machine design

BY ENGINEERS FOR ENGINEERS

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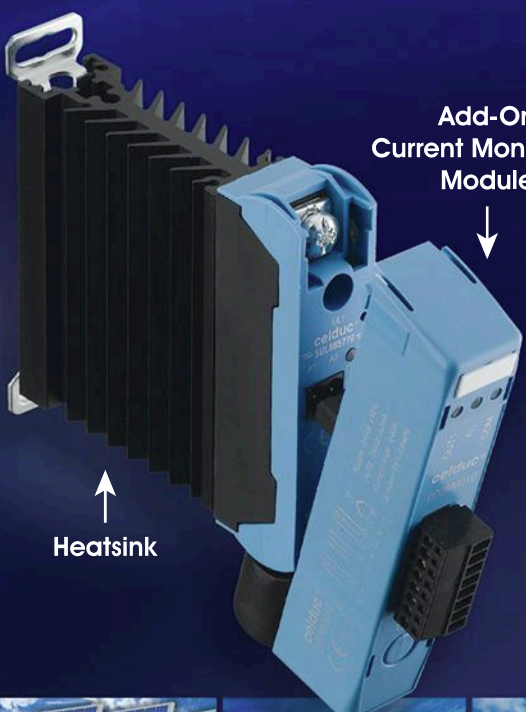

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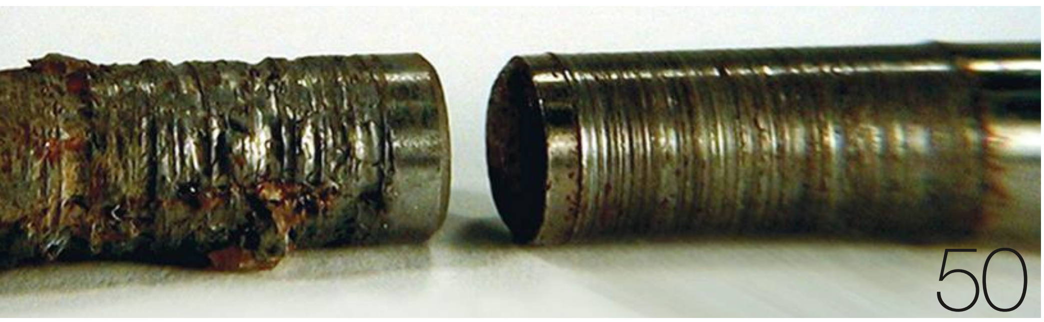

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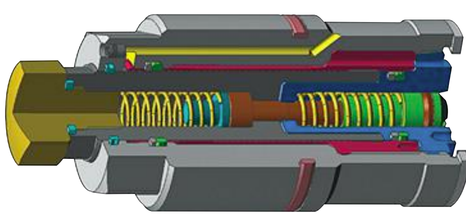

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Paid subscriptions include issues 1-12. Rates: U.S.: $139/year; $199/two years. Canada/Mexico: $159/year; $239/two years; All other countries: $199/year; $299/two years. Cost for back issues are U.S. $10.00 per copy plus tax, Canada $15.00 per issue plus tax, and Int'l $20.00 per issue. OEM Handbook and Supplier Directory, $50.00 plus tax. Prepaid subscription: Penton Media (MACHINE DESIGN), P.O. Box 2100, Skokie IL 60076-7800. Periodicals postage paid at Kansas City, MO and additional mailing offices.

Can GST #R126431964. Canadian Post Publications Mail Agreement No.40612608. Canada return address: IMEX Global Solutions, P.O. Box 25542, London, Ont., N6C 6B2.
Digital subscription rates: U.S.: $69/year. Canada/Mexico: $79/year. All other countries: $99/year. Print/Digital combo subscription rates: U.S.: $174/year; $249/two years. Canada/Mexico: $199/year; $299/two years; All other countries: $249/year; $374/two years.
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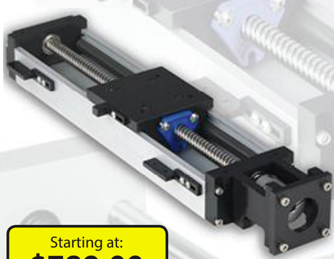

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CONNECTING THE DIGITAL WORLD WITH MANUFACTURING

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What does it take to make something? What tools do you need to take an original idea from the design board to actual physical production? These are the questions Autodesk wanted to answer when it launched its first-ever Forge Development Conference. Technology Editor Carlos Gonzalez reports back from this event that offered guidelines for success with the Internet of Things.

CHOOSING HOLDING BRAKES

http://machinedesign.com/motion-control/what-look-when-choosing-holding-brakes

Engineers must sort through multiple properties and other considerations when selecting a holding brake for their rotating-equipment designs.

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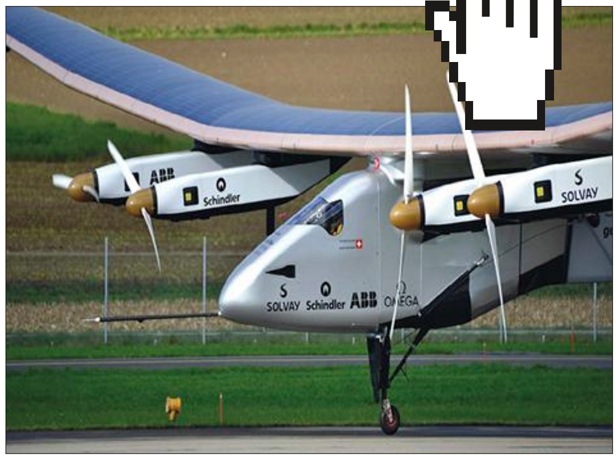
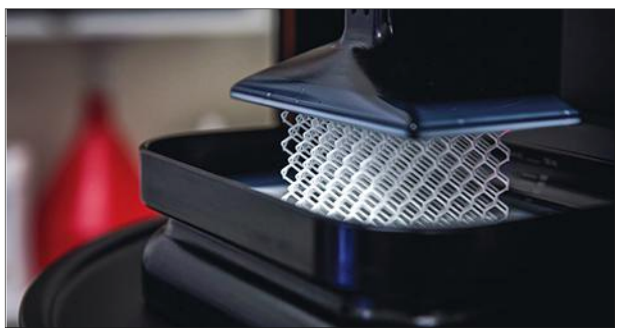


SOLAR IMPULSE 2 FLIES AROUND THE WORLD

http://machinedesign.com/sustainable-engineering/solar-impulse-lands-new-york-city

With its recent stop in New York City, the "green" prototype plane Solar Impulse 2 moved one step closer to completing its round-the-world journey—without benefit of fuel. Learn more about this innovative aircraft's record-breaking flight, and what it means to the world—and the environment.



3D PRINTER GETS SPLASHY RELEASE—BUT WILL IT CHANGE THE WORLD?

http://machinedesign.com/3d-printing/3d-printer-gets-splashy-release-it-won-t-change-world

3D printing start-up Carbon (formerly Carbon3D) was recently in the spotlight when it launched its first commercial offerings: a printer, dubbed the M1, and a range of resins for it targeted at prototyping and low-volume manufacturing applications. Contributing Tech Editor Anthony Vicari takes a look at the new printer, and the interest in 3D printing from the investor community.

machine design
JULY 2016

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Editorial

CARLOS M. GONZALEZ | Technical Editor
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An American in Germany: Lessons from Hannover Messe 2016

Before working for *Machine Design*, I had worked primarily with U.S.-based engineering firms. I would say that my trip to Hannover Messe 2016 was my first encounter with the engineering world of another country. Besides dealing with different units and trying to do conversions in my head (1 kilometer equals 0.62 miles just in case you were wondering), the approach of engineering is different. Certain things that perhaps we do not do enough are standard procedures in Germany and vice versa. Yet the most promising thing I saw is how these two worlds are becoming one cohesive engineering world.

In my previous job, shipping in parts from across the seas was a hassle. The main problem was collaboration. There were times we could not get on the same page. There were several reasons why two countries could not play well together. Sometimes it was things like customs and shipping, things out of our control. The other problems were methodologies, different international standards, and design procedures. This is where I see the world of the Internet of Things coming into play. It goes by many names depending on whom you talk to: Industry 4.0, Smart Manufacturing, Industrial IoT, or Manufacturing 2025. But regardless of the name, the fact that IoT depends on interconnectivity forces companies and countries to work together, to create joint standards, and to create one unified IoT world.

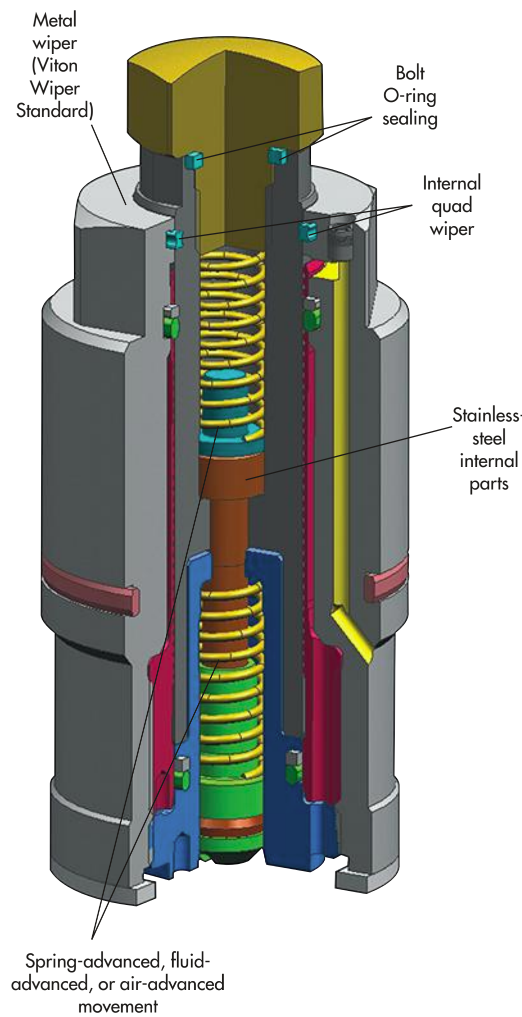
The visit by President Obama, along with the selection of the United States as the Partner Country, indicates that worlds are merging. Many people I interviewed had similar answers when I asked them what is the difference between IoT in the U.S. versus in the European Union. For the EU, it was the support and involvement of government in developing IoT. The German government is actively involved in creating and establishing Industry 4.0 as the leader of IoT. It benefits them because it makes them the center of the IoT world, and you cannot really argue with that as the size and scope of Hannover Messe proves. The opinion from E.U. companies on the U.S. and IoT is that the companies involved are making the push for it to grow. While the U.S. is supporting IoT, made evident by the President's visit, it is not a unified effort. The companies in the States are creating what they believe IoT to be. While this may allow for certain aspects to grow faster, either via trial and error or by large investments into the technology, growth comes independent of others, creating different methodologies on how to enact IoT.

This is where collaboration becomes essential. The Internet of Things does not just mean interconnected devices, but also interconnected networks, job sites, and people. We will be able to monitor and affect job sites across the world. Organizations like Industrial Internet Consortium and conferences like Hannover Messe are important because they create universal standards and provide educational opportunities that will be necessary for companies as they build their IoT systems, to ensure we are all on the same playing field of connectivity. md

Hydraulic Work Supports Achieve High Performance

CARR LANE ROEMHELD (www.clrh.com) offers a wide range of hydraulic work supports that automatically adjust to the workpiece height, then lock securely to become fixed rests. Available in spring-advanced, fluid-advanced, and air-advanced types, these work supports are extremely compact, starting at just 1 in. diameter, with maximum pressures up to 7500 psi. The high-performance supports, which are designed for 500,000 cycles, come in more than 60 different standard sizes and styles, with supporting forces from 145 to 23,000 lb. Added features include contact bolt O-ring sealing, stainless-steel internal parts, and a metal wiper on the exterior.

For more information, contact Carr Lane Roemheld Mfg. Co., 927 Horan Drive, Fenton, MO 63026, 1-800-827-2526, or click "CNC Machining" at clrh.com. md



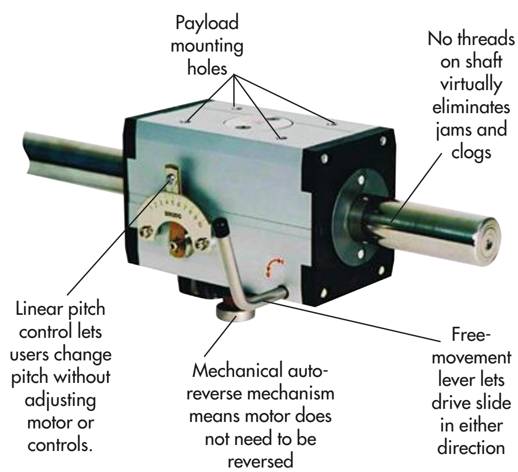
Rolling-Ring Drives Now Have Adjustable Pitch

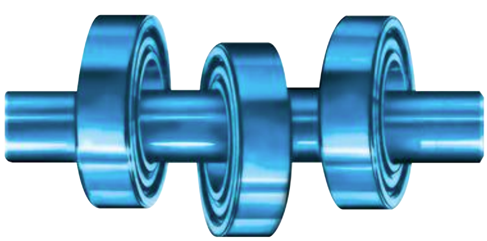
UHING ROLLING-RING DRIVES from Amacoil (www.amacoil.com), Aston, Pa., convert the constant rotary motion of a plain shaft into reciprocating linear output. Rolling-ring drives are mechanical alternatives to electronically controlled linear-motion drives and may be used in machines requiring automatically reversible linear motion for applications such as ejecting, cutting, winding, and spraying.

RG drives now feature a pitch control lever that lets users change the linear pitch independently of the drive motor speed or other controls. This essentially creates a variable-speed drive system free from programming or electronics. By gearing the drive shaft to the drive motor, operators are able to modify the pitch range for a specific rolling-ring drive based on application requirements.

The pitch control lever may be moved through 100 discrete settings. Each setting increases or decreases the linear-pitch value by 0.01. This gives all RG drives a pitch adjustability range of 10:1. For example, if the RG3-15 drive is geared for a maximum linear pitch of 22.8 mm (0.9 in.), the operator can use the pitch control lever to reduce pitch down to 2.28 mm (0.09 in.).

Depending on size, rolling-ring drives can provide axial thrust ranging from 7 to 800 lb (30 to 3,600 N). md

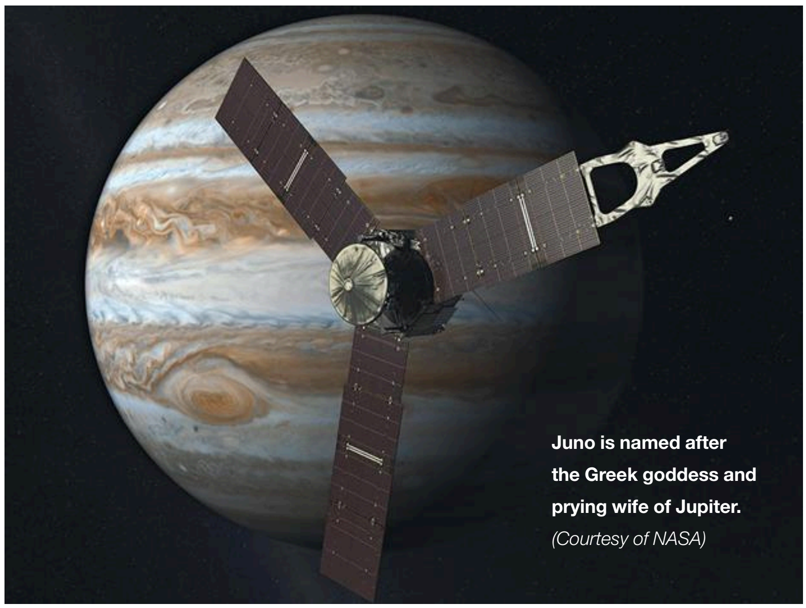



A rolling-ring drive inside the actuator converts rotary motion into linear motion.

News

Eagerly Awaiting Word from Jupiter

In August 2011, NASA launched Jupiter Near-Polar Orbiter, commonly known as Juno, embarking on a five-year journey to Jupiter. Now, Juno is less than a month away from exploring beneath the gas giant's stormy atmosphere. It's expected that findings made by the craft will help determine or open the door to explanations on the planet's origins, which date back to the infancy of our solar system.



Juno is named after the Greek goddess and prying wife of Jupiter. *(Courtesy of NASA)*

On the 4th of July, Juno will begin a 35-minute burn of its main engine before entering Jupiter's polar orbit. Over the course of 20 months, the payload will pass by Jupiter's north and south poles 37 times, completing each orbit every 14 days. Juno will skim Jupiter's atmosphere up to 3,100 miles above its cloud tops, rotating three times per minute to get a full view.

In that time, Juno will create a 3D map of Jupiter's colossal magnetosphere, which is 20,000 times stronger than that of the Earth and the cause of Jupiter's intense radiation band. Juno will also create a detailed map of Jupiter's gravitational field to finally determine Jupiter's mass distribution and core makeup.

In addition, high-resolution spectral cameras paired with telescopes will capture images of Jupiter's underlying clouds, while spectrometers and particle detectors will analyze the plasmas that generate Jupiter's powerful auroras at its poles.

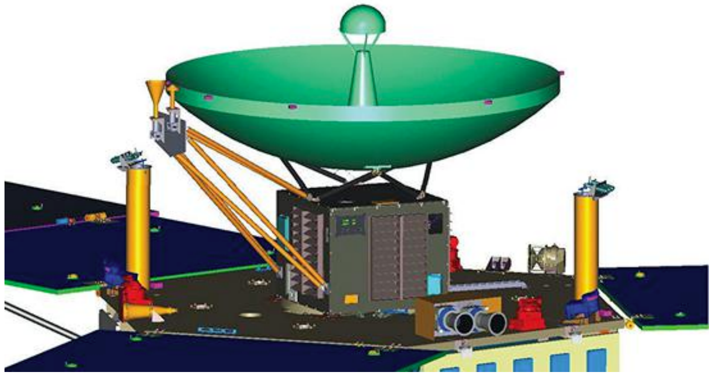
Technicians install the radiation vault around Juno's instruments in a Lockheed Martin clean room in Denver, May 2010. *(Courtesy of NASA/JPL-Calech/LMSS)*

JUNO'S SOLAR PANELS

Juno requires 18,000 solar cells to gather enough energy for its journey—508 million miles from the sun. In January, Juno broke the record as the first solar-powered spacecraft to fly further than 493 million miles from the sun. During Jovian orbit, Juno will run at a mere 405 watts.

JUNO'S RADIATION VAULT

During its polar orbit, Juno will repeatedly pass through the intense radiation belt that surrounds Jupiter's equator, charged by ions and particles from Jupiter's atmosphere and moons suspended in Juno's colossal magnetic field. The belt, which measures 1,000 times the human toxicity level, has a radio frequency that can be detected from Earth and extends into earth's orbit. Therefore, most of Juno's electronics are contained in a six-sided titanium radiation vault. Exposed electronics may be made of tantalum and tungsten to reduce damage, or be encased in mini-vaults adopted from Martian explorers. The technology used to create Juno's radiation vault for radiation- and heat-resistant electronics will benefit other spacecraft in future space missions.



Juno's gravity-science dish sits on top of the radiation vault and sends radio and microwaves to the Deep-Space Network in Goldstone, Calif. *(NASA/JPL/Caltech)*

Here are the nine technologies that Juno will use to probe Jupiter:

GRAVITY SCIENCE EXPERIMENT

Using advanced gravity science tools, Juno will create a detailed map of Jupiter's gravitational field to infer Jupiter's mass distribution and internal structure. Any perturbations from orbiting bodies, such as its Galilean moons, will be recorded as well. Juno will continually receive X-band (microwave) and Ka-band (radio) signals from a Deep Space Network (DSN) transceiver in Goldstone, Calif. As Juno changes its position and proximity to the planet during orbit, it will mirror these signals back to the transceiver, which will measure Doppler shifts in the transmission caused by Jupiter's gravitational pull.

At Goldstone, the signals will be calibrated to account for distortion by Earth's atmosphere so that a detailed map may be generated after several orbits. The radio and microwave signals will be transmitted with limited interruptions from solar wind, the asteroid belt, and Jupiter's ionosphere.

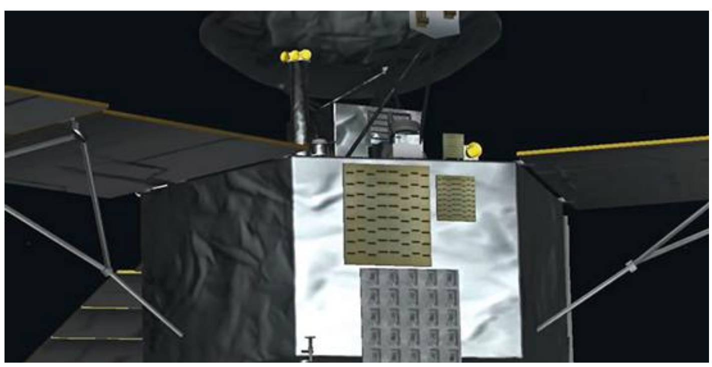
VECTOR MAGNETOMETER (MAG)

Juno's next mission is to map out Jupiter's massive magnetic field, which extends approximately 2 million miles toward the sun, shielding Jupiter from solar flare. It also tails out for more than 600 million miles in solar orbit. The dynamo is more than 20,000 times greater than that of Earth; it is thought to be caused by liquid metallic hydrogen that flows and conducts electricity in Jupiter's outer core at pressures as high as 3 million bar.

However, to confirm the origin of the magnetosphere, NASA awaits data from Juno. Learning about the magnetosphere will also tell more about Jupiter's radiation belt and plasmas made up of trapped ions and charged particles in the magnetosphere. These are responsible for continuous aurora at Jupiter's poles.

MICROWAVE RADIOMETERS

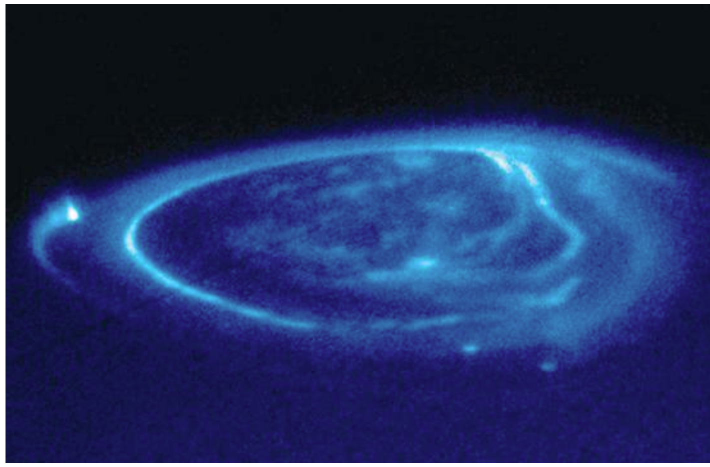
Next, microwave radiometers (MWR) will directly detect six microwave and radio frequencies generated by the atmosphere's thermal emissions. This will aid in determining the depths of various cloud forms. It will sense concentrations of volatiles including oxygen, nitrogen, sulfur, and water vapor in Jupiter's underlying clouds, sounding the atmosphere as deep as 1000-bar pressure, and detecting frequencies between 600 MHz and 22 GHz. By determining levels of these volatiles deep within the atmosphere, scientists will be able to gain further insight about Jupiter's formation at the infancy of our solar system. Antennae on Juno's MWR are built by the California Institute of Technology's Jet Propulsion Lab.



The MWR antennae (gray panels) are on the outside of the radiation vault.

DETAILED MAPPING OF AURORA BOREALIS AND PLASMA CONTENT

As Juno passes Jupiter's poles, cameras will capture high-resolution images of aurora borealis, and particle detectors will analyze the plasmas responsible for them. Not only are



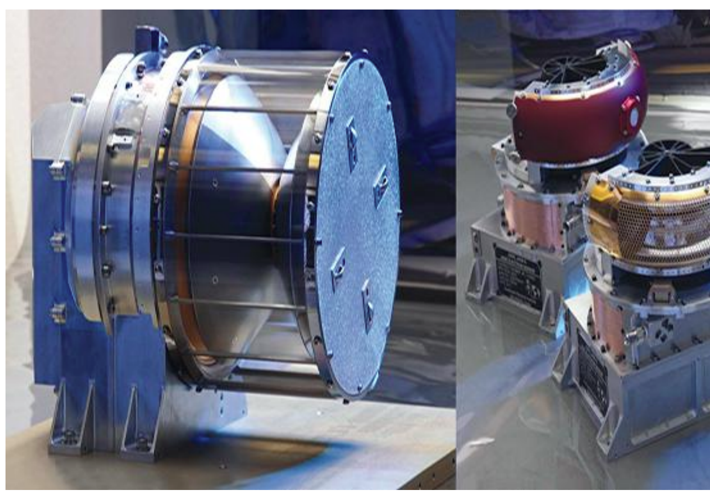
The Hubble Space Telescope captured this ultra-violet image of Jupiter's northern lights, which are more than 100 times more energetic than on Earth.

Jupiter's auroras much larger those of Earth, they are also more frequent because they are created by atmospheric plasma rather than solar flare.

JEDI MEASURES HIGH-ENERGY PARTICLES

Three Jupiter energetic particle detector instruments (JEDIs) will measure the angular distribution of high-energy particles as they interact with Jupiter's upper atmospheres and inner magnetospheres to contribute to Jupiter's northern and southern lights.

The JEDI will measure the energy of electrons at 25 kilo-electron volts (keV) to 1 megaelectron volt (MeV), along with the energy and species of ions from 30 to 1,000,000 keV. Each JEDI contains all necessary hardware to function independently of the spacecraft. They are arranged inside the electronics vault to analyze incoming particles from all angles of the spacecraft as it spins, processing over 30,000 events per second.



JADE MEASURES LOW-ENERGY PARTICLES

JADE, the Jovian Auroral Distributions Experiment, works in conjunction with JEDI to measure the angular distribution of lower-energy electrons and ions ranging from 0 to 30 electron volts (eV). Like JEDI, it analyzes particular interactions with the magnetosphere and the atmosphere to determine the mechanisms behind Jupiter's auroras.

WAVES MEASURES PLASMA MOVEMENT

The radio/plasma wave experiment, called "Waves," will be used to measure the radio frequencies (50 Hz to 40 MHz) generated by the plasma in the magnetosphere. Waves includes a sensor that measures the electric field of radio waves, and another that measures the magnetic component. It includes two field-programmable gate arrays (FPGAs): one executes commands and manages data outputs; the other carries out Fourier transforms and signal processing to translate analog signals to digital ones, as well as performs spectrum analysis and noise cancellation.

UVS, JIRAM CAPTURE NORTHERN/SOUTHERN LIGHTS

By capturing wavelengths of 70 to 205 nm, an ultraviolet imager/spectrometer (UVS) will generate images of the auroras' UV spectrum to view the auroras during the Jovian day.

In addition, the Jovian InfraRed Auroral Mapper (JIRAM) leverages an infrared camera and spectrometer to map out the auroras' infrared spectrum. JIRAM will extend outward below the spacecraft to obtain a full view during Juno's orbit, and receive operation commands from Juno. JIRAM will also be used to explore the dynamics and chemistry of Jovian hot spots and atmosphere convection. Both UVS and JIRAM contain a single telescope to generate up-close images of auroras at the poles.

HIGH-RESOLUTION CAMERA

Finally, JunoCam, a high-resolution color camera, will capture red-, green-, and blue-wavelength photos of Jupiter's atmosphere and aurora. The team expects the camera to last about seven orbits before being destroyed by radiation.

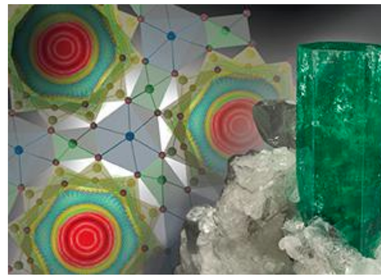
Part of NASA's New Frontiers Program, Juno represents a joint effort between NASA's Jet Propulsion Laboratory, the Southwest Research Institute, NASA's Marshall Space Flight Center, Lockheed Martin Space Systems, and the California Institute of Technology. ■

Three JADE instruments, developed by Southwest Research Institute, are on three opposite internal sides of the hexagonal radiation vault. *(NASA/SwRI)*

WATER MOLECULES TAKE on Hexagonal Structure in Nanoscale Spaces

IN A PAPER published in Physics Review Letters, Oak Ridge National Laboratories presents findings for a quantum state of water in which a molecule's hydrogen atoms occupy six ground states around oxygen at once. What resulted was that their classically bent linear shape transforms to a hexagonal, double-top structure with virtually a zero dipole moment.

The phase is an effect of hydrogen quantum tunneling caused by tight confinement of individual water molecules in spaces that rival their size. In this experiment, water molecules are confined to the lattice spaces in a beryl gemstone that measure 5 angstroms—about the width of 5 atoms. The team used high- and low-energy neutron scattering to determine the position of hydrogen atoms. Experiments were carried out by the Spallation Neutron Source at the ORNL and at the neutron facility at Rutherford Appleton Laboratory in the U.K.



Hydrogen atoms in a water molecule exist in six configurations; water molecules take on the hexagonal shape of their nano-channel containers within a beryl crystal. (Source: Oak Ridge National Laboratory)

The report includes computational modeling of this new quantum state, which will be valuable for researching the behavior of water in tight spaces, from nanoscopic crevices in rocks to carbon nanotubules and other man-made nanostructures. It may lead to new discoveries in drug delivery to individual cells using nanoneedles. Based on the neutral polarity of these new molecules, water is bound to act much differently with its surroundings than it does in classical systems.

QUANTUM TUNNELING

Quantum tunneling (QT) describes a particle's ability to pass energetic barriers that, according to classical physicals, were otherwise not possible. It is best explained by describing a particle as a wave. Unlike particles, the absolute position of a wave cannot be determined; rather, its position can be expressed as a probability that it exists "here" or "there," and in turn, a wave occupies more than one space at a time.

Also, unlike matter, wave particles can propagate through barriers that would be energetically impermeable to matter. So while a quantum-wave particle may exist in several positions, it exists in a single position when observed as a particle of matter. In turn, observation of the particle on the other side of an energy barrier becomes a probability.

Quantum tunneling, which is a cause of many phenomena, is widely taken advantage of in technology. For example, as transistors continue to exponentially shrink and their barriers get thinner according to Moore's law, electrons will increasingly tend to leak between the barriers of an off-state transistor. Scientists may try to minimize this effect, or exploit it by altering the thickness of energy barriers for controlled QT.

Moreover, scanning tunneling microscopes leverage QT by introducing a voltage bias that causes electrons to tunnel from subject atoms to the metal scanning tip. This generates a current that can be detected for atomic imaging.

That said, QT can result in a broad range of unexpected molecular configurations, even those that are not classically and energetically favorable. The hydrogen atoms of water trapped in beryl crystal channels spread out or "delocalize" from the central oxygen, shrinking the energy barrier between each configuration down to about 50 meV. In turn, the two hydrogens can more easily tunnel through six separate ground states. Since the probability of each space occupation is the same, the molecule takes the form of a symmetrical hexagon, with each space being occupied at the same time.

The team used low-energy neutrons to detect hydrogen's position as it tunnels through six separate ground states. They brought the system down to 5 Kelvin to eliminate most thermal effects that could obscure the results of QT. The scattering test identified seven peaks in the scattering spectrum. A second set of experiments used high-energy neutron scattering at Rutherford Appleton Laboratory, revealing kinetic energy that is 30% lower than usual in water's hydrogen. This proved the "delocalization" theory of hydrogen from oxygen when confined in beryl.

The results from ORNL are consistent with the results of another experiment conducted by Boris Gorshunov of the Moscow Institute of Physics and Technology. In his experiment, terahertz spectroscopy was used to detect the ground energy levels of water in beryl. ■

DAN LEVINE | CEO, CytexOne

IIoT Challenges and Promises

To get an idea of the challenges facing the Internet of Things, we talked with Dan Levine, CEO of CytexOne, New York City. Levine's firm creates automated Internet of Things (IoT) environments for commercial, industrial, and residential spaces, including insurers, restaurants, hotels, and apartments.

Security is a major concern with the IoT. Any idea how companies will be able to provide it?

IoT security involves protecting access to the equipment, such as an internet-connected car or house, as well as protecting customer and company data. It is, in my opinion, a failure where there is a measurable chance that equipment and data could be susceptible to hackers. Not only can equipment be damaged, infiltration can create a dangerous hazard and interfere with or downright cripple production and business process. A strong system and network designer are critical, as are robust design and ongoing monitoring.

With customer and company data stored in the cloud, a totally different type of security is needed. That security must be provided by the IT team storing the data, and to do a good job, the IT team must include a solid team of security experts who stay on the cutting edge and ahead of common technology.

It's said that locks and security are really not meant to stop anyone from breaking in, just to slow them down. And most people do not try to break into something that's locked. But if they really want to—and have the time, money, and motivation—they can. Not many hackers will break into a single piece of equipment or device unless it is sold in high volumes to consumers or industry, and not unless their action will cause meaningful disruption. That's why consistent, reliable monitoring is critical not just for systems, but for systems of systems as well as individual devices.

How will companies solve these security issues?

Some companies will be better at it than others. IoT is dynamic. There will necessarily be many different security products and vendors. End users and interim management companies—and even IoT service providers and designers and companies—need firms like CytexOne because they offer services to guide; insulate; protect and proactively monitor; and repair systems and potential pitfalls of what can otherwise be a security minefield. Successful companies will include real-time monitoring of the security and vulnerability of their networks; constantly scan and analyze security and performance; and—most importantly, repair—all in real time.

Does the IoT need unifying standards for issues such as security, interoperability, and performance?

Unifying standards would be helpful in that they would increase adoption levels and remove the temptation or perceived necessity of reinventing the wheel, and avoid wasting time rediscovering the failures others have already experienced. On the other hand, a tight unifying standard may limit innovation. We are in an era of endless innovation with technology, much like the machine age of the 19th Century. It's just imperceptible to many people. To establish market share, a great product and service are necessary, and those come only from innovation and devotion to the cause.

That is not to say that unifying standards won't make it easier to find, track, and avoid security vulnerabilities. And once a vulnerability is found in hardware or software, unauthorized access to many sites is possible. For example, a bug that came out in Android could be widely exploited by hackers. If they could get a text message with certain characters in it to the phone, it would give them full access to the phone. To complicate the problem, the open-source nature of Android and the fact that the phones don't all centrally update makes it difficult to patch the bug. There are many phones still totally vulnerable.

There are certainly some standards in IoT, such as the wireless frequencies used (ZigBee, Bluetooth, Z-Wave). But in the software-stack arena, it has been like the Wild West. There are so many different platforms, and many do not last a long time. A company can invest and deploy a platform that seems great and works well, but then if the company that developed and supports the platform goes out of business, that platform is effectively dead.

For instance, a company called Quirky developed an IoT platform called Wink that was accessible to everyone, with devices available in Home Depot, Staples, and other places.

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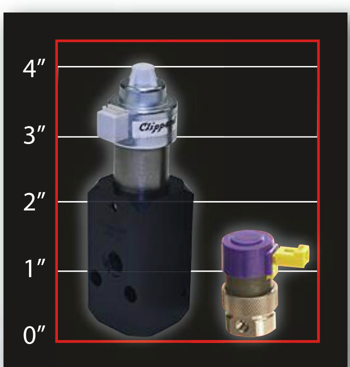

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There was all sorts of money invested in the company, and then it went out of business. All of the companies that had been using it ended up with hubs that were useless. NASA also bought a hub, Revolve, but then shut it down. Even Staples had a hub that got shut down. In the industrial sector, it is expensive, if not impossible, to retrofit one device to work with a new hub. More focused platforms, more focused communication, and more streamlined and approachable hubs and platforms are available, and companies like mine design systems and systems of systems that are secure and take advantage of available hardware.

So should there be a greater need for standards covering hubs and other critical infrastructure?

It is ideal to have certain standards. But right now, companies want to own their own platform and software. Without standards, no one really owns either. So although having IoT standards would be phenomenal, it's a difficult task. Eventually, the companies that survive will adopt a standard in the years to come, and they will be set on adoption rather than some entity mandating it. It will depend more on who buys what and what gets used more.

Who or what should establish IoT standards?

Well, we've seen that governments managing standards can be tricky. And which government would it be? The U.S.? The U.K.? And how would that government interact with other governments around the globe, especially those that might not have any buy-in behind the standard? Would it be private companies? Private equity managers who fund companies? Can it become as ubiquitous as the internet? Perhaps. I think it needs standardization like electricity. After all, the IoT is a commodity and a necessity, like electricity.

Should some non-profit organization set them?

That would also be problematic. As more people and companies join those organizations, the harder it is for the group to incorporate innovation into the standard, and the less evolutionary and open to change they become. Everyone has an opinion and agenda. And some companies have been known to use standards as competitive advantages and as a weapon in the marketplace.

So when it comes to the IoT, it will likely come down to the participants in the marketplace setting the standards.

Are there any challenges specific to the Industrial Internet of Things, the IIoT?

Many people in the industrial sector have spent a long time in their industry, and most people believe they do things better than anyone else. This sometimes leads to companies deciding to reinvent the wheel internally rather than looking externally for solutions that are already built and proven. Outside solutions do not provide the same level of job security for teams that have been working on problems for a long time. So perhaps the biggest hurdle will be overcoming resistance from the managers and employees themselves.

On the other hand, the IIoT is a much easier sell than the consumer side of the IoT. For a business, there's a value proposition and you can show an ROI. It's not a convenience or luxury item; it's a true ROI and competitive advantage. The IIoT should lead to reduced cost structures, increased operational efficiencies and manufacturing yields, higher quality of products (fewer defects), more efficient sourcing of materials, and lower expenses due to smaller staffs but higher output. For consumers, this means lower costs and better products.

Will all manufacturing companies go to the IIoT?

The short answer: yes. One day, everything will be connected to the internet. Everything. Even the pavement on your driveway and walls in your house will be connected to the internet in some way. It's just a matter of time. I would say it will reach nearly 100% in 100 years, and reach over 50% of things within 15 to 30 years. It's possible to do it now, but people don't realize the benefit, or the inexpensive investment for total access and environmental management, avoiding repairs, and managing energy consumption, as well as people and processes.

Will well-off, established industries be better positioned to implement IoT than startups and smaller companies and industries?

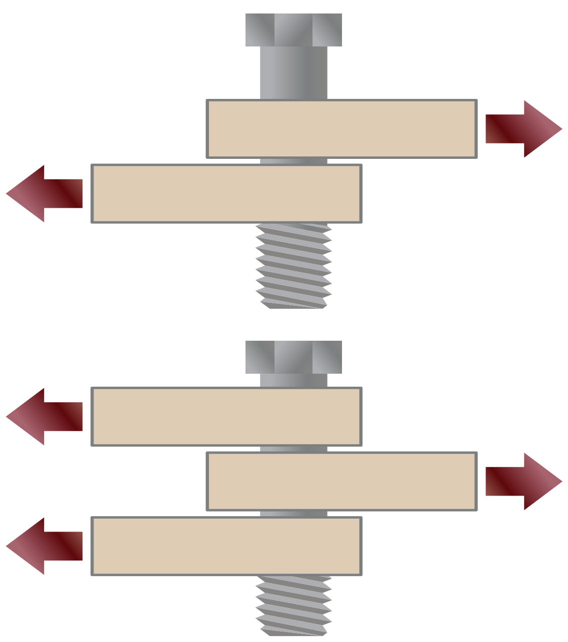
No. Just the opposite. Startups and smaller firms are more limber and robust than large companies. Some companies, like IBM and GM, are so large, with so many departments and government-like bureaucracies, that it seems that most can't be as nimble as change and innovation require.

For example, when Microsoft launched Office 365, it was reported that there was infighting and resistance inside the company from groups that had been selling Office on the desktop as a perpetual license rather than subscription license. It's remarkable that in an innovation-dependent industry, large companies that brought technology to the masses, such as Microsoft and IBM, are almost behind the curve. So it will depend on the individual company's structure and culture as to whether the institution and individual employees are willing to change.

Another related problem is that some established companies have large teams filled with groups of geniuses working on IoT technology. Sometimes they solve the problem, but often they just get bogged down. They want to build the solution themselves, internally. They feel they can do it better. But they lack the IoT experience and up-to-date technology knowledge and know only their own industry and what worked in the past. Startups and smaller companies don't have any legacy people, processes, or products. md

What's the Difference Between Bearing, Shear, and Tear-Out Stress?

Here is a short introduction into bear shear and tear-out stresses in bolted joints and how complex they can be.



Depending on the design, a pin or bolted joint might share a load over multiple surfaces.

JOINTING IS A basic function of engineering. For example, bolting two parts together can involve material properties and loading forces. Here, we will focus on preloading, shear, and tear-out in a bolted assembly. However, designers must consider multiple engineering principles, including the internal and external loads discussed in a number of articles on the *Machine Design* website (*www.machinedesign.com*).

Engineers may have learned about these stresses in school, but one of the factors that complicate what might seem like a simple bolted joint is the clamping force, or preload. Calculating non-preloaded connections can use typical shear and bearing formulas explained later in this article. However, preload is often a factor in a joint's fatigue life; it introduces tensile forces, and can promote creep.

In a rigid assembly, the preload is higher than that of the service load—thus the service load will, or should, have little effect on the fastener tension forces. This reduces fatigue failure even when a dynamic of fluctuating load is applied. This only applies if the designer considered the difference of the tensile strength and endurance limit of the fastener. A cyclic stress on a joint will be designed to the endurance limit, not the tensile strength of the fastener. For example, if a fastener has a minimum tensile strength of about 150 Kips, but the endurance limit is 15 Kips, a joint under a cyclic load will not be able to exceed 15 Kips; otherwise, it can fail prematurely due to fatigue.

According to a technical memorandum for determining bolt load published by NASA, bolts should typically generate a clamping force that, if designed properly, will carry less than 20% of the external loads on the bolts. The majority of the work is performed by the compressive energy induced on flanges while the bolts are tightened.

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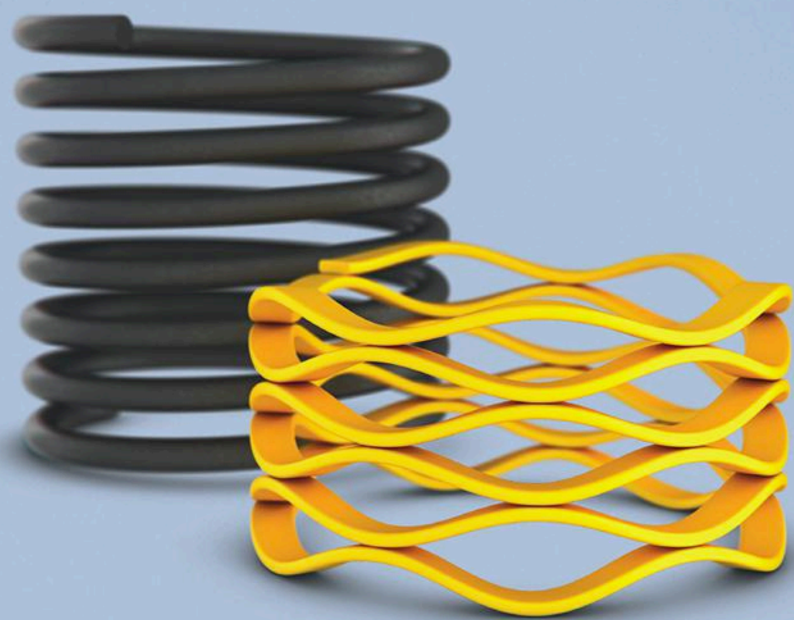

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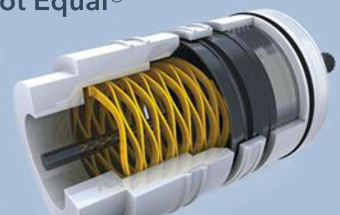

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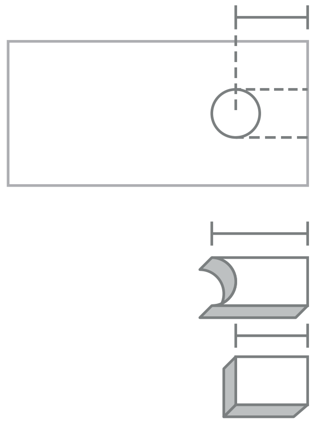

Calculating tear-out is similar to other stress equations (force divided by area). However, unlike some others, you can choose at what point you calculate the area. Tear-out area is sometimes taken from the center of the bolt hole to the outside of the material—increasing the area by the radius of the hole. A more conservative approach is to take the area from the edge of the bolt hole to the edge of the material.

Many variables affect preload, including tensile strength, finish, head style, and lubrication. Lubricants will reduce the torque required to produce a clamping force. Coatings may reduce or increase required torque. Multiplying the standard dry torque by as much as 0.45 to 1.70 can compensate for lubrications and coatings. For example, Molybdenum grease, film, and paste can reduce the torque needed to produce a proper clamping force by 30%, 40%, or 45%, respectively.

Unfortunately, there is no simple, totally reliable way to compute the precise preload needed for every application *(for more information visit http://machinedesign.com/fasteners/calculating-proper-preload-threaded-fasteners)*. Factors such as the bolt head, thread type, washer, and fastener plates also help increase surface area to prevent creep, which will cause the preload to be reduced and potentially cause slippage or introduce another mode of failure. There are standards that can also help guide you in preloading your fasteners. However, this is not a quick fix, as each standard focuses on a different application or technology. ASTM, ANIS, ASME, IOS, and others may overlap, while others might have gaps between them.

The Federal Aviation Administration offers this example: "The amount of clamping force exerted by a properly tensioned fastener is normally stated to be about 75% of the proof load. The proof load of an SAE J429 Grade 2 bolt is 4,250 lb. The resulting clamp force is:

$$4{,}250 \times 0.75 = 3{,}187.5 \text{ lb.}$$

The amount of torque required to achieve this load is approximated by:

$$T = K \times D \times Fp$$

where:

T = bolt torque in inch pounds
K = friction coefficient (dimensionless)
D = nominal bolt diameter (inches)
Fp = Axial clamp force (pounds)

Substituting the numbers into the equation:

$T = 0.2 \times 0.375 \times 3{,}188 = 239.1$ inch pounds or approximately 20 ft.-lb.

So a dry SAE Grade 2 bolt should be torqued to approximately 20 ft.-lb. to achieve a clamping force of 3,188 lb."

However, NASA's Technical Memorandum mentions that bolts can be 65% to 90% of a material's yield strength. Again, this shows the range of a bolted joint can vary depending on application, safety factor, standards, and how conservative you are with calculations. According to NASA, it also is generally safe to assume the uncertainty for hand-operated torque wrenches on lubricated fasteners to be ±25%. When using a load-sensing instrument, though, the preload uncertainty factor may be reduced to ±5% uncertainty.

BEARING STRESS

Bearing properties are forces acting on the hole a bolt goes through. A bearing test is used to determine if there might be any deformation of the hole. Preloading will reduce bearing forces, but not all bolted joints are preloaded. To calculate bearing stress, divide the force over the contact area between the fastener and hole. Theoretically, it is often the simple area of the bearing surface.

$$\delta b = P/Ab$$

where:

δb = bearing force
P = axial forces acting on the fastener or plate
Ab= bearing area

Depending on the clearance between the fastener and the hole, the bearing area could be the length of the contact area multiplied by the diameter of the hole. If there is clearance, multiplying the answer by Pi divided by four will be more accurate. Neither of these equations takes into consideration that the stress is not distributed equally across the diameter of the hole. Stress distribution is closer to an ellipse, with more force in the direction of the axial force. Adding more fasteners reduces bearing stresses by increasing the area over multiple holes.

MINIMUM BOLT PRETENSION IN KIPS

Bolt Size (inches)	A325 Bolts	A490 Bolts
½	12	15
5/8	19	24
¾	28	35
7/8	39	49
1	51	64
1 1/8	55	80
1 ¼	71	102
1 3/8	85	121
1 ½	103	148

* Equal to 0.07 of the minimum tensile strength of the bolts and rounded to the nearest kip as specified in ASTM – A325 and A490 bolts with UNC threads.

Data taken from AISC Table J3.1.

ASTM specifications for A325 and A490 high-strength bolts are to be tensioned to 70% of the minimum tensile strength. The table above shows this minimum bolt pretension for empirical bolt sizes. The percentage can vary, but this is an adjustment depending on the materials' offset yield point. For rigid steel parts, the basic guideline given by the *Machinist's Handbook* is to tighten the fasteners to 75% of off-set yield point or proof strength. Lower torques should be considered for flexible joints—joints with gaskets, or assemblies subject to high temperatures.

SHEAR STRESS

For bolted joints without a preload shear, stress is calculated the same as bearing stress: force over area. Like bearing stress, it is also an average stress and the maximum shear will be higher. If a bolted joint has no separation or clearance, a direct shear situation—shear without bending—can occur.

$$\tau = V/A_{shear}$$

where:
τ = Shear stress
V = force
Ashear = Area in shear

Direct shear is ideal, as it reduces or eliminates extraneous stresses and slippage. However, even preloaded joints may be subject to excessive loading, impact loads, or creep that would reduce a preload and may cause shear with bending. Sometimes called a transverse load, this is defined, generally, by the pre-derived equation:

$$\tau_{max} = 4V/3A$$

This is still a simplified way of designing a bolted joint. Keep in mind that it is important to understand any and all potential loads and how they will act on the joints. A bending stress on a beam can increase tensile and shear stresses on the bolts. *(For a way to visualize bending in a beam, see "What's the Difference Between Beam Diagrams?" on machinedesign.com.)*

TEAR-OUT

Tear-out is a type of shear. Instead of shearing the bolt, the force will shear the material surrounding the hole. To prevent tear-out, it is suggested that the distance from the edge of the material to the edge of the hole be at least equal to the diameter of the hole. Edge-to-hole diameter ratios ranging from 1.5 and 2.0 are common.

Stress concentrations can dissipate relatively quickly, but the distance to the edge of the material or another stress concentration could induce tear-out stresses. The same edge-to-hole ratio may provide an idea of spacing between bolts holes, too. It is important for a company to define which standards and equations they want engineers to follow so that joints are designed uniformly and minimize variation. There are resources online for this purpose, such as distance calculators. Ideally, they should show how they are being calculated or what standards they are following. If they don't, simply use them as estimates or something to check your work against.

MINIMUM EDGE DISTANCE FROM THE EDGE OF A STANDARD HOLE TO THE EDGE OF A CONNECTED PART IN INCHES.

Bolt diameter	At sheared edge	At rolled edges of plates, shapes, bars, or gas cut edge
½	7/8	3/4
5/8	1 1/8	7/8
¾	1 1/4	1
7/8	1 ½	1 1/8
1	1 ¾	1 1/4
1 1/8	2	1 1/2
1 ¼	2 1/4	1 5/8
Over 1 ¼	1 ¾ × Diameter	1 ¼ × Diameter

*data taken from AISC table J3.4

The AISC J3.4 roughly follows a 1.5 ratio where the AISC J3.5 indicates the distance from a bolt hole to the edge of the material should be 12 times the thickness of the connected part, but not more than 6 in. For the distance between bolt holes the distance is 24 times the thickness of the thinner body/part, but not more than 12 in.

MARGIN OF SAFETY

The safety factor will change based on the tension on the fasteners, strength of material, and other factors. Using preload will reduce shear and bearing forces, as the movement in the joint reduces through friction or compressive forces. *(To find out more about how external loads affect the elastic center of the fasteners, see "How Bolt Patterns React to External Loads" on machinedesign.com.)*

Safety factor and the margin of safety can be changed to provide a preload. Note that this normal force will change the margin of safety. There are many equations for safety factors and margins of safety. The following is to show that the allowable stresses are generally divided by the actual stresses. If you are designing something to be lightweight and the margin of safety is close to zero, but you didn't factor in the preload, the joint might actually be lacking a factor of safety.

MS = (tA/Pb)-1
where:
MS = Margin of safety
tA = Tensile allowable
Pb = Total axial bolt load

For the shear margin of safety, simply swap out tensile and axial for shear. For combined bending and shear you can be left with:

$$MS = \frac{1}{\sqrt{R_b^2 + R_\tau^2}} - 1.0$$

where:
Rb = Total axial bolt load/bending allowable
Rτ = (Safety factor × force)/shear allowable

Some calculations will include the preload value, where the tensile force on the bolts is multiplied by the total of the square root of the shear and bending forces. Different companies have their own equations that have been honed via years of experience. Without this experience, finding experts or expert reference material is important when designing a bolted joint. They aren't as simple as your introduction to statics course in college might have made you think. md

VICTORIA FRAZA KICKHAM | Distribution Editor

Distributors Bet on AUTOMOTIVE, LIGHTING, IoT

Distributors focus on new opportunities in the "connected" auto industry and increasing demand for lighting controls in the second half of 2016 and beyond.

Slow and steady were the business buzzwords at this spring's Electronics Distribution Show in Las Vegas, where leaders from electronic component manufacturing and distribution firms converged for three days of one-on-one business meetings and networking. In addition to honing their capabilities as solution providers in today's marketplace, distributors in particular say they are focused on three key markets they will be investing in this year: automotive, lighting, and the Internet of Things (IoT).

These areas register as top market opportunities for sellers of electronic components and related services, despite today's slower business conditions. Some represent well-established strongholds for many companies, while others—particularly IoT—are fertile ground for new research and investment. Here's a look at how some leading distributors view today's best opportunities:

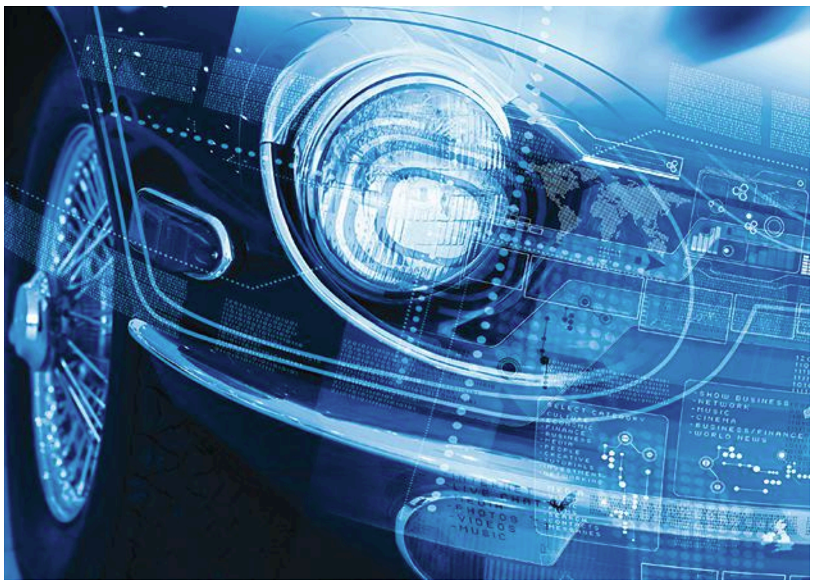

Image courtesy of Thinkstock

AUTOMOTIVE OPPORTUNITIES

Avnet Electronics Marketing sees continued growth opportunities in the automotive industry, according to Chuck Delph, who will take over as president of Avnet EM Americas this month. Delph points to consumers' changing attitudes about cars as a key reason for that optimism. For buyers today, the car is a shell for connectivity, placing greater importance on options surrounding safety, comfort, and convenience.

"It's interesting how the automotive market is changing," Delph says. "From the distribution perspective, it's not just the electronics [that are] going into the car. It's also our ability to service the content in the car."

Beyond electronics, services surrounding data, security, and business analytics represent potential market opportunities for distributors, he says.

"We're in a mature industry. Many people want to say 'woe is me' about the market. But I see it differently," Delph says. "You have to come at these markets and say, 'how do we behave differently?' That's what we are doing."

LIGHTING THE WAY

Delph points to growth opportunities in lighting as well—particularly related to controls. LEDs themselves have become a mature market, but the potential remains on the controls side of the business, distributors agree.

"Lighting remains a growth vertical because of all the electronic content that goes into the controls," Delph explains. "So you will hear us talking about investment there. It's the lighting vertical itself that will continue to grow."

Sager Electronics continues to see "a lot of wins in lighting," adds Faris Aruri, the company's vice president of corporate marketing, due to its focus on drivers and controls.

"That was a market you expected to be huge because there

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was so much talk," Aruri says, referring to the LED craze of a few years back. "I think it's still got so much room [for growth]."

Rich Davis, president of WPG Americas, agrees, pointing to WPG's success with large lighting projects in cities nationwide. "It's not so much [about] selling the individual component," he says. "It's selling the complete assembly or complete solution."

BANKING ON IoT

Davis adds that WPG is using its experience in lighting to guide its work on the newest frontier: the IoT. He explains that when LED lighting was taking off, the market was flooded with start-ups and industry hopefuls looking for design and product support—many of whom did not succeed. The IoT is a similar phenomenon.

"Right now, it's a 'we'll see' in many ways with the IoT. We're waiting to see who will grab the bull by the horns," Davis explains. "We are probably more aware of that because of where we've been. As you try to grow an organization, [you have to be] concerned that you use your resources well."

WPG Americas is a division of Taiwan-based WPG Holdings and is focused on four key areas in the Americas: IoT, embedded, power, and lighting. The company has been steadily expanding in the United States, opening three new facilities—in Massachusetts, New York, and Illinois—in the last nine months.

DAETWYLER ACQUIRES PREMIER Farnell

SWISS INDUSTRIAL AND electronics distributor Daetwyler Holdings announced that it will acquire British distributor Premier Farnell, which sells electronic components and solutions and also markets the Raspberry Pi computer through its Premier Farnell, element14, and Newark brands.

The companies said in a prepared statement that the deal "creates a leader in high-service distribution of electronic components and in doing so [realizes] significant value for the shareholders of both companies."

Daetylwer Holdings will pay approximately $870 million in cash for Premier Farnell. The deal is expected to close in the fourth quarter of 2016.

The companies will have combined revenues of approximately 2.5 billion Swiss francs. Daetwyler is comprised of two business groups: Its Technical Components division sells electronic, automation, maintenance and related components and solutions, and its Sealing Solutions

Avnet's Chuck Delph points to automotive business, lighting controls, and the Internet of Things as promising markets for the remainder of 2016 and into 2017.

Avnet is focused on IoT as well, having recently hired an executive to lead the initiative across the company's electronic components and technology solutions business units. Eric Williams was hired as vice president of IoT earlier this year. Delph emphasizes the potential for solutions selling in this market, where companies focused on solving customers' problems with a combination of products, services and technology are in the best position to capitalize on new business.

"It's an exciting time," Delph says. "We have an opportunity in a mature industry to create growth and innovation—to create models that differentiate [us]. Rather than sit around and wait for our competitors' moves, we have to say 'how do I separate myself even further?'" ■

division supplies customized sealing solutions to customers in automotive, health care, civil engineering, consumer goods and similar industries.

The acquisition brings together companies with complementary product and service offerings and fits Daetwyler's strategy to grow in North America, Asia and elsewhere in Europe. It also combines Daetwyler's focus on maintenance, repair, and operations (MRO) markets with Premier Farnell's focus on design engineering business.

Commenting on the acquisition, Daetwyler's Chairman of the Board Ulrich Graf said, "Premier Farnell and [Daetwyler] both have long and successful histories in high-service distribution for electronic components. By combining forces, we expect to significantly increase our competitiveness and extend our product range, facilitating a one-stop-shopping experience for our wide range of customers from a multitude of industries."

Premier Farnell goes to market as Newark element14 in North America and ranked 9th on *Global Purchasing's 2016 Top Electronic Components Distributors* report with $1.5 billion in

JEFF KERNS | Technology Editor
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An Infrastructure-Free IIoT?

Technology is expanding faster as connectivity offers sensing and control, preventive maintenance, supply-chain optimization, and full remote control of industrial processes.

Just as an integral becomes more accurate as it increases its subintervals (the value of "n"), so can industrial processes through offering more data points. Traditionally, a technician might check gauges a few times a day, week, or month. However, if a gauge indicates that nothing is wrong, or it is within an acceptable range, the technician may not make a note of the gauge reading. Attaching a cost-effective sensor able to sample and record raw data multiple times per minute, hour, or day greatly increases the process's "n" value. Aggregating more raw data points opens the door for statistical software and algorithms to translate raw data into process information to make maintenance or business decisions.

Automation company ABB says it's the process information extracted from raw data that adds value. Through years of designing and testing motors, ABB has found key parameters to watch for in raw data to indicate properties that hinder performance.

"You need to know what the key condition indicators are for a process," says Tom Bertheau, ABB product manager, condi-

OTTO improves throughput, reduces costs, and is flexible to changing material flow patterns. This infrastructure-free robot offers a payload capacity of 3,000 lb. and a typical return on investment in 18 to 24 months.
(Courtesy of Clearpath Robotics)

As shown in the table, the cost of sensors has steadily dropped over the last decade.

A GENERAL COMPARISON OF ACCELEROMETERS FROM 2004 TO 2015		
Accelerometers	2004	2015
Size	5 × 5 × 1.8 mm	2 × 2 × 1.7
Current	4000 micro-amps	100 micro-amps
Volts	5 V	1.8 V
Cost	+$2 per sensor in bulk	$0.30 per sensor in bulk

tion monitoring. "Raw data alone doesn't tell you anything. Through sensing, it is possible to aggregate raw data, which then uses algorithms and statistical software to communicate process information that tells a user that they might have a bearing or cooling problem."

For example, temperatures in a motor can increase due to varying loads on the shaft or voltage from the power supply. Installing a sensor package able to measure and communicate these variables not only alerts a technician that maintenance is needed, but will help troubleshoot a temperature problem. If voltages fluctuate within operating range, it wouldn't be reason for alarm. However, if fluctuating temperature and power consumption presented a technician with a warning to pay closer attention to the input voltage, it may improve the motor's lifecycle. Low voltage can increase the amperage of the motor, causing overheating. High voltage can push the magnets to a point of saturation that draws excessive current while not providing much benefit. In addition, while motors can handle some variation in voltage operating beyond these limits, high or low voltage, causes stress that often correlates to an increase in amperage and temperature, and a decrease in lifecycle.

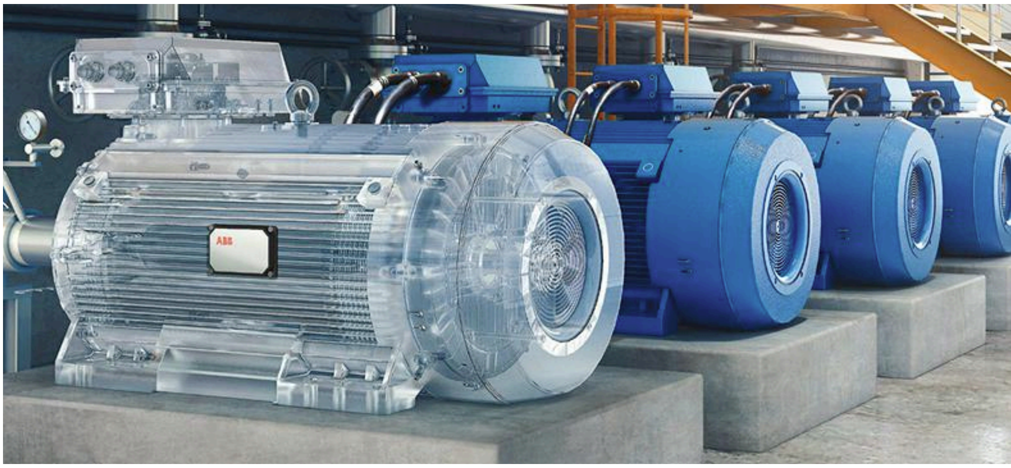
While new machines are integrating sensing technology, older or legacy equipment may not have this ability. Some companies developed sensor packages that can retrofit to legacy equipment to solve this problem. However, knowing where to start is the question. Often, companies are slow to integrate because the cost to replace is high, and retrofitting may open a myriad of problems managers many not understand how to navigate.

COMMUNICATE THE BENEFITS OF RETROFITTING

The first step toward retrofitting is for engineers and plant technicians to communicate to develop an Industrial Internet of Things plan with managers. A root-cause analysis for key information the company needs for maintenance plans or managerial decisions can reduce the amount of IIoT devices in a plan. This keeps the system more cost-effective and less complex. In some cases, it is possible to see that an IIoT device might have the greatest value by integrating it into a low-cost piece of equipment.

For example, low-voltage motors are popular for multiple reasons, but a big one is the price. Investing money to connect such an inexpensive piece of equipment, such as a low-voltage motor might seem pointless. However, "many customers used low-voltage motors," said Bertheau. "We found roughly 50% of industrial energy goes into low-voltage motors and with an approximation of about 3 million motors in the field this represented a lot of power." In areas where electricity is expensive, such as in Europe, ensuring these motors are running efficiently adds up. In addition, while the motors are cost-effective downtime for unscheduled maintenance can easily cost more than the motor. Now, the idea of investing money into an IIoT device for an inexpensive part sounds more logical.

ABB is offering sensing technology for low-voltage motors. In some of ABB's tests with sensing technology, downtime was reduced up to 70%, and ABB estimates preventive maintenance



Sensor packages help connect IIoT with services and people. ABB released a sensor package to add features without the need to add infrastructure. This sensor package is equipped with a battery that can last for five years and enough memory for about a month's worth of data storage. A technician only needs to walk within a few meters of the sensor package, with a smartphone, to keep the value-added data synchronized with the software on the internet. *(Courtesy of ABB)* will extend the life of the motor by 30%. Bertheau adds, "This data can be used to improve motor efficiency by 10%. Not completely through peak performance by ensuring it runs with good bearings and alignment, but by monitoring the power input and output. If you notice you are using more energy than you need, you could replace the motor with a smaller one that will use less energy. It might also be possible to modify the drive to be more efficient for the application."

New motors can come with sensors built in, but there can be greater value in retrofitting, as there is little value in replacing working equipment. Informing technicians about bearings going bad through the process data can check inventory for the replacement parts needed for the job and schedule maintenance at a convenient time.

INTERIM APPROACHES

Many companies may not be ready to update equipment and PLCs with IIoT technology, but they still want the added benefits that connectivity can provide. This has led to branch technologies that use sensor packages with Bluetooth low energy and Wi-Fi. These new smart sensors and sensor packages may need to be wired and programmed into the existing control system or require a power source. But a trend is to offer sensing capabilities while being as independent as possible. Sensor packages are coming with batteries that will last for years and wireless links. As a result, with or without a system or infrastructure in place, it is possible to add connectivity to a process. This eliminates some of the concerns about utilities and patching in a new technology with a legacy technology.

"Ideally, enterprise information technology (IT) systems should include or accommodate architecture that is based on the Industrial Internet of Things, which leverages internet protocol down to the sensor level," says Erik Dellinger, manager for the IoT for Kepware. "While IIoT is gaining momentum, the reality today is that enterprise IT systems must interface with older technologies. Innovative suppliers are meeting this challenge with unique, easy-to-use, and cost-effective technology that enables cloud-based, Big Data solutions to collect and organize data. Called intelligent data aggregation, it revolutionizes the implementation of an enterprise system."

This sensor-based approach reduces integration time and cost, but it can act independently or with current IIoT programs. For example, the Fujitsu components division recently teamed with Cratus, a sensor technology company, to offer sensor packages that can take advantage of the use of smartphones. "There has been a movement for companies to use employees' personal cell phones for business purposes, whether it is for company email or installing an app for wireless communication," says Bruce DeVisser, Fujitsu components product manager. "Technicians can document information by opening up an app on their phone and simply walk up to a device and use its Bluetooth or near-field communications (NFC) to update

Developer boards offer a way to tinker with the IIoT. Systems will often include multiple ways to connect, such as Wi-Fi, Zigbee, Bluetooth, etc. For example, Samsung's ARTIK 5 and ARTIK 10 Developer Kits are geared toward the Internet of Things. The kits include multiple ways to connect, plus a power supply, and a USB connection for programming.

information." A technician can have an app or dashboard on a smartphone that updates information when the technicians are in range and transmit this data to the internet through the Wi-Fi connection in the phone. Once the data is on the server, software is able to produce process information and send it wherever it is needed—even back to the technician's phone.

SECURITY RISKS

However, simplifying access to equipment and information means it might be easier for the wrong person to access it. Security is also relatively simple with these types of sensor packages. If someone maliciously gains access to your system, a sensor package with this type of connection generally cannot change or impact the device being monitored. For example, a hacker can't overload the sensor package to cause a motor to shut down. Hackers, if they could access the server, Wi-Fi, Bluetooth, etc., would only be able to see how much a company's motor is vibrating. If it is possible to link this information into a feedback loop into a PLC program, there may be a chance for malicious acts. But most sensor packages, for now, seem to be focused around informing humans what might need to be changed or maintenance, not control of the machines themselves.

ADDING RF

Another trend for wireless sensing is to offer remote control. Technically, devices that are controlled remotely might not need to be connected to the internet. Yet, connected RF devices can offer IIoT-like sensing and control. From welding to construction equipment, RF is able to connect, communicate, and control. This IIoT-like add-on is focusing on the same features as the previously mentioned trend—adding more information and possibly control with minimal capital and infrastructure.

Other wireless technologies are helping to reduce the infrastructure needed for connected devices. For example, self-driving robots can use photo, infrared, and touch sensors to navigate an environment. They may provide better or more efficient service by using light detection and ranging (LiDAR). LiDAR technology today is still relatively expensive, but advances have shrunk the technology to the point where it can be implemented directly on a circuit board. It also is available for a dramatically reduced price.

Impressively, self-driving robots can incorporate radio frequency, LiDAR, and cameras to "observe" and drive safely in an area. These technologies can take up computational power, but can't interfere with the robot's ability to drive. Self-driving robots wouldn't be marketable if they crashed into things because they were buffering.

"We must do more with less," said Simon Drexler, director of industrial solutions at Clearpath. "It isn't enough to make a robot that can accomplish a task, it must show a return on investment or justify itself economically. One of the ways a material transporter, such as Clearpath's OTTO, does this is not just by moving things independently, but offering extra data. The software allows the robot to give data on the most optimal paths and provide insight on how to improve operations. For example, if the most popular parts are at the back of the shop, the computer can suggest moving them to the front to save time."

While mass production is reducing cost, providing in-house logistics, preventative maintenance, and more information to make decisions, IIoT technology is increasing its economic feasibility and companies need to be educated in this technology to stay competitive. When leveraging IIoT technology correctly, the question isn't "will there be a return on investment?" but "how long will it take to get the return?" With new retrofit products, the time for a return on that investment is being reduced. md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ADVANCING TOWARD Safer Automation Design

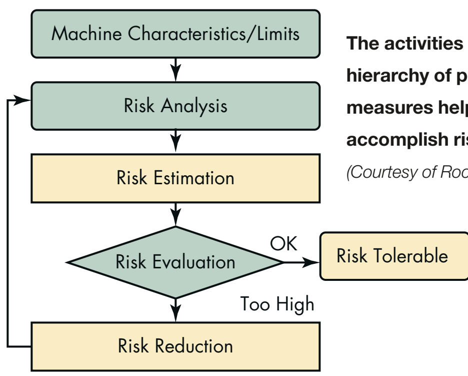
Progress made in safety regulations and standards, along with product safety features, helps ease integration of safety methods for motion-control systems.

Since the 1970s, safety has been a part of automation and motion control. The problem has always been that many safety regulations are out of date and safety methods resulted in basic "stop" or "lockout" functions that would halt production.

A "Survey of Occupational Injuries and Illnesses" conducted by the U.S. Bureau of Labor Statistics highlighted that in 2013, private industry employers reported a little more than 3.0 million nonfatal workplace injuries and illnesses. That's an incidence rate of 3.3 cases per 100 equivalent full-time workers.

Nonetheless, in the last decade, many changes have been implemented to improve and better integrate safety. This trend includes a raised focus on safety analysis and smart products that make it essentially harmless to incorporate safety methods.

TYPICAL RISK ASSESSMENT



The activities listed in the hierarchy of protective measures help to accomplish risk mitigation. *(Courtesy of Rockwell Automation)*

MACHINE SAFETY STANDARDS

In the United States, the Occupational Safety and Health Administration (OSHA) and the National Fire Protection Association (NFPA) administer machine safety standards. Overseas in Europe, the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO) are used as the barometer for regulation standards, which are applied at a global level for other countries like China, India, and the U.S.

The multitude of agencies and standards may confuse machine builders and engineers in cases where hardware can fall under more than one standard. If an injury occurs within the U.S., would OSHA investigate and inquire if the machine was as safe as possible? Prior to 2012, a programmable logic controller (PLC) could be built to comply with the European Union's Machinery Directive (EN/ISO 13849-1) but not comply with the NFPA 79, the U.S. equivalent that addresses safety-rated PLC and safety buses. This muddies the waters for engineers trying to build devices that follow the proper safety regulation.

Another hindrance is the current state of safety regulation. Since the 1970s, machine safety standards have been slow and not kept up with the technology. Before 2002, all hardwired components were required to use emergency-stop pushbuttons. This diminished the flexibility to reduce production downtime; it was not until after 2002 that users were allowed to use safety PLCs and software-based controllers.

Similar problems were occurring in Europe, as the EN 954-1 safety standard did not cover programmable electronic safety equipment or failure probabilities as far back as 2009. In 2011, the EN ISO 13849-1 and EN 62061 replaced the EN954-1 that covered all machine and process safety systems sold within Europe.

In the last 10 years, we are seeing safety-standard updates being applied to all major manufacturing countries. Sean O'Grady, a product manager of valve terminals and electronics

HIERARCHY OF PROTECTIVE MEASURES

	Protective Measure	Examples
Most Effective	Eliminate the Risk	• Design It Out • Process Substitution
	Physical Guarding	• Fencing or Barriers • Fixed Covers
	Engineering Controls (Safeguarding Technology)	• Interlocks, Light Curtains, Safety Mats • Monitoring Relays, Safety PLCs
	Awareness Means, Personal Protective Equipment (PPE)	• Signs, Warnings, Annunciation Lights • Safety Glasses, Gloves & Footwear
Least Effective	Training & Procedures (Administrative Controls)	• Work Procedures • Lockout/Tagout (LOTO)

The risk-assessment lifecycle is designed for continuous improvement of the safety program.

(Courtesy of Rockwell Automation)

from Festo, says, "Globally, many countries and industries have taken advantage of the groundwork created by the European Union (EU) machine directive of 2006. For instance, EN ISO 12100 covers general principle of design for machinery safety, while EN ISO 13849-1 deals specifically with safety-related parts of control systems. Within the U.S., for example, various regulations and industry standards reference these documents directly."

EN ISO 13849-1, for instance, applies to many technologies, including electrical, pneumatic, hydraulic, and mechanical. This standard provides requirements for the design and integration of safety-related parts of control systems, including some software aspects of safety-related systems. It can also be applied down to the component-parts level of the system.

DESIGNING WITH SAFETY PROGRAMS

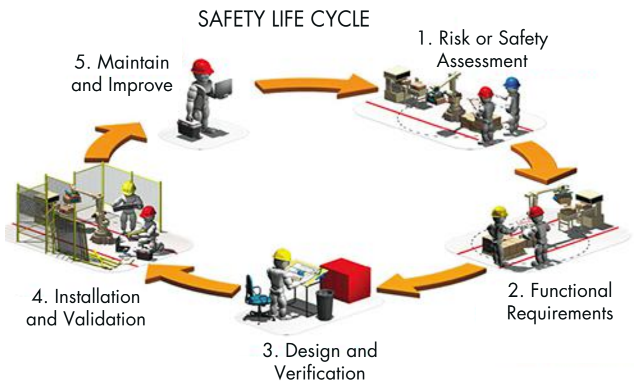
With new standards come new procedures. Risk assessment, formerly known as hazard analysis, is the process of identifying a risk (or hazard identification), risk estimation, and developing a risk-mitigating protective measure. Risk assessment is the basis for defining machine safety. The definition of risk assessment has been added to ISO standard 12100, and is included in other international and regional standards, too, including IEC61508, IEC61511, and IEC62061.

To help mitigate risks, companies should be using safety programs to identify and solve possible risk situations. These risks can not only harm human beings physically, but may also affect revenue and/or earnings. Manufacturing institutes several safety programs:

- **Occupational Safety and Health:** Employee training and education of safety procedures and proper machine use.
- **Product Safety:** Safety warnings for proper use, machinery, and equipment repair maintenance.
- **Machine Safety and Safeguarding:** Physical safeguarding, safeguard controls, and safe work procedures.
- **Environmental Safety:** Clean-up procedures and proper containment requirements to avoid air and ground contamination.
- **Property and Equipment Safety:** Systems that protect capital investments, such as automated sprinkler systems.

Safety programs are comprised of risk analysis, risk-mitigation measures, and training/supervision related to work procedures. Risk analysis is the first step in which two quantities are measured: the magnitude of potential loss and the probability that loss may happen.

To effectively identify a risk, one analyzes the employee activities and the potential risks they may encounter through defined work practices, or the potential risks that employees can introduce due to lack of training or experience. Risk analysis should also identify risks caused by potential environmental exposure, limited safety protection measures, improper installation, or equipment failures. Not only are these risks inherent to workers, but also to plant equipment and the environment.



The Safety Life Cycle from Rockwell Automation is one example of a safety program, designed to implement safety procedures and increase efficiency of a production process. *(Courtesy of Rockwell Automation)*

The process defined by these standards is one of a lifecycle approach on how to implement an effective process to identify and quantify machinery-related risks. The risk is quantifiable in terms of severity, frequency of exposure, and probability of avoidance. To lower the quantified level of risk, one implements protective measures.

Protective measures represent any act that lowers the level of risk. This can be done by eliminating the risk through a better design, using physical guards, including engineering controls like light curtains or safety PLCs, and providing better training and procedures. These protective measures should be documented and their effectiveness recorded for future evaluations. Using documentation in the risk-assessment process is critical so that companies are able to show their due diligence and best engineering practices.

After implementing protective measures and proper documentation, the next step is training and supervision. All operators require proper training to effectively use the machines and perform their tasks safely. The tasks and roles of the operators should be clearly defined, along with having full knowledge of their processes.

SAFETY PROGRAMS AND COMMON TERMS

One example of a safety program is Rockwell Automation's Safety Life Cycle. Rockwell Automation utilizes different safety methods and procedures to help reduce the time to design and develop safety solutions. The Safety Life Cycle improves safety by identifying the steps required to properly assess and mitigate any risks.

The first step is to perform a hazard or risk assessment by identifying hazards and estimating their associated risks. The next step is determining the functional safety system requirements, which involves evaluating safeguard options based on industry standards.

Following those two steps is the design and verification of the system. Designing systems includes planning the system architecture, documenting safety-circuit design, and procuring the appropriate materials.

Once the design is complete, the next task is to install and validate the system. This involves operating the system, ensuring it responds correctly to failures and safeguards that are in place. Once verified, the last step is to maintain and improve the system. Continued monitoring and recording of the system's performance is essential so that the results can then be integrated back into the top of the lifecycle for a better risk assessment.

The PowerFlex 755 with safe-speed motion monitoring, developed by Rockwell Automation, allows for maintenance access without requiring complete shutdown of a device. This improves upon the downtime that would normally impact a production process.

Festo's MS6-SV safety valves offer the VOFA solenoid valve platform with spool-sensing technology for safe stop and reverse motion.

Designing safety programs that adhere to new safety standards also typically involves having to learn new terms. According to Duško Marković, manager of application & specification, and Dr. Carsten Springhorn, quality manager, both from Aventics, "If safety of a machine depends on a correct function of the control system, it is called 'functional safety' with special requirements on the availability of the safety function. In functional safety, the main focus is on 'active' parts of the control system, meaning components of control systems responsible for identifying a dangerous situation (input/sensors), deriving the suitable reactions (logic), and implementing these measures in a reliable form (output/actuators)."

Festo Corp. has listed some of the common terms that design personnel should get to know in order to comply with the new standards:

- **$B10_D$:** The number of switching operations at which 10% of samples fail. This value is required to calculate the overall performance for a safety circuit. It only applies to the dangerous failures and is given over a lifetime of 10 years.
- **CCF:** *Common cause failure* is generally the single failure or condition that affects the operation of multiple devices. Normally this would be considered an independent failure—isolated to an individual part or process. In reality, it can have a domino-like effect that will affect other subsystems or parts.
- **DC:** *Diagnostic coverage* involves the combination of hardware, software, and testing of related diagnostics. It is the ratio between the probability of detected dangerous failures and the probability of all dangerous failures.
- **DC_{avg}:** The *average diagnostic coverage* for a system or component.
- **SRP/CS:** *Safety-related parts of a control system* refers to all safety-related control elements regardless of the type of technology: electrical, hydraulic, pneumatic, etc. It does not

specify safety functions or performance levels.

- **Designated architecture:** The predetermined structure of an SRP/CS. Choosing a system architecture is one of the first steps of the safety program.
- **MTBF:** *Mean time between failures* indicates the mean time between two failures for a particular component.
- **$MTTF_d$:** *Mean time to fail* is the mean time between two dangerous failures.
- **PFH:** *Probability of failure per hour* is the probability of a failure per hour for that component to assist in detecting random hardware safety integrity.
- **PFH_d:** This represents the *probability failure per hour for dangerous failures* for that component to help detect random hardware safety integrity.
- **PL:** *Performance level* of the SRP/CS to operate a safety function and to reliably achieve it.
- **PL_r:** The *performance level required* is the goal for designing the actual safety circuit. The result of determining the designated architecture is in part to determine the required performance level of a safety function.
- **SIL:** *Safety integrity level* is a common term used by safety component and device manufacturers when designing safety systems and circuits.

MODERN SAFETY TECHNOLOGY

According to Kyle Hall, product engineer of fieldbus technology for Turck, the greatest challenge in implementing new safety programs is to "get customers onboard with the safety assessment and validation procedures." The problem is a familiar one: Fear over implementing new standards and systems into current architectures. However, new technology and products are now being designed with safety in mind.

Modern advances into safety have helped ease the installation of safety programs by integrating safety functions into their products. Jim Grosskreuz, product manager for Rockwell Automation, speaks to how "safety is becoming a core function of motion control." This is evident in Rockwell's product line, which includes the PowerFlex 750 series with safe-speed motion monitoring. Three stages of safe-speed monitoring allow for better operation of servos:

1. Safe direction: Configured to monitor the safe direction, a shutdown occurs if the motor attempts to rotate in the dangerous direction.

2. Safe limited speed: The safe-speed module initiates a shutdown if the motor exceeds a pre-determined speed (the safe max speed). It then ramps down to a safe speed and the maintenance door control logic is set to unlock. This enables access to the machine for cleaning or clearing. A risk assessment is needed to determine the safe maximum speed for the axis.

3. Standstill (zero) speed: The safe-speed module initiates a safe stop upon deactivation of the inputs. Standstill speed is used to declare motion as stopped. The system is at standstill when the speed detected is less than or equal to the configured standstill speed. The door control logic is set to unlock when standstill has been reached.

This control logic allows for safe access and maintenance to the machine, but does not stop production. This reduces downtime by 60 to 70%.

Festo, for instance, integrated safe inputs and outputs directly into its pneumatic-valve terminals. In the past, a machine designer would need to specify an appropriate safety relay or safe output, and perform all of the required safety calculation and documentation. The designer would then have to manage the proper installation, commissioning, verification, and validation of the resulting safety function to ensure proper function and legal compliance. By selecting an integrated solution, time and effort is reduced while also providing the designer with additional diagnostic capabilities and more complete documentation, which facilitates legal compliance.

TURCK's TBPN block is a hybrid PROFIsafe / PROFINET station allowing safety I/O to be distributed around a machine or plant over the existing PROFINET / Ethernet network.

Ethernet connections offer new ways of connecting machines to safety devices that can regulate other devices. An example would be the TBPN Ethernet hybrid input/output (I/O) safety block developed by Turck. The block can execute safety functions locally or exchange safety I/O with a variety of controllers. On the safety side of the PROFIsafe/PROFINET module, the user has two safety inputs to connect different safety sensors, such as light curtains or emergency-stop buttons. Two additional safety channels can be used either as inputs or bipolar outputs.

Two of the I/Os can also be connected as IO-Link masters. When combined with Turck's I/O hubs, users can connect up to 32 additional I/Os to the module. The non-safety digital I/O as well as one of the IO-Link ports can be safely switched off by internal safety circuits.

These products are designed in accordance with the latest safety regulations. Recent changes in standards allow safety regulations to be applied internationally, and they have been updated to include the latest technology advances. Such product advances now make integrating safety an afterthought. md

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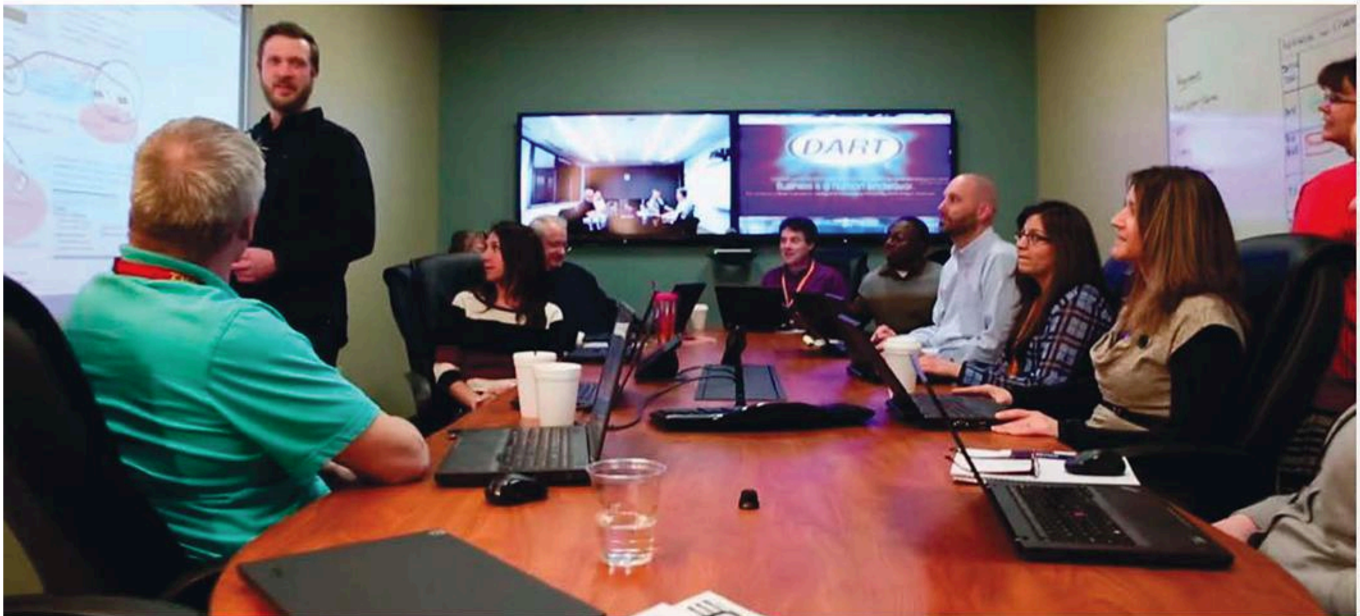

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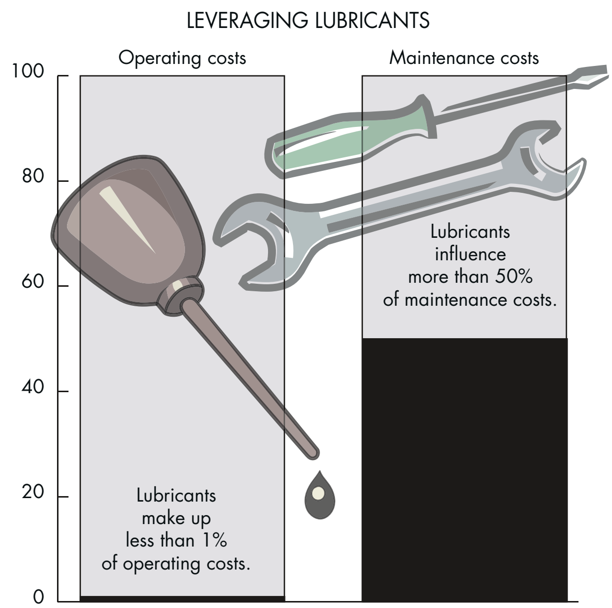
Proper lubricant selection significantly reduces failures and increases product efficiency. And PFPEs are often the best choice.

The average machine has 20 grease points to maintain. That means 20 points of potential failure, all of which can ultimately lead to unplanned downtime and maintenance expenses. In up to 50% of all machine failures, the cause can be traced to improper bearing lubrication.

With proper lubrication, however, these failures—along with their associated costs, warranty claims, and downtime—are largely avoidable. In many cases, perfluoropolyethers (PFPEs) are the ideal long-lasting lubricants for extreme environments that require either chemical inertness or extreme pressure and temperature capabilities.

High-performance PFPE lubes, such as Krytox lubricants, offer the broadest performance capabilities. Although these lubricants cost more initially, the added expense is more than recovered through the longer component lifespans, reduced warranty claims, and corresponding increase in consumer value.



THE PFPE ADVANTAGES

Broader performance capabilities sound great, but what does it really mean in terms of lubricants, and how will they affect premature bearing failure?

The ASTM D-3336 endurance test evaluates the life of greases in ball bearings by rotating a bearing at a set speed and temperature and measuring the bearing's effective performance life. In this test, PFPEs routinely outperform hydrocarbons. At 10,000 rpm and 350°F (177°C), most lubricants fail in less than 1,000 hr. PFPEs last significantly longer, with one grade (Krytox AUT 2E45 grease) performing for more than 25,000 hr—the equivalent of almost three years—without failing. The test was actually stopped before the lubricant failed.

In ROF tests, which also measure the useful life of greases as a function of various temperatures and speeds, PFPE greases lasted 21 to 64 times longer than competitive lubricants. PFPE's extended performance capabilities let some components operate for life without ever being re-lubricated; they're essentially considered "lubed for life." Other components can get by using significantly less PFPE lubricant per application.

PFPE lubricants also out-perform other lubricant classes both in high and low temperatures. As machine temperatures

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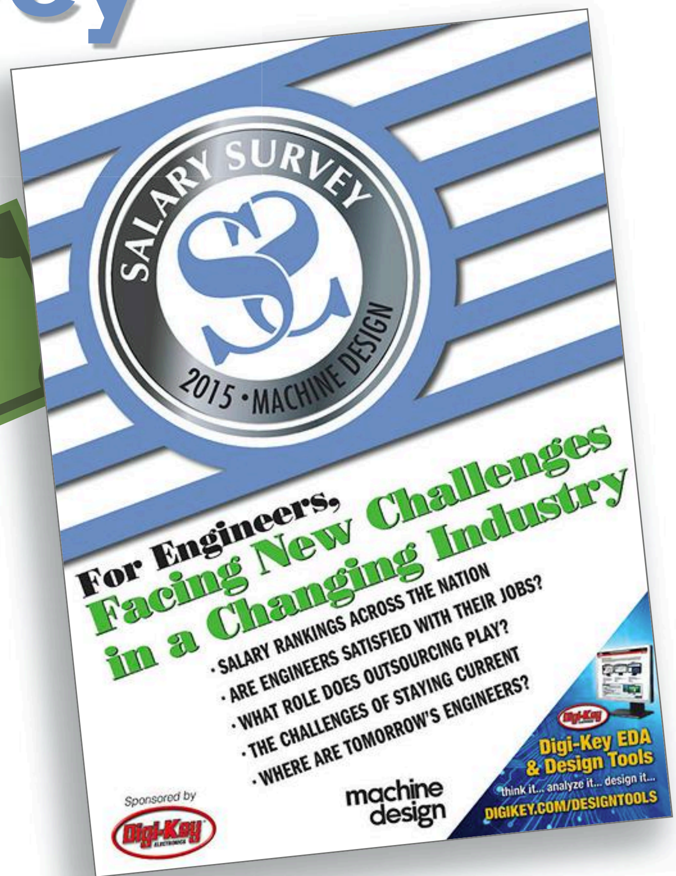

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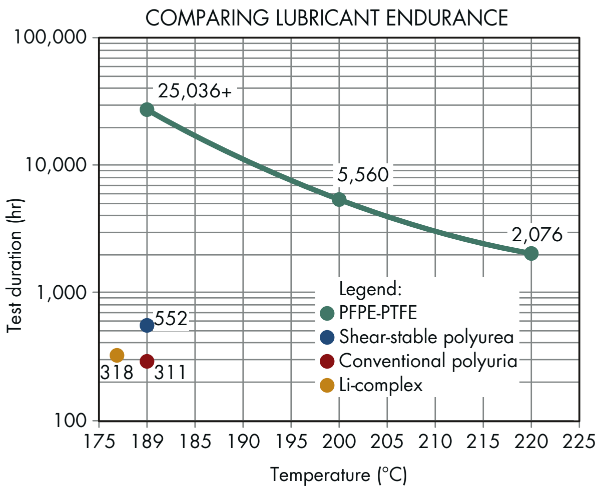
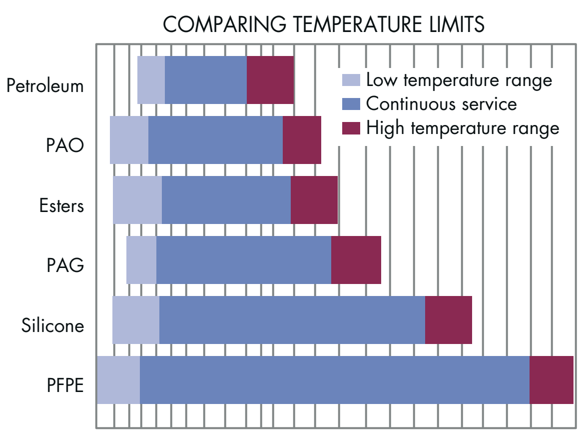


The results of an ASTM D3336 test of the life of ball bearings as a function of the lubricant used shows that PFPE/PFTE grease does the best. None of the other lubricants could last nearly as long.

rise above 248°F (120°C) or fall below 32°F (0°C), petroleum-based lubricants begin to fail, forcing re-lubrication and production interruption. Conventional synthetic lubricants don't perform much better. PFPE lubricants are effective up to 400+ °C (752+ °F) and down to −75°C (−103°F).

In a side-by-side high temperature test, hydrocarbon and PFPE (Krytox GPL 227) greases were placed in an oven at 232°C (450°F) for 40 hours. The hydrocarbon grease, which was specifically advertised for high-temperature applications, lost 40% of its weight and ceased being an effective lubricant. Some of it also degraded into tar. The PFPE remained unchanged in weight and appearance with its lubricating abilities fully intact.

One of PFPEs' greatest advantages is their stability across a wide variety of operating conditions despite material exposure. Unlike almost all lubricants, PFPEs are chemically inert, meaning they do not react with chemicals or materials. Furthermore, they are nonflammable and nontoxic, repel water and oil, resist solvents, and are compatible with oxygen and reactive gases, as well as most common elastomers, plastics, and metals.



The PFPE lubricant outperformed other lubricants when it comes to high- and low-temperature performance.

Even with these extreme capabilities, PFPEs are completely safe to handle. According to the Safety Data Sheets, a Krytox PFPE lubricant is safer to handle than sugar. In fact, PFPE lubricants are available in several medical and food grades, are environmentally friendly, and do not contain hazardous VOCs. The PFPE oils are also recyclable.

Lastly, PFPE greases offer better performance under pressure. PFPE lubricants' high load-carrying capability and good lubrication characteristics under boundary and mixed friction conditions make them ideal for use in high-loading and slow-speed conditions.

In a Pin and Vee Block Test (ASTM D-3233)—an evaluation of wear and friction using extreme pressure and line contact sliding motion—PFPE lubricants reach the maximum load in the test, while hydrocarbon lubricants display signs of extreme wear and often cause catastrophic early failures.

PFPE lubricants also outperform hydrocarbon lubricants in a four-ball extreme pressure test (ASTM D-2596), which measures a lubricant's performance under extreme pressure using a point-contact sliding motion. The test steadily increases the load on a rotating steel ball in contact with three fixed balls until they seize and welding occurs. The loads and wear scar diameters leading up to the weld point are used to calculate the load wear index (LWI), an indication of how well the grease prevents wear when operating below the weld point.

Petroleum greases feature a LWI of approximately 50, and synthetic hydrocarbons have LWIs close to 100. PFPEs maintained stability at LWIs more than twice the LWIs of hydrocarbon lubricants, and matched or exceeded the LWIs of synthetic hydrocarbons.

THE PERFORMANCE GAP

Lab data is important, but how does it translate to industrial applications? Here are a few examples of how OEMs and industrial manufacturers used PFPE lubricants to reduce bearing failures and improve overall performance.

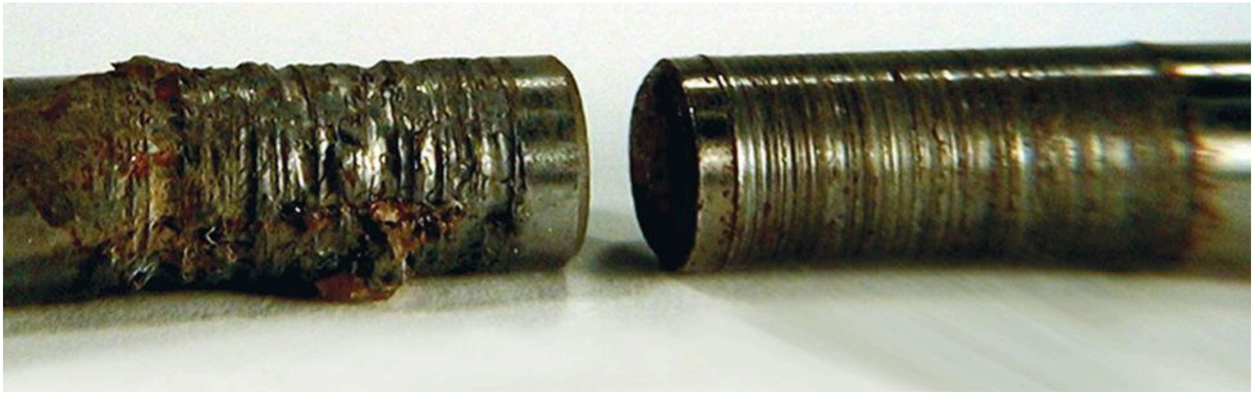
A copper rod manufacturer believed lubricating its rollers' bearings—which saw operating temperatures over 400°F (200°C)—with a synthetic hydrocarbon grease every four hours was its best choice. But after switching to a PFPE lubricant, it lowered the re-lubrication interval to a month and went from replacing 186 bearings annually to just four, thus cutting bearing failures by nearly 98%. Switching to PFPEs also reduced maintenance costs, parts costs, and production downtime. A cost analysis showed a total annual savings of almost $67,000.

A polyethylene manufacturer was struggling with maintenance costs and frequent shutdowns of its high-capacity, sealed centrifuge because of hazardous material exposure. Specifically, a mineral-oil lithium thickened grease used in the centrifuge bearings leaked and led to premature bearing failures. The leaking solvent also created an additional hazardous exposure threat to workers. The new lubricant needed to be non-reactive and insoluble to hexane, provide enough adhesion to avoid leaks, and remain fluid enough to deliver the required lubrication.

The manufacturer turned to PFPEs. Since doing so, unplanned shutdowns and re-lubrication have both been reduced, with re-lubrication down to twice a year. These dramatic results decreased maintenance costs and increased worker safety.

One chemical manufacturer was plagued by frequent bearings failures in its reformer furnace blower due to the lithium grease decomposing at the 554°F (290°C) operating temperatures. The company sought out a chemically inert lubricant capable of performing alongside ammonia with a once-a-year re-lubrication cycle due to the production losses, maintenance safety risks, and potential fire hazard associated with shutdowns.

A high-temperature PFPE lubricant designed to provide its best performance between 392°F and 572°F (200°C and 300°C), met the challenge. Because PFPEs are nonflammable and chemically inert, safety improved. As a result, the bearings in the reformer furnace blower do not lose lubricity and the maintenance schedule can remain confidently at 12-month intervals, cutting down on the company's operating costs and minimizing safety risks.

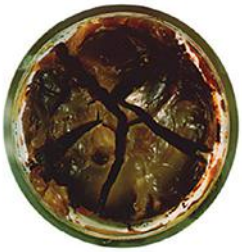


After a Pin and Vee Block Test (ASTM D-3233), the part that was coated with a hydrocarbon-based lubricant (left) shows sign of extreme wear and friction. The one using a PFPE lubricant reached the maximum load in the test virtually unscathed.

QUANTIFYING THE TOTAL COST OF OWNERSHIP

Lubricant selection directly affects the total cost of ownership (TCO) for any piece of equipment. According to *Power Magazine*, lubricants make up less than 1% of a plant's operating cost, but can directly influence more than 50% of a plant's maintenance costs. Combine that with downtime and productivity loss, and lubricant selection significantly impacts end user TCO.

Here's an example: A pulp and paper manufacturer used a PFPE grease to prevent unexpected bearing failures in its pulp dryer, which had previously experienced approximately 10 bearing failures per year. The new grease saved the mill an estimated $1.7 million in downtime each year on the pulp dryer alone. If the company had extended the use of PFPE lubricants to the plant's 3,000 electric motors, which ran with-


Hydrocarbon

PFPE

After a heat test, the hydrocarbon-based lubricant was dried out and useless, and some had been converted to tar by the heat. The PTFE lubricant, Krytox GPL 227, was still fresh and able to do its job.

out re-lubrication and suffered regular breakdowns, the mill could have saved an additional $6 million.

How is that possible? We know the cost of operating a single 50-hp electric motor without any re-lubrication for six years—which is the average size, state and lifetime of the plant's electric motors—has an estimated net present value (NPV) of more than $4,800, while the same motor using a PFPE grease has an NPV of approximately $2,700 (a savings of more than 43%). Multiply that savings by the 3,000 electric motors on site and it yields a total saving of more than $6 million over a six-year period.

PFPE's stable, lasting performance under harsh conditions can help generate significant savings over the equipment's lifespan, and specifying the lubricant class upfront can drive sizable end user value. According to another annual cost comparison between a PFPE and conventional hydrocarbon lubricant, PFPEs cost 23.5% less ($1,772 vs. $2,250). md

For more information on Krytox PFPE lubricants, visit Krytox.com/PFPE.

Carbide Tooling Gets Cutting-Edge Geometry

A SPEED-DRILL R4 geometry of carbide round tools offers high cutting speeds and a long useful life for tools that work with gray cast iron, ductile iron, and forged steel. The corner radius design is tangential to the drill point and non-tangential to the diameter, for high-production drilling applications in automotive-engine and chassis components,. Tooling options include standard drill and end mill programs for all material groups; special tools include step drills, core drills, reamers, tapered drills, tapered reamers, and combination tools (drilling–milling) and provide outstanding cost/performance ratio. They will be featured in September at IMTS in booth #W-1292.

MONAGHAN TOOLING GROUP, www.MonaghanTooling.com,

Cordless Tools Come in a Range of Configurations

UP TO SIX LiveWire cordless tools may be controlled on the plant floor via a single controller for production applications that require torques from 3 to 90 Newton-meters (special versions available upon customer request). The system includes an LCD interface with configurable buttons and status indicators, and offers precise torque, angle, and speed control.

Tools may be used up to 1,700 rundowns per battery charge; they extend preventative maintenance to 500,000 cycles– twice that of the previous design. They are available in right angle, pistol grip, crowfoot, and tube-nut configurations. A 2 right-angle model is also available for a compact, lighter design. Its modular-accessory platform allows customization and differentiation by adding a barcode scanner, gyroscope, or tool location module. Tool holders, suspension bails, and protective covers are available for production line integration, along with battery, charger, and power-module options.

CLECO TOOLS, ClecoTools.com

AC-DC Module Features Improved Efficiency

THE PFE1000FA SERIES of ac-dc power modules target industrial and commercial off-the-shelf (COTS) applications, along with LED signage, test and measurement, broadcast, and communications equipment. An upgrade to the previous PFE1000F series, it improves efficiency by 4% to achieve a 90% rating. It incorporates power factor correction, regulation, and input-output isolation into its design and can be used in outdoor and liquid-cooled power systems. It operates from an 85-265 Vac input and its nominal outputs are 12, 28 and 48 Vdc, adjustable +/-20% via a trim-pin.

TDK-LAMBDA, www.tdk-lambda.com

Stainless-Steel Hinges Target One-Way Doors

THE GN 129.5 stainless-steel hinges are available in metric sizes to suit a wider range of systems. RoHS compliant, they are made for doors that are flush with the outside frame, making them suitable for trap doors that must only be detachable from the one side. Once assembled, they cannot be unhinged. The hinge body, pin, and washer are available in 303 or A4 316 stainless steel. Hex nut and serrated washer are made of 304 stainless steel.

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ABSOLUTE MACHINE TOOLS, http://absolutemachine.com, (800) 852-7825

recessed by 2.4 in. from the front of the enclosure, improves its size-compatibility with many applications. The six-slot VMEbus backplane contains passive terminations and ABG connectors to interconnect with horizontally mounted 6U boards to save space. The cooling system consists of fans on the left side of the unit, taking in cool air through a removable filter and exhausting air from the right side. Finally, a rear-mounted custom embedded 5- or 12-V power supply unit provides 400 W of power via an electromagnetic-compatibility (EMC) screened mains inlet. The unit is EMC-screened to a commercial level.

VEROTEC, www.verotec.co.uk, (603) 821-9921

IMTS Features Power-Distribution Connectors

THE MINI POWER Distribution series of connectors targets harsh manufacturing environments and brings a plug and play solution to industrial motors, machines, and power applications. They enable quick disconnect high-power applications and come in 3-pole, 4-pole and 7-pole configurations. A full line of accessories are available including adapter plugs, closure caps and plugs, and integrated cable drops. A variety of tees are also available to create the main trunk cable with quick disconnect drops in order to distribute power to multiple machines throughout the system. The modular design enables users to mix and match assorted parts without the need for hardwiring or specialized tools. Some common applications include automated machine tools, distributed motor control, material handling, packaging equipment, and robotic systems. They will be featured at IMTS in September in booth #E-4152.

MENCOM, www.mencom.com

Pneumatic Pinch Valves Reduce Maintenance Needs

THE MODEL 600 series of pneumatic pinch valves ensure non-contamination of media, while enabling fast change out of tubing and valves in fluid, air, or gas systems that use flexible, disposable tubing. They eliminate adhesive dispensing of viscous, sticky, and corrosive materials that eat away at the internals of wetted valves and constantly drive up the need for replacements. The series comprises three models (603, 604 and 606) that support tubing outer diameters up to 0.375 in., 60 psi media pressures, and hardness ratings up to Shore 70 material. Units are equipped for panel mounting and easy tube loading, and are available in single-acting, normally-open, closed, or double-acting formats. All units weigh less than a pound.

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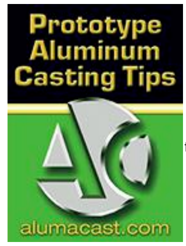

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Impact of Breakthrough Innovations on Design for Manufacturing and Assembly

Design for Manufacturing and Assembly (DFM/A) is a technique well entrenched in most companies that design and build products. Originating in the late 20th Century, DFM originally focused on optimizing the design of components for rapid low-cost production, while DFA focused on optimizing designs for rapid low-cost assembly.

As the DFM/A body of knowledge matured, the focus expanded to optimizing designs for reliability and serviceability. For example, changing the oil filter on a car is a dirty job. Hot engines and tight access spaces caused many service technicians to wish the oil filter was on top of the engine and easy to reach when one pops the hood. Well, by trying to optimize serviceability, it turned out reliability was reduced. Gravity takes the heavy dirt particles to the lowest point possible and a filter on top of an engine won't catch them. And so, oil filters remained where they always were. The point is that when one tries to optimize a specific parameter, another parameter is usually degraded, and tradeoff decisions have to be made.

These days, all kinds of electronics, sensors, and software are making their way into product designs. New plastics, composites, and special alloys are replacing traditional iron and steel designs. Increasingly, there are forces to make designs more environmentally friendly to manufacture and to be recyclable when the product comes to the end of its life.

This article examines the impacts of emergent breakthrough innovation techniques on the DFM/A body of knowledge. In my April 2016 *Machine Design* column, 10 distinct breakthrough innovation techniques were described. These techniques will increasingly affect the designs of new products and their ability to be manufactured or assembled. Some techniques will have great impact; others will have low or neutral impact.

Breakthrough techniques that are software-intensive, such as Big Bang and Digical Innovation, will decrease the need for DFM/A expertise. Techniques that cause products to be "stretched" to meet the needs of consumers at both the high and low ends of the economic spectrum—such as Reverse Trickle-Up and Ambidextrous Innovation—will likely not significantly increase or decrease the need for DFM/A expertise.

Techniques that are technology-driven, such as Disruptive and Emerging Technology Innovation and Lead User Analysis, where entirely new platforms result, will necessitate DFM/A thinking from the beginning. Techniques that migrate and defeature high-end products to address the needs and economic capabilities of low-end markets, such as Bottom-Of-Pyramid Innovation, will also necessitate DFM/A thinking from the beginning. The re-thinking of design approaches, implied by techniques such as Design Thinking, will also likely result in intensive DFM/A activity.

Techniques that apply to both new products and to the redesign of existing products to minimize the environmental footprint (such as Sustainable Innovation) will likely result in the expansion and growth of the DFM/A body of knowledge. "Design For X" capabilities such as Design For Environment, Design For Recyclability, and Design For Disassembly were first postulated many years ago, but there was little demand. In fact, there was actually resistance. Manufacturers did not want to trade off their ability to efficiently turn out products for both speed and cost reasons to maximize their customers' ability to recycle a product at the end of its life. As well, societal values were not at a point where consumers would pay more for environmentally friendly products.

But, times are changing and environmental friendliness is becoming more important. Studies are now showing that businesses and consumers are increasingly willing to pay a premium for products that minimize impact on the environment.

In summary, breakthrough products that disrupt markets and change the basis of competition will affect DFM/A practices in the years ahead. Most breakthrough techniques will increase the need for DFM/A expertise in some way. Sustainable Innovation, in particular, will likely result in the growth of nascent DFM/A approaches where societal values are now becoming great enough to cause designs to be optimized for environmental impact and recyclability. md

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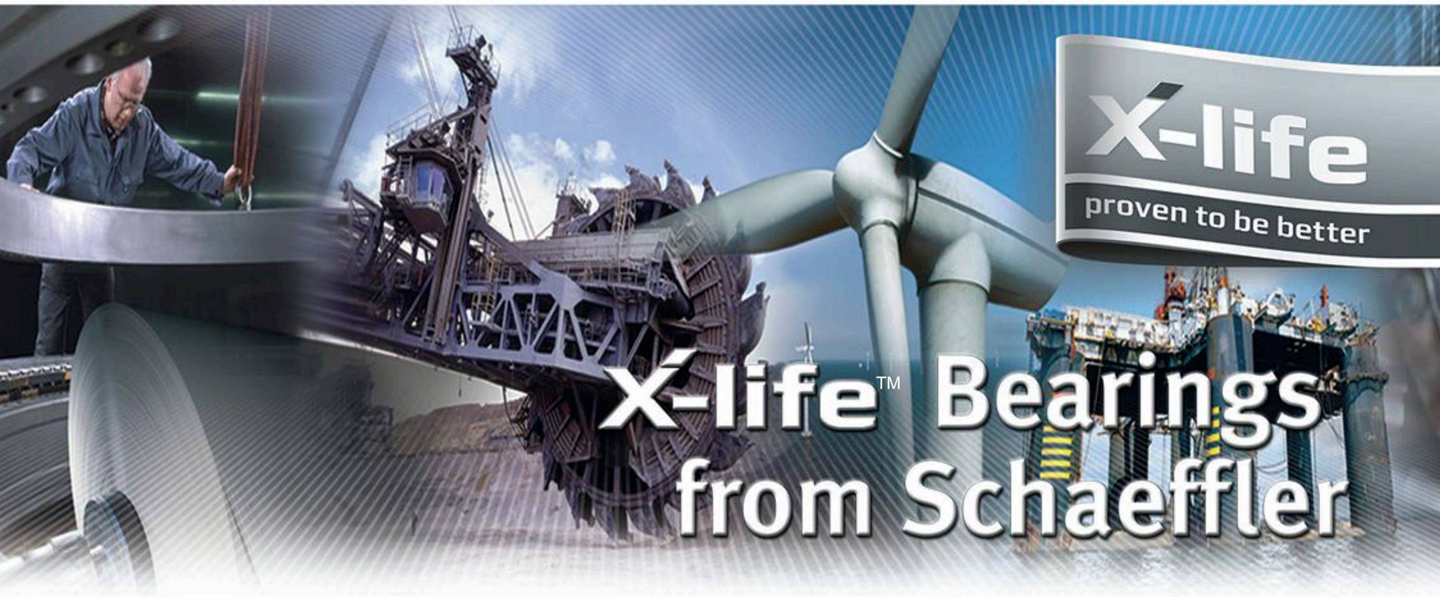

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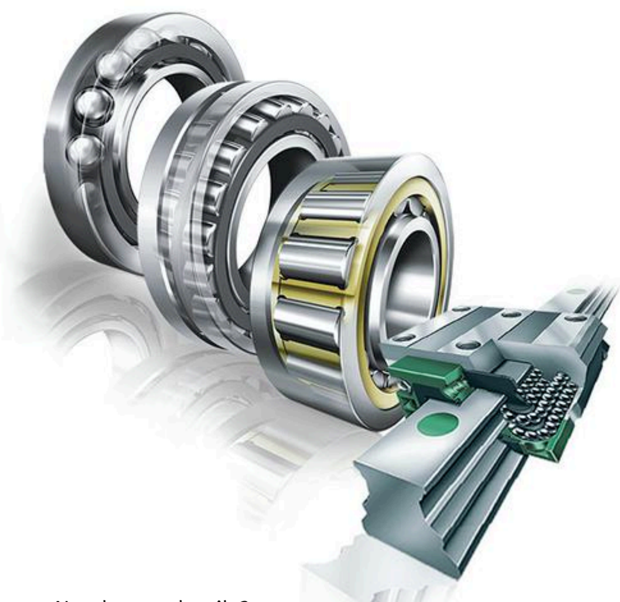

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