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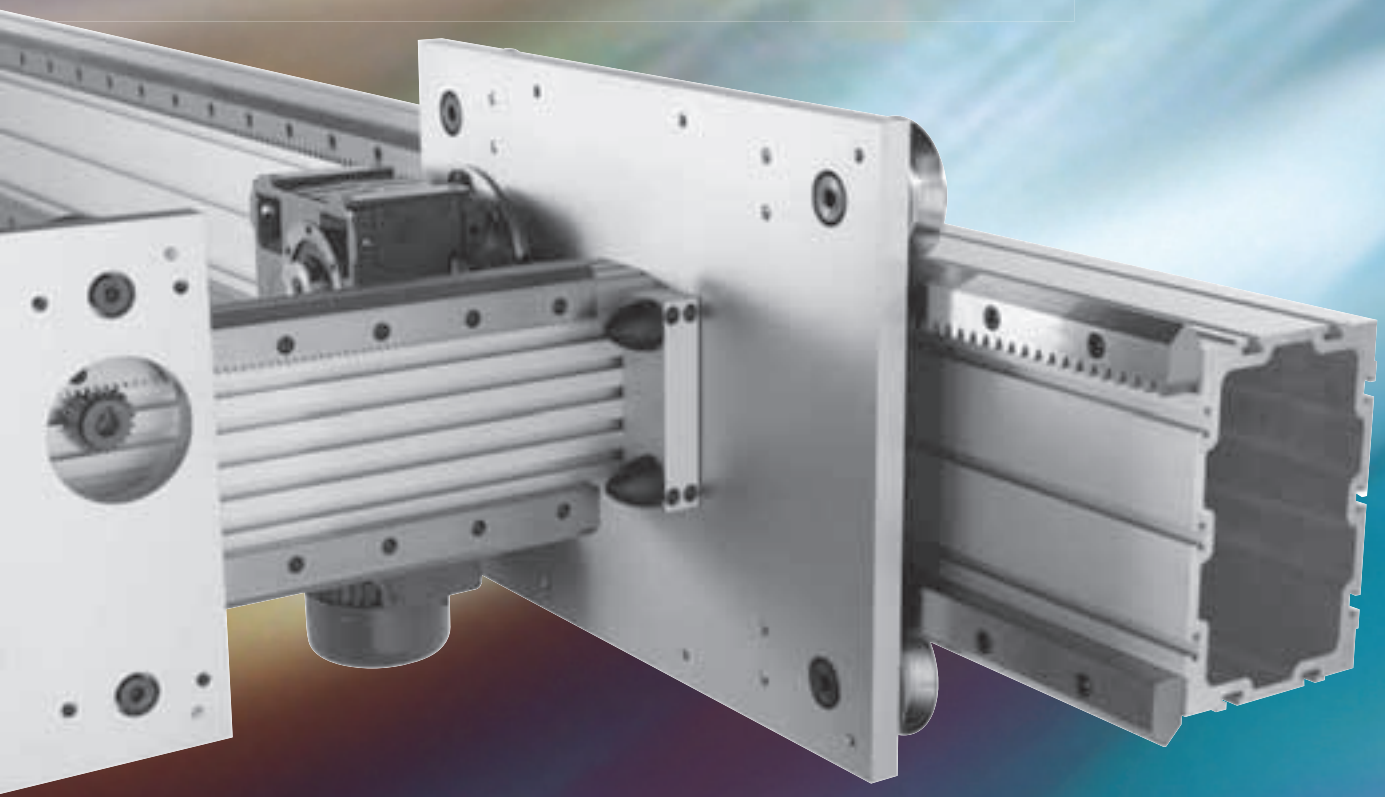

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- Bearing Maintenance—Replace or Refurbish

Power Play

- Bowling for Bots

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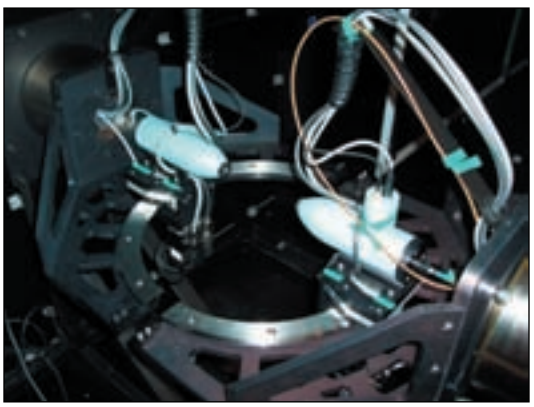

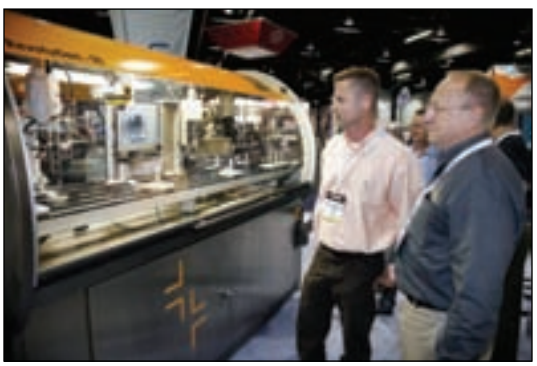

TECHNICAL ARTICLES

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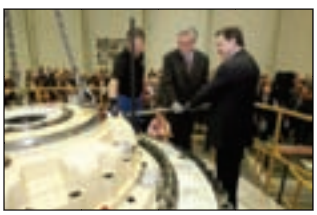
DEPARTMENTS



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Reach new levels of performance with Warner Linear

Rugged actuators and controls from Warner Linear provide years of trouble-free service

Warner Linear offers a wide variety of standard electric actuators, each specifically designed to meet the needs of light-duty, general-duty, or rugged-duty applications. All models feature energy efficient operation with exceptional load holding power and are engineered for maintenance-free, long-life performance. Rugged spur gearing, industrial-grade synthetic lubricants and high performance motors combine to provide maximum capability and value. Units are gasketed and sealed for operation in industrial and mobile outdoor applications. Thermal overload switches are included for motor protection.

An array of actuator controls is also available. These units allow for actuator control from remote locations, stopping at predesignated locations, and providing positioning feedback in volts via PLC. Models are well suited for a broad range of application needs including simple-to-use switch box controls for basic extend/retract function to state-of-the-art microprocessor based digital electronic controls using SMT design and manufacturing processes.

www.warnerlinear.com/pte0808

1.800.825.6544

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1425 Lunt Avenue
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Phone: 847-437-6604
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EDITORIAL

Publisher & Editor-in-Chief	Michael Goldstein *publisher@powertransmission.com*
Managing Editor	William R. Stott *wrs@powertransmission.com*
Senior Editor	Jack McGuinn *jmcguinn@powertransmission.com*
Associate Editor	Matthew Jaster *mjaster@powertransmission.com*
Assistant Editor	Lindsey Snyder *lsnyder@powertransmission.com*
Editorial Consultant	Paul R. Goldstein

ART

Art Director	Kathleen O'Hara *kathyohara@powertransmission.com*

ADVERTISING

Advertising Sales Manager	Ryan King, RK Media, Inc. *ryanking@powertransmission.com* Matt Matteucci *mmatteucci@powertransmission.com*

CIRCULATION

Circulation Manager	Carol Tratar *subscribe@powertransmission.com*

RANDALL PUBLISHING STAFF

President	Michael Goldstein
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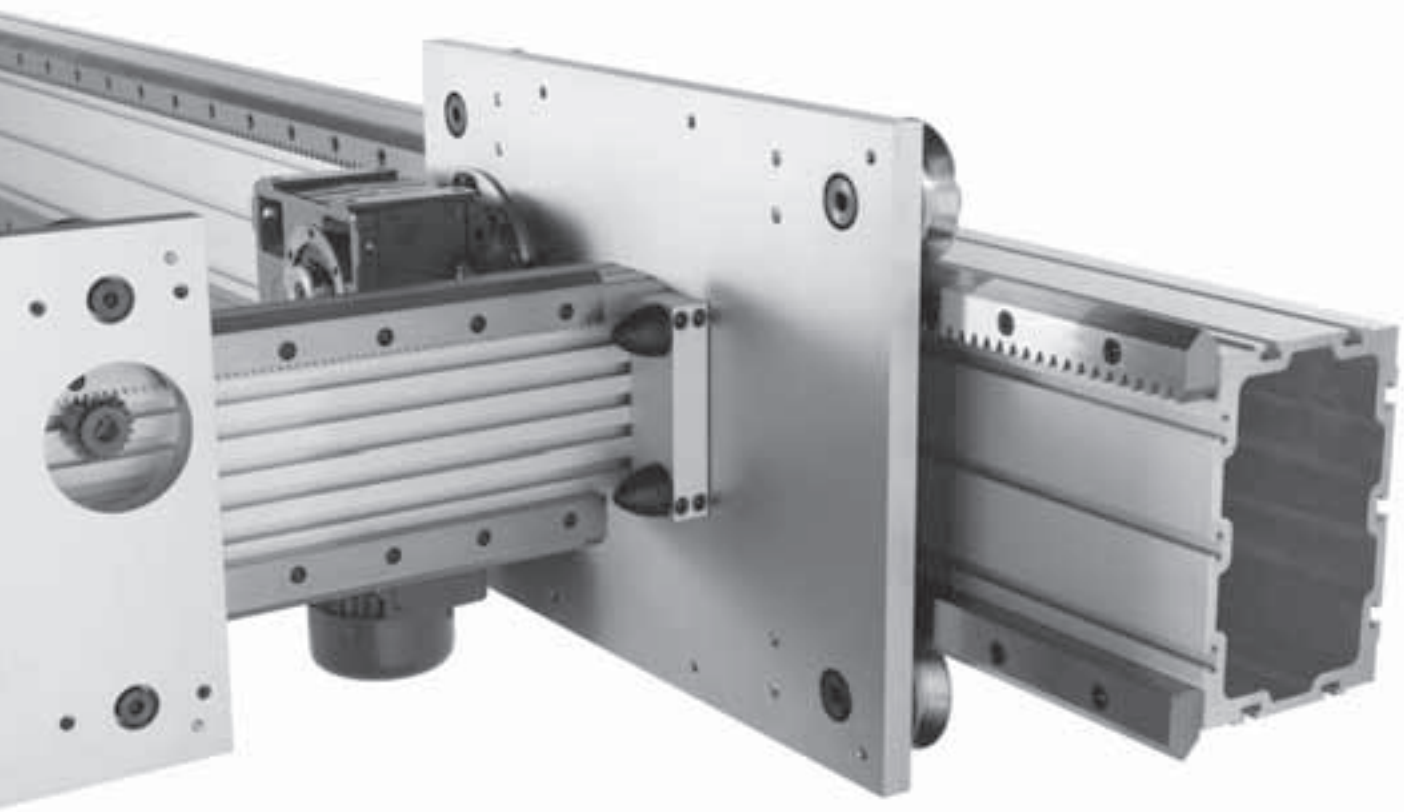


Heavy Duty Slide System

OFFERS VERSATILITY & FLEXIBILITY IN MOTION CONTROL

If the general rule is "bigger and better," then manufacturers of linear motion products appear to be following suit. In order to meet increased load and life requirements, HepcoMotion has released an advanced version of its Heavy Duty model called the HDS2. The heavy duty linear motion system, available in North America from Bishop-Wisecarver, addresses new markets in material handling involving larger x-z gantry systems.

"HDS2 really provides an exceptionally flexible program for arduous applications," says Chris Rees, sales director at HepcoMotion. "The additions to the range will enhance its performance and will provide customers with far more application possibilities."

The introduction of specific components reduces the engineering time required to get the system up and running. The components include larger bearings with an increased load capacity, three sizes of construction beams, single edge V-slides and flat tracks and a range of drive options. Stainless steel or corrosion resistant material help the HDS2 handle most high-load applications.

The HDS2 can be supplied in component form or as a ready-mounted assembly complete with rack-driven carriages. Customers have the option of choosing commercial slides for general use or high-precision ground slides where greater accuracy and smoothness are required.

The slides and tracks are available in single-piece construction up to four meters long and supplied in single- or double-edge formats. Driving forces for heavier loads are achieved through a range of spur or helical rack and pinion options. An engineering package includes a range of rack-driven carriages, with automatic lubrication facility and helical-bevel gearboxes that can be driven by AC or servo motors.

For design flexibility, the HDS2 features versatile construction beams. A larger aluminum beam is available that eliminates the need for the customer to machine a steel structure, and a compact beam is an option if space is limited. This beam can also be used to create a high capacity lifting z axis. The ability

to mount directly to HepcoMotion Standard back plates is also available.

HDS2 has an increased range of bearing sizes, including a 150 mm diameter vee bearing and a 144 mm diameter roller, incorporating high capacity taper bearings. The maximum bearing capacity is now 50 kN, and they are available in removable format for easier replacement in case of failure. These double-row bearings are tolerant to debris, according to the company's press release. Low friction cap wipers expel dirt in harsh environments and provide automatic lubrication for a longer service life. A removable cover allows system adjustments without disassembly.

For more Information:

Bishop-Wisecarver
2104 Martin Way
Pittsburg, CA 94565
Phone: (925) 439-8272
Fax: (925) 439-5931
www.bwc.com

HepcoMotion
Lower Moor Business Park, Tiverton Way
Tiverton, Devon, England EX16 6TG
Phone: (44) 1884 243400
Fax: (44) 1884 243399
www.hepcomotion.com

Short Inductive Proximity Sensors

FIT INTO CRAMPED SPACES

A family of ultra-short inductive proximity sensors designed by Balluff Inc. for OEM applications fits into tight spaces, allowing for more flexible machine design. The Balluff SuperShorty sensors are low in mass, affording sudden acceleration and deceleration without adding excessive inertial load on dynamic, fast-moving equipment.

"These sensors are so small that OEM engineers now have free reign to

integrate sensing functionality in areas that previously couldn't accommodate any conventional sensor," says Henry Menke, product marketing specialist. "As rugged inductive sensors, they can survive in close proximity to industrial processes where shock, vibration and liquid or particulate contamination would quickly take optical sensors out of action."

The SuperShorties come in 6.5 mm smooth and M08 threaded housings. Balluff offers them in 10 mm length or 6 mm, and connectorized models are 18 mm long. Each variation has a 1.5 mm sensing range. "The sensing electronics are fully integrated into the miniature housings, so no bulky external amplifiers are required," says Jeff Himes, product specialist. "Despite the SuperShorty sensors' extremely small size, their electrical outputs are fully protected against short circuits and polarity reversal—plus they have a current rating of 150 mA."

The SuperShorty sensors are designed for high-speed pick-and-place equipment, miniature grippers, linear slides, miniature valves, compact actuators and other compact, precision mechanisms.

For more information:

Balluff Inc.
8125 Holton Drive
Florence, KY 41042
Phone: (800) 543-8390
Fax: (859) 727-4823
balluff@balluff.com
www.balluff.com

Linear Actuator Designs

SUITED FOR RAPID MOTION, CONFINED SPACES

Haydon Switch and Instrument, Inc. introduced two size 11 hybrid linear actuators: external and double-stack non-captive. Both designs offer a range of resolutions from 0.003175 mm to 0.0508 mm per step and deliver thrusts of up to 133 N.

In the external design, the lead screw is part of the motor, using a mating nut to translate along the screw. The motor steps, and the lead screw rotates but does not advance. The external actuator integrates a motor, coupler, lead screw and nut into one part. The ends of the lead screw can be machined to use outboard bearing support for longer lead screw lengths. The external linear actuator is designed for linear travel in restrictive spaces.

The double-stack, non-captive design has the lead screw placed axially through the motor's center. It requires restraining from rotating, which can be accomplished by attaching the screw to a non-rotating member of the mechanical assembly, according to Haydon's press release. The internal threaded rotor will rotate, and the lead screw moves axially but does not rotate. The external actuator was designed for long linear travel and applications where both ends of the lead screw are held. These

continued

applications include medical equipment, semiconductor handling, valve control, x-y tables, handheld instruments and telecommunications.

For more information:
Haydon Switch & Instrument, Inc.
1500 Meriden Road
Waterbury, CT 06705
Phone: (203) 756-7441
Fax: (203) 756-8724
info@hsi-inc.com
www.hsi-inc.com

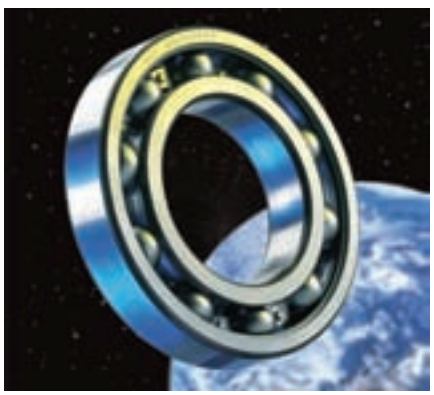
Deep Groove Ball Bearings

OPERATE SMOOTHLY, QUIETLY

SKF Explorer deep groove ball bearings feature raceways and cage geometry that provide smooth, quiet operation, accuracy, speed, low friction, low operating temperatures and longer service life, according to the company's press release. They can be used in electric motors, gearboxes and rotating equipment like those in packaging, food and beverage, medical, general manufacturing and construction industries.

The Explorer bearings offer a running accuracy up to ISO tolerance class P5, dimensional accuracy to ISO tolerance class 6 and exceed the ISO width tolerance class Normal. The tight width tolerances allow designers to minimize the tolerance stackup in shaft systems.

High grease retention is possible due to the sealing designs, which also protect the bearings from contamination without compromising speed. The deep groove bearings are constructed from steel with low oxygen content; this prevents fatigue-inducing oxide that may form in the material. The Explorer bearings are available in a range of bore sizes and dimensions, and SKF can customize them for specific requirements.



For more information:
SKF USA Inc.
1510 Gehman Road
Kulpsville, PA 19443
Phone: (800) 440-4SKF
skfusainfo@skf.com
www.skfusa.com

Enhanced Stepper Motor

DELIVERS 25 PERCENT MORE TORQUE

A stator-enhanced model of Portescap's h3 Series Step Motors features magnets in the stator, which provide 25 percent more torque output across the entire speed range. The original h3 models deliver up

to 40 percent more torque than the typical hybrid step motor, according to Portescap.

"The increased torque is achieved through additional stator magnets that are inserted between each stator tooth," says Dave Beckstoffer, Portescap product specialist, stepper technologies. "These block the magnetic field from flowing around the stator teeth, which forces more of the magnetic field to flow through each tooth to produce the highest torque output of any hybrid step motor available today."

The 1.8-degree step motors have an aluminum housing to improve heat dissipation, neodymium iron boron magnets to increase the torque density and a bearing retainer and o-ring that reduce motor noise, according to the company's press release. With a larger bearing the motor can handle higher side and radial loads. The h3 Series Step Motors come in NEMA 17, 23 and 34 frame sizes, and several stack lengths are available for each frame size. Windings can be customized for specific needs.

By using a smaller motor that delivers the same performance as larger hybrid steppers, machine builders can make the size and weight of their machines smaller with the h3. This also enables machine builders to use smaller drives to lessen power requirements and costs of the entire system. An RoHS-compliant hybrid

step motor, the h3 Series Step Motor can be used in applications including semiconductor equipment, medical devices and laboratory instrumentation.

For more information:

Portescap, a Danaher Motion company
110 Westtown Road
West Chester, PA 19382
Phone: (610) 235-5499
Fax: (610) 696-4294
Sales.america@portescap.com
www.portescap.com

Transmission Torque, Shaft Misalignments

MINIMIZED BY ZERO-MAX COUPLINGS

The Control-Flex couplings from Zero-Max are designed for precision feedback requirements of encoder applications. They feature clamp-style zero-backlash hubs, and electrically insulating components provide low weight and inertia. They are recommended for use wherever encoders are found: applications such as machine tool, conveying and automated assembly systems, medical device and packaging, according to Zero-Max.

The Control-Flex couplings are constructed with two hubs for attaching to the system shafts and a center flex member, which is attached to the hubs through pins. Zero-Max offers two versions of the couplings. The single-flex disc design is for standard torque capacity, and the two-flex disc design provides higher torque capacity and torque stiffness.

"Control-Flex couplings satisfy the high performance requirements of today's encoders that convert rotational speed into precise electrical signals," says Robert Mainz, sales manager for Zero-Max. "They are a better option for these high-precision applications than

standard beam style couplings, which tend to vibrate, loosen and produce inaccurate encoder readings."

For more information:

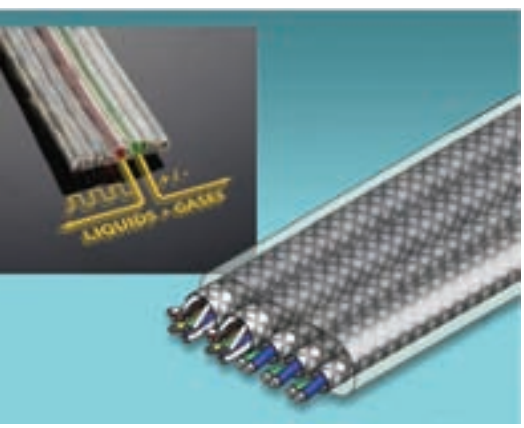
Zero-Max
13200 Sixth Avenue North
Plymouth, MN 55441
Phone: (800) 533-1731
Fax: (763) 546-8260
Zero-max@zero-max.com
www.zero-max.com

Silicone Cables

DESIGNED FOR HIGH-PERFORMANCE MOTION CONTROL SYSTEMS

The Motion Series PLUS (MS+) flat power/signal cables from Cicoil integrate six power conductors and 20 signal wires in a flat cable 0.80" x 0.2".

"Motion Series PLUS cables add an extra level of versatility to our Motion Series line," says Howard Lind, president of Cicoil. "For multi-axis applications, the new configuration of the Motion Series Plus allows designers to place the cables side-by-side for maximum flexibility, or stack them for a very condensed and compact cable bundle."



The Motion Series PLUS cables come in two feature options. Cicoil can integrate Teflon tubing for fluid or gas transmission. The second option is Cicoil's StripMount integrated mounting aid, which is embedded in the cable. The StripMount eliminates the need for cable management systems that can be bulky and expensive. The mounting aid inserts fasteners through the cable to fasten it to most surfaces.

The cables have a single-axis design that can be ganged for one to three servo motion axes. Silicone encapsulation provides a one-piece construction, and the cable has a 10 million-cycle service life. The silicone process also allows for temperatures from –65°C to +260°C. The cables resist water, steam and chemicals, and are suited for vacuum or clean room environments, according to the company's press release. Custom designs are available.

For more information:
Cicoil Corp.
24960 Avenue Tibbitts
Valencia, CA 91355
Phone: (661) 295-1295
Fax: (661) 295-0813
www.cicoil.net

Bellows Couplings

MULTIPLY LATERAL MISALIGNMENT TOLERANCE

A series of double flex bellows couplings from R+W America accommodates more than a few thousandths of an inch of shaft offset. The BKL-DOUBLEFLEX couplings are designed to avoid the lateral and/or angular misalignment that can occur from tolerance stack-up in machined interfaces between motor frames, gearboxes and their driven shafts, according to the company's press release.

The BKL-DOUBLEFLEX demonstrates higher flexibility in the angular directions of each bellows, which enables the coupling to increase lateral misalignment tolerance. Depending on the coupling size, the BKL-DOUBLEFLEX provides five times more lateral misalignment, high torque stiffness with no backlash and low inertia. The model can be used for servo drives in packaging equipment and special machinery applications.

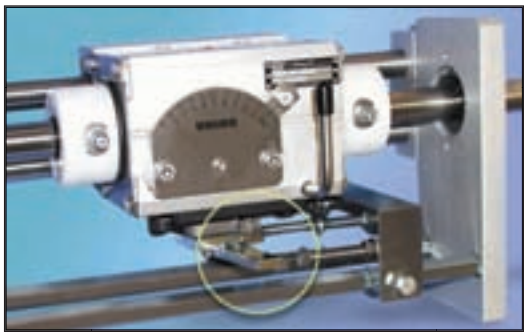
The BKL-DOUBLEFLEX series comes in torque ratings from 15–500 Nm, and it can accept English or metric shafts from 8–62 mm. For problematic encoder coupling installations, special mini versions are available.

For more information:
R+W America
1120 Tower Lane
Bensenville, IL 60106
Phone: (630) 521-9911
Fax: (630) 521-0366
info@rw-america.com
www.rw-america.com

Heavy-Duty Linear Drive

REVERSES WITHOUT DRIVE MOTOR

Amacoil/Uhing's model RG80 linear drive supplies up to 800 pounds of side thrust for heavy-load, linear motion applications. The drive eliminates a need for electronic controls and a reversible motor using "rolling ring" linear motion engineering, which enables mechanical control over reversal. Linear pitch can be adjusted manually without gear



reduction or adjusting the drive motor speed.

The RG80 drive is a friction drive, so it needs to run on a case-hardened, ground shaft. The speed and travel direction are determined by the angle of the rolling ring bearings relative to the drive shaft. The drive contacts an end stop once a stroke is finished. The end stop pivots the bearings, reversing their direction, but the drive motor continues to rotate without changing direction, gears or other controls. Applications include linear motion in packaging and converting equipment as well as other production machinery needing a reciprocating linear motion component, such as spraying, slitting, scanning and winding. The RG80 drive is sold in a complete assembly with shaft, pillow block end supports, bearings and adjustable end stops, or separately.

For more information:

Amacoil Inc.
2100 Bridgewater Road
Aston, PA 19014
Phone: (800) 252-2645
Fax: (610) 485-2357
amacoil@amacoil.com
www.amacoil.com

Belt Tension Tester

MEASURES USING SOUND WAVES

The Econobelt belt tension tester measures tension using sound waves instead of force deflection. The tester is portable, and it produces repeatable results in seconds in any environment. The 507C uses four AAA batteries to run, comes with a cord sensor and is available with an inductive or flexible sensor and a cord sensor.

For more information:

Quality Transmission Components,
A Division of Designatronics, Inc.
125 Railroad Avenue
Garden City Park, NY 11040
Phone: (516) 437-6700
Fax: (516) 328-3343
www.econobelt.com/Press/TensionTesters.htm

AC Motor Speed Controls

SUITED FOR VARIED ENVIRONMENTS

Bodine Electric Company's Pacesetter models 2994 and 2998 are three-phase AC motor speed controls for driving 230 VAC, 50 or 60 Hz, inverter-duty, three-phase gearmotors and motors from 1/8 hp to 1 hp. Both models are operated by a single-phase 115 or 208/230 VAC line voltage.

The NEMA-4X/IP-65 rated enclosure positions the 2994 model for high protection in harsh environments like industrial or food processing conveyor systems, feeders, pumps and outdoor applications. The stock model has a speed potentiometer and power switch in the control's front panel. Several motor overload protection features are incorporated, including RMS current limit, short circuits and AC inrush at startup. The control shuts down automatically in the event the AC line input voltage varies from the operating range. The control is protected by input-transient suppression that absorbs power spikes. A line filter is built into the 2994, meaning it is CE approved, and it is also RoHS compliant.

Housed in a NEMA-1/IP40 enclosure, the Pacesetter 2998 offers a basic environmental protection suited for applications like packaging equipment, conveyor systems and other industrial uses. No programming is necessary, and motor horsepower, AC line input voltage and output frequency are jumper selectable. The model 2998 offers the same protective features as the 2994, in addition to the same panel features and CE certification.

For more information:
Bodine Electric Company
2500 West Bradley Place
Chicago, IL 60618
Phone: (773) 478-3515
Fax: (773) 478-3232
info@bodine-electric.com
www.bodine-electric.com

Laser Calibration System

INCREASES SPEED, ACCURACY

Renishaw introduced the "lean design" XL-80 system, a laser interferometer calibration system that allows four times faster slew rate, 10 times higher dynamic data capture rate and improved total system accuracy in portable packaging. The XL-80 is capable of linear measurement speed to 4 m/s, provides resolution of 1 nm and warms up in less than six minutes.

The XL-80 analyzes nanometer-level motion in calibration, error-mapping and compensation ranging from lab equipment, semiconductor processing machinery and radiosurgery tools to coordinate measuring machines, lithography equipment, advanced machine tools, robots and assembly systems. A signal gain switch provides an optional 80 m linear range or increased signal strength at shorter ranges.

The system has an accuracy of +/–0.5

ppm, which is sustained over the entire operating range of 0–40°C. The system ensures accuracy when experiencing variations in temperature, pressure and humidity because it updates the environment factor after seven seconds using a USB link.

Compared to Renishaw's previous ML-10 system, bandwidth was improved from 5 kHZ to 50 kHZ, allowing the XL-80 to capture detailed data of small, high-frequency movements. Weight was reduced by 70 percent to less than 3 kg, which includes connecting cables, power supply and sensors. The tripod and stage have also been reduced in size. A multi-signal connector facility provides a standard trigger signal-in for data capture, an analog voltage-out facility and optional quadrature signal output.

For more information:

Renishaw Inc.
5277 Trillium Blvd.
Hoffman Estates, IL 60192
Phone: (847) 286-9953
Fax: (847) 286-9974
www.renishaw.com

2D Encoder

COMPENSATES FOR ERRORS IMMEDIATELY

Heidenhain's 1Dplus encoder measures linear guiding and thermal drift errors while the stage or machine is moving, so the two-dimensional encoder immediately processes and compensates for errors. Applications include any type of motion stage such as stacked stages, gantries, wafer processing and large flat panel display production and tests.

The 1Dplus encoders have gratings in two dimensions and no friction. They can measure the x and y directions at the same time with models that have two or three scanning units, which allow the calculation of the rotation angle of the bracket housing them.

The accuracy grade for x-axis measurement is +/–1 µm and has a

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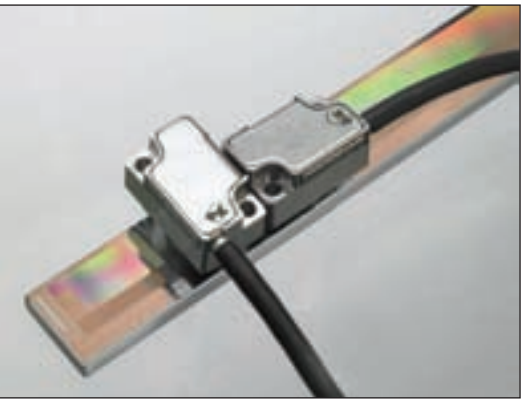


reference mark. The encoder has a grating period of 8 µm and a signal period of 4 µm. Current measuring length is 300 x 2 mm, and the 1Dplus scale is 20 x 4.9 mm.

For more information:

Heidenhain Corporation
333 E. State Parkway
Schaumburg, IL 60173
Phone: (847) 490-1191
info@heidenhain.com
www.heidenhain.com

Linear Actuator

REDUCED IN HEIGHT AND WEIGHT

The DryLin ZLW-0630 linear actuator from igus inc. has a smaller mounting height and lower weight than its predecessor for designing a compact linear drive system. The actuator is 1.22 inches high and weighs 1.76 pounds. The unit is made of a toothed-belt linear drive with a hard-anodized aluminum profile, a compact linear guide, plastic sliding elements and plastic end blocks.

The DryLin ZLW is for applications with high speeds up to 6.5 feet per second and those that require quick positioning of small loads in industries such as packaging, automation, medical technology and food and beverage manufacturing.

"The compact version of DryLin ZLW, igus' first linear actuator, is an impressive addition to the DryLin product line," says Matt Mowry, DryLin product manager for igus. "This new system is lightweight, maintenance-free and can be used in a wide array of applications requiring a high speed, compact linear unit."

For more information:

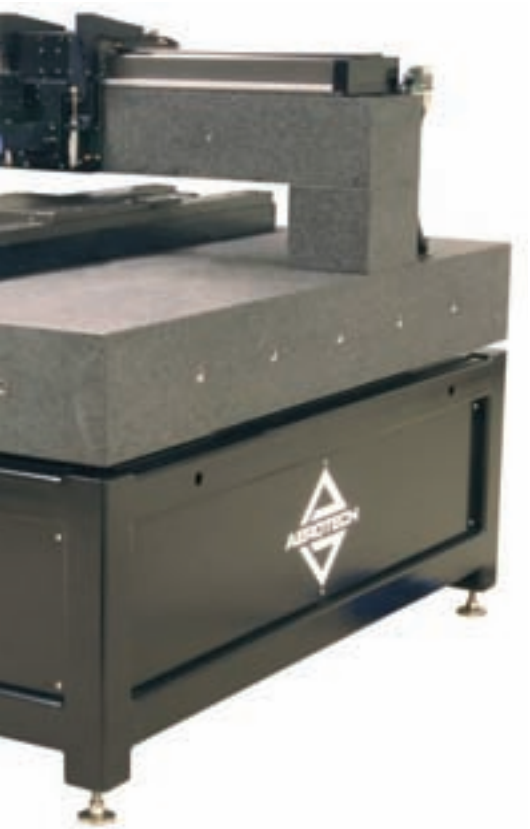
igus Inc.
PO Box 14349
East Providence, RI 02914
Phone: (800) 521-2747
Fax: (401) 438-7270
www.igus.com

Photovoltaic Panel Scribing System

CONFIGURES SPLIT AXIS OR GANTRY

The SolarScribe automation series from Aerotech has both mechanical and air-bearing versions of split-axis and gantry-style systems to accommodate all PV/FPD scribing applications, according to the company's press release. With direct-drive linear motor stages capable of traveling up to 2.5 meters, the SolarScribe systems also offer multihead scan axes, z and theta correction axes and machine base/ isolation arrangements. Other options include single- or multiple- step axis carriages, several z-axis choices, a theta stage with integral brake, passive or active vibration isolation, a machine base and a control enclosure.

Aerotech's Automation 3200 control system allows the SolarScribe series advanced trajectory generation options,



such as multi-block look-ahead, which helps avoid dynamic errors. The A3200 is entirely digital, and it features position-based laser firing output that matches the laser pulse frequency to the current scribing speed automatically; this enables an added jolt in throughput. Motion Designer software is capable of generating or importing motion trajectories, then running and evaluating the trajectory.

For more information:

Aerotech, Inc.
101 Zeta Drive
Pittsburgh, PA 15238-2897
Phone: (412) 963-7470
Fax: (412) 963-7459
sales@aerotech.com
www.aerotech.com

Is Maintenance Included in Your Strategic Plan?

ROBUST MAINTENANCE CAPACITY CAN BE THE DIFFERENCE BETWEEN ONGOING PROFITS AND IMPENDING DOWNFALL.

Jack McGuinn, Senior Editor

Joel Leonard appearing before a congressional Facilities Forum panel in Washington, D.C.

Few would now argue that what some may have perceived just a few years ago as "Chicken Little" stories regarding the depletion of this country's skilled manufacturing workforce are now in fact firmly based in stark reality. Math skills: down. Science skills: down. Number of graduating engineers: down. High-skills positions: unfilled.

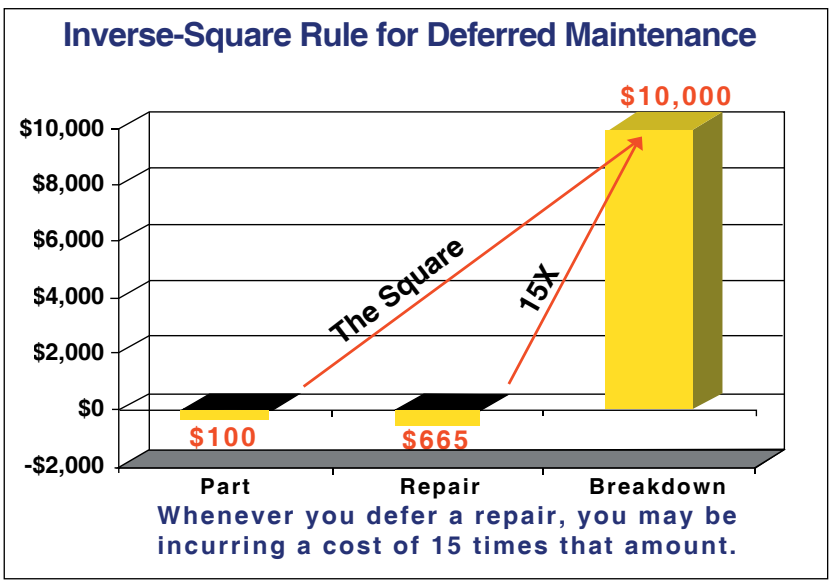
And, unfortunately, it gets worse.

The same crisis—yes, crisis—applies not only to high-end manufacturing and production. What has gone largely unnoticed is that there is also an impending, major shortfall of skilled workers in the maintenance sector of not only manufacturing, but in our nation's infrastructure as well. As the 21st century rolls on, the following issues will be among those of paramount importance in maintenance. And a commonality they share with manufacturing is the inescapable fact that ignoring these challenges will only serve to blunt this country's

already imperiled competitive edge. Those challenges include:

- Feeble infusion of new talent.
- Tighter budget restrictions.
- Reducing equipment down time.
- More robust environmental regulations and mandates.
- Training, educating and retaining skilled workers.
- Predictive maintenance/asset reliability.
- Energy management.
- Staying abreast of new technologies.

All of the above areas typically linked with manufacturing are entirely applicable to maintenance as well—including preventive, predictive and reactive. Yet, we learn practically every day of another major incident regarding defective equipment or structures. Cranes tipping, bridges collapsing, airlines shutting down or oil pipelines rupturing—whatever the catastrophe, negligence or inadequate maintenance is often the cause.



Charts courtesy of Joel Leonard.

But beyond the sometimes tragic consequences of headline-grabbing incidents, what is missed is the fact that robust maintenance programs not only serve to prevent such mishaps; they also provide companies willing to implement them with a competitive edge that can make the difference between continued growth or incremental decline. And this is true in every sector of business and the economy. While a nation's crumbling infrastructure—roads, schools, libraries, electrical grids, the aforementioned bridges, etc.—is certainly a major story that requires reporting, the purpose of this article is to cast light on maintenance and its role in keeping a company's production humming.

To lend a major assist in that regard, *Power Transmission Engineering* was able to catch up with Joel Leonard, a man of several hats, including contributing editor to *Plant Services* magazine; host of that publication's online SkillTV; a Compete 2.0 Skills Team member of the Council on Competitiveness and a staff member of MPACT Learning Center, LLC (a professional group devoted to providing course offerings, consultation services and other resources specific to the maintenance industry).

But Leonard's greatest calling is that of "maintenance evangelist," a fitting appellation bestowed upon him by his peers (to be specific, a professor from the University of Tennessee) in recognition of his passion and work to enlighten industries of every sector regarding the impending shortfall of experienced maintenance workers and, more importantly, how getting truly serious about robust maintenance implementation can be a legitimate game-changer for companies willing to do so.

"It's been almost an avalanche of headlines that have been hitting the public, to the point that the maintenance crisis is no longer just in the engineering community," says Leonard, "It's in dinner table discussions. The people are finally becoming aware of these issues to the point that action is finally being taken."

One major action already in progress is the previously cited Council on Competitiveness, a consortium of leaders and thinkers from industry, academia and government charged with developing a "national skills strategy" addressing four critical areas:

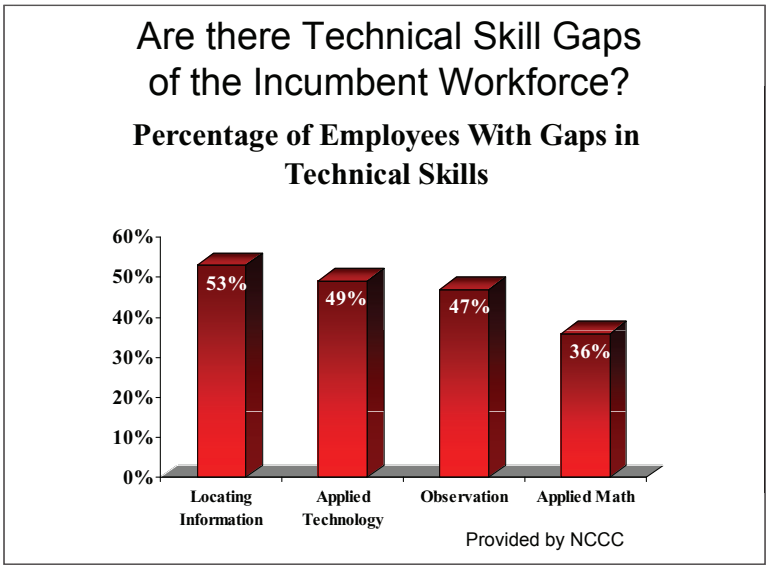
continued

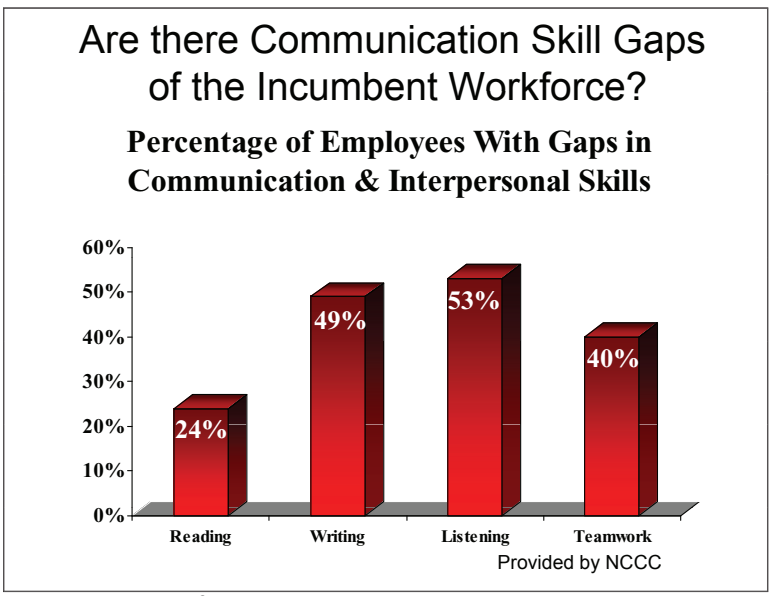
• Meet the demand for middle skills.
• Build service economy skills.
• Compete for innovative advantage.
• Create skills for sustainability.

This, of course, is a big-picture endeavor, encompassing more than maintenance concerns. But it serves to put our country on notice that there is much work to be done if we are to remain a leader in the global economy—the group's central mission. Regarding that initiative, Norman R. Augustine, retired chairman and CEO of Lockheed Martin Corporation, echoes a sentiment that is beginning to gain increasing currency.

"Global leadership has come to be accepted by many Americans as our country's birthright," he says. "However, we would be wise to keep in mind that in the 16th century, it was Spain that was the dominant nation; in the 17th century, it was France; in the 19th century, it was England; and in the 20th century, it was America. The book hasn't been written on the 21st century yet, but it is clear that no nation has an entitlement to the future."

As for Leonard, he has his own initiative for addressing maintenance issues—"Reliability Nation." And he has his own thoughts on why it has come to this.





Graphs courtesy of Joel Leonard.

"With our technical programs being legislated out of our high school systems and apprenticeships being cost-reduced out of organizations at the same time that we're having the largest demographic in the history of mankind leaving the workforce, we've had some really stupid decisions in upper levels of management in the last 10 years," he laments. "Companies that are bean counter-focused, they look at apprenticeships as a negative. Yeah, it costs money and training is expensive. But try not training—that's extravagance.

"And now we're finally beginning to realize what's happening and there's finally some effort being put forth and I'm privileged to have a voice in that process."

That "voice," oddly enough, includes a song Leonard penned—a broadside, if you will—calling out decision makers over maintenance matters. He calls it "The Maintenance Crisis Song." Here's the first verse:

"No one wants to work in the boiler rooms,
No one wants to work with the tools,
The nation's youth are taking the easy way out,
There's no one left to fix our schools.
Maintenance technicians are 'bout to retire,
Company executives got no one to hire,
How safe does that make you feel?
How safe does that make you feel?"

(*Ed. Note: For complete lyrics, go to* www.skilltv.net)

Indeed, aside from his "evangelist" persona, Leonard also possesses the heart of a showman—a P.T. Barnum-type marketer, if you will. He believes that's what it takes in our American Idol culture to generate the attention this issue deserves. In the hope of reaching a wider audience, Leonard's disturbing ditty has been recorded in a number of different genres—from rock to soul, from hip-hop to gospel. The song was the result, appropriately enough, of Leonard's attendance in 2002 at a Society for Maintenance and Reliability Professionals (MSRP) conference in Nashville, long a hotbed for music making.

"(I decided that) just going to the conference and talking to engineers or writing articles about this isn't going to fix it; we're going to write a song;" he says. And after enlisting some musicians who put his lyrics to music, "Now we have nine different genres of the same song."

Since then, Leonard has been on a whirlwind schedule that takes him all over the country and to Europe (Brussels, e.g., to offer the opening remarks at the EuroMaintenance Conference), delivering the word to business groups regarding the maintenance and reliability crisis. That includes trips to the nation's capitol, as well. Leonard was invited to speak be-

fore a congressional Facilities Forum, and was also able to gain the ear of various congressmen, congresswomen and senators, all in the hope of lighting fires under behinds and initiating movement.

"In the last several months I'm finally meeting with some people who can actually do something about it. When I met with (Senator) Ted Kennedy (before his illness) I challenged him by asking why there isn't an MIT or Harvard MBA program teaching the value contribution of maintenance. If you go to an average engineering or maintenance conference, there's at least four or five different tracks that teach maintenance guys and engineers how to communicate with upper management to ask them for the resources that they need.

"And if upper management already understood (maintenance's) value contribution, they could be managing towards that and the guys wouldn't have to be asking permission to do their jobs."

So how bad is the problem? The evidence is daunting.

For instance, when at that maintenance engineering conference in Nashville, the audience of engineers was asked how many would be retiring in the next 10 years. Answer—90 percent. And there's no shortage of other examples. For instance:

• According to Council of Competitiveness's Compete 2.0 Skills report, for every 10 workers who retire, there are only three to seven to replace them. The Bureau of Labor Statistics forecasts an annual shortage of 350,000 auto technicians through 2010.

• The American Welding Society states that the average welder today is middle-aged or older. They estimate that more than half of that segment's workforce is nearing retirement and that a potential shortage of 200,000 skilled welders may exist by 2010.

• The average age of the power management workforce approaches 50, according to industry reports, with half of them slated for retirement in the next 10 years. Perhaps worse, an Edison Electric Institute survey states that about 20 percent of the nation's electric transmission workforce is set to retire in the next five years.

Again, keep in mind that these shortages in skilled workers not only compromise the country's infrastructure; they also affect a typical company's bottom line. Who is going to repair the fleet trucks, the lift trucks and other necessary vehicles? Who is going to make welding repairs to your facility? Who is going to maintain your industrial motors and engines? Who will fix the plumbing? And speaking of plumbing, Leonard is fond of quoting John Gardner, a former U.S. Secretary of Health, Education and Welfare, to help make his point about the low regard that is held for the maintenance worker.

"The society that scorns excellence in plumbing, because plumbing is a humble activity, and tolerates shoddiness in philosophy, because philosophy is an exalted activity, will have neither good plumbing nor good philosophy. Neither its pipes nor its theories will hold water."

As with most everything else these days, Leonard points out, even plumbing is much more than the low-tech trade of yesterday. He reminds that plumbing systems today are PLC-controlled and sensed, and contain high-tech lubricants and solvents and are integrated with electrical and electronic systems.

Leonard has traveled the globe preaching the gospel of reliable maintenance that is, essentially, two things—capacity and strategy. Maintenance should be considered part and parcel of a company's best practices; it should be considered by any good business as a strategic decision, not just a knee-jerk reaction to something broken that needs fixing.

"Maintenance is the capacity assurance provider," says Leonard. "And what we need is a structured, nationwide approach where we start investing in maintenance reliability as a value contributor—and start having MBA programs that teach that.

"It's not a zero-sum game out there. As the rest of the world gets caught up and realizes that the American Dream can be had by all, we shouldn't be bemoaning the success of others. What we should be doing is not forgetting what got us where we're at and start abandoning some of the key components that made us successful. And that a qualified, skilled workforce is not something to look down our nose at.

"We need 2,000,000 maintenance engineers. Where are we going to get them? Everyone wants to play, but no one wants to plow."

Amen, brother.

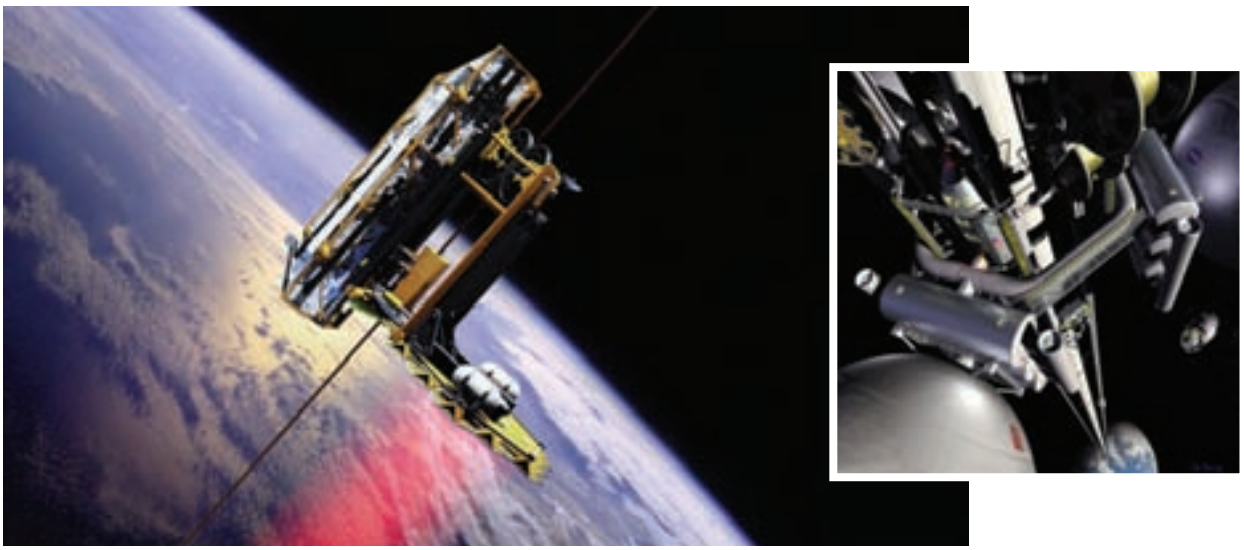
For more information:

Joel Leonard
Phone: (336) 338-1011
Joel@SkillTV.net
www.skilltv.net

MPACT Learning Center, LLC
Pinehurst Bldg. / Ste. 301
2 Centerview Drive
Greensboro, NC 27407
Phone: (336) 379-1444
Fax: (336) 379-1995
www.mpactlearningcenter.com

SMRP
8400 Westpark Drive / 2nd FL
McLean, VA 22102
Phone: (703) 245-8011; (800) 950-7354
Fax: (703) 610-0249
www.smrp.org

Turning Science Fiction



Conceptual art on the space elevator courtesy of The Spaceward Foundation.

The Space Elevator Games will begin in September 2008.

into Fact

AEROSPACE COMPETITION AIMS TO MAKE SPACE ELEVATOR A REALITY

Matthew Jaster, Associate Editor

Fans of Arthur C. Clarke may remember a concept in his 1979 novel, *The Fountains of Paradise*, of an orbital elevator used to raise payloads from the ground to a satellite as a more cost-effective means of transporting material to outer space. NASA claims that Clarke was asked at a conference in 1979 how long it would take to actually produce such a device and he sarcastically remarked, "Probably about 50 years after everybody quits laughing."

While the idea of a space elevator does sound a bit far-fetched, it didn't stop a group of scientists and engineers from discussing the possibility of designing one. Working under the NASA Institute for Advanced Concepts Phase II grant, Bradley C. Edwards, Ph.D., had the objective of producing initial designs. He would soon be widely recognized as the developer of the modern space elevator.

After years of debates on materials, available technology and funding, Edwards and his engineering team believe a space elevator could be operational in the next 15–50 years. It was once estimated to take more than 300 years to produce the space elevator, but major developments in carbon nanotubes and power beaming have significantly raised the stakes and altered the timetable.

A Railroad to Space

The biography for Ben Shelef at *www.spaceward.org* says it all. "An aerospace engineer by day, Ben dons the mask and cape of space crusader by night and engages in daring escapades such as space elevator games and robotic challenges." Shelef, co-founder of The Spaceward Foundation, says conducting a project that basically brings science fiction to life is "by far the most inspiring thing one can work on."

The Spaceward Foundation is one of many non-profit organizations participating in NASA's Centennial Challenge Program, an annual competition awarding prize money for innovations in aerospace technology. The foundation's main objective is to get the right people in both the aerospace and academic fields thinking about the technology needed to design and construct the space elevator. Shelef is optimistic that the knowledge gained through these yearly competitions will move NASA one step closer to actual production.

The space elevator is a climbing mechanism that can travel beyond Earth's gravitational pull from an anchor on the Earth to a counterweight beyond geosynchronous orbit. Cargo and passengers could "ride" the climbing mechanism in a straight line up into space. Shelef explains what exactly a trip on a space elevator might entail:

- The "lobby" would be an anchor station at sea level.
- Points along the line used to jump off to lower orbits.
- The GEO point, where you step off and are in perfect geosynchronous orbit (36,000 km above sea level).
- Points along the line used to jump off to interplanetary trajectories (going to Mars, asteroids, etc.).
- Counterweight, the end of the line, the roof floor where only elevator technicians can go (100,000 km above sea level).

The elevator can best be described as a physical railroad to space that runs via a cable, theoretically 25,000 miles long. Until the early 1990s, few in the science community believed a material existed strong enough to support such an operation. With the discovery of carbon nanotubes—a material that contains extraordinary mechanical properties—scientists were confident the space elevator could be produced.

The Space Elevator Games

According to the website, The Spaceward Foundation is managing two engineering competitions, known as The Space Elevator Games, on topics such

continued

as tether strength and power beaming to further space elevator research.

One of the more appealing aspects for Shelef is the number of commercial organizations involved in the competition. Companies like Bosch Rexroth, G2 Engineering, Access I/O, Gizmonics and Trumpf Laser are contributing material in the hopes of advancing the technology.

In the strong tether competition, teams test and measure the tensile strength of the proposed elevator tethers. In order to make the experiment exciting, the foundation created a head-to-head strength competition between engineering teams.

The tether pull machine used in the competition is a boxlike structure about 12 feet long and 18 inches high. The tethers are connected to the machine end-to-end to run a comparative test between two samples. Essentially, the machine grabs the two samples at their respective ends and pulls their free ends toward each other. As the force increases, one will break and the other is declared the winner.

Shelef recalled using an aluminum framing product from Bosch Rexroth for his day job and thought it would work for the space elevator competition. Since 2005, the Bosch Rexroth framing has been an intricate part of the tether competition.

The tether pull machine can be assembled quickly using Bosch Rexroth connectors and the aluminum framing unit is reusable. This allows for some flexibility if design teams need to make any changes or adjustments during the competition.

Kevin Gingerich, marketing services manager for the linear motion/assembly branch at Bosch Rexroth, is pleased the company participates in innovations like the space elevator project.

"The Space Elevator Games, for us have a twofold purpose," Gingerich says. "One is to achieve a certain public relations presence to an audience that is operating in the realm of science fiction. These engineers and scientists are innovative thinkers, and we're more than happy to offer a product that can be used in a unique way. More importantly, it's just a neat thing for Bosch Rexroth to be a part of."

Although the framing Bosch Rexroth provides won't actually be used in the elevator itself, it plays a pivotal role in the test rigs for the tether competition. Shelef hasn't ruled out the possibility of Bosch Rexroth hardware being used elsewhere. "Perhaps in the optical components of the laser," Shelef says.

When the competition first began in 2005, organizers wanted a 50 percent improvement in breaking force from year to year. The 2007 competition produced mixed results.

"The standard material-based tethers performed the same," Shelef says. "The first carbon nanotube tether showed up last year, but was not closed to a loop so it wasn't measurable. The next sample will be ready to measure in September 2008."

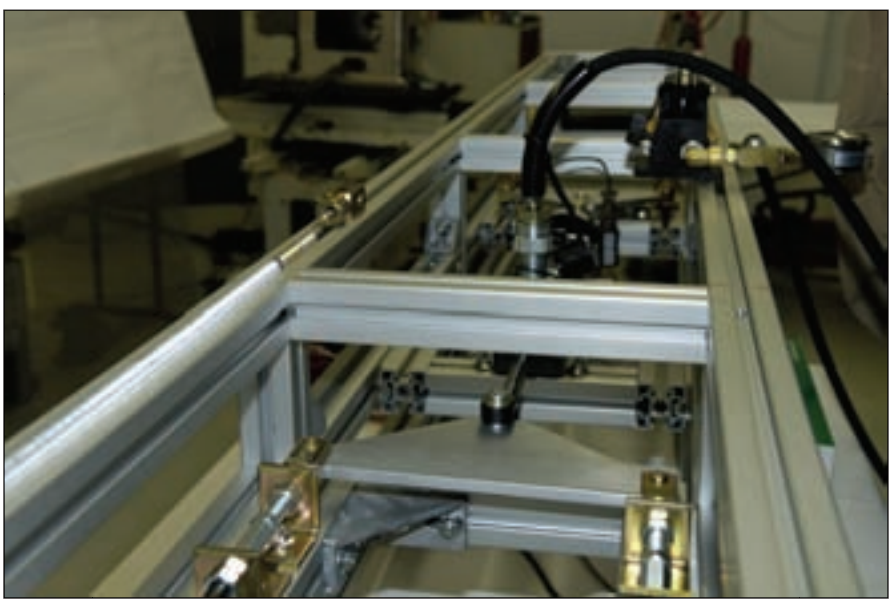
In addition to the tether tests, researchers have been working on solutions to power the electric cars (known as climbers in space elevator jargon) that travel up and down the elevator. The biggest obstacle in this portion of the project is powering the cars. Typically, the fuel or batteries end up weighing more than the cars can lift.

Dr. Edwards came up with a solution in 2000 while working at the Los Alamos National Laboratory. He called his technique power beaming. In power beaming, the electric cars carry photovoltaic cells that face back towards Earth. The ground station projects a laser beam at the cars, which in turn converts the light into electricity to drive the motors. The main benefit of this method is that it allows the scientists to leave the fuel tank on the ground, making the cars very lightweight.

The Spaceward Foundation hosts a power beaming competition in which teams build mechanical devices that propel themselves up a cable. The challenge is to receive the transmitted power and transform it into mechanical motion. Beamed power competitions in 2006 and 2007 produced noteworthy results, but no team has been able to meet the criteria to claim the cash prize.

For the 2008 competition, teams will be expected to drive their laser-powered devices up a cable 5 m/s over 1 km (10 times as high and twice as fast as the 2007 competition). Trumpf Laser is providing an 8 kW laser beam to interested teams participating in the power beaming competition.

"We'll provide the entire engineering and management that goes with the installation and transport of the equipment to and from the competition site," says Dr. Holger Schlueter, vice president of Trumpf Laser division. "In addition, we offer teams the necessary training on the equipment, provide support for the optical, electrical and mechanical



Bosch Rexroth provides the aluminum framing for the strong tether competition.

integration, set and monitor safety standards and conduct several test runs for the teams that participate."

Schlueter says that Trumpf initially got involved in the project because the space elevator competition gives worldwide visibility to laser technology.

"We believe there is a future market for high-quality, high-average power distribution through laser beams," Schlueter says. "This competition provides a unique opportunity for visibility into sectors that otherwise might never have considered lasers or Trumpf as a solution provider."

Trumpf plans to provide support at this year's competition, and if the prize in power beaming is not claimed in 2008, they are committed to supporting it again next year.

The strong tether competition tests the tensile strength of proposed elevator tethers.

Trumpf Laser is providing the TruDisk 8002 laser for the power beaming competition.

One Step Closer to Reality

Shelef is excited the foundation is making a substantial mark in aerospace technology with advancements in space elevator research. The space program, in general, has suffered somewhat of an identity crisis in the last 20 years. Math and science in the classroom isn't as popular as it was years ago and the general population sees less practicality in spending millions on space research projects.

The Spaceward Foundation aims to change that. It intends to get young minds interested again in the space program. It also hopes to inspire adults who may have forgotten how important the U.S. space program is to the future of exploration and commerce.

The commercial companies supporting the program have already discovered several advantages to participating in the space elevator competition.

"We see that we are of interest to a whole new group of engineering students that would like to work for Trumpf, which is a very attractive side effect for us," Schlueter says. "Some of these students are active in space elevator projects; others have heard about it in the news and are interested in a company that does such cool things."

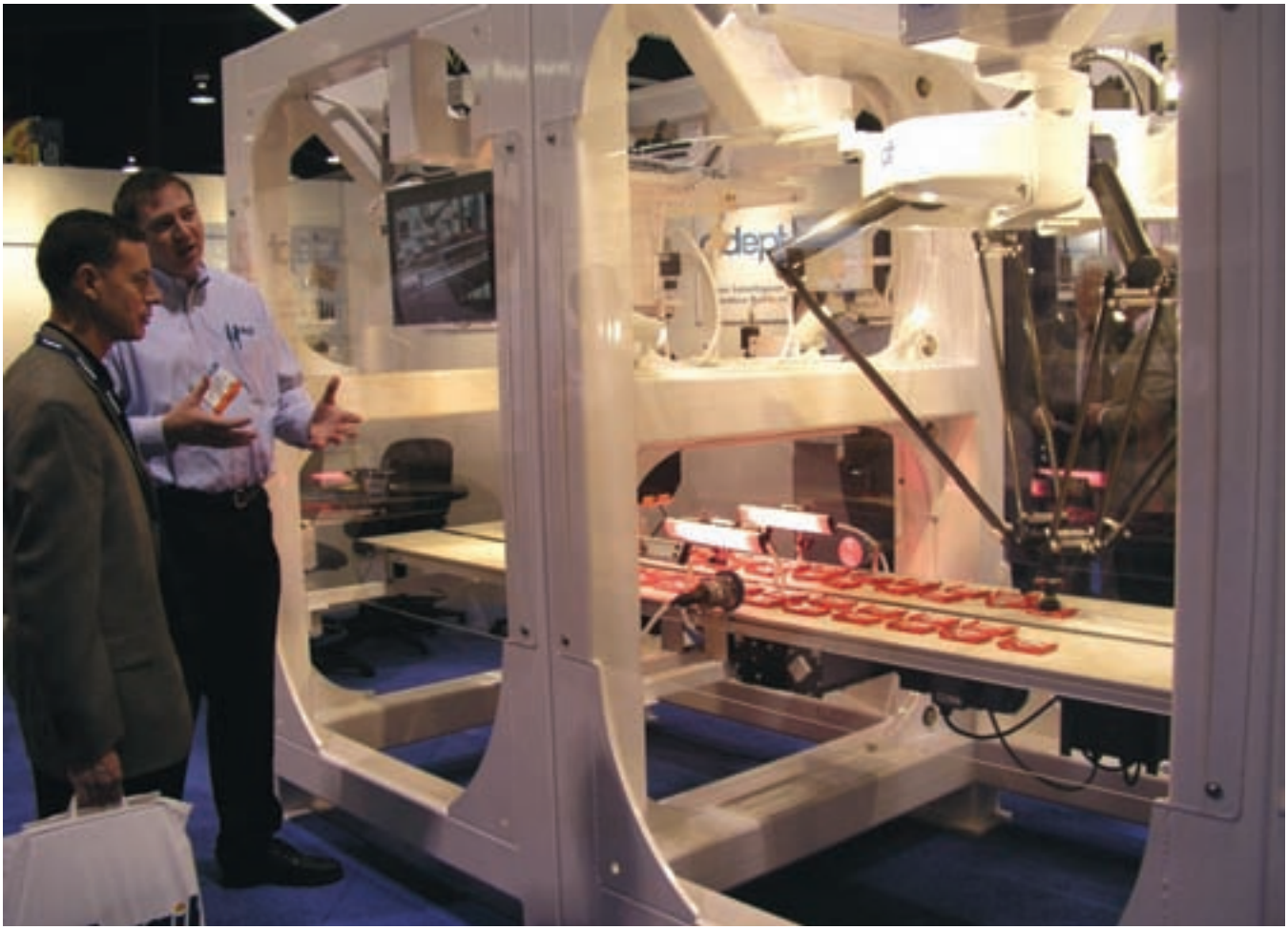
Gingerich adds that Bosch Rexroth might find it challenging to draw a line between cutting edge technology and science fiction, but that won't prevent the company from continuously pursuing such projects.

"We're always trying to develop material that can help our customers be as productive as they can be. Often that means taking some risks at the forefront of technology," Gingerich says. "Ben Shelef is an entrepreneur and an impresario. Through the force of his own will, he's driving this space elevator technology forward, and we're happy to support the process."

As Shelef prepares for the next wave of competitions this September, there's a feeling of anticipation that the team is getting closer to making significant progress. When asked for an "unofficial" timetable for the project, Shelef responds quickly.

"Our current estimate is to show strong carbon tethers by 2010, show space elevator-strong carbon nanotube tethers by 2020 and have the space elevator working by 2030," Shelef says.

Some may call that optimistic or overconfident; just don't tell The Spaceward Foundation team it's impossible.




Revolution - SS

Nine Manufacturing Trade Shows Under One Roof

NATIONAL MANUFACTURING WEEK CONVENES OUTSIDE CHICAGO

Lindsey Snyder, Assistant Editor

Industry leaders will gather to showcase their latest technologies September 23–25, in Rosemont, IL. Presented by trade show organizer Canon Communications, National Manufacturing Week comprises nine manufacturing shows: Design Engineering, Plant Engineering, Industrial Automation, Enterprise IT, Assembly Technology Expo, Electronics Assembly Show, PLASTEC Midwest, Medical Design and Manufacturing Midwest and Green Manufacturing Expo.

Between these shows, 40,000 manufacturing professionals and more than 2,000 suppliers are expected in areas like aerospace/aviation, transportation/motor vehicle, defense, electronics, medical/pharmaceutical, computer/communications, food and beverage, industrial/agriculture and household appliances. Over the course of three days, buyers will have 400,000 square-feet of products and services to browse on the show floor, providing opportunities to accommodate important specifications and requirements.

Beyond the exhibition show floor, conference sessions for each show will take place Monday through Thursday from 9 a.m. to 4 p.m. Badges provide attendees with access to any conference session in addition to the exhibition. The sessions are designed to be informative forums, provide technical information and tips for improvement in each of the nine show categories.

Lean and green manufacturing are two related topics that appear overwhelmingly as conference session subjects. A show-opening keynote panel discussion entitled "So the Grass *Is* Greener on the Other Side: How Industry Leaders are Practicing Sustainability and Increasing Tomorrow's Prof-

continued

itability," is being held Tuesday, September 23 at 9 a.m. Four panelists represent Philips Healthcare, Hewlett-Packard, Best Buy and Exelon Corp. They will discuss how their respective companies have developed environmentally sound policies. Attendees will hear how design and manufacturing practices can embrace sustainability efforts, how supply chains can be reversed and how energy-efficiency programs can save energy and money. Bottom line cost-savings, end-of-life product design and corporate social responsibility will be covered.

Several other conference sessions address lean manufacturing in different applications. One such session is devoted to applying lean six sigma principles to machinery control system design. Attendees will be given a brief introduction to how the six sigma practice can be applied to building machinery. The session will also cover the hidden costs of component system integration, the strengths and weaknesses of multiple control system theories and the pyramid of engineering intervention as a cost-to-benefit comparison tool. Other lean manufacturing sessions include "Let's Make Maintenance Lean," "The State of Lean Manufacturing in 2008," "Making your Quality Management System Lean," and many others.

Innovation in supply chain management is the subject of another conference session, which will discuss methods to prosper in the global value chain. Topics include the type of value chains that can open new markets, challenges and tips to improve quality and competitiveness.

There's more on the global manufacturing subject with several sessions discussing the issues in outsourcing. One of these sessions aims to help small- and mid-sized manufacturers establish wholly-owned enterprises in China. The "China option" will be covered in regards to benefits and risks as well as the different steps along the way, such as contracting with a sourcing company and relationships with contract manufacturers. The session will identify five phases of implementation from concept to operational audits. A separate session on outsourcing is titled "An Often Overlooked Resource for Efficient Outsourcing." Attendees will learn how to reduce the various risks involved at different levels.

Professionals in the plastics industry can participate in the National Plastics Design Competition organized by the Society of the Plastics Industry's (SPI) Alliance of Plastics Processors (APP). The competition has been held for 36 years, but this is the first time it is co-located with PLASTEC Midwest. "Placing the APP's 2008 competition at PLASTEC Midwest will showcase the plastics industry's innovative designs and emerging technologies to a more diverse array of end-market industries and a much greater number of people than ever before," says William Carteaux, SPI president and CEO.

The National Plastics Design Competition is an opportunity for any department of the plastics industry value chain to demonstrate innovations, learn about emerging research and technologies as well as hear from keynote speakers. New design categories and awards are a feature of this year's contest, including bio-process systems, innovative packaging applications, medical products, sustainability, nanotechnology and bio-based materials.

With nine trade shows sharing a location and running concurrently, there is a full load of industry relevant activities. Suffice to say attendees will have no trouble filling their schedules.

National Manufacturing Week
September 23–25, 2008

Design Engineering
Plant Engineering
Industrial Automation
Enterprise IT
Assembly Technology Expo
Electronics Assembly Show
Plastics USA/Plastec Midwest
Medical Design and Manufacturing Midwest
Green Manufacturing Expo

Location:
Donald E. Stephens Convention Center
5555 N. River Road
Rosemont, IL

Exposition Dates and Hours:
Tuesday–Thursday 9/23–9/25
10 a.m.–4 p.m.

Conference Dates:
Monday–Wednesday 9/22–9/24
9 a.m.–12 p.m.

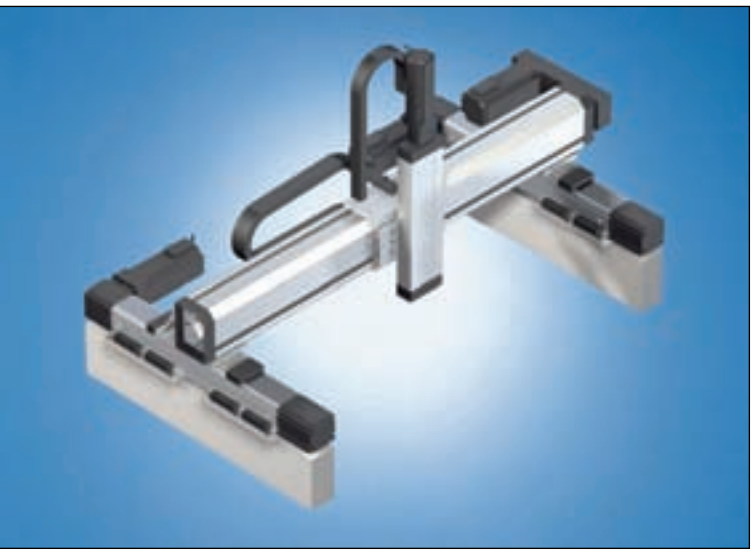
Conference Registration:
Before August 29–
One Day $395
Two Days $595
Three Days $745
Four Days $795

After August 29–
One Day $495
Two Days $745
Three Days $895
Four Days $945

Product Preview

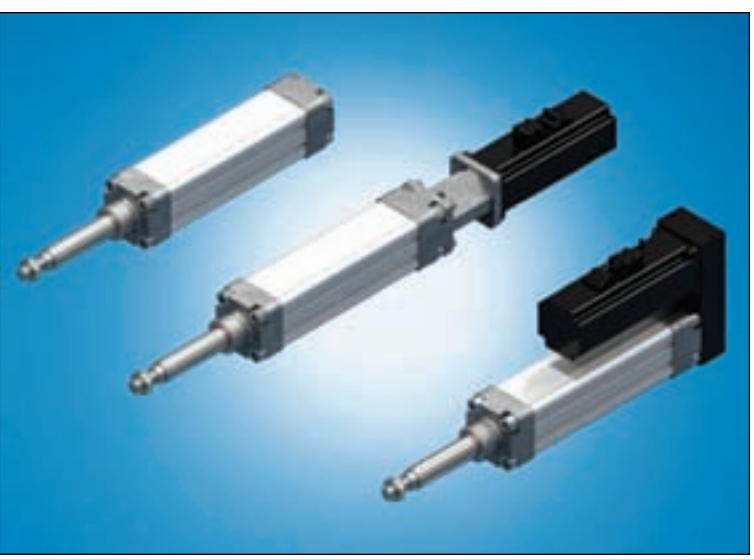
Take a sneak-peek at what a few power transmission-related companies will have on display at the exhibition.

Bosch-Rexroth Corp: Booth 105, 305
Bridge Modules Span Long Unsupported Lengths



The BKK and BKR Bridge Modules are an expansion of Rexroth's linear modules. The aluminum extruded profile provides high torque stiffness to reduce deflection where the module is not completely supported. Y axes for gantry systems are an example of this where the bridge modules replace the configuration of parallel linear modules.

Inside the aluminum extrusion are two ball rail systems with four steel runner blocks at a 90-degree angle to increase load capacity. They are completely enclosed with an aluminum cover and polyurethane sealing strips. The BKR belt-driven model comes in length variations up to 8,000 mm. The BKK ball screw-driven model is suitable for higher thrust forces and lengths up to 5,500 mm, and it is available with ball screw supports for even higher speeds at longer lengths.



Also on display at the Bosch Rexroth booth will be a TSsolar Conveyor, a technology recently released for solar cell manufacturing. The conveyor line provides gentle material flow, clean, particulate-free operation and the capability to operate in temperatures up to 200°C.

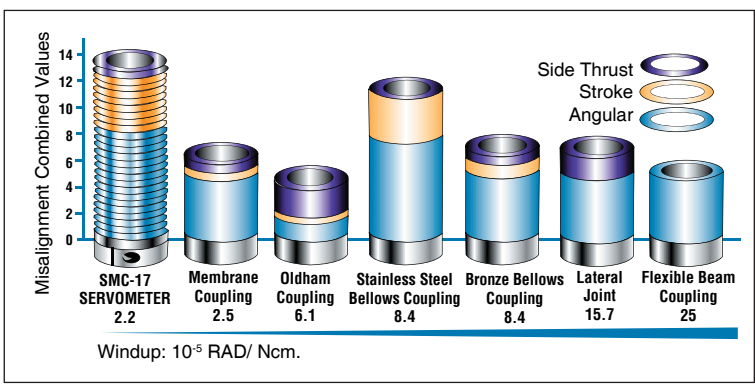
Electromechanical cylinders will also be at the Rexroth booth. These provide high thrust, high-speed capabilities flexibly and with control to applications that use hydraulic or pneumatic cylinders. They are corrosion-resistant and suited for packaging and material handling applications as well as assembly and robotics, wood manufacturing, metal forming, plastics, paper converting and web handling, according to the company's press release.

A ball screw actuator in the electromechanical cylinders eliminates stick-slip effects while providing precise positioning and high repeatability. They are more environmentally friendly than hydraulics due to the level of efficiency and low-maintenance they offer. The cylinders come in six sizes from 32 mm to 100 with stroke lengths up to 2,000 mm and up to 1.6 m/sec in speed. They have the same connection dimensions as an ISO 15552 pneumatic cylinder, so they can be placed into traditional pneumatic applications. They allow for direct and parallel motor mounting, several rod end, flange, trunnion and clevis mounting options as well as step and servo motor options.

For more information:

Bosch Rexroth Corp.
5150 Prarie Stone Parkway
Hoffman Estates, IL 60192
Phone: (973) 785-4630
www.boschrexroth-us.com

Servometer: Booth 4742
Electrodeposited Bellows Provide High-Frequency Interconnection



The PMG electrodeposited bellows are an alternative to spring-loaded type test pins in high-frequency test applications. The electro-deposition process allows for bellows to be made of different materials including gold, nickel, copper and silver, which increases the bellows' conductivity and provides

continued

low DC resistance with minimal insertion loss. They are rated for a maximum current of 4 amps and are capable of lifetime spring and force repeatability (108 cycles).

Servometer's PMG bellows perform in long-life applications with flexibility, precision and maximum sealing. They offer one-piece construction and have no moving parts, so they prevent resistance or impedance factors. They are available as small as 0.5 mm diameters with .008 mm walls for PCB applications, and shape options are unlimited. The thin walls lower rotational inertia, which results in minimal drive power losses during intermittent operation. The electro-deposition's geometric construction allows the bellows to fit more convolutions in a given length than hydro-formed bellows, according to the company.

The concentricity of the electrodeposited bellows is held to within 12.7 µm. They exhibit no cyclic speed variation through 360 degrees rotation, and the bellows' can potentially last for 108 life cycles. Servometer can coat the bellows with noise reduction materials if necessary. The bellows are ROHS compliant and can be used in instrumentation, laser, medical, aerospace, solar, semiconductor, vacuum and oil machinery applications.

For more information:

Servometer Precision Manufacturing Group, LLC
501 Little Falls Road
Cedar Grove, NJ 07009
Phone: (973) 785-4630
Fax: (973) 785-0756
info@servometer.com
www.servometer.com

Automation Direct: Booth 4906
IronHorse Worm Gearboxes Prevent Leakage

The power transmission product line from Automation Direct has expanded to include the IronHorse gearboxes in four ratios from 5:1 to 60:1. They are manufactured from one-piece, cast-iron housings. The main gear is made from aluminum bronze casting—instead of phosphor, which is less rigid— and they use a C-flange input and carbon steel shaft with either right-hand or dual-shaft output. The one-piece output shaft hub secures the output shaft bearing, and both shaft ends have double bearing sets. Double-lipped embedded oil seals thwart leaking from occurring; the gearboxes are capable of altering drive direction by 90 degrees and can be mounted in any direction, except motor-up. Applications include reducing output speed, increasing torque, changing drive direction and running two loads from one motor, according to the company's press release.

ProSense pressure sensors will also be on hand at the Automotion Direct booth. They are vacuum pressure sensors, an alternative to mechanical switches, and they monitor system pressure in hydraulic and pneumatic applications. They use capacitive sensing and strain gauge technologies.

The stainless-steel housed PTD series vacuum transmitters convert system pressure into an analog output signal. Output options include 4 to 20mA or 0 to 10 volts and offer up to 1,000 psi. They have a flexible film circuit, and a ceramic sensing element for overpressure protection.

The PSD series electronic pressure switches perceive gas and liquid pressure up to 5,800 psi using a 316 stainless steel process connection and gas-tight measuring cell. The sensors can adjust without system pressure or supply voltage, so calibration is unnecessary. The PSD series has a switching life of 50 million cycles and features a dual-switching DC output.

For more information:

Automation Direct
3505 Hutchinson Road
Cumming, GA 30040
Phone: (770) 889-2858
Fax: (770) 889-7876
www.automationdirect.com

Baldor Electric Company: Booth 4117
C-Face Gearmotor Employs Energy Efficiently

The Dodge Quantis Gold C-face gearmotor combines the Baldor Reliance Super-E Premium Efficient Motor with the Quantis in-line helical (IHL) or right angle helical bevel (RHB) reducers to produce a complete gearmotor package that maximizes energy efficiency. Configurations up to 10 hp are available.

The Quantis ILH and RHB features include NEMA clamp-collar design, foot-mounted housing, standard inch output shafts, nitrile output and output lip seals, A1 mounting and Mobilegear 600 XP 220 oil. The RHB unit also offers flange mounted housing configurations and tapered hollow bores with twin-tapered bushings, according to the company's press release.

The Baldor Reliance Super-E Premium Efficient Motors are constructed with rolled steel and cast iron, and they feature TEFC enclosures, 1,800 rpm, 60 Hz and voltages ranging from 230 to 460 V. They are inverter capable for variable-torque inverter drives and 20:1 constant-torque applications. They were designed to perform in dusty, dirty and humid environments.

Baldor is also exhibiting a high-power brushless servo motor. The BSM132 runs up to 20 hp with the option of blower cooling, allowing up to 34 hp. Speed up to 5,000 rpm is possible, and the servo motors have continuous stall torque from 70 Nm to 120 Nm. The BSM132 is sealed against dust and low-pressure water jets. Feedback includes resolver or absolute encoder and a double-insulated, multicoated magnet wire for reliability. Applications include those that require high-power, accurate positioning such as packaging, food processing, beverages, material handling, shearing and printing.

For more information:

Baldor Electric Company
5711 R.S. Boreham, Jr. Street
Fort Smith, AR 72901
Phone: (479) 646-4711
Fax: (479) 648-5792
www.baldor.com

American Precision Prototyping: Booth 4335
Accura Materials Simulate Molded Plastic

Stereolithography (SLA) rapid prototyping and manufacturing processes by American Precision Prototyping (APP) solely use the Accura family of materials from industry partner 3D Systems to create custom motion control parts. APP will have various parts on hand at the show that were produced with these materials by the SLA process including cast urethanes, rapid metal castings and CNC parts.

The Accura Xtreme material is the most recent addition. It resembles injection molded polypropylene, ABS and polycarbonate, but molding, tooling, dies and traditional machining is replaced by the SLA process. Accura Xtreme is durable and resists impact and thermal resistance over 60°C. They are suited for assembly applications, including various fit, form and function parts. The Accura Bluestone material is suited for motorsport and aerospace applications because it resists humidity and deflects high heat.

"Accura materials are the broadest range of materials available and meet the demands of virtually any application," says Jason Dickman, APP president. "I have been in the RP (rapid prototyping) industry for many years and have witnessed firsthand the evolution of Stereolithography materials from the early acrylate materials that yielded inaccurate, brittle parts to those today that are closer to production-grade materials than ever before."

For more information:

American Precision Prototyping LLC
19503 East 6th Street
Tulsa, OK 74108
Phone: (866) 918-1004
www.approto.com/landing
sales@approto.com

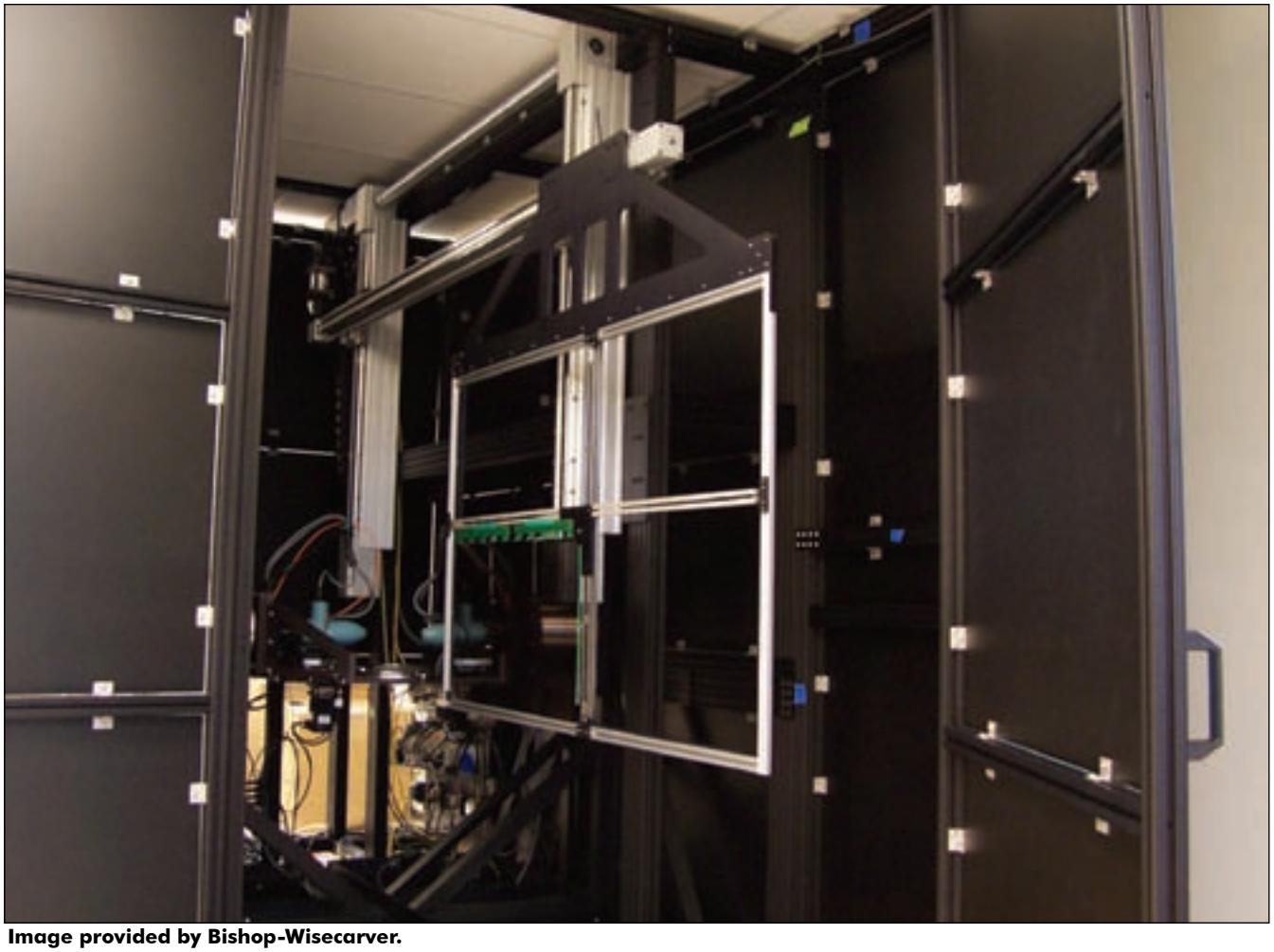


Image provided by Bishop-Wisecarver.

Motion System Management

COMPANIES FOCUS ON CUSTOMIZATION & QUALITY IN LINEAR MOTION

Matthew Jaster, Associate Editor

Alan Haveson, CEO of Lee Linear, says a war is coming. It's more symbolic than anything else, but it may have a rather adverse effect on the spending habits of customers in the linear motion industry. It's a battle between what a customer wants, what a customer needs and what a customer is willing to pay for.

Quality vs. cost is a looming issue in linear motion as well as many other manufacturing industries. Rising surcharges in materials and fuel costs are forcing executives to reexamine their game plan in an attempt to keep manufacturing vital here in the United States.

For years, linear motion has been a niche market that many felt was limited in its scope. People working within the industry, however, see the products expanding to new markets every day.

"No matter what happens as we move forward, bearings, hydraulics, fluid and linear motion products will forever be there," Haveson says. "The products that are in the field have a myriad of uses and can be taken as far as the mind can let it go."

There's a strategic initiative in place to focus more on the needs of the customers in regards to quality control, technological assistance and R&D. Employees at Bishop-Wisecarver, Danaher Motion and Lee Linear are coming up with innovations to strengthen both new and established relationships with their customers. Whether manufacturing full linear motion assemblies or linear motion components, the end result is better products and greater involvement with each application.

You Pay for What You Get

Due to rising costs, many companies have no choice but to raise prices. With the economy in question, this may be the worst time to do so. Faced with surcharges, employees recently sat down at Lee Linear to address this problem.

"For us, it's not as simple as just adjusting the price," says Jim Ashworth, vice president at Lee Linear. "We've seen increases upwards of 15 percent. How do you justify that kind of percentage back to your customer? You can't do it."

The objective at Lee Linear is to help drive down the costs for its customers and make them more aware of the quality issue. While this is overlooked in many industries, it's a priority when dealing with the accuracy and precision needed for linear motion components.

"It's the things customers don't have the capability of doing, like measuring the true roundness of a shaft," Ashworth says. "Today, people shop by price instead of the quality of the item. Some companies have run shafting through a grinder only twice before sending it out to the marketplace. For us, it's important to make sure you manufacture a product that's going to give your customer the longest life out of the bearing and shafting."

Haveson compares shopping for linear motion technology to shopping for a typical consumer product.

"Put three refrigerators side by side with different prices," Haveson says. "Many consumers would lean toward the lower priced unit. But when you really look at each one individually, do you ever consider the fact that the doors fit right, the shelves are in there, the trays work properly, the motor functions and all the components are working together? This is what we need our customers to understand about linear motion."

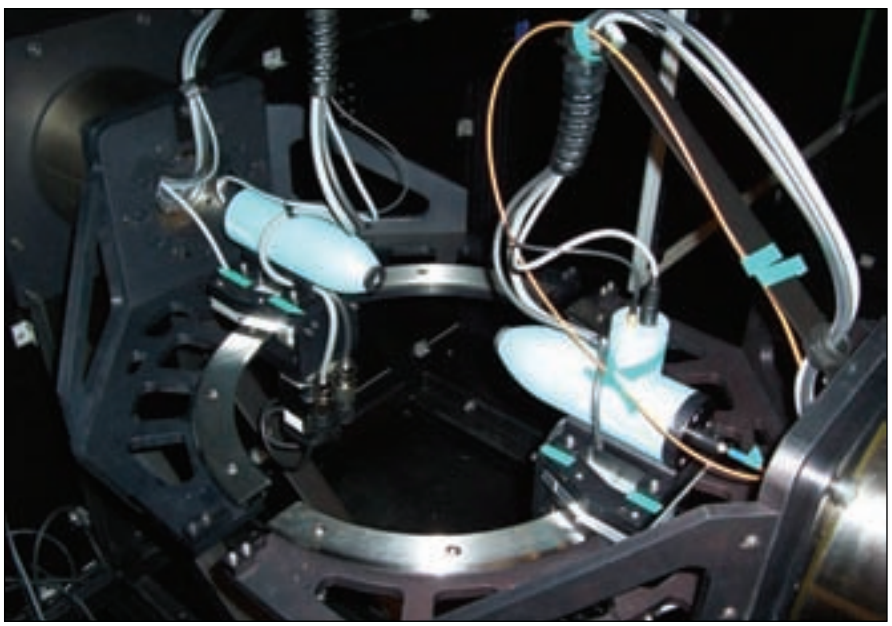
Haveson believes the consumer perception is to pay too much attention to the cost. "The very first thing that comes into your mind is the cost when the reality is the cost is the last thing you need to consider, in my opinion."

In addition to stressing the quality of its products, Lee Linear is also getting more involved with each customer request, right from the initial planning period.

"Being privy to the application and knowing what's involved can really help. We have a customer that's a printing equipment manufacturer, and they're constantly coming to us with new draw-

continued

This exercise equipment for rehabilitation uses bearings and shafts from Lee Linear.



This custom metrology equipment application by Bishop-Wisecarver includes both rotary and linear motion.

This automatic boxcar painter uses bearings from Lee Linear.

ings and asking how we can help them drive out costs. We've been doing that for years and have a good relationship with them. Probably the only way U.S. manufacturing is going to be here 30 years from now is to work directly with the customers both early and often."

Haveson stresses the importance of letting the customers know they are dealing with precision items, a crucial aspect in linear motion.

"You've got your low-end and high-end material, but you're always going to look for something in the middle of the road that's going to give you the most bang for your buck," Haveson says. "I think as the technology grows, there's going to be a need for more accuracy and longer life and customers will embrace the quality issue. They'll realize spending more now will save them more money in the future."

Customer-Driven Technology

Danaher Motion is better serving its customers with the creation of a unique, web-based sizing and selection tool. *Linear Motioneering* allows users to optimize machine design and operations in just a few simple steps.

"The program basically allows users to input loads, select the accuracies you need and the life and the environment it would operate in," says Pete Castelli, engineering manager at Danaher. We'll output a solution set that generates a part number, a price, downloads a model or drawing and gets a quote for the customer."

Created in 2007, *Linear Motioneering* is now public for the systems division. Its success in linear motion slides has prompted Danaher to create similar programs for other divisions.

"We're now coming to a point where customers will be able to use this technology for gearboxes, shafting and ballscrews," Castelli says. "It's a real innovative tool for those who aren't sure what direction they need to go when they originally visit the website."

Castelli notes that customization is becoming the underlining theme in linear motion.

"We're seeing a lot of price pressure and it drives you to do some value engineering," Castelli says. "The applications in linear motion are becoming much more specialized, and from the engineering side, it's just a little more resource-intense. We're much more heavily involved in customization."

Castelli thinks many companies are pulling back to their core expertise and customers are no longer looking for off-the-shelf items.

"They want a linear motion company to come in and customize the application; we're seeing this in the medical industry right now. Engineers want to make sure the right people are working on each new job."

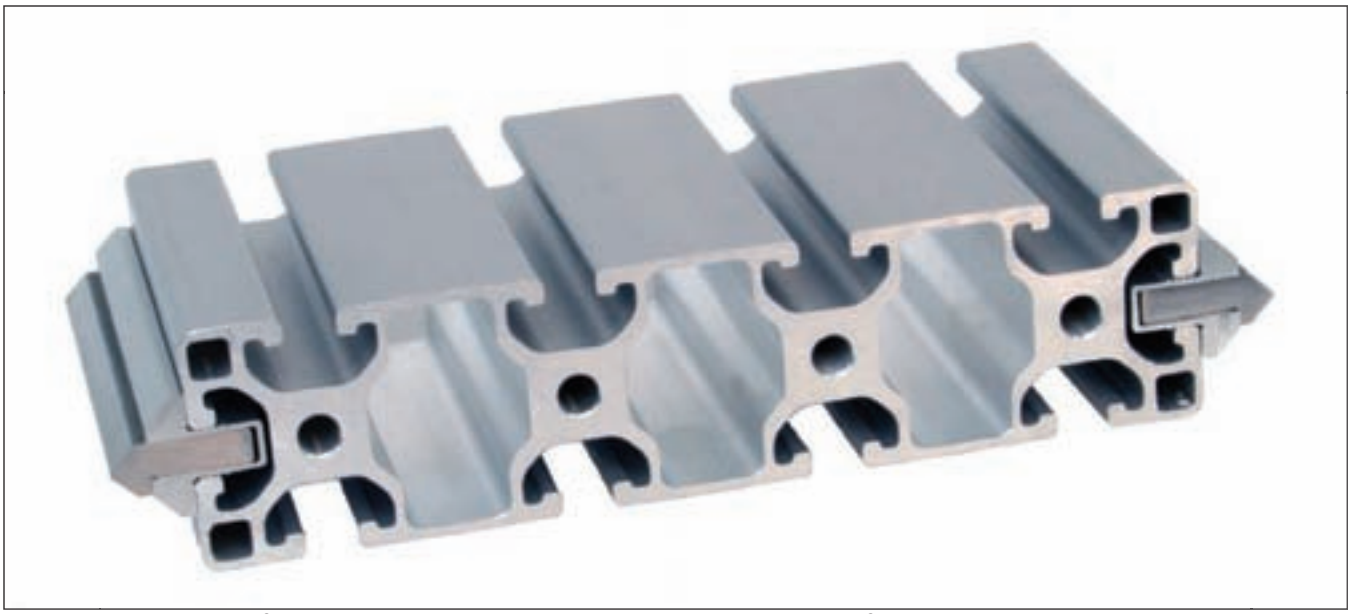
The outlook for linear motion products at Danaher has been a bit of a juggling act. Castelli says that they have seen some decline in the packaging and manufacturing fields and some incredible uptick in the medical and semiconductor industries.

"There's some growth in areas we didn't expect and some decline in other areas. Our goal is to make sure our customer base knows it's a linear motion assembly that we're selling and this sizing and selection tool is a great focal point."

Ease of Installation

Bishop-Wisecarver has several wheel and track sizes to accommodate its linear motion assembly for packaging, small shops and other manufacturing markets. A key factor in its success is that the systems can handle harsh environments.

"Our product is insensitive to contamination," says Nigel Watson, engi-



The QT Clamp Extrusion from Bishop-Wisecarver is currently being installed in its first application.

neering manager at Bishop-Wisecarver. "It has a self-cleaning mode of operation and we've always been recognized for our overall quality in this department."

Watson, like many others in linear motion, is fighting a battle against cost-conscious customers in 2008. Many customers need a system designed for a specific load, and cost is definitely a factor.

"Our customers are not only looking for good performance, but they're also looking for high value. We're combating this with a new product that offers to use our standard wheels and track with a low-cost installation, an installation our customers can provide," Watson says.

The product in question will be featured at the Bishop-Wisecarver booth at IMTS 2008 as well as the International Woodworking Fair (IWF) 2008. Watson explains that the concept will eliminate the use of fasteners to the rails by securing the track using an aluminum clamp.

"These clamps can lend themselves to any extrusion. You have to tailor the clamp to the slot size. We're looking to do a full range of these in the near future," Watson says.

With responsibilities in the applications, mechanical engineering and quality departments, Watson's very familiar with what is being designed and innovated, and he oversees much of the development.

"Our customers are very aware of our product lines and I think the small size of our company allows us to be very flexible with their various demands," Watson says. "While the growth isn't great in linear motion right now, it's definitely a time when we're looking at our systems and responding to our customer's needs. This will certainly help the revenue stream as we go forward."

For More Information

Bishop-Wisecarver
2104 Martin Way
Pittsburg, CA 94565
Phone: (925) 439-8272
Fax: (925) 439-5931
www.bwc.com

Danaher Motion
Thomson Systems
761 Koehler Ave.
Ronkonkoma, NY 11779
Phone: (631) 467-9814
Fax: (631) 467-9814
www.danahermotion.com

Lee Linear
727 South Avenue
Piscataway, NJ 08854
Phone: (732) 752-5200
Fax: (732) 968-7080
www.leelinear.com

Photo courtesy of Bishop-Wisecarver.

Calculating Pressure Concentration Factors In Keyless Locking Assemblies

Sandro Zamboni and Massimiliano Margonari, MAV S.p.A.

Figure 1—The MAV 1008, 4061, 2005 and 1061 keyless locking assemblies.

Introduction

One of the most important goals for designers and producers of mechanical components is to supply customers increasingly high quality products with clearly defined performance expectations. For this purpose, MAV S.p.A., an established manufacturer of locking assemblies and shrink disks, began to explore several years ago the methods of computer simulation to improve the components in production and to support the design process. This has substantially reduced laboratory testing, limiting its use to simply validating certain configurations, resulting in a significant reduction in times and costs for the certification of new products.

There are a wide number of different reasons that led the MAV engineering division to make this decision. Firstly, there is the management's belief that investing in applied research and numerical simulation is an effective means to ensure the

best possible results at the least possible cost, with obvious advantages; secondly, there is the growing technical need for fast, reliable and accurate instruments to offer the best possible response to the demands of the market.

The technical data of most interest to the mechanical engineer designing a locking assembly are usually the values for maximum transmissible torsional and flexural moments. Once the geometry, friction coefficients between the surfaces and the pre-tightening torque applied to the screws have been established, these values may be calculated using a number of equations formulated on the basis of simplified models, which are widely accepted and used by engineers. The results obtained are always safety biased; the mathematical models used often provide transmissible moment values well below the real capabilities of the system, as demonstrated by a series of tests conducted by MAV on a variety of different products.

It is useful to know the distribution of contact pressure between the locking assembly and the shaft throughout the system's life cycle and, in particular, during assembly and certain operating conditions. Unfortunately, there are no simplified models to help provide indications on the distribution of tension generated by the locking assembly on the mechanical components that it connects. In fact, no laboratory test currently exists that is capable of giving even partial answers to these questions. Literature cites the results obtained in the early 1980s and a number of indications on the matter. These results were obtained via the finite element analysis of extremely simplified, axially symmetric models, probably because of the limitations of the hardware and software resources available at the time.

However, while the data obtainable from two-dimensional simulation models may undoubtedly be interesting, and MAV has also made use of this technique, they do not provide any information on the behavior of locking assemblies near the gaps in the rings, where peak tensions are expected.

The accurate determination of contact pressure distribution is no small matter. Knowing the position and intensity of any tension peaks facilitates the job of the engineer, who will thus be able to make full use of the mechanical capabilities of the system in question while still maintaining adequate safety levels. To shed more light on this aspect, MAV has conducted a detailed study, using an entirely numerical approach, to produce more precise and reliable data concerning the real distribution of forces generated on a shaft by a locking assembly. The study considered the MAV 1008, 4061, 2005 and 1061 series of products. For each series, four different shaft sizes were considered to give the broadest and most detailed vision possible. The study also developed three-dimensional models with extremely accurate geometrical representation. The resulting models were highly complex and demanding in terms of computing power.

How a Locking Assembly Works

Figures 1 and 2 illustrate the four different types of locking assembly considered for this study. Tables 1 and 2 also contain pertinent information concerning geometry, the screws used and the theoretical reference values for contact pressure obtained with simplified models. The operating principle for a locking assembly is rather simple: a number of conical section rings are brought together by tightening screws, which generates high contact pressures between the shaft, the hub and the locking assembly itself. This arrangement holds the components tightly together, enabling the transmission of torque. The rings in contact with the shaft and the hub always have a longitudinal gap to reduce their circumferential rigidity, facilitating and improving the elimination of free play between components.

The locking assembly is usually mounted on the shaft and the screws pre-tightened in the tried and tested criss-cross sequence to limit possible eccentricity in the final configuration. The hub is mounted outside the locking assembly and enables the transmission of torque. The hub must be appropriately

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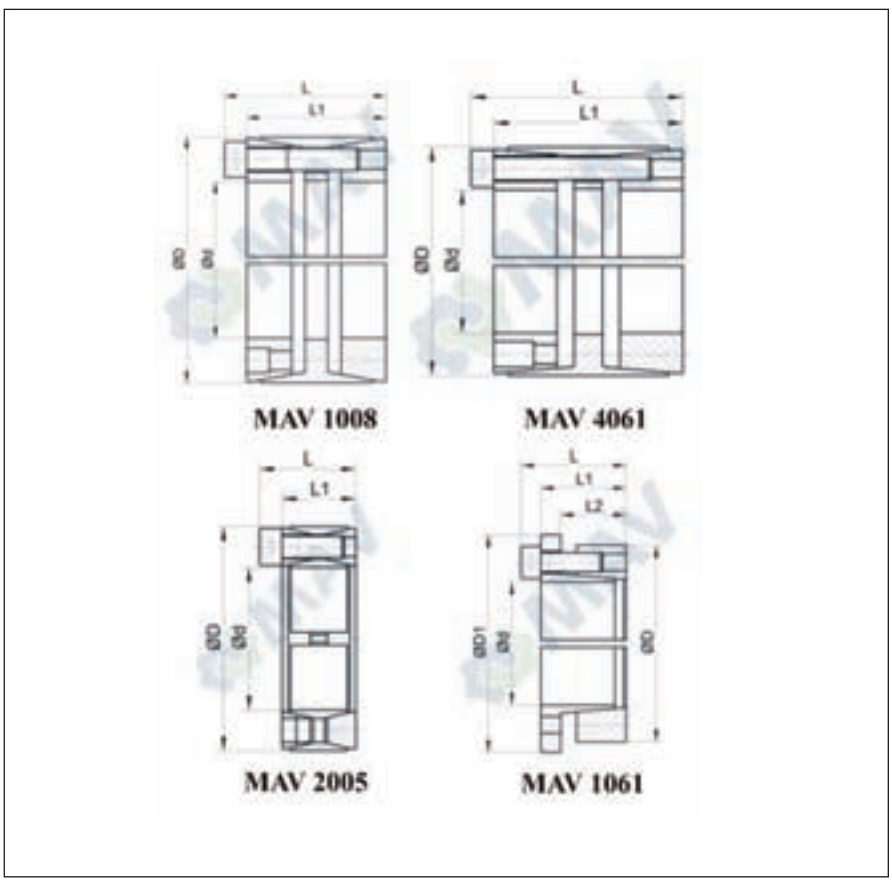

Figure 2—Longitudinal cross-sections of the MAV 1008, 4061, 2005 and 1061 locking assemblies, indicating the most significant dimensions.

Table 1—Dimensions of Locking Assemblies and Hubs Used in the Study. The Shaft Diameter is Equal to the Interior Diameter (d) of the Locking Assembly.								
	Dimensions (mm)							
	Locking Assembly						Hub	
MAV 1008	d	D	L	L1			External diameter	Depth
70 x 110	70	110	74	66			150	60
100 x 145	100	145	114	102			300	100
200 x 260	200	260	165	149			450	140
400 x 495	400	495	225	203			900	200
MAV 4061	d	D	L	L1			External diameter	Depth
50 x 80	50	80	74	66			150	60
100 x 145	100	145	114	102			300	100
200 x 260	200	260	165	149			450	140
400 x 495	400	495	225	203			900	200
MAV 2005	d	D	L	L1			External diameter	Depth
50 x 80	50	80	32	24			150	28
100 x 145	100	145	45	33			360	40
200 x 260	200	260	66	52			580	58
400 x 495	400	495	112	90			990	100
MAV 1061	d	D	D1	L2	L1	L	External diameter	Depth
50 x 80	50	80	89	27	35	43	150	27
100 x 145	100	145	154	33	45	57	290	33
200 x 260	200	260	269	51	65	79	480	51
400 x 495	400	495	504	94	116	138	910	94

Table 2—Type and Number of Screws Used with Locking Assemblies Considered in Study.				
	Screws (class 12.9) Number and Type	Mean theoretical pressure (MPa)		Maximum Theoretical Transmissible Torque (N-mm)
		On shaft	On Hub	
MAV 1008				
70 x 110	8 M10	197	125	$7280 \cdot 10^3$
100 x 145	10 M12	215	148	$19400 \cdot 10^3$
200 x 260	18 M14	166	128	$95300 \cdot 10^3$
400 x 495	22 M22	168	136	$609500 \cdot 10^3$
MAV 4061				
50 x 80	8 M8	198	124	$4120 \cdot 10^3$
100 x 145	11 M12	210	145	$27700 \cdot 10^3$
200 x 260	16 M16	181	139	$149900 \cdot 10^3$
400 x 495	24 M22	188	152	$863900 \cdot 10^3$
MAV 2005				
50 x 80	12 M8	282	176	$2160 \cdot 10^3$
100 x 145	14 M12	307	214	$11690 \cdot 10^3$
200 x 260	30 M14	254	195	$65450 \cdot 10^3$
400 x 495	36 M22	218	176	$393360 \cdot 10^3$
MAV 1061				
50 x 80	7 M8	191	119	$1800 \cdot 10^3$
100 x 145	8 M12	206	142	$10100 \cdot 10^3$
200 x 260	15 M14	153	118	$50900 \cdot 10^3$
400 x 495	21 M22	146	118	$377900 \cdot 10^3$

sized to effectively oppose any radial deformity of the locking assembly and may, for reasons of space but also for aesthetic or cost reasons, also incorporate drums, gear wheels or any other mechanical component deemed necessary.

Once the pre-tightening torque for the screws has been applied, the system consists of parts solidly connected to one another and may be subjected to external loads. The MAV 1008 and 2005 are defined as self-releasing locking assemblies. If the screws are removed after fitment of the locking assembly, they tend to loosen and return to their initial undeformed configuration. This is due to the fact that the rings have a highly conical section (8, 10°), and the coefficient of friction, usually considered to be 0.12, is not high enough to keep the components in the deformed configuration. This is an extremely desirable characteristic, as the locking assembly may be mounted and removed numerous times during its life cycle. Conversely, the MAV 4061 and 1061 are known as self-locking components. With a conical section of less than 5°, these exhibit the opposite behavior of that described above. In this case, the screws perform no particular structural role and serve only to deform the rings sufficiently.

As can easily be understood, the pressure generated on the shaft is not uniformly distributed (which would be considered an ideal condition) and varies both longitudinally and circumferentially due to the varying rigidity of the holes of the rings constituting the locking assembly (see examples in Figures 7 and 8). Furthermore, as mentioned previously, contact between the gaps in the rings and the shaft and hub constitutes a substantial element of disturbance and can cause undesirable tension peaks. This is why three-dimensional modeling was chosen, focusing on zones of discontinuity, such as edges and gaps in the rings.

CAD Models

Autodesk Inventor 10 software was used to produce the three-dimensional models of the locking assemblies considered. The capability of the software to parameterize the geometries modeled was extensively

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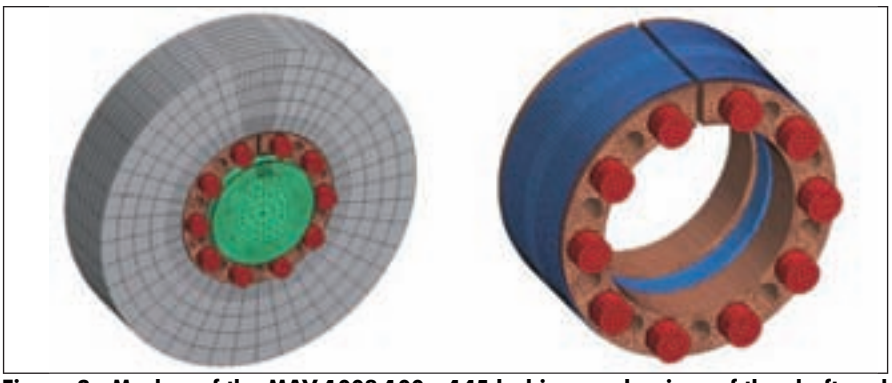


Figure 3—Meshes of the MAV 1008 100 x 145 locking mechanism, of the shaft and hub (left) and of the locking mechanism alone (right).

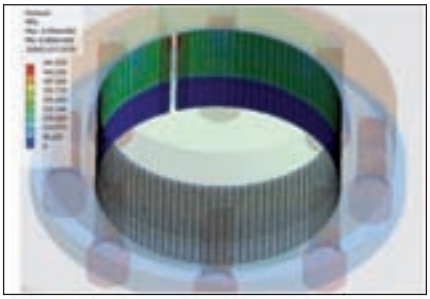


Figure 4—MAV 1061 100 x 145, shaft-locking assembly contact pressure on locking assembly at the end of the screw tightening stage. Note the concentration of pressure near the gap, at the front zone of the flange.

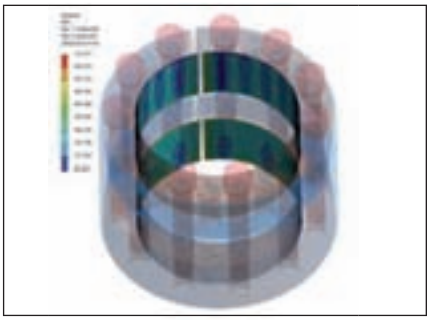


Figure 5—MAV 4061 100 x 145, shaft-locking assembly contact pressure on locking assembly at the end of load application. Note the reduction in contact pressure near the ring holes.

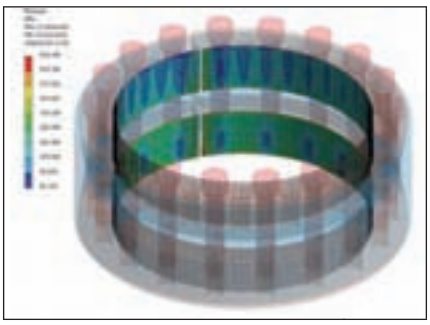


Figure 6—MAV 1008 200 x 260, shaft-locking assembly contact pressure on locking assembly at the end of the screw tightening stage. In this case there are two concentrations of contact pressure located at the front zones of the two rings, in correspondence with the gaps.

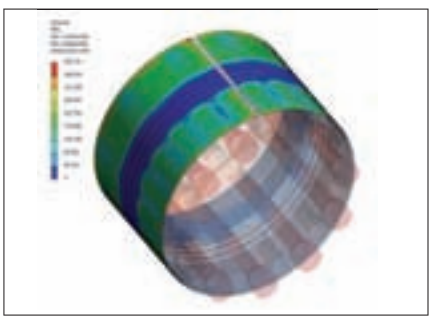


Figure 7—MAV 4061 100 x 145, hub-locking assembly contact pressure on locking assembly at the end of load application. Note the circumferential zone in correspondence with the flange, where contact pressures are very low and, in some cases, nil.

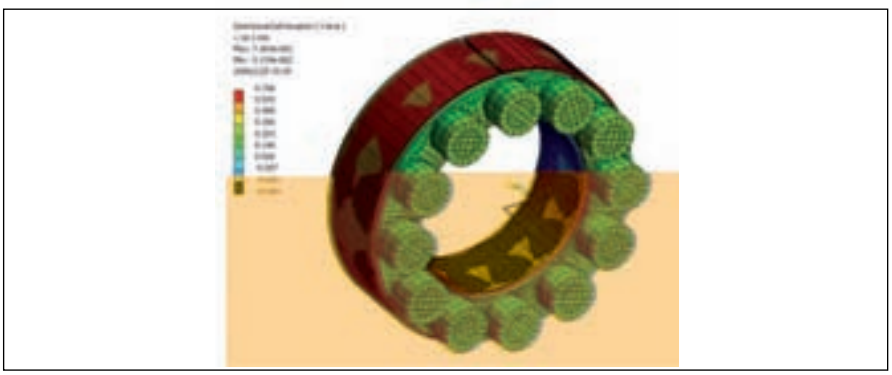


Figure 8—MAV 2005 50 x 80, radial displacement of the locking assembly at the end of the pre-tightening stage. The inner ring closes onto the shaft while the outer ring opens onto the hub.

exploited to speed up the preparation of the models themselves. While this required more work than usual procedures, it permitted the analysis of additional measurements when deemed necessary, without requiring significant extra effort. Painstaking care went into modeling, bearing in mind from the start of the procedure that the geometries created would subsequently have to be processed by a finite element mesher. In particular, a substantial "defeaturing" process was applied to the geometries to minimize the number of nodes and small surfaces that do not contribute significantly to the definition of elements and do not influence structural response. This presented clear advantages during mesh construction. The external surfaces of all components were subdivided into as uniformly shaped quadrilaterals as possible, permitting a more uniform subsequent meshing process, especially in contact areas.

The IGES format was chosen to facilitate transfer of the geometries into the finite element simulation environment.

FEM Models

Ansys 10.0 software was used for the numerical simulations. In particular, the Workbench environment was used for the preparation of the models and the visualization of the results, whereas the batch launch was conducted on a Linux machine for the actual analyses. Only elements with quadratic form functions were used and the 'Hex Dominant' setting was enabled to ensure greater mesh uniformity, as this reduces the number of nodes used and achieves better results than other settings. 'Weak springs' were also used to prevent rigid behavior in certain parts of the model. The very low rigidity of these springs enabled a solution to be reached without significantly altering the response of the system. Table 3 indicates the number of nodes and elements and the degrees of freedom for each individual model. Note that the number of contact and target contact elements are always identical in each model. This is because symmetrical contact definition was always employed. Managing the contact elements is fundamental; augmented Lagrangian formulation methods were always used, monitoring penetration occurring between bodies and modifying the parameters in successive instances where necessary. A coefficient of friction of 0.12 was chosen, as this value was considered sufficiently low and statistically reliable for describing steel-steel contact. The material, which is identical in all parts involved, was con-

Table 3—Finite Element Models: Nodes, Elements and Degrees of Freedom Applied in Analyses.

Model	Nodes	d.o.fs	Elements				
			SOLID 186-187	CONTA 174	TARGE 170	PRETS 179	COMBIN 14
MAV 1008							
70 x 110	292,537	887,601	79,293	15,135	15,135	8	312
100 x 145	360,336	1,080,994	97,643	20,724	20,724	10	360
200 x 260	425,297	1,275,861	51,458	25,729	25,729	18	552
400 x 495	462,964	1,388,854	127,141	29,925	29,925	22	648
MAV 4061							
50 x 80	314,089	942,257	87,281	15,168	15,168	8	312
100 x 145	351,697	1,055,075	96,304	21,457	21,457	11	384
200 x 260	411,116	1,233,322	110,871	27,683	27,683	16	504
400 x 495	450,338	1,350,972	121,679	27,785	27,785	24	696
MAV 2005							
50 x 80	356,263	1,068,771	104,024	17,495	17,495	12	432
100 x 145	366,645	1,099,913	105,956	18,584	18,584	14	480
200 x 260	299,780	899,268	82,701	19,033	19,033	30	864
400 x 495	528,261	1,584,717	149,978	32,658	32,658	36	1008
MAV 1061							
50 x 80	207,692	623,071	59,031	11,109	11,109	7	264
100 x 145	240,670	722,003	68,132	13,607	13,607	8	288
200 x 260	436,743	1,310,208	122,083	23,614	23,614	15	456
400 x 495	587,715	1,763,112	166,613	32,675	32,675	21	600

sidered to be a linearly elastic isotropic material, with a Young modulus of 200 GPa and a Poisson coefficient of 0.3. The only non-linearity considered in the models is due to the presence of contact points with friction. Certain analyses conducted in the past have shown that including other non-linearities, such as plasticity or large-scale deformation and large-scale movement, introduces no advantages in terms of the quality of the results for locking assembly shaft contact pressures and significantly increases calculation times.

Contact Pressure Concentration Factors

The primary objective of this study is to identify a simplified quantity for use during the design stage that is sufficiently representative of the state of tension induced on the shaft by the locking assembly. The following formula is often defined for this purpose:

$$FCP = \frac{p_{max}}{p_m} \qquad (1)$$

where *FCP* is the Contact Pressure Factor and p_{max} and p_m are, respectively, maximum and mean contact pressure.

This is calculated with the following equation:

$$p_m = \frac{\int_{A_c \text{ if } p(x) > 0} p(x)\, dAx}{\int_{A_c \text{ if } p(x) > 0} dAx} \qquad (2)$$

where p(x) is the contact pressure at point x on surface A_c. Obviously, in the calculation of the integrals given above, only the area where contact pressure is not nil following the application of loads is considered, not the initial contact surface. We must also remember that the contact surface between bodies is generally not known beforehand and depends, obviously, on the deformation modes of the structure.

$$F_R = \int_{A_c \text{ if } p(x) > 0} p(x)\, dAx \qquad (3)$$

Equation 3 represents the radial force transmitted from the locking assembly

continued

Table 4—Mean Contact Pressures Determined at Each Load Step, for Each Measurement and for Each Series of Locking Assembly Considered.

Mean Contact Pressures (MPa)				
MAV 1008				
Load Step	70 x 110	100 x 145	200 x 260	4000 x 495
1	194.4	214.2	183.0	182.9
2	198.9	219.8	185.8	185.3
3	200.0	220.2	185.9	185.8
4	200.5	220.4	186.2	185.9
5	200.6	220.7	186.7	186.2
6	200.8	221.1	186.6	186.4
MAV 4061				
Load Step	50 x 80	100 x 145	200 x 260	400 x 495
1	196.1	208.8	230.7	201.3
2	198.4	211.0	230.6	201.8
3	198.1	211.0	230.3	202.2
4	198.0	210.5	230.1	202.3
5	198.0	210.5	230.2	202.4
6	198.4	210.5	230.4	202.5
MAV 2005				
Load Step	50 x 80	100 x 145	200 x 260	400 x 495
1	259.0	250.4	246.8	193.5
2	263.3	252.1	248.8	194.9
3	264.2	252.6	250.5	195.5
4	265.3	253.1	250.8	195.7
5	266.3	253.5	251.3	196.0
6	267.8	253.3	252.0	196.3
MAV 1061				
Load Step	50 x 80	100 x 145	200 x 260	400 x 495
1	192.5	193.4	152.6	150.2
2	193.6	193.0	152.6	150.2
3	193.6	194.8	152.4	153.2
4	193.2	194.8	152.7	152.6
5	192.5	194.6	152.1	152.8
6	187.2	193.8	152.3	153.6

Table 5—Mean Contact Pressures (FCP) Determined at Each Load Step, for Each Measurement and for Each Series of Locking Assembly Considered.

Contact Pressure Concentration Factors (FCP)				
MAV 1008				
Load Step	70 x 110	100 x 145	200 x 260	4000 x 495
1	2.1	2.1	1.9	1.9
2	2.3	2.3	2.2	2.1
3	2.3	2.2	2.0	2.1
4	2.3	2.2	2.0	2.1
5	2.3	2.1	2.0	2.1
6	2.3	2.2	2.0	2.1
MAV 4061				
Load Step	50 x 80	100 x 145	200 x 260	400 x 495
1	2.6	2.1	2.0	2.0
2	3.2	2.8	2.2	1.9
3	2.9	2.6	2.1	1.8
4	2.9	2.5	2.1	1.8
5	2.8	2.5	2.1	1.9
6	2.8	2.5	2.1	2.0
MAV 2005				
Load Step	50 x 80	100 x 145	200 x 260	400 x 495
1	1.6	1.9	1.4	1.6
2	1.6	1.9	1.4	1.6
3	1.8	2.0	1.6	1.7
4	1.9	2.1	1.6	1.8
5	2.0	2.2	1.7	1.9
6	2.3	2.3	1.8	2.0
MAV 1061				
Load Step	50 x 80	100 x 145	200 x 260	400 x 495
1	2.8	2.3	2.0	1.4
2	2.9	2.5	2.2	1.5
3	3.3	2.9	2.7	1.7
4	3.4	3.0	2.8	1.8
5	3.5	3.2	2.9	2.0
6	3.7	3.3	3.1	2.0

to the shaft and to the hub. In this study, Equation 1 was not used because it is not considered sufficiently representative in this context. Instead, a modified version of the formula was proposed, as described as follows.

It is known that in finite element analysis, when a linear elastic behavior is attributed to the material, there are no limits to stress values attainable within the bodies. Where there are concentrated forces, sharp corners or contact between parts, the values for the state of tension in some nodes may increase indefinitely and congest the calculation mesh. This is a logical consequence of the fact that elastostatic equations permit the non-definition of the tension state in certain points in space; a well-known example of this is the Boussinesq problem, to which there is an analytical solution.

However, the integral of the state of tension calculated for a finite domain that also includes singularities is well defined and represents the result of the applied forces. In the case of a locking assembly, the transmitted radial force (Eq. 3) always assumes finite values, even though there are points in which the contact pressure $p(x)$ is not defined or, in the case of an FEM model, increases indefinitely to congest the mesh.

For this reason, the following definition was introduced:

$$FCP = \frac{p_{perc}}{p_m} \qquad (4)$$

where p_{perc} is a pressure value not known beforehand, representing the pressure at which the majority of the radial force (in our case 99.75%) is transmitted.

The value of p_{perc} may be calculated with the following equation:

$$perc\ F_R = \int_{A_c \text{ if } p(x)>0} p(x)\, dAx \qquad (5)$$

where *perc* is a real number slightly less than unity (in our case 0.9975). Thus, the value p_{perc}, which is independent of the calculation mesh (as demonstrated in a separate study), is sufficiently representative of the pressure concentration. It is important to note, however, that the *FCP* only considers the normal component of

the state of strain at the contact surface and, therefore, cannot provide exhaustive information regarding the effective state of tension.

Another limit consists in the fact that the *FCP* provides no description of stress distribution, which is important in evaluating whether a situation is dangerous or not. For operational purposes, it was decided to consider the pressure at the centroid of the contact elements. Mean pressure is therefore:

$$p_m = \frac{\sum_{e = lif\, p(e) > 0}^{N_e} p_e A_e}{\sum_{e = lif\, p(e) > 0}^{N_e} A_e} \qquad (6)$$

where N_e represents the number of elements considered while p_e and A_e represent, respectively, the pressure and the area of the e-th element. To calculate p_{perc} it is sufficient to generate a list in ascending order of pressure and, starting from the lowest values, determining the following:

$$perc\, F_R = \sum_{e = lif\, p(e) > 0}^{N_k < N_e} p_e A_e \qquad (7)$$

as N_k is the number of elements necessary to satisfy Equation 7. The pressure of the N_k-th element in the list is exactly p_{perc}.

Load Histories and Boundary Conditions

Load histories consist of six different steps: the pre-tightening torque is assigned to the screws during the first step, simulating the assembly stage. During the second step, a torsional moment equal to approximately 90% of the theoretical slip value is applied to the hub. In the subsequent steps, the torsional moment is maintained and the flexural moment is progressively increased to a value equal to 50% of the corresponding torsional moment applied. Throughout all load steps, circumferential displacement of the nodes of one of the transverse faces of the shaft is inhibited, as is transverse displacement of the node on the axis of the opposite face. This allows the shaft to deform freely without interfering with its internal state of strain.

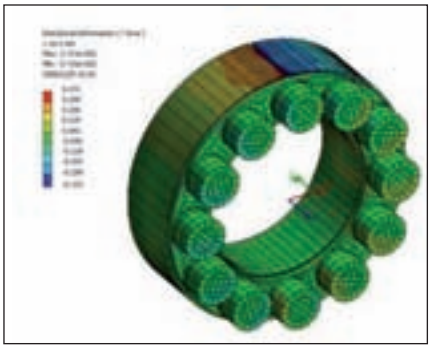


Figure 9—MAV 2005 50 x 80, circumferential displacement of the locking assembly at the end of the pre-tightening stage. The outer ring tends to open, particularly in proximity with the gap, whereas the inner ring in contact with the shaft displays the opposite behavior.

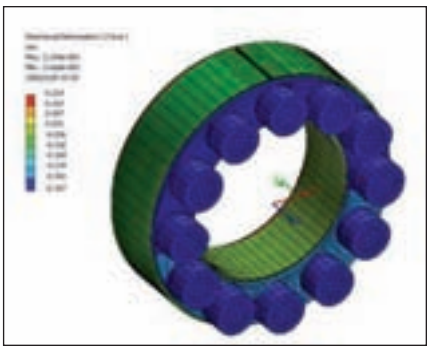


Figure 10—MAV 2005 50 x 80, longitudinal displacement of the locking assembly at the end of the pre-tightening stage. The two conical rings tend to approach one another in a practically symmetrical manner. Overall displacement of the locking mechanism is on the order of a few hundredths of a millimeter.

Results and Conclusions

Tables 4 and 5 give the principle results obtained with the study. In particular, the tables specify the mean pressure values on the shafts, as determined with Equation 6, and the pressure concentration factors, determined with the procedure described previously.

Note how the mean contact pressures for a given measurement vary little with each different load step. This is justified, on the one hand, by the fact that the contact surface remains unaltered (no phenomena of detachment between the locking assembly and shaft ever occur), and, on the other hand, by the fact that as maximum values increase (also by little), this is compensated by an analogous reduction in minimum values. Minimum pressure never assumes values below 30 MPa, ensuring satisfactory adherence between the locking assembly and the shaft, minimizing the risk of fretting.

Note also that an apparently high pressure concentration value, as may be seen with the MAV 1061, is not an indicator of poor locking assembly quality or synonymous with low mechanical performance. The *FCP* must always be evaluated alongside the mean pressure value and maximum transmissible loads, in relation with the effective requisites of the project. This article has briefly described the results obtained using a number of finite element analyses conducted on four different types of locking assembly. The main goal of the exercise was to determine, to a satisfactory degree of precision, the concentration factor for the contact pressure generated on a shaft by a locking device. The main reasons for the study are the fact that this value cannot be determined by laboratory tests and a scarcity of information available in literature. The results obtained are interesting as they demonstrate that, unexpectedly, peak contact pressure depends very little or not at all on the value of the flexural moment applied, even when the latter reaches values well above those encountered in practice. The reduction in *FCP* with increasing shaft dimensions, a behavior seen practically throughout the entire series, is also very interesting.

Sandro Zamboni *is president of MAV S.p.A.*

Massimiliano Margonari *is a FEM analysis expert with MAV S.p.A.*

Bearing Repair Provides Valuable Alternative To

BEARING REPLACEMENT FOR HEAVY INDUSTRIES

Jay Alexander

Introduction

When a bearing is damaged, it is often removed from service and replaced before it reaches its full, useful and economical life. Advancements in bearing design, materials, bearing maintenance and repair methods have greatly improved the potential for and popularity of bearing repair as an effective way to extend the life of the bearing.

A high-quality repair program also can address the challenge of determining if and when a bearing can be repaired. Regardless of original manufacturer, a wide range of services are available for all bearing types.

A repaired bearing, depending on the required level of service, can often be returned to like-new specifications in about one third of the time and at a savings of up to 60 percent off the cost of a new bearing. Furthermore, experience has shown that a successfully repaired bearing can run a life cycle comparable to that of the first cycle of the bearing. Growing popularity of repair programs in heavy industries shows an increased understanding of the significant value, both in time and cost, compared to replacing bearings.

Common Terminology

The following is a list of common industry terms used to describe bearing service options. These terms are used interchangeably across the industry, but do not necessarily represent the same scope of work to be performed.

- *Repair*: Describes a wide range of services that can be performed on a bearing. The term "repair" is generally referred to in this paper as any level of work performed to a bearing.
- *Recertification*: Certification of a bearing for service. This generally applies to an unused product with an outdated shelf life.
- *Reconditioning*: Polishing, honing or tumbling of bearing components to remove very minor surface defects (primarily rust or corrosion) that could lead to more extensive damage if not removed.
- *Remanufacture*: Process of removing aggressive surface damage by using a grinding or hard turning process. Also includes the replacement of any unserviceable components.

Bearing repair is not a new concept, but it

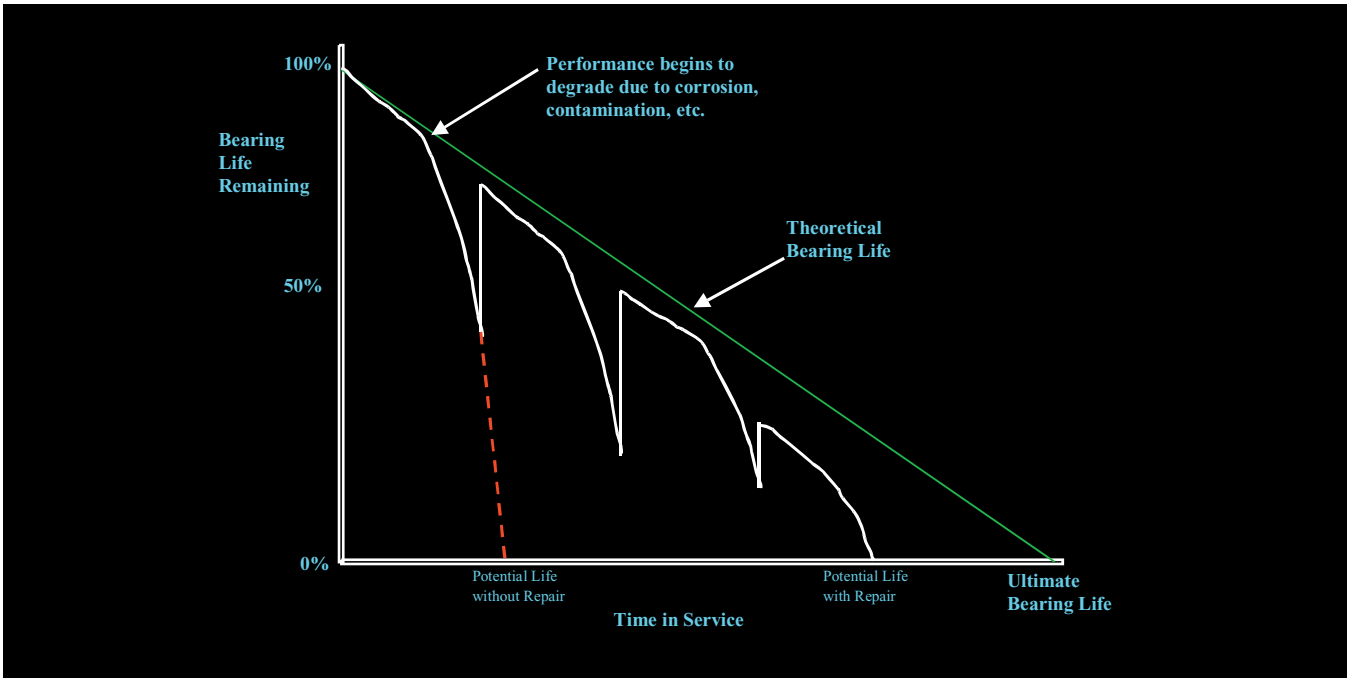


Figure 1—Time in service vs. bearing life remaining.

is increasing in popularity with heavy industrial customers, providing a tangible value. Advancements in bearing design, steel cleanliness, bearing maintenance and repair processes have greatly improved the potential benefits for bearing repair.

When a bearing is damaged, the entire operation will suffer, resulting in additional costs, lengthened maintenance work schedules, unnecessary downtime and extended on-time delivery to final customers. In most heavy industrial applications, bearings are removed from service before they have reached their full use and economic life. Bearing repair can be an effective way to extend the life of the bearing further along its theoretical bearing life, making it an economical alternative to purchasing new.

A Case for Repair

Initial bearing design takes into account the use and application of the bearing and establishes a corresponding prediction for service life and fatigue life. Regardless of the design or manufacturer, bearings often deviate from these expectations due to factors such as improper installation, contamination, inadequate lubrication or misalignment. In fact, less than 10 percent of bearings used in a heavy industrial application reach their design L10 life.

Advancements in technology, materials, condition monitoring and reliability-based maintenance programs, combined with economic pressures, contribute to an increased potential for successful bearing repair programs.

When compared to the manufacture of a new bearing, bearing repair is considered a more environmentally friendly procedure, requiring less energy input and reducing raw material consumption and waste. The majority of energy required to manufacture a new bearing—melting and refining steel, material forging and turning, heat-treatment and grinding—is conserved through bearing repair.

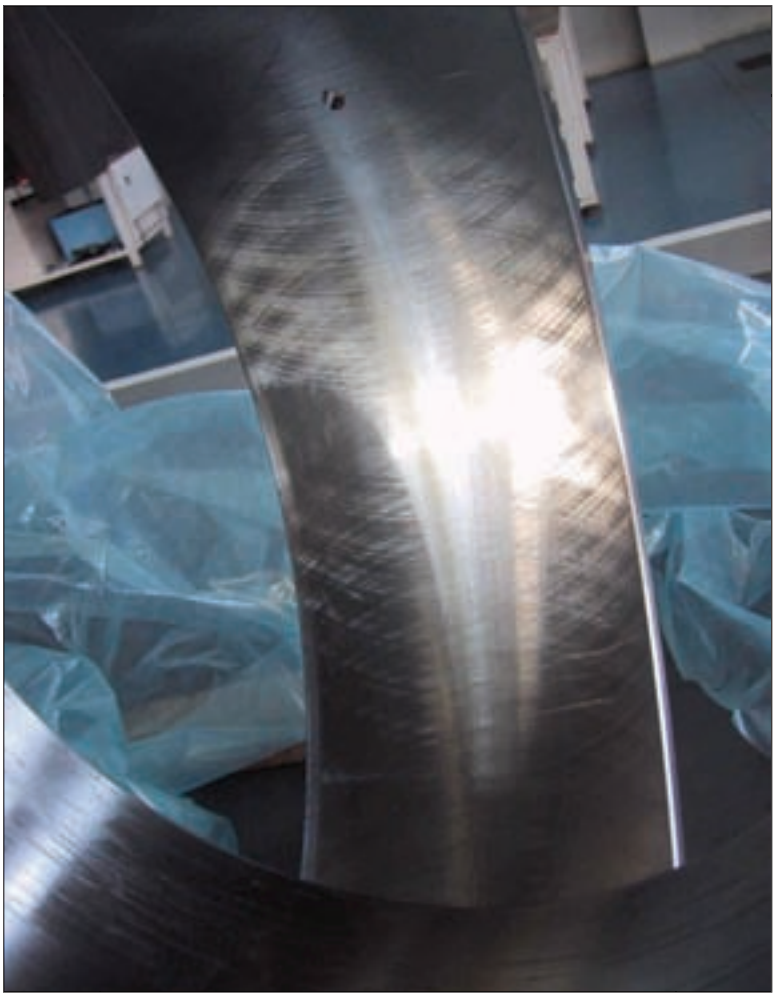
In addition to cost and time savings, bearing repair maximizes the opportunity to achieve the theoretical bearing life cycle. A common question is whether a repaired bearing will last as long as a new one. Studies performed by bearing manufacturers and independent researchers have shown that a properly repaired bearing will run a second service cycle comparable to that of the first. Repaired bearings often reuse materials that have already proved reliable in the application, therefore reducing the risk of bearing failure. It should also be stated that it is critical that replacement parts are made using materials and tolerances specified by the OEM. Any deviation from OEM specifications will increase the risk of premature failure.

Bearing Repair—What's Eligible?

Although it offers many benefits, repair is not always the best option for a damaged bearing. The challenge of properly utilizing bearing repair services is determining if and when bearings need to be repaired, and deciding which option is the best economical and long-term decision.

Depending on the repair facility, limitations

The outer race of a spherical roller bearing in need of bearing remanufacture.



The outer race of a large spherical roller bearing after remanufacture, which includes the process of removing aggressive surface damage by using a grinding or hard turning process.

exist on the minimum and maximum size of bearings and product types that can be repaired. There are many different types of repair suppliers, ranging from small facilities limited in their scope of work and knowledge to large bearing manufacturers with an unlimited range of products and services.

The scope of work also limits the size of bearing that can be repaired. Nevertheless, all bearing types are eligible for repair, regardless of the original manufacturer, including tapered roller bearings; spherical roller bearings; cylindrical roller bearings; ball bearings; thrust bearings (including slew rings up to 120"); and cross roller bearings.

A critical step in any bearing repair program is to recognize potential problems through regular monitoring and inspection. Careful review of the output will help to identify the need for repair, such as:

- The bearing is nearing or has exceeded its suggested life expectancy
- Operating temperatures have exceeded 200° Fahrenheit
- Exposure to excessive vibration
- Sudden changes in lubrication and temperatures
- Excessive operating audible sounds
- Loss of bearing seal integrity

Properly trained and experienced personnel involved in routine inspections serve as the first line in deciding if a bearing needs repair. Early detection of a problem through routine checks, preventive and predictive maintenance, and vibration analysis can reduce unnecessary downtime and expense, and help to capitalize on the capabilities and benefits of bearing repair.

The Remanufacturing Process

Once a product is returned to a repair service center, all bearings undergo a thorough cleaning process. Next, the bearing is disassembled. During disassembly, trained repair technicians will:

1. Record the bearing information.
2. Record actual internal clearances.
3. Complete the disassembly and tag with unique identifiers.

Next, a detailed inspection of all the bearing components is performed and its findings are recorded. The initial inspection includes looking for major problems or damage such as fractures, major spalling or heat-induced bluing. These are red flags that the bearing may not be eligible for repair. Components also are examined to determine the scope of work required.

In addition, technicians measure the bore,

O.D. and width of the bearing, as well as record the roundness of the major race components. The type and degree of damage determine whether it can be repaired, and how best to do so. The level of detail supplied in this inspection report depends on the facility performing the work.

A wide range of repair services/methods are available. Depending on the facility capabilities and level of damage, some repairs can be performed on-site using existing personnel or a bearing manufacturer's service personnel. In general, on-site programs are suited for recertification or reconditioning processes, not for the remanufacturing process. Below is a detailed description of the repair service levels:

• *Recertify*: Clean, examine, verify internal clearances; preserve and package.

• *Reclaim*: Polish using proprietary vibratory process; preserve and package.

• *Recondition*: Combines recertify and reclaim services.

• *Remanufacture*: Clean, examine, grind raceways, manufacture new roller sets and major components as required; reset internal clearances; preserve and package.

Additional services available include:

• *Modification*: Special features may be added to existing or new bearing assemblies to enhance performance, retrofit to special applications or upgrade to more recent product designs.

Once the proper repair choice is made and the process completed, the bearings are reassembled and packaged for storage and transportation. Generally, a final inspection is performed on the bearing to ensure that it meets the assembly criteria specified by the bearing design. Again, consider that different suppliers perform different levels of inspection and packaging. Bearing manufacturers that perform bearing repair often follow the same procedures as with a new bearing.

Degrees of Damage

Specific damage modes encountered during a repair service include:

• *Fretting*—Usually shows up in red or black oxides of iron occurring under close-fit conditions; also called friction oxidation.

• *Scuffing*—Smearing, scoring or galling as a result of removed and transferred metal from one bearing component to another due to sliding contact.

• *Staining*—Surface discoloration without pitting, such as from oil oxidation.

• *Wear*—Contact surface degraded and worn away by mechanical action in use.

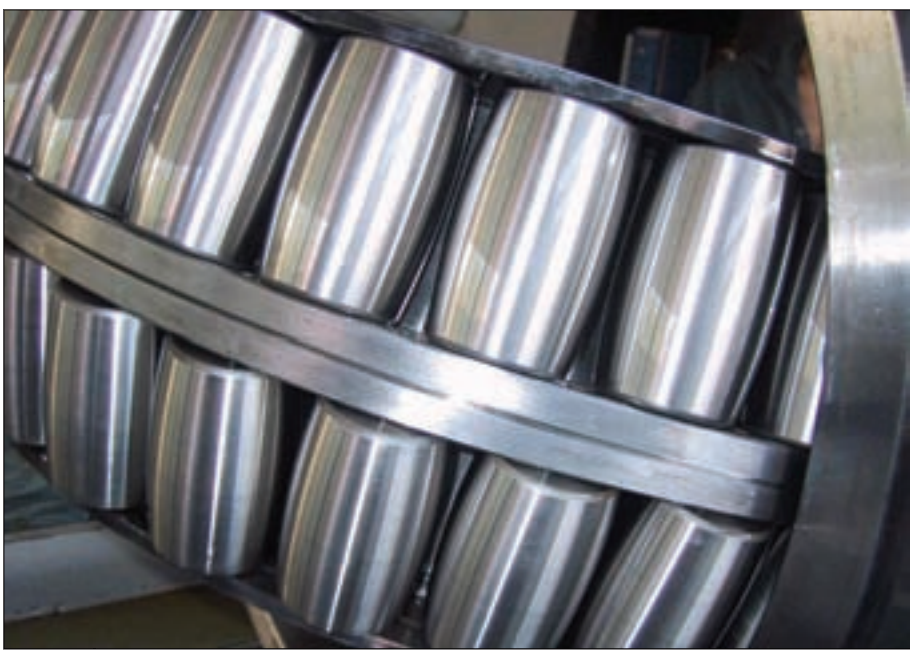
• *Corrosion/etching*—Chemical action (rust) that attacks bearing component surfaces.

• *Debris denting*—Localized surface depressions caused by debris or foreign material.

• *Brinelling*—Permanent deformation (displaced metal, not just wear) of bearing surfaces at roller/raceway contact areas caused by excessive load or impact.

• *Spalling*—Breaking away of metal on raceway or rolling element in flakes or scale-like

A large spherical roller bearing and outer race showing the condition of a bearing in need of bearing repair services.



Spherical roller bearings post bearing remanufacture.

particles; also called flaking, fine-grain or course-grain spalling.

• *Heat checks*—Surface cracks caused by heat from sliding contact, usually formed in direction of motion.

• *Crack/fracture*—Significant visible surface cracks, usually caused by abuse or unusual operating conditions.

There are many publications available on assessing or interpreting rolling element bearing damage. A common topic discussed is how to identify the following damage:

• *Chemical damage*—Etching, stains, corrosion pitting, rust or fretting corrosion.

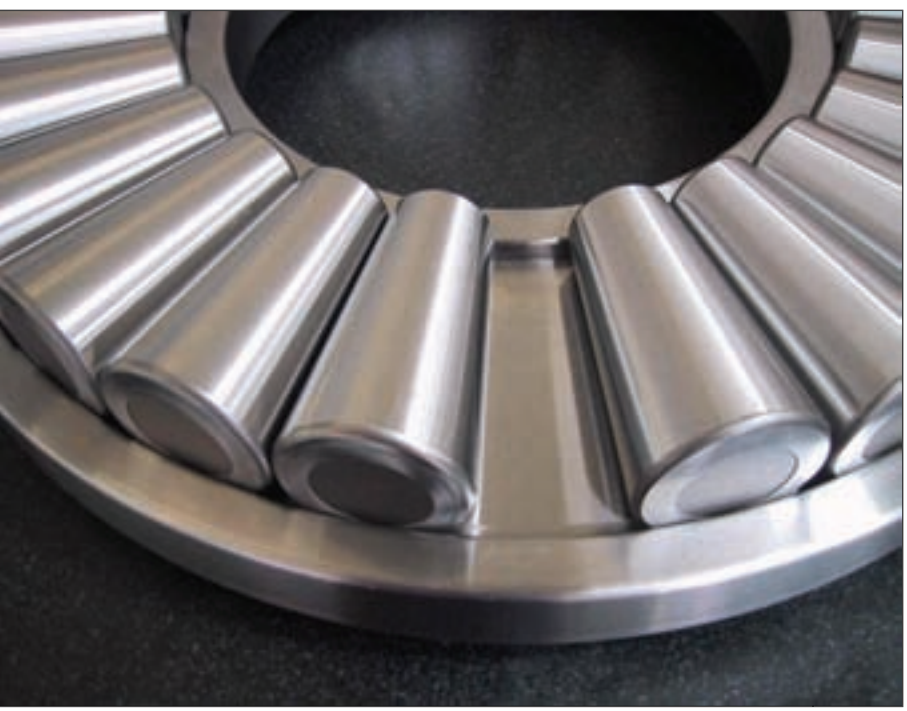
• *Heat damage*—Discoloration or checks.

• *Electrical damage*—Burns, fluting or pitting.

• *Mechanical damage*—Fatigue flaking; cracks and spalling; fracture; nicks; peeling or smearing; brinelling; indentation; scoring; abrasive wear; installation damage; misalignment or lubrication failure.

Most resource manuals describe the damage and may help to eliminate the causes, but they rarely venture into the relationship between damage and repairability. It is always recommended to contact a bearing service technician to assist in any damage assessment or repair feasibility.

Thrust roller bearings and outer race before the bearing repair process.



Thrust roller bearings and outer race after the bearing repair process.

Repair Options/Methods

Various industries and applications may demand different scopes of repair service, but generally, repair service tends to fall into three types:

Type I service generally describes the recertification or clean-and-inspection repair process.

Type II generally applies to the reconditioning or polishing repair process.

Type III service is for bearings with more extensive damage, typically requiring remanufacturing.

Note that Type III involves extensive processes, such as regrinding of races, replacement of rollers or cage components and may even include replacement of a bearing race. Often, the regrinding of raceways will require the manufacture of oversize rollers in order to maintain bearing geometry and clearance in bearings where radial internal clearance is critically held. In cases where lateral clearance is held, oversize rollers, new spacers or additional shims would be provided.

These levels of repair have traditionally been suited for bearings with a bore size of eight inches O.D. and greater, but bearings as small as three inches in O.D are fair game. Smaller bearings that were often thrown away can now be handled, if received in large quantities, and returned to service. Cleaning, inspection and the application of a polishing finish can return these used bearings to like-new condition for a fraction of the cost of replacement. It is always good practice to have a bearing service technician review product before it is returned to a repair center to make sure it is economically feasible to repair.

Turnaround time on reconditioning and re-

pairs can be as short as two to four weeks, depending on the need and scope of work required. Companies utilizing bearing repair should always request a complete, itemized quote that includes cost and estimated repair time when requesting any type of repair service.

Repair Limitations and Expectations

Although bearing repair has proven to be a cost-effective solution, it is, like any service, subject to limitations.

Bearings can be repaired, often more than once, but not indefinitely. A general rule of thumb is that bearings should not have more than three regrinds. Regrinding removes surface material, so it needs to be done carefully. The Timken Company's standards suggest that the maximum stock removal on any race should be .025"of the diameter, and the roller size should not exceed .015" in diameter from the original equipment manufacturer standard size. These recommendations help reduce the risk associated with altering the design integrity of the bearing. Please note that Timken's guidelines are not industry-standard rules. In fact, some repair centers have no stated limitations on design alterations.

If done correctly, repaired bearings offer like-new performance. However, it is important to recognize and understand how repair options address damage modes. For example, polishing can address a variety of damage modes but is not effective for the removal of debris indentations or wear. In such cases, do not expect like-new performance if the bearing is only polished since that does not repair all damage.

It is recommended to consult with a bearing manufacturer representative and/or application engineer to help determine the cause, extent and suggested repair of the damage. It also is critical to have any bearing repair performed by properly trained and experienced personnel; unnecessary repairs can lead to additional damage and limited bearing life. Common repair mistakes include:

- Improper polishing techniques that cause changes to geometry and/or profiles that do not correct worn geometry and contact conditions
- Improper grinding techniques and processes that can cause surface cracks and damage or improper geometry and/or profiles
- Mixing of preset components
- Improper profile, internal geometry, finishes and clearance settings that can cause bearing failure

In addition to expertise, proper equipment is required to fix the problem and ensure damage has been reviewed and properly removed. The appropriate measuring equipment, such as laser tracing and profiling equipment, CMM and precise measuring machines are essential to perform thorough inspections on repaired product.

Conclusion

The growing popularity of bearing repair demonstrates the increased understanding of the benefits and value it offers. A high-quality bearing repair program and supplier is one that provides: wide-range of service options; outstanding service; detailed explanation of the work scope to be performed; significant experience with bearings; replacement of any component back to OEM standard; product that matches the performance of a new bearing; good warranty and the service to back it; sound quality assurance documentation; and an ability to service any product type and make.

A quality bearing repair program can provide significant savings compared to discarding and purchasing new bearings. And, of perhaps equal importance, lead time for repair is substantially less than that of a new bearing.

For more additional information:

The Timken Company
1835 Dueber Avenue SW
Canton, OH 44706-0932
Phone: (330) 438-3000
Fax: (330) 458-6006
www.timken.com/industrialservices

Jay Alexander *is manager of Industrial Bearing Services, at The Timken Company's Tyger River facility in Union S.C. He has 12 years of experience in bearing repair services, as well as four years experience in design engineering and manufacturing engineering. Alexander holds a degree from Clemson University in mechanical engineering.*

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September 8–11—SAMPE Fall Technical Conference and Exhibition. Memphis Marriott Downtown, Cook Convention Center, Memphis. Representing many facets of the material and process engineering industries, approximately 800 engineers, R&D engineers and educators attend the Society for the Advancement of Material and Process Engineering's (SAMPE) annual technical conference. Related topics include chemical engineering, design, operation and maintenance of chemical and material manufacturing processes. Technical sessions and panels discuss advanced materials and applications while the two-day exhibition consists of distributors and manufacturers of advanced materials showcasing new products and services. This year's SAMPE conference is co-located with the American Society for Composites and ASTM International, a voluntary standards developing organization. Significant contributions were made by the U.S. Air Force Office of Scientific Research. Some of the panels and featured talks include industrial applications of multifunctional materials, ionic polymer-metal composite—soft actuator and sensor—and polymer nanocomposites research in Canada.

September 8–13—IMTS 2008. McCormick Place, Chicago. The International Manufacturing Technology Show takes place once every two years, and it is the largest exhibit of manufacturing technology in North America with 15,000 machine tools, controls, computers, software, components, systems and processes. This year's show is focusing on connecting global technology. Displays from 1,500 companies cover 1.2 million net square feet of space, and 90,000 buyers and sellers are attracted from 119 countries. For more information, visit *www.imts.com*.

October 1–2—Making Lean Work for the Job Shop and Small Manufacturer. Doubletree Hotel Chicago-Oakbrook, Oakbrook, IL. This event sponsored by the Society of Manufacturing Engineers reveals how companies can begin to run a lean enterprise using tours, videos and testimonials. Attendees have the opportunity to network and share experiences they have been challenged by, as well as effective practices. Industry professionals will be in attendance to discuss available options and impart success stories. The event aims to provide information that people can put straight to use for improving processes and products. For more information, visit *www.sme.org/leanjobshop*.

October 15–17—SMMA 2008 Fall Technical Conference. Sheraton Westport Plaza Hotel, St. Louis, MO. The Motor and Motion Association (SMMA) is focusing on energy efficiency and inflation as a motor design challenge at the Fall Technical Conference. The manufacturing trade association is made up of companies and individuals in the electric motor and motion control industries. The event schedule includes presentations, breakout sessions and networking opportunities. With a separate registration there are pre-conference options—SMMA Motor and Motion College courses and Electric Motor Education and Research Foundation (EMERF) Workshop. The SMMA college courses will concentrate on how to improve electric motor efficiency, fundamentals of brushless motor control and advanced motor design. The EMERF Workshop will discuss the combination of the EMERF lamination steels database with motor simulation programs. Current and prospective members are invited to attend, and discounted registration is offered for several attendees from the same company. For more information, visit *www.smma.org*.

October 29–30—Aero Engine Expo. Espace Grand Arche, Paris. The 2008 Aero Engine Expo features the International Aero Engine Conference in its 17th annual installment. The expo is a leading event for the international aero engine industry with over 100 companies exhibiting and holding networking lunches and receptions. "Meet the Buyers" sessions provide roundtable networking opportunities and one-on-one meetings. This year's expo brings in a "Meet the Experts" session for visitors, exhibitors and delegates to participate in free seminars conducted by leading experts. For more information, visit *www.aeroengineexpo.com* and/or email *colinh@aviation-industry.com*.

October 21–23—PrecisionFab Metal and Plastics Expo. Expo Guadalajara, Guadalajara, Mexico. The 21st annual PrecisionFab Expo is an exhibition of tools, equipment, materials, supplies and services used by manufacturing industries in Mexico, which produced over $220 billion of manufactured goods in 2007. The three-day show attracts 6,000 manufacturing professionals, engineers and directors from hundreds of companies. This year's event is the first to feature plastics to provide a more comprehensive mélange of materials fabrication products and technologies. It is also co-located with three other events comprising International Design and Manufacturing Technology Week, which has taken place in Guadalajara for 14 years. Attending buyers manufacture auto parts, home appliances, electronics, telecom equipment, medical devices and metal and plastic enclosures. Conference sessions are free and will discuss productivity strategies, methods for minimizing lead times, manufacturing design and quality assurance. For more information, visit *www.expoprecisionfab.com*.

Bishop-Wisecarver

INCREASES IN-HOUSE PRODUCTION, EXPANDS IN CHINA

By adding a Mägerle MGC-L-550.35.45 grinder to the Bishop-Wisecarver machine shop, the company expanded in-house production capability. The machine is one of the longest in North America, measuring 5.5 meters in the x-axis and weighing 50 tons. It can process lengths up to 4.5 meters, so it is currently used for Bishop-Wisecarver's UtiliTrak product line, which produces steel and aluminum channels in 3.6 meter lengths.

The Mägerle grinder features an articulating head, so the machine can grind both inside running surfaces in one setup. The grinding wheel is reshaped periodically or continuously by a hidden dresser in the head, which avoids interruptions in the process that can occur with a fixed table-mounted dresser. The machine demonstrates high accuracy. "I'm very pleased with the quality of parts produced with this process," says Kelly Walden, Bishop-Wisecarver plant superintendent. "Consistency from batch to batch has also greatly improved, with variation within a couple of ten-thousandths of an inch."

Bishop-Wisecarver has expanded service and support in China with an office catering to the growing customer base in the country. The Shanghai office is led by Jennifer Ye, who has worked in import, export and domestic sales of industrial products. Business relationships with China-based distributors and the regional branch bring local service and inventory to the region while lowering the timing and costs of shipping. The office is located at Room 1107, No. 728, Xin Hua Road, Shanghai 200052, China, phone: (86) 21-52580936, e-mail *Jennifery@bwc.com*.

"The China market is key to our global strategy," says Ray Harrington, vice president of business development for Bishop-Wisecarver. "We see abundant opportunity to advance Bishop-Wisecarver's presence in Asia, and the opening of the Shanghai office reinforces our commitment to current and potential partners and customers in the region. Local sales support and technical expertise significantly improve the customer experience with better service, improved communication and reduced sales cycles."

PT/MC Market Outlook Data

REPORTS MIXED RESULTS

The Power Transmission Distributors Association (PTDA) released the April 2008 month-end trend data for distributors and manufacturers of power transmission/motion control (PT/MC) products, which reflected varying results for U.S. and Canadian distributors.

In the United States, sales of PT/MC products were up 6.4 percent for April in comparison to the previous month. Distributors' sales increased 11.5 percent from April 2007 while accounts receivable collection days dropped 4.3 percent since March 2008, and U.S. distributors' confidence index was at 5.8, on a 10-point scale, for the fifth consecutive month.

PT/MC sales in Canada improved by 8.6 percent from March 2008 over its 6.6 percent the previous year. Compared to March 2008, accounts receivable collection days fell 6.9 percent. Canadian distributors' confidence level was at 5.7 for the third month in a row.

U.S. manufacturers' sales fell 2.7 percent from March, while Canadian sales experienced a 0.4 percent decline from the previous month. Compared to 2007, sales in April 2008 were up 2.1 percent but were down 2 percent in Canada. The April 2008 orders were down 3.6 percent from the month before while confidence levels fell by 0.4 and 0.2 in the United States and Canada, respectively.

The overall decline in sales is reflected by product-by-product sales from March to April 2008 by manufacturers in both countries. U.S. manufacturers' sales improved in three

categories: gear products; clutches and brakes; and standard industrial motors. Sales declined in variable speed drives, positioning systems/linear motion products, unmounted bearings, shaft couplings, mounted bearings, mechanical drive systems and other power transmission products. Canadian manufacturers experienced negligible losses in April due to positive sales gains in more than half of products manufactured.

Hansen

OPENS ENVIRONMENTAL-CERTIFIED PLANT

Ivan Brems, CEO Hansen Transmission International, and Stefan Lammens, managing director of Hansen Transmission's Lommel wind energy business unit, receive the environmental certificate from Daniël Frickel, marketing and training manager for Lloyd's Register Quality Assurance Belgium.

After investing around 180 million euros, the expanded Hansen Transmissions Lommel, Belgium factory was officially opened by Flemish Minister-President Kris Peeters. He also helped assemble Hansen's 20,000th wind turbine gearbox and released the ISO 14001 certificate for the plant's environment management policy, which includes strategies for energy, product storage, air emission and waste.

The Lommel facility was expanded from 45,000 to 110,000 square meters and from 193 to over 800 employees, and it has a 6,000-megawatt capacity for manufacturing multi-megawatt wind turbine gearboxes. "Thanks to the

continued

Above: Flemish Minister-President Kris Peeters officially opens the Hansen Transmissions expanded factory in Lommel. Below: Peeters helps assemble Hansen's 20,000th wind turbine gearbox along with CEO Ivan Brems.

unique location of the fully integrated production plant in Lommel and a team of more than 800 highly qualified and experienced employees, we are capable of meeting the various needs and quality demands of this fast-growing industry," says Ivan Brems, CEO of Hansen Transmissions. "Today, we supply four of the five largest turbine constructors and together, our clients represent over 60 percent of the market for gearbox-driven wind turbines."

Hansen devotes most of its gearbox production to wind turbine gearboxes. The celebrated 20,000th gearbox will be supplied to Hansen's largest wind energy client, Vestas Nacelles A/S.

The environmental certification audit was conducted by the international certification organization Lloyd's Register Quality Assurance. The final audit report noted a well organized environment management system in terms of care and performance in addition to devoted staff and management, according to Hansen's press release. "Hansen wants to play an exemplary role in environmental policy," says Stefan Lammens, managing director of Hansen's wind energy business unit. "Through an environment management system, structural attention is paid to the environment in all our operations. After a thorough environmental aspect analysis we have defined concrete objectives in an action plan. We aim to minimize the impact on the environment and to permanently improve our environmental performance. Being granted the ISO 14001 certificate is the pinnacle of all the efforts made by Hansen up to now."

Hansen's yearlong action plan goals include reducing overall energy consumption, keeping inventory of raw materials, monitoring and minimizing chemical agent use, generating more separate waste streams and providing a complete waste management system.

PCB Piezotronics

FORMS AEROSPACE AND DEFENSE DIVISION

An Aerospace and Defense division of PCB Piezotronics will develop products and programs specifically for aerospace, civil and military aviation, defense, homeland security, nuclear and test and measurement industries, according to the company's press release. Ronald J. Livecchi was appointed senior director of the division.

The Aerospace and Defense division's product offerings include sensors and instrumentation for health and usage monitoring systems, helicopters, fixed-wing aircraft, combustion monitoring pressure sensors, high-temperature engine vibration monitoring sensors and aircraft hydraulic pressure sensors. Some typical testing applications addressed are vibration and fatigue, qualification, aircraft and engine ground, blast pressure and hydraulic system pressure measurements, structural dynamics and engine vibration monitoring.

Livecchi, as senior director, is in charge of worldwide strategic target market development, technical sales, marketing, applications engineering, program management and customer

service relative to the aerospace and defense sector. In the aerospace industry for 30 years, most recently Livecchi served as vice president and general manager for Mokon. He has held leadership positions at Jabil Circuit, Parker Hannifin Aerospace, Moog and Lord Corporation. Livecchi received a Master of Science degree in mechanical engineering from the University of Michigan and a bachelor's degree in mechanical engineering from Cornell University.


Ronald J. Livecchi

PCB Piezotronics also introduced an automotive sensors division, which posted a 20 percent first-quarter sales growth. The division operates from a facility in Novi, Michigan specializing in the global automotive test market—including vehicle NVH and dynamics, vehicle and component performance and durability, legislative, safety and powertrain testing applications.

Regal Beloit

ACQUIRES CHINESE MOTOR COMPANIES

Joyce Court Holding Ltd. and Grand Delight Investments Ltd., shareholders of Wuxi Hwada Motor Company and Wuxi New Hwada Motor Company, have been acquired by Regal Beloit Corporation.

Collectively known as Hwada, the company designs and manufactures integral IEC and NEMA electric motors used in industrial applications such as compressor, pump, paper and steel processing and power plants. Half of Hwada's product sales are to China's industrial markets. The company will be reported as part of the Regal Beloit's electrical sector, according to the company's press release. Hwada, purchased for $27 million, is estimated to bring $75 to $80 million in sales to Regal Beloit.

"This is another significant, strategic-focused expansion of our industrial business in high-growth markets," says Henry W. Knueppel, chairman and CEO of Regal Beloit. "The acquisition represents our first wholly owned industrial motor facility in China. Hwada is currently one of the top industrial motor companies in China. It enjoys a reputation of product excellence and rapid growth and comes with an excellent management team."

Alpha Gear Drives Inc.

CHANGES NAME

Wittenstein is the official name for alpha gear drives Inc. as of July. The German-bred company launched in North America in 1992 and created the subsidiaries Wittenstein aerospace and simulation and Wittenstein Arena Corporations. These companies moved to a centralized facility in Bartlett, IL in 2005, consolidating all sales, development and production departments in the same location with the purpose of synergizing research and communication efforts, according the company's press release. Wittenstein founder Manfred Wittenstein was recently elected president of the German Engineering Federation (VDMA), after serving as vice president since 2004.

RBC Bearings

ACQUIRES MOTION CONTROL MANUFACTURER

The assets of Precision Industrial Components LLC (PIC Design) have been acquired by RBC Bearings Incorporated for $6.6 million and assumption of certain liabilities. RBC Bearings, headquartered in Oxford, Connecticut, manufactures precision plain, roller and ball bearings for industrial, defense and aerospace industries. PIC Design, in Middlebury, Connecticut, manufactures and supplies tight-tolerance, precision mechanical components used in the motion control industry. The estimated sales for PIC Design from 2007 is $10 million, and the company has more than 20,000 customers.

"The addition of PIC brings us a very unique franchise offering a wide array of products to the general industrial marketplace," says Dr. Michael J. Hartnett, the chairman and CEO of RBC Bearings. "As the pioneer and leader in the field of precision industrial component manufacturing and design, PIC provides us with additional technology, expertise and complementary products that will help strengthen the value we deliver to our customers. This acquisition is in line with our stated strategy and goal of continually expanding our base, adding value to our clients and increasing our value to the marketplace."

Sporian

DEVELOPING HARSH ENVIRONMENT SENSORS FOR U.S. NAVY

An operational sensor suite for monitoring a jet engine's combustion chamber environment is being developed by Sporian per a contract with the U.S. Navy. The sensors must survive temperatures up to 1,500°C, pressure exceeding 750 psi, exposure to corrosive and oxidizing gases and other extremely harsh conditions.

"Our goal is to develop an operational sensor that improves the Navy's ability to perform condition-based maintenance and prognostic health management," says Dr. Kevin Harsh, principal investigator for Sporian. "Simply put, this could mean improved visibility of needed maintenance activity while reducing unnecessary maintenance efforts. The bottom line is to provide lower cost and increased operational availability."

The results of Sporian's development efforts will be monitored by the Naval Air Systems Command at Patuxent River, and the Rolls-Royce Corporation in Indianapolis will consult with Sporian. Tom Bronsett, instrumentation development engineer for Rolls-Royce, says, "In the later stages of the development effort, Rolls-Royce will subject the Sporian sensors to a rigorous testing regime, exposing the sensors to turbine engine hot section pressures and temperatures."

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Meet Harry–The Kinematic Kegler

Seven-Foot-Tall Bowler Throws Strikes for Scientific Research

They call him Harry. He's tall, steady and swings a bowling ball so accurately he can actually embarrass the competition. Employed by the United States Bowling Congress (USBC) in suburban Milwaukee, Harry is the consummate bowling professional.

"He's our best employee," says Paul Ridenour, research engineer at the USBC. "He's always on time and he never complains about anything."

To top it off, Harry isn't even human. He's a computer-controlled hybrid machine that combines hydraulics, air pressure and electronics to power his precision mechanical arm, all in the name of scientific research.

"Harry was conceived primarily because a human bowler can only be so accurate on the lanes," Ridenour says. "We needed a more precise way to gather data on the motion characteristics of bowling balls."

Named in honor of Harry Lawrence, a former testing facility employee, the machine was designed and constructed in the mid 1990s, and officially began working for the USBC in 1999. Using hands operated by air hydraulics, Harry can pick up and release the bowling balls and duplicate shots at ball speeds from 14–22 mph.

"Harry tosses the ball down the lane and the data is analyzed by the Computer Aided Tracking System (CATS)," Ridenour says. "We have 23 sensors on the lane that track the balls location and speed and then the data is reviewed on a lane grid."

Harry's hands open and close with a piston and cylinder assembly. He gets some much needed assistance from springs and gravity to propel the balls down the bowling lane.

"He's quite a unique piece of equipment and we have a patent on the device because of this," Ridenour says. "He's been an intricate part of our ball motion study program and a key component to our research at the USBC."

Bowling insiders have recently raised concerns that ball cover stocks and cores, combined with improved lane surfaces and oil patterns, are having too great an impact on scoring compared to player skill. The research "conducted" by Harry has resulted in a new manufacturing specification that will put limits on the porosity and chemistry of new bowling ball surfaces in 2009, according to a USBC press release.

While boasting incredible accuracy and scoring potential, Harry is not immune to defeat at the hands of a human opponent. During the 2005 Masters pre-week, professional bowler Danny Wiseman defeated Harry in a friendly match.

"He's lost a couple of matches here and there," Ridenour says. "One of the things about bowling is that there is a certain oil pattern on the lane, once you throw the ball you can see how the game will play. Harry is sometimes too accurate for his own good."

Win or lose, the robot certainly knows how to have some fun. At the 2007 Masters, Harry participated in a vivid reenactment of a famous 1995 professional match where Randy Pedersen lost on what many consider the worst break in the history of the PBA.

"If you've never seen the Randy Pedersen meltdown, it's worth checking out online," Ridenour says. "Harry did a pretty good job of capturing the moment."

While there's plenty of other research projects on tap at the USBC, Harry will only be asked to continue doing what he does best.

"He's a ball thrower, plain and simple," Ridenour says. "He knows the job he has to do and he does it better than anybody else."

To see Harry, the robotic bowler, in action, visit *www.bowl.com*.

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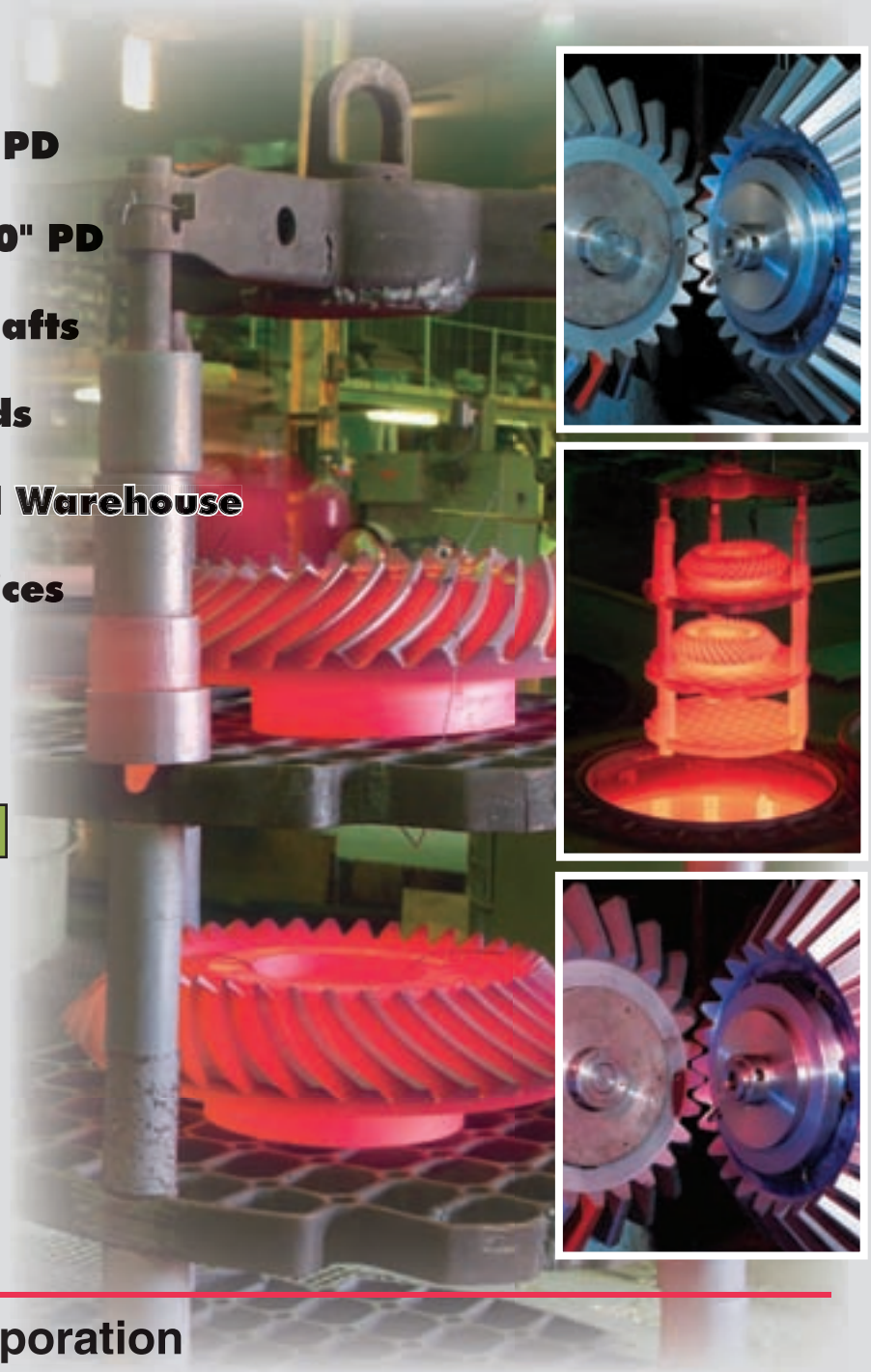

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