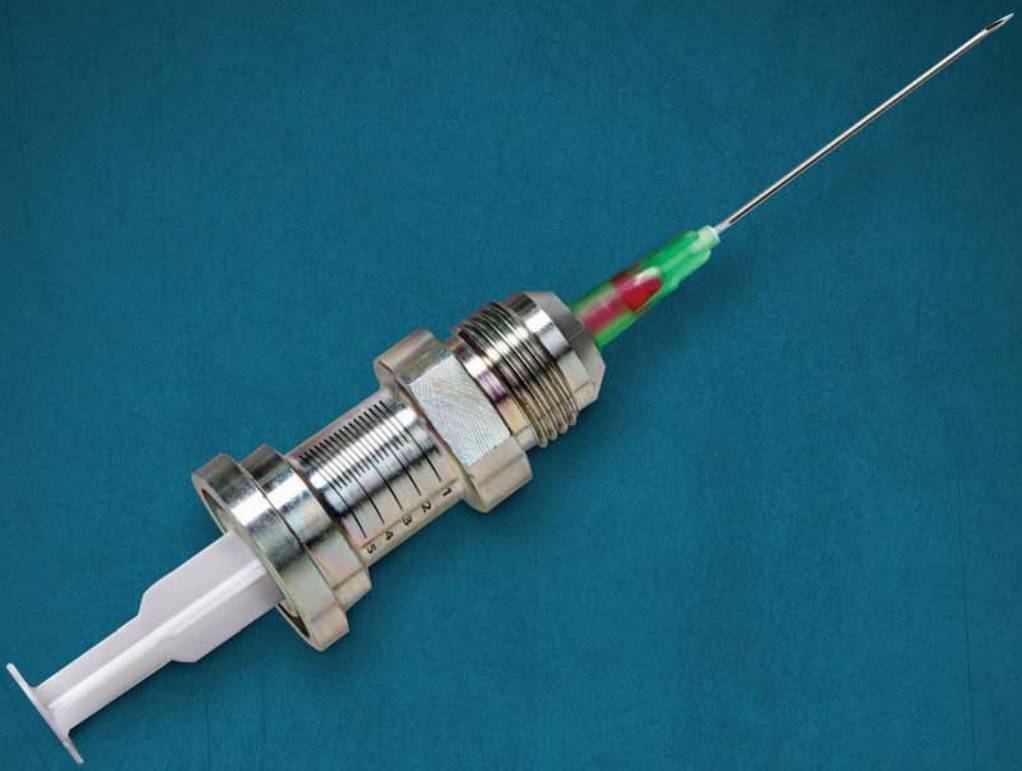

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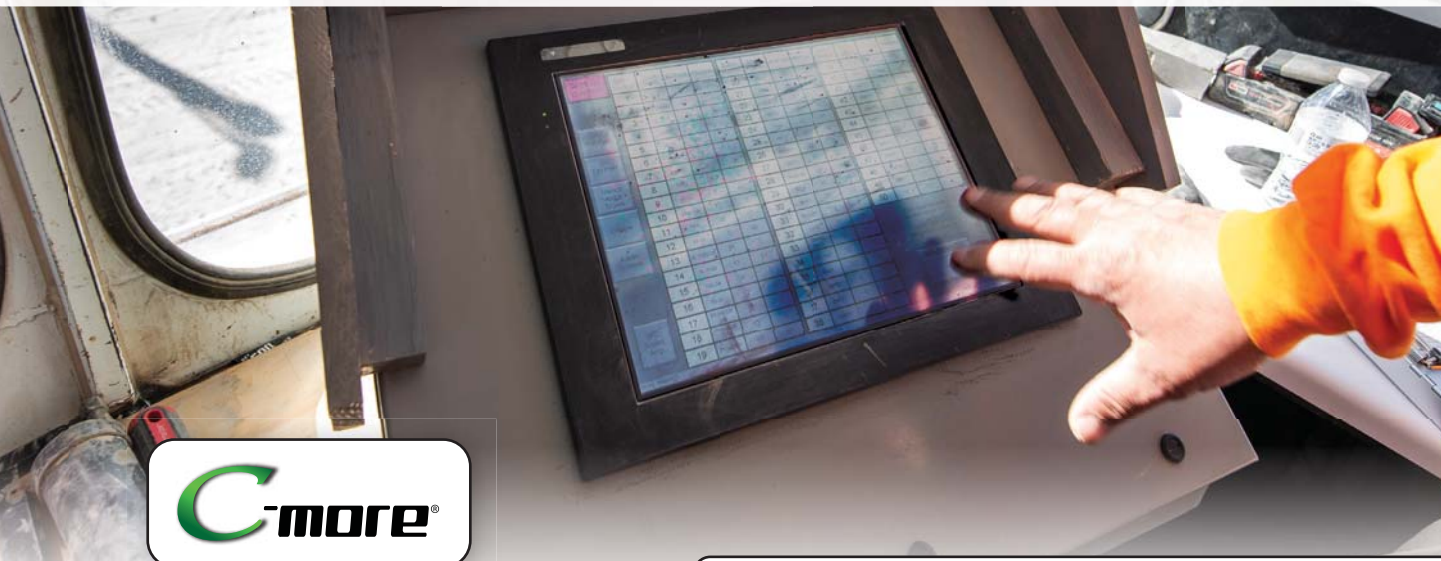

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Smarter Pneumatics: A Smart Decision

ADDING NEW, advanced manufacturing solutions to existing systems can seem to some like the old canard, "If it ain't broke, don't fix it." The ability to easily add, monitor and analyze sensor data on pneumatic systems and other fluid power applications is really more along the lines of, "I can maintain it before it breaks."

The promise of the Industrial Internet of Things is to seamlessly capture machine data to monitor performance and measure machine health. The use of intelligent systems and dynamic analytics leads the way toward improved operational efficiency and a reduction in maintenance costs and downtime.

Building intelligence into systems at the front end is expected as new machines are developed. But it is the vast retrofit market where the greatest value can be found. No one wants to "rip-and-replace" an existing system when adding sensors and software can achieve the same outcome.

The barriers to implementation of these smart systems can include many factors—time, talent, capital investments. But as Kevin Kakascik of AutomationDirect writes this month, these barriers can—and should—be easily scaled by better understanding the benefits.

"Many end-users and OEMs are finding it easy to add IIoT capabilities to their pneumatic equipment and other automated systems," Kakascik writes. "Regardless of the make, model or age of the equipment and associated controllers, there are intelligent devices and cloud-enabled PLCs making this not only possible, but practical."

One of the first practical outcomes will be reduced maintenance costs. I've always considered maintenance a profit center as opposed to a cost center, and better managing machine health allows plant leaders to conduct preventive maintenance at a lower cost and at a time convenient to the operations team, as opposed to fire-fighting crises when equipment underperforms or needs repair.

But the greater benefit of a smart system is a better understanding of overall system performance. As it pertains to pneumatics, you can start by better understand and manage your compressed air costs. (As an aside, energy should be considered another profit center).

You can review cycle times and the performance of solenoids. You can take control of the overall operation. Data drives understanding, and that's a great and often untapped asset.

It's concept Kakascik emphasizes in this article. "Not only is this approach flexible, but it is also modular and scalable," he writes. "Users, systems integrators and OEMs can add IIoT functionality on a trial basis, and then roll it out on a much larger scale when proven."

That's the essence of "smart manufacturing."

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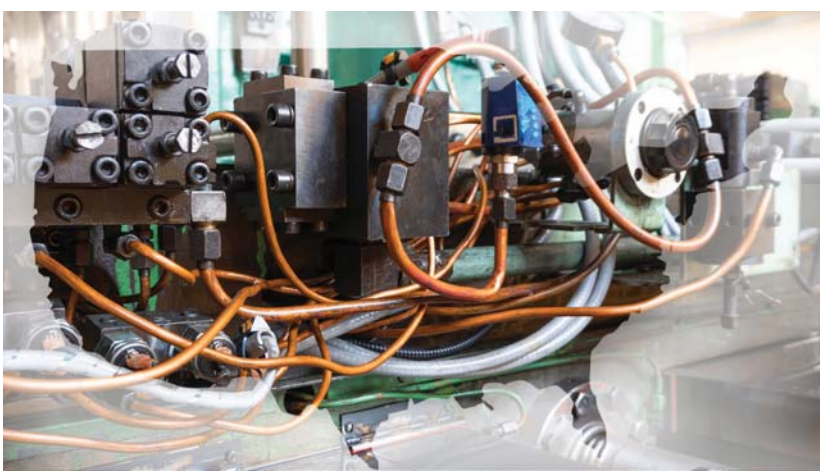
News

The State of Fluid Power in the U.S. in 2020

by Stephen Mraz



Fluid power systems, which includes hydraulics and pneumatics, transmit more power in smaller spaces than other forms of power transmission, making fluid power the technology of choice for engineers and designers across dozens of industries and markets, according to the most recent (2020) *U.S. Fluid Power Industry Brief* from the National Fluid Power Association (NFPA).

Many industrial sectors suffered during the COVID-19 pandemic. The fluid power industry, for example, saw annual shipments of pneumatics and hydraulics products drop by as much as 20^ compared to the previous year.

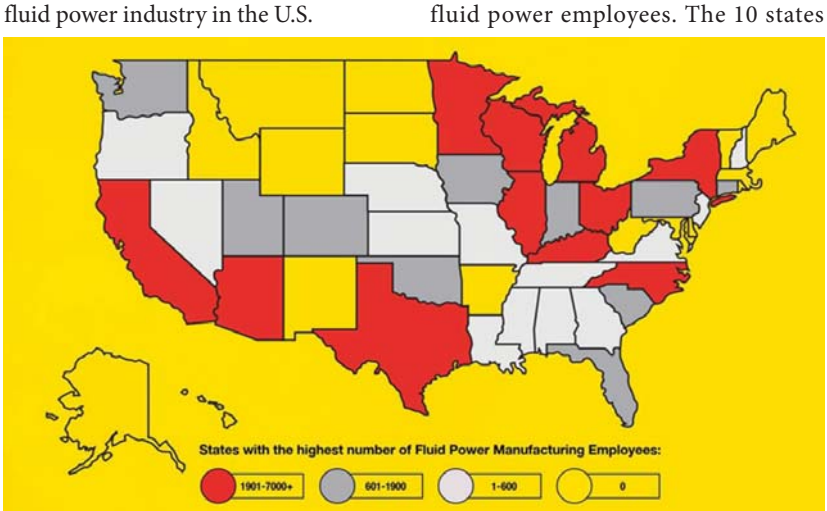
The fluid power industry did manage to change direction to support healthcare efforts in limiting the spread of COVID-19 and treating those who contracted it. For example, many fluid power companies adjusted production and design schedules to focus on ventilators, protective gear and other tools for doctors, nurses and other essential healthcare workers.

Here's a quick look at the state of the fluid power industry in the U.S.

In 2020, about 744 U.S. companies had more than 64,000 people on their payroll to make $18.2 billion of fluid power components. These companies also managed to make and export fluid power components worth $5.6 billion to 190 countries around the world. This was a 60% increase over exports in 2010, 10 years earlier.

The top 10 export destinations, accounting for 72% of all hydraulic and pneumatic exports, are Mexico, Canada, China, Germany, the United Kingdom, Brazil, Australia, Japan, Singapore and France.

The U.S. companies making fluid power components are spread across 34 of the 50 U.S. states. Those companies spend $4.4 billion on salaries for their fluid power employees. The 10 states



Companies that employ fluid power engineers and technicians are based in 34 of the 50 U.S. states.

with the highest number of fluid power employees are Ohio, Michigan, Illinois, California, New York, Texas, Wisconsin, Arizona, Minnesota and Kentucky.

U.S. companies that use fluid power components employ more than 845,000 people for an annual payroll exceeding $60 billion, according to the NFPA.

When the COVID pandemic calms down, the fluid power industry is looking to move forward. To that end, NFPA has devised a technology roadmap that identifies key research and development challenges for the industry that will guide it in meeting the needs of its customers. The new goals for this roadmap mirror those of many other engineering disciplines and companies. It includes helping customer clients:

- Increase availability and up-times.
- Increase productivity and performance by automating operations and using integrated data and intelligence.
- Deliver equipment and machine on-time delivery by decreasing lead times.
- Reduce capital and operating costs.
- Comply with environmental and safety regulations and machine directives.
- Simplify maintenance and make it more predictable by leveraging data and intelligence.
- Increase energy efficiency by reducing weight and increasing power densities.

TOP HYDRAULIC MARKETS	
Market	Share of Hydraulic Market
Construction Machinery	26.2%
Agricultural Machinery	14.4%
Automotive (including light trucks)	10.9%
Material Handling (including conveying)	8.7%
Oil & Gas Machinery	4.7%
Class 4-8 Trucks	4.5%
Lawn & Garden	3.4%
Mining Machinery	3.4%
Metalworking and Machine Tools	2.7%
Power Generation	1.6%
Plastics Machinery	1.0%
Paper Machinery	0.8%
Sawmill & Woodworking Machinery	0.5%
Aerospace Product and Parts	0.3%
Other	17.0%

TOP PNEUMATIC MARKETS	
Market	Share of Pneumatic Market
Automotive	14.4%
Food Processing	6.3%
Packaging Machinery	4.2%
Medical Equipment	4.1%
Semiconductor	3.2%
Class 4-8 Trucks	2.8%
Metal Working and Machine Tools	2.7%
Material Handling	2.4%
Oil & Gas Machinery	1.5%
Paper Machinery	1.0%
Printing Machinery	0.9%
Chemical Processing	0.8%
Plastics Machinery	0.6%
Sawmill & Woodworking Machinery	0.5%
Aerospace Product and Parts	0.3%
Other	54.4%

NFPA to Support Internship Hiring for Members

by Bob Vavra

In an effort to help member companies connect with future workers interested in the fluid power industry, the National Fluid Power Association (NFPA) has created a program to support internship programs.

Students can apply through the NFPA to be placed in intern and co-op programs with member companies. The NFPA will pay those companies $5,000 if they hire a student for an open position to help cover the training and onboarding costs.

"This program will help members find qualified candidates who are interested in fluid power and will help students get directly connected to fluid power internships, co-ops and full-time jobs," NFPA officials said in a press release.

To be eligible, companies must be an NFPA member, have a quality fluid power internship or co-op program at the company, and submit an application.

The awards will be paid directly to the NFPA member company after the student goes through the application process and is hired by the company.

There was no announced limit for the awards, but NFPA officials said the effort to place students will continue if the budgeted money for the program runs out. "NFPA will notify members once the annual budget has been spent, but we will continue to send student resumes to members if they are interested in receiving them," association officials said.

"There is no application deadline. We will continue to accept member applications until the budgeted funds are depleted for the year."

For further information, contact Lynn Beyer (lbeyer@nfpa).com.

TOM WYATT | HEIDENHAIN Corporation

Encoder Types: MAKING THE RIGHT CHOICES

Understanding the fundamentals is key to a tailor-made solution.

Encoders play an integral role in almost every mechanical system that involves motion monitoring or control. There are a variety of types that work with different kinds of motion with different options for how they detect and communicate. These are some of the foundational elements and variables in the world of encoders.

WHAT DOES AN ENCODER DO?

When it comes to motion—speed, distance and direction—feedback systems, encoders of one type or another are typically at the core of the operation. Put simply, they record movement metrics and communicate them in a way that a control system and/or person can use to adjust or monitor.

COMMON ENCODERS

Encoders are most often used to measure linear or rotational motion. Everything from how they are constructed to the signaling method can vary based on their environment, application and budget.

LINEAR ENCODERS

These measure straight-line motion. Sensor heads that attach to the moving piece of machinery run along guideways. Those sensors are linked to a scale inside of the encoder that sends digital or analog signals to the control system.

Rotary encoders measure rotational movement. They typically surround a rotating shaft, sensing and communicating changes in its movement. While they are accurate, rotary encoders are often used when speed management is the biggest concern. Traditionally, rotary encoders are classified as having accuracy above ± 10" (arcseconds). Rotary encoders are also available equipped with important functional safety capabilities.

When deciding on a rotary encoder for pairing with a motor, an engineer must consider the five key encoder properties that have the largest influence on motor performance: positioning accuracy, speed stability, audible noise, power loss and bandwidth. Read more about what to look for here.

ANGLE ENCODERS

Similar to their rotary counterpart, angle encoders measure rotation. These, however, are most often used in applications when precise measurement is required. HEIDENHAIN offers angle encoders with accuracy down to ± .04" (arcseconds) and resolutions up to 29 bits.

THE DIFFERENCE BETWEEN ABSOLUTE AND INCREMENTAL OUTPUT

Incremental encoders measure in relation to a starting point. Every time a system is turned on a new zero reference point is established, or a new one will need to be reestablished by the user. Markings or steps are spaced equally apart on the scale, or disc in the case of rotary encoders. The encoder generates

A HEIDENHAIN exposed linear encoder.

Rotary encoders are often used when speed management is the primary concern.

a pulse-like signal based on each marking, which is translated to a signal.

On the other hand, absolute encoders recognize a distinct location at all times. It's not relative to another and there's no need for reestablishing a zero point. Instead of equally spaced marks, distinct tracks or markings transmit a unique code at each location to a serial control.

THE DIFFERENCE BETWEEN MAGNETIC AND OPTICAL ENCODERS

How encoders recognize and process the various coding or markings is different. Magnetic encoders use the relation between static and/or dynamic magnetic fields or distinct tracks and translate those into signals. The other common design is optical, which uses light that's passed through glass and recognized by a receiver. Magnetic assemblies are generally more simple, compact and durable, while optical encoders are extremely accurate and able to function in areas with other magnetic forces.

THE DIFFERENCE BETWEEN SEALED AND EXPOSED ENCODERS

Encoders are critical to the proper

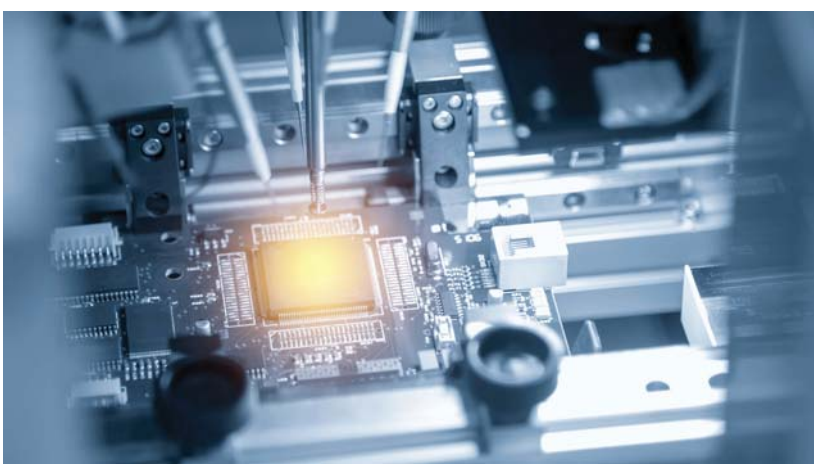
function of their mechanical system. The slightest inaccuracy or malfunction can cause a significant ripple effect on whatever the larger operation may be. Those systems and operations take place in widely different environments, from machine tools where coolant and/or metal chips may be moving around at high speeds and pressures to sterile medical labs.

Sealed and exposed encoders provide options that suit whichever type of environment in which they'll be deployed. Sealed encoders encase the most delicate components of the encoder, protecting them from whatever contamination may be present. Exposed encoders take up less space, generally excel in high-speed scenarios and are often deployed in high-precision measuring applications. hp

TOM WYATT is director of marketing and communications, HEIDENHAIN Corporation (www.heidenhain.us). A version of this article first appeared on the company's website.

ENCODERS AND THEIR APPLICATIONS: Keeping Control

Industries have different uses and requirements for controls and positioning. By Tom Wyatt



Encoders are critical to the positioning in production of advanced electronics.

Encoders are critical components in all kinds of mechanical systems. They are especially prevalent in industrial settings where large machinery performs repeatable tasks, high-precision prototyping or delicate work.

ENCODERS FOR THE ELECTRONICS INDUSTRY

Encoders are critical to the production of advanced electronics, one of the fastest growing and advancing industries in the world. Rotary, angle and linear encoders are all used in one form or another in the electronics sector. Encoders of the highest accuracy and resolution are often the choice considering the small work areas and components—especially when it comes to semiconductor fabrication.

Vacuum environments are also common in electronics production. Encoders, including angle and linear, need to be built specifically for the unique ventilation, gas and temperature conditions that come with work in a vacuum.

ENCODERS FOR CNC MACHINING

CNC machines must maintain position in the face of heavy workpieces and spindles, multi-axis movement and high speeds. Encoders play a huge role in all of the components working together to mill, drill and bore correct parts. We also develop a full line of popular control systems and touch probes used to program CNC machines.

In 2018, we worked with Major Tool & Machine to help rebuild one of the largest machine tools in the world. Custom linear encoders were developed to accommodate the gantry mill's staggering axes travels: the X axes alone measured 740 in. each.

ENCODERS FOR AUTOMATION

The automation industry is booming, and it couldn't be without capable encoders. Robotic arms, like this one developed by grinding machine company Strausak, are ubiquitous in manufacturing environments. Any unmanned mechanical systems will rely on consistent and accurate motion and measuring.

Encoders are also being used to automate transportation, as with Sweden's high-speed train, the SJ3000, which employs a custom-made, absolute MC 400 encoder from Leine Linde. It helps operate a redundant system that controls the train's speed and braking automatically if necessary.

ENCODERS IN THE MEDICAL INDUSTRY

Encoders are prominent in the medical industry because of the precision necessary to accurately and safely test and treat the human body—and develop new pro-

cedures in the lab. For example, you'll find HEIDENHAIN LIC 2100 exposed linear and ECN 1123 EQN 1135 rotary encoders used in CT and MRI scanning machinery for help with precise imaging and patient safety. Radiation therapy is another application that requires precise linear and angular technology with no room for error.

Similar absolute rotary encoders are used in one of the most advanced breast cancer treatments in the world. The GammaPod by Xcision Medical Systems is billed as, "the world's first stereotactic radiotherapy system optimized for treating breast cancer."

Encoders are prominent in the medical industry because of the precision necessary to accurately and safely test and treat the human body, as well as develop new procedures in the lab.

ENCODERS IN ROBOTICS

Whether it's an articulating arm that picks and places equipment in a manufacturing plant or more mobile, automated, guided robots, they all use encoders. By their nature, automated systems need these effective speed and positions feedback systems to function with limited human assistance. In many cases, encoders with a small profile are best suited for a robotic design, so that all the required technology can fit together in a robot that's sized appropriately to its use.

Encoders all serve the same general purpose of measuring motion and signaling feedback, but their configurations, capabilities and applications vary widely. They have played a significant role in almost every facet of life, especially industrial and technological pursuits. And that won't be changing any time soon. hp

SRAVANI GULLAPALLI, SAMEER SATHAYE | Shell Global Solutions (U.S.) Inc.

Can Zinc-Based Hydraulic Fluids Improve System Performance?

Some engineers believe zinc-based oils are doomed to cause sludge and varnish formation. But rigorous testing proves them wrong.

Engineers and designers often opt for zinc-based hydraulic oils based on their ability to resist wear and oxidation, along with their efficient performance. Still, some equipment manufacturers believe hydraulic oils with zinc increase sludge and varnish formation, which can raise maintenance costs due to plugged filters and a shorter oil life.

These manufacturers frequently rely on specific tests to identify oils that let sludge form. Some of the major tests used for this purpose include:

- The Bosch Rexroth A2F10 piston pump test (JCMAS P 045).
- The high-temperature Indiana stirring oxidation test (ISOT).
- The 1,000-hr turbine-oil oxidation stability test (TOST ASTM D4310).
- The dry-in-the-absence-of-added-water turbine-oil oxidation stability test (TOST ASTM D7873).
- The thermal stability test (ASTM D2070).

Until now, many zinc-based hydraulic oils have not performed well in these tests, especially the Bosch Rexroth A2F10 test. But engineers at Shell recently used this arsenal of tests to confirm that their new offering, a zinc-based hydraulic fluid, would reduce sludge formation and

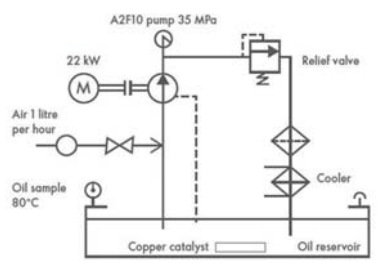
	Unit	Standards
		JCMAS P 045:2004
		(500h)
Change in Kinematic Viscosity at 40 °C	%	10 max.
Change in acid number	mg KOH/g	2 max.
Sludge (0.8-µm Millipore)	mg/100mL	10 max.

protect against wear and oxidation.

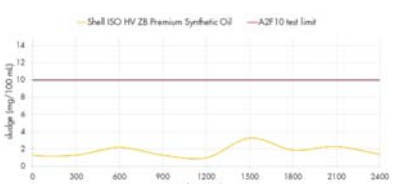
The new fluid is made using gas-to-liquids (GTL) technology. It converts natural gas, the cleanest-burning fossil fuel, into high-quality liquids that would otherwise be made from crude oil. GTL products are colorless and odorless, and have almost none of the impurities found in crude oil such as sulfur, aromatics and nitrogen.

GTL products include transport fuels, motor and hydraulic oils, and the ingredients for everyday necessities such as plastics, detergents, and cosmetics.

Here's a look at the testing regime the



Here are the test criteria fluids must have to pass the A2F10 test for sludge formation caused by hydraulic fluid.



This graph shows sludge accumulation in different lubricants, with the new synthetic, zinc-based fluid coming out on top.

new oil had to successfully pass to prove it can reduce sludge and varnish formation and have a longer operational life. The tests focused on the new synthetic oil's performance in environments where zinc-based fluids have been traditionally expected to underperform their zinc-free counterparts.

A2F10 PUMP TEST

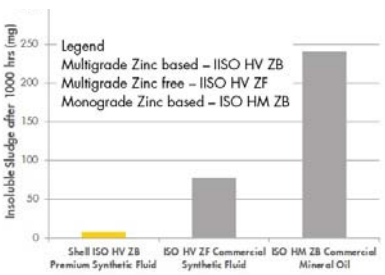
This Bosch Rexroth piston pump test (JCMAS P 045) evaluates the oxidation stability of hydraulic fluids under operational conditions. The operational life for mobile equipment is based on this test and it is one of the few pump tests that calculates an oil's ability to resist sludge formation. If the zinc-based fluid performed well, it would mean the fuel's overall formula affects sludge formation more than just the fact the formula includes zinc *(see chart, p. 14)*.

In the test, a Bosch Rexroth A2F10 pump sends a fluid pressurized at up to 350 bar (5,000 psi) through a relief valve. A tank holds 13 liters of lubricating fluid at 80°C, and a copper specimen placed in the tank accelerates fluid oxidation. Air flowing at 1 L/hr sent into the inlet pipe also speeds oxidation.

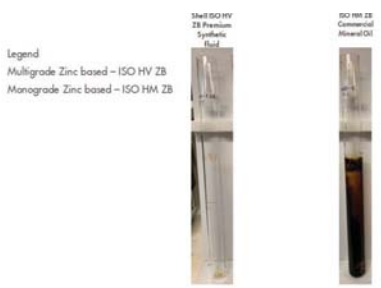
Fluid samples taken at regular intervals are analyzed. Measured parameters include viscosity, viscosity change, increase in the acid number and foaming, and sludge levels. The total fluid volume decreases over time, thereby artificially increasing the oxidative stress on the fluid.

The oil-drain interval is then estimated as four times the number of success-

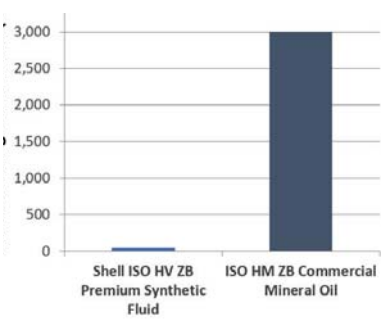
These filter pads were put in the new zinc-based hydraulic fluid (left) and the other in a poorly performing zinc based hydraulic oil (right), both for 1,000 hr. The pad exposed to the new fluid appears clear, while the pad exposed to a poorly performing zinc-base oil is caked with black sludge. This indicates that not all zinc-based hydraulic oils are the same with respect to sludge formation.



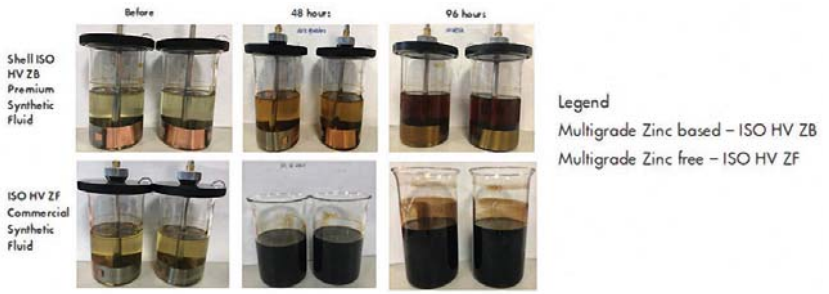
This graph shows the TOST 1,000-hr sludge data for three products. The lower the number represents better in this test.



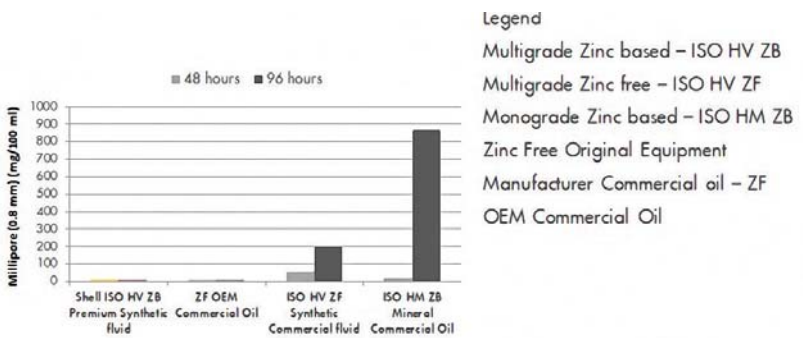
Results from the temperature testing shows less sludge forms in Shell's new synthetic fluid (left) compared to a commercial mineral fluid.



This chart compares the sludge formed on samples placed in a synthetic zinc-based fluid and a commercial mineral oil for the ASTM D7873 test. The top one (from Shell) led to less sludge formation.



You can visually compare the performance of a zinc-based fluid with a commercial zinc-free fluid in the high temperature ISOT test. Samples of the zinc-based fluid (top) appear transparent even after 96 hr, while samples in the bottom panels of a commercial zinc-free fluid turn opaque at 48 hr. This opacity indicates sludge formation and enhanced oxidation of the zinc-free lubricant as opposed to the much lower oxidation of the zinc-based fluid.



Comparison of sludge formed in the high temperature ISOT test by four different hydraulic fluid samples.

ful hours in the test. (Actual oil-drain intervals can vary depending on the equipment used, operating temperature and maintenance practices.)

Shell's new zinc-based fluid met and exceeded the A2F10 test limits even after 2,400 hr, which could indicate the oil's operational life exceeds 9,600 hr.

ASTM D4310

The ASTM D4310 TOST 1000-hr test determines a hydraulic fluid's tendency to oxidize and its contribution to sludge formation and corrosion in the presence of heat, water and catalysts (copper and steel, materials commonly used in pumps). Sludge is filtered and reported at the end of test.

The reservoir holds the fluid at around 60 to 70°C, but it can get hotter when the pump operates, especially if the oil does not spend enough time (residence time) in the reservoir.

Typically, if a hydraulic fluid's additives or base oil are thermally unstable, filter pads in the test would be significantly discolored and coated with sludge at the end of the 2,000-hr test.

Quantifying the sludge helps highlight the performance difference between the fluids.

The DIN sludge limit for this test is 200 mg at end of test. Pump OEMs requirements are even more stringent, requiring 100 mg or less at end of test.

The test found that then zinc-based fluid has significantly less sludge than the DIN standards, OEM limits, a commercial monograde (ISO HM) zinc-based mineral hydraulic oil and even a commercial multi-grade (ISO HV) zinc-free (ZF) synthetic hydraulic fluid.

ASTM D7873

A third test for sludge, the ASTM D7873 Dry TOST test, is typically used for turbine oils rather than a hydraulic fluid. It indicates a lubricating fluid's sludge and varnish forming tendencies by measuring its oxidative and thermal

stability when heated to 120°C (about 250°C) with catalysts, but in the absence of water. 120°C might seem high, and typical hydraulic systems do not get this hot, but subjecting hydraulic lubricant to this test can help uncover any potential thermal stability issues. Technicians measured the sludge level according to ASTM D7873 after 1,008 hr into the test.

Quantifying the results, the sludge measured for the new synthetic zinc-based lubricant was statistically less than that formed by the commercial mineral oil. This data underscores the fact that if formulated carefully, zinc containing fluids can reduce or prevent sludge formation properties.

HIGH-TEMPERATURE TEST

The high-temperature Indiana stirring oxidation test, done according to JIS K2514, also checks the oil's oxidation and sludge formation characteristics and it does so under conditions that promotes oxidation: blowing dry, hot (165°C) air and including oxidation catalysts. Fluid samples are forced through paper filters to calculate sludge build-up.

Fluids that do well in this test likely have excellent thermal stability.

This test is typically used to test compressor lubricants. Lubricants formulated with zinc-free chemistries have less sludge formation in this test. Thus, this test is considered "favorable" to zinc-free lubricants.

ASTM D2070 TEST

This thermal stability test evaluates a lubricant's ability to resist breakdown under high temperatures. In the test, a fluid sample with catalysts added is heated to 135°C for 168 hr. No air or oxygen is added to promote oxidation—just heat—and the sample is not agitated. After the test, sludge deposits are weighed. as are the weight losses of the catalysts.

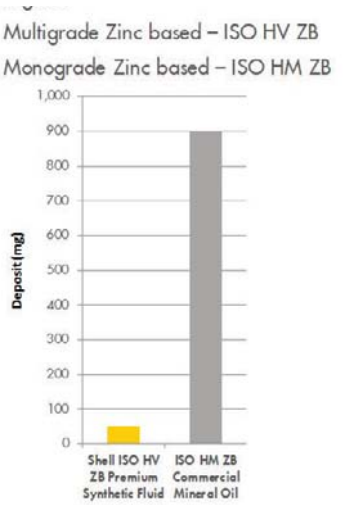
This test simulates environments in which wear and corrosion might arise from copper surfaces rubbing against steel surfaces. This test is considered

Samples of three different fluids at the beginning and end of the ASTM D2070 thermal stability test: the new zinc-based fluid, a zinc-free commercial fluid and zinc-based hydraulic fluid. The darker the fluids are, the more oxidation has taken place.

particularly important in assessing a lubricant's ability to resist sludge formation on phosphor, which is used in the bronze slipper pads commonly found in axial piston pumps.

THE VARNISH TEST

This test, a proprietary Shell in-house test, accelerates varnish formation on aluminum rods using temperature cycling. The company developed what it considered a much-needed test for varnish formation. The aluminum rods are weighed before and after being put in different fluids, and then the mass of varnish on each rod is measured.



This chart shows the difference in sludge accumulation on aluminum rods after the Shell varnish test.

Varnish is a tough, adherent oxide or carbonaceous material that coats the internal surfaces of machines such as pumps. Hot surfaces, as well as long-term operations, turn varnish into a hard, shiny, brittle coating. In contrast, sludge, which is sometimes a precursor to varnish, is soft and sticky and can move through the system until it finally comes to rest—usually at sump bottoms, troughs, strainers, filters, and narrow fluid passages. Varnish can prematurely wear important hydraulic components and cause pump failures. It can also make the system overheat, plug filters and make valves stick, leading to costly unplanned maintenance.

Key characteristics for a good hydraulic fluid are that it protects against wear and minimizes sludge and varnish formation. Zinc-based fluids do all of this, but not all zinc-based fluids are the same. After undergoing all these tests, however, researchers concluded that Shell's gas-to-liquid technology can be used to make effective zinc-based fluids .hp

SRAVANI GULLAPALLI is an associate technology manager and Sameer Sathaye is a project leader for industrial lubricants at Shell Global Solutions (U.S.) Inc.

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SYSTEM INTEGRATORS: The Key to Project Success

Companies about to upgrade their hydraulic controls should consider hiring a system integrator to bump up the project's chances at success.

For a host of reasons, many companies—including those making or modifying hydraulic components, controls and equipment—strongly resist asking for help when it comes to product development and implementation. Most of their reasons may revolve around ego and short-term cost considerations, but some companies just insist on doing everything in-house. From a business perspective, however, "doing everything" entails undertaking tasks outside a company's core competencies, which is often a fraught decision.

Companies eyeing upgrades and installations of hydraulic controls would do well to consider bringing system integrators (SIs) into their projects to improve the project's chances at success.

That said, SIs are like every group of engineering professional: Some are amazing, and some less so. Some seem to almost instantly establish a rapport with a client company's design team and management; others always seem like out-of-touch outsiders. Like many consultants, some overstate their capabilities.

To help companies get the most out of using SIs, here are some observations we have made at Delta Computer Systems over decades in the hydraulics and motion control industries.

WHY OUTSOURCE TO AN SI?

First, it's important to understand the need for bringing system integrators into your design team. It might help if you consider hiring SIs as outsourcing, subcontracting or facility management. Your firm lacks the expertise to tackle complex wiring and components or pro-

gramming in proprietary development environments, so you bring in outside resources. And that can take the form of contracting with SIs to provide the critical expertise.

SIs can provide a wide range of benefits, including:

- Lowering operating costs.
- Upgrading the technical capabilities for tackling a project.
- Providing formal and informal technical training for staff on the team.
- Reducing or eliminating the need for staff to become fluent in a particular programming language or environment.
- Freeing staff for other, potentially more lucrative and beneficial tasks.
- Delegating project scoping, planning, procurement and upfront capital expenditures.

"The biggest benefit to hiring SIs is their experience," says Nick Bell, controls engineer and programmer at Milwaukee-based InterConnecting Automation, Inc. "We're not working with 1980s PLCs anymore. The power and capabilities are far greater, and users are pushing the limits every day with how they are using PLCs.

"You need someone who understands modern bi-directional communications, varies signal types, programming and debugging," Bell continues. "Additionally, a lot of the systems deal with high voltages, so it can become dangerous if proper precautions and protections aren't taken on the systems."

Hiring an SI can bring in expertise from across a variety of control systems, some of which may be beyond your company's knowledge or experience and be overlooked or ignored during planning. Good SIs can help guide decisions on controls integration according to priorities you establish early on, such as budget priorities and future scalability. In the end, SIs may be the quickest and best route to a finished system that delivers the performance you need.

Good SIs can help guide decisions on controls integration according to priorities you establish early on, such as budget priorities and future scalability.

AN SI AS A PARTNER

Anyone experienced in subcontracting knows you can hire help in an impersonal, all-business fashion, as if interfacing with a machine. And there's nothing wrong with this. System integrators are consultants often hired to execute specific tasks, which can be done in an almost scripted manner.

However, companies will likely get more from SIs if they hire them as if they are bringing a partner into the fold. Ultimately, SIs want to collaborate, build and see projects succeed. No one wants to be just a cog in a machine; respecting an integrator's feelings and desires can make a world of difference in the relationship and the success of the project.

In some cases, building partner relationships is easier with local SIs rather than multi-regional or national organizations. Smaller outfits might only have one or two employees, but they can often deliver the same or better benefits and partnerships as their larger counterparts. It's the personality of your SI representative that will likely have more to do with the quality of the company/SI relationship rather than the size or reach of the SI's firm. In other words, companies shouldn't overlook smaller SIs.

Some SIs specialize in certain systems, which is generally a good thing. This means a company can take advantage of that deep expertise. For companies that didn't standardize on a particular control platform, or if one their priorities is to remain platform-agnostic for future compatibility and/or scalability, it is usually best to team up with SIs who have a broader rather than a narrower knowledge base.

Also consider brand-agnostic SIs are less likely to be under pressure to sell or meet quotas for a particular brand. This frees them to keep your priorities and

needs above all others.

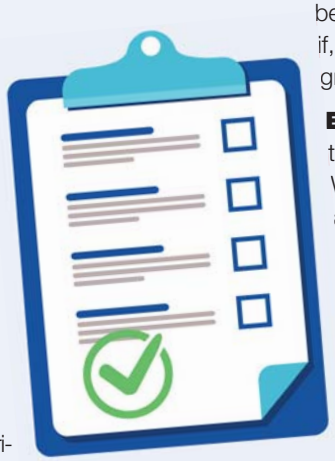
Similarly, be leery of how SIs might gain long-term control of your systems. For example, some SIs have been known to password-protect their code and force clients to hire them for every change. It's clearly a nefarious tactic to be avoided (and specifically called out in contracting agreements), and one step removed from ransomware.

When companies treat SI as partner, they're more likely to keep the SI involved in all stages from planning through review. And SIs should have the qualifications to ensure specified components (especially controls) meet requirements and are the parts actually used. They should have a record of delivering results defined by a project's established metrics and goals.

THE SYSTEM INTEGRATOR'S "PRENUPTIAL" AGREEMENT

When you're young and in love, chances are higher that you'll rush headlong into marriage on wings of passion and…well, good luck. When you're 50 and more experienced, however, with potentially more to lose, you might trust emotion less than prudent communication codified in a well-planned document.

Similarly, when starting out on an SI partnership, don't assume first impressions and friendly handshakes will get a difficult project into the win column. Have as many conversations as necessary to clearly define the project's variables and roles from planning to ongoing support. The details and decisions should be compiled into a formal agreement, if only as an addendum to a statement of work.



Here is some advice on the discussions and agreements companies need to have with SI, all based on my firm's industry experience:

Define the project's scope. This should include all the stakeholders in the project so that the effort is collaborative and no one will feel their voice hadn't been heard once the project is completed. The scope should lay out objectives, establish all project constraints, and clearly define what are and are not project deliverables.

It should also include milestones with dates as metrics for assessing progress being made toward reaching those milestones. If there are assumptions, note them, and if there are criteria that must be met before the project is complete both by the SI and client, they need to be detailed.

Also, don't shy away from being exact and specific about the deliverables' look and feel. What are the specific sequences for cylinders? What should touchscreen interfaces look like? More detail up front breeds less waste and better outcomes down the line. And be advised, scope documents can and do exceed 50 pages.

Establish responsibilities. "Some customers just want the SI to do the programming," notes Nick Bell. "Others want the complete kit and caboodle—spec the motors, run the conduit, land everything and handle all the control system's electrical needs. So set unambiguous expectations on what you want from the integrator, because some won't touch any other job if, for instance, they're only doing the programming."

Establish durations. Will this be a long-term relationship or a one-time project? Will the SI be on retainer, billing for time and materials? Or will the work be for a clearly defined contract, paid for hitting milestones or on completion?

Play the field. Make sure to explore the SI's fluency and track record in your particular control-system type, brand, technology or application. How long has the SI worked in your industry? Try not to pick the first candidate that looks like a reasonably good fit.

Go through the options in this section and carve a long list of prospects down to a short list of top candidates. When one job can win or lose potentially millions of dollars in revenue, do not cut corners at this stage.

Define support details. This is a major area some clients overlook. For example, training should be built into the agreement if needed. Specify how much training there will be and when you'll know training is complete. Will the SI be under contract for ongoing technical support? If so, for how long and under what terms?

Will the SI have the ability and responsibility to remotely administer and troubleshoot the system, or must such matters be handled on-site? Surprisingly often, the "after sale" details play the largest role in determining a project's long-term value.

POTENTIAL SI PROBLEMS

Obviously, there can be problems with SIs. But it's not always the SI's fault. For example, when an SI handles design and implementation of the machine controls, company employees may not be involved and thus don't feel much ownership. The SI could set up training, but staff may not get much from it. This can add cost and complications once the SI leaves and employees must troubleshoot and fine-tune parameters alone.

To prevent this, companies can arrange for the SI to provide employee training after commissioning. "A lot of our customers want to learn," says Bell. "They don't necessarily want to do the technical stuff, but they want to have the knowledge and control. If they can't understand the system and how to make changes, then every tweak means going back to the SI."

Another source of problems stem from using smaller SI firms. Larger SIs may have better volume pricing arrangements with suppliers, better vendor support and better access to limited inventory. (This is why distributors with SI-like capabilities may be a better choice in some cases.) Additionally, with more support staff, larger firms often have availability when smaller SIs are closed or with another client. Also, can the SI stay on-site to finish commissioning if there are unexpected time overruns?

Not least of all, the lines between project scope and system ownership can get blurry. For example, if a power supply is defective or performing outside of spec, who is responsible—you, the distributor or the SI? Such concerns should not sour companies on SIs. Rather, talk about these

These people know how a given SI work on projects in terms of real-world expertise and secondary-but critical factors, such as being a team player, adaptability and the ability to add value above and beyond the stated project's scope.

concerns and issues up front when vetting SIs for a new project.

GETTING THE RIGHT SI

The best way to find capable SIs is to listen to their customers, industry colleagues and other business owners, engineers and industry insiders. Nothing speaks louder and with more authority than hearty recommendations from someone you know and trust and who has the appropriate industry knowledge and experience.

These people know how a given SI work on projects in terms of real-world expertise and secondary-but critical factors, such as being a team player, adaptability and the ability to add value above and beyond the stated project's scope.

Recognize that highly recommended distributors may offer SI-like services, but being more than happy with how a distributor handles distribution does not guarantee that they will be adept at providing integration services. Companies must

ask distributors the same questions and have the same conversations they would with a prospective SI. Alternatively, distributors can likely recommend a range of successful SIs if they don't offer those services themselves.

Several trade publications maintain annual directories of SIs. In addition, the same publications may offer articles detailing system integrators' work in different projects and illustrating their fields of expertise. If nothing else, those publications and websites carry SI advertisements that explicitly reference your needs and state their capabilities.

Finally, there are trade groups such as the Control System Integrators Association (CSIA). It hosts a web directory of SIs, the CSIA Industrial Automation Exchange. This resource lists SIs from around the world and lets users filter by different criteria, including CSIA membership, as well

"Synergy" may be an overused buzzword, but it definitely applies to well-crafted collaborations between industrial companies and SIs.

as CSIA certification—which, according to CSIA CEO Jose Rivera, demonstrates an SI's commitment to the business and industry.

"The CSIA Best Practices and Benchmarks Manual sets the standard for professional management of an SI company," says Rivera. "SI companies that successfully deploy best practices and can successfully demonstrate that can earn three-year certification through an audit.

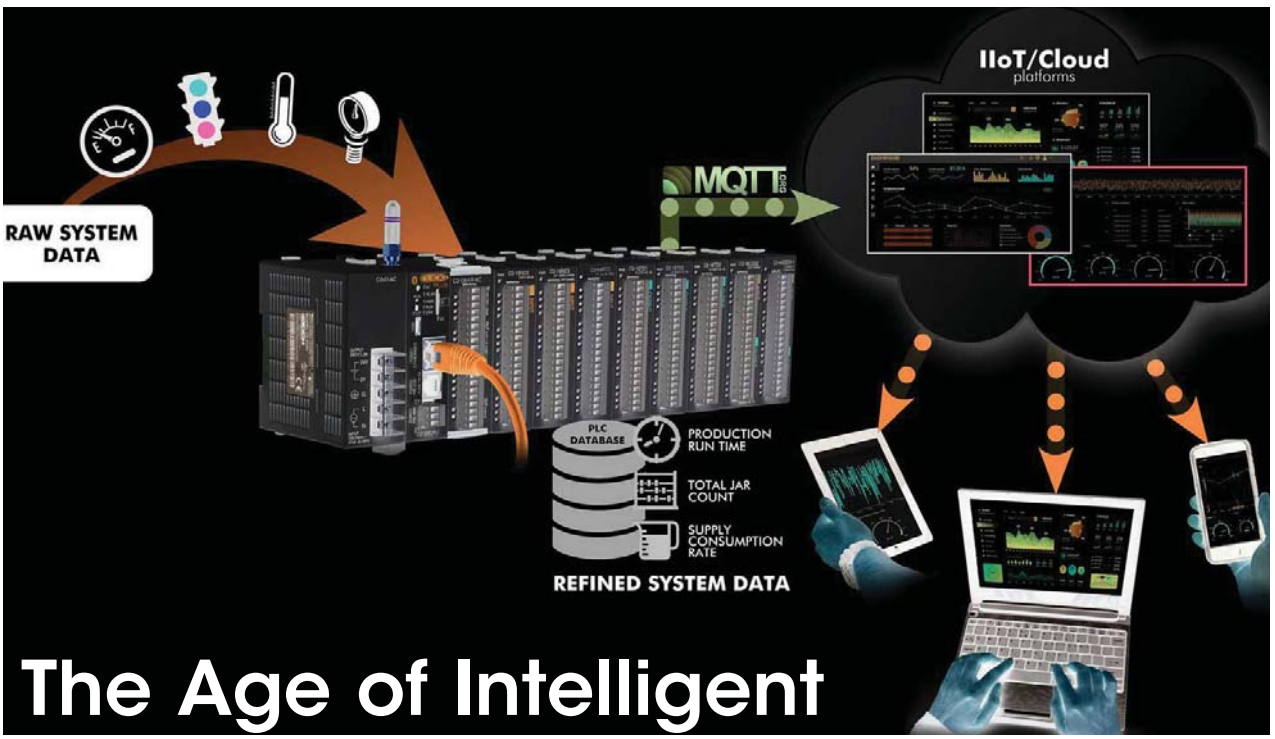
"Synergy" may be an overused buzzword, but it definitely applies to well-crafted collaborations between industrial companies and SIs. Each acts as a force multiplier on the other rather than just adding their strengths to each another. It radically expands the expertise brought to bear on a host of challenges and elevates the potential of the entire engineering team.

The SI community is somewhat hidden from the industry. Most SIs grow through word-of-mouth and can fly under the radar for decades. That's why many industrial firms have little to no experience with them. This is unfortunate. Strong SI partnerships can deliver outsized value and benefits that last for years. It would be wise move to investigate some SI options on your next control project. hp

Editor's Note: More information on the CSIA certification, can be found at http://www.controlsys.org/certification/mark-of-excellence.

AARON HEINRICH is the motion products marketing manager and regional sales manager for Delta Computer Systems, Inc.

KEVIN KAKASCIK | AutomationDirect



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The Age of Intelligent PNEUMATICS

Cloud-capable PLCs and smart solenoid manifolds deliver value for OEMs and end-users alike.

As an original equipment manufacturer (OEM) or end-user of equipment, what are the most important operational qualities that should be built into machines? For many people, top-of-mind attributes would include safety, maximum uptime, ease of use and maintenance, and efficient operation. But another topic is trending as an increasingly must-have feature—Industrial Internet of Things (IIoT) connectivity.

Whether new or existing equipment uses PLCs, other microcontrollers or even basic hardwired circuits, the design goal for automated machinery has long been safe and reliable operation. Connecting with the machine and sensor data, and then transmitting this information somewhere to be viewed and analyzed—key IIoT capabilities—has been a secondary consideration.

Today's sophisticated end-users look for as much data as possible to visualize what is happening at the machine and to then operate it most effectively. For both new and retrofit machine automation projects, intelligent solenoid manifolds and cloud-capable PLCs are now available to help facilitate IIoT data connectivity.

SHOW ME THE DATA

Designing IIoT connectivity into new equipment is usually a little easier than retrofitting it into existing machines because all the latest products can be used. But there is a lot more existing than new equipment, and the underlying IIoT principles are the same in either case.

Fortunately, new controller and intelligent field device technologies are including built-in ways to make data available for both new and retrofit projects. Here are just a few types of IIoT data that can be provided by machines and equipment:

- Running, stopped and waiting status.
- Alarm signals.
- Cycle counts and rates.
- Intelligent solenoid and variable frequency drive diagnostics.

In the most basic sense, this data is useful if it can simply be visualized using human-machine interface software, a mobile app or a web page. Data handling and storage can be localized on-premises, but it is often more convenient in terms of accessibility and administration if the data is connected with cloud

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For pneumatic equipment of all types, the addition of sensors and IIoT data-gathering capabilities provides greater insight into how systems are working and how they can be operated more effectively.

storage and services.

Beyond basic visualization, other roles for data include historical logging, event logging, reporting and deeper analysis. Useful analytics take effort to implement, but can help warn about pressure fluctuations, potential leaks and unexpectedly slow-moving cylinders or other pneumatic devices.

To make all this possible, there needs to be a way to monitor the signals, and a way to transmit them to the cloud.

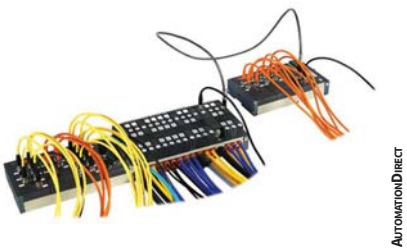
SIMPLE AND SMART SIGNALS

The most basic way to monitor field signals is by using traditional I/O connections, which might be discrete (on/off) or analog (variable). Some signals may already be wired to existing automation, but other data points of interest, such as electrical and compressed air sensors, might need to be added.

For example, a pneumatic machine already in service may only use a low-pressure switch to stop operation if the air pressure goes too low. Adding a pressure transmitter to obtain an actual pressure value would allow comparison of machine performance in relation to the air supply. One approach to accomplish this is to add the sensor and wire it to the existing I/O, and to then modify the existing controller—if there are spare I/O points, and if modifying the PLC program won't impact the equipment warranty.

An alternate is to add new remote I/O modules, or a PLC with I/O, to gather these points separately from the existing control system, and effectively in parallel with it. We will look at the PLC option in the next section, but a main reason this "add on" approach is so attractive is because it does not affect the existing automation in any meaningful way.

The proliferation of smart field devices is revolutionizing how field signals can be monitored. Many devices include Ethernet or Wi-Fi connectivity, so they can talk directly to the cloud or be consolidated under an IIoT PLC. Even traditional automation elements like solenoid manifolds need not be hard-wired to I/O anymore because they are available with on-board communication



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OEMs and system designers can integrate intelligent pneumatics and I/O, like the AutomationDirect PAL modular electro-pneumatics shown here, in a compact and organized footprint.

modules designed to interact well with PLCs using common industrial protocols, like EtherNet/IP. This reduces field wiring and makes it easier to create IIoT solution installations, and it provides many options for OEMs and system designers to distribute pneumatics and I/O in an organized way throughout an automated machine or system.

Not only are basic on/off commands available, but these manifolds can provide extended diagnostic data about the hardware, and some of them can accept I/O modules to provide an all-in-one remote I/O solution. Intelligent pneumatics and I/O are especially useful for new installations.

PLC CLOUD CONNECTION

Whether the signals for new or retrofit installations will be simple or smart, it is typically necessary to provide additional computing to create an IIoT project. In past years this has often required specialized gateway devices, or even industrial PCs. Modern PLCs

now have what it takes to enable field-to-cloud connectivity in a more streamlined manner.

PLCs are already ideal for the operating environment because they are built robustly and have many I/O and industrial field bus options. Most newer models use Ethernet, and some even include Wi-Fi and/or Bluetooth for improved ease-of-installation and configuration. Wireless connectivity is a significant advantage because it enables quick and inexpensive installations, avoiding the downsides of traditional conduit and cable installation in the field.

One important cloud-ready upgrade in recent years is the addition of the IT-friendly MQTT protocol, which has become the preferred method for communicating data to the cloud.

A modern PLC can provide the control and data capabilities for new equipment designs. Versions are available which let users easily, economically and securely add IIoT connectivity to existing machines without impacting the underlying automation. Depending on the PLC feature set, the data can be transmitted to a IIoT cloud service or the user's own database and analytics systems, and some models are certified to work directly and natively with cloud services.

IIOT-EMPOWERED EQUIPMENT

In addition to specifying new equipment with convenient built-in communications, many end-users and OEMs are finding it easy to add IIoT capabilities to their pneumatic equipment and other automated systems. Regardless of the make, model or age of the equipment and associated controllers, there are intelligent devices and cloud-enabled PLCs making this not only possible, but practical.

Not only is this approach flexible, but it is also modular and scalable. Users, systems integrators and OEMs can add IIoT functionality on a trial basis, and then roll it out on a much larger scale when proven. And they can incrementally add new signals as experience develops. With an IIoT system in place, users have the information they need to run efficiently. They can receive early indications of developing problems, using this information to reduce downtime for maintenance and repair. hp

KEVIN KAKASCIK is a technical marketing engineer at AutomationDirect. Over his 20-year career he has held controls engineering positions for machine OEMs, entertainment industry systems integrators and material handling systems integrators where he estimated, designed, commissioned and started up systems.

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A Team of Individuals

Debbie Brady

Manager of User Marketing

Debbie has been working in audience development for most of her career. She has a soft spot for Hydraulics & Pneumatics and takes personal pride in ensuring that all subscribers have requested the magazine, and they all specify fluid power components.

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- Average monthly reach: **264,284**
- Average unique monthly visitors: **146,013**
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