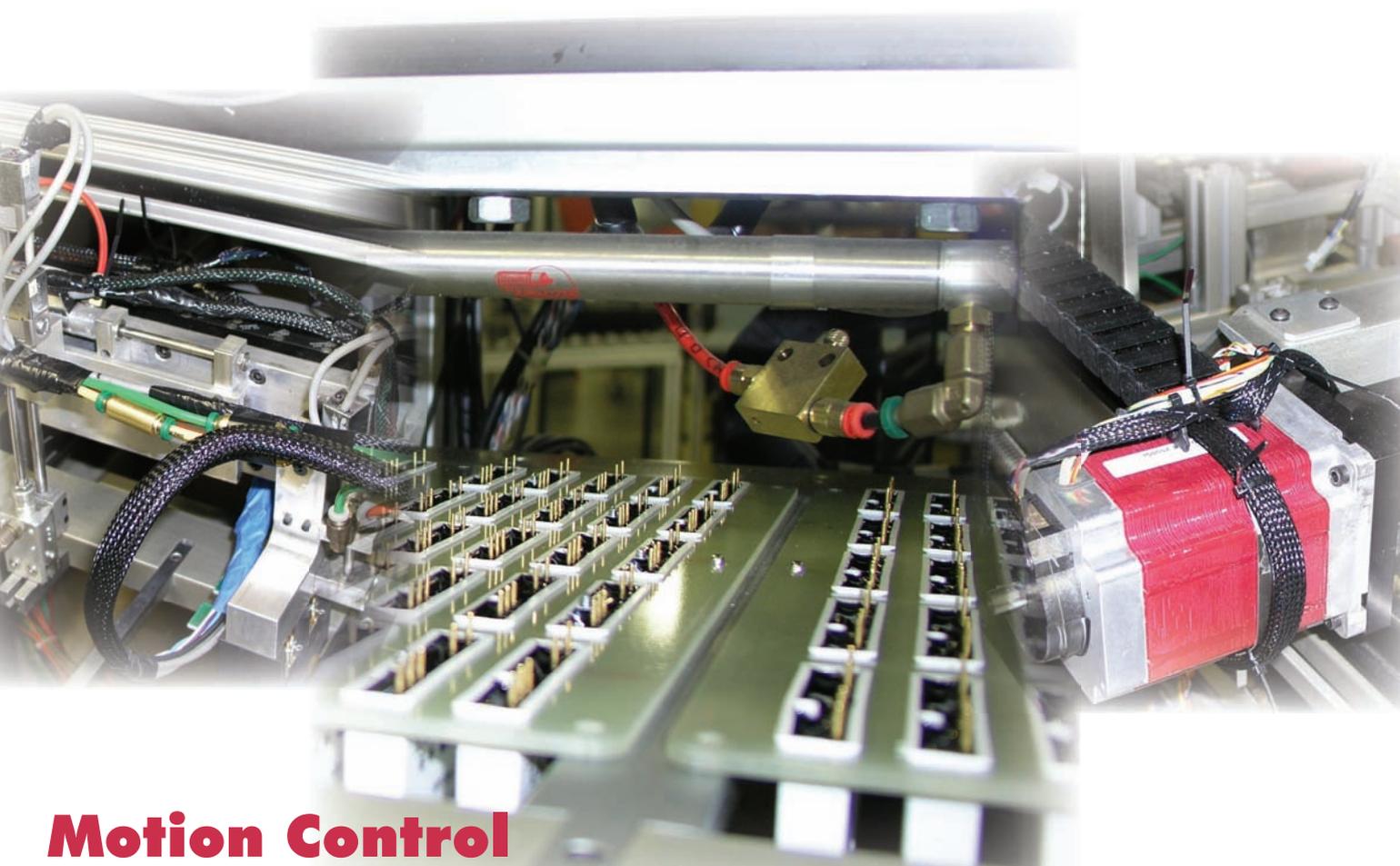


PTE

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Motion Control

- **Don't Sweat the Guitar Fret**
- **Enhanced Product Testing
a SNAP**
- **High-Load Bearings Guide
Chinese Gearboxes**

Technical Articles

- **Couplings, Part II**
- **Improved Sealing
Technology**

Power Play

- **Techno Art in Motion**

The strong silent types.

Huco Dynatork air motors are designed for quiet, high-speed positioning performance.

Dynatork air motors feature very low noise levels compared to other air motors, combined with high torque output (up to 550Nm) and low air consumption. The unique Dynatork design makes them the world's only precise stepable air motor.

**80%
LESS
AIR**

Dynatork air motors can stop-start and drive instantly under load. Near instant reversing under load is achieved through the use of 5 port control valves. Maximum torque is transmitted at start and can be adjusted with a pressure regulator. Speed control can be instantly adjusted to fine limits and programmed control devices can be utilized.

Air motors from Dynatork are increasingly being specified for hazardous or sensitive applications including food processing, paint systems, wood working, and paper converting. These motors can operate underwater and are not affected by airline condensate. Models are available with non-lubricated gas supply eliminating contamination in clean environments. Plastic and stainless steel models are ideal for use in wet, corrosive applications.

*Compared to vane style motors



www.huco.com/pte1208

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Formsprag Clutch
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Bibby Transmissions

 **Huco**
Dynatork

TECHNICAL ARTICLES

Design and Application Criteria for Connecting Couplings, Part II

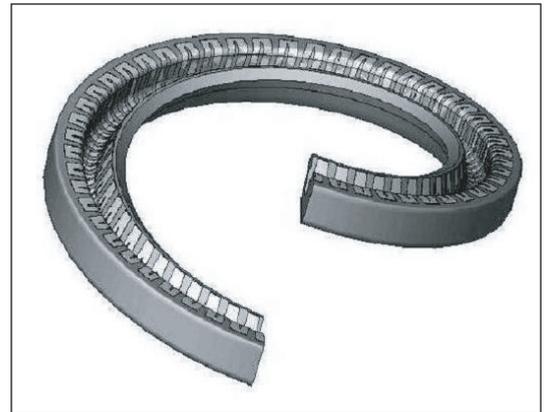
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GEAR TECHNOLOGY

THE GEAR INDUSTRY'S INFORMATION SOURCE

GEAR TECHNOLOGY

brings you technical articles on gear and gear drive design, manufacturing, testing and troubleshooting, from fundamentals to cutting-edge research. If you need to learn about gears, there's no better place than *Gear Technology*,—and it's Free!

Also, if you purchase or specify gears, bearings, motors, speed reducers, gear drives or other mechanical components, visit www.powertransmission.com for the most comprehensive online directory of power transmission components and their manufacturers.

A "Whodunnit?!" IN GEARBOX FAILURE



Francesca isn't just for high-velocity, high-precision, high-temperature applications... she's also the key to successful gearbox design and maintenance.

At AGMA's Gearbox CSI Forum: Critical Tools for Optimum Gearbox Design, that one just has to follow gearbox failure and determining the important process of identifying the root cause to specific failures.

It's bearing life and basic gear mesh analysis methods to produce gearbox failures, but when it comes to gearbox failures, there are a number of overlooked factors: design, fabrication, lubrication and the handling of gear and bearings. "If a failure is not properly addressed, the problem will continue to recur and will result in greater downtime and cost to the gearbox manufacturer," says Raymond Drago, who presents the course along with colleague Joseph Lemski.

The seminar will present design, service and wear problem methodologies that he and Lemski also accompanied by a discussion of the failure and to avoid making the problem worse for one created by the solution.

Primarily aimed towards gearbox designers, many other gear professionals, purchasers, specifiers and users who their gearboxes and help solve and do maintenance people, operators and inspectors who are often responsible for gearbox failures will benefit by understanding the underlying cause of the failure, which is a critical factor in the economic and long-term reliability of gearbox (gearbox) systems," Drago says. "Further, by understanding the country origins, these operators are their better prepared to specify exactly

the gearbox systems they will operate with in their specific environments.

Drago and Lemski have worked with each other for over 20 years in environments that include aerospace, consumer products, medical devices and various industrial applications. They have presented numerous R&D seminars, design roundtable dinners, chief engineers and designers at leading organizations, and Lemski holds the title of chief bearing specialist for the firm.

This seminar addresses a broad range of topics that include design, maintenance, and

www.geartechnology.com November/December 2008 **GEAR TECHNOLOGY 73**

Induction Hardening of Gears and Critical Components Part II

Dr. Volker Buchner

Management Summary
Induction hardening is a heat treating technique that can be used to selectivity harden portions of a gear, such as the flanks, roots and tip of teeth, providing improved wear resistance and contact fatigue strength without affecting the integrity of the core and other parts of the component that may require change. This article provides an overview of the process and special considerations for heat treating gears. Part I, which covered gear materials, design considerations, and design and non-destructive testing methods, can be found at www.geartechnology.com. Part II covers heat treating and surface hardening concepts used with it.

Gear Spin Hardening (Using Rotating Inductors)
Spin hardening is the most popular induction hardening approach, and it is particularly appropriate for gears having face, and modulus or tooth (Figure 1). Gears are rotated during heating to ensure an even distribution of energy. Single-face or multi-face inductors that encircle the whole gear can be used (Ref. 1).

When applying rotating coils, there are five parameters that play major roles in obtaining the required hardness parameter: frequency, power, cycle time, coil geometry and induction hardening patterns that are determined by variables in base metal, frequency and power (Ref. 1).

As a rule, when it is necessary to heat-treat only the tooth tips, a higher frequency and high power density should be applied (Ref. 1).



www.geartechnology.com November/December 2008 **GEAR TECHNOLOGY 47**

STATE OF THE GEAR INDUSTRY

Results of Research on Trends in Employment, Outsourcing, Machine Tool Investment and Other Gear Industry Business Practices

In October, Gear Technology conducted an anonymous survey of gear manufacturers. Respondents were sent by e-mail to thousands of individuals around the world. More than 300 individuals at gear industry locations responded to the online survey, answering questions about their manufacturing operations and current challenges facing their businesses.

The respondents considered how all work at locations where gears, spindles, sprockets, screws and similar products are manufactured. They work for gear manufacturing job shops (47 percent), captive shops at OEMs (50 percent) and design manufacturing shops for maintenance, spares and their own use (3 percent).

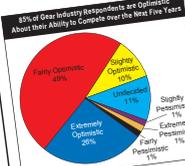
The survey covers gear manufacturing around the world, with 58 percent of respondents working in the United States, and 42 percent outside the United States.

A full breakdown of responses can be found at the end of this article.

What Factors Are Presenting Significant Challenges to Your Business?

- “Availability of capital.”
- “Corporate executive in a U.S. manufacturer of replacement gears.”
- “Available labor (employment) in the U.S.”
- “Customer supply chain pressure that undercuts their ability to source materials and how to support growth.”
- “Purchasing professionals at U.S. gearbox assembly plants.”
- “Disruptive innovation.”
- “Corporate executive in a U.S. manufacturer of marine transmission units.”
- “Commercial viability of OEM manufacturers.”
- “Chief engineer at a U.S. manufacturer of pump shafts for construction/mine equipment.”
- “Corporate chief market driver.”
- “Corporate executive at a U.S. manufacturer of off-road gears.”
- “Continuous product evolution.”
- “SBA representative at an Italian speed reducer manufacturer.”
- “Gear technology solutions.”
- “Production workload at an Indian automotive gearbox manufacturer.”

65% of Gear Industry Respondents are Optimistic About Their Ability to Complete over the Next Five Years



How Do Respondents Describe Their Manufacturing Operations and Technology?

Facilities and Equipment Beginning to Show Their Age: 7%

It's Amazing We Still Have Customers: 2%

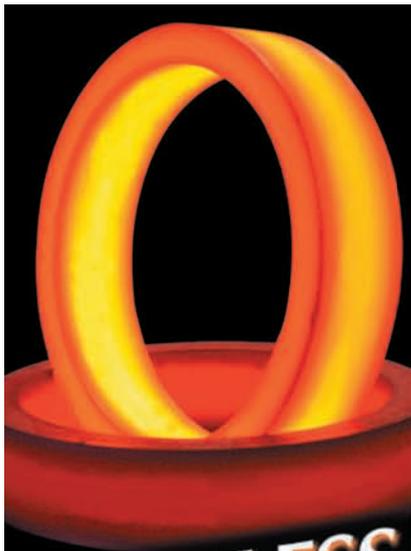
World Class: 21st Century: 16%

Competitive with Most in Our Industry: 61%

Good but Room for Improvement: 24%

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What Can Handle a Crowd of 80,000 and is Still Asking for More?

The screenshot shows the homepage of powertransmission.com. At the top left is the logo for powertransmission.com, and at the top right is the Warner Electric logo. Below the logos is a navigation bar with links: Home, Advertise, Subscribe, About Us, Buyers Guide, Search, Login, and geartechnology.com. The main content area is divided into several sections:

- POWER TRANSMISSION ENGINEERING**: A section for the April 2008 issue of PTE (Power Transmission Engineering). It includes a cover image of a mechanical part and links to "Read Complete Issue (PDF)", "Table of Contents", "Subscribe", and "Submit an Article".
- BUYERS GUIDE**: A central section with a search bar and "Login | Register" links. It features two columns of product categories:
 - A-Z Company List**:
 - Actuators
 - Adjustable-Variable Speed Drives
 - Bearings
 - Chain & Chain Drives
 - Beltting & Belt Drives
 - Brakes
 - Clutches
 - Controls
 - Couplings & U-Joints
 - Complete Product List**:
 - Gears
 - Gear Drives
 - Gear Mfg. Services
 - Hydraulic Power
 - Linear Motion
 - Motors
 - PT Accessories
 - Sensors
 - Other Categories
- FEATURED ARTICLE**: A section with two graphs labeled "Weibull PDF" and "Weibull CDF".
- CALENDAR**: A section with a link to "See All Calendar Events" and a listing for the "10th Annual European Supply Chain & Logistics Summit (May 13-15)" in Düsseldorf, Germany.
- Product Advertisements**: Several logos for suppliers are displayed on the right side, including Fairfield, GTG, Custom Motion Control, Precipart, Schaefer, and Schneebberger.

■ Find suppliers for the products you need

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■ Improved Buyers Guide format (free listings now available)

powertransmission.com averages more than 80,000 unique visits per month

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Hybrid System

LAYS BRICK FOR NEXT-GEN CONTROLLERS

There are a lot of different hybrids out there these days. Hybrid cars are on the tip of tongues from Tokyo to Detroit as we plunge ever further into our pockets to cover oil costs. But any multitude of factors combined for a specific purpose warrant a hybrid classification. The two-faced term could refer to anything really: hybrid machine, hybrid coupling, hybrid security—in reference to finances—and even mythological hybrids like the griffin, centaur or mermaid.

The latest item bearing the hybrid label to hit the power transmission market is Delta Tau Data System's Power

PMAC, a motion computer, which fuses a controller with a full-fledged, Linux operating system into a compact and powerful tool for most commercial, industrial or military applications.

"What really distinguishes the Power PMAC is that it's a hybrid beast," says Curt Wilson, vice president of engineering for Delta Tau Data Systems, Inc. "It can be used as a dedicated controller, but it also gives sophisticated programmers the access to a general purpose computer. Same processor. Same hardware. Same environment."

The Power PMAC provides advantages over both traditional dedicated controllers and general-purpose computing engines because it permits the user to choose for each aspect of an application which approach is more suitable.

One of the most significant

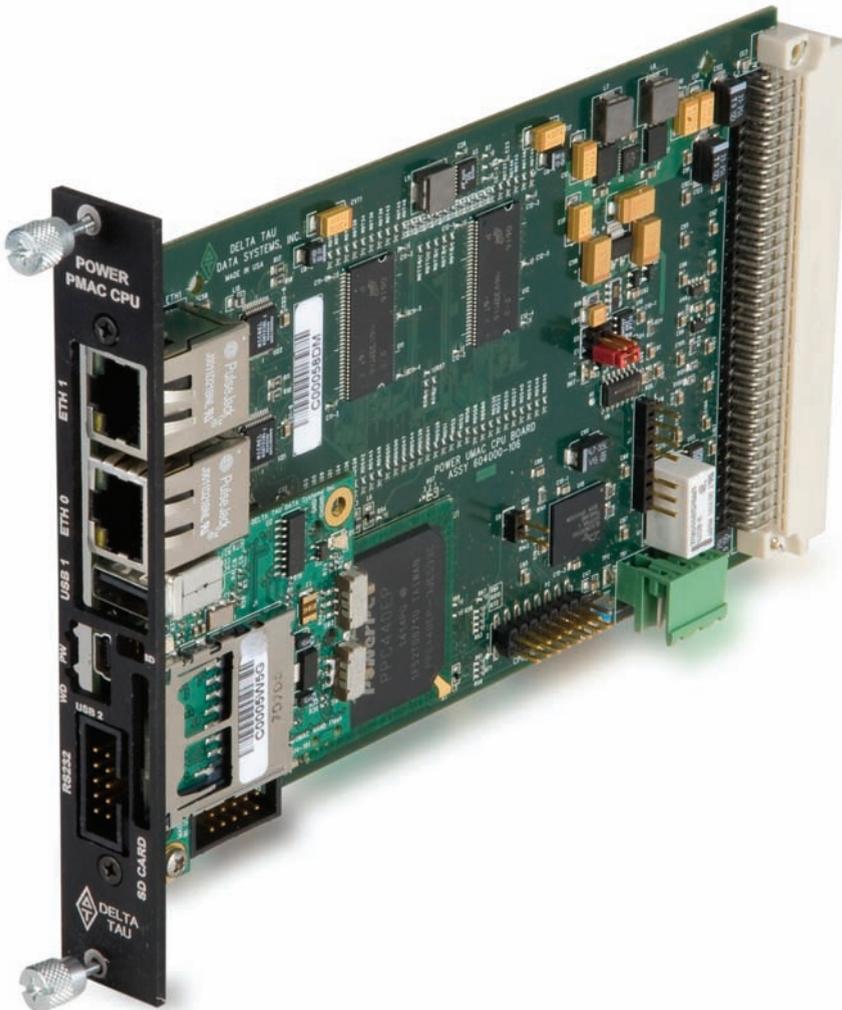
options designers have with the Power PMAC is to write programs using Delta Tau's script language or a popular programming language like C or C++. The main difference is "a script language is generally easier to use, but more limited in its functionality," Wilson says. "You don't have access to all of the powerful tools that you have in a language like C. C is very open, very powerful, but it's difficult for the novice and potentially dangerous for the unaware."

A designer could by accident write over critical memory, which is easy to do in C and would result in a crash. It's what computer hackers look to achieve, according to Wilson.

Delta Tau considered the pros and cons of these software writing tools when the Power PMAC was conceived four years ago and realized the benefits each has for users looking to fulfill varying needs. "With each generation of controller, we listen to what people tell us, both customers, and probably more importantly, the accounts we didn't get, and why didn't we get them," he says. "One of the important things we noticed was in accounts where there were very serious programmers who were used to all the tools of a language like C; these people were very hesitant to use a controller that they sensed was limited by the simplification of the script programming approach."

The script language simplifies some tasks in a way that compensates for issues a standard language may run into. Wilson cites two particular tasks as the most important ones the script language takes care of. "It's handling, under the hood and invisibly to you, what's called the type matching of variables. It converts them automatically as needed. [Secondly] it has what we call a sequencing engine that is automatically sequencing program execution move by move."

Another key feature is the embedded Power PC processor, which is about 10 times faster for floating point math calculations. "The floating point math is so fast and efficient in this processor; we can do things we couldn't



do in previous generations. We're talking about sophisticated floating-point algorithms," Wilson says.

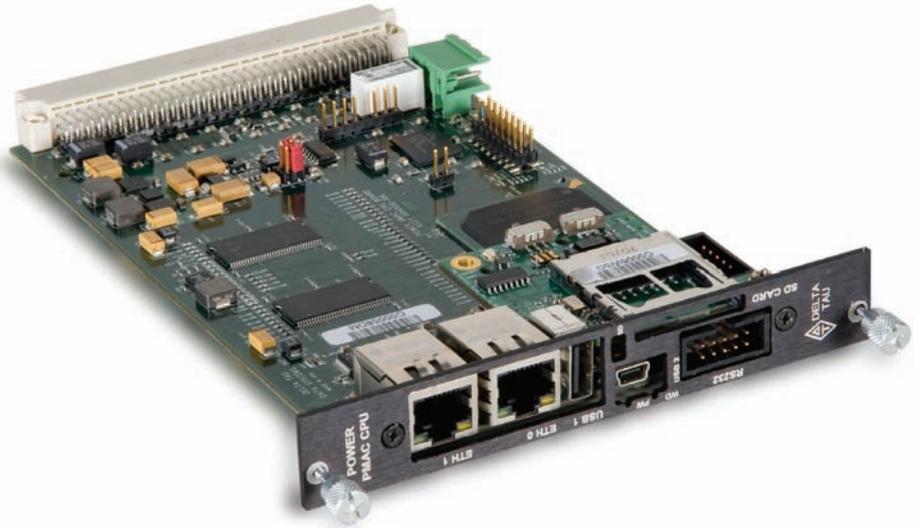
This type of processor features low heat dissipation, so there is no fan required to prevent the chip from overheating. It also has built-in peripheral interfaces like Ethernet, USB and PCI, which add to the compact, efficiency factors while allowing the Power PMAC to be accessed from any computer in any location.

There are many other new features in the Power PMAC like a built-in web browser and a fully integrated development environment. Also, "as a full fledged computer, it has an organized file system like your PC," Wilson says. "It allows you to write software for what are called both real time tasks—things that must happen now—and what are called background tasks in C or C++." It supports up to 32 independent axes in a single coordinate system."

The Power PMAC is equipped with about 100 times more memory than traditional controllers. "The huge memory permits programs that run for days to be completely loaded into the memory and then run. With previous controllers, you had to sort of dribble it in as you were running, which is much more difficult. This makes it much easier. Just load the whole thing in and say 'run.'"

The Power PMAC is being officially released to the market come the New Year, but it has been pre-released for sampling purposes to selected customers, who have overall provided very positive feedback, Wilson says. One user is faced with a particularly difficult control program, which requires a custom servo algorithm that closes the feedback loop as efficiently as possible—10,000 times per second. Using the Power PMAC, this user is able to write the algorithm in C, and with the high-speed processor, it executes about 100 times faster than the previous controller would allow.

Delta Tau may have set the bar a little higher for motion control technology with the Power PMAC,



and there are already visions for further developing the product in the future. "We will be building one that fits in your computer's PCI expansion slot," Wilson says. "We're also planning an enclosed controller/drive combination—both the brains and the power circuitry. By combining the controller and drive in a single package it dramatically reduces both size and cost to the users, and it reduces the complexity of wire because it's all internal."

In closing, Wilson alludes that the Power PMAC's introduction responds to current market trends, and motion system designers will find the product better equipped to fulfill their needs. "People continue to push the envelope on speed and accuracy and complexity

of projects. As they get more and more complex, you've got to manage the complexity in more formal ways. That's what things like the integrated development environment [IDE, which provides for seamless C/C++ and script application development] do, and a lot of people like to work through an IDE as much as possible for these complex projects."

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Fax: (818) 998-7807
sales@deltatau.com
www.deltatau.com

Yaskawa

REDUCES PARTS IN
COMPACT DRIVE



The J1000 AC drive from Yaskawa Electric America, Inc. claims to be the world's smallest compact drive with 70 percent less space required. With fewer parts used in the drive's construction, mean time between failure (MTBF) is increased to 28 years, and other component lifetimes are also extended, such as fans, capacitors and thermal optimization, according to the company's press release.

"The new J1000 was designed with three main principles in mind consisting of quality, reduced cost of ownership and maintainability," says Todd Ammerman, Yaskawa MicroDrive product manager. "All of these allow for the customer to get the most out of their products at a cost-effective price."

The goal to reduce cost of ownership is accomplished by compact

design, side-by-side mounting and the capacity to run a larger motor with normal duty rating. An over-excitation braking feature allows the drive to limit stop times without external braking resistors.

The J1000 AC drive can store files for programming several drives quickly or backing-up the system, and it is equipped so hardware or software can function for this purpose. The drive is maintained by lifetime monitors, which constantly supervise how well the key components are working.

The J1000 drive is sized from 1/8 to 7.5 hp. Voltage classes are all 50/60 Hz; they are 200-240 V single-phase, 200-240 V three-phase and 380-480 V three-phase. Other standard features include an open loop V/f control with a 40:1 speed range, starting torque of

150 percent at 3 Hz, a 5-digit LED keypad, vibration resistance to 50 Hz and a swing PWM function to decrease motor noise.

Applications for the J1000 include industries such as material handling, food and beverage, fan and pump control, packaging, agricultural machines and industrial washers. The drive is RoHS compliant and has CE, UL and cUL global certification.

For more information:

Yaskawa Electric America, Inc.
2121 Norman Drive South
Waukegan, IL 600085
Phone: (800) YASKAWA
Fax: (847) 887-7310
www.yaskawa.com



OneGear Product Line

OFFERS MAXIMUM
MOTOR USE

The Allen-Bradley OneGear product line from Rockwell Automation supplies a full range of motor and power control center options. The line includes the full voltage non-reversing controller, intelligent protection systems and 10 kV to 15 kV SMC Flex controllers.

Designed for next generation

medium voltage control, the OneGear line of products can be used with full voltage and solid-state, reduced voltage applications and it supports operating voltages up to 15 kV. OneGear uses vacuum-contactor and circuit-breaker switching technology for flexible solutions. Each product is available with arc-resistant cabinets, and they provide remote monitoring, diagnostic capability and detailed motor protection, so the maximum motor utilization can be achieved without damage or downtime.

"OneGear is a complete line of medium voltage control products that have been

designed to meet global standards,” says Ralph Paling, manager, integrated marketing communications at Rockwell Automation.

The inaugural products are only a start for the OneGear line. “Over the next three years, OneGear will expand and feature a complete line of motor control products which will include reversing, multi-speed and synchronous

controllers, as well as main and tie breaker units,” Paling says. “OneGear will offer a complete line of non-variable speed medium voltage control.”

When asked how the product line may help to expand Rockwell Automation’s customer base, Paling points out that, “OneGear allows Rockwell Automation to market these products globally, instead of just

NEMA, which is restricted to North America alone.”

For more information:

Rockwell Automation Response Center
1070-1 Hampshire Avenue South
Bloomington, MN 55438
Phone: (800) 223-5354 x 2118
www.ab.com/mvb/onegear.html

Redesigned Air Motors

MINIMIZE NEED FOR COMPRESSORS

A redesigned series of air motors from Huco Dynatork has reduced the need for air compressors in paint stirring applications. Plants in both the United States and the U.K. have switched from traditional vane motors to air motors. According to the company’s press release, one automobile plant is saving over \$150,000 annually on power and equipment costs.

Via an integral rotary valve, air up to 100 psi is supplied to each of the three pistons in turn. The free-floating pistons transmit torque on start-up that can be adjusted via a pressure regulator, resulting in high torque at variable low speed and low noise.

Because the Dynatork air motor traps the compressed air within the piston/cylinder, allowing for maximum energy conversion, the unit is easier to seal than a vane motor cylinder. The air motor consumes up to 80 percent less air than a vane motor, providing a significant cost savings even at maximum torque. It can be used in harsh and hazardous environments thanks to redesigned internal air passages that replace the external tube structure, and it can operate in constant start-stop applications under loads



displaying similar characteristics to a stepper motor.

“The original purchasing criteria for the motors, given by the U.K. automaker, were greater reliability on 24/7 operation and freedom from lubrication to avoid the possibility of contamination,” said David Lockett, joint managing director of Huco Dynatork. “However, by changing to the air motor, this manufacturer has gained considerably more. The company has now installed 42 Dynatork motors which have provided a capital saving of two 600 scfm compressors and an overall power saving of 152 kVA per year.”

Available in aluminum, stainless steel for harsh environments and plastic for high-pressure washdown environments, the air motors can be

supplied as fully submersible units for lubricated or non-lubricated operation.

The air motors are available with maximum torques up to 16 Nm or 550 Nm with gearbox. Huco has also introduced a new controller that holds the motor speed constant under variable load for paint and other liquid stirring applications where torque reduces as the paint or liquid levels fall.

For more information:

Huco Dynatork (Altra Industrial Motion Co.)
Merchant Drive
Hertford, England SG13 7BL
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www.huco.com



3D Production Systems

EMPLOY DISSOLVABLE WAX SUPPORT TECHNIQUE

The ProJet CP 3000 3D production system from 3D Systems Corporation produces high-speed, high-volume casting patterns from digital data for foundry prototyping and end-use parts applications such as medium- to large-sized mechanical parts for engines, pneumatics, aerospace, general manufacturing and other heavy equipment. The company also released the ProJet CPX 3000 system, which specializes in high-resolution production of extremely detailed wax patterns for medical instruments and devices, mechanical parts, replicas and other uses.

The ProJet CP 3000 and CPX 3000 use standard investment-casting materials and processes for investment casting of final parts that are produced with 3D Systems' VisiJet CP200 or CPX200 wax build, a new material, and VisiJet S200 dissolvable wax support material, which together create wax patterns for casting. The 3D printers are capable of complex or highly-detailed geometric shapes, which traditional CNC or milling procedures cannot produce.

The dissolvable wax support system leaves smooth support-side surfaces while both build and support materials do not require special handling and are environmentally friendly. The process does not entail production patterns from photocurable materials, which may be subject to thermal expansion during casting, effectively limiting the part-size and geometries capable of being cast.

The CP 3000 production system



Hilliard
Motion Control

The logo for Hilliard Motion Control features a stylized red and white geometric pattern above the company name. The name 'Hilliard' is in a bold, black, sans-serif font, and 'Motion Control' is in a bold, red, sans-serif font.

Solutions

A large, red, 3D arrow pointing upwards and to the right, with the word 'Solutions' written in a bold, black, sans-serif font along its length.

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At Hilliard, we've built a reputation on solving motion control problems. We are structured so that you receive direct contact with our engineers for important consultations. Special designs that fall outside standard product lines are met economically and efficiently.

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www.hilliardcorp.com



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100 West 4th Street
Elmira, NY 14902
607-733-7121
hilliard@hilliardcorp.com

has a large x-y-z build volume (11.75 x 7.3 x 8 inches) and a single-pass print-head design, so it can build one large or several smaller patterns across the x-y build area without giving up build time. Longer unattended operation is possible with both production systems by optimum use of the z-direction build volume—in the CP 3000 case—facilitated by part stacking and nesting features for the patterns produced.

“We are very pleased to be able to deliver the new ProJet CP 3000 3D production system, the first high-volume wax pattern production system designed specifically for general foundry casting applications,” says Buddy Byrum, senior director of 3D printing solutions for 3D Systems. “The ability of this new precision manufacturing tool to quickly produce easy-to-cast precision wax patterns directly from CAD should reduce our customers’ cycle time and production costs, resulting in improved final part quality and functionality.”

The ProJet CPX 3000 production system has two optional build modes. A high-definition, HD, mode creates small to large parts that have excellent surface finish. In the extreme high definition, XHD, mode, a 16 micron layer thickness is provided for parts with fragile, fine-feature detail common in micro-casting applications.

“We are delighted to deliver a true, fast, 100 percent wax-based investment casting solution, ideal for foundry and other industry segments that addresses all of the required professional casting requirements and is packed with real cost savings,” Byrum says.

For more information:

3D Systems Corporation
333 Three D Systems Circle
Rock Hill, SC 29730
Phone: (803) 326-3900
www.3dsystems.com
moreinfo@3dsystems.com

Digital Module Range

INCREASES POWER OUTPUT, SUITS MEDICAL USES



A new range of digitally controlled output modules has been added to the NV-Power family of configurable AC-DC power supplies from TDK-Lambda Americas. The new range increases power output up to 1,450 W peak rating for 10 seconds. They suit the industry demand for low-profile configurable power solutions from 350 W to over 1,000 W for broadcast instrumentation, medical equipment, ATE, automation, routers, servers and security networks.

This trend for low-profile power solutions “is being driven by requirements for higher efficiency power supplies, smaller equipment, portable equipment and the increasing need for standard product easily adaptable to custom output voltages,” says Dorrel Vernon, senior product manager at TDK-Lambda.

The modules’ digital control is useful for customizing an application based on specific requirements. An integrated magnetic transformer makes the modules smaller and more efficient. The NV-Power uses an eight-

bit microcontroller for integrating maintenance processes, which effectively replaces discrete components such as comparators and op amps. This feature reduces the parts count to 50 percent, making room for 40 percent more board space for power components while power densities are capable of up to 19 W/in³.

The new range of output modules are components designed for use with the NV-350 and NV-700 series power supplies.

Up to 350 W of output power with <180 VAC mains is possible with the NV-350 series. It provides up to 660 W continuous with >180 VAC mains, and up to six outputs users choose can be achieved in a 1.6 x 3.75 x 10.8-inch package.

The NV-700 series supplies up to 700 W of output power with <180 VAC mains and up to 660 W continuous with >180 VAC mains. As many as eight user outputs can be provided in a 1.6 x 4.92 x 10.8-inch package.

continued

The modules include EMC-improving design features such as Lambda's patented Multi Resonant Topology (MRT). "[This] is an electronic design by which switching losses are dramatically reduced, and therefore enables higher efficiencies to be achieved—typically around 90 percent," Vernon says. "MRT also features soft switching, which minimizes the generation of switching spikes and harmonics, ensuring that the power supplies offer excellent EMC/EMI performance."

This new range of modules in particular appeals to medical equipment applications because the input to output isolation meets the 4 kVAC reinforced requirements for medical use. TDK-Lambda conforms to the international standard IEC601. A substantial category

in this standard is reinforced insulation for medical applications.

"Reinforced or double insulated power supplies must withstand a dielectric test at 4 kV for medical applications, whereas the corresponding figure for industrial use is just 3 kV," Vernon says. "Any shortcoming in isolation would result in a higher risk of electric shock for a patient or system operator.

"Power supplies that are approved to less than 4 kV may be used in medical applications as part of a reinforced barrier, provided that the insulation provided by the power supply is regarded as a lesser 'basic' or 'supplementary' barrier," he says. "In this case additional isolation is required within the end equipment to achieve the requirements of a reinforced barrier between the mains supply and

the user.

"The new digitally controlled module range was designed for full compliance to reinforced insulation specifications, eliminating the need for end users to design in additional isolation on the end equipment."

Suitable medical applications include MRI, ultrasound, optical lasers, x-ray equipment, blood/chemical analyzers, surgical equipment, chargers, hospital beds, incubators and patient monitors.

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Transformer Relays

REMOVE TRIPPING, MAGNETIZING INRUSH

Schweitzer Engineering Laboratories, Inc. introduces the SEL-787 and SEL-487E transformer protection relays, which employ simultaneous harmonic blocking and restraint to do

away with tripping caused by external faults and magnetizing inrush states.

Both products feature Commissioning Assistant software that recognizes unsuitable CT configurations and produces compensating settings. They can combine with substation control systems using serial ports, dual failover Ethernet connections and various protocols.

The SEL-787 relay can replace most electromechanical relays to safeguard two-winding transformers in industrial plants, utilities and other mission-critical facilities. It connects to networks using Modbus, DeviceNet, DNP3 and IEC 61850 protocols, and it takes plug-in modules for AC voltage and neutral current, I/O, communications or RTD inputs.

The SEL-487E shields and monitors transformers with two to five windings. The relay can identify turn-to-turn faults that are 2 percent of the

total winding. Internal error damage is reduced using a sub-cycle adaptive differential element, and the relay monitors and controls breakers and disconnect switches with front-panel LCD one-line diagrams.

"With transformer manufacturing lead-times exceeding two years and prices doubling in the past four years, no one can afford to be caught off guard losing a transformer," says Joe Mooney, SEL R&D manager. "We developed these advanced transformer relays to provide the best return on investment for every power transformer."

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Music in Motion

WOODWORKING PROCESS GETS MUCH NEEDED UPGRADE FOR GUITAR MANUFACTURER

Matthew Jaster, Associate Editor

Experienced guitar players will tell you the feel of the fret board is one of the most important factors when selecting a guitar. Some will even sacrifice the tonal characteristics for just the right “feel” from the neck and fret board. Guitar manufacturers believe the machining of the fret board is a key operation that contributes to the instrument’s quality and playability.

Engineers at C.F. Martin & Co., an acoustic guitar manufacturer based in Pennsylvania, thought its own fret board machining process was in need of an upgrade.

In the original process, the required finish was produced by a special swinging jig that held the fret board while putting it through a motorized sanding belt. This handmade process made it easy for particles to clog the sanding belt, causing vibration. In order to achieve the required quality of the finish, the fret boards often had to be put through the process twice.

Fred Walters, engineering project manager at Martin, enlisted the assistance of Brian Rasley, a local machine builder and CNC applications consultant in Pennsylvania, to determine if the machining process could be improved.

“We were in the initial planning stages to upgrade the process when Rasley came along with a few ideas for a new system,” Walter says. “This seemed to be a much better solution to the old method that was done by hand.”

Rasley found several issues that needed to be addressed in order to meet

continued



C.F. Martin & Co. is celebrating its 175th anniversary as the oldest surviving guitar manufacturer worldwide.

Martin Guitar's standards:

- The belt would clog because several boards would run on the same tangent point
- All the material was being passed over the belt on the first run
- The operator had to be very skilled to run the fingerboards
- There was only one belt in operation
- The tooling changeover was too long
- The jig wasn't rigid and would flex while sanding
- It was difficult to run Micarta, a material frequently used at Martin
- The ivoroid binding would burn and spark sometimes
- They couldn't do the flat sanding on the previous system

Rasley concluded that the company needed a more adaptable system to incorporate at least four different radii. He also designed a quick-change tool system for changing the radii tooling.

With the help of David Lunn, the East Coast regional motion control specialist at Baldor Electric, Rasley built a machine with Ethernet-compatible motion control components that employs six axes of motion to automate the sanding process.

"Lunn jumped on board immediately and was very helpful as we developed the machine concept and how to employ some of Baldor's newest products," Rasley says. "He came to the shop several times to help with integrating, wiring, etc. until we had motion."

The upgraded system includes two vector motors that power the sanding belts, two servo motors that raise the sanders and a servo motor that swings the fret board in an arc. The swinging arm is powered by a linear motion axis that moves it across the sanding belts.

Lunn believes converting a handcrafted process requires precision and repeatability on the part of the new machine.

"This was achieved with a motion controller, linear and rotary servo motors and a very well built and robust design of the system," Lunn says. "Considering Brian Rasley had not used Baldor motion control products previously, he designed and built a system that incorporated our products and performed perfectly from the first test run."

Arthur Cooper, Rasley Enterprises' systems programmer, developed an algorithm for controlling the sanding process that removes the material in small increments while minimizing the clogging effects of the sawdust. He also programmed a human-machine

interface (HMI touch screen) that allows Martin to load the optimum sanding routine based on the different wood used. Included in the HMI screens are diagnostics, a belt changing process, sander speeds, initial offset and secondary offset.

"The machine is safe, versatile and can accomplish much more than the old system could accomplish," Cooper says. "The key is the accuracy. It's the most important aspect of the upgrade."

The architecture of the machine is based on a Powerlink-compatible machine controller called NextMove e100 that controls all six axes of movement. By using Powerlink, the electrical design of the machine is simplified. Programming was also made easier by using Baldor's *MINT* environment, an in-house programmable language from Baldor that can handle motion, I/O and HMI tasks.

Rasley said his team had to learn *MINT* programming on the fly for the project.

"I can't say it was easy, but we did find that it's very robust and has a very open architecture. The hardest part was the learning curve. Once we learned the language, we were off and running."

The result of the new fret board machining process has been noteworthy. The machine has been in service since December 6, 2007 and the company is now capable of hitting its daily quota in a shorter period of time.

The new machine can run more than 320 pieces in an eight-hour shift. (Previously, 150–200 pieces were sometimes run in an eight-hour shift.) Rasley says the company has gone from 40 percent rework to 3 percent. Production has increased by approximately 60 percent.

"Now, they're looking at the upstream wood milling process so the fingerboard rework will probably drop down to 1/2 percent," Rasley says. "We hit all the issues mentioned earlier and a few more that weren't on my original list."

The biggest benefit is the incremental cutting where each pass removes a programmed amount of material. While the arm is swinging through the arc, the machine is moving across the width of the belt; thus, no tangent point clogging. The machine uses a cog free linear motor that moves it 14 inches per second and stops within .002" of the programmed location when



With assistance from Rasley Enterprises and Baldor, C.F. Martin & Co. has updated its fret board machining process.



The new system can run more than 320 pieces in an eight-hour shift.

in rapid mode.

The operators involved in the assembly and final setup of the guitars have noticed the quality of the new fret boards. They can now manage the fret boards more precisely, adjusting the relationship between the front (roughing) sanding and the rear (finishing) sanding to accommodate different style belts as they experiment to find optimum belt performance.

Rasley is servicing the machine under a one-year warranty, and says there have been several upgrades to the code as well as additional features to improve the operation. He has quoted several other motion control projects, including an automated side press machine for Martin and a deep-hole drilling machine for a Pennsylvania lumber company. 

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Rolling the World



Power Up!



If you have a background in gears, bearings, motors, belts, couplings, sensors or actuators, we'd like to talk to you. Powerplay, the new back page feature in *PTE*, is all about your industry. If you've got a funny anecdote, an interesting observation or perhaps a limerick on motion control, feel free to send it our way. This column is dedicated to the stories too radical to make the cut in industry or product news. We need story ideas, and we're confident you can provide them.

The rules are quite simple: submit a story idea about the power transmission industry, make it entertaining as well as informative, and become a *PTE* magazine editor-at-large today (salary not included). Submit your award-winning material to publisher@powertransmission.com.

BSA

IS THE FORUM THAT KEEPS BEARING COMPANIES ROLLING

Jack McGuinn, Senior Editor

In today's increasingly competitive global economy, industries and the companies that serve them are always looking for an edge. Price and quality being routinely accepted as a given, businesses—large and small—are always looking for a little help.

For the worldwide bearing industry, that help exists in the form of the Bearing Specialists of America (BSA), a collective of 48 dues paying member companies with more than 2,000 branches and 45 bearing manufacturers. The association's scope reaches from North America to Europe, Japan, Brazil and New Zealand. In essence, the BSA exists to serve and represent authorized distributors who stock and sell warranted ball, roller and other anti-friction bearings for any number of applications. It's a perfect example of strength through numbers.

"Any (bearing) manufacturer, large or small, that participates in BSA can have access to a well-trained sales force unequalled in size to that which BSA member companies provide," says Douglas Savage, president of BSA member com-

pany Bearing Service Inc. "Recent international expansion of members and participating manufacturers reaches all over the world. The amount of inventory carried by all BSA members combined is more than any manufacturer has or could afford."

Indeed, the not-for-profit BSA provides synergy between its manufacturing members and distributor companies. Founded in 1966 by a merger of the Anti-Friction Bearing Distributors Association and the Association of Bearing Specialists, the group serves to provide a forum for networking to share ideas, to offer interactive educational activities and to meld the disparate mix of companies into one unified industry voice. And that voice speaks for a \$33 billion industry, with 30 million bearings made daily, according to BSA figures.

"The BSA provides a highly efficient forum to communicate and share information with our manufacturers' most important distributor customers," says William C. Moore, senior vice president of sales development and channel management for SKF Service Division USA. "Nowhere else do we have access to the number of distributor executives and the time to discuss issues and ideas in a sustained fashion."

The networking and knowledge sharing that the BSA prides itself for happens in various ways. There is an annual convention, as well as Fall and Winter meetings of BSA committees. They include the Educational Services, Information Technology & Supply Chain and the Distribution-Manufacturer Relations committees.

As for governance, BSA has a board of officers and directors who serve at no pay.

Perhaps BSA's greatest contribution is in its sales training activities open to all member companies. Some examples:

- *The Certified Bearing Specialist (CBS) program.*

The only program of its kind in the industry, the CBS qualifies the specific skill sets necessary to certify as a bearing industry professional and specialist. Much like an ISO quality program certification, having BSA-certified employees provides a company



Annual conference provide valuable networking opportunities for BSA members.

with credibility in the eyes of its customers.

- *Employee training aids.* These include the BSA In-House Training Guide, a detailed primer for industry education. It is used widely for new and remedial training.
- *Bearing Briefs.* A bulletin that provides members with up-to-date information on specific topics of note, both technical and otherwise.
- *Online sales training.* Sales programs developed and presented by noted online sales guru Joe Ellers, tailored specifically for the bearing industry.

Also of note, BSA in 2005 published a white paper, "Value of Distribution: 2005; Critical Resources for Bearings Consumers." The paper provided insights on how leading edge bearing customers measure distribution value and how to leverage it to the utmost in doing business.

How does a company gain membership? Applicant distributor companies must for at least two years be involved in the "stocking, selling and distributing as an authorized distributor of a full range of basic types and sizes of new, factory-warranted bearings for replacement or maintenance purposes," according to BSA bylaws. The product offerings must be diverse enough to enable the applicant company to "serve and, in fact, the applicant must serve, on an effective and timely basis, the industrial replacement and maintenance requirements of its accounts or potential accounts." Other requirements include maintaining a full-time sales force; an adequately equipped and staffed office including shipping and warehouse facilities; having a warehouse inventory of new bearings large enough to effectively service its customers; having personnel capable of drawing specifications and recommending changeover applications; and to generally assist its customers regarding other technical, bearing-related issues.

With those factors in place, BSA's sales training efforts dovetail nicely with a member company's revenue goals. As mentioned, BSA enlisted the Ellers method of web-based sales training programs. They address both inside and direct sales needs, as well as those of sales managers. The training modules are completely self-paced for incremental progress, with each one taking up to 10 months to complete. Each module contains:

- Content and pre-assignment materials
- Audio training lectures which can also be downloaded as MP3 selections
- PowerPoint presentation notes for each audio presentation
- Corresponding action items to begin implementing
- Module tests
- Sales manager companion for each module

There are also occasional live Q&A teleconferences.

As is the case with most professional associations, BSA works at partnering with other groups to its own members' benefit. Possibly most notable, it partnered with the Power Transmission Distributors Association (PTDA) in 1998 to develop an electronic format for uploading product info

and price quotes to member companies of both groups. The single-format, single-system program is now used by manufacturers, distributors and OEMs. It allows manufacturers and distributors to interface regarding inventories, pricing and the like; streamlines operating efficiencies and improves accuracy by eliminating manual keyboarding; and reduces now-costly transportation charges and simply the general cost of doing business.

In addition, BSA is a sponsor of the Association Education Alliance (AEA), whose stated mission is "to identify, evaluate and develop, at an affordable cost, educational programs for use by member associations." The centerpiece of the program is the annual University of Industrial Distribution, a program devoted to the special needs of wholesale distributors, "along with a number of webinars and live training programs covering topics of interest to BSA member distributors," according to the BSA website.

On the political side of the street, BSA is a member of the lobbying trade group The National Association of Wholesaler-Distributors (NAW). NAW pursues government relations issues, educational efforts and a number of other industry-related initiatives.

Lastly, BSA also has partnered with the National Association of Manufacturers and the Coalition for the Future of Manufacturing.

"Bearings are a critical component in industry and vital to the success of the bearing and power transmission distributor," says Chuck Kitchen, vice president of Interstate Bearing Systems and vice chairman of the BSA Distribution-Manufacturer Relations Committee. "Technology and practices are ever changing, and so, too, must we. Members of BSA are among the elite in the bearing industry and are serious about the business. While yes, we do compete, we all have a common goal—to be the best. And BSA provides that forum." 

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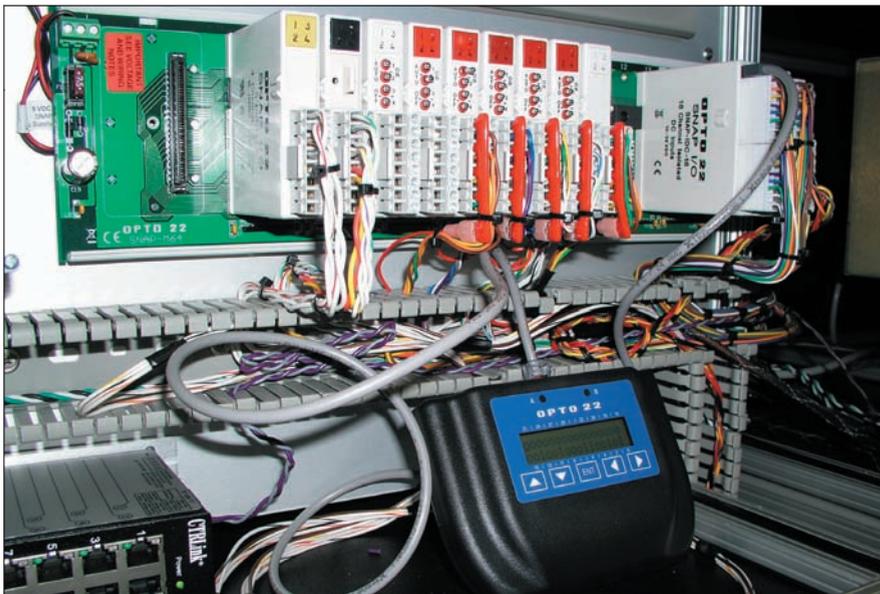


William C. Moore

Control System Upgrades Product Testing and Validation Machinery

OPTO 22 EMBEDS SNAP MOTION CONTROL SUBSYSTEM IN PRODUCTION EQUIPMENT TO CONTROL, MONITOR AND GATHER OPERATIONAL DATA

David Crump, Opto 22



A close-up of the G4 Handler SNAP Pac Motion Control System.

In the center of Opto 22's Temecula, California factory sits the G4 Handler, a large machine used for final assembly and testing of all of the company's G4 modules—single point input/output modules used mainly for applications involving the sending and receiving of digital signals. Since the introduction of the G4 in the mid-1980s, Opto 22 has sold millions of these modules, and 20 years later, they remain one of the com-

pany's best selling products.

"The G4 Handling machine will test our G4 style digital input and output modules as well as insert the screw into the modules," says Ron Koss, production manager. "These modules will then be used to either sense or switch an AC or DC voltage."

The G4s are guaranteed for life, so in order to make this guarantee, the company must submit the modules to rig-

orous testing before they're shipped to customers. The G4 Handler is the machine used to perform these tests. Built by Opto 22 manufacturing engineer Ron Schmidt, the machine individually tests each G4 module twice. Performing these tests requires large trays with 50 G4 modules at a time to be loaded into the G4 Handler. The trays move back and forth and left and right on X and Y axes, while the machine puts each one through several tests. These include an in-rush current test, minimum and maximum current load tests, as well as inductive, capacitive, and resistive tests, which ensure that the modules can handle signals for varying types of electrical equipment such as transformers, power supplies, motors and lights.

"The G4 Handler even tests the small LED on each module that lets you know when it's operating," Schmidt says.

However, all this testing first relies on the trays of modules moving fluidly back and forth. Accomplishing this required the use of multiple servos—electric motors coupled with a position feedback device used to affect mechanical motion for a specified distance. Re-

cently, the servos on the G4 Handler, in service for close to two decades, needed to be replaced. Unfortunately, Schmidt and the maintenance engineers at Opto 22 could not find an economical replacement.

They made the decision to replace the G4 Handler's servo motors with stepper motors. This approach is somewhat uncommon, but for Opto 22's purposes it was a viable and much more affordable option.

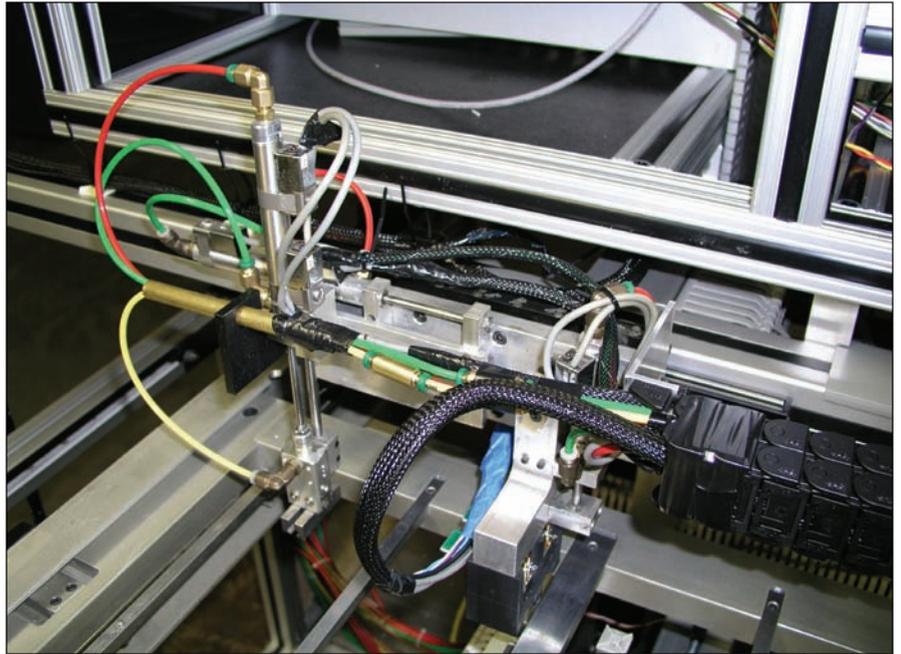
Another reason for switching to steppers was because the G4 Handler upgrade coincided with the release of Opto 22's SNAP PAC Motion Control Subsystem, which is specifically designed for use in motion control applications that utilize steppers, such as winding, cut-off, assembly and packaging.

Combining a SNAP PAC programmable automation controller, a SNAP Motion Communication Module, a SNAP Motion Breakout Board and PAC Control, which is the control programming component of Opto 22's *PAC Project* software suite, the SNAP Motion Control Subsystem accomplishes multi-axis stepper motor control along with traditional analog, digital and serial-based automation. The subsystem was developed in late 2006 and introduced early in 2007 as part of Opto 22's flagship SNAP PAC System product line.

"With operation of the G4 Handler machine already including a host of digital functions and now with a clear need for stepper motion as well, we knew it was an ideal opportunity to test drive the Motion Subsystem in a quirky and unique situation where we would be embedding Opto 22 SNAP PAC I/O in a machine used to test Opto 22 G4 I/O," Schmidt says.

Schmidt worked with Opto 22 design engineer Nick Riley, who developed the Motion Subsystem, to match the G4 Handler's servos to equivalent stepper controllers that had enough torque to adequately move the G4 Handler components.

"For verification purposes, we also needed steppers that included encod-



Spotlight on the G4 Handler's air cylinder.



The G4 Handler testing modules.

ers," Riley explains. "The encoders convert the movement of the stepper motor into a pulse that can be measured and used to confirm that the steppers are, in fact, where they're supposed to be."

Meanwhile, Schmidt began dismantling the G4 Handler—first stripping out the servos and then redressing the belts and harnesses that enable the machine to move trays of modules side to side and back and forth. Next, the machine's Mystic I/O system was removed and replaced with the new SNAP PAC System's more dense and versatile multi-channel I/O.

"That older generation Mystic system was used mainly for digital functions that take place within the G4 Handler, like powering on and off, and activating the machine's reject arm—a small component that removes and dumps any G4 module that fails testing," Schmidt says.

According to Schmidt, switching to the new SNAP PAC System's high density modules saved significant space, as they provided 16 times the density of the old system. The overall consolidation benefit was considerable, and Schmidt was able to condense the functionality of

continued

six single-channel bricks down to a single rack. Thanks to the new SNAP PAC System's high I/O density, Schmidt was able to replace an entire 16-channel I/O brick with a single 16-channel SNAP module.

"With the PAC system, you can do inputs, outputs, analog, digital, motion control, serial—we have so much input/output capabilities that you can do almost anything you'd like," Riley says. "With our system—PAC control system—you have a single development environment, which means you only need one software suite to program everything. You don't need multiple systems or multiple programming environments."

Other functions handled by the SNAP PAC include activating a bolt feeder that inserts a small securing screw into each G4 module, control of the air cylinders that rise up and down as they apply the high voltage test heads to the modules as well as miscellaneous analog functions.

The SNAP PAC System also controls the Motion Control Subsystem. The Motion Communication Module resides on the same rack as the digital and analog modules and uses an RS-485 serial interface to connect to a breakout board that, in turn, connects to and drives the G4 Handler's stepper motors to move the tray tables on the X

and Y axes based on the commands sent by the SNAP PAC.

"In this application, one of the major benefits of using the SNAP PAC System—and one that our customers who have similar motion control needs appreciate most—is the ability to consolidate all I/O functions in a single platform," Schmidt says. "In other words, you don't need multiple devices or components to handle typical digital points—like a machine's limit switches—and then another system for recording analog readings—like machine temperatures—and then a third system to execute the machine's motion control. With the Opto platform, all sensor and component interfacing and all control is performed by a single system, and all functions are defined using a single development environment."

The SNAP Motion Control Subsystem was programmed with PAC Project, the programming suite used with Opto 22 SNAP PAC Systems. PAC Project includes programming software that features both scripting and flowcharting, an HMI development application, debugging tools and the OptoMotion command set, which supports several Magellan Motion Processor commands. Kathy Spignese from Opto 22's product support team used these OptoMotion commands to specifically define the parameters of the G4 Handler's motion

processes, including position, velocity, acceleration, and time delays for the trays of modules as they move back and forth into proper position for testing.

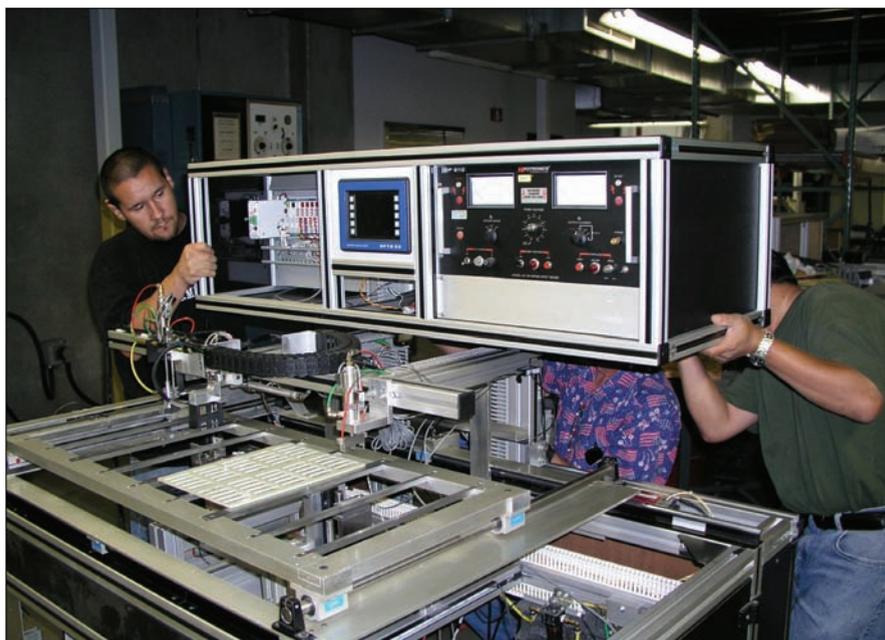
"For the stepping, I programmed the Motion Subsystem to position the trays underneath the test heads, so in succession, each G4 module can be properly tested," Spignese explains. "I was also able to specify smooth stops or abrupt stops as needed."

Spignese has also programmed the SNAP PAC to record production data, specific module test results (i.e., pass/fails) and this data will be made available to Opto 22 production supervisors and other authorized personnel. Specifically, the OptoDataLink component of PAC Control will enable data exchange between the SNAP PAC System and company enterprise databases—like Microsoft SQL Server and Microsoft Access. In this instance, possessing a multi-domain control system like the SNAP PAC, with its data acquisition capabilities as well as connectivity and data integration software tools, has proved most beneficial.

While outfitting the G4 Handler with the Motion Control Subsystem, Schmidt made a few other changes to make the machine more efficient and easier to use, including making all the controls more accessible. Previously, the G4 Handler's machine controls consisted of a collection of switches and indicators situated in various locations on the machine. However, during the motion control upgrade, a good deal of internal space was saved through rewiring these controls to an OptoTerminal-G70 operator interface terminal. The terminal serves as a centralized control interface—installed at shoulder level—from which all machine controls are more easily reached. It also aids greatly when training operators on how to use the G4 Handler. 

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Opto 22 employees raise the control's interface to improve accessibility.

High-Capacity Bearings

CARRY THE LOAD FOR CHINESE GEARBOX MANUFACTURER



SKF's new HCCRB bearings allow for heavier loads in various-sized wind turbines.

The signing of a contract for more than 5,000 sets of SKF's latest high-capacity cylindrical roller bearings (HCCRB) for wind turbines will impart added load-carrying capacity, more reliability and longer life to the Nanjing Gear Company's (NGC) line of gearboxes for wind generation applications.

About 50 percent of the bearings are destined for gearboxes of European and American manufacture, with the remaining half going to Chinese and other Asian-country customers.

With a range of gearboxes suitable for wind turbines from 200 kW to 2 MW, NGC will boost the competitiveness of their brand. NGC is a leading supplier in China for gearboxes for wind turbines. It is also a leading supplier in China for high-speed and heavy-load gearboxes for many industries, including steel and mining.

The HCCRB bearings will be of differing sizes—from 150 mm bore diameter up to approximately 300 mm—and utilized

continued

in all of the classical cylindrical bearing positions in the wind turbine gearboxes where non-separate mounting is acceptable. This is typically the case in planetary wheels.

H. Yueming, NGC general manager, says SKF was chosen for what represents NGC's biggest buy from the company to date because "In the wind power business, we attach great importance on high quality and innovation. We chose SKF because we know that the most important component to ensure reliability of the gearbox is the bearing. We will have the best bearing supplier in the world to ensure the quality of the gearboxes we produce." He adds, "We also believe that SKF will provide the best technical service in the bearing field and we hope to develop long-term cooperation to make technology exchanges to enhance our capabilities."

Zhou Zhijin, NGC vice-general manager, comments, "Successful prototype tests and technical information from SKF experts at their cylindrical roller bearing development center in Germany were very influential in finalizing the decision to select the new high-capacity version."

While the HCCRBs are a new product offering for SKF, they weren't developed exclusively for NGC.

"No, not specifically," says Albert Krauss, SKF product manager for cylindrical roller bearings. "NGC was just the first customer who is using them in series for their gearboxes. However, the NGC items are tailor-made for their" gearbox applications. Krauss adds that the HCCRBs are not yet available in all sizes, "But beyond the planetary bearings, which are usually" custom-made, "there will be a range of standard dimensions available in the future."

Unique feature of the HCCRB. The unique feature of the HCCRB is that load-carrying capacity has been increased substantially, while maintaining the boundary and internal dimensions of standard, cylindrical roller bearings. In effect, a bearing was created that boasts load-carrying capacity comparable to a full-complement bearing, but with the added benefits of a bearing with a cage. Along with the higher carrying capacity, the new design offers increased life. Calculations show that in one particular application, the SKF Explorer version of the HCCRB will have an increase in bearing rating life of 35 percent when compared with the standard, full-complement version, and 43 percent when compared to a standard caged version.

All of which begs the question—will these bearings serve as the gold standard for wind turbine applications?

"We believe so," says Krauss. "Most of the gearbox manufacturers are testing them, and some of them have already decided to use HCCRBs in their new gearboxes."

The bearings are made of standard-bearing steel 100Cr6, and the rings and/or rollers are black-oxidized for wind turbine applications. Krauss points out that the oxidation "assists in reducing wear in the running-in phase of the bearings in such heavily loaded applications."

Increasing load carrying capacity. According to ISO international standard 281, there are two ways to increase the load-carrying capacity while maintaining standardized boundary dimensions:

1. Increase the roller dimensions while maintaining the same number of rollers.
2. Increase the number of rollers and maintain the roller dimensions.

There are technical problems with the first method because increasing roller dimensions reduces the inner and outer ring thicknesses as well as the width of the side flanges. This reduction results in less ring stiffness and flange strength, which in turn increases the risk of reduced bearing life due to increased wear, fretting corrosion, ring creep or even ring fracture.

The second method offered theoretical improvements—commonly known by bearing companies—and many have applied it to its fullest extent.

A design that allows the maximum number of rollers is the full-complement design. The rollers are placed between the rings, leaving no space for a cage. Such bearings have limitations because the rollers are always in direct contact with each other, causing sliding, increased friction and heat generation. Under certain circumstances—among them higher speeds—the above-mentioned characteristics lead to wear and premature bearing failure.

Bearings with cages (the vast majority of bearings produced worldwide) do not have this problem because the rollers sit in cage pockets, preventing them from contacting each other. However, the addition of the cage takes up space, which reduces the maximum number of rollers possible.

How Cage Feature was Developed

The unique feature of the HCCRB was achieved by a completely new window-type cage design that resulted in two versions:

1. An outer ring shoulder-guided cage (code JA).
2. An inner ring shoulder-guided cage (code JB).

With these cages, an extra one or two rollers per row can be added to the bearings for the standard range, all of them separated by a cage. For customized bearings, even more rollers are possible. It is these rollers that deliver the additional carrying capacity, while the cage increases bearing life and overall

Bearing Execution	Standard	SKF Explorer*		
		High-capacity cylindrical roller bearing with an outer ring guided cage (JA)	High-capacity cylindrical roller bearing with an inner ring guided cage (JB)	Integrated standard cylindrical roller bearing with a machined brass cage
Customized bearing for wind gearbox application	Full complement cylindrical roller bearing	High-capacity cylindrical roller bearing with an outer ring guided cage (JA)	High-capacity cylindrical roller bearing with an inner ring guided cage (JB)	Integrated standard cylindrical roller bearing with a machined brass cage
Number of rollers per row	29	28	26	24
Relative calculated bearing	100	135	109	92

*SKF Explorer bearings with increased load-carrying capacity.

performance compared to a full-complement version.

The new cages differ from the standard cage in a number of ways that are not readily apparent.

Most noticeable is that the standard cage is oriented around the connection circle of the mid-points of all rollers, while the new cages are moved toward the outer ring (JA type) or the inner ring (JB type), thus allowing more space for more rollers (Fig. 1).

The new cage designs were tested with prototype HCCRB bearings for more than one year in many different tests to fully evaluate their capabilities and compare them with bearings fitted with standard cages and full-complement bearings. All tests showed no limitations of the new bearing designs compared to standard designs. In fact, the new cage designs provide the following additional benefits:

1. Improved oil flow via the decreased cross section of the cage, which reduces heat generation.
2. Lower weight that reduces inertia forces.
3. Reduced slip in low-load conditions, which reduces the risk of smearing.

Comparisons of Different Designs in Wind Turbine Gearbox

Figure 2 shows a gearbox application where the bearing under consideration is supporting a planetary wheel. Calculations of four different bearing types show that the two new HCCRB bearings significantly outperform both the standard caged version and the standard full complement version.

The new HCCRB bearings will enable NGC to offer higher load carrying capacity to their customers while affording them either enhanced gearbox reliability or a smaller gearbox, depending on the expected loads to be transmitted through it. And with wind turbine designs increasing in size and MW output all over the world, this positions NGC for greater new-business potential for large-sized turbines. 

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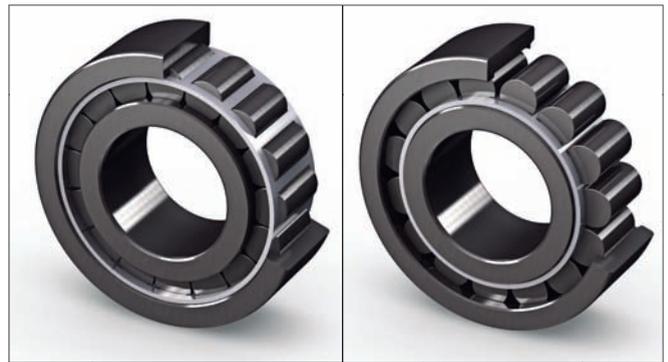


Figure 1—Type JA left; Type JB right.

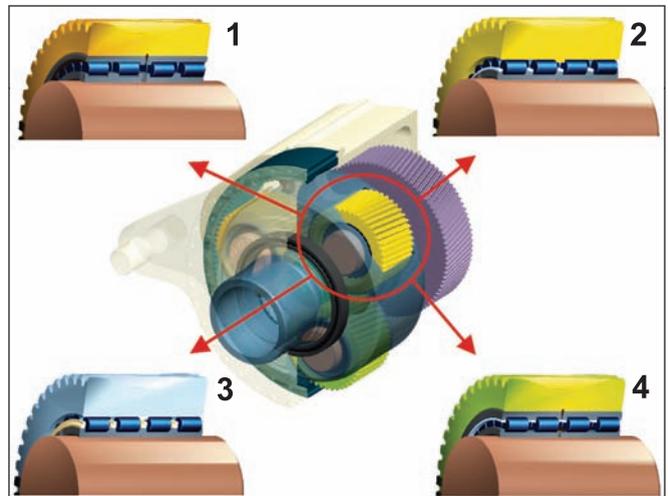


Figure 2—(1) Full-complement bearing; (2) HCCRB version JB; (3) standard CRB with brass cage; (4) HCCRB version JA.



Nanjing Gear Co. headquarters.

“So, essentially I need to be



a little bit more jolly then?"



MERRY CHRISTMAS



Roscoe, Illinois U.S.A. www.forestcitygear.com

Selection and Performance

CRITERIA FOR POWER TRANSMISSION COUPLINGS—

PART II

Eugene I. Rivin

“A flexible coupling, although it is relatively small and cheap compared to the machines it connects, is a critical aspect of any shaft system, and a good deal of attention must be paid to its choice at the design stage.” —from the Resolution of the First International Conference on Flexible Couplings

Introduction

Part I of this article appeared in the October 2008 issue. It provided an overview and general classifications of power transmission couplings, along with selection and performance criteria for rigid couplings and misalignment-compensating couplings. Part II continues the discussion with selection and performance criteria for torsionally flexible and combination-purpose couplings.

Torsionally Flexible Couplings and Combination Purpose Couplings

Torsionally flexible couplings usually have high torsional compliance (as compared with the torsional compliance of shafts and other transmission components) in order to enhance their influence on transmission dynamics. Figure 9a shows an example of a purely torsionally flexible coupling with an elastomeric flexible element having low stiffness in the torsional direction (shear of rubber ring) and high stiffness

in the misalignment-compensation directions (compression of rubber ring). Figure 9b shows a torsionally flexible coupling with a metal flexible element (Bibby-style coupling). The flexible element is a spring steel band wrapped around judiciously shaped teeth on each hub and deforming between the teeth. The deformations become more restrained with increasing transmitted torque; thus the coupling has a strongly nonlinear torsional stiffness characteristic of the hardening type. The lowest stiffness is at zero torque (Fig. 9c) increasing towards the rated torque (Fig. 9d), becoming very high at the allowed peak torque (Fig. 9e) and approaching a rigid condition at an overload/shock torque (Fig. 9f). Since some misalignment-compensating ability is desirable for many applications, use of purely torsionally flexible couplings, with combination-purpose couplings being used as torsionally flexible couplings with more

or less compensating ability.

For torsionally flexible and combination-purpose couplings, torsional stiffness is usually an indicator of payload capacity. In such cases, the basic design criterion can be formulated as a ratio between the stiffness in the basic misalignment direction and the torsional stiffness. In the following analysis, only radial misalignment is considered. Since couplings are often used as the cheapest connectors between shafts, and since end users often do not have full understanding of what is important for their applications, it is of interest to analyze what design parameters are important for various applications.

Torsional Flexibility

Torsional flexibility is introduced into transmission systems when there is a danger of developing resonance conditions and/or transient dynamic overloads. Their influence on transmission dynamics can be due to one or more of

the following factors: torsional compliance, damping or nonlinearity of load-deflection characteristics.

Reduction of torsional stiffness of the transmission and, consequently, shift of its natural frequencies. If a resonance condition occurs before installation (or change) of the coupling, then shifting of natural frequency due to use of a high torsional-compliance coupling can eliminate resonance; thus dynamic loads and torsional vibrations will be substantially reduced. However, in many transmissions (e.g., vehicle transmissions), frequencies of the disturbances acting on the system and natural frequencies (especially in variable speed transmissions) may vary widely. In such instances, a simple shift of the natural frequencies of the drive may lead to a resonance occurring at other working conditions, but the probability of its occurrence is not lessened. A reduction in the natural frequency of a drive, for example, is advisable for the drive of a milling machine only at the highest spindle speeds and may be harmful if introduced in the low-speed stages.

A shift of natural frequencies of the drive may be beneficial in transmissions with narrow variations in working conditions. If, however, a drive is operated in the pre-resonance region, an increase in torsional compliance would lead to increased amplitudes of torsional vibrations, and thus to a nonuniform rotation. In some cases excessive torsional compliance may lead to a dynamic instability of the transmission and create intensive self-excited torsional vibrations.

An important feature of multispeed or variable-speed transmissions is the changing of effective torsional compliances of components with changing output speeds due to changing reduction coefficients, although the physical condition of the components does not change (Ref. 1). As a result, the role of the coupling as a compliant member can dramatically change depending on configuration of the drive. While compliance of a coupling of any reasonable size installed in the high-speed part of the system (close to the driving motor)

would not have any noticeable effect at low output rpm, compliance of a coupling installed in the low-speed part of the system (close to the working organ,

such as a wheel of the vehicle or a cutter of a mining combine) would be very effective, but the coupling size and cost might become excessive due to high **continued**

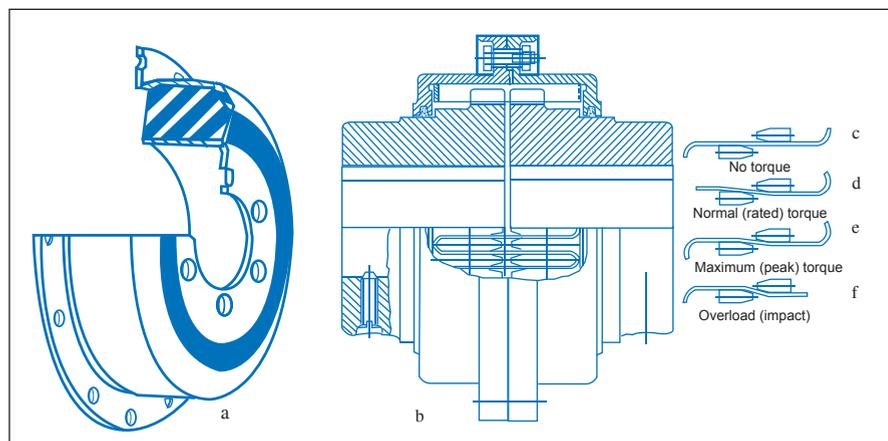


Fig. 9—Torsionally-flexible, radially-rigid couplings: a) Dynaflex LCD, Lord Corp.; b) all-metal Bibby coupling.

Nomenclature	
D	External diameter
d	Internal diameter
L	Length
F_{com}	Radial force, or bending moment
F_t	Tangential force
R_{ef}	Effective radius
T	Transmitted torque
μ	Friction coefficient
k	Stiffness factor
k_{com}	Combined stiffness of elastic connectors
E	Radial misalignment
D_p	Pitch Diameter
θ	Angular misalignment
L_{eq}	Sound pressure level
η	Efficiency
k_{sh}	Shear stiffness
ψ	Relative energy displacement
V	Potential energy
P_t	Tangential force
W	Energy per coupling revolution
β	Loss factor of rubber

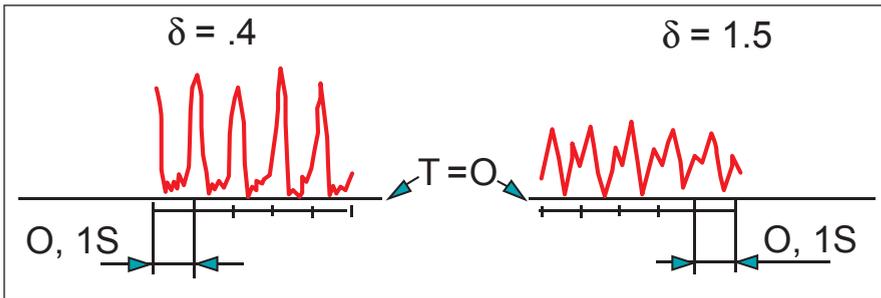


Fig. 10—Dynamic load in a milling machine drive with: a) manufacturer-supplied motor coupling ($\delta = 0.4$); b) high damping motor coupling ($\delta = 1.5$).

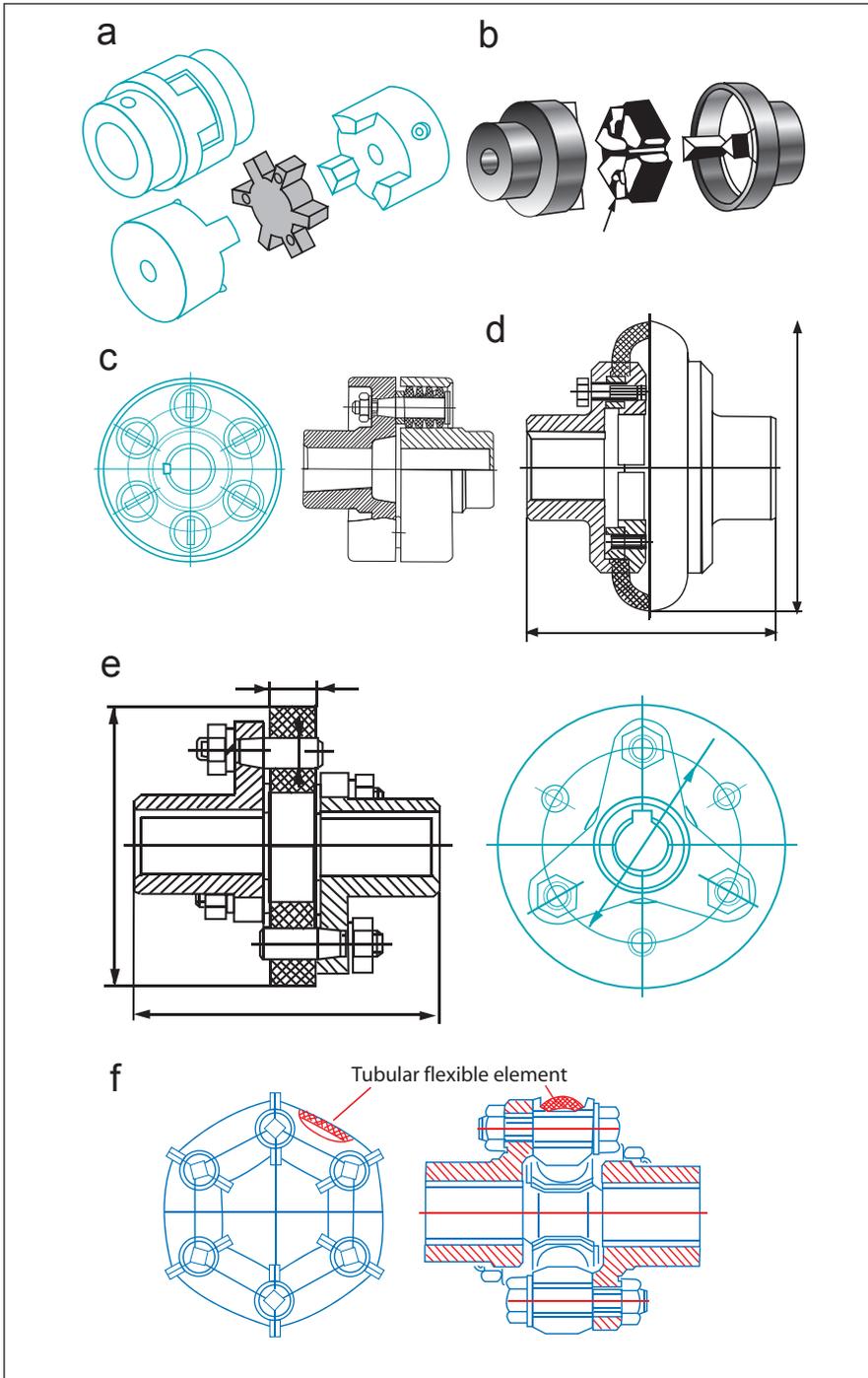


Fig. 11—Some combination purpose couplings: a) spider (jaw) coupling; b) modified spider coupling (lip providing bulging space for the rubber element); c) finger-sleeve coupling; d) toroid shell coupling; e) rubber disc coupling; f) Centaflex coupling.

torques transmitted to the spindle at low rpm.

Increasing effective damping capacity of a transmission by using a high damping coupling or special dampers.

When the damping of a system is increased without changing its torsional stiffness, the amplitude of torsional vibrations is reduced at the resonance and in the near-resonance zones. Increased damping is especially advisable when there is a wide frequency-spectrum of disturbances acting on a drive; e.g., for the drives of universal milling machines. The effect of increased damping in a torsionally flexible coupling of a milling machine transmission is illustrated in Figure 10 (natural frequencies $f_{n1} = 10$ Hz, $f_{n2} = 20$ Hz). Figure 10a shows the resonance for an OEM coupling (flexible element made from neoprene rubber, log decrement $\delta \approx 0.4$). After this element was made from a butyl rubber (same compliance, but $\delta \approx 1.5$), the peak torque amplitude was reduced by ~ 1.8 times, the clearance opening (source of intensive noise) was eliminated, and oscillations with f_{n2} excited by the second harmonic of the excitation force, became visible (Fig. 11b). A common misconception about using high-damping elastomers for coupling elements is their alleged high heat generation at resonance. Due to vibratory torque amplitude reduction with high-damping couplings, the heat generation at the resonance is *decreasing* when the high-damping coupling is used (Ref. 1). The influence of a flexible element on the total energy dissipation in a transmission increases with increasing of its damping capacity, of the torque amplitude in the element and of its compliance. For maximum efficiency, the flexible element of a coupling must therefore have as high an internal energy dissipation as possible; it must also possess maximum permissible compliance, and must be located in the part of the system where the intensity of vibrations is the greatest.

Introducing nonlinearity in the transmission system. A nonlinear dynamic system may automatically detune away from resonance at a fixed-frequency excitation. For example, when

damping is low, a relative change of the stiffness by a factor of 1.3 reduces the resonance amplitude by ~1.7 times, but a relative change of stiffness by a factor of 2 reduces the resonance amplitude by ~1.85 times. Thus, nonlinear torsionally flexible couplings can be very effective in transmissions where high-intensity torsional vibrations may develop and where the coupling compliance constitutes a major portion of the overall compliance.

Vehicles usually have variable speed transmissions. The same is often true for production machines. In order to keep the coupling size small, it is usually installed close to the driving motor/engine, where it rotates with a relatively high speed and transmits a relatively small torque. At the lower speeds of an output member, the installed power is not fully utilized and the absolute values of torque (and of amplitudes of torsional vibrations) transmitted by the high-speed shaft are small. In vehicles, the installed power is not fully utilized most of the time. Thus, an important advantage of couplings with nonlinear load-deflection characteristics is feasibility of making a reasonably small coupling with low torsional stiffness and high rated torque. An overwhelming majority of power transmission systems are loaded with less than 0.5 Tr for 80–90% of the total “up” time. A nonlinear coupling with a hardening load-deflection characteristic such as one in Figure 14 provides low torsional stiffness for most of the time, but since its stiffness at the rated torque is much higher, its size can be relatively small.

Compensation Ability of Combination-Purpose Couplings.

A huge variety of combination-purpose couplings is commercially available. Unfortunately, selection of a coupling type for a specific application is often based not on an assessment of performance characteristics of various couplings, but on the coupling cost or other non-technical considerations. As a result, bearings of the shafts connected by the coupling may need to be more frequently replaced than when an optimized coupling is used; the device

might be noisier than it would be with a coupling type optimal for the given application, etc.

Figure 11 shows some popular designs of combination-purpose couplings.

Combination-purpose couplings do not have a compensating member. As a result, compensation of misalignment is accomplished, at least partially, by the same mode(s) of deformation of the flexible element as used for transmitting the payload. To better understand the behavior of combination-purpose couplings, an analysis of the compensating performance of a typical coupling with a spider-like flexible element is helpful. The coupling in Figure 12 shows a schematic of the jaw coupling in Figure 11a. It consists of hubs 1 and 2 connected with a rubber spider 3 having an even number $Z = 2n$ of legs, with “ n ” legs (“ n ” might be odd) loaded when hubs are rotating in the forward direction and the other n legs loaded during the reverse rotation. Deformation of each leg is independent. The radial (compensation) stiffness of the coupling with $Z = 4$ is

$$k_{com} = \frac{F}{e} = 2k_t \quad (15)$$

$$\sqrt{\cos^2 \alpha + \frac{k_r}{k_t} \sin^2 \alpha}$$

where F is radial force caused by the radial misalignment e and acting on the connected shafts, k_t is stiffness of one leg in compression (tangential direction), k_r is stiffness in shear (radial direc-

tion), and α is angle of rotation of the coupling. Equation 15 shows that the total radial force F fluctuates both in magnitude and in direction during one revolution.

For a coupling with $Z \geq 6$,

$$k_{com} = \frac{F}{e} = \frac{n}{2} (k_t + k_r) \quad (16)$$

or F is constant and is directed along the misalignment vector.

The ratio k_r/k_t varies with changing rubber durometer H , and for typical spider proportions, $k_r/k_t = 0.26-0.3$ for medium $H = 40-50$, and $k_r/k_t = 0.4$ for hard rubber spiders, $H = 70-75$.

A spring/tubular spider coupling modification is shown in Figure 8 (Ref. 4). In this design, each leg of the spider can be represented by a coil spring loaded radially by the transmitted torque. For the tightly coiled extension spring k_s ;

$$k_t \approx \frac{\pi^2 E n d^4}{3.74 D^3}; \quad k_r = \frac{G d^4}{8 D^3 n} \quad (17)$$

thus $k_r/k_t = 1/53n^2 = 0.02/n^2 \approx 0$.

The torsional stiffness of both spider coupling designs is

$$k_{tor} = n k_t R_{eff}^2, \quad (18)$$

where the effective radius $R_{eff} = 0.75 R_{ex} = 0.75(D_{ex}/2)$. The ratios between torsional and compensation stiffness values are as follows:

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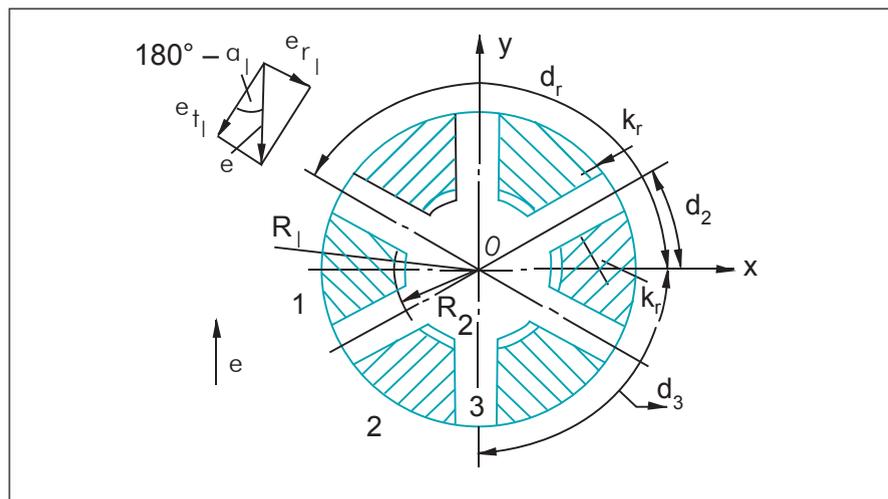


Fig. 12—Schematic of a spider coupling: hubs (1, 2) and rubber spider (3).

$$\text{for } Z = 4, \left(\frac{k_{com}}{k_{tor}} \right)_{\max} = \frac{1}{R_{eff}^2} \approx \frac{1.8}{R^2}; \quad \frac{k_{com}}{k_{tor}} = \frac{0.9}{R^{ex}} \quad (18b)$$

$$\text{for } Z \geq 6, \frac{k_{com}}{k_{tor}} = \frac{1.15}{R_{ex}^2}, H =$$

$$40 - 50 \frac{k_{com}}{k_{tor}} = \frac{1.25}{R_{ex}^2}, H = 65 - 75;$$

for the spring spider coupling per Figure 8, $Z = 6$,

In general, the ratio of radial (compensating) stiffness and torsional stiffness of a combination-purpose flexible coupling can be represented as

$$\frac{k_{com}}{k_{tor}} = \frac{A}{R^2}, \quad (19)$$

where the A is the "Coupling Design Index"

A allows one to select a coupling design better suited to a specific application. If the main purpose is to reduce misalignment-caused loading of the connected shafts and their bearings for a given value of torsional stiffness, then the least value of A is the best, together with a large external radius. If the main purpose is to modify the dynamic characteristics of the transmission, then minimization of k_{tor} is important.

Comparison of Combination Coupling Designs.

The bulk of designs of torsionally flexible or combination-purpose couplings employ elastomeric (rubber) flexible elements. Couplings with metal springs possess the advantages of being more durable and of having characteristics less dependent on frequency and amplitude of torsional vibrations. However, they may have a larger number of parts and higher cost, especially for smaller sizes. As a result, couplings with metal flexible elements, as of now, have found their main applications in large transmissions, usually for rated torques 1,000 N-m and up. Use of the modified spider coupling in Figure 8 may change this situation.

Couplings with elastomeric flexible elements can be classified in two sub-groups:

(a) Couplings in which the flexible element contacts each hub along a continuous surface (shear couplings as in Figure 9a, toroidal shell couplings, couplings with a solid rubber disc/cone, etc.). Usually, torque transmission in these couplings is accommodated by shear deformation of rubber;

(b) Couplings in which the flexible element consists of several independent or interconnected sections (rubber disk and finger sleeve couplings as in Figure 11c, spider couplings as in Figures 11a and 11b, couplings with rubber blocks, etc.). Usually, torque transmission in these couplings is accommodated largely by compression or "squeeze" of rubber; thus they are usually smaller for a given rated torque.

Comparative evaluation of the commercially available couplings based on available manufacturer-supplied data on

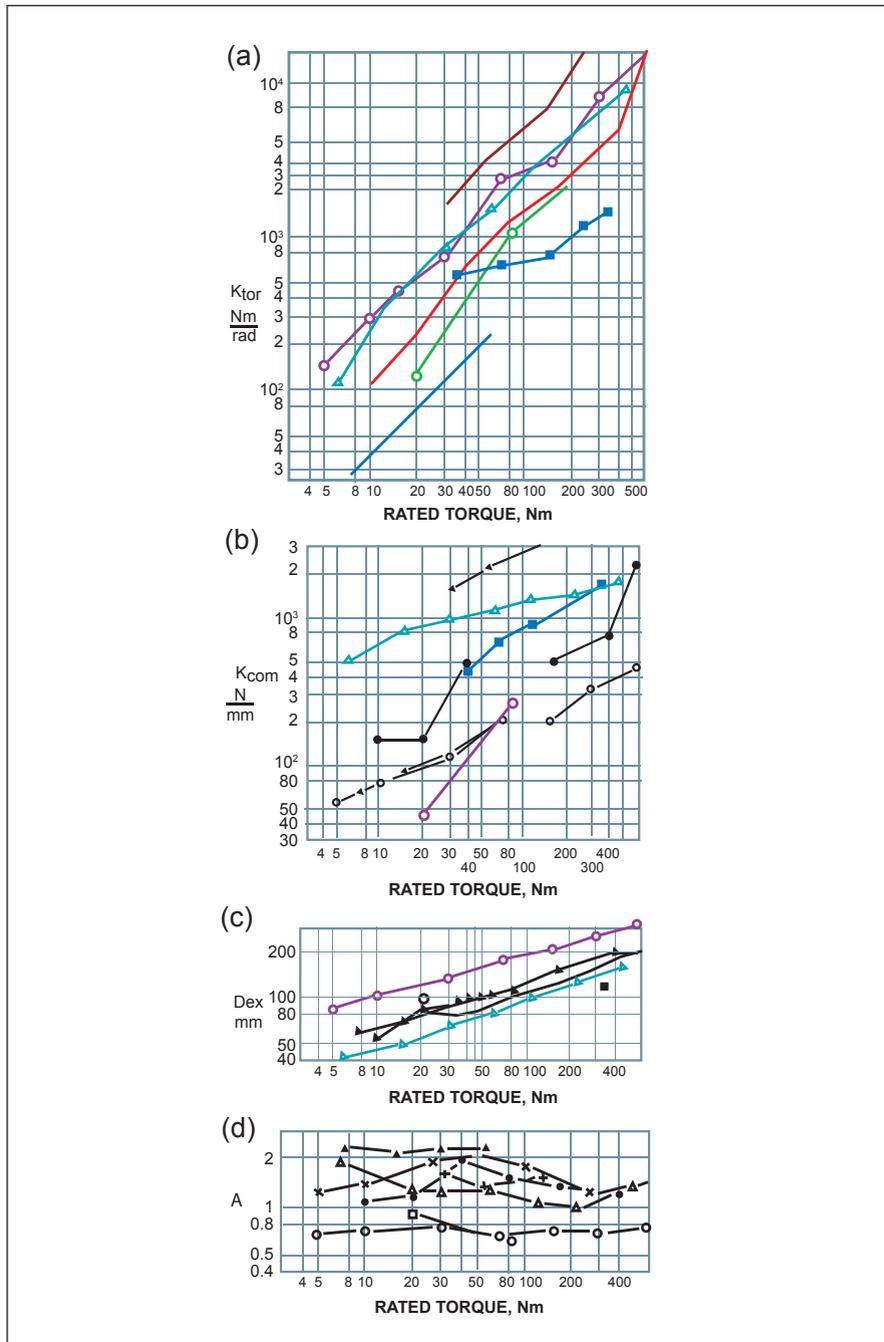


Fig. 13—Basic characteristics of some combination-purpose couplings; a) torsional stiffness; b) radial stiffness; c) external diameter; d) coupling design index. \blacktriangle - spider coupling in Fig. 10b; \blacktriangle - spider coupling with straight rectangular legs; $+$ - finger sleeve coupling; \circ - toroid shell (tire) coupling; \square - rubber disc coupling; $-$ Centaflex coupling; \bullet - test results for coupling in Fig. 12 (same coupling at various transmitted torque).

flexible couplings is presented in Figure 13. Plots in Figures 13a–d give data on torsional stiffness k_{tor} , radial stiffness k_{rad} , external diameter D_{ex} , and design index A .

The “modified spider” coupling in Figure 11b is different from the conventional spider coupling shown schematically in Figure 11a by four features: its legs are tapered, instead of uniform width, and made thicker even in the smallest cross section, at the expense of reduced thickness of protrusions on the hubs; lips on the edges provide additional space for bulging of the rubber when the legs are compressed; and the spider is made of a very soft rubber. These features substantially reduce stiffness values while retaining the small size characteristic of the spider couplings.

Data for “toroid shell” couplings in Figure 13 are for the coupling as shown in Figure 10d.

The “spider coupling” for $T_r = 7$ N·m has the number of legs $Z = 4$ while larger sizes have $Z = 6$ or 8 . This explains differences in A ($A = 1.96$, close to theoretical 1.8 , for $Z = 4$; $A = 0.98$ – 1.28 , close to theoretical 1.15 – 1.25 , for $Z = 6$ or 8).

Values of A are quite consistent for a given type of coupling. Some variations can be explained by differences in design proportions and rubber blends between the sizes.

Plots in Figure 13 help to select a coupling type best suited for a particular application, but do not address issues of damping and nonlinearity. Damping can be easily modified by proper selection of the elastomer. High damping is beneficial for transmission dynamics, and may even reduce thermal exposure of the coupling.

A coupling with a hardening nonlinear characteristic may have high torsional compliance for the most frequently used sub-rated (fractional) loading in a relatively small coupling. Accordingly, the misalignment-compensating properties of a highly nonlinear coupling would be superior at fractional loads. The coupling in Figure 14 (Ref. 5) employs radially compressed rubber cylinders for torque transmission in one direction (117) and

for the opposite direction (118), between hubs (111 and 113) attached to the connected shafts. This design combines the desirable nonlinearity with a significantly smaller size for a given T_r (due to the use of multiple cylindrical elements with the same relative compression in each space between protruding blades, and due to high allowable compression of the rubber cylinders (Ref. 6), thus allowing use of smaller diameters and, consequently, many sets of cylinders around the circumference). Test results for such coupling for $T_r = 350$ N·m are shown as ■ in Figure 13; in this case the data does not refer to different T_r , but to the same coupling at different transmitted torques.

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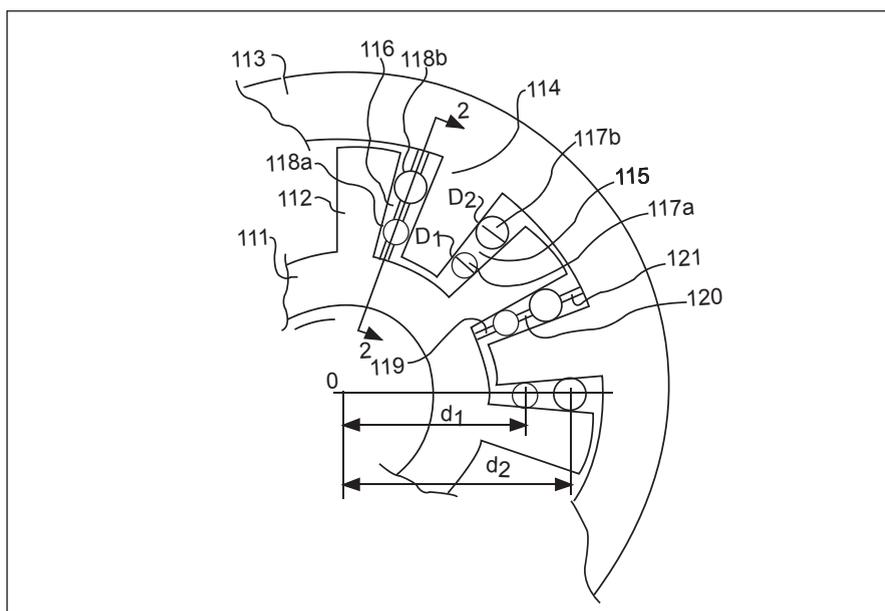


Fig. 14—Torsionally flexible coupling with flexible element composed of radially compressed rubber cylinders.

Eugene I. Rivin was a Principal Staff Engineer at Ford Motor Co., from 1976–1981. Since 1981 he has been professor at Wayne State Univ. Major professional achievements of Dr. Rivin are in transmission dynamics, vibration/noise control, machine tools/tooling, robotics, advanced machine elements, creative problem solving. He published many monographs, book chapters and articles. Most recent books: “Mechanical Design of Robots,” 1988; “Stiffness and Damping in Mechanical Design,” 1999; “Passive Vibration Isolation,” 2003; “Innovation on Demand,” 2005 (with V. Fey). He authored/co-authored 60+ patents, with some inventions widely implemented worldwide. Out of this number, 18 patents relate to power transmission components (gears, flexible and rigid couplings, keys and other rigid interfaces/connections for machine tools and other mechanical systems). He is an elected Fellow of the International Academy of Production Engineering Research (CIRP), of ASME, and of SME.

Improved Sealing Technology

EXTENDS EQUIPMENT LIFE

David C. Roberts

(Presented at Power-Gen International, December 11–13, 2007, New Orleans)



Figure 1—Failed roller bearing elements.

Introduction

The primary sources of bearing failure are lack of lubrication and contaminant ingress. Industrial sealing devices are the primary protection against bearing failure. When the sealing device fails, bearing failure is imminent. Therefore, extending the life of sealing devices extends bearing life and in turn improves equipment uptime. The primary measurements of equipment uptime are: Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR). Each of these metrics is discussed in detail, including their primary methods of calculation. Once established as measurable values, attention is then given to improving MTBF and MTTR through sealing innovations. In examining MTBF, common causes of premature seal failure and new

technological developments to extend time between failures are considered. In examining MTTR, new products available to facilitate and streamline the repair process are the central focus.

Understanding Bearing Failure

Whether the equipment in question is a pulverizer, a turbine, conveyance equipment or something else altogether, there is usually a bearing system either driving or being driven by the equipment. In any application where power is transmitted from one point to the next, a bearing system is used to support rotating elements (usually a shaft) and to support the related loads, while at the same time reducing power losses due to friction. The most common types of bearings are ball and roller bearings.

Under textbook conditions, typical

ball and roller bearing failures occur due to surface fatigue. Either the bearings or the raceways will begin to pit, resulting in audible noise (Ref. 1). As the rolling elements continue to degrade, noise and vibration increase and, eventually, the rolling elements will fracture. This ruins the bearing system and possibly damages connected elements.

A standardized method of predicting bearing failure is the L10 life (also called B90 or C90 life), which is based on the theorem that 90% of a random sample of bearings can be expected to meet or exceed a stated number of revolutions at a given size and load. In actual applications, bearing failure is not so straightforward.

Most bearing systems fail to meet their predicted life due to issues other

than fatigue failure. It has been reported that only 1% (of bearings) actually fail due to pure fatigue. Conversely, the majority of bearing failures are from a lubrication-related issue. This means that most bearing failures can be either prevented or have their service life extended (Ref. 2). Thus by determining the modes of failure and methods of prevention of these lubrication-related issues, bearing life can be drastically improved, avoiding the costly expense of bearing failure.

Understanding the Sealing System

The primary system to protect and extend the life of bearings is the sealing system. When compared to the costs of repairing or replacing the bearing system, the sealing system is much more economical to address. Typically, the sealing system protects the bearing in two ways: it reduces excessive bearing temperatures by retaining lubricant, and it prevents damage from foreign material by excluding external debris. Common sealing devices for rotating equipment include: compression packings, labyrinth seals, mechanical face seals, radial lip seals and hybrid combinations of these seals. For decades, radial lip seals have been the most common form of industrial bearing protection. In recent years, labyrinth seals (or bearing isolators) have increased in popularity due to their non-contact features.

Radial Lip Seals. A common misconception about radial lip seals is that the lip portion of the seal is intended to be in direct contact with the sealing surface at all times. While this was the case with early lip seal designs, modern lip seals include specialized geometries to create a hydrodynamic sealing element. These designs may include “raised helical or parabolic ribs, triangular pads, or sinuous wavy lip elements” (Ref. 3). The hydrodynamic effect causes lubricant to recirculate under the sealing lip and back into the bearing system, causing the seal to ride on a thin meniscus of oil, which significantly reduces friction and seal element abrasion. The meniscus film is typically 0.00018" (0.0046 mm) thick (Fig. 2).

In order to achieve hydrodynamic sealing, it is necessary that the shaft be

appropriately prepared. Therefore, most radial lip seals require a shaft surface finish of 10 to 20 μin (0.25 to 0.50 μm) Ra. In addition to the appropriate surface finish, the shaft must have the appropriate surface hardness. Most seal manufacturers recommend a minimum hardness of 30 Rockwell C (RC). If the surface hardness of the shaft is less than this value, grooving of the shaft can occur, resulting in leakage.

It is also necessary to understand that single-lip seals are unidirectional—they can either act to retain lubricant or exclude debris, but cannot necessarily do both. For the seal orientation shown in Figure 2, the seal will only retain oil. It will not act to exclude foreign debris from the bearing system. To exclude debris in a light-duty environment, a seal with a dust or scraper lip may be used. For heavily contaminated environments, a positive excluder lip design is required (Fig. 3).

Although in principle radial lip seals ride on a meniscus of oil, in practice this is not always the case. There will be periods, particularly at start-up and shut-down,

when the seal lip is in direct contact with the shaft, resulting in power losses. As hydrodynamic sealing is achieved, this power loss is reduced. Further, the direct contact of the sealing lip against the shaft leads to seal abrasion and eventual failure. The friction and abrasion properties of the sealing material, therefore, play an important role in seal performance. Other factors that will affect seal performance include, but are not limited to, operating temperature, pressure, misalignment and runout and bore condition.

Labyrinth Seals. As the need for energy conservation has increased, non-contact seals have become more commonplace in industry. The most common type of non-contact seal is the labyrinth seal. Traditional labyrinth seals use a tortuous pathway to block both the escape of fluids and the ingress of contaminants. They include a static portion that is mated to the application housing and has one or more inside diameter grooves. A dynamic portion of the seal is mated to the shaft and has one or more protrusions (sometimes referred to as teeth or

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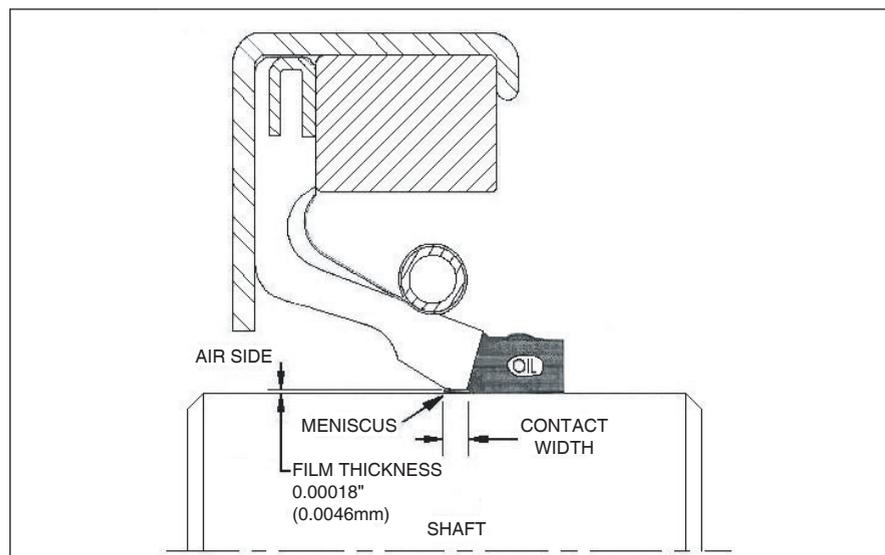


Figure 2—Meniscus film thickness is typically 0.00018".

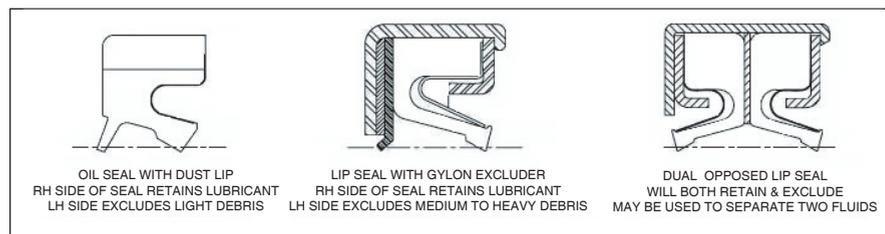


Figure 3—For heavily contaminated environments, a positive excluder lip design is required.

knives) that run inside the grooves of the static portion of the seal. For this reason, the static portion of the seal is referred to as the stator, while the dynamic portion of the seal is referred to as the rotor (Fig. 4).

The principle of operation for a basic labyrinth seal is based in statistical motion of a particle on either side of the labyrinth. The more complex the pathway, the less likely that the particle can penetrate from one side of the labyrinth to the other. Early labyrinth seals were considered an option only in applications where some degree of leakage was allowable. Today, labyrinth seals have evolved into bearing isolators (hybrid labyrinth designs), which utilize basic labyrinth technology along with other methods of retention/exclusion including centrifugal force, pressure differential and drain back design. Today, bearing isolators can provide a much higher-performing sealing solution than traditional labyrinth seals.

Standards for Equipment Reliability and Maintainability

With a basic understanding of primary sealing methods, the issue of improving equipment efficiency through innovative sealing technology can be addressed. First, however, a method is required to measure equipment performance. The basic factors used in measuring equipment performance are based in statistics. Primarily, the ratio of uptime

vs. downtime is involved. In quantifying equipment performance, there are two established standard indicators defined as follows:

- Reliability—the probability that the equipment will perform its intended function, within stated conditions, for a specified period of time.
- Maintainability—the probability that the equipment will be retained in, or restored to, a condition where it can perform its intended function within a specified period of time.

The reliability indicator is quantified by comparing the productive time to the number of failures occurring within a specified time period. The most common method of measurement is the Mean Time Between Failures (MTBF). This value is calculated by the total productive time, which only refers to events occurring during the manufacture of product, divided by the total number of failures during the given productive time. The result is the “average time the equipment performed its intended function between failures” (Ref. 4).

$$MTBF = \frac{PT}{N} \quad (1)$$

Where:

MTBF = Mean Time Between Failures

PT = Productive Time

N = Number of Failures That Occur

During Productive Time

The maintainability indicator deals with the time required to retain or restore equipment to a state such that it will continue to function as designed. The primary value used to measure this indicator is the Mean Time To Repair (MTTR). It is defined as follows:

$$MTTR = \frac{RT}{N} \quad (2)$$

Where:

MTTR = Mean Time To Repair

RT = Total Repair Time

N = Number of Failures That Occur

Innovations in Sealing Technology Improve MTBF

In order to improve the MTBF, the life of the operating components must be extended. It has already been noted that bearing failures rarely occur due to actual fatigue of the bearing surfaces, more often occurring due to lubrication related issues. Therefore, by improving the system’s ability to retain bearing lubrication and prevent bearing contamination, the life of the bearing system will be extended significantly.

There are two modes where seal failure affects MTBF. In the first case, the seal fails, the failure is noted, and the system is shut down to replace the seal. Some amount of downtime is incurred to replace the seal. In the second case, the seal fails, but the failure is not noted until bearing failure occurs. Significantly more downtime (and cost) is incurred than in the first case. However, in both cases extending seal life is vital to reducing MTBF and the significant costs associated with bearing failure.

Understanding Seal Failure

In determining how to improve seal life, it is first necessary to understand how seals fail. Modes of failure include thermal degradation, excessive wear due to abrasion, lack of lubrication, chemical degradation and changes in physical properties while in service.

As noted earlier, in an ideal sealing application, the seal lip never directly contacts the shaft surface, but rather rides on a thin film of oil called a meniscus. In typical applications, there are likely periods of dry running of the sealing element

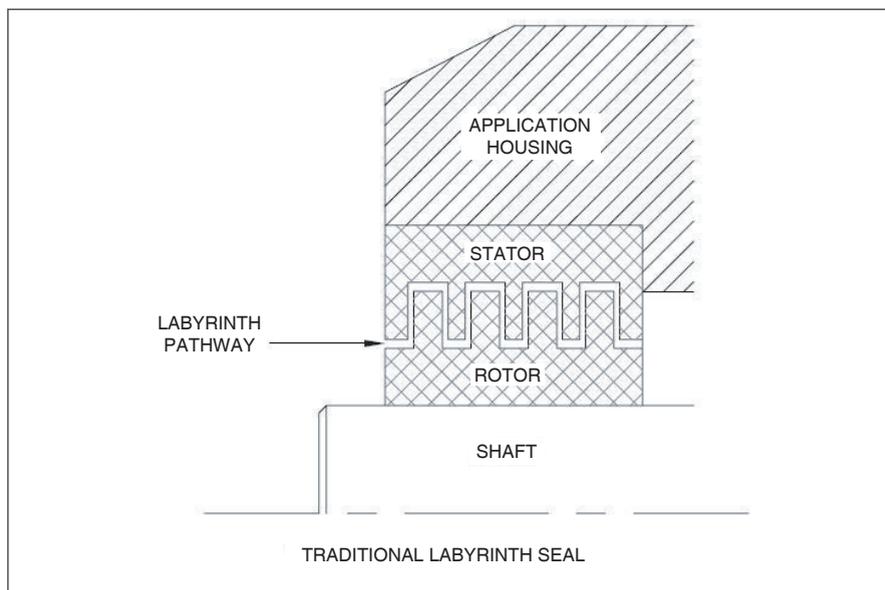


Figure 4—The static portion of the seal is referred to as the stator, while the dynamic portion of the seal is referred to as the rotor.

(this condition is especially noted during start-up). This condition increases the under-lip temperature and may cause the seal lip to become hard and brittle. When this occurs, the seal lip can no longer follow the eccentricities of the shaft and leakage results. The direct contact of the seal lip and the shaft also contributes to the abrasion of seal material. This abrasion will eventually decrease the seal's radial cross-section such that the seal lip no longer completely contacts the shaft, again resulting in leakage. A lack of lubrication or actual dry running of the seal exacerbates these conditions.

When exposed to chemicals not compatible with the seal material, abnormal swelling may occur. Also, over the course of a seal's service life, the physical properties of the sealing elastomer may significantly change, again resulting in leakage. Properties subject to change include hardness (durometer), tensile strength, elongation, volume, wear width and Taber wear factor.

Material Innovations
Improve Seal Life

The factors that contribute to seal failure are directly related to the properties of the materials used to manufacture sealing products. For contact seals, elastomers are typically used due to their resilient nature, although some thermoplastic materials are also utilized. Common sealing materials include acrylonitrile butadiene (Buna-N, NBR); hydrogenated nitrile rubber (HNBR), fluoroelastomer (FKM—Viton), silicones, and polytetrafluoroethylene (PTFE—Teflon).

In addition to these materials, Garlock Klozure engineered the Mill-Right family of elastomers. These elastomers offer significant improvements in performance over industrial-grade sealing materials. Specific areas these elastomers focus on include improvements in abra-

sion resistance chemical resistance, and physical property retention.

Abrasion Resistance

In order to improve a material's wear resistance, a method of quantifying this property is needed. The most common method of measuring a material's resistance to abrasion is the Taber wear test (ASTM D4060). The Taber wear test starts with precisely weighed sample specimens of a particular elastomer. The specimens are "mounted to a rotating turntable and subjected to the wearing action of two abrasive wheels, which are applied at a specific pressure" (Ref. 5). When the test is completed, the specimens are re-weighed to determine how much material was abraded away. Results are reported in mg loss/1,000 cycles. Therefore, the lower the reported value, the better the seal's durability.

Typical nitrile rubbers have a Taber wear factor of 500 mg loss/1,000 cycles or greater. Garlock Klozure's new Mill-Right N has a Taber wear factor of 145.5 mg loss/1,000 cycles—a 73% improvement in wear resistance over industrial-grade nitrile rubber. Similarly, the resistance of HNBR was increased 65%, and that of FKM, 90% (Table 1).

Industrial grade nitrile rubber (NBR) loses 548 mg per 1,000 cycles in testing. Compare this to Mill-Right N, where only 145.5 mg are lost under the same testing conditions. The material loss of Mill-Right N is only one-fourth that of industrial grade NBR. Therefore, seals made from Mill-Right N are likely to be in service significantly longer than those made from industrial grade nitrile.

The improvement in material abrasion resistance is highly significant, as it directly relates to service life. As abrasion occurs, the lip geometries responsible for hydrodynamic sealing begin to disappear. Further, the required interference

between the sealing lip and the shaft reduces, making the seal less capable of handling misalignments in the system. Abrasion may continue to the point where this interference becomes virtually nonexistent. Therefore the less a material abrades away, the longer it will continue to perform.

Chemical and Physical Properties

Two common methods of determining a material's ability to retain its physical properties over time are heat aging testing and ASTM 903 oil immersion testing. This testing requires that properties such as hardness, tensile strength, elongation and volume are measured prior to exposing the sample to heat or oil, and are retested after a specified time of exposure.

When exposed to chemicals or heat, all elastomers will experience some change in physical properties. The baseline for property retention is perfection—no changes when exposed to chemicals or heat. However, no elastomer will perform perfectly in service. The goal is to get the elastomer to perform as close to perfection as possible. This is a difficult task since the processing and formulation required to maintain certain properties may have an opposite effect on others. Therefore, material formulation and development often ends up being a trade-off between the retention of various properties.

If the properties of a sealing material change in service, this will have a significant effect on the overall performance. For instance, changes in volume may affect sealing effectiveness in two ways: 1) If the material shrinks in service, the necessary interferences will be decreased; 2) If the material swells, interference will be excessive. A decrease in interference may affect the seal's misalignment and retention capabilities. An increase in interfer-

continued

Table 1—Taber Wear Factor Comparison

	Industrial Grade NBR	Garlock Klozure Mill-Right N	Industrial Grade HMBR	Garlock Klozure Mill-Right ES	Industrial Grade FKM	Garlock Klozure Mill-Right V
Taber Wear Factor (mg loss/1000)	548.0	145.5	113.2	39.2	481.4	49.2

ence may reduce the hydrodynamic effect and result in excessive temperatures.

The Mill-Right materials have improved the retention of physical properties. The radar charts located in the accompanying appendices show the specific improvements regarding each property. The baseline of perfection is noted on these graphs. The deviation from perfection is noted for both the specific Mill-Right material and the industrial grade material.

Other Material Innovations—Gylon

On April 6, 1938, DuPont chemist Dr. Roy J. Plunkett discovered polytetrafluoroethylene (PTFE). This was a remarkable discovery, since up to that time it was believed that chlorinated and fluorinated ethylenes could not be polymerized. In 1945, DuPont registered this new material as Teflon. PTFE has desirable sealing qualities because it is virtually inert to all chemicals, has a very

low coefficient of friction and does not absorb moisture from its environment. However, unfilled PTFE has a tendency to cold flow (permanently deform under load) while in service, making it questionable as a sealing material. Also, being a very rigid material, when used as a radial lip seal, PTFE often lacks the ability to consistently follow the shaft eccentricities found in a typical sealing system (Refs. 6 and 7).

In the 1960s, Garlock developed a new method of manufacturing PTFE and named this proprietary material Gylon. Originally intended for use in gasket applications, this new material incorporated special fillers to increase stability such that cold flow in service was virtually eliminated. Later this technology was applied to radial lip seals. Garlock Klozure’s ps seals employ a thin Gylon gasket rolled into a radial lip configuration. This thin feature reacts similarly to

an elastomer in following shaft eccentricities in a sealing system. The advantages of this type of seal include the ability to run dry without abrading, an extremely low coefficient of friction and the ability to handle high-pressure applications up to and even exceeding 150 psi. However, these seals will not handle excessive shaft-to-bore misalignment or speeds in excess of 2,000 feet-per-minute. Examples of ps seals are shown in Figure 5.

**Sealing Product Innovations—
Bearing Isolators**

Radial lip seals can provide a consistent, reliable sealing system for most applications. However, there are drawbacks. The elastomer materials can be aggressive when applied to the surface of a soft shaft material. If the shaft surface hardness is less than 30 RC, grooving can occur over time. This groove becomes a leak path for lubricant or an ingress for contaminants. The radial lip seal can also induce a power loss in the system due to the drag force of the seal against the shaft surface. Although this power loss may be small relative to the power consumption of the entire system, increasing demands for power conservation may drive end users to seek alternative sealing methods. In conveyance systems where multiple idle rollers may be driven from a primary source, frictional losses from sealing devices can add up significantly. Other considerations include the fact that most radial lip seals cannot run dry and that most radial lip seals are unidirectional in sealing capacity. For these and other reasons, bearing isolators are becoming more commonplace in industrial sealing systems (Table 2).

Bearing isolators, developed from labyrinth seals, incorporate the concept of a tortuous path for fluid sealing with concepts such as centrifugal force, pressure differential, and drain-back design. Bearing isolators can incorporate a unitized two-piece design consisting of a rotor and a stator. The rotor is mated to the shaft by means of an o-ring, while the stator is mated to the housing bore in a similar fashion. The stator is statically engaged in the housing bore, while the rotor rotates with the shaft. Any wear occurs internal to the bearing isolator.

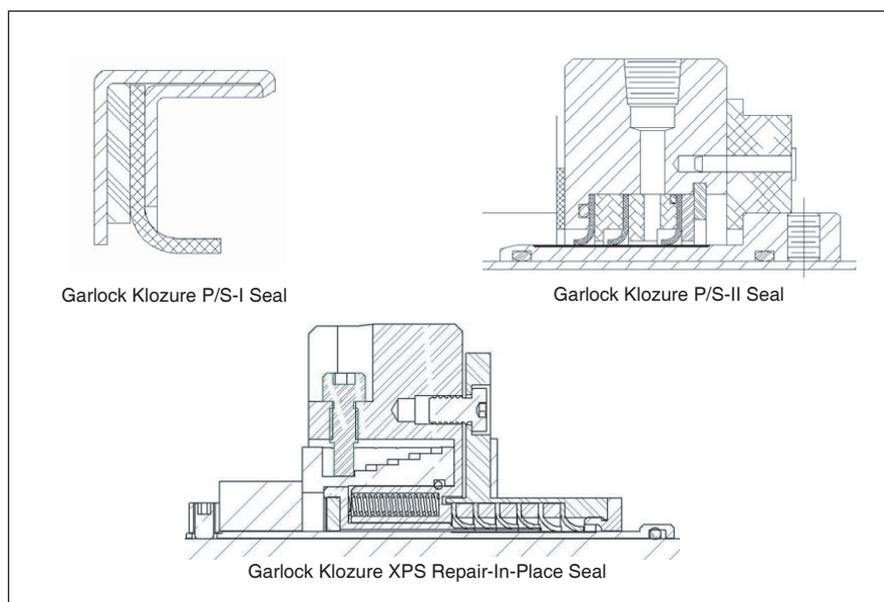


Figure 5—Garlock Klozure P/S-Seals.

Table 2—Comparison of Common Capabilities of Radial Lip Seals and Bearing Isolators		
	Radial Lip Seals	Bearing Isolators
Require Min 30 RC Shaft Surface	YES	NO
Noted Power Loss	YES	NO
Dry Running	NO	YES
Offer Both Retention & Exclusion	NO*	YES
Pressure Sealing	YES	NO
*Assuming single lip oil seal		

This is minimized by using low-friction materials of construction, resulting in a highly extended service life. Typically, these bearing isolators, when properly specified and installed, will have service lives equal to or greater than the bearing system.

One industry that has pushed the demand for non-contact seals is wind power generation. Testing by Chitren & Drago, targeting wind power applications, showed that an average oil seal consumes 285 watts of power during normal operation, while during start-up the power consumption spikes to 670 watts. Under similar conditions, a bearing isolator only consumes 120 watts during normal operation, with spikes up to 150 watts during start-up. Other case study data showed the service life of bearing isolators to be up to 65 times that of traditional oil seals (Ref. 8).

Innovations in Sealing Technology Improve MTTR

To significantly improve MTTR, it is necessary to identify the steps involved in sufficiently repairing equipment and the time related to each step. In seal maintenance and repair, the most time-consuming steps include the disassembly and reassembly of bearing equipment. This may include the disassembly of pillow blocks, motor housings, pump housings, etc., with the necessary realignments and adjustments required after reassembly. One of the main reasons for this is that solid seals must be installed over the free end of a shaft with all attached components removed from the assembly. The innovation of a split seal allows the user to install the sealing device without having to completely disassemble the equipment, drastically reducing maintenance time. While the concept of splitting an elastomeric seal has existed for several decades, this concept has only recently been applied to bearing isolator seals. Another innovation to improve MTTR is that seals that can be repaired without removing the seal from service, known as repair-in-place seals.

Split Radial Lip Seals. A split radial lip seal is a relatively simple concept. It involves removing a section of an all-

rubber seal to create a seal with a single split point. The seal can be opened along the axis of rotation to allow easy assembly over the diameter of the shaft. Some split seals include a garter spring which needs to be assembled around the shaft onto the seal during installation. This can be cumbersome and even a possible source of equipment failure if the spring becomes dislodged during installation of the seal into the housing bore. Some split seals can include a molded-in finger spring, which eliminates the need for a garter spring and contributes to even load distribution at the contact point on the shaft.

Most split seals require a cover plate in order to be retained within the housing bore. Otherwise, they may “walk” out of the equipment. A cover plate is simply a flat metal plate (either whole or split) that can be bolted against the housing to retain a split seal (Fig. 8).

It is vital that the seal width and bore depth be properly fitted so that there is appropriate axial retention of the split

seal. Some seals include a reinforced heel molded into the rubber to improve bore retention. Due to the heel reinforcement, this type of seal does not require a cover plate for housing bores under 10 inches (254 mm) in diameter (Fig. 9).

Split Bearing Isolators. A project recently developed and currently in field testing at the time of this writing is the split bearing isolator (Fig. 10). This seal uses the same labyrinth technology, including a unitized rotor and stator incorporated into a seal that is split into two halves at the 3 o’clock and 9 o’clock positions. This new seal has performance specifications similar to previous bearing isolator seals, but it allows for easier installation.

The First Repair-in-Place Seal. While many innovations seek to reduce MTTR, few if any have been able to completely eliminate it. The Garlock Klozure XPS mechanical seal was recently developed with this concept in mind—to completely eliminate the need

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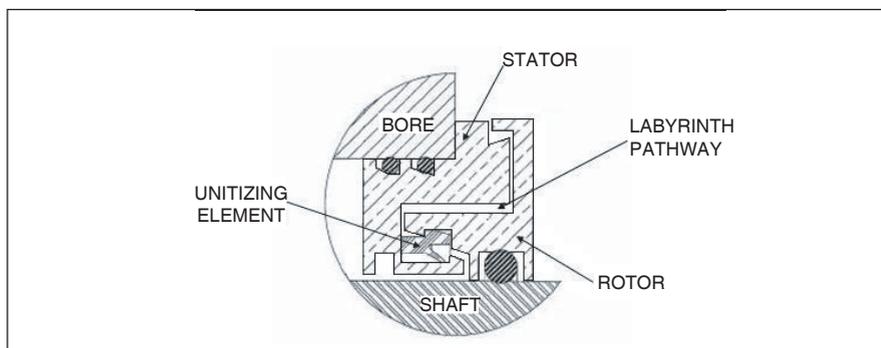


Figure 6—Garlock Klozure Guardian Bearing Isolator.

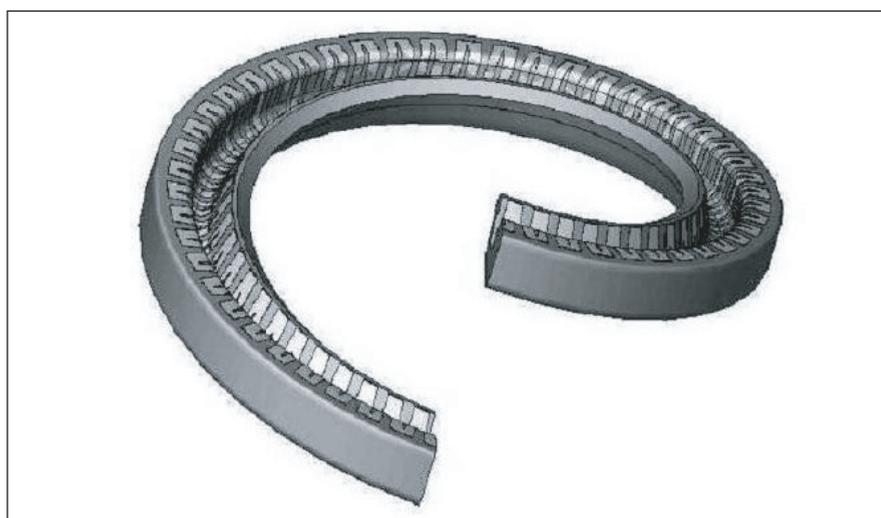


Figure 7—Garlock Klozure Model 23 Split Seal.

for seal replacement (Fig. 11).

The XPS seal uses ps-type sealing technology, which involves a thinly formed Gylon lip running on a hardened sleeve. The seal includes a total of six Gylon lips; however, only two are initially deployed. Four additional sealing elements are stored behind the primary elements on a deployment sleeve. When

failure of the primary sealing elements is noted, or when dictated by the preventive maintenance cycle, a simple turn of the deployment screw moves a fresh set of sealing lips into place without any significant downtime.

Common sealing applications for the XPS mechanical seal may include boilers, scrubbers, pumps, motors, conveyors

and gear boxes. Common sealing media may include water, caustics and petroleum-based lubricants. When the last set of sealing lips has exhausted its service life, the cartridge-based deployment section can be refurbished, allowing the XPS seal to be reloaded for further in-place repairs (Ref. 9).

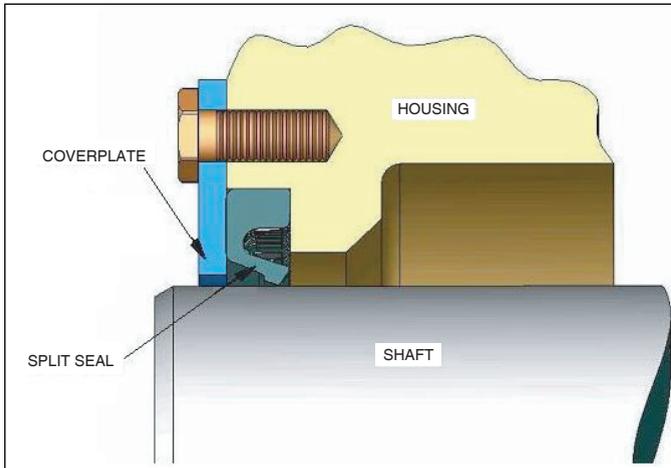


Figure 8—Split Seal with cover plate.



Figure 9—Garlock Klosure Model 26 Split Seal.

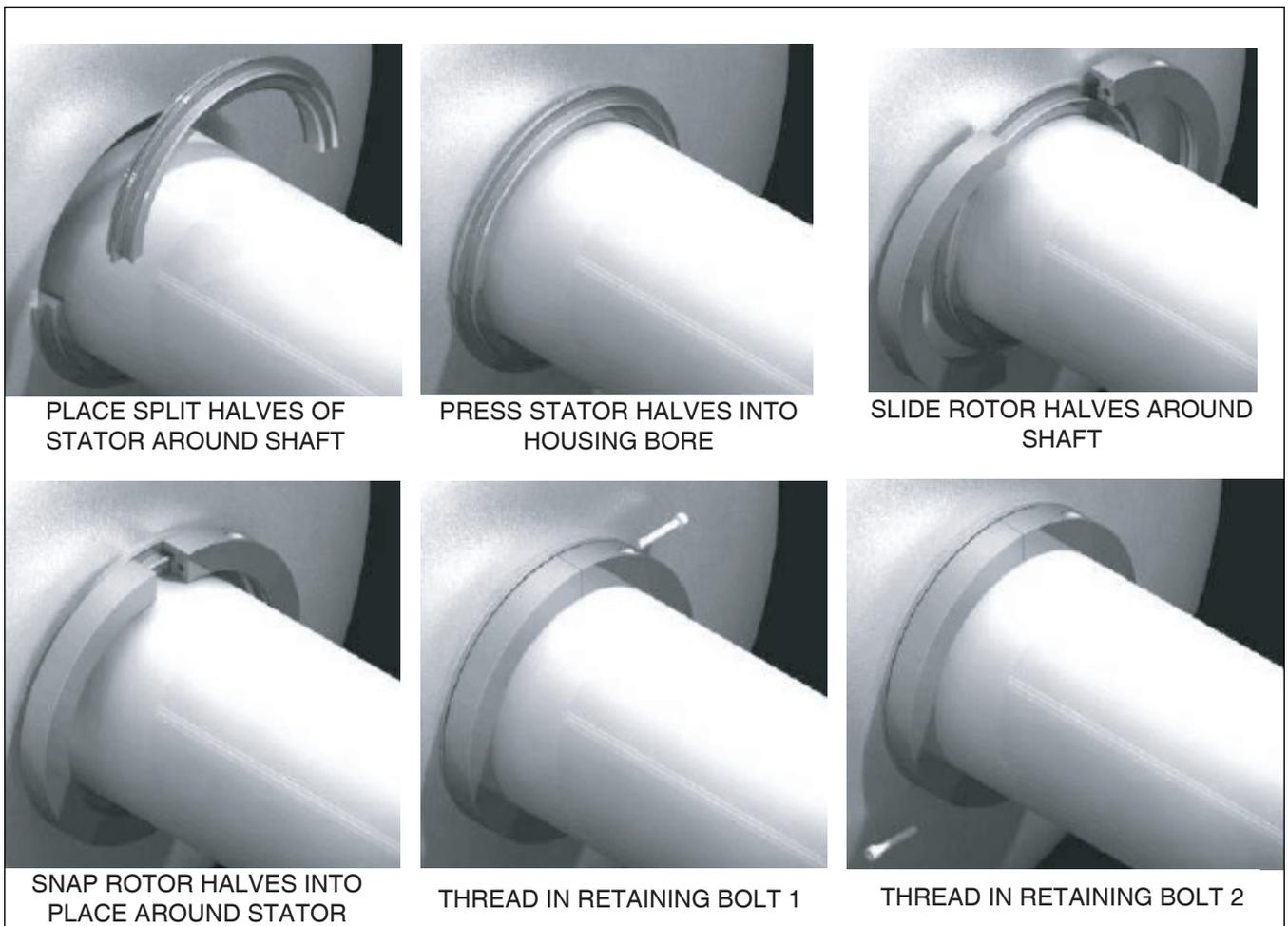


Figure 10—Installation of Garlock Klosure Guardian Split

Conclusion

Improving equipment life is not a simple task. Equipment needs to be broken down into systems, systems into sub-systems, and sub-systems into components. However, since the bearing system is one of the key elements of power generation equipment, significantly improving its life will have a profound effect on the overall equipment performance. Appropriate sealing devices are critical to bearing efficacy. Utilizing tools such as Mean-Time-Between-Failures and Mean-Time-To-Repair provides the necessary metrics to gauge system performance. New innovations such as advanced sealing materials and non-contact seals help to improve these indicators, as well as to meet requirements for increased power conservation. Innovations such as split seals and bearing isolators, as well as repair-in-place technology, can significantly reduce maintenance costs.

Improving equipment life is a continuous process. Demands for increased efficiency and decreased power consumption will continue. Thus the need to innovate will continue, building on existing technologies and developing new ones. 

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See Appendix—Mill-Right Data, pg 40.

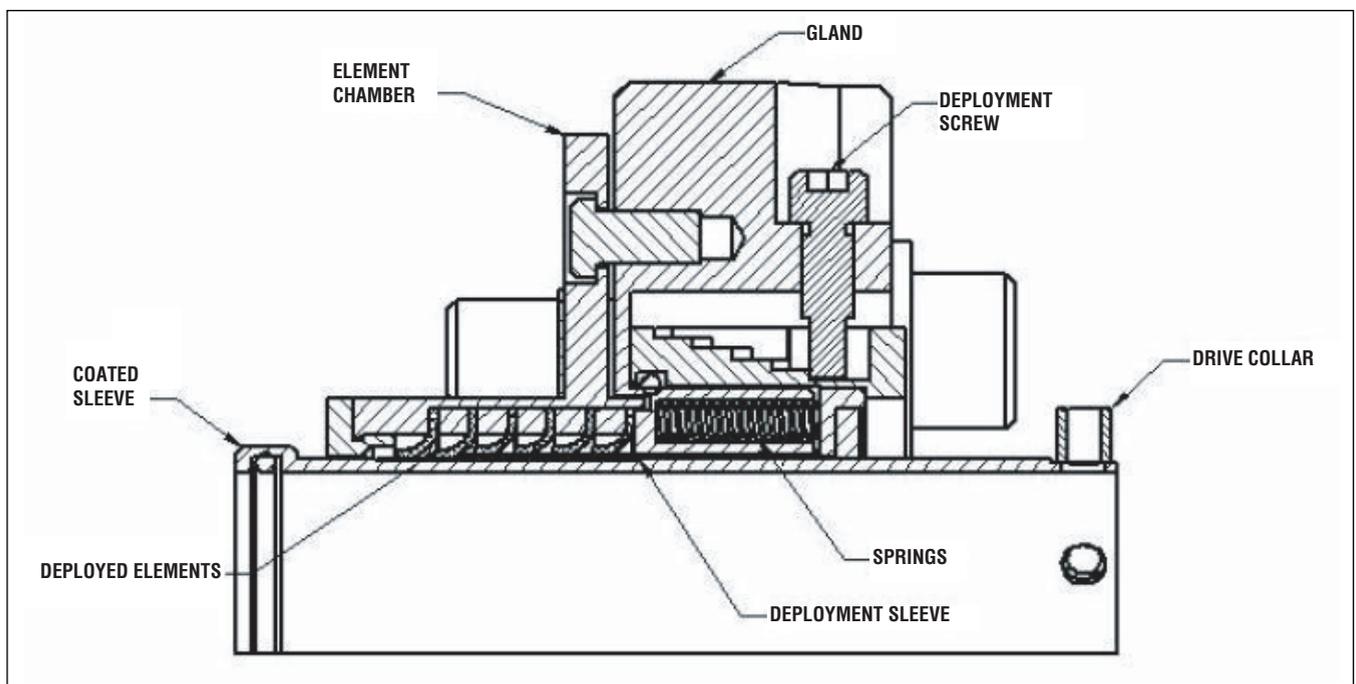


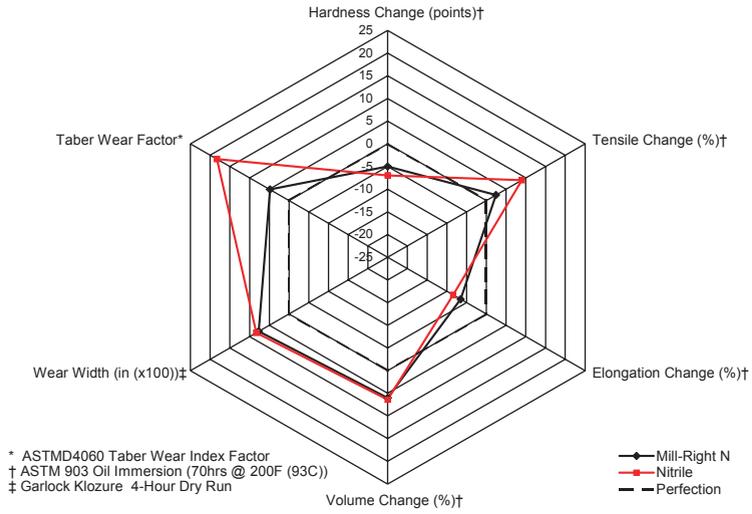
Figure 11—Garlock Klozure XPS Mechanical Seal.

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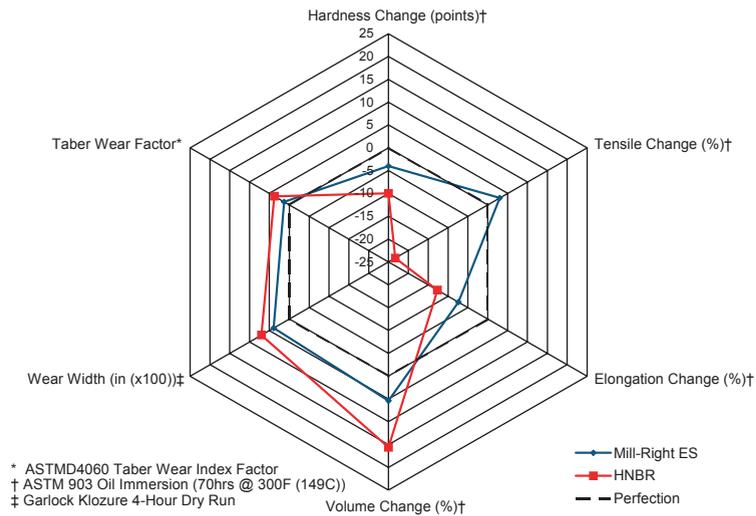
Appendix—Mill-Right Data Mill-Right N Radar Chart

These charts compare Mill-Right N's ability to retain its physical properties over time with that of industrial grade nitrile rubber.

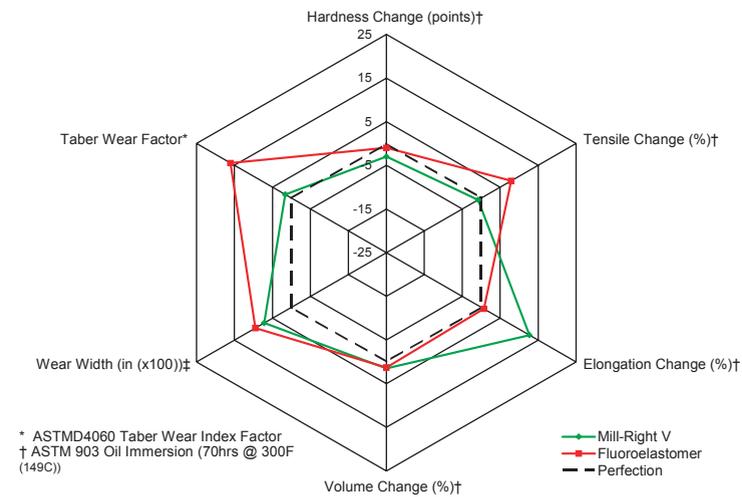
Garlock Klozure Mill-Right N Vs. Nitrile



Garlock Klozure Mill-Right ES Vs. HNBR



Garlock Klozure Mill-Right V Vs. Fluoroelastomer



**HVAC&R INDUSTRY
EMBRACES GREEN AT**

AHR Expo

As if there wasn't enough green at last year's green-themed AHR Expo, this year organizers have planned a full blown green invasion of the HVAC&R industry.

The International Air-Conditioning, Heating, Refrigerating Exposition is the largest trade show for the HVAC&R professional with more than 70 educational sessions, 375,000 net square feet of exhibit space and 50,000 anticipated attendees from more than 120 countries. After a successful installment in New York, the 61st AHR Expo returns to the site of its historically largest shows, McCormick Place, Chicago.

"At the last AHR Expo (2008 in New York) we started to set in motion features that acknowledged the growing emphasis on green in the HVAC&R industry," says Clay Stevens, president of International Exposition Company, which is responsible for producing and managing the show. "We recognized the critical role played by our industry in saving energy and assuring a safe and healthy indoor environment.

"The 2009 show will take the green and sustainable emphasis to the next level."

Placing significant emphasis on environmentally friendly and energy-efficient products and technologies, some of the contemporary subjects encompassed by the show include green building, sustainable design, renewable energy, efficiency and indoor air quality. Several more green seminars and sessions are scheduled in comparison to the 2008 program.

The U.S Environmental Protection Agency's Energy Star Program will have a booth while conducting an educational session as well. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)



The AHR Expo will span 375,000 net square feet of exhibit space at Chicago's McCormick Place. (Courtesy of Oscar Einzig)



Many of the new products and technologies on display emphasize environmentally-friendly features and energy efficiency. (Courtesy of Oscar Einzig)

events



The 2008 AHR Expo took place in New York City and attracted tens of thousands of attendees worldwide. The 2009 expo returns to Chicago, the site of its most successful past shows. (Courtesy of Oscar Einzig.)

will present various seminars on a number of green topics. Exhibitors can submit their greenest products to the expo's Innovation Awards in the "Green Building" category.

Last year the award went to Carrier

Corporation's Evergreen 23XRV chiller, which is, according to the company, the world's first integrated variable speed, water cooled, screw chiller. The product is ideal for efficiently chilled water plants.

The Green Mechanical Council will host two educational programs free for interested attendees, including a three-hour workshop focusing on defining common phrases and terms, pointing out misconceptions to overcome and identifying the trends that are making green practices mainstream.

Any exhibiting companies that showcase products for improving indoor air quality will be provided with an Indoor Air Quality (IAQ) designation sign to display.

A day-long educational program entitled LEED Implementation for Building Operations and Maintenance will be presented by the U.S. Green Building Council (USGBC). The course is designed for professionals in charge of implementing LEED (Leadership in Energy and Environmental Design) building standards and includes successful project strategies through different credit categories while guiding attendees towards certification.

The HVAC Mobile Green

Classroom will be on site thanks to the Partnership for Environmental Leadership, a collaborative effort of six eco-conscious industry associations. The trailer is a hands-on learning environment, which features new technologies for sustainability in mechanical service and construction including tips to improve building energy efficiency while considering occupant health, safety and comfort.

Some of the new technology demonstrations featured in 2008 included solar collectors or hot water systems, HVAC system design software, micro-computer control system for green technology boilers and carbon neutral building design.

Onsite training opportunities will be available in coordination with MCAA's LEED AP training programs and the UA/MSCA's Green Awareness Training and Certification Program.

"As a leading information resource for the HVAC/R industry, it is critical that the AHR Expo keep its attendees on the cutting edge of the latest 'green' products and issues," Stevens says.

The show also reflects a commitment to green principles with the choice of venue. McCormick Place uses many recycled and environmentally friendly products, which include renewable and fully compostable cold beverage cups, flatware and packaged food boxes as well as entirely recycled paper products in the restrooms. Organizers feel a responsibility to help disseminate information about the latest industry trends and help companies keep up with the times.

"Every one of the last few years has seen the green theme gain in emphasis and importance. HVAC buyers and manufacturers (sellers) alike are now taking green issues more seriously. The degree to which products and systems help buildings measure up to green standards now impacts the whole selection and decision-making process," Stevens says.



Attendees check out the latest HVAC+R products. (Courtesy of Oscar Einzig.)

December 10–12—Introduction to Metallurgical Lab Practices.

ASM International Headquarters, Materials Park, OH. This beginning level course is designed for people with basic or limited familiarity to a materials lab or metallurgical lab practices and non-technical professionals like those in sales or purchasing. The students will learn metallography through sectioning, mounting, grinding, polishing and etching samples. For more information, visit www.asminternational.org.

January 12–15—ProMat 2009.

McCormick Place South, Chicago, IL. The Material Handling Industry of America sponsors ProMat 2009, which is addressing the changing workforce, latest manufacturing equipment and technologies as well as distribution and supply chain issues. There will be over 800 exhibits and an educational conference with a keynote address entitled “Building the Workforce of the Future.” The conference will also feature more than 100 educational sessions covering trends, best practices and cutting edge equipment and technology solutions for improving productivity and profits throughout the supply chain. For more information, contact Carol Miller at cmiller@mbia.org, (800) 345-1815 or www.mbia.org.

January 19–21—Northwest Food Manufacturing and Packaging Convention and Exposition.

Oregon Convention Center, Portland, OR. The 95th installment of this annual show attracts 4,000 food processing industry professionals from all parts of the country. More than 450 booths are on display for CEOs, plant managers, purchasing managers, production and quality assurance managers and mechanics. Educational sessions will focus on topics that include energy and environment, government affairs, radio frequency identification (RFID) workshop and productivity and innovation. For more information, visit www.nfpamembers.org.

January 26–30—AWS Certified Welding Supervisor Seminar.

Hilton Suites Atlanta Perimeter, Atlanta. If you’re involved in the welding field, consider this five-day intensive supervisor training and certification course. The course focuses on necessary knowledge supervisors need to improve productivity, throughput, weld quality, safety and environment. It focuses on the science more than the art of welding in addition to the economics of welding. The program attracts engineers involved with design drawings, foremen, lead welders, line leaders, purchasing personnel, corporate welding instructors and detailers or drawing preparation personnel. The seminar is offered in various locations across the country. For more info, visit www.aws.org/certification/CWS.

February 3–6, World of Concrete.

Las Vegas Convention Center, Las Vegas. World of Concrete is an annual international event for the commercial concrete and masonry construction industries, which attracts over 1,700 suppliers spanning more than 900,000 net square feet of exhibits. On display are new products, technologies, tools and equipment. Outdoor exhibits and event areas bring hands-on demonstrations, resources and techniques. More than 150 seminars are held beginning a day before the exhibition. For more information, visit www.worldofconcrete.com.

February 10–12—Pacific Design and Manufacturing Show.

Anaheim Convention Center, Anaheim, CA. This show is co-located with Automation Technology Expo (ATX) West, WestPack, MD&M West, Electronics West, PLASTECH West Pavilion and Green Manufacturing Expo. The annual show in its 11th year features over 350 exhibiting companies and pavilions that include CAD/CAM and rapid prototyping, enterprise software technology and contract manufacturing. This is the West’s largest

advanced design and manufacturing event, cumulatively attracting 45,000 manufacturing professionals.

February 17–19—Expo Manufactura.

Cintermex, Monterrey, Mexico. This international manufacturing trade show is Mexico’s rendition of IMTS in its 14th installment. The event includes over 350 companies, representing over 600 brands from around the world, 8,500 professionals are expected to attend in search of equipment, machinery, processes and solutions for industries that include automotive, aeronautical, electrical appliance and medical devices. A conference program includes keynote speeches, seminars, presentations and manufacturing solutions that include Six Sigma practices and other efficiency standards. For more information, visit www.expomanufactura.com.mx, or contact Shane Poblete at (301) 493-5500.

February 24–26—Houstex 2009.

George R. Brown Convention Center, Houston. Organized by the Society of Manufacturing Engineers, this event looks to stimulate ideas, expertise and business connections in manufacturing technology. On showcase will be advanced machine tools and production systems for industries including energy, medical and aerospace. An advanced technology conference will address “Manufacturing Processes for Oil and Gas.” Houstex is co-located with the International Pump Users Symposium, and attendee badges provide full access to both shows. For more information, visit www.sme.org/houstex.

Danfoss

DOUBLING ILLINOIS FACILITY



Domestic and global growth for Danfoss Drives has compelled the company to begin a major expansion to its Loves Park, IL facility. In order to meet the increased demand, additional equipment and personnel is required, so the larger facility will include production and office space.

The Loves Park facility designs and produces variable

frequency drives for AC motors in heating, ventilation, air conditioning, water, wastewater, food and beverage, material handling, petrochemical and other industrial applications. Once the expansion is completed, the facility will be LEED-certified and registered with the U.S. Green Building Council, which is a rating system that promotes sustainable design and construction with the purpose of increasing operating efficiency.

“As both our domestic sales and export business for Danfoss VLT drives have grown exponentially, so has our need for increased production capacity and additional office space,” says David Holmgren, purchasing manager. “The expansion will allow Danfoss to accommodate the 250 additional employees we have identified will be required to support our growth while maintaining the level of service our customers have come to expect from us.”

The new building will fully occupy the 18-acre area the company moved into—but did not fill—in 2001, and Danfoss Drives purchased an additional 17 acres of adjacent land for further possible expansion in the future. A groundbreaking ceremony took place September 16, and Danfoss hopes the new facility will be completed and fully operational by the third quarter 2009.

New CEO

ANNOUNCED BY ALTRA

Altra Holdings, Inc appointed Carl Christenson to succeed Michael L. Hurt, P.E. as chief executive officer, effective January 1, 2009. Christenson is currently the company’s president and chief operating officer. Hurt has been CEO since Altra was founded in 2004, and he will continue with the company as executive chairman and chairman of the Board of Directors through 2009.

“I am very proud of the organization we have built over the past four years,” Hurt says, “Carl Christenson has been an



Carl Christenson

important part of our leadership team since the company’s inception, and I believe he has the qualities and talents necessary to be successful as our CEO. I have worked closely with Carl for over 20 years, and I am confident that Carl will flourish in this new role. While I am looking forward to spending more time with my family, I plan to continue to be actively involved in various

strategic initiatives of the company and assist Carl with his transition.”

“I am honored to have the confidence of the Board to serve as chief executive officer,” Christenson says. “Mike has been a tremendous mentor and has assembled a first-class management team under his leadership. I am excited to have the opportunity to lead such a dynamic company into its next phase of growth.”

Christenson has over 27 years of experience. He was director of Altra starting in July 2007 and president and chief operating officer since January 2005. Prior to joining Altra, Christenson was president of Kaydon Bearings. He has also held management positions at TB Wood’s Corporation—now an Altra subsidiary—and positions at the Torrington Company. He has an M.S. and a B.S. in mechanical engineering from the University of Massachusetts and an M.B.A. from Rensselaer Polytechnic.

“Carl brings decades of relevant experience to this new role,” says Larry McPherson, chairman of the nominating and corporate governance committee. “He was extremely effective as the company’s president and chief operating officer, and we believe he will be equally effective as the company’s new CEO. We appreciate Mike Hurt’s tremendous contributions to the success of the company over the past several years and are fortunate that he will continue to be an important part of this organization even after the transition.”

Baldor

ACQUIRES MASKA INC.

Baldor Electric Company has acquired Maska, Inc., a designer, manufacturer and marketer of sheaves, bushings, couplings and related mechanical power transmission components headquartered in Ste-Claire, Quebec.

Maska employs 180 people mostly located in Canada but also in a new Chinese facility. The company's 2007 sales were around \$33 million. The transaction provides Baldor with a second plant in China for supporting international growth and a market share of sheaves and bushings in North America.

"We are excited to announce the addition of Maska to our line of mechanical power transmission products," says John McFarland, chairman and CEO of Baldor. "Over the past five years the management team at Maska has increased sales and profits by nearly 50 percent. Their two automated and efficient facilities produce a large variety and some of the highest quality products available in the marketplace. Maska's sheaves and bushings complement our Dodge line with each having success in different parts of the market."

Renold

ACQUIRES INDIAN CHAIN BUSINESS, SUPPLIES NYC TRANSIT

Renold PLC has acquired a 75 percent interest in L.G. Balakrishnan & Bros. Ltd., a manufacturer and distributor of industrial chains in India. The sale allows Renold to bring its products into the Indian market with an established production base and sales distribution network. LGB employs 500 people at its headquarters in Tamil Nadu.

Renold has also been awarded a contract from Mitsubishi to supply couplings and gearboxes for the New York City Metro North Transit Authority. The components will be part of the propulsion systems in a fleet of rail cars due out in 2009. "This is another significant contract win for Renold and augments our order book, which at the end of June was already 32 percent ahead of 12 months ago," says Bob Davies, Renold chief executive.

Renold's order book was 36 percent higher at the end of August 2008 than it was in August 2007, according to a press release.



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Service Engineering COMPLETES EXPANSION

A 12,000 square-foot expansion to Service Engineering, Inc.'s Greenfield Indiana plant was completed for a ribbon-cutting ceremony October 31. The 41-year-old company manufactures automation, parts handling and feeder bowl equipment for the medical, pharmaceutical, electronics, automotive, cosmetics, consumables, fasteners, and ordnance industries.

"We are in the final stage of an expansion that is being done in conjunction with a major capital equipment reinvestment," says Ryan Jennings, service engineering president. "The changes that we are making will revolutionize the way our products are manufactured, and by taking these steps, we maintain our position as the leader in our industry.

"This investment in technology puts us literally on the cutting edge," Jennings says. We now have the capabilities to cut, bend and weld more efficiently than anyone in our industry. Our customers demand that our equipment be available to them at the best possible value and at the shortest available lead time. Service Engineering plans to accomplish both, and we will do it with consistency and at a volume that our competition simply cannot."

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Timken

EXPANDS, TARGETING WIND ENERGY MARKET

In anticipation of strong growth in the renewable energy sector, The Timken Company announced plans to expand production capacity at the Tyger River facility in Union, SC. Timken is making this investment in an effort to fortify its capability to supply highly-engineered large-bore bearings used in wind turbine main-rotor shafts and gear drives.

The Tyger River facility expansion enables Timken to serve North American demand and bring increased capabilities to create prototypes for new wind-turbine programs. The development will start in 2009 in hopes to begin new production by 2010.

"This investment exemplifies how we're reshaping our portfolio to grow and optimize our business from top to bottom," says James W. Griffith, Timken president and CEO. "We stand to achieve greater returns by refocusing existing assets and investing in new capacity to serve our most promising market sectors, which certainly includes wind energy."

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Beauty in Algorithms

It took the introduction of fractals and chaos theory to get Bruce Shapiro interested in motion control. While conducting medical research on his PC, Shapiro began computing images of the Mandelbrot Set on his computer. He was intrigued by the fact he could use an algorithm to compute the value of each pixel on screen to create beautiful images.

After discovering some stepper motors in a bin at an electronic junk shop, he had a revelation.

“Although I didn’t know how to run the stepper motors, I understood immediately that they break motion into controllable pieces—motion pixels. And then the light bulb went on. Might it be possible to use algorithmic control of motion pixels to create beautiful movement?”

He’s been pursuing the question ever since.

Shapiro, an M.D. by vocation, practiced several years as an internist in California and Minnesota before retiring to pursue his interest in motion control. He was able to purchase the necessary components at local “tech-junk” shops in the Minneapolis/St. Paul area, material that had flowed out of monthly auctions at automation-based companies like 3M and Honeywell.

The early focus of his work was on what Shapiro called “studio machines,” do-it-yourself CNC machines that he designed as static sculptures. These custom machines would later become performance CNC machines, combining electronics, mechanics and programming to create motion control art. (A popular example of this art form is the Fountains of Bellagio in Las Vegas created by WET Design.)

One of Shapiro’s earliest performance



projects was “Sisyphus,” a two-axis, polar coordinate NC device which moves a magnet beneath a field of sand. A steel ball pulled by the invisible magnet rolls through the field, creating highly intricate dune patterns. “Sisyphus III” was permanently installed at Technorama, the Swiss Science Center

outside of Zurich in 2003.

While Shapiro has a deep affinity for all his creations, his favorite installation, entitled “Ribbon Dancers,” debuted in 2006 at the Science Center of Iowa in Des Moines. While the project is still a two-axis NC device, the geometry is now spherical and there is no limit to travel in either axis. The result is two colorful ribbons that continuously “dance” near the ceiling of the science center.

“This is the first of my projects that truly required closing the loop (for safety reasons), and moving from stepper to servo-based systems has been somewhat of a religious experience for me,” Shapiro says.

Shapiro’s work in motion control has also been a significant teaching tool for students interested in science and mathematics. His very first project was an Easter egg coloring machine called “Eggbot.” Shapiro teaches a course entitled, “From Bits to Bytes... to Bots,” at the Science Museum of Minnesota that instructs children how to build their own version of the machine.

“The wonderful thing about motion control is that it provides a tremendous incentive to figuring out where you goofed. Do-it-yourself robots never work perfectly the first time,” Shapiro says. “It’s this Sherlock Holmes process that leads to deep learning.”

Currently, Shapiro is working on the fourth installment of a series called “Pipedream.” This is a large array of clear, fluid-filled vertical tubes. By controlling solenoid valves, he can introduce air in the tubes so that the resulting bubbles create images. “Pipedream

IV” is scheduled for installation at Discovery World in Milwaukee in January 2009.

For more information on Bruce Shapiro’s Art of Motion Control and to watch a video of his work, visit www.taomc.com.

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