THE MAGAZINE FOR INDUSTRIAL VEHICLE TECHNOLOGY, DESIGN & ENGINEERING

June 2014

iVT INTERNATIONAL
INDUSTRIAL VEHICLE TECHNOLOGY

AEF takes on:
Camera systems and high voltages

What's new in:
CANbus & sensors

Design Challenge:
Hydraulic hybrids

Interview:
Dave Beddow,
VP Manufacturing Operations, Crown Equipment

Let's talk dirty

Who says your hydraulic oil really is clean?

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iVT Industrial Vehicle Technology International
JUNE 2014 VOL 22 No. 2
www.iVTinternational.com
Published by UKIP Media & Events Ltd

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iVT International USPS 018-627 is published quarterly, in February, July, September and November, by UKIP Media & Events Ltd, Abinger House, Church Street, Dorking, Surrey, RH4 1DF, UK.
Annual subscription price is US$102/£57. Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping USA Inc, 155-11 146th Street, Jamaica, NY 11434. Periodicals postage paid at Jamaica, NY 11431.
US Postmaster: send address changes to *iVT International* c/o Air Business Ltd, c/o Worldnet Shipping USA Inc, 155-11 146th Street, Jamaica, NY, 11434.
Subscription records are held at UKIP Media & Events Ltd, Abinger House, Church St, Dorking, Surrey, RH4 1DF, UK.
Air Business is acting as our mailing agent.
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Average net circulation per issue for the period 1 January-31 December 2013 was 10,338.

Published by
UKIP Media & Events Ltd,
Abinger House, Church Street,
Dorking, Surrey RH4 1DF, UK
Tel: +44 1306 743744
Fax: +44 1306 742525
Ed. fax: +44 1306 887546

Printed by William Gibbons, Willenhall, West Midlands, WV13 3XT, UK

Member of the Audit Bureau of Circulations

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FOREWORD

Since sinking a pond in my back garden this February, I've developed an almost childlike fascination for observing the host of insects, bugs and creepy-crawlies it has already attracted. That's probably why I found myself engrossed in a program on the topic of insect dissection (no, really) broadcast on the inestimable BBC4 a few weeks ago – though while I began watching in full anticipation of emerging slightly more knowledgeable about our tiny friends, enemies and tormentors an hour later, little did I expect I was also about to gain a greater understanding of CANbus.

Yes, I must confess my secret shame: in all the years we've been covering this subject, the majority of it has gone completely over my head. I can tackle the topics of engines, transmissions, fluid power and ergonomics with the best of them, but when it comes to CAN, it all just merges into a jumble of bit rates, bytes and megabits per seconds. It's more a case of CAN't for me, I fear…

But as I watch some beetle-loving boffin slice open a cockroach to explain how its central nervous system works, my ears prick up at his use of the phrases 'information highway' and 'gathers input from the sensors' (actually, though, in retrospect, he probably said 'senses'). Then he lifts up a pair of nerve cords running all the way down its body and I dimly recall that CANbus uses a 'simple' two-wire system. Next he highlights a ganglion, one of several bundles of nerve cells (or 'nodes', I smile, nodding sagely) dotted around the insect's interior and points out that, being close to the organs they control, those specific signals can travel a shorter distance than if they had to go all the way up to the brain (CAN controller) and back. "You have to think of the insect as having its brain all the way down its body rather than in just one section," says the egghead entomologist, poking at a spongy mess in its head.

Now, I'm scarcely more of a biologist than I am an electronics whizzkid, but this all suddenly seemed to make the whole topic crystal clear. I could instantly see how the insect versions of


By Jove, I think he's got it! A bee in my garden sarcastically applauds my belated understanding of the basics of CANbus

pressure, tilt or speed sensors transmit their status to the nearby nodes to ensure optimum performance at all times (though as anyone who has ever tried to usher a bumblebee out of the bedroom window will testify, they're not always foolproof) and see a parallel with machines thousands of times heavier.

So, armed with this newfound clarity, I arrived at the office a day or two later, eager to compile our feature on CAN and sensors – only to find that CANbus has recently been 'enhanced' with the FD protocol. Short of understanding that this flexible data rate essentially makes it much better, I think I'm back to square one. But this topic is explained in far greater detail than I could ever hope to understand on page 20, followed with a look at the use of 'ordinary' CAN systems and technologies on crane applications. Then we've another couple of pages in our Bulletin Board section looking at some of the latest sensors and other electronics.

So with all that CAN content, perhaps we should all be grateful that our cover story is reserved for the topic of optimizing hydraulic performance through avoiding contamination – otherwise a rather unpleasant image of the inside of a cockroach could have been the first thing that greeted you this morning…

Richard Carr, editor, iVT International

Coming up in the September issue of iVT

• Ergonomics and styling • Intuitive information delivery • Composites • EIMA preview
• Case studies: Yanmar concept tractor & Lamborghini Nitro • Global market report

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Square deal

AFTER THREE YEARS, STILL'S SIX-IN-ONE cubeXX CONCEPT BEGINS TO TAKE MORE FUNCTIONAL SHAPE

MAIN IMAGE:
cubeXX in low-lift pallet truck configuration

BELOW:
The autolift function raises goods to a comfortable height while in order picker mode

HAMBURG, GERMANY – Following its first presentation as a concept study at CeMat 2011, Still's cubeXX has now been shown as a functional prototype at this year's edition of the show.

This multifunctional vehicle, comprising six vehicles in one compact shell (tugger train, low-lift pallet truck, counterbalance truck, high-lift pallet truck, double-decker pallet truck and order picker) has been further developed as part of the OEM's involvement in the Fraunhofer Institute for Material Flow and Logistics' (IML) Hub2Move research project.

The premise of the project is that the future distribution hub (a movable handling center) must rely on handling, conveyor and storage technology that can easily adjust to changing requirements within a few days, or run at a new site within a few weeks.

Calling on the decentralization of conveyor technology, IT support or transport order management and traffic control, a crucial part of this will involve reliance on cellular transport systems and autonomous vehicles to implement the main task of conveying in different versions with compatible functionality and reduced complexity.

Future-proof forklift

Shown operating semi-automatically at CeMat, the prototype – which can also be manually operated or employed as a mobile autonomous robot – therefore highlights the role that the latest technologies – especially sensors – will play in achieving this vision.

Just as with Still's new iGoEasy system (see *iVT Advanced Lift-truck Technology* 2014, p4), the cubeXX can now be controlled by an iPad, enabling functions such as unfolding the forks, extending the load supports, lifting mast or the driver's cabin, switching to the tugger train function, or docking the additional counterbalance, to be operated remotely. Only the tool currently needed is unfolded at any one time.

Energy is supplied by an easily accessible and rapid-charging lithium-ion battery, which, with interim charging, should provide enough energy for all-day use. The drive unit comes from Still's CX order picker.

The T-frame design used in Still's new LTX tractor – and for all of its future vehicle generations – has also been adopted here. Perhaps the major novelty, however, is the carbon fiber telescoping mast which, due to its low weight, requires less mass in the counterbalance while still offering greater resistance to permanent strain due to its ability to withstand deformation.

The front load supports incorporate a ball rather than a wheel to enhance lateral movement, even when handling over pallets. Outstanding maneuverability around the front axle is therefore guaranteed, with the ability to make 90°, 180° and 360° turns.

Making light of it

Designed in accordance with the latest ergonomic and safety insights, the LED lighting concept incorporates four daylight running lights on the load side, searching headlights, lateral lamps, headlights, rear lights and daylight running lights on the drive side. The lamps light up red when reversing, pale red when braking, and white during any forward movement. When in fully automatic mode, a firmly installed light source in the truck's roof acts as a safety indicator system, emitting a pulsating blue light around a rotating laser.

The communication screen on the load side indicates current functions, such as driving direction, lifting conditions, running mode, current vehicle configuration, battery charge and location in the warehouse. This view is also reflected on the remote operator's iPad, ensuring intuitive operation from afar.

A camera mounted on, and moving with, the fork carrier sends all data concerning automatic pallet lifting via WLAN to other autonomous vehicles, employee iPads, or warehouse management systems.

With interfaces for control, drive and lifting frame, the cubeXX is controlled via CANbus, which also controls synchronization of speed and the convertibility of the truck's configurations, and monitors the movement of lifting height and cabin positions. The electrically connected person protection attachment at the front and rear, and the manual emergency off-switch at the rear, further aid safe automatic operation.

LEFT: **The load supports ensure a safe stance for work as a high-lift pallet truck**

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cubeXX concept vehicle and iGo solutions:
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HYBRID FIGURE

OSAKA, JAPAN – 2,500 unit sales after its initial launch in 2008, the third generation of Komatsu's hybrid excavator was introduced at ConExpo.

Boasting an increased operating weight of 49,383 lb and 1,57yd³ bucket capacity, the HB215LC-2 also features enhanced hybrid components that have further improved its fuel efficiency (an average of 20% over the standard model) in association with the new Tier 4i Komatsu SAA4D107E-2-A 139bhp engine. An Auto Idle Shutdown function has also been integrated.

Kinetic energy generated during swing braking is then converted to electricity, passed through an inverter and temporarily stored in an ultracapacitor, which then instantaneously delivers the equivalent of 60 additional horsepower to accelerate the superstructure and/or assist the engine, as dictated by the hybrid controller.

Instead of a DPF, the hybrid machine relies on a DOC for PM reduction, utilizing 100% 'true passive regeneration'. This long-life design requires no scheduled replacement interval, reducing ownership costs further. The engine also relies on a variable-flow turbo to provide optimum airflow under all speeds and load conditions.

A new cab also formed part of the upgrade, with a reinforced box-structure framework helping achieve ROPS certification. Mounted on viscous isolation dampers, and including a higher-capacity air suspension seat, it ensures vibrations felt by the operator are reduced too.

A high-res 7in LCD monitor enables the selection of up to six work modes to match machine performance to the operation, and provides data on eco-guidance, operational records, fuel consumption history and utilization.

THEY WERE EXTENDABLE

LEXINGTON, KY – Unveiled at ConExpo, Link-Belt's TCC-500 telescopic crawler crane is said to offer a load chart that rivals lattice crawler cranes with a similar base rating.

Consisting of a base section plus three telescopic sections, the full-power boom features a high-tensile steel box-type construction with diamond-shaped steel impressions in the vertical side plates to enhance the strength-to-weight ratio.

Extending from 10.8-33.8m, its fly options include an 8.7-15.6m two-piece bi-fold lattice, for a maximum tip height of 50.44m.

Highly maneuverable on or off the jobsite, the TCC-500 can be transported in just one load with its standard 11,340kg counterweight, reaching 3.01m in height and 3.49m wide when on the trailer. Three possible track widths – 3.49m, 4.12m, or 4.63m when fully extended – are enabled by a hydraulic cylinder mounted in the lower frame. Two travel speeds enable travel up to 3.2km/h.

A Tier 4F Cummins QSB6.7 engine produces 215bhp, and drives a variable-displacement piston pump package that is able to provide positive, precise control during independent or simultaneous operation of crane functions. It relies on simple though dependable hydraulic pilot-operated control valves to distribute flow to all functions.

CONSTRUCTION FOCUS

JIM MANFREDI, *MACHINERY OUTLOOK*

FEELING THE HEAT

Volvo CE's Braås facility is now carbon neutral. The 45,000m² ADT facility in Sweden is powered entirely by renewable energy sources, including wind, biomass and hydropower. This follows in the footsteps of Volvo Trucks, which recently became the first carbon-neutral facility in the automotive sector.

The first step began in 1999, when Växjö Energi, a local energy supplier, was commissioned to install a district heating plant, fueled by wood chips, to provide central heating for local residents and employees. Braås then joined a Group initiative in 2007 that saw it switch to green electricity.

That brought the site to 87% CO_2 neutrality; staff then identified the greatest source of energy consumption as the LPG burners used for heating the rust protection treatment ovens. These were systematically replaced with district heating. The burners in the component paint shop, which reach temperatures of 120°C, were also switched to electrical heating. The site's diesel forklifts were also replaced with electric battery models.

PARTNERS IN MINE

Komatsu and GE Mining have formed a 50:50 JV to build underground mining equipment. Komatsu GE Mining Systems LLC will be located at the GE Transportation facility in Erie, Pennsylvania, USA.

The two companies have previously collaborated on surface haul trucks, with GE's Transportation division lending its expertise in electric drive systems. Now it will provide that expertise to Komatsu's underground equipment.

GE also plans to develop a new high-speed 1.5mW diesel engine that will be available in Q1 of 2016.

COMPACTION FACTORS

JCB is to close the factory in Gatersleben it acquired as part of the acquisition of Vibromax, the German compaction equipment manufacturer, in 2005.

Graeme Macdonald, JCB CEO, said, "The decision to relocate production to the UK and India is right for our business. The decision wasn't taken lightly ... [it] will improve competitiveness in the compaction sector. It will also create a far more sustainable position on which we can build as we grow business in the future."

The company will shift production of the products made in Gatersleben by the end of June this year. Walk-behind compactors and the two smallest tandem rollers in the range will be built at the JCB Attachments factory in Uttoxeter, UK.

Production of all soil compactors and two larger models of tandem roller will be moved to JCB's factory in Pune, India. Production of the 403 wheeled loader will also be moved back to the UK following its previous transfer to Germany in 2011.

KEEP ON TRUCK KING

Zoomlion announced in March that it was close to signing a truck JV with a major global truck OEM as it seeks to diversify the types of equipment it manufactures and sells. The company has been in talks with several global truck heavyweights for a 50:50 vehicle and engine joint venture in China. The company said that the JV will become a major player in the medium- to higher-end heavy truck segment in China, both in terms of technology know-how and capacity.

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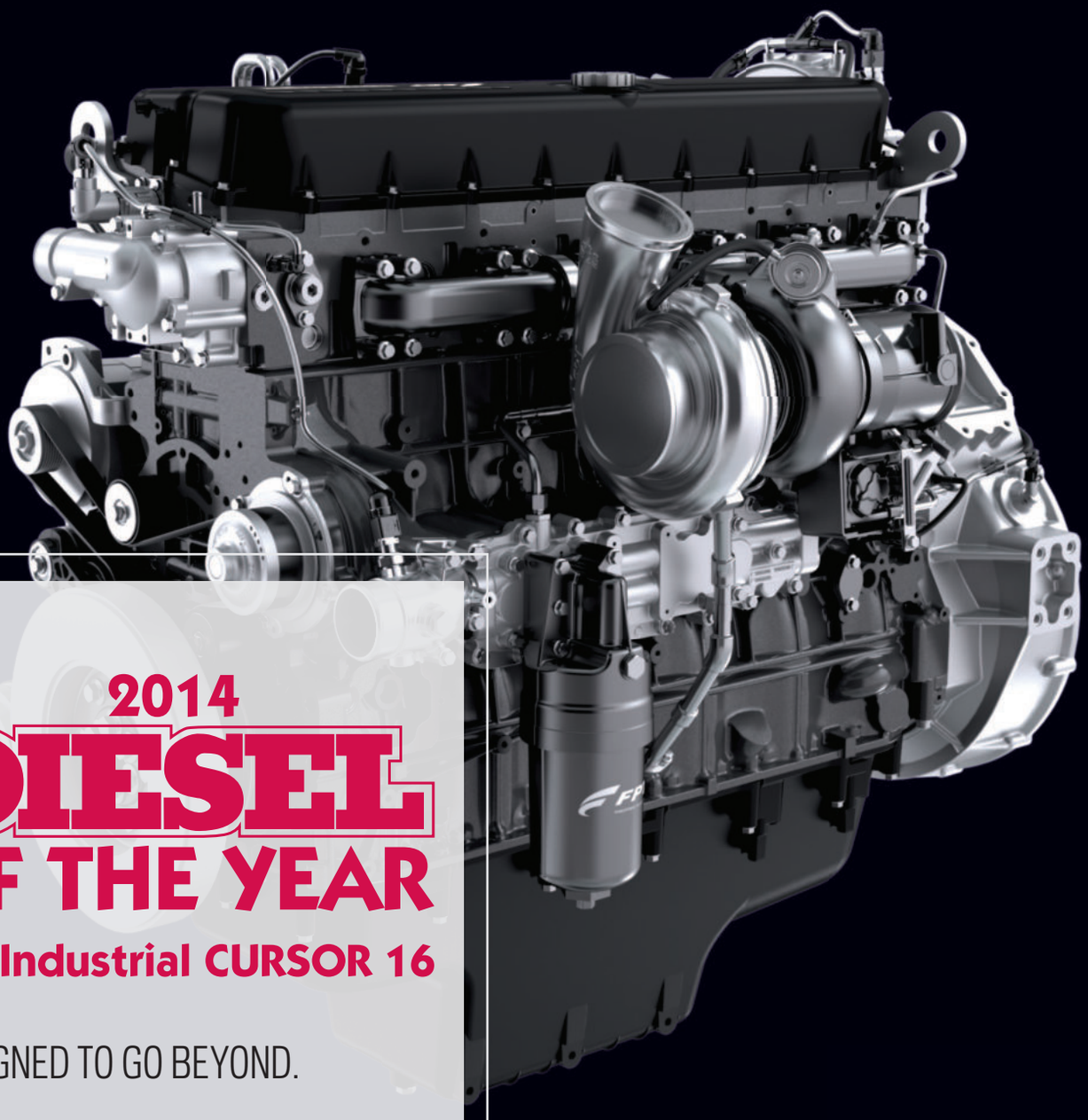

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A FOOT IN BOTH CAMPS

CAMPODARSEGO, ITALY – Equipped with rubber tracks on the rear and 20in tires at the front, Antonio Carraro's Mach 2 extends its Mach range of rubber-tracked tractors designed for use on sloping terrain.

At 1,440mm wide, 2,950kg with roll bar, a low center of gravity and a certified speed of 35km/h, this configuration ensures high maneuverability, traction and stability even on steep slopes, while performing more like an all-rounder.

Suspended on silent-block bearings on top of the Actio oscillating chassis to absorb vibrations and dampen noise, the operating station is very spacious, comfortable and easy to access. RGS, the reversible driving system on a rotating turret, enables the seat and all equipment to be turned 180° in a few seconds, enabling safer driving in the opposite direction.

Its elegant onboard instrumentation includes a backlit, anti-reflection display screen suitable for night-time use, digital tachometer and PTO rev counter, while the lighting equipment comprises parabolic optical assemblies offering a wide range of illumination.

The 87bhp Yanmar Stage IIIA engine powers a 16+16 gearbox with a synchronized inverter that can be engaged while the tractor is moving. Its smooth-engaging clutches do not require adjustment, due to the hydraulic control that recovers play caused by wear.

SAME BUT DIFFERENT

TREVIGLIO, ITALY – As an evolution of its Iron^3 range, Same's Audax ST has been designed to provide the same renowned traction capability, while making light work of ploughing and transport.

Available in 200hp or 220hp configurations, the Audax ST's entire transmission block has been redesigned around the SDF Smartronic transmission, with a new front support and greater front axle capacity.

With 24 gears engageable under load, the Smartronic's first group of 12 gears provides all the speeds necessary for field work – up to 19km/h in top gear. The second group, for road transport, enables travel at up to 50km/h or 60km/h at 1,750rpm.

Add on the nine low-ratio gears and the speeds become 33+33, and thereby provide perfect adaptation for work starting from 650m/h.

When terrain conditions change the demands on the engine speed or load, the APS device electronically selects the most suitable gear for a smooth driving experience. The driver can also adjust the aggressiveness of the change of direction to suit the specific application by means of the Sense Clutch shuttle with reactivity modulation.

The long wheelbase and wet disc brakes ensure heavy work can be tackled, even in harsh conditions. PowerBrake hydraulic brakes provide maximum stopping power with minimum pedal pressure.

Superb soundproofing and materials, such as the soft-grip steering wheel, enhance the user experience of the pneumatically suspended MaxiVision cab.

AGRICULTURAL FOCUS

PETER HILL, *iVT INTERNATIONAL*

INVESTING IN TRACTORS

Several tractor OEMs are investing in new facilities. Production of Belarus tractors has started in Cambodia through a JV between MTW and Mekong Agriculture Tractor Co. The US$5.3m Belarus Mekong LLC enterprise has a new factory west of Phnom Penh, with capacity for 3,000 units a year, initially 50-90hp models for domestic and export sales in the region.

MTW is reportedly negotiating a similar venture in Turkey that would involve some local sourcing as well as assembly.

In Turkey, Turk Traktor – a CNH/Koç Group JV – is set to open a US$80m assembly plant to complement the existing facility at Ankara making 50-110hp models for domestic and export sales in Case IH and New Holland colors. Turk Traktor is CNH Industrial's R&D and Manufacturing Centre of Excellence for tractors of this size distributed globally.

Italy's Argo Tractors plans a US$13m investment to build 60-180hp Landini tractors in Brazil. Tiago Bonomo, CEO of Argo Tractors Latin America, says the Belo Horizonte region boasts component suppliers and qualified manpower.

Deere & Co is building in Brazil too, investing US$40m to create capacity at its plant in Montenegro to make 350-420hp 8R tractors. Production for worldwide markets will remain at Waterloo, IA, USA.

"Manufacturing the 8R in Montenegro should make it eligible for FINAME financing," noted Markwart von Pentz, head of Deere Worldwide Agriculture.

... AND HARVESTERS TOO

At Zweibrücken in Germany, John Deere has extended production of rotary combines to include the entire S-Series – previously only made in the USA – to meet growing demand for higher-capacity harvesters in the European and CIS markets. The plant, which has benefitted from a €20m investment, already makes straw walker models.

CNH Industrial has begun making cotton and sugar cane harvesters in Chinese factories, and Claas recently acquired a majority stake in Shandong Jinyee Machinery Manufacture Co.

SCANIA SCORES

Belgian crop harvester OEM DeWulf will soon use only Scania engines in its self-propelled potato and carrot harvesters. The four-row Kwatro was first with Scania power – a 12.7-liter 368kW DC13 drives the 30.4 metric ton machine. In the updated R3000 two-row potato lifter, a 243kW Deutz TCD 2013 is replaced by a 9-liter Scania DC09 boasting 257kW peak power output and SCR-only emissions technology for Tier 4 Final compliance.

Scania has also scored with John Deere, supplying an initial 200 engines from its 12-liter range produced in São Paulo for Deere cane harvesters built in Brazil.

REMEMBER THE ALAMO

The Alamo Group has entered the specialist farm vehicle sector by acquiring Kellands Agricultural and its subsidiary Multidrive Tractors.

"This acquisition is part of a continuing business strategy to enter into the self-propelled sprayer market," said Christian Davies, general manager, UK agricultural division.

Alamo's main products are tractor- and truck-mounted vegetation control mowers, but it also produces snow clearance equipment, street sweepers, excavators and vacuum trucks.

HANDLING FOCUS

MICHAEL LEU, *FORKLIFTACTION.COM*

EFFICIENCY DRIVE

Kion Group plans to start enlarging its global plant structures to meet an anticipated increase in demand. "Our key objective ... is to locate our production even closer to the fast-growing [emerging markets]," said its CEO Gordon Riske.

Specific investments are aimed at increasing efficiency in core plants. The company is also starting development of trucks for markets such as the USA on the basis of existing product platforms. It will also further expand its R&D activities in Asia, where around one-third of all its R&D employees are now based.

Riske also expressed his confidence about this year, with "continued momentum for stabilization of demand in western Europe and for further growth in North America and Asia."

EYES ON EUROPE

Jungheinrich plans to continue expanding in growth markets, boost its position in Europe and strengthen its IC forklift business. According to its market intelligence, global demand grew strongly in Q1 2014, jumping 10% to 272,300 trucks. Europe, its main sales market, saw a 7% increase, with demand in the west up 10%, but down 7% in the east. Sales in the Asian market expanded by 17% and in North America by 14%.

In Q1 of 2014, the OEM posted a 12% YoY increase in both its net sales and earnings, with incoming orders for new trucks up 5% for the same period.

"Having shifted the production of warehousing and system equipment to the Degernpoint factory, we will make substantial investments in our main [CB trucks] plant in Moosburg," said board chairman Hans-Georg Frey. "Other focal points are the construction of a new training center on the Norderstedt premises, the expansion of the used equipment center in Dresden, the construction or acquisition of branch offices in Asia, and the establishment of a new HQ in Hamburg-Wandsbek."

MIND THE GAPS

Clark Europe is accelerating its strategic positioning as a full-range supplier. COO Rolf Eiten says it is part of Clark's sales strategy to "fill any gaps successively with new machinery".

Currently a full-range supplier of industrial CB forklifts up to 8 metric tons, the OEM will launch heavy-duty machines boasting capacity of up to 18 metric tons and a load center of 1,200mm in Q4 of 2014.

FORKLIFT GROWTH

Toyota (TICO) says the forklift market as a whole expanded globally, with the markets in China and North America showing growth, Europe displaying evidence of a recovery, and the market in Japan maintaining solid sales. The OEM enjoyed an increase in worldwide unit sales, resulting in a 36% net sales growth of the material handling equipment segment to US$7.9bn. It is anticipating further growth, forecasting US$8.6bn for net sales for fiscal 2015.

UNIVERSITY CHALLENGE

Toyota (TMHE) has signed a strategic partnership with Linköping University's Department of Management and Engineering. During the first year, the parties will develop guidelines for the collaboration, keeping in view the long-term goal "to produce world-class scientific results focusing on lifecycle analysis and sustainability".

Global material handling online: www.forkliftaction.com

LEADING THE CHARGE

SHAOGUAN, CHINA – BYD, the world's largest producer of rechargeable batteries, claims operating costs of its four-strong line-up of lithium-iron phosphate ($LiFePO_4$) lift-trucks can be 20-25% lower than that of lead-acid models.

Not only does the battery chemistry require less time and energy for recharging, it can also extend total battery life to the point where users never need to replace their truck's original battery.

It also does away entirely with the need for battery maintenance, and cuts the emissions associated with traditional battery charging.

With over double the lifetime of a lead-acid battery, as well as 1-2 hour and incremental charging, and up to 40% lower energy consumption during charging, a major reduction in operating costs are possible.

The $LiFePO_4$ battery is said to be much cleaner and safer than lithium-ion, and will not burn or explode, even under pressure or when punctured. The technology has also been proven in thousands of electric vehicles worldwide, including buses and cars.

The range of AC trucks – which comprises three four-wheeled CB forklifts of 2.0-, 2.5- and 3.5-metric tons (CPD2000/2500/3500), and a 2.0 metric ton powered pallet truck (CBD2000) – is claimed to be the world's first full range of lift-trucks powered by this battery technology. A three-wheel 1.6 metric ton CB truck is also due for launch, with reach trucks, stacker trucks, order pickers and tow trucks also on the cards.

The ride-on trucks are available in Basic or Comfort configurations. Features and options include full suspension Grammer seats, fingertip electronic controls, heated cabins, regenerative braking, programmable performance characteristics, active stability control and a selection of clear-view masts, in an attempt to compete with the most advanced trucks on the market. Drive controls from Danaher are used on the CB trucks, and from Zapi on the pallet truck.

ELECTRIC RAISER

ASCHAFFENBURG, GERMANY – Linde has expanded its range of electric CB trucks with the launch of the E60 to E80 series. This comprises four models from 6-8 metric ton capacity, plus an 8 metric ton model with a 900mm load center.

The 80V trucks feature a powerful encapsulated drive unit with two 11kW three-phase AC traction motors integrated into the front axle, giving high maneuverability and a turn radius of just 3m at a length of around 3.5m. Maintenance-free wet disc brakes with energy recovery and coordinated power modules extend the battery life, with lifting speeds of up to 0.46m/sec, or 0.56m/sec on the way down enabled by two extremely quiet 21kW three-phase AC lift motors.

Active ventilation conducts battery gases away via the rear of the truck, so it can be charged with the doors closed.

Of similar spec to those of the IC trucks, the cab includes a larger footwell, wide steps visible from above, and a hydraulically dampened seat.

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RICHARD CARR, iVT INTERNATIONAL

DON'T QUOTE ME...

HERE ARE THE HIGHLIGHTS FROM THE CONEXPO PRESS CONFERENCES – WHEN THE PRESENTATIONS ARE FINISHED AND THE TOP BRASS DOESN'T KNOW WHAT'S GOING TO BE ASKED NEXT...

Speaking frankly, the press conferences at ConExpo – or any other show – can often be little more than a good excuse to take the weight off an editor's sore feet for an hour or so. Our ears often only really prick up when the official presentations have finished and the floor is open for questions. So not wishing to keep all the juicy bits to ourselves, here's our review of the show in terms of the highlights from the press conferences (those that weren't held at an ungodly hour of the morning, at any rate...)

DOUG OBERHELMAN, CHAIRMAN AND CEO, CATERPILLAR

After massive investment in engine technology, where do you see R&D investment in the future?

"After what's been a 15-year journey or more, we're now freeing up all our engineering resources to be able to go back to an unbelievably long list of things we've been thinking about for a long time. So as we see Tier 4 investment requirements go down, we have across-the-board improvements to make.

"This industry has invested tens of millions of dollars to produce smokeless, smell-less, more efficient than ever engines with better fuel economy through drivetrains and hybrid systems. There's an untold number of fuel-saving options out there we can't even imagine yet; I can't wait to free up those funds to do some really fun things that we've had to hold off."

Cat group president, Steve Wunning, added: "Basically, we've identified some long lead time technologies to develop, they're five to seven years out and include 13 themes – things like power density, autonomous vehicles, technology-enabled solutions, prognostics, diagnostics, LNG fuels and alternative fuels."

MARTIN WEISSBURG
PRESIDENT, VOLVO CONSTRUCTION EQPT

Volvo's press conferences have been able to maintain the high levels of intrigue popularized by Tony Helsham, despite several changes of leadership in the interim. And given that Martin Weissburg, its new president, kicked off his presentation by admitting he wasn't pleased with recent results, that seems unlikely to change. He also announced plans to allocate more R&D resources to driving down product cost without cheapening it – while still improving quality – provoking *iVT*'s question:

Does that cover the manufacturing process and/or the vehicle technology, and which specific areas might you be looking at?

"I can't give examples as we're looking at so many areas," he responded. "We want to drive efficiency in every aspect of the organization as we need to drive greater levels of profitability, which in turn supports greater levels of investment. So it will be both on the technology side and in manufacturing efficiency, but they're continuous improvement activities that have been going on for a while. But as we're now coming over the heavy stint for meeting engine regulations, there's more R&D dollars available to allocate resources toward these cost reduction and efficiency measures."

Unsurprisingly, Volvo's recent acquisition of Terex Trucks provoked some fierce speculation, particularly concerning those 'surplus' ADTs:

Are you going to sell Terex ADTs under your SDLG brand?

"We haven't closed on the acquisition, but our focus is to leverage the existing structure, branding and distribution in place to make sure we're capturing those unit sales and getting a return on our investment. We have the Terex brand rights for up to – and perhaps beyond – five years. As we integrate that organization, we'll be looking at how we should be optimizing it relevant to our multiband positioning and strategy, but right now no decisions have been made."

Do you regret selling the Euclid rigid hauler line? And now that you've acquired a 100-ton hauler, will you be developing a larger excavator to load it?

"We don't have regrets about the past and are very pleased with the timing of the Terex acquisition. We don't comment on product introductions until we're ready to introduce those products, but our existing line fits reasonably well and we'll continue to look at the product portfolio to see how we should be optimizing it.

Is your portfolio complete? What about a dozer?

"We're very pleased with the breadth and depth of our product line today and are very focused on protecting and growing our core – the haulers, excavators and wheeled loaders. We always have our eyes open for things that might fill existing gaps in our product line. Dozers are something we've been looking at and thinking about for years. We always have our eyes open, but no announcements will be made today!"

We're now seeing your SDLG brand in North America – is that meant to be a complementary move?

"In the last four months our export strategy for SDLG wheeled loaders has reached North America – we're very much in the early stages but are seeing very strong returns already. We do not see it as competing with the Volvo CE product, but as complementing it. It's such a large market and we do see a need for that value proposition in the US. I don't see SDLG bumping up against the Volvo brand at all – there's a good line of demarcation between them."

TIM FRANK
FOUNDER AND CHAIRMAN, ICP
[INTERNATIONAL CONSTRUCTION PRODUCTS]

Much of that SDLG strategy was in fact formulated by Tim Frank during his time at Volvo, and he's now hoping to repeat that success with a very different strategy. Joined by several former colleagues from Sany America, his new **ICP** start-up aims to bring the very best Chinese equipment into North America (and eventually Europe) via an online ordering procedure as well as dealer partners, with the vision of a multibillion-dollar equipment platform at prices 30-45% below leading brands.

Initially this appeared to me to be little more than a thinly disguised Lonking dealership, as the products currently on offer all come from that OEM. So several questions arose:

Do you have plans to team up with other Chinese or international manufacturers?

"We are loyal to Lonking and the products it manufactures, so we won't carry other wheeled loaders, forklifts, excavators, road rollers, etc, as that would compete with Lonking. But we would look at products they don't manufacture – for instance, there are lots of quality backhoes coming out of India. The question is, do they fit our model – and are they a big player? You will probably never see us represent anyone under US$1.5-2bn."

Did you speak with anyone else before deciding to go with Lonking?

"I spoke with my mother and my wife...! No, Lonking was by far the first choice, and is one of the world's finest manufacturers of wheeled loaders and other products – for instance, it makes an extraordinary excavator. Sometimes you get inside these companies and you don't fit with their culture or their willingness to support; many Chinese companies are 'sell and run' and that's not how our program works at all. Lonking made a lot of investment alongside us to make it work."

Given that many see the main obstacle to Chinese products taking off in the West being the absence of appropriate support, ICP's three-year warranty, 48-hour parts guarantee in association with TVH and a 30-day money-back guarantee will certainly help to put minds at rest. Hopes are therefore high to hit the 300-unit sales target for 2014.

GRAEME MACDONALD
CEO, JCB

Perhaps with this (ICP's) sort of competition in mind, **JCB** used ConExpo to announce the launch of a new entry-level 3CX backhoe loader aimed at large-fleet owners and rental customers worldwide – although initially available only in North and Latin American markets. It's perhaps most noteworthy for a cab that's much more functional in terms of layout and design, with a simpler operator interface and control system.

iVT therefore asked CEO, Graeme Macdonald:

Is the basic interior something you're likely to carry over onto your excavators and wheeled loaders, perhaps to better compete in the South American markets being targeted by Chinese OEMs?

"We're looking across all our product ranges – that 3CX is very much an entry-level product for rental customers. Emerging markets require a different specification for those machines, so the answer is 'Yes' – we're certainly looking at our range of equipment to take that sort of design philosophy forward."

And finally, you'd be forgiven for thinking that JCB would have been safe from questions about Volvo and Terex, but not so:

What's the status of your ADTs? You have a cooperation with Volvo for skid-steers, so could there be a deal for them to supply you with Terex ADTs?

"We have no plans at all to talk to Volvo about that product range. We are looking very closely at our ADT range – that's an important range for us, particularly in North America."

JOHN MAJOR
MARKETING MANAGER, **PETTIBONE**

Pettibone's press conference unveiled the new 154 CaryLift, with the primary engineer being Philip LaTendresse, grandson of the design's original inventor. But *iVT*'s interest was especially aroused on hearing the claim that, now Lull's traversing-boom telehanders are to be discontinued, Pettibone will be the only remaining manufacturer, producing five Traverse models with lift capacities ranging from 7,000-11,000 lb:

Is the traversing market in decline? How have your sales figures been over the last few years, as a proportion of all telehandler models you sell?

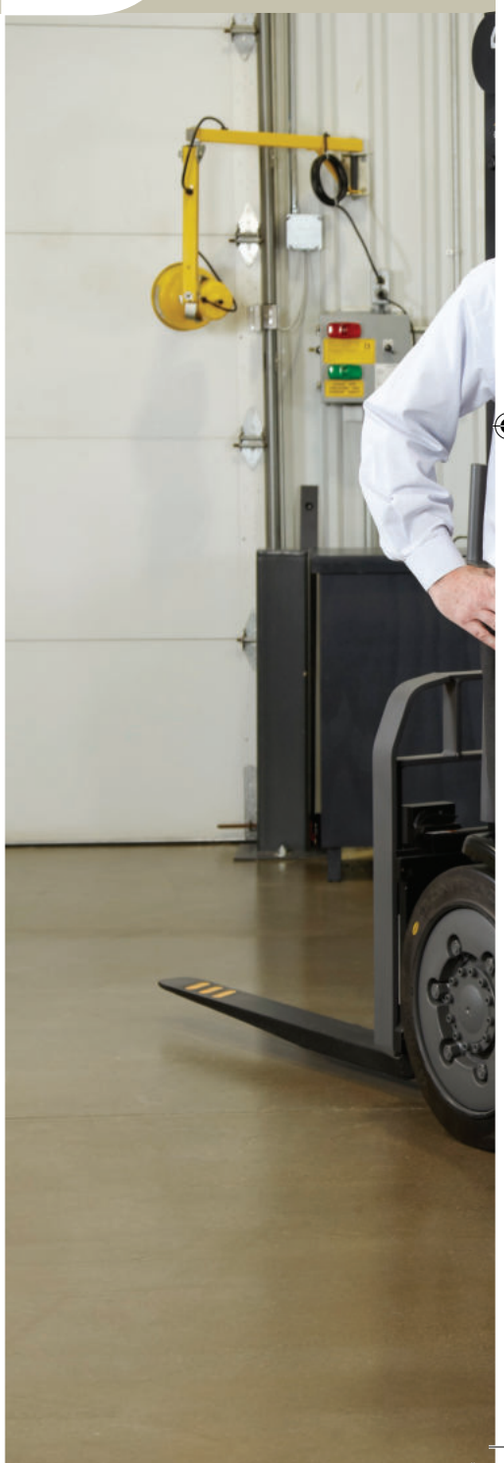
"Like the rest of the industry, we've been coming back from the decline of 2008/2009, but we've been seeing increases each year. We're very optimistic and expect to see increases continue through 2014 and beyond. I can't speak as to why Oshkosh decided to discontinue the Lull brand, but traversing machines are a low percentage of our overall build – we build less than 300 of those per year.

"We have no new models due to be introduced this year but we'll see some in the future. We don't think we'll be the only player in this space for long – we think someone else will want to get back and join us, but we'll be ready with a top-performing product."

RICHARD CARR, iVT INTERNATIONAL

ONWARD AND UPWARD

DAVE BEDDOW, VP OF MANUFACTURING OPERATIONS AT CROWN EQUIPMENT, REVEALS WHY THE COMPANY'S COMMITMENT TO THE VERTICAL INTEGRATION MODEL IS PLAYING A KEY ROLE IN ITS SUCCESS



Long renowned for its penchant for mergers and acquisitions, the industrial vehicle sector is practically the dictionary definition of 'horizontal integration'. So it made a change to be discussing the alternative integration plane during my visit to one material handling equipment manufacturer late last year – but then, given that the OEM in question was Crown Equipment, which produces up to 85% of the components used in its trucks, perhaps I should really have been expecting it.

Dave Beddow, Crown's VP of Manufacturing Operations, kicked off our discussion in New Bremen, Ohio, by referring to a recent visit from *IndustryWeek* that resulted in an article entitled *The Virtues of Vertical Integration*.

"As you may know, vertical integration kind of goes against the grain of manufacturing, particularly here in the USA," he states. "So that article covered our inter-relationships among engineering, manufacturing and design – not just for the trucks but their components as well.

"That inter-relationship is firmly embedded in the Crown culture – and by maintaining on-time delivery of our trucks and aiding four major product launches, it enabled our manufacturing plants to double their output within two and a half years of coming out of the recent recession."

Do it yourself

Mike Gallagher, Crown's VP of Design, once said, "We'd find it hard to achieve the Crown brand promise with everybody else's supply content," and Dave is equally convinced that if the company was focused only on welding and assembly, it would have enjoyed far less success.

"When you control 85% of the supply chain internally, it really has a huge advantage. The synergy we have means that when it comes to product revisions and enhancements, we can immediately begin discussing it with the person that assembles it, with the design engineer and the electrical engineer that is creating the software behind the product.

"Take wiring harnesses, for example. A couple of years ago, we almost got out of that business – we just felt that we weren't competitive enough. However, with our existing employees, we ultimately were able to relocate the plant locally and then basically doubled the size of our operation by utilizing automation, lean manufacturing and ideas from our manufacturing personnel.

"Now, within just three days a wire harness can be produced and assembled within a truck. With the hundreds of engineering revisions

"IT'S MORE OF A 'WE SHOULD MAKE THE COMPONENT UNLESS THERE'S A REASON WHY WE SHOULDN'T' ETHOS RATHER THAN THE OTHER WAY AROUND"

Dave Beddow with the Crown C-5 – developing an engine for its only IC truck would have been a step too far, but close cooperation with John Deere Power Systems ensured an optimum fit

and product enhancements we have each year, it's priceless to have that operation just down the road."

It's a concept that the firm's founders and owners, the Dicke family, hold dear. "It's more of a 'We should make it unless there's a reason why we shouldn't' ethos rather than the other way around," Dave explains. "It's the DNA of the company; it enables us to explore – but it is challenging!"

As an example, he mentions that the AC motor originally purchased for use in Crown's trucks wasn't quite the right fit for the product. The company therefore started to design, engineer and assemble its own motors, before realizing there was also an opportunity to make the stator, and then to machine the end head. "Then we said, 'Why don't we make the laminations that create the stator?' so we partnered with a company that makes the stamping press, made the necessary investment and have exceeded our original return on investment."

And the rest...

So what about that outstanding 15% of outsourced components – are there plans to consolidate even further? Presumably batteries are the one major component that is still outstanding – so given there's no major lift-truck manufacturer

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that currently produces its batteries in-house, could Crown be the first to break the mold?

"In a previous life, I was responsible for an automotive lead-acid battery manufacturing plant, and it's messy!" Dave reveals. "But at this point, we have no intentions!

"The vast majority of our vertical integration is made under a value proposition covering safety, quality, cost and delivery. So we price check components continually, to make sure that doing it internally provides the best value.

"There have been few things that we decided not to maintain – Jim Dicke III [Crown president] once asked, 'Has there ever been anything that we have brought in-house that we have regretted?', and we couldn't think of one."

"THE VAST MAJORITY OF THE VERTICAL INTEGRATION THAT WE DO IS MADE UNDER A VALUE PROPOSITION COVERING SAFETY, QUALITY, COST AND DELIVERY"

Crown started out in the AC motor business by focusing on design and assembly (below) before moving into producing the laminations, stators and doing its own end head machining (right)

Pressing concerns

Bringing stuff in-house reached an entirely new level eight years ago, after a staff meeting was interrupted with the news that a key supplier was going out of business. A manufacturer of seat decks for Crown's ride-on counterbalanced trucks and doors for its electric pallet trucks, its sudden demise would have badly affected production at several plants.

"In a very short amount of time, we had carried out an assessment and acquired its assets. Some people say that we went from 85% to 86% vertically integrated that day, as we were now in the deep draw press business. That operation has paid for itself every year since we purchased it, and because of that success and the growth of our counterbalance business, we then managed to secure a 1,000,000ft^2 brownfield site nearby, and relocated the team 30 minutes up the road.

"I am part of a manufacturing alliance with my peers, and one day the question came up: 'How much time do you typically spend assessing the acquisition of companies?' Other people were saying 'six months', 'a year', 'a year and a half'… when it came to me, I said, 'Four hours!'

"I was exaggerating, of course, but the point is we were able to act very quickly without compromising our due diligence. Many companies would not have been able to act that

quickly, and their customers would have been severely inconvenienced.

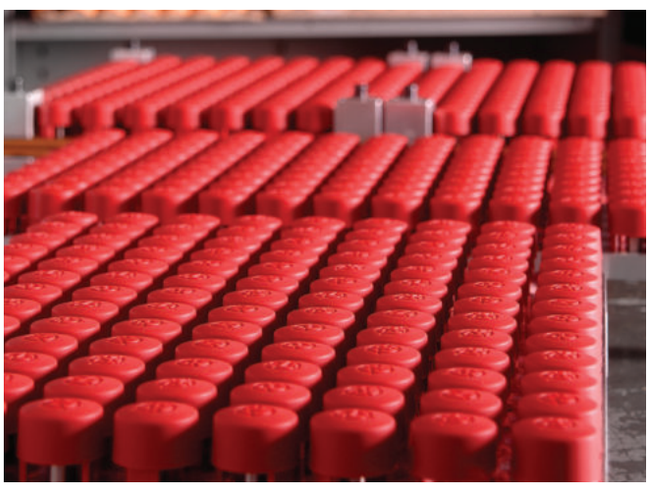
"That seat deck uses a unique draw process with a 1,250-ton hydraulic press. When we came to rebuild that piece of equipment, we discovered there were only two others in the USA that had the same capability – and it took us several months to find them."

Work with me

Dave points out another couple of areas that he believes add up to the 'Crown difference' – with most of its 15 manufacturing sites located in rural agricultural areas, a consistent approach to hiring and training staff complements their typically strong work ethic. And all those plants – whether in China, Mexico, Germany or the USA, rely on the same quality and lean systems and standards.

"The third piece that really helps us from the standpoint of vertical integration is that we have great relationships with machine tool builders and manufacturers," he adds. "Crown isn't just considered to be an outstanding lift-truck, but an outstanding manufacturer, too, so there are a lot of companies who want to be able to say that they are partnering with Crown.

"We visit many of them every year to learn more about their next generation of technology that might be incorporated into our product



TOP: **Automated AC stator assembly line**

ABOVE: **Assembly of the EDS (Emergency Disconnect Safety) button for Crown's RR and RC forklifts**

design. It's that type of relationship that enables Crown to benefit from partnerships we might not have if our manufacturing was disseminated throughout a bigger supply chain. For example, our robotic partners will take some of our product and come up with advanced processes, to work with us on things that we have never really discovered before."

In fact, Dave reckons that if the company was to outsource its global tool room operations – a major component of its vertical integration strategy – it would be equivalent to a multimillion dollar standalone business. For instance, the primary tool room operation, based in New Bremen, employs 30 tool builders who produce all tooling used for welding, machining and assembly, and works with 11 designers on design and tooling work for its injection-molding operations.

And with 10 injection-molding pieces of equipment producing 3.5 million parts per year, he also claims that Crown is effectively one of the top injection molding companies in the state of Ohio, demonstrating its commitment toward the vertical integration model.

That said, somewhat surprisingly – and in a departure from its roots as a supplier of temperature controls and antenna rotators – the company does not supply components to other industrial vehicle manufacturers.

Keep it lean

Quality is what lies behind that entire model; hence the implementation of lean Six Sigma methods and a quality management system certified to ISO 9001 2008.

Crown's lean manufacturing journey began in 1999, when truck manufacturing was still a stall-build process, with one worker assembling the entire machine. The first stage of switching to lean manufacturing transformed that to the one-piece flow system now common to most of its plants. The second generation of lean manufacturing focused on continuous improvement, ultimately leading to an 80% reduction of inventory in some areas.

So while certain Crown products are manufactured in China as well as Germany or the USA, the same quality and training systems apply. "Some customers might hesitate when they hear a truck comes from China, but when we reassure them it's been built in a typical Crown manufacturing plant, it really takes the issue off the table."

It almost sounds like the only part missing from Crown's model is the raw materials themselves, I point out as we wrap up – another steel, rubber or copper shortage could still play havoc with production. Dave agrees, but points out that Crown has a superb purchasing organization focused on particular commodities. However, nothing sums it up better than a quote I subsequently found from Larry Wuench, retired head of MCFA, on the *Forbes* website: "If they [Crown] had their way, they would have their own iron mines." **iVT**

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THOMAS WAGGERSHAUSER, IXXAT AUTOMATION

FLEX APPEAL

WAY BACK IN 1986, WHO WOULD HAVE BELIEVED THAT CANbus WOULD SOON STRUGGLE TO KEEP UP WITH THE DEMANDS MADE UPON IT? THE ADVENT OF CAN FD, WITH ITS FLEXIBLE DATA RATE, CAN MEAN OEMs AVOID HAVING TO MAKE THE SWITCH TO MORE EXPENSIVE SYSTEMS

The growing demands in the number of nodes, transfer rates and cycle times have led to bottlenecks that the limitations of 'classic' CAN (8 data bytes and 1Mb/sec data rate) cannot fulfill: the data rate that depends on the network expansion and the short data length for service and analog data play a particular role here.

In daily use, these limitations will often be circumvented by means of compromises. The division of the CAN system into different network segments in various applications – or even into parallel networks – means that the existing technology is constantly being exhausted, which has often led to alternate solutions that are complex and expensive in terms of configuration, setup and maintenance.

In principle, making a switch to using high-performance industrial Ethernet technologies would be possible, but the increased level of investment that is usually necessary, and the change in the data structures and mode of thinking required for the configuration, in particular for time-controlled systems, can often represent a considerable challenge in extensive networks.

In addition, a switch in tools for development, commissioning and service is necessary, which will often deter many users from attempting a complete conversion.

At the same time, there is the desire to continue to use existing know-how in a useful manner. This is where CAN FD plays a role: CAN FD (CAN with flexible data rate) is an extended version of the well-known classic CAN that greatly extends the usable data rate and usable data length.

On the other hand, the tried-and-tested CAN concepts have been retained, such as arbitration based on message IDs, event-driven dispatch of messages, and acknowledgement of messages received by means of the acknowledgement bit.

Message received

As used in classic CAN, message acknowledgement by receivers offers a wide range of advantages by means of confirming the success of the transmission within the transmitted message. Potential transmission errors are quickly detected and the data can be retransmitted extremely quickly.

Arbitration of the messages based on the CAN identifier will also offer advantages for control applications by avoiding collisions during data transmission and providing short latency times for high-priority messages even at higher bus loads.

The disadvantage is that at sampling time, the same bus level must exist across all nodes to avoid faults. Accordingly, a bit interval must make sufficient signal propagation time available between the two most remote nodes in a network, including their bus activation. The bit interval, and consequently also the data rate, are therefore directly dependent on the network extension; at an expansion of 40m, up to 1Mb/sec is possible, but at 250m extension this drops to as low as 250Kb/sec.

To greatly increase the data rate without having to change existing communications technology, CAN FD works with two different bit rates. The 'arbitration rate' for the control commands (including arbitration, message type, end detection and acknowledgement) is dependent on the propagation speed and thereby on the network extension.

By contrast, a second 'data bit rate' is optionally also used – for the data content and data security. At

this point in time, only the message transmitter occupies the bus, which means that direct feedback within the bit time is unnecessary.

The maximum achievable data rate is therefore only dependent on the transmission characteristic of the transmission medium, rather than the signal propagation. CAN FD networks currently enable productive use with 8Mb/sec, whereby the CAN FD standard permits up to 15Mb/sec. This bit rate has also been successfully used in various test systems.

The two data rates are set independently of each other in the CAN FD controller using two bit-timing registers. Switching between the two data rates is performed using two control bits in the protocol. The first bit reserved up until now is used as the Extended

CAN FD standard permits up to 15Mb/sec

1. **Message received**
2. **Extended user data**
3. **Data security**

CAN FD

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Data Length bit (EDL), and defines a CAN FD message due to its recessive level. The actual bit rate switch is performed by a newly added bit, the Bit Rate Switch bit (BRS), in which a switch to the higher bit rate is made at sampling time. Switching back is performed at the time that the CRC restriction bit is sampled.

Extended user data

The control data is still transmitted using the well-known lower bit rates, thereby limiting the achievable data rates. So by increasing the user data area to up to 64 bytes, more data is able to be sent in fast transfer mode, thereby effectively increasing the data rate.

Classic CAN provides only 8 data bytes, which is no longer sufficient for many data applications, such as for transmitting high-precision analog values or for controlling a multi-axle robot with its diverse encoding values and drive commands. To this, service data must also be added, which up to now has greatly reduced the effectiveness due to the transport protocols that are required for transmission of more than 8 bytes.

CAN FD now also provides the option to use up to 64 data bytes. In so doing, larger data blocks can be transmitted in a single message – particularly in the case of process data, more complex devices can now be completely controlled using only a single process message. For service data, the necessity for transport protocols is reduced, as a single CAN FD message is often only required for configuration data and similar.

To prevent extending the control data unnecessarily, CAN FD also uses only 4 bits for the data length code – the values 0 to 8 are taken directly from classic CAN. The values that were up till now undefined (9 to 15, i.e. 1,001 to 1,111) are used for the new, extended data lengths: besides 0 to 8 bytes, 12, 16, 20, 24, 32, 48 and 64 bytes are now also available for the user data. Data lengths that differ from these are not possible, meaning unused areas must be padded with 'filler values'.

Besides the fast transmission of the data area, the effectively usable data rate can be greatly increased using CAN FD, and the cycle time

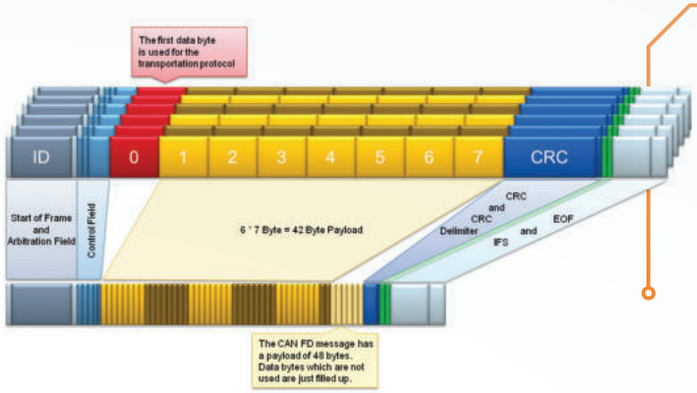

FIGURE 1 (LEFT): **In this example, configuration data totalling 42 bytes is transmitted. To do this in classic CAN, a transport protocol must be implemented to enable transmitting the entire data quantity in 8-byte messages. The example is based on a model transport protocol that only uses the first data byte for controlling the data stream. This means that up to 7 bytes are still available for each CAN message. Depending on the transport protocol implemented, additional data fields can be necessary for control.**

Below this, by comparison, is a single CAN FD message with 48 bytes of user data, which can replace the six classic CAN messages required. As the data is also transmitted at a higher bit rate in the CAN FD message shown above, this CAN FD message needs much less bus time than the classic CAN messages. In addition, the use of a single CAN FD message greatly simplifies the administration of the data stream

can be considerably reduced. In this manner, a CAN FD network with 500Kb arbitration, 4Mb data transmission and 64 data bytes can achieve an effective data rate of over 5Mb/sec.

The combining of multiple independent data packets into a single message means that data administration is made considerably simpler, as the individual messages no longer need to be synchronized with one another at great cost. The fast transmission of larger data packets in comparison with classic CAN enables transfer of eight times the data volume (64 bytes) in roughly the same time that would be required for a classic 8-byte CAN message. In this way, high-priority messages can be transmitted much more quickly and the real-time capability improved.

Bits and pieces

Despite the increased data packet size in comparison with classic CAN, the enhanced version fulfills the same requirements in respect of data security. This is achieved by using longer CRC check keys with adapted algorithms, for example. Depending on the number of data bytes being transmitted, one of three different CRC algorithms is used: the previous CRC formula for messages with up to 8 data bytes, as well as two enhanced algorithms with up to 16 data bytes or more than 16 data bytes for messages. The algorithm to be used by the CAN controller is then determined by the data length code.

For improved data security, additional suggestions have been implemented. As a result, the CRC in CAN FD messages always starts with a stuff bit; after another 5 bits an additional stuff bit is included – contrary to the CAN stuff bit rule,

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this is independent of the bit values of the previous bits. Each stuff bit has the complementary value of the previous bit.

One disadvantage of switching from CAN to faster communications systems is the frequent requirement for a complete conversion: all CAN participants must be adapted to the new system, e.g. EtherCAT.

Alternatively, the machine controller can be extended to use multiple heterogeneous networks.

Both procedures offer advantages and disadvantages. Using CAN FD, an additional, 'gentler' option is now also available: because CAN FD controllers can also be used as classic CAN nodes, all network nodes can be gradually replaced by CAN FD-capable devices. As soon as the entire network is CAN FD-capable, the advantages of CAN FD can be used to the fullest extent.

This is likely to be of particular interest to manufacturers of special-purpose machinery, where network participants that cannot be replaced by freely available nodes are often used – in particular, customer-specific devices or internally developed devices.

Tools available for CAN FD

A number of solutions are available for the development of CAN FD-based devices and networks; in particular, PC-CAN FD interface cards suitable for a wide range of PC interfaces, for example, the IXXAT CAN-IB 500/600 PCIe cards from HMS Networks.

These CAN cards contain a comprehensive range of driver packages for Windows, Linux and other operating systems, and enable simple connection into existing systems and the quick addition of existing software packages to CAN FD networks, as they support both CAN and CAN FD.

Besides the hardware interfaces with the relevant driver software, test and analysis tools are required for the effective implementation of CAN FD. In this regard, HMS Networks will shortly be offering a high-performance complete solution at a convincing price by way of a CAN FD-capable version of the well-known IXXAT canAnalyser.

Open topics for CAN FD

Besides the tools mentioned above, there are further important aspects for the use of CAN FD. For instance, it is advisable to apply standardized higher protocols for use in industrial applications: work is underway at CiA (CAN in Automation) on the conversion of CANopen to CAN FD – this CANopen V5 specification, which also contains extensions for CAN FD, is expected to be available very shortly.

An additional, important aspect for using CAN FD lies in inexpensive microcontrollers that are available in quantities, with integrated CAN/CAN FD controllers. The devices available up until now mostly rely on FPGAs with CAN FD IP cores. Microcontrollers with integrated CAN FD logic are frequently high-performance components with multiple CPU cores for complex controller devices in vehicles. So until simple, cost-effective microcontrollers with integrated CAN FD support become available, FPGA-based systems represent the most flexible solution.

CAN FD extends the application area for CAN-based solutions by means of greatly improved data rates, a simple configuration and the retention of analysis options known from classic fieldbuses. The impending availability of CANopen for CAN FD means that the new network system can be implemented in the industrial sector, and offers an effective solution for networks with a data rate of 100Kb/sec to 5Mb/sec. With the option to use the higher data rates or the extended data framework either individually or in combination, the flexible design of CAN FD makes it extremely suitable as an adaptable fieldbus system for special-purpose machinery. **iVT**

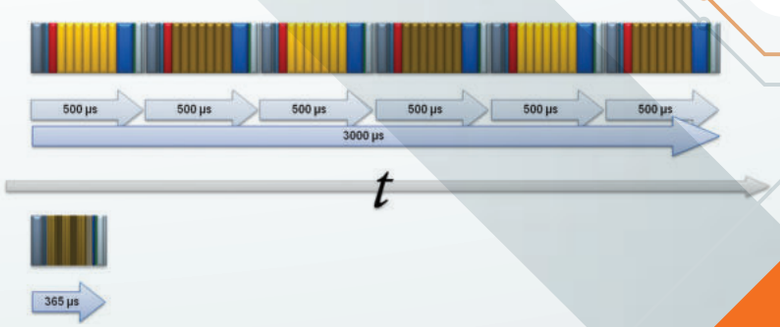

FIGURE 2 (BELOW): **The CAN messages displayed in Figure 1 in a single timeline: for classic CAN a data rate of 250Kb/sec is assumed here. For messages with 8 bytes of user data (1 byte for the transport protocol and 7 bytes of user data in the example) and the maximum possible number of stuff bits, a classic CAN message requires around 500µs bus time. If the transmitting node is able to send all six messages consecutively without delay, the bus will be completely blocked for 3ms for transmitting the 42 bytes of user data.**

By comparison, a CAN FD message with 48 bytes of user data, 250Kb/sec arbitration rate and 2Mb/sec data bit rate occupies the bus for only approx. 365µs – also with the maximum number of stuff bits. The quicker data transmission also improves the real-time behavior of CAN systems due to the markedly shorter response times, and at the same time increases the data rate and reduces the complexity of data administration

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The degree of automation in industrial vehicles has increased visibly in recent years – as have the safety requirements that must be satisfied to prevent critical situations occurring. The implementation of the directives for machine safety specified in EN ISO 13849 is, however, far from trivial. The redundant or intrinsically safe systems demanded by the standard greatly increase the effort required in terms of OEM time and resources.

In addition, integrating certain components into the overall safety system can be difficult.

Safety technologies in the area of mobile elevating work platforms are already established – not least because they have been defined for years in the EN280 standard as a result of the demanding safety standards required of machinery that carries people. Mobile cranes, in contrast, have generally been seen as 'load-bearing machinery', meaning that they need to satisfy other preconditions, involving less-stringent safety requirements.

But in that machine sector too, the development of regulations governing machinery has recently been aimed at achieving evermore demanding safety standards. Cranes may not actually carry people, but the risk of one overbalancing does pose a considerable risk to them. It is therefore becoming increasingly important for crane manufacturers to integrate safety structures into their machinery, which has a knock-on effect on the systems that control and monitor all onboard functions.

Maximum range, maximum load

The whole purpose of machine control is to be able to use the crane safely at the greatest possible range in all directions, while lifting the heaviest possible loads. The capacity and performance of the stabilizers is one of the most decisive criteria in achieving this end, enabling the crane to extend its telescopic parts higher and further without causing a hazard.

It is therefore important to analyze the crane's real-life features in relation to stabilizers in order to arrive at an appropriate assessment of its range. Until recently, stabilization values were entered – or at least confirmed – entirely manually, and on the basis of these values, the crane's load moment limitation was calculated on the basis of its load moment, providing a measure of how far the telescopic boom could be extended in every direction.

An alternative solution – fitting final switches to each stabilizer to automatically detect whether the

They may not actually carry people, but an overbalancing crane poses great risks. Moba's diverse range of products to fulfill functional safety requirements can therefore prove invaluable to OEMs

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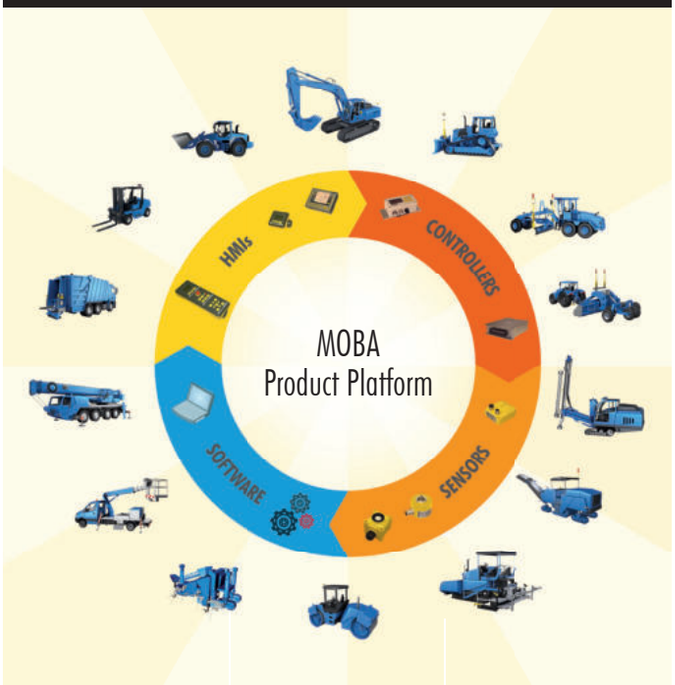

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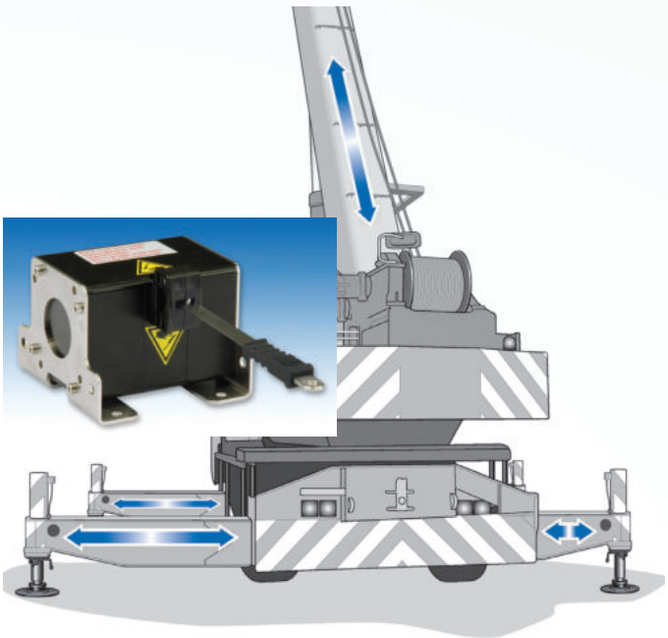
stabilizer is extended – is far more convenient for the user, who no longer needs to enter values manually. Using this approach, however, the switches can only detect whether or not the stabilizer is fully extended – if, for instance, space limitations mean that a stabilizer can only be extended halfway, this fact cannot be detected by the final switch. The system will then use the load moment set for unextended stabilizers, which in turn will mean that the actual maximum appropriate projection length is not calculated.

Lately, an increasing number of linear measurement systems – often cable sensors – are being employed to record stabilizer projection length. If such measures fulfill the requirement set for functional safety, then there is no longer a need for the user to confirm the crane's safe setup. The relevant machinery standards most often refer to EN 13849, requiring that the machinery satisfies performance level 'd' (PLd).



ABOVE: **ASM's WB21 tape extension sensor is ideal for use in environments where more delicate sensor types would struggle to survive**

Safety through redundancy

Although PLd requirements can also be fulfilled using a structure corresponding to Category 2, a Category 3 structure also has its advantages, in ensuring a twofold, redundant system architecture to provide reliable fault detection. This belt-and-braces approach ensures the proper functioning of the machinery control system and makes it possible to use the mobile crane more safely.

In the early years of automation of mobile machinery, most systems used for the purpose were analog in design, each containing redundant components; for example, two slope sensors and two controllers in order to monitor any tilting. Although this approach fulfilled functional safety requirements, it also required a great deal of effort.

Digital data transmission, though, reduced the effort required. The use of a CANbus greatly reduces cabling cost and allows new components to be added later. The advantage of a Category 3 structure is that CANopen is fault-resistant, real-time capable and easily extendable whenever necessary. So when that structure is retained, other, more flexible options open up, such as the easy integration of CANopen safety sensors with redundant sensors. Only a single CANbus is needed to allow the use of CANopen safety sensors (PLd) or to duplicate CANopen sensors. The cross-referencing of values returned by sensors, a job that is performed by redundant controllers, fulfills PLd requirements on functional safety.

While both sensor channels are connected to the same bus, they send their messages using two different node IDs. As this setup ensures reliable fault detection, it is considered PLd compliant.

In addition, this setup gives far greater freedom to select from the variety of different sensors on the market. It enables two normal, one-channel sensors or redundant CANopen sensors or even CANopen safety sensors to be integrated and combined without causing problems.

Redundant control systems such as this are already being used quite frequently in automating a variety of cherry picker platforms to meet the requirements on functional safety and have already proven themselves as reliable in practice.

Moba manufactures a diverse range of products that fulfill the requirements on functional safety. Redundant controllers and slope sensors are part of such systems, but there are also other specialized sensors that record loads and use ultrasound in a transmitter-receiver arrangement for the contact-free detection of stabilizer extension.

The company has also made a name for itself in operating units. Its modular console design based around CANbus has been given the Red Dot Design Award, and offers the possibility of designing a variety of specialized operating units, depending on user needs.

Tale of the tape

Launched at ConExpo 2014, the WB21 tape extension sensor from ASM provides up to 20,000mm measuring length in a compact housing. Due to the design of the sensor and the inherent strength of the stainless steel tape, they can be used in environments and areas where other sensors would struggle to survive, such as hard-to-reach areas where directional changing pulleys are used or where extreme temperatures cause problems such as icing. It is therefore perfectly suited for installation on cranes, excavators, forklift trucks, hoists and access platforms.

The lifespan of this range of tape extension sensors is totally unaffected by the use of pulleys, which makes them the perfect choice for safety-critical areas often found in crane operation.

This new sensor features a quality molded housing, which enables lower construction costs for a rugged sensor that meets a high sealing level of IP67/69K (operational) making it an affordable choice for today's demanding markets. It is also available with a choice of three analog and three digital outputs (SSI, CANopen or CAN J1939), and a linearity of +/- 0.10% with the option of redundant outputs.

Mounting anxiety?

While truck-mounted cranes have become an indispensable tool, with compact dimensions that enable them to be simply driven to the jobsite and put into position, the latest technology means that the operating range of the

boom can now be pushed to even greater limits. This becomes even more necessary when parked cars, trees or slopes prevent optimum positioning, or prevent outriggers from being completely extended.

Infinitely adjustable swiveling and telescopic outriggers, along with PLC controls and sensor technology make both positioning and operation easier. In Böcker Maschinenwerke's truck cranes, Wachendorff's WDGA absolute encoders employing Endra multi-turn technology are used to ensure boom stability.

Measurement values from different sensors are therefore continuously recorded and the current overturning torque and allowable, non-critical operating range calculated at all times. Due to the variable support system, the range is not necessarily circular – it can also be pear-shaped or elliptical, depending on how far each outrigger is extended. Before the system reaches critical limits, it locks automatically and will then prohibit any further movement or additional loads to be lifted. To do this, values such as the boom's incline and rotation angle are recorded – each one twice, and separately from the other.

"All safety mechanisms have redundant monitoring," confirms Dirk Seiger, who is responsible for electronic and control technology at Böcker. "Many of our cranes can be converted for use as work platforms in just a few steps. Even stricter safety rules apply then, as people are being carried."

Wind instruments

FSG Fernsteuergeräte provides a range of sensor components for crane systems including live ring encoders, anemometers, indicators and linear transmitters. Sensors are available with a variety of signal outputs or interfaces: 0-3.4V DC speed signal, 4-20mA, 4-20mA intrinsically safe with Atex certification, CAN network with CANopen protocol, and Profinet (optionally with Profisafe protocol).

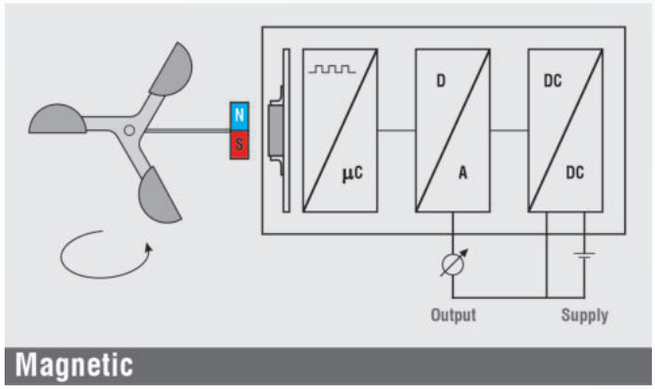
The company also provides live ring encoders with a spring-loaded external gear wheel that combine to detect the swing angle and speed of telescopic crane booms. The multi-turn live ring encoders can be connected to the gear rim of the boom drive to register its rotations, and are IP68-protected to withstand rugged environments.

For load calculations, FSG produces linear transmitters that detect load-dependent displacement in spring arms. These devices are available as potentiometric or inductive models.

The company's wind-warning systems ensure enhanced safety and enable monitoring in cranes and excavators by detecting windspeeds up to 50m/sec and wind directions from 0° to 360°. Anemometers are employed for detecting – and, in connection with the appropriate indicator – monitoring maximum wind velocity. The indicator contains an electronic LED circular bar graph display with a maximum limit value contact that can be adjusted from the outside. If the maximum value is exceeded, the potential-free contact is switched.

Windspeed is measured by means of a magnetic system; or, alternatively, users can choose a tachometer generator-based model. Wind direction is indicated by a wind vane.

The anemometer is available in two versions, one for installation on mobile crane jibs and another for pedestal or standpipe installation. Featuring an encapsulated housing, all versions are suitable for rugged environments: with the magnetic measuring system, they reach IP66 protection, or IP64 with a tachometer-generator. An optional, thermostat-controlled heater enables their use in temperatures as low as -50°C.



Magnetic

TOP: **Magnetic measuring of windspeed ensures an absolute wear-free recording**

ABOVE: **FSG anemometer is suitable for excavators as well as cranes**

LEFT & BELOW: **Wachendorff's WDGA absolute encoders ensure maximum boom stability on truck cranes from Böcker Maschinenwerke**

Users can select between a 4-20mA output with a two- or three-wire connection, a CANopen digital output or a Profinet interface (with optional Profisafe protocol).

The magnetic measuring system ensures an absolute wear-free and non-contact signal recording, which is reliable even under extreme environmental conditions. A corrosion-resistant cross arms-driven permanent magnet creates a signal change within the magnet sensor located inside a generally closed aluminum casing. A downstream processor converts these magnet pulses into an analog measuring signal or digitally coded (pulse output or CAN) signal. A tacho-generator incorporated into an aluminum casing is driven by the windspeed.

Being proportional to the windspeed, the output signal is taken in the form of a voltage in the two-wire circuit. **iVT**

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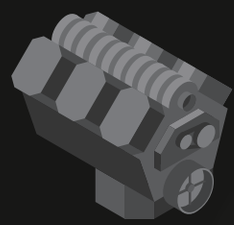

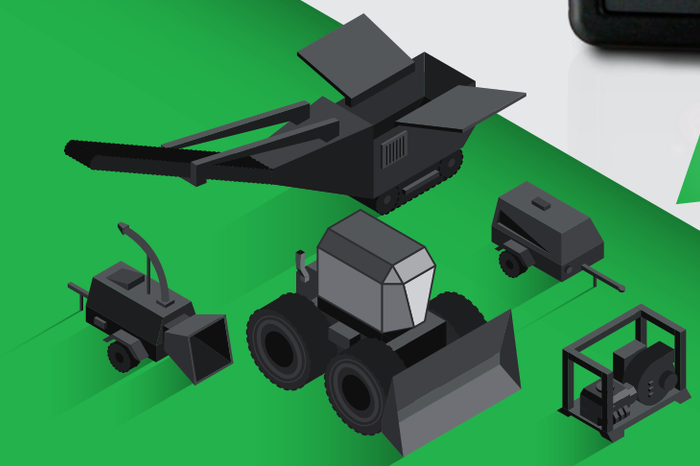

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MATCH MAKERS

WHEN SEVEN INTERNATIONAL AG EQUIPMENT OEMs AND TWO ASSOCIATIONS FOUNDED THE AEF IN 2008, THEY FOCUSED ON ONE TOPIC ONLY: ISOBUS. NOW THE ORGANIZATION HAS EXPANDED ITS SCOPE TO THE TOPIC OF COMPATIBLE HIGH-VOLTAGE TECHNOLOGY AND CAMERA SYSTEMS

There are few other sectors of the automotive industry under as much pressure to innovate as the agricultural sector. Ask a strategist at a tractor manufacturer about the future and you are immediately met with the response: "Increasing yields on smaller areas of land while using fewer resources."

This answer may seem cryptic to some, but it simply means that we have to find new ways to improve processes because current machines have only a limited potential for increasing yields. Probably the most promising approach is the use of electric drive technology, which has already revolutionized other sectors. Therefore, under the AEF (Agricultural Industry Electronics Foundation) umbrella organization, numerous companies are working toward a joint solution for a tractor outlet as a first step toward decentralized drive technology and the automation of agricultural processes.

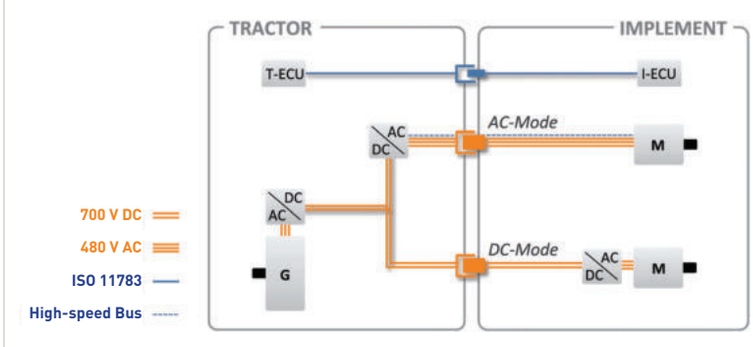
Flexible vision

In contrast with other industrial vehicles, the agricultural sector is dominated by machinery (tractors) that relies on attached implements. The currently established solutions, which rely on mechanical PTO shafts and hydraulic connections, are now approaching their limits.

This vision of more flexible tractor/implement combinations based on sensors requires special solutions, which is reminiscent of the decentralized drive technology used in machine tools, robotics and packaging machines. This requires a level of performance that, today, only electric drive systems are able to attain.

The many different types of motion that are necessary to carry out the diverse processes of ground cultivation, plant care and harvesting provide a rich field of activity for electric drive systems – from simple speed changes through to complex movement tasks.

The tractor is increasingly taking on the role of control station and energy supply. The need to transfer



energy between equipment produced by different manufacturers therefore led to concerted efforts to produce a standardized power interface. Under the umbrella of the AEF, 48 companies are currently working together on a power connection, which is intended to lead to a proposed standard. Just as for hydraulic or mechanical systems, the attached implements can also be operated via electric drives using the existing ISObus communication.

The high-voltage approach

When we talk about high-voltage technology on a tractor-implement combination, we generally mean voltages up to 700V DC or 480V AC. The aim is effectively to overcome the limitations of protective low voltages of up to 50V DC so as to enhance electrical performance of the attached implement.

The high-voltage power interface is being designed to provide 700V DC and/or 480V three-phase AC electric power. Which voltage will be present depends on the application and/or the tractor configuration.

If only DC voltage is provided, the redundant connector pins can be omitted. In 700V DC mode, the interface will drive the electrified implements, with one inverter per electric machine on the implement itself. The speed control of the electric machine is carried out on the implement independent of the tractor. The number of electric drive systems that can be powered is limited only by the maximum power that is made available by the tractor. However, an additional high-speed bus communication is not required for a pure DC system.

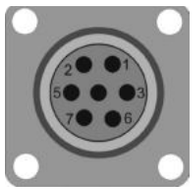
In 480V three-phase AC mode, inverters will be provided on the tractor to drive one electric machine per inverter on the implement. As the speed control of the electric machine resides on the tractor, a high-speed communication bus, included in the AEF AC/DC connector design, is required.

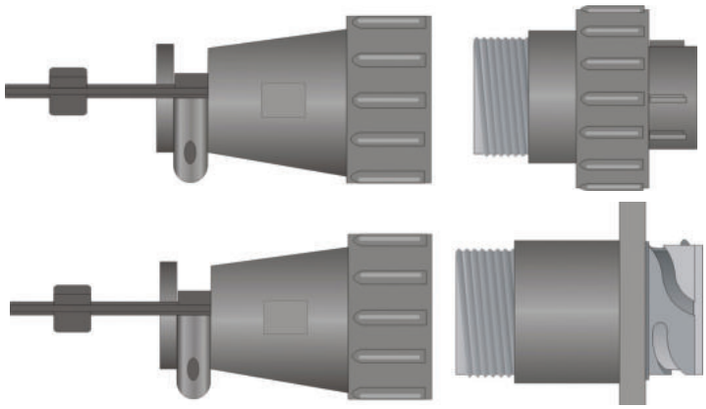
The existing ISObus, ISO 11783, will be used to enable the overall communication and to allow the control tasks between tractor and implement in this DC/AC high-voltage system.

The high-voltage interface will support both of these approaches and provide power up to 150kW. This means that, in the majority of cases, the maximum power is only restricted by the diesel engine and generator power. The prototype of such an interface has already been undergoing intensive field testing for two years. Currently, reducing its size and cost are the main focus, with the eventual aim being to approach

LEFT: **A field test of a Fendt tractor with an electric drive axle on the push-off trailer with DC power transfer**

BELOW LEFT: **A schematic diagram showing a high-voltage DC/AC system**





TOP (FIGURE 1): **Illustration of a male connector inside a tractor cabin**
ABOVE (FIGURE 2): **Illustration of a female connector on a video cable of a camera on the implement**
BELOW (FIGURE 3): **A connector pin assignment**

Pin	Pin assignment
1	+ Switched power supply camera
2	Reserved for future assignment by AEF
3	Analog video ground CAM 1 (standard)
4	Analog video signal CAM 1 (standard)
5	Analog video ground CAM 2 (optional)
6	Analog video signal CAM 2 (optional)
7	Power supply camera

ABOVE: **An Amphenol tractor connection terminal**

the standardization bodies with a proposed standard in 2015.

Cameras no longer obscure

The increasing demand for cameras on agricultural implements and the large number of camera brands that are available to the market, together with the wide variety of terminals and monitors in tractor cabs, has now raised the issue of incompatibility. In order to enable users to connect cameras mounted on any implement to terminals or monitors with analog video inputs installed on any tractor, the association has recently begun to address this issue within a dedicated project group.

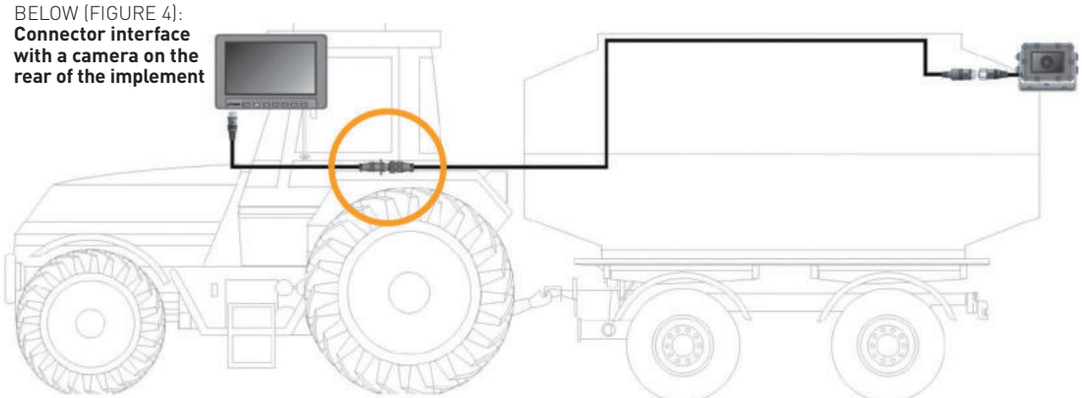
The AEF Camera Systems project team was charged with the task of developing a guideline for a standard camera connector interface between tractors and implements. Including experts from global manufacturers of tractors, implements, camera systems and connectors, the team tackled the task in several steps; the first being to define the scope of the project. In the second step, technical and commercial requirements that a connector interface for cameras has to meet were identified.

The team then surveyed the market for existing solutions, and developed a scorecard to evaluate and compare connector models, which finally led to a unanimous decision for a particular connector design.

During the project, several conditions were established that impacted the scope of the project. First, in order to reach a fast solution, it was decided to initially focus on analog camera systems and address digital systems in a second phase. Another measure to ensure speed was to look for a solution that already existed and has been proven in the market. This provided additional benefits, such as avoiding tooling investments and validation cycles.

Second, due to space constraints and the likely overload of numerous connectors on the back of tractors, it was decided to go for an in-cab-mounted solution. Finally, because one standard will never be able to cover all possibilities, it was agreed to standardize only the analog video connection, without addressing the auxiliary functionalities, such as the audio signal, power lines to switch actuators and control lines, or control networks for multicamera systems.

BELOW (FIGURE 4): **Connector interface with a camera on the rear of the implement**



The solution

After the definition of the technical and commercial requirements, and completion of the evaluation of various existing solutions, the camera systems team decided on the best solution and created an *AEF International Guideline* document detailing the new camera connector interface between tractors and their implements. Figures 1-4 are excerpts of this guideline.

Once the manufacturers of tractors and implements have applied this guideline, machine owners will be able to connect cameras with terminals or monitors regardless of the supplier or brand of the components.

This will give equipment owners much more freedom and flexibility when it comes to choosing their preferred combination of cameras and terminals independent of suppliers. After all, the greater ease of installing camera systems will lead to an increasing installation rate, which in turn will enhance the safety on and around tractors and their implements, ultimately leading to a reduction of accidents caused by agricultural machines.

Standardized communication

Established as a 'round table' of the agricultural industry by seven leading companies and two trade associations, the AEF makes the ISObus technology defined in ISO 11783 come to life.

ISObus preferentially standardizes the communication between tractors and implements, but also the data transfer between those mobile systems and farm management systems, thereby ensuring far greater compatibility.

The voluntary association of more than 150 companies from the ag industry and their suppliers has recently introduced a Conformance Test for the AEF ISObus Certification of tractors and implements. The results of these tests will be stored in the freely accessible AEF ISObus Database, www.aef-isobus-database.org, that can be used to check the compatibility of machinery.

A certification label has also been issued, which marks AEF certified products. Go to www.aef-online.org for more information. **iVT**

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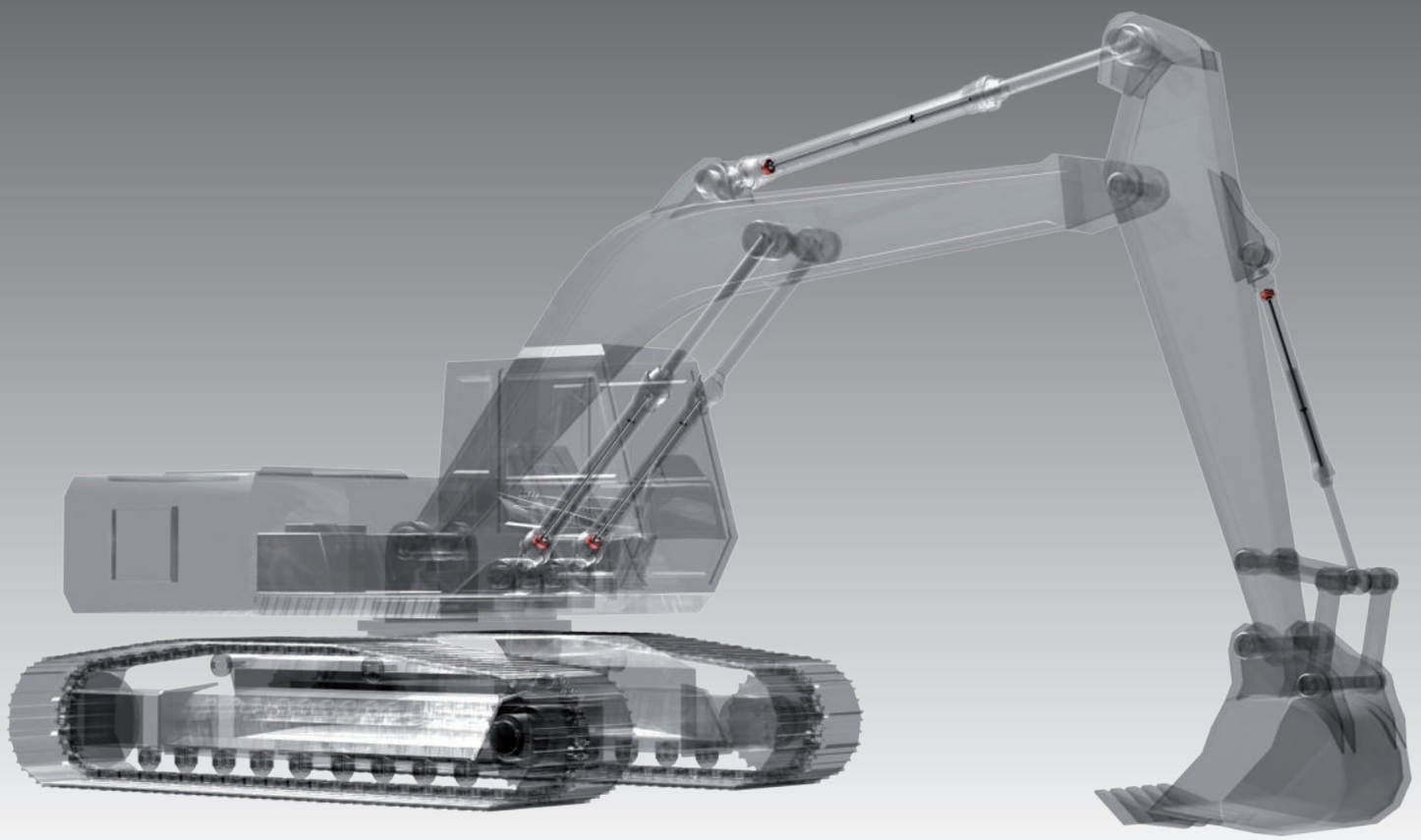

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For any mobile hydraulic or lubrication system, the development of a target cleanliness level – and planning how to achieve it – is just as much a part of system design as the selection of the pump, valves, actuators and bearings.

In most systems that suffer from contamination problems, the cause is likely to be either poorly conceived filter placement, whether because of a lack of understanding of the dynamics of fluid flow, or the inability of the filter elements to maintain their high performance levels throughout their service life in the system.

The proper selection and placement of contamination control devices in a system to attain the targeted cleanliness will help eliminate (the root cause of) up to 80% of hydraulic system failures.

Further down the line, the system cleanliness approach helps afford the end user of the vehicle a cost-effective approach to contamination control that means the price of the filters and elements can be quickly recovered by the savings resulting from improved vehicle performance, increased component life, increased oil life, increased uptime and fewer repairs being required.

Leave it out

There are four primary ways for solid contamination to enter a hydraulic fluid/circuit: contaminated new oil, built-in contamination, internally generated contamination and ingested contamination. Each of these sources needs to be understood, as each is a major consideration in filter placement.

New machinery will inevitably contain a certain amount of built-in contamination, inadvertently left in the system or a component during initial assembly or a system rebuild. Care taken in system assembly and in new component flushing reduces this but never eliminates it.

Typical built-in contaminants can include burrs, chips, flash, dirt, dust, cleaning rag fibers, sand, moisture, pipe sealant, weld splatter, paint and flushing solution.

The amount of contamination removed during the system flush depends not only on the effectiveness of the filters being used, but also the temperature, viscosity, velocity and 'turbulence' of the flushing fluid.

Unless high velocities and turbulence are attained, much of the contamination will not be dislodged until the system is in operation, with catastrophic component failure being a possible result. Irrespective of the standard of flushing executed by the machine builder, an off-load period of running-in should be regarded as essential for any new or rebuilt hydraulic or lubrication system.

Contamination from the immediate surroundings can also be ingested into the fluid power or lubrication system. For off-highway equipment, in particular, there is a wide variation in environmental conditions by application, location and even by weather conditions.

There are four major ways that dirt can be ingested into a system: via reservoir vent ports (breathers), power unit or system access plates, components left open during maintenance, and cylinder seals. The key is to restrict the access that


F
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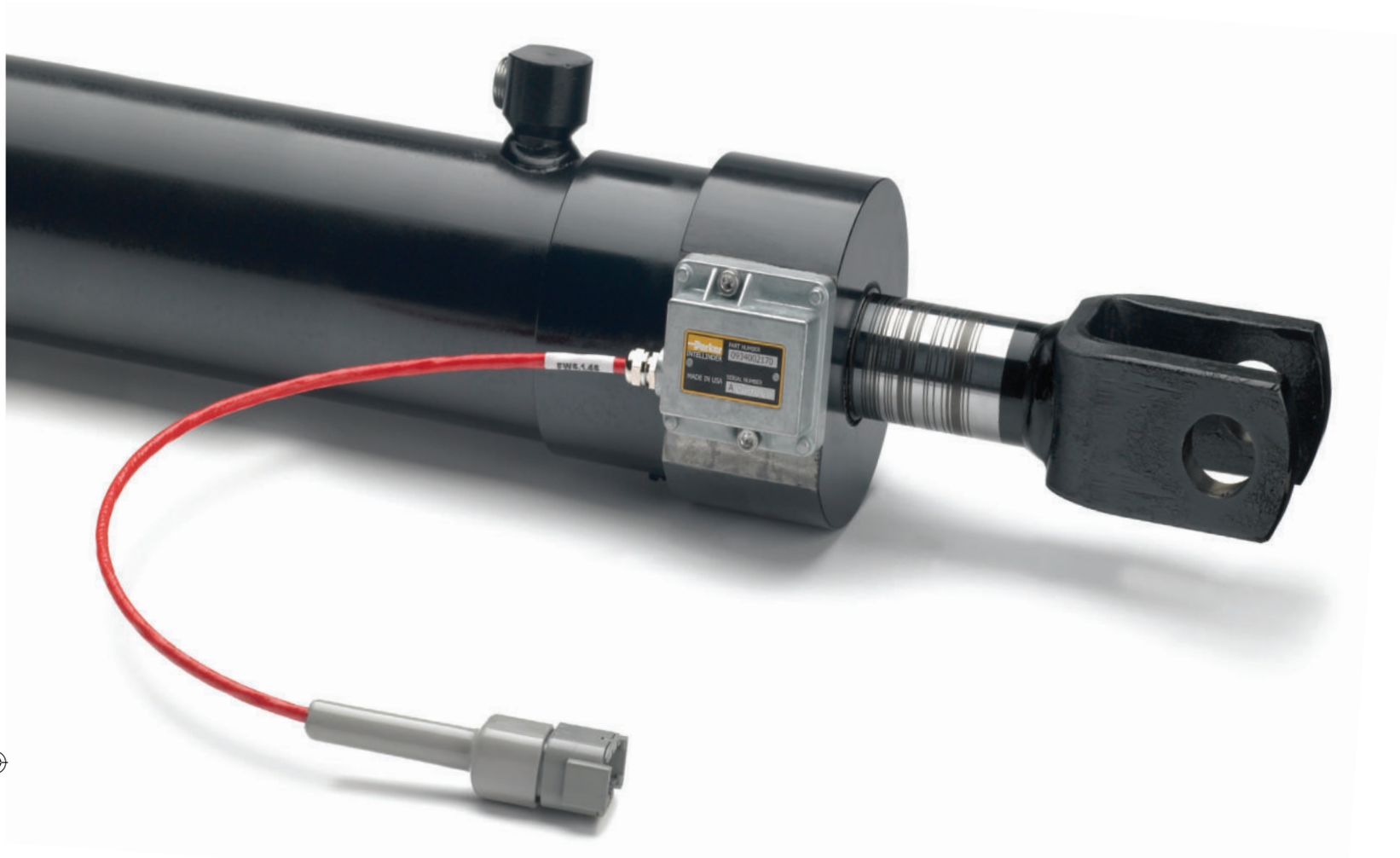
CLEAN
CRITICAL
OIL CONTAMINATION LEVEL
F
E



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environmental contamination has to enter the system.

However, the most dangerous contamination to a system is that which is generated by the system itself – caused by wear, corrosion, agitation, fluid degradation or oxidation. These particles are 'work hardened' to a greater hardness than the surface from which they came, and are very aggressive in causing further wear in the system.

In a system running on properly cleaned fluid, very few particles are generated, although all components (especially pumps) create a small amount of particles during routine operation. In a system where these particles are not quickly captured, the elevated contamination levels will cause the number of additional generated particles to increase at a highly accelerated rate.

The best way to prevent contamination generation within a system is therefore to start with a clean (fully flushed) system and keep the system fluid clean, while the end user should monitor the condition of the fluid regularly.

Good intentions

Nevertheless, however desirable it may be to assemble any component or system using optimum parts in the confines of a clean, controlled manufacturing environment, this may not always be possible.

Even if the fluid is stored under reasonable conditions, the principal contaminants upon delivery to the machine may still include rust, scale, fibers and sand.

Many of the particles resulting from built-in contamination – specifically particulate contaminants such as weld splatter, dust, fibers and paint chips – are below the human visual threshold of 40μm. But although they cannot be seen, they can still be damaging to a hydraulic system.

It therefore often becomes necessary for the entire hydraulic system to undergo a clean-up process after final assembly so as to reach the desired roll-off cleanliness level. Adherence to these levels will provide the OEM with a better product and fewer warranty claims.

The main purpose of roll-off cleanliness is to minimize damage to the various system components in their infancy. To underscore the importance of establishing roll-off cleanliness standards, the ISO has been developing new standards that outline the cleaning of components and systems.

One standard, ISO 16431:2012 (Hydraulic fluid power – System clean-up procedures and verification of cleanliness of assembled systems), describes 'roll-off cleanliness of an assembled hydraulic system upon release from the production area', highlighting the need to provide the customer with the cleanest possible equipment.

There are many ways to clean a system, and it is up to the OEM to decide which method(s) to use. The goal is to reach the desired cleanliness level at the most reasonable cost and minimum time interval.

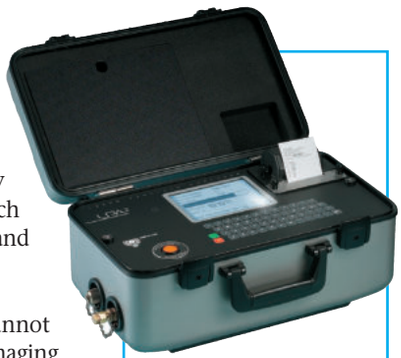
One method is to let the system run through its normal operating cycle and to let the system filter(s) clean the fluid. The hydraulic system will operate at low pressure during the cleaning/flushing process.

The primary advantage of this method is simplicity. However, a typical disadvantage is that the system filter(s) might not have sufficient dirt-holding capacity to last through one cleaning. In fact, several element changes may be necessary to clean a dirty system.

This method may also damage system components if the initial contamination level is too high.

An alternative is to use a filter cart, sometimes referred to as a filter buggy or kidney loop (following the idea of kidney dialysis). This mobile, self-contained unit filters the fluid off-line using its own pump, motor and filter. It is designed to operate at a low pressure – usually less than 100psi.

The best way to use this device is to attach its suction and return hoses to the reservoir with fluid fittings and let it run while the system is running at a low pressure. Oil returning to the reservoir from the return line will now be filtered through the filter cart. This off-line process supplements system filter(s) and decreases clean-up time. However, this method may also damage system components.



TOP: **MP Filtri's LPA2 is a highly precise, lightweight and fully portable twin laser particle analyzer and particle counter suitable for on-site and laboratory applications**

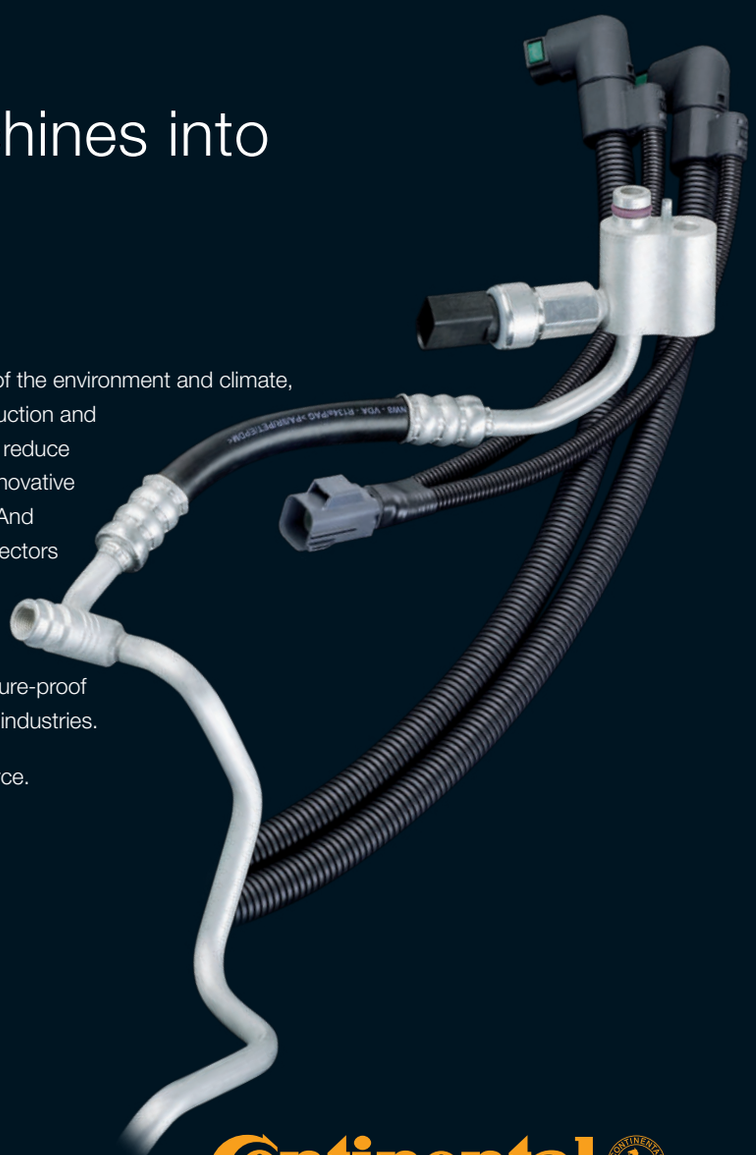
ABOVE: **MP Filtri's ICM (Inline Contamination Monitor) measures and displays particulate contamination, moisture and temperature levels. It is designed specifically to be mounted directly to systems where ongoing measurement or analysis is required**

OUT WITH THE OLD...

One often-overlooked way to make off-highway machinery more efficient and cost-effective could be a simple change of hydraulic fluid. Evonik's Dynavis is an additive technology for hydraulic fluids that boosts their performance by optimizing their properties over a wider range of application temperatures. Because the hydraulic pump is subject to internal leakage, the longer and more intensively the equipment is used, the hotter the fluid becomes and the higher the loss of efficiency. But Dynavis technology goes beyond reducing internal efficiency loss: it also breaks the vicious cycle in which hot hydraulic fluid is heated further. With Dynavis, pump output remains stable even after several hours of operation under full-load conditions. The equipment's increased agility and performance results in more completed load cycles – and fuel savings of 5% or higher.

In the first field test of high-performance hydraulic fluid formulated with Dynavis, operators noticed a big difference compared with conventional fluid. Extensive and numerous field tests followed, which confirmed these initial findings over and over again. Experienced operators are excited about Dynavis. "I was amazed at how much faster I can work … with a standard fluid I could move 96 shovels in about 20 minutes; with Dynavis I could do 130 in the same time," says Friedel Brandt, an excavator operator for the past 30 years and winner of the Cat Operator Competition.

We Turn Strong Machines into Clean Power Packs



To satisfy the stringent guidelines for protection of the environment and climate, we have improved our clean solutions for construction and agricultural equipment: The air conditioning lines reduce CFC emissions by as much as 95% thanks to innovative technology – an extremely thin film barrier layer. And the SCR lines, equipped with heated quick connectors that ensure optimized contact, meet the latest emission limits specified for modern engines. Our hoses, hose lines and connection elements contribute substantially to the construction of future-proof and eco-friendly vehicles and machines in many industries.

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A third solution is to design an off-line filter that can be attached to the system at system pressure, connected in such a way that it becomes the power supply. The equipment can be cycled using hydraulic power from the off-line system.

The main system does not need to be run, except to remove oil from the lines that are not in circulation. The cart flow is not required to be as large as the system flow, as the idea is to cycle the system for flushing purposes, but not necessarily as fast as at normal operating speed. This method will minimize damage to system components.

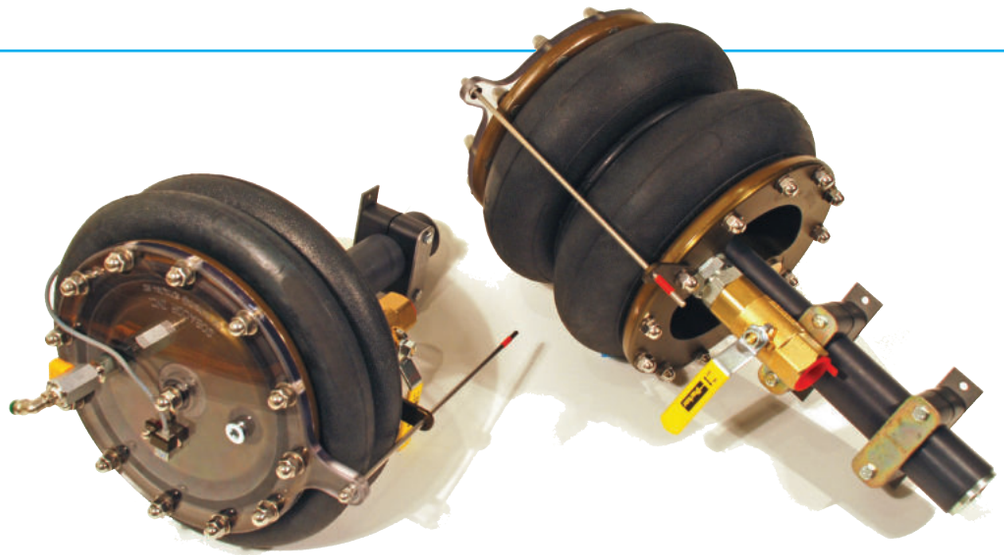
It is not, however, economically feasible to remove all contaminants. Most systems can operate trouble-free despite a small amount of contamination – the level that can be tolerated depends upon the sensitivity of the most critical component.

System reliability continues to improve, however, as ideal conditions are reached. Diminishing returns on increasing effort is the limiting consideration. This threshold for the contamination level is established by the component manufacturer and ultimately by the system builder.

The size and type of filter used are vitally important when making calculations for cleaning a system. The analysis presented here makes use of the following assumptions:

• Contaminants are uniformly distributed in the fluid;

RESERVOIR CLOGS?



Onboard storage is another area where the efficiency of hydraulic fluids can be affected – or enhanced. In fact, reduced contamination is just one advantage of Smart Reservoir's innovative Variable Volume Reservoir (VVR), a reservoir a fraction of the size of the conventional hydraulic oil reservoir it can replace on mobile and stationary applications. Available in 7 or 14-liter capacities, they are light at 16 and 30kg respectively (with full oil content) and on certain applications can replace conventional hydraulic oil reservoirs that can be 30-40 times larger

Key to the concept is the flexible chamber, which expands or contracts as cylinders are activated or as the fluid's temperature changes. Being sealed, slightly pressurized (0-0.6 bar) and airless means the VVR can dramatically reduce solid contaminant ingestion and oxidation, which can increase fluid life by four to five times. No exposure to air, humidity or contamination allows a greater life expectancy for mineral and biodegradable fluids in particular.

And with moisture exposure totally eliminated, it is reasonable to expect reduced filtration costs and longer-lasting hydraulic components.

The VVR maintains a relatively constant pressure at the pump inlet, supercharging the pump(s) and making cavitation impossible, whatever the altitude and angle of the reservoir. The pressurization is generated mechanically by a spring and is not affected by temperature or ambient pressure.

The VVR can handle any flow and was successfully tested for six weeks with a Hagglunds MB283 (500hp) hydraulic drive, using just over 4 liters of hydraulic oil instead of the 300 to 450 liters normally required based on a pump flow of 150 l/min.

ON THE WEB

Link to HydroDynamic Buggy video via:
www.iVTinternational.com

Fluid enters the reservoir only when volume compensation is needed (i.e. a cylinder in motion) and/or for thermal compensation; otherwise the returning flow goes direct to the pump inlet (closed loop). Unlike the traditional reservoir rule of thumb where returning oil goes into a dwell time of two or three minutes before going back into the network, the VVR's oil goes into a continuous loop.

Traditional reservoir rules must be re-evaluated from old beliefs – e.g. the dwell time will contribute in settling contaminants. With today's micron size filtration mixed into viscous fluid, that is doubtful. Convection cooling capacity of these reservoirs is poor in comparison with high-performance coolers.

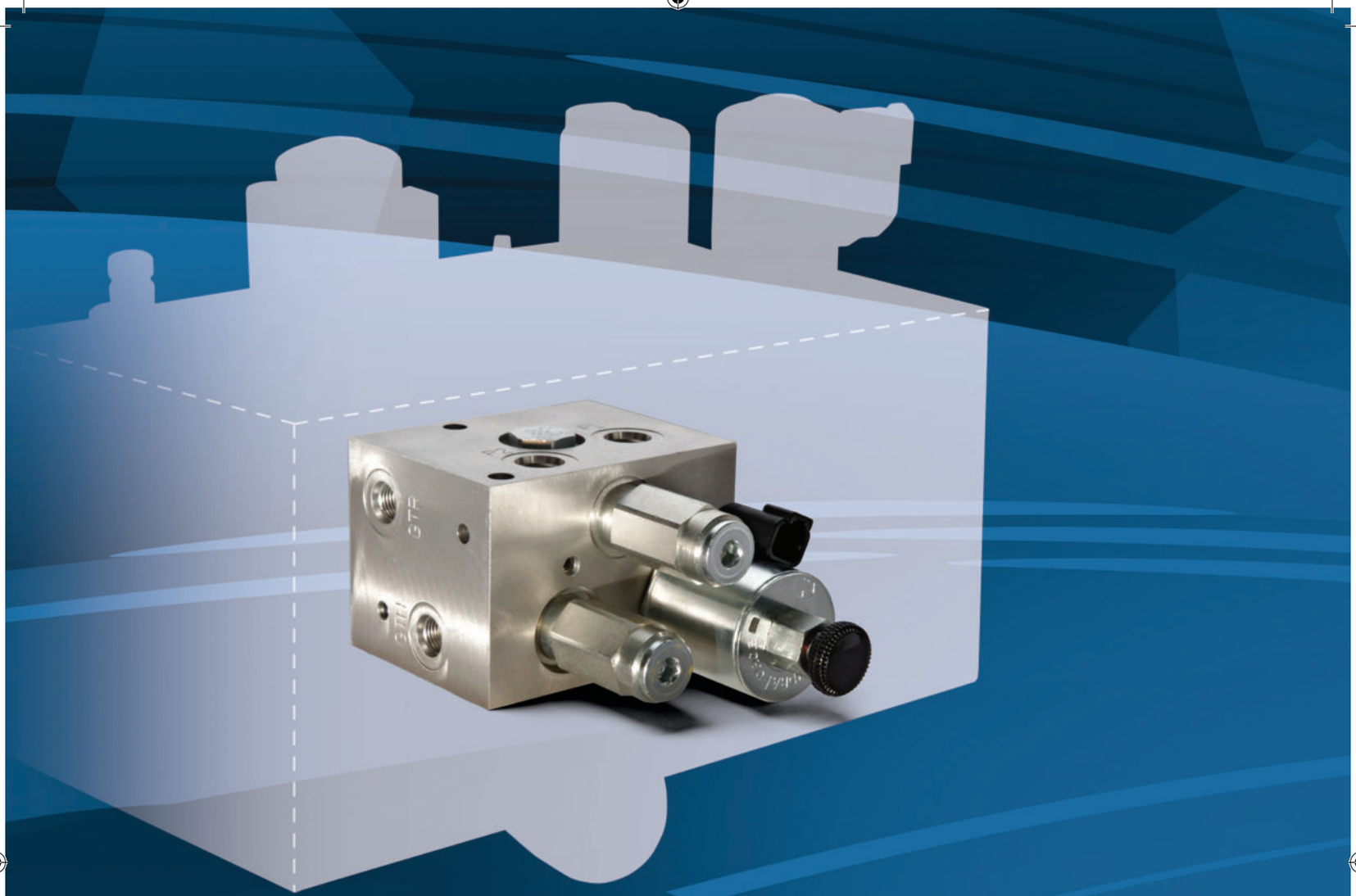
The appropriate VVR size is determined by two factors: the maximum total differential volume generated by cylinders (rod volume) and the system fill volume, as the oil will expand by a maximum of 10% between -25° to +105°C. Typically, when a VVR is used with applications using cylinders, 75% of capacity will be reserved for the differential volume, while the remaining 25% will be kept for fluid thermal expansion.

One obstacle to widespread adoption of the VVR is that there is still a belief that reservoirs efficiently cool the oil and allow particles to settle – but as reservoirs will always be affected by the ambient temperature where they sit, they can only cool the oil marginally.

Selecting the right oil cooler will provide 100% of the cooling required, regardless of the reservoir size in any climate, while today's filter technology means that contaminant decantation/sedimentation is no longer part of the equation – the smallest particles would take days to settle.

Depending on the size of the oil reservoir being replaced by the Variable Volume Reservoir and the type of oil used, a VVR can provide fast payback. When replacing reservoirs of 200 liters or more, the VVR will typically pay for itself within the second or third oil fill when using mineral oil, which will be less than two years in most cases.

For larger reservoirs, or users of more expensive biodegradable oil, payback can be achieved at the first oil fill. Given that 30 times less oil may be required and it can last up to five times longer, that can result in about 120-150 times less oil being needed.



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When you incorporate a multi-function hydraulic cartridge valve solution in your machine design, you can reduce manifold size, the number of ports, and machining costs, while increasing flow passage efficiency. HydraForce multi-function valves incorporate two or more functions into a single valve, allowing for the design of a lighter, more compact valve package. The result is more responsive machine performance and efficient use of available horsepower. Discover a more efficient manifold solution at **hydraforce.com/Multi-Function_valves**.

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• During the roll-off cleaning phase, no additional contaminants enter the system;
• The filter exhibits uniform efficiency throughout its working life;
• The filter does not go into bypass. If it does, the element is replaced.

In order to avoid filter element change during the roll-off clean-up, the filter must be adequately sized. It has been observed that contamination may inadvertently be added to the system during element changes.

Don't settle for less

Generally, after a hydraulic system has reached the required cleanliness level, the system has been running for a considerable amount of time, and at working temperature. The hydraulic media and the particulate contamination are homogeneous, or evenly mixed. Therefore, when the hydraulic system is shut down, the particles will settle in the reservoir, hydraulic components and system pipework.

When start-up is then initiated, the particle and hydraulic media are no longer homogeneous. This can then lead to initially high levels of contamination for a considerable length of time until the system is back up to temperature, and the particles and hydraulic media are once again homogeneous

Real applications will, of course, vary from this idealization to some degree, although the variation is not expected to significantly affect the outcome.

But the adoption of proper roll-off cleanliness procedures protect equipment in its infancy and result in fewer warranty claims. The end-customer is ultimately provided with a high-quality system with clean components that meet his initial use needs. Roll-off cleaning, however, is only the starting point for trouble-free system operation.

The final responsibility in controlling contamination lies with the user, who must maintain proper filtration and practice responsible contamination control in the system to keep the hydraulic fluid clean. Once the vehicle enters operation, the final – though ongoing – step is to confirm that the target cleanliness level is being maintained. **iVT**

Thanks to Eaton Hydraulics and MP Filtri for their contribution to this article

TOLERABLE SOLUTIONS

Eaton's pumps, motors, transmissions, valves, cylinders, controls, hoses and fittings offer a combination of proven technology and innovative design that translates directly into enhanced uptime and reliable performance.

While all of its components are designed and manufactured to high standards that maximize their dirt tolerance – special materials, surface preparations, and flow paths are used to ensure reliable operation – all of them operate best on properly cleaned fluids.

"In any hydraulic system, whether it's on a combine harvester in Russia's vast farming region, a sugar cane loader in Egypt, or a skid-steer loader, I believe the cleaner the fluid, operating lifetime and overall performance of the system will be far superior," says Richard Jacobs, president of Eaton's Hydraulics Business in EMEA.

"Fluid cleanliness is the lifeblood of a healthy system. That it's acceptable to operate outside the manufacturer's guidelines for fluid cleanliness? It's a complete myth!

"But whether you need a single component, a custom-engineered solution, or anything in between, we are the partner of choice for mobile applications that simply have to work."

THE ISO CLEANLINESS CODE

I was once in a meeting with a group of managers when a vendor began to talk about the ISO Cleanliness Code, *writes Dan Helgerson*. As a Certified Fluid Power Accredited Instructor (AI), I immediately saw this as an obvious teaching moment, so I enquired, "Does anyone here want to know what those numbers mean?" The answer was a quick and resounding, "No!"

But the ISO Cleanliness Code is the industry standard, so we ought to know what it means. Basically, by looking at particles in three different size groups and then seeing how many of them are in a specific volume of fluid, we can make an evaluation of the overall condition of the fluid. The sizes chosen are 4, 6 and 14μm, with 100ml of fluid being sampled.

A fancy machine looks at the sample and counts the particles it sees – but rather than providing the actual particle count, it is described in terms of how it relates to the factor of 2. For example, if there were 512 counted particles in a 100ml sample of fluid, there would be 2x2x2x2x2x2x2x2x2 or 2^9 number of particles and we are given the number 9 as the count. This represents the number of times 2 would be multiplied by itself to equal the particle count. But… this does not mean that 512 particles were counted; it means that between 2^8 and 2^9 particles counted, or somewhere between 256 and 512 particles. Adding another layer of complexity, that is the maximum contamination level expected to be found in only 1% of the sampling. So, the 9 means that we can expect to find between 2.5 and 5 counted particles in every 1ml of fluid.

As an example, let's say we have a test result that shows a cleanliness level of 17/13/9. That doesn't *exactly* tell us anything – what it gives us are two categories for describing the cleanliness of the fluid. It provides information on the size and quantity of particles in the system. The first number represents the range of particles that are 4μm or larger in 1ml of a sample fluid – but not a precise number of those particles. The second number represents the range of particles that are 6μm and larger, and the third number represents the range of particles that are 14μm and larger. Therefore, the numbers will always be in descending order as each number includes the particles in the next group. Remember, the number is the power to which 2 is multiplied. That result is then divided by 100 and rounded to give the maximum number of particles of a certain size and larger that you would expect to find in 1ml of fluid. The actual particle count would be somewhere between half of that number and that number.

In a 17/13/9 result, the particle count includes all sizes 4μm and larger represented by 17. That means we have a maximum number of particles 4μm and larger of 2^{17}/100, or 131,072. Divided by 100, we get 1,312, so the maximum number of particles 4μm and larger in the sample would be 1,300 (due to the rounding off). The minimum number of particles 4μm and larger would be 2^{16}/100 or 655 (but, because of the rounding, the number used is 640). The bottom line is that the 17 tells us that we have somewhere between 640-1,300 particles 4μm and larger in a 1ml sample.

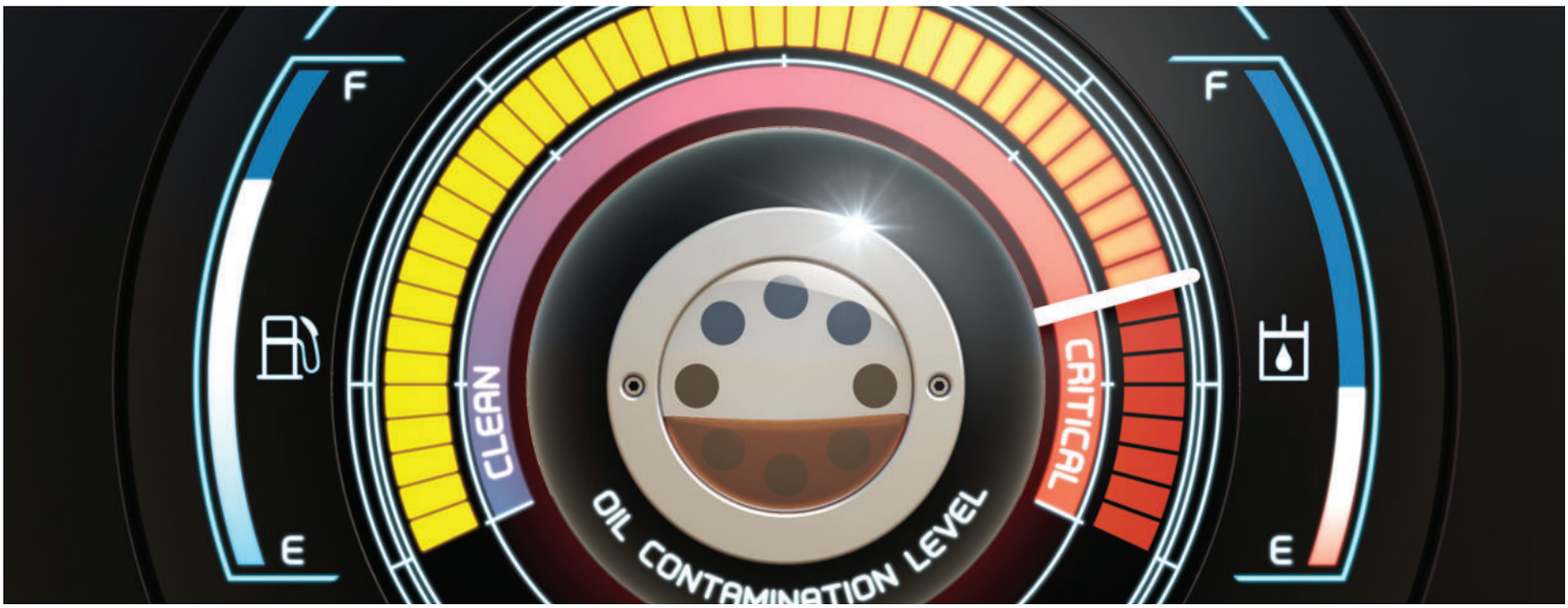
The 6μm and larger particle count is represented by 13 so those particles would number anywhere between 40 and 80. The 14μm and larger particle count is represented by 9, so there would be 2.5-5 particles of that size.

This is where we need to be careful. The difference between 17/13/9 and 18/13/9 could mean as many as 1,200 more particles, or it could mean just 1 more particle. That is why it is important to get sampling over time.

Table 1 (overleaf) shows the code numbers and what they mean. The number color matches the highlighted row on the chart.

Now that we have a way of describing the contamination level, how do we determine what the level ought to be? Different components have a different tolerance for contamination. A system with a gear pump, poppet valves and cylinders will not require the same cleanliness as a system using piston pumps, servo valves and piston motors.

Studies to determine the cleanliness level required for various components resulted in a chart (Table 2, p46) that helps us know how clean a particular system needs to be. We can now set a target cleanliness level based on the contamination tolerance level of the most sensitive component in the filtered fluid stream. We can also isolate and target super-sensitive components and provide them with their own dedicated filtration systems.



DIRTY ROTTEN SCOUNDRELS

DON'T BE FOOLED BY APPEARANCES – THE ENEMY MAY BE HIDING IN PLAIN SIGHT, SAYS DAN HELGERSON OF THE INTERNATIONAL FLUID POWER SOCIETY

It is generally well known that the primary cause of failure in fluid power systems is contamination. Yet, I once went to visit a customer who had purchased a used log loader, fitted it with a new gear pump – while leaving the fluid and everything else unchanged – and then discovered that the pump was failing after less than a week!

I opened up his pumps and knew immediately that the problem was contamination, but was not sure of the source. When I mentioned that I did not see a filter, he informed me that he had clean oil and did not need one. How did he know his oil was clean? He said he had taken the cover off the reservoir and felt the oil! It felt clean, so he knew he did not need a filter.

The problem with contamination is that there will never be a bunch of uniformly shaped and sized ball bearing-style particles in the fluid. Contamination is the irregular-shaped debris resulting from wear, assembly, dust in the air, and/or anything else that can break loose and be caught up in the fluid stream, and ranges from the miniscule up to big chunks.

What my customer didn't realize is that the particles that do the most damage in fluid power systems are the ones between 10-25μm in size. The smallest particle that can be seen by the unaided human eye is about 40μm, and a red blood cell is about 7μm. If the particles that do damage are not much bigger than a red blood cell, then feeling the oil is not going to provide very valuable information about its cleanliness.

"I KNOW MY FLUID IS CLEAN BECAUSE I HAVE A 3μm FILTER." (YOU CAN SUBSTITUTE THE MICRON RATING OF YOUR CHOICE HERE, BUT IT'S STILL THE WRONG ANSWER)

Particles below 10μm tend to be too small to get jammed between the mating surfaces of components. As long as the fluid keeps moving, they stay suspended and just pass on through the narrow passageways. The particles over 25μm tend to be too big to fit between the mating surfaces. They remain in the fluid stream and get dumped back into the reservoir, unless of course some clever salesperson managed to foist a filter into an unsuspecting customer's circuit.

The particles that really tear up a system are the ones that can get

ISO Code 17/13/9

Code	2 to code power	Actual particle count
6	64	0.32-0.64
7	128	0.64-1.3
8	256	1.3-2.5
9	512	2.5-5
10	1,024	5-10
11	2,048	10-20
12	4,096	20-40
13	8,192	40-80
14	16,384	80-160
15	32,768	160-320
16	65,536	320-640
17	131,072	640-1,300
18	262,144	1,250-2,500
19	524,288	2,500-5,000
20	1,048,576	5,000-10,000
21	2,097,152	10,000-20,000
22	4,194,304	20,000-40,000
23	8,388,608	40,000-80,000
24	16,777,216	80,000-160,000

TABLE 1: **Explanation of ISO codes (color-coded example)**

jammed between the moving parts. These particles are nasty looking, with sharp edges. When they get crunched between a valve spool and a housing, they may well take a chunk out of the housing or etch away at the sharp edges of the spool. Then they create more nasty little particles! Once the process starts, if left unchecked, the fluid will be ready to fail even the most stringent 'feel test'.

Now this is not to say that the smaller particles are not an issue. They are. As a matter of fact, the newest ISO cleanliness standards (see Table 1, above) require us to keep track of those little bitty particles below 5μm. When the fluid is moving at high velocity, these particles act rather like a sand blaster and eat away at the surfaces as they zip by. If that wasn't bad enough, they will also collect in the nooks and crannies and can make a spool stick or clog up an orifice.

Filter tips

The other wrong answer that I often hear is, "I know my fluid is clean because I have a 3μm filter." (Feel free to substitute the micron rating of your choice here, but it's still the wrong answer.)

Having a filter does not ensure clean fluid. The best filter on the planet will struggle to keep your fluid clean if it is bypassing or sited in the wrong location. Most filters have a bypass spring inside so that, when the filter begins to fill up, it doesn't cause an excessive amount of backpressure. The bypass spring enables the fluid to go around the filtering element and head on

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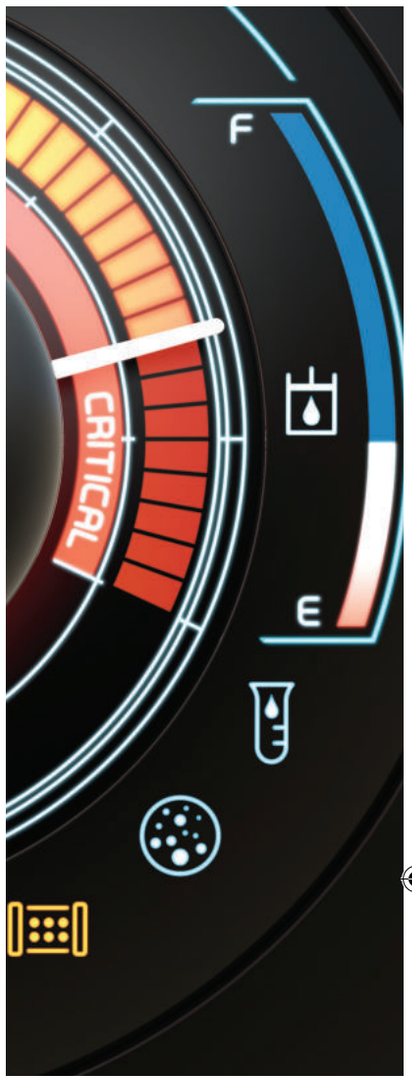
PUMPS			
Pressure	<2,000psi (<140 bar)	<3,000psi (<2,100 bar)	>2,000psi (>140 bar)
Fixed gear	20/18/15	19/17/15	18/16/13
Fixed vane	20/18/15	19/17/14	18/16/13
Fixed piston	19/17/15	18/16/14	17/15/13
Variable vane	19/17/15	18/16/14	17/15/13
Variable piston	18/16/14	17/15/13	16/14/12
VALVES			
Directional (solenoid)		20/18/15	19/17/14
Pressure (modulating)		19/17/14	19/17/14
Flow controls (standard)		19/17/14	19/17/14
Check valves		20/18/15	20/18/15
Cartridge valves		20/18/15	19/17/14
Screw-in valves		18/16/13	17/15/12
Prefill valves		20/18/15	19/17/15
Load-sensing directional		18/16/14	17/15/13
Hydraulic remote controls		18/16/13	17/15/12
Proportional directional (throttle)		18/16/13	17/15/12
Proportional pressure controls		18/16/13	17/15/12
Proportional cartridge valves		18/16/13	17/15/12
Proportional screw-in valves		18/16/13	17/15/12
Servo valves		16/14/11	15/13/10
ACTUATORS			
Cylinders	20/18/15	20/18/15	20/18/15
Vane	20/18/15	19/17/14	18/16/13
Axial piston motors	19/17/14	18/16/13	17/15/12
Gear	21/19/17	20/18/15	19/17/14
Radial piston motors	20/18/14	19/17/15	18/16/13
Swashplate motors	18/16/14	17/15/13	16/14/12
HYDROSTATIC TRANSMISSIONS			
In-loop fluid	17/15/13	16/14/12	16/14/11

This information was taken from the Certified Fluid Power Electronic Specialist Study Manual dated 12/18/09, pages 10-30.



ABOVE (TABLE 2): **Target cleanliness level for components at various operating pressures**

through the system, still carrying its contaminants.

Ironically, filters tend to filter better as they get dirty, because the elements are made up of material that is full of little tiny holes with somewhat irregular shapes. When the irregularly shaped particles get stuck in these holes, the average size of the holes gets smaller and smaller, making the filter more and more efficient. However, this cannot go on indefinitely. At some point, the backpressure builds to a critical level and something has to give – hopefully the bypass spring.

So, what is the right answer to the question of how to be certain fluid is clean? The answer is, "Have it tested." Fluid testing is the only way to ensure a proper level of cleanliness based on the level of sophistication of the working components.

It is important to get the sample out of the working fluid because in fluid that is at rest, for example, in the reservoir or during a shutdown, the particles may have settled to the bottom of the reservoir, making the fluid appear cleaner than it really is.

You can test the fluid with your own equipment or send it out to an independent lab. You need to find out about the size and number of particles that are in the fluid, as well as the type of particles that are in the fluid. This will provide valuable information as to what components are wearing out and so can help in planning scheduled maintenance.

It will also reveal whether airborne contaminants are getting into the fluid so you can check to be sure your breather is filtering properly.

The fluid should also be sent to the fluid manufacturer for testing to be sure it still has the correct amount of additives. The formula for the fluid is often kept secret so only the manufacturer of the fluid can tell you how it measures up.

However, an often-overlooked source of contamination is the new fluid that is added to the reservoir. The standard cleanliness level of new fluid does not meet the requirement for most components. Therefore, the fluid should always pass through a filter as it is added to a reservoir.

Given that some manufacturers will extend the warranty on their components if users keep their fluid clean and maintain good records, this acts as strong evidence that the primary cause of hydraulic failure is contamination. **iVT**

Dan Helgerson is a certified fluid power professional, writer and frequent presenter regarding fluid power energy issues. He can be reached at Dan@cfpsos.com

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DC DESIGN

DESIGN A HYDRAULIC HYBRID ENERGY RECOVERY SYSTEM THAT WILL HELP REDUCE FUEL CONSUMPTION IN AN OFF-HIGHWAY VEHICLE OF YOUR CHOICE

REVERSIBLE HYDRAULIC PUMPS

Amos Boaz

Amos Boaz is a specialist in industrial design and styling of high-performance vehicles. He also lectures in the Bezalel Academy of Art and Design, Jerusalem

LEFT & ABOVE: ***The chassis houses the oil pumps and electric motors***

FAR LEFT: ***Cutaway view shows fuel tank location of the oil pumps, electric motors and pistons***

The Orpela MT500 haul truck concept is an innovative, efficient and cost-effective mine truck solution, able to carry 500 tons, in contrast to the current limit which is around 400 tons. That means more minerals can be moved in less time, or the same payload with fewer trucks overall. A sustainable solution, the concept is designed rather like an aircraft, with each system being duplicated to avoid the problems caused by a broken-down truck blocking work flow. With eight wheels and an articulated steering system, the MT500 enables optimum maneuverability around the mine.

Each producing around 4,000bhp in conjunction with the diesel engines, the dual generators deliver electricity to the hub motors (one per axle) and the oil pumps. The generators are positioned at the front of the truck, each in its own cabinet along the width of the hood. When the main doors on the front of the hood are opened, the generators can be easily removed for maintenance, with the aid of a forklift truck.

The cooling systems push air through the motors, as these are also used as a means of braking the truck. These systems are also mounted inside each axle, which are connected to the chassis with four joints and two oil-filled pistons, enabling smoother off-highway travel.

Lifting the extreme weight of a laden dump body, which is raised and lowered by hydraulic pistons, demands a lot of power. When the body is lowered, the hydraulic pumps turn in reverse, transferring energy into an accumulator. This energy is quickly made available for the next raising procedure, thereby drawing less power from the generators and reducing overall fuel consumption.

The truck's cab provides a large glazed area for optimum all-round visibility. Access to the cab is from behind the front wheels, via a ladder, while the comfortable service platform on the hood provides access to the dual retarders and all the electronics units.

The MT500 concept was developed in cooperation with Dave Porter, and by its reliance on currently available systems, could be produced tomorrow.

www.amosboaz.com • amosboaz@netvision.net.il

DC

RECOVERY OF HEAT AND KINETIC ENERGY

Alberto Seco

Alberto has been involved in design projects from cell phones to heavy equipment. After a spell at an Italian design consultancy and as an industrial designer, he now works in the auto sector

The **ADT HY²** hydraulic hybrid energy recovery system is based around the 50+Active suspension system (*iVT* June 2013), which acts as a flexible link between the front and rear frames, improving stability and minimizing rollover of the cab.

In contrast to current ADTs, hydropneumatic suspension is not only limited to the wheels, but is extended to the frame using two large cast upper and lower 'H' arms controlled by a pair of suspension cylinders and hydraulic accumulators. These dampen energy from bumps to produce a smooth ride for maximum operator comfort. Position sensors in the frame continually measure and adapt to uneven terrain, while the lateral sensors measure any roll and constantly adjust cylinders to accommodate for this.

The increase of pressure in the accumulators converts kinetic energy into hydraulic energy that can drive an axial piston pump coupled to the gearbox to provide an additional source of power. A valve control block positioned between the accumulators and this pump controls the filling and discharge cycle, protecting the system from excessive pressure. An ECU monitors the engine performance for optimal operation, so less fuel is consumed without sacrificing power requirements. When more power is needed, the ECU therefore manages the stored energy in the accumulators to provide an additional source of power and to help reduce fuel consumption.

The **Poclain 400 HY²** (iVT Sept 2010) energy recovery system is based on the recovery of heat from the hydraulic oil tank. In a conventional excavator, the hydraulic oil must be refrigerated, but because electric-drive systems provide some of the best solutions for the recovery and storage of energy, the HY² concept excavator has been equipped with a series hybrid system that can transfer this thermal energy to the hydraulic pumps when needed.

Semiconductors and thermoelectric materials extract the heat from the hydraulic oil tank, and send it to a supercapacitor, while an electric motor positioned between the engine and the hydraulic pumps supplies additional power to reach an overall power rating of 500bhp. The thermal energy focused on the hydraulic oil tank is therefore converted into additional hydraulic energy to help drive the swing hydraulic motor, the equipment hydraulic cylinders or the track-drive hydraulic motors. Because the generator uses electricity from the capacitor to provide power-up engine assistance, fuel consumption is also reduced.

A further advantage of replacing the hydraulic fluid cooler (which usually involves a wasting of energy) is the reduction in size of the hydraulic oil tank, leading to less oil, reduced maintenance costs and an improved ecological approach.

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ON THE WEB

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PETER FEUCHT

The joy of six

THE DEVELOPMENT OF A HEXAPOD WHEELED LOADER – WITH HALF-A-DOZEN DRIVE ELEMENTS PERMITTING ALMOST UNLIMITED MOVEMENT IN ANY DIRECTION – CALLED FOR THE USE OF TEMPOSONICS POSITION SENSORS BEFORE CELEBRATIONS COULD BEGIN

As a result of their special kinematics, parallel positioning mechanisms can be found in many areas of application. In the industrial field, hexapods are used in testbeds and simulators for machine tools and production machines, or in driving and flight simulators. Because of the complexity of control tasks, however, parallel kinematics has not yet been adopted for use in mobile machinery.

In recent years, however, manufacturers of wheeled loaders have been keen to improve the operational flexibility of the overall machine. For this purpose, new equipment and three-dimensional controllability of the attachments are required. At Dresden University of Technology, the Institute for Processing Machines and Mobile Machines has addressed the development of this operating equipment with parallel kinematic structures for mobile machines in the framework of a sponsored research project.

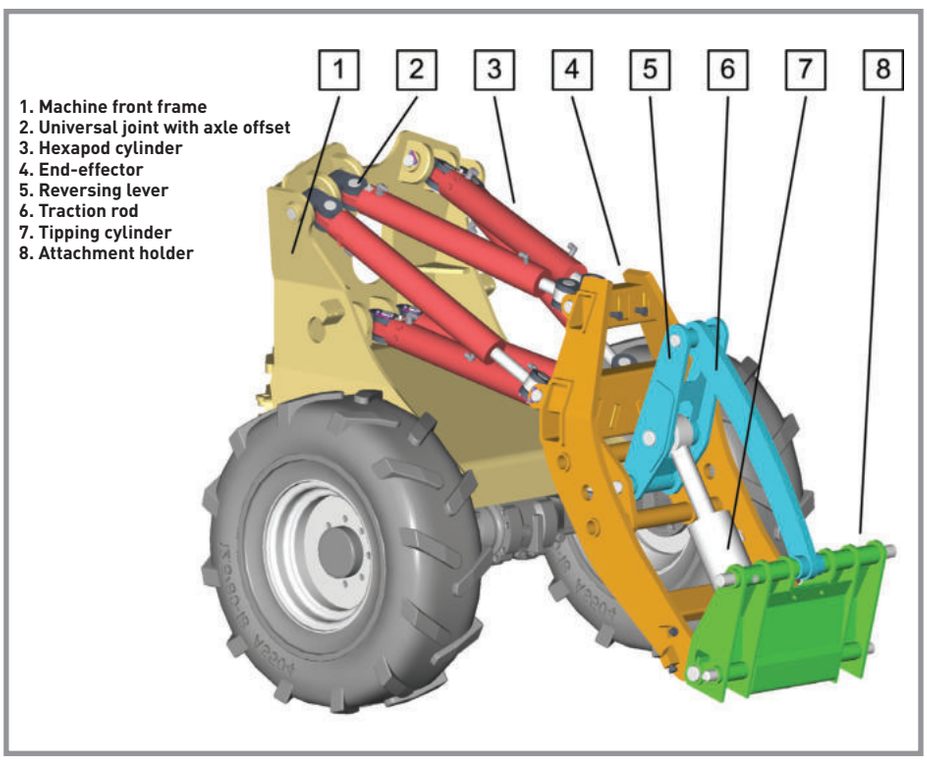
The result is the new Hexapod Mobima (short for 'mobile machine'), a spatially moving machine with six drive elements (actuators). The machine enables the operator to move standard attachments in up to 6DOF (three translational degrees and three rotational degrees). Moreover, additional superimposed, process-specific operational movements are possible. Using the tipping mechanism, which is isolated from the chassis, an additional overall tipping angle of approximately 180° can be realized. Finally, the hexapod is able to generate spatial trajectories that are especially adapted to the particular work process.

Thomas Hentschel, project leader at the institute, is certainly enthusiastic about the development: "Our project was based on the idea of realizing a multitude of spatial work movements in only one basic machine. The hexapod we have designed is able to perform these movements."

Aside from being very robust and compact, the hexapod structure also offers high potential for sequencing, control, positioning and automation.

Six cylinders add mobility

As a reference for technical implementation of the hexapod into industrial vehicles, the 3070CX80 wheeled loader from Weidemann was chosen. The prototype hexapod loader comprises two assemblies: the lifting mechanism, which is the actual hexapod, and the tipping mechanism, termed the manipulator.



The lifting mechanism is controlled by means of two differential cylinders located at the bottom. Isolated from the chassis, the tipping mechanism (Z-bar linkage) features a tipping cylinder at the top, a reversing lever and a traction rod. The work attachments are mounted using a quick-acting hydraulic system.

The kinematic structure of the hexapod comprises a base and a work platform. This is a special type of parallel mechanism, connecting the two platforms via six differential cylinders mounted in a circuit, which explains the universal spatial mobility. Each differential cylinder can be controlled individually. For this purpose, the actuators have been equipped with Temposonics MH series position sensors, which measure positions as well as velocity. A CANbus protocol is used for data communication between sensors, actuators and electronic control systems.

Apart from the constructive design, the hexapod development also included the implementation of a novel CAN protocol-based control structure, whereby the limited maximum volume flow of the hydraulic pump and the trajectory-dependent volume flow requirement was a particular challenge. Due to the integration of Temposonics sensors, both the cylinder position and also the speed in axial directions can be measured exactly at any time and transmitted to the control system. These values are used by the system computer to determine the setpoints for opening the relevant servo valves. The control system is a single-axis controller with cascade controller for speed and displacement as well as setpoint pilot control. Monitoring and synchronization are carried out via a common interpolator.

Hentschel explains the special requirements on the integrated position sensors: "A prerequisite for the

ON THE WEB

Link to Hexapod Mobima videos via:
www.iVTinternational.com

LEFT: **Construction of the hexapod loader**
ABOVE: **The hexapod wheeled loader is built on a Weidemann chassis**

position sensors was direct CANopen support, full integration into the differential cylinders, as well a high-accuracy position and speed measurement, in order to meet the requirements of the complex control tasks. With its magnetostrictive position sensors for mobile machines and adequate consulting, MTS Sensor Technologie has provided highly satisfactory support."

The MTS sensors with CANopen can be connected directly to the fieldbus as a slave. In addition to displacement, the units can also measure the speed during position changing and therefore the motion behavior of the cylinder. As a result, the individual movements of any overall movement are able to be synchronized by means of several independent hydraulic cylinders.

The hexapod wheeled loader can be moved interactively by the operator via a joystick. It is subjected to changing load situations and must also be able to operate smoothly under very difficult environmental conditions. Temposonics MH sensors have been designed especially for mobile machinery, and therefore satisfy these requirements. Due to their compact construction, the sensors can be easily installed in the cylinders. They are also absolutely maintenance-free and offer unlimited durability. Moreover, they deliver a continuous position signal, which permits continuous control of cylinder and machine functions.

Magnetostrictive position measurement

The Temposonics MH sensors can be integrated completely in the hydraulic cylinder. The sensors with CANbus interface meet the requirements of Safety Integrity Level 2 (SIL 2) to IEC 61508 and therefore also the requirements of Performance Level 'd' to ISO 13849-1. This means the MTS position measurement systems are approved for safety functions on mobile machines. Measuring lengths from 50-2,500mm are available, all of which are able to deliver optimum measuring results with a linearity of <±0.04% F.S. and a repeatability of <±0.005% F.S.

This high degree of operating safety is ensured by built-in diagnostic functions of the M-Series position sensors, which have been designed for high-demand operation. In the sensor head, the signals are checked and changes are detected immediately. The sensor transmits the position value to the control system only after the diagnostic test. In this way, Temposonics sensors provide a safe failure fraction (SFF) of 95% at a hardware fault tolerance (HFT) of 0. Due to the SIL 2 classification of the sensor, this corresponds to an average probability of failure (PFH) in a range from ≥10-7 to <10-6 per hour.

All MTS position sensors operate according to the magnetostrictive measurement principle, with wear-free, contactless position measurement based on the use of magnetomechanical effects. Maintenance or recalibration is unnecessary during the entire sensor lifetime. The sensor head is accommodated in the bottom of the cylinder, whereas the rod immerges into the piston rod. Sliding over the sensor rod, a ring-shaped position magnet is mounted in the piston and marks the position of the piston rod.

The quick installation of the Temposonics position sensors is due to the connector system for easy click-on mounting without the need for tools, which has been developed by MTS. During installation, the contact carrier is taken out of the cylinder through a bore hole and the flanged housing can be clicked in position easily from the outside. When installing the cylinder with its integrated sensor in the mobile machine, the Temposonics sensor can be connected at various angles using a universal M12x1 connector. The time-consuming solder and screw terminal connection of conductors, polarity errors or solder tags are excluded.

Mounted in the hydraulic cylinder, the integrated sensor does not require costly mounting of protective devices. The ease of installation also continues when connecting to the control system, where only the measuring range (i.e. the sensor signal at span start and end) is saved (an absolute sensor). Expensive mechanical adjustment is not necessary.

Magnetostrictive Temposonics sensors deliver a measurement signal with high signal-to-noise ratio. Good signal quality and cylinder integration make them insensitive to external influences. They operate extremely reliably in the presence of electromagnetic interference up to 200V/m and are highly resistant to shocks up to 100*g* and vibration up to 25*g*.

Future applications

Hexapod Mobima is provided primarily for use in wheeled loaders. Other fields of application include operating equipment for motorgraders, a suspension system for the cabins of industrial vehicles, or special applications such as mining machines.

"In addition to its very high productivity and positioning accuracy, the Hexapod Mobima is also characterized by its vibration dampening, easy and safe handling, and a high automation potential," says Hentschel. Future cooperation with MTS Sensor Technologie concerning further projects is already planned. **iVT**

Peter Feucht is product manager for mobile hydraulics at MTS Sensor Technologie

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USING BARCODES FOR FASTER, ACCURATE MEASURING, NEXT-GENERATION POSITIONING SOLUTIONS INTEGRATED WITH HIGH-PERFORMANCE CYLINDERS ENSURE PREDICTABLE CONTROL OF CRITICAL OPERATIONS UNDER THE HARSHEST CONDITIONS

Procuring an easy-to-use position sensor for mobile and industrial hydraulic cylinders was once something of a challenge. Fortunately, Parker Hannifin has introduced a new approach to position sensing that eliminates the problems associated with standard sensor technologies, such as gun drilling, dead zones, repeated calibration, limited temperature ranges, costly installs and lengthy repair times.

Intellinder absolute position sensor technology provides plug-and-play simplicity with a novel design that eliminates costly modifications to the cylinder and is versatile enough to accommodate multiple sensors for independent position-signal redundancy. The Intellinder sensor incorporates multiple patented technologies and is integrated with Parker's high-performance cylinders in a protected configuration that makes installation and replacement quick and easy.

An innovative lens design using time-tested, highly engineered optics produces sharp barcode images that enable excellent sensor accuracy, resolution, linearity, repeatability and hysteresis so as to ensure consistent, predictable control of critical operations. The sensing system uses identifying barcodes on the rod itself, so that position is accurately communicated continually and directly to the controller. Because measuring from a reference point is not required at start-up, the Intellinder technology is faster than incremental positioning methods, delivering a higher level of performance. Accurate positioning begins at power-on, with no need for calibration.

ABOVE: **Robust Intellinder technology integrated with Parker's hydraulic cylinders takes position sensing to a new level of reliability, providing consistent, accurate positioning in the toughest industrial and mobile applications**

RIGHT: **This versatile technology can be applied to multiple cylinder functions, such as tilting, lifting, extending and steering**

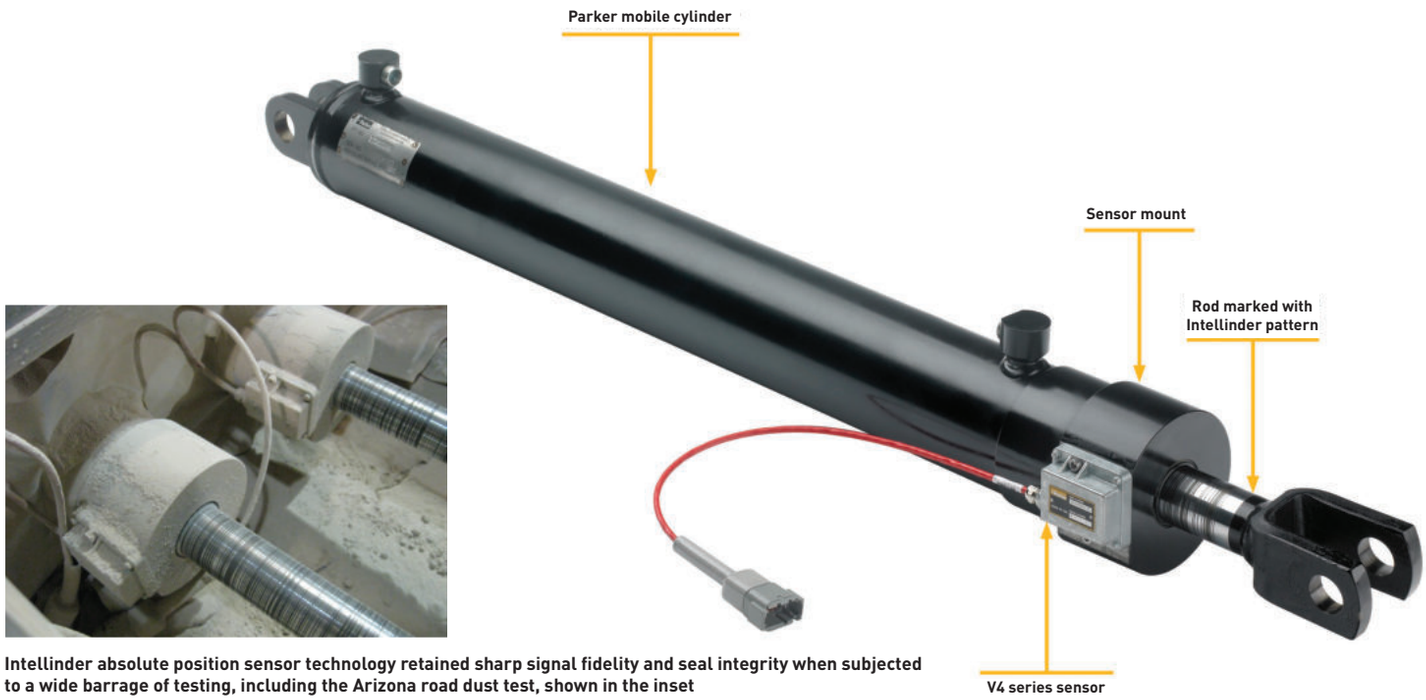
Exhaustive testing

Prior to its formal introduction, the Intellinder sensing system underwent comprehensive testing using a wide range of industry-standard and customized testing protocols. Signal strength and seal life were validated under endurance axial-load testing (SAE J214) and the abusive conditions of side load and Arizona road dust environments. Additionally, the system was field tested in multiple applications and environments including accelerated life testing.

Environmental testing demonstrated consistent performance in operating temperatures ranging from -40° to 105°C. The system also retained fidelity and seal integrity when exposed to thermal shock, humidity and vibration; as well as in conditions of total immersion, dust and power washing. From an electrical perspective, the system remains resistant to electronic noise and has demonstrated predictable performance, using standard industry protocols, in conditions of radiated susceptibility, radiated emission and electrical transients.

The barcoded cylinder rods exhibited durability levels comparable to that of standard chrome rods, remaining corrosion-free and maintaining their readability after 200 hours of exposure to salt spray, and when tested for resistance to fertilizer, bleach, ammonia, battery acid, cleaners, moisture-control agents and dust-control agents.

The engineering complexities called upon to create this innovative new approach to position sensing



Intellinder absolute position sensor technology retained sharp signal fidelity and seal integrity when subjected to a wide barrage of testing, including the Arizona road dust test, shown in the inset

translate not only to improved performance in extreme applications, but also to new application possibilities. For instance, the clever Intellinder design eliminates the linkages required by external sensors and protects the optical sensor from damaging environments, enabling easy installation on double-rodded cylinders and the redundancy to support limp-home modes. Intellinder technology can also be applied in other forms beyond cylinders, such as a limit switch, a rotary sensor, or as a multitude of additional application-specific solutions.

The system provides long stroke capabilities of 6m or more, and the same sensors can be installed in multiple independent configurations for monitoring and controlling a diverse array of operations. Rod diameters range from 25-127mm, with no limitations in bore-size.

Vehicle life, operator comfort and productivity can all be improved through precise cylinder rod position and speed control. For industries such as material handling, construction, agriculture, waste removal, forestry, mining, oil and gas, marine and the military, Intellinder technology makes possible a wide range of practical functions, including, but not limited to:

- Electronic cushioning;
- Auto-leveling;
- Load monitoring;
- Return-to-position;
- Lift, extend and handle;
- Compress and compact;
- Steer and brake;
- Open and close;
- Load and tip;
- Danger zone avoidance;
- Speed control;
- Auto-stow.

Robust performance

The simplicity of its use belies the sophistication and robustness of the Intellinder system's engineering. Health monitoring technology continually scans the rod's surface to identify conditions that might, if left undetected, cause sensor damage, seal leaks and related system failures. On-screen alerts can help ensure that critical conditions are quickly addressed, before unplanned downtime.

The flexibility afforded through the use of multiple sensors mounted around a single piston rod helps ensure fail-safe performance in the most challenging circumstances. Intellinder absolute position sensor technology integrates with the Parker IQAN electronic control system and a comprehensive selection of system-compatible pumps, valves, cylinders, fittings, hoses and mobile electronic controls to ensure successful monitoring and control in harsh application environments. Parker heavy-duty cylinders operate at 3,000psi and feature a zero-leak sealing package, as well as skived and burnished tubing, for extended seal life. The cylinder's chrome-plated rod resists nicks and bending, while hardened pin-eye bushings optimize cylinder service life.

The novel, problem-resolving Intellinder system is now readily available and fully supported by Parker Hannifin worldwide. It arrives fully assembled and integrated with a Parker hydraulic cylinder, which can be mounted and connected to the hydraulic control system quickly via a single electrical connection to the controller. The system's integrated design, which uses a rugged plated die-cast zinc alloy housing rated to IP67 for the sensor and electronics, provides exceptional durability, minimal downtime, reduced maintenance requirements and extended service life to improve operational productivity.

Because the sensors have been designed to be interchangeable across multiple systems and in diverse applications, inventory requirements can be considerably reduced. The same Intellinder sensor can be used in multiple applications on a vehicle, replacing string pots, internal sensors and proximity switches. The system's only operational requirements are an electrical power source with input voltages from 8-32VDC, and communications connections using J1939 CAN protocols. **iVT**

Mike Laurich, commercialization manager at Parker Hannifin's Hydraulics Group, has over 20 years of experience developing innovative products and solutions

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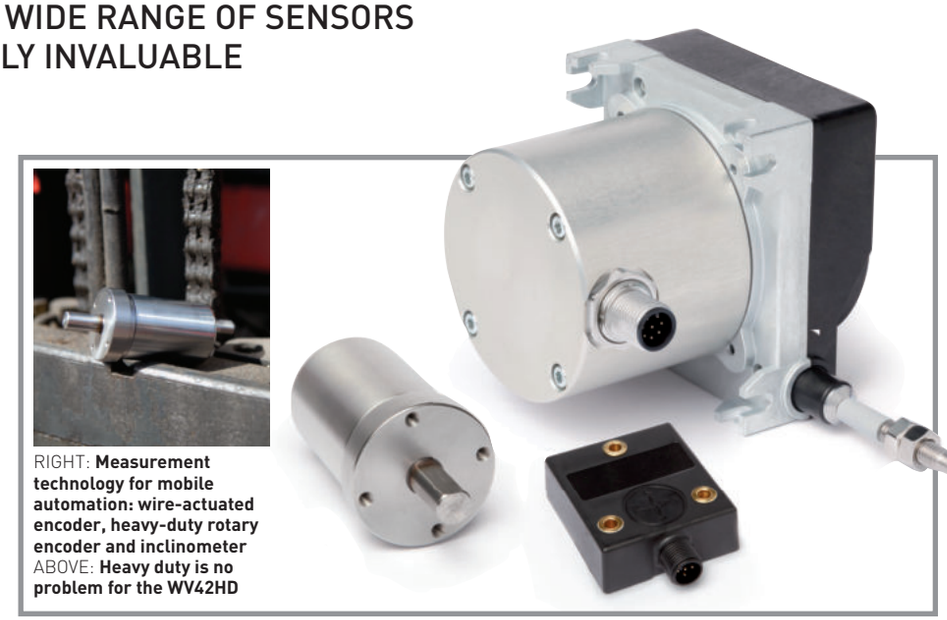
On solid ground

ACCURATE POSITION DETECTION OF STABILIZERS IS CRUCIAL FOR THE SURE FOOTING OF CRANES AND WORK PLATFORMS, MAKING THE SUPPORT OFFERED BY A WIDE RANGE OF SENSORS AND ENCODERS PARTICULARLY INVALUABLE



RIGHT: **Measurement technology for mobile automation: wire-actuated encoder, heavy-duty rotary encoder and inclinometer**
ABOVE: **Heavy duty is no problem for the WV42HD**

Millimeters can be a crucial factor in the secure footing of crane and hoist supports. Otherwise, there is a risk of the crane tilting or even overturning, or the load being unevenly lifted, which can result in strain and damage. There is, therefore, a real need for easy-to-integrate measurement solutions with a good price-performance ratio and high product quality. With its wide variety of wire-actuated encoders, Siko offers just the right products for this; products that feature an extremely compact, robust design and suit a wide range of applications.

Accurate position detection of the supports is therefore indispensable for safety when the boom is extended, to prevent the crane or truck from tilting or overturning. The actual measured values of the extended supports are compared directly with the length of the extended boom. Complete extension of the boom is therefore possible only when the supports are also extended to the maximum length.

Siko has developed a new generation of wire-actuated encoders specifically for safety-related requirements: the SG32 and SG42. These devices have a maximum measuring length of 3,000mm or 4,000mm and transmit the output signal to the controller twice. This ensures increased personal safety, such as when lifting cages to raise personnel to heights, as measuring signals are received twice.

Advantages of wire-actuated encoders include:
- Temperature range down to -40°C;
- Robust in use – even in wet and dirty conditions;
- Easy installation of the cable reel;
- Flexible system integration due to optional output signals and interfaces;
- Available in a variety of measuring lengths;
- High safety and reliability due to redundancy of the sensor system.

Heavy-duty IP69K rotary encoders

Many rotary encoders are pushed to their limits, especially for mobile machinery, heavy industry, and outdoor use or offshore applications. High accuracy alone is not sufficient in these cases, as measuring tasks always have to be carried out smoothly and with precision even at -40°C or +85°C, and when exposed to shock and vibration, dirt and moisture.

The reasonably priced WV42HD heavy-duty rotary encoder is flexible to use. Different interfaces, such as CANopen, SSI or analog are available. The encoder always uses the wear-free, magnetic measuring principle and battery-free, multiturn technology to its advantage. The innovative technology is encased within a stainless steel housing of just 42mm diameter, enabling it to be used in applications with limited installation space.

Its high IP69K protection class, combined with robust ball bearings (intermittent shaft load rating 300N, continuous shaft load rating up to 270N), makes the WV42HD the perfect choice for reliable measuring under extreme environmental conditions, such as high humidity, fluctuating temperatures and aggressive media (salt spray test according to DIN EN ISO 9227 >240 hours).

Advantages of heavy-duty rotary encoders include:
- IP68 and IP69K protection, with stainless steel housing;
- Resistant to salt spray and acids;
- Protection against strong magnetic fields;
- Absolute, battery-free measuring principle.

IK360 inclinometer

The IK360 inclinometer rounds off Siko's portfolio of sensors for mobile automation. The sensor uses the natural force of gravity to accurately map positions with a system accuracy of ±0.1° or ±0.5°. The IK360 is available as a single-axis (0…360°) or as a two-axis (±80°) version. The compact IK360 enables quick and simple installation, as well as a variety of interfaces. The compact inclinometer also impresses with its high IP68 and IP69K protection class, enabling its use even in splash-prone areas, such as on-road vehicles, or under constant immersion in water.

Other possible applications include checking the inclination of lifting equipment or personnel cages, for example on fire trucks, or detecting the alignment of construction equipment.

Advantages of the IK360 inclinometer include:
- System accuracy ±0.1°; resolution 0.01° and ±0.5°;
- Interfaces RS232+I, RS232+U, CANopen;
- Easy three-point mounting;
- Temperature compensation;
- Operating temperature: -40° to +85°C;
- Directly programmable on-site, via teach-in function.

Innovation awareness, expertise, transparency and reliability are the core values in the over 50-year history of Siko. Founded in Buchenbach, Germany in 1963, the family business quickly developed into a reliable partner for rotary and linear measuring systems, actuators, and rotary and wire-actuated encoders, used throughout the mechanical engineering sector and in industry. Today, Siko has a presence in more than 30 countries through independent sales representatives and subsidiaries. **iVT**

Jürgen Schuh is sales manager at Siko

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JOHN RUDDOCK

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WITH THE ADVENT OF TOUGH EMISSIONS LEGISLATION, HIGHLY SOPHISTICATED CAN CONTROL MODULES ARE WIDELY BELIEVED TO BE AN INCREASINGLY INTEGRAL PART OF INTERNAL COMBUSTION ENGINES

Having designed and manufactured control systems for almost four decades, Deep Sea Electronics (DSE) has seen many changes in market demands. While producing a wide range of control modules for fixed-speed engines primarily used in generator applications, DSE saw the first of the new electronic CAN engines beginning to enter the genset marketplace more than 10 years ago. These modern engines required a higher level of control and monitoring, so the company began to develop a range of controls to meet the CAN demands.

For example, more safety features, additional alarms and enhanced engine protection were all required and, more recently, sophisticated features, such as DPF control with various options for the cleaning process, have been designed into these products. The products have now been on the market for a decade or so and are highly regarded and recognized as tried, trusted and reliable solutions in the generator industry.

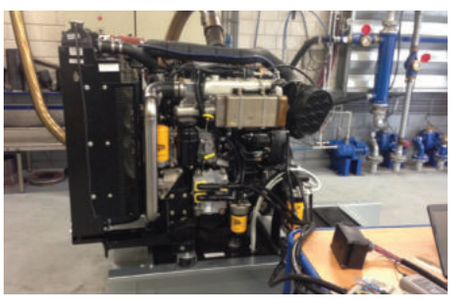
With the continued success of DSE's CAN controls, there was a natural overlap into closely related markets and some of the products were adopted for use in engine-only applications, such as pumps and compressors. With growing interest in its products from this sector, DSE launched the DSEE800, the first of a family of dedicated engine-only control modules, which has specific integrated features for variable-speed engines, facilitating the highest level of economy of operation in terms of capacity, engine response and fuel efficiency.

The new module has been designed specifically for applications where robust control and monitoring of a diesel engine is required, such as stone crushers, conveyors, pumps, irrigation and other applications requiring variable-speed engines. The product uses the DSE Configuration Suite PC software tool, common to other DSE controllers, to enable users to program according to their needs, ensuring a flexible control solution for all applications.

The DSEE800 incorporates some enhanced safety features and sophisticated instrumentation through the ECU/ECM or directly through the control module, with user-friendly operation in common with all the DSE range of products. Features such as ECU/ECM Wake-up can prevent the engine from failing to start due to low temperatures, while a comprehensive list of alarms for warning, controlled shutdown, immediate shutdown, malfunction or ECU/ECM malfunction, etc, can be programmed for the most sophisticated engine protection. Independent trip levels can also be set for early diagnostics and prevention of potential faults.

LEFT: **The E800 offers sophisticated control and monitoring features for modern engine applications**

BELOW: **The newest Tier 4 engines are used during product development and final testing**



The right network

DSE's development engineering team has built up a network of close partners chosen for their expertise, experience and reputation in their field of operation. This ensures that when the product is released, it is exactly right for the market. In developing the E800, DSE established a close working relationship with Brinkmann & Niemeijer Motoren to help determine relevant product features. This Dutch company is a leading OEM with a history spanning many decades in emergency power solutions, gensets for the construction and rental markets, and is heavily involved in water pump sets and hydraulic sets.

Rigorous testing of the E800 by its senior engineers, together with DSE development engineers, put the product through its paces over the four months to January 2014. They were keen to see the product tested to its limits by constructing a series of complex tests simulating a wide range of engine applications.

Bert van Mullem, service manager for Brinkmann & Niemeijer, was one of the leading engineers involved in testing the product, and also contributed toward its development by liaising with DSE design engineers. "We are the Dutch distributor for JCB and used its new Interim Tier 4 engine for testing. This is a brand-new engine equipped with a sophisticated engine management and emission control ECU system. All E800 tests were completed with great success.

"The facia and control button layout of the E800 is very robust and suitable for water pump environments, and the operation logic for variable-speed engines is ideal for many applications. More often there is the demand for a more load-dependent form of operation and an intelligent way of controlling the engine during start-up and stop – the E800 has all these features and is very easy to use. The new DSEE800 is a very interesting product and we will definitely be choosing it for our engine applications." **iVT**

John Ruddock, product development manager, has worked for DSE for over 13 years

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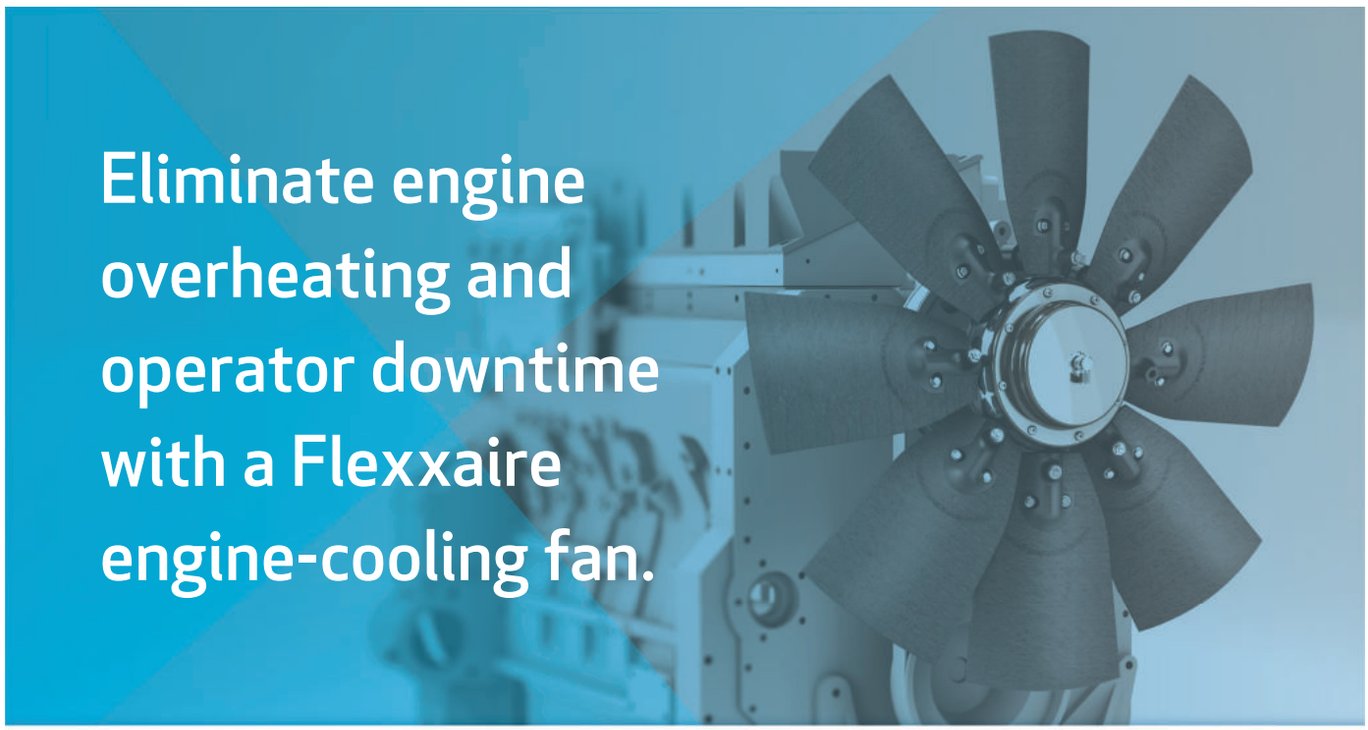

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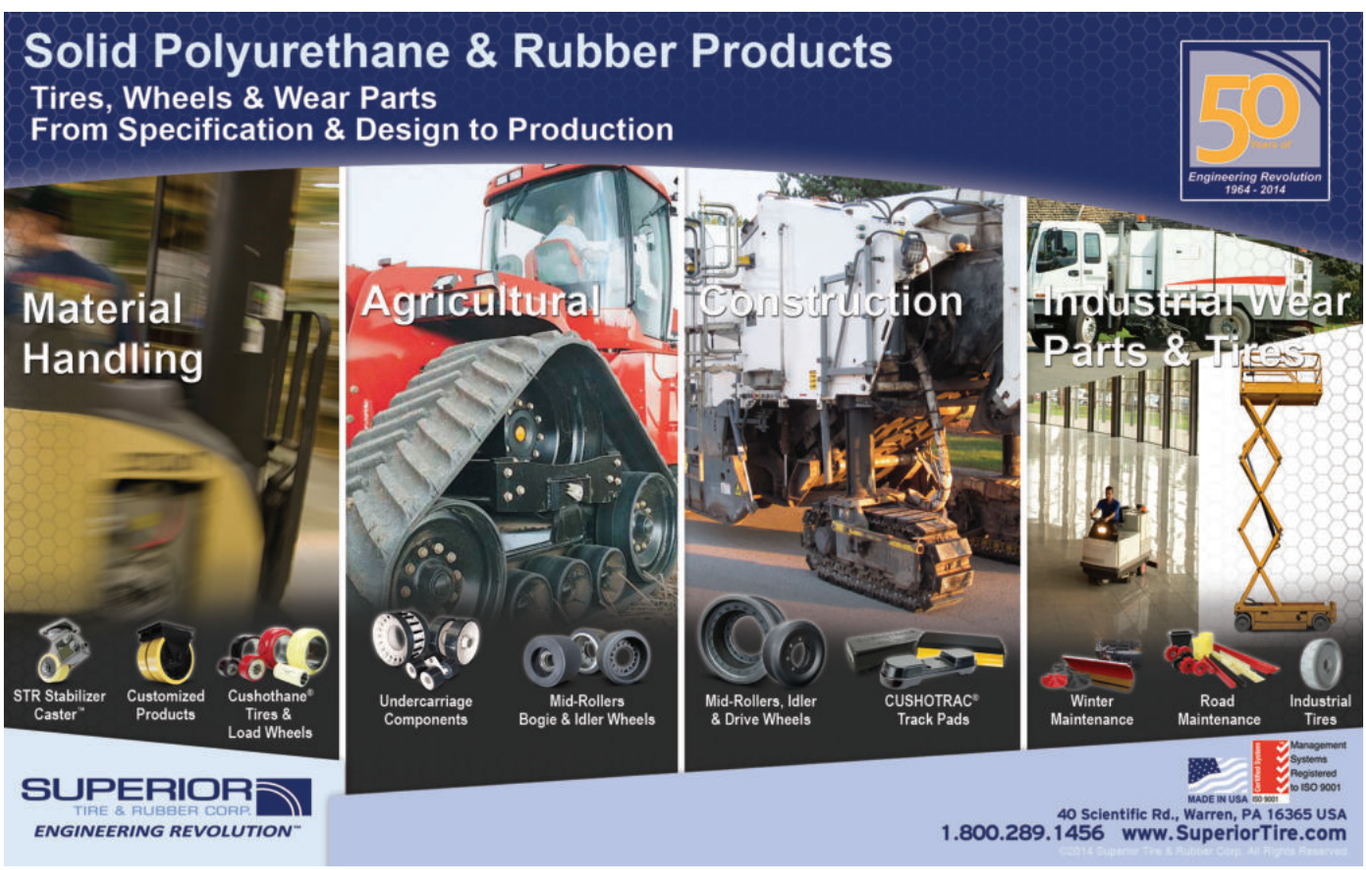

LILIA LITAU

Safe mode

BY COMBINING THE MOST VITAL OPERATING INFORMATION – USING A CHOICE OF PRESENTATION STYLES – WITH A FULLY PANORAMIC CAMERA DISPLAY FUNCTION, MOTOCANDIS IS PLAYING A CRUCIAL ROLE IN REDUCING ACCIDENTS IN THE WORKPLACE

A particularly important issue – especially for operators of construction equipment, other industrial vehicles and commercial vehicles – is safety at work. So by providing a comprehensive overview of the working area around the machine, the Motocandis display unit from Motometer not only displays the vehicle's operating status but also increases safety for people and objects.

Motocandis analyzes the data of a modern engine management system directly and displays it on a high-resolution, low-reflecting glass color monitor (6.5in VGA display). Two video cameras can be easily connected on each video input. Offering workspace observation by showing a detailed view of important working areas or objects, Motocandis enables work to be undertaken accurately and without any damage to people or property.

The solution also offers a high-quality extensive panoramic view. The Motocandis V2.0 includes 17 new software features, including display rotation in 90° steps; day and night mode; variable number of languages; and simultaneous display of two video images, which can also be displayed mirror-inverted. Motocandis therefore makes the place of work clearer, safer and more comfortable.

ABOVE: **Motocandis increases safety at work**
BELOW: **Motocandis analyzes the data of a modern engine management system directly and displays it on the high-resolution glass color monitor**

No programming knowledge required

The multifunctional Motometer display is individually programmable. Because of the user-friendly interface and the simple handling via mouse-click, engineers using the Motocandis software require no special programming knowledge.

It is possible to show other information at the same time alongside the camera pictures, such as the real-time clock, distance, or operating hours counter. All information can be individually shown with the Windows-based calibration software. The operator chooses from a variety of presentations of the data such as the classic round display, bar chart, text, or digital values. The camera images can be displayed in full-screen or picture-in-picture format, either on a continuously or event-driven basis. A simulation tool enables animation in the workplace. Furthermore, specific bitmaps, fonts or logos can be used.

In addition to the traditional periodically shown standard information, Motocandis can also present vital warnings and error codes, as well as further information. This increases safety in the driver's cab. It is therefore possible to program an event-controlled display that shows when defined thresholds are exceeded, whether below or beyond. If a defined temperature, speed or pressure range is passed, the Motocandis shows it clearly on the display. In case an acoustic warning is preferred, a buzzer (acoustic pressure 85dB/m) can be switched on or off.

Innovative and highly resistant

The menu of CAN displays can be operated with the six illuminated, freely configurable keys and an ergonomically mounted rotary knob. The two independent CAN interfaces (CAN 2.0 B, with 11bit and 29bit identifiers) can be used as a comfortable CANbus bridge when transferring data from CANbus 1 to CANbus 2. The transfer rate is adjustable up to 1 Mbit/sec. The CAN interfaces support standard SAE J1939 and CANopen.

The rugged housing of the display is designed to withstand the special requirements of harsh operating environments in terms of temperature, humidity, vibration and EMV ascendencies. The high resolution

(640x480 pixel) and the internal graphics processor make highly detailed and fluent images possible. The unit is set up for a supply voltage between 9-32V, and the real-time clock is buffered against interruptions in the power supply of up to 500 hours. **iVT**

Lilia Litau is responsible for marketing and public relations at Motometer GmbH

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CATH MERSH

Smaller, simpler, smarter

WHEN DOWNSIZING OR HITTING THE SUB-56kW THRESHOLD IS A KEY GOAL FOR MANY OEMs LOOKING TO AVOID SOME OF THE COMPLICATIONS OF TIER 4, SPECIALIZED SOFTWARE WILL ENSURE THAT THE USE OF SMALLER ENGINES IS NO BARRIER TO PRODUCTIVITY AND PERFORMANCE

Efficient machine performance – and the optimum way to maintain it – has preoccupied the industrial vehicle industry ever since the first emissions standards loomed on the horizon. Now, continuous endeavors at Danfoss have created the most advanced opportunities to date in the form of intelligent electrohydraulic systems that can optimize power and productivity – even when diesel engines are downsized.

The company took the first step toward intelligent machine control with the launch of its PLUS+1 mobile electronic control systems back in 2004. Designed to support mobile machine manufacturers in maximizing the use of available power in emissions-compliant systems, PLUS+1 enables simple control system development and a faster time to market. Ten years on, PLUS+1 software, hardware and the user-friendly PLUS+1 GUIDE programming environment are still setting the agenda.

Software for next-level performance

The latest developments are a direct result of the software capabilities. Version 7.0 of PLUS+1 GUIDE, Work Function Control (WFC) subsystem software and PLUS+1 Best Point Control for the Danfoss H1 range of closed-circuit pumps and motors contain valuable features for next-level machine performance. In addition to compliance with the Tier 4 emissions standard – this year entering its final phase-in period – Danfoss has made functional safety an integrated part of its software design.

Marco Tacke, product marketing manager for software solution services at Danfoss, describes the benefits for machine developers and operators alike: "We are confident that the new software tools and features of our programming environment will help manufacturers reduce their development costs and achieve certification more easily. With the new opportunities for intelligent control, operators can rely on their machine to adjust to varying work conditions and demands while they focus their attention on the task in hand."

The drag-and-drop principle of PLUS+1 GUIDE is simplicity itself for control system developers, who only need to select the relevant software components and application blocks and then string them together in the programming workspace. Since its introduction, programmers have been able to develop complex, customized control systems after undergoing the minimum of training.

ABOVE: **A downsized engine is no barrier to performance with the latest Danfoss software**
BELOW: **With GUIDE version 7.0, developers can base their screen design on a display that already exists, upgrading and rescaling as required**

With version 7.0, Danfoss has introduced a series of features and options that reduce the development workload even further and ensure optimum machine

functionality before prototype production begins. Among them is a new capability to export available code for electronic displays from one machine to another, thereby eliminating the need to program from scratch. Developers can base their design on a display that already exists, upgrading and rescaling as required, depending on the display model.

"The ability to reuse available display solutions and graphics reduces manual work by up to 80%," Tacke elaborates.

For the first time, machine simulation models can now also simulate the behavior of the electronic control system due to the new GUIDE-to-Simulink functionality. The export of PLUS+1 software code to Matlab Simulink, using Simulink's S-functions, enables glitches in the control system design to be identified and resolved at an earlier stage. Saving time and cost, this responds to the growing trend to employ computer simulation models before building the first machine prototype. Electronic controls that have performed well during the computer trials can be uploaded directly to the physical machine.

The extra confidence provided by simulation is boosted further by the PLUS+1 GUIDE 7.0 quality

assurance tool, which supports the creation of certification documentation. Computer-run tests are used to compare the system inputs written into the software code with the expected outputs. Any bugs and errors are swiftly detected – a great help, particularly when working with different versions of code. Retesting then focuses only on those functions where issues have been identified and resolved.

When programming in PLUS+1 GUIDE, system developers can make use of the WFC subsystem application software and PLUS+1 Best Point Control software for intelligent transmissions based on H1 pumps and motors. The principle behind both is to secure maximum performance in response to real-time operational data.

Productivity at lower power

WFC has been specially designed for machines where the diesel engine has been downsized to below the key 56kW threshold, where other Tier 4 requirements apply. Used with PLUS+1 microcontrollers and other hydraulic and electronic components, WFC maintains machine productivity at this lower power rating.

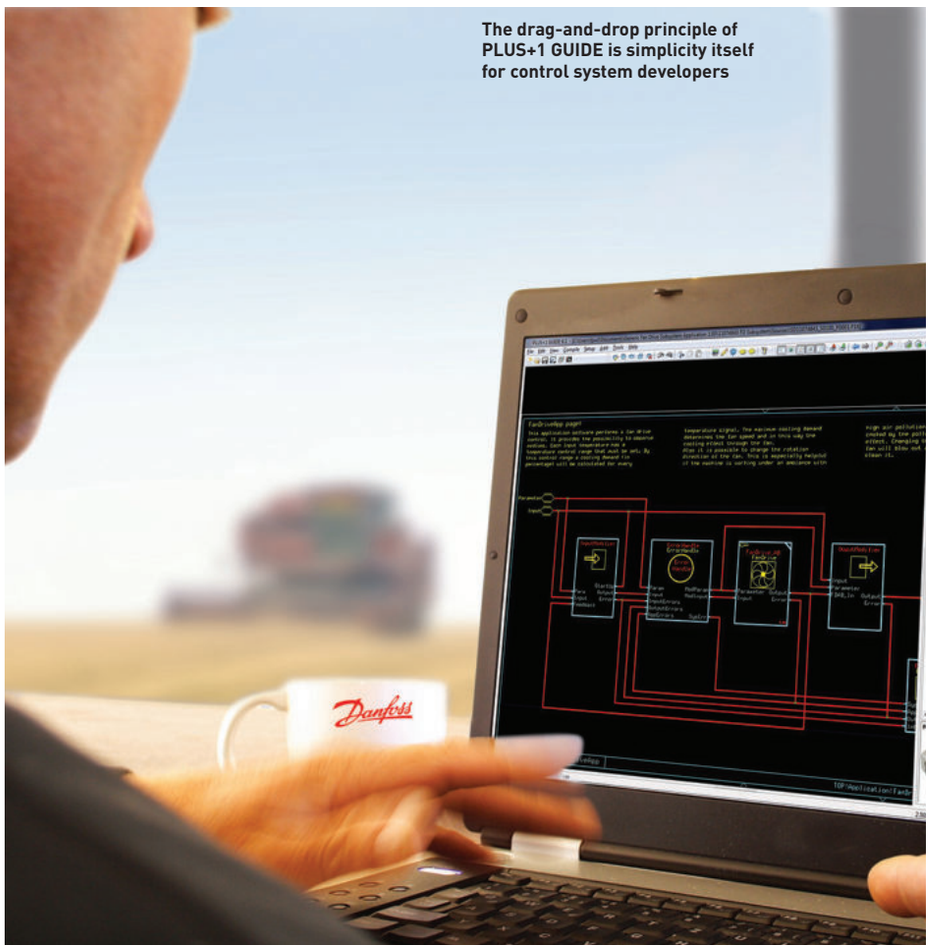
WFC comes with three core functionalities: anti-stall, flow sharing and intelligent engine speed control – making it ideal for machines with power-demanding work functions, such as aerial lifts, telehandlers, backhoe loaders, forestry machinery and truck-mounted cranes. Validation testing on a backhoe loader has documented the ability of WFC to live up to its design objectives. Efficiency and productivity evaluations confirm the potential to downsize the engine by 18% and achieve fuel savings of 19%.

The closed-loop anti-stall function monitors the difference between the engine speed set point, actual engine speed and the load signal from the engine controller. "When the algorithm detects a situation that could lead to engine stall, the command to the flow control valves is reduced to lower the power demand from the hydraulic system," explains Boris Laudenbach, program manager telematics at Danfoss.

The benefit to operators is that they no longer have to worry about stalling, which may require lengthy restart procedures depending on the work function underway at the time of stopping. In the past, machines have been designed with excess engine capacity in order to counter this risk. Now, with the introduction of anti-stalling software, engine power can be reduced without compromising efficiency, and it is no longer necessary for operators to power up the engine when stalling seems imminent. Instead, they can devote all their attention to the work in progress.

The electronic flow-sharing function offers a whole new range of possibilities for machine manufacturers and end users. Systems and application engineer Torben Juul explains, "In addition to the features of traditional hydraulic flow-sharing valves, electronic flow-sharing makes it possible to adjust the sharing ratio or give priority to specific machine functions. Manufacturers can then define selectable modes with individual flow-sharing settings that are optimized for each work task.

"Along with the other WFC features, this makes the machines much easier to operate, thereby increasing their productivity."



The drag-and-drop principle of PLUS+1 GUIDE is simplicity itself for control system developers

Intelligent engine speed

Intelligent engine speed control – the third core function – adjusts the engine speed dynamically in accordance with actual flow demands – a move away from the fixed engine speed approach, where the rpm is set to meet peak flow requirements. PLUS+1 Best Point Control follows the same principle when managing transmissions, continuously calculating the engine operation point as a function of power demand. On top of the clear improvement in efficiency and considerable fuel savings, engine lifetime is extended by the reduction in wear and tear.

"The overall objective of WFC is to match actual work requirements with hydraulic power. Operator feel, productivity and fuel efficiency can be maintained or even improved after downsizing the engine," Laudenbach adds.

At the same time, though, these mobile electronic developments from Danfoss take the pressure off manufacturers who cannot afford to compromise on performance, regardless of emissions standards and cost-driven markets. Intelligent transmissions and work functions bring all goals within reach. Using the latest PLUS+1 GUIDE programming environment, even the most complicated control systems become fast and simple to create. **iVT**

Cath Mersh is a freelance journalist writing for Danfoss

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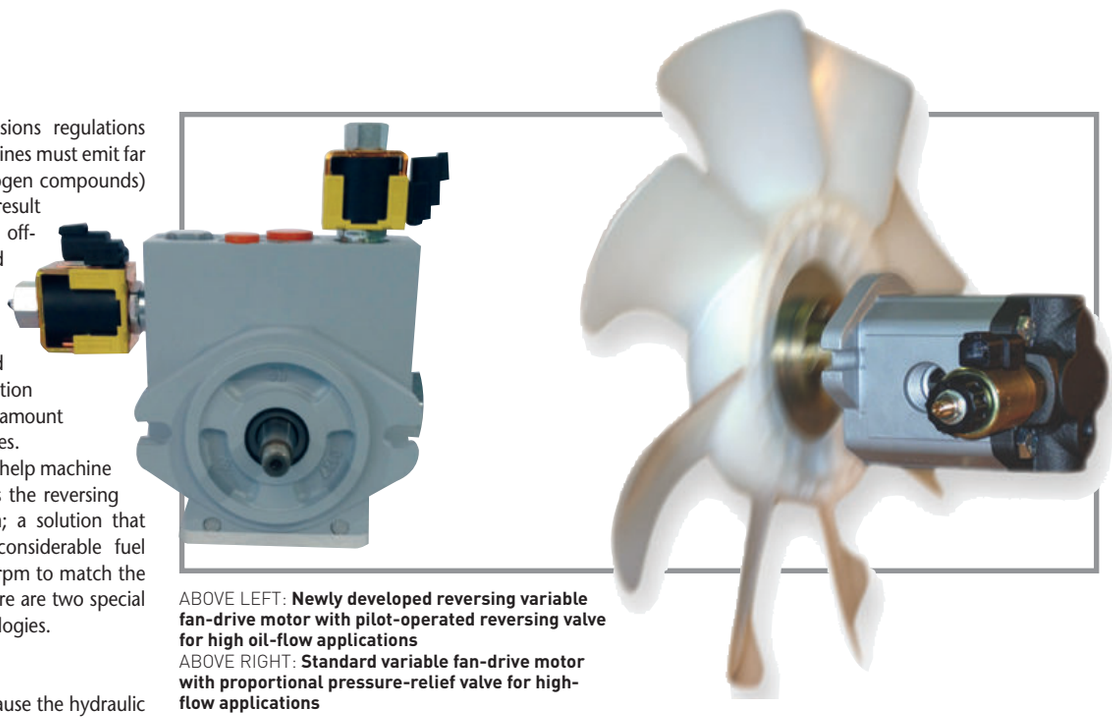
JURAJ HANUSOVSKY

Fan the flames

WITH TIER 4 A PRIORITY, THE NEED TO IMPROVE COOLING EFFICIENCY MEANS THE MOVE TO HYDRAULIC FAN SYSTEMS IS UNDER FULL STEAM. ALL THAT'S NEEDED IS A SUITABLE MOTOR TO POWER THEM...

The Tier 4/Stage IIIB emissions regulations mandate that new diesel engines must emit far lower levels of NOx (oxides of nitrogen compounds) and PM (particulate matter). As a result of these regulations, designers of off-highway machinery are challenged with the increased costs of the engines and their aftertreatment, a reduction in net vehicle power, reduced installation space, reduced hydraulic flow (due to lower application speeds of the engine), and a limited amount of time to implement design changes.

One of the technologies that can help machine designers meet these regulations is the reversing hydraulic variable fan-drive system; a solution that offers many benefits, including considerable fuel savings (achieved by adjusting fan rpm to match the real need of cooling). However, there are two special advantages over competing technologies.



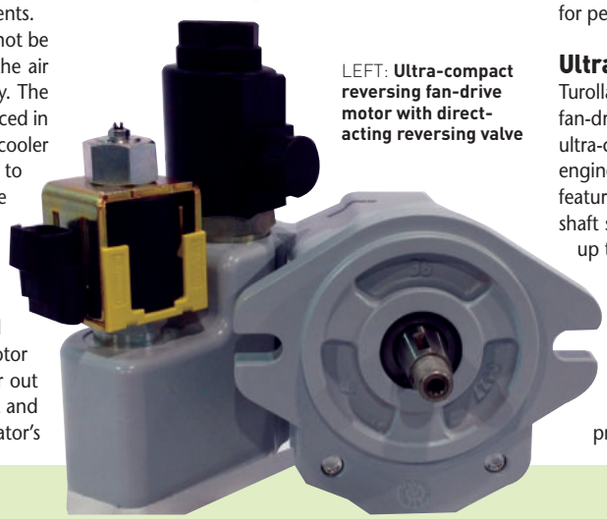
ABOVE LEFT: **Newly developed reversing variable fan-drive motor with pilot-operated reversing valve for high oil-flow applications**
ABOVE RIGHT: **Standard variable fan-drive motor with proportional pressure-relief valve for high-flow applications**

Engine room

The first is the layout flexibility. Because the hydraulic fan motor is connected to a pair of hoses rather than a belt drive or visco-clutch attached to the engine, the radiator and fan can be placed anywhere on the vehicle. The relocation of radiator and fan makes additional room available for the other components inside the engine compartment, which is important for designers who have to conserve space in their quest to fulfill the Tier 4 and Stage IV requirements.

In fact, the engine compartment may often not be the best place to position a radiator because the air drawn in by the fan is likely to be hot and dirty. The radiator and hydraulic fan should instead be placed in a location on the vehicle where ambient air is cooler and cleaner. This flexibility also lends itself to distributed cooling designs, enabling separate coolers for different fluids to be strategically sized and situated throughout the vehicle for optimum performance and efficiency.

The second special benefit is the reversing function. If the hydraulic circuit is equipped with a flow-reversing valve, the hydraulic motor can rotate in the opposite direction to push air out through the radiator. This is done to purge dirt and debris, which can otherwise reduce the radiator's cooling efficiency by as much as 50% when clogged. This feature is especially useful in applications where the vehicle operates in particularly dirty environments and it can also eliminate the need for screens, which add cost and size to the radiator as well as reduce the air flow. The reversing feature can also blow water out of the radiator to prevent damage caused in the event of it freezing in cold climates.



LEFT: **Ultra-compact reversing fan-drive motor with direct-acting reversing valve**

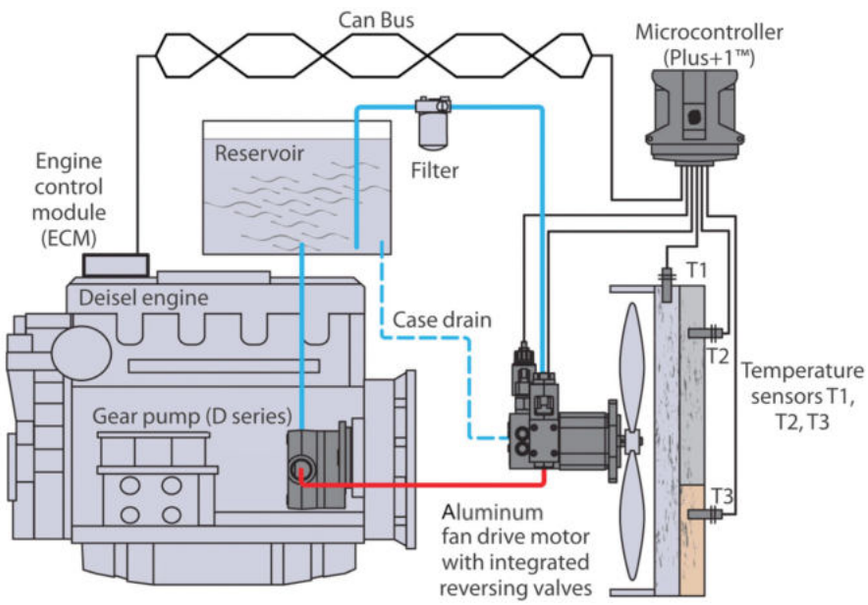
Reversing can occur on-demand whenever the operator presses a switch, or it can be programmed into the ECU to occur at regular intervals. Reversing also improves productivity by eliminating the need for periodic cleaning and maintenance.

Ultra-compact motors

Turolla is fully aware of the advantages of hydraulic fan-drive products and has therefore developed new ultra-compact reversing hydraulic motors, specifically engineered for fan-drive systems. Its fan-drive motors feature a reversing rear cover, dust protector for the shaft seal and can withstand operating temperatures up to 110°C – all of this in standard configuration.

Turolla also offers D-series cast iron motors, which are renowned for their robustness and high-pressure operation. These can eliminate the need for an outrigger bearing, even for large-diameter fans in tough applications.

The company's ultra-compact reversing and proportional fan-drive motor is designed for fan



ABOVE: **Typical hydraulic fan drive system with reversing function for radiator cleaning**

drive systems requiring proportional speed control with reversing capability in a small axial package size. Cartridge valves optimized for fan-drive applications will minimize pressure drop and offer greater power savings. There are two types of configurations: one for applications up to 55 l/min, and a high oil-flow option that reaches 80 l/min.

Turolla's ultra-compact reversing and proportional fan-drive motors integrate the following features:

- High-performance, pressure-balanced aluminum gear motor;
- Integrated dust cover to protect the shaft seal;
- Durable aluminum casting optimized to provide short length and minimize weight;
- Proportional pressure-relief valve for the modulation of fan speed;
- Anti-cavitation valves to bypass flow in the event of sudden fan deceleration;
- PLUS+1 Danfoss electronic controller unit-compliant;
- Deutsch connector DT 04 (IP69K) and optional DIN 43650 connector. **iVT**

As fan-drive application leader, Juraj Hanusovsky, PhD, is responsible for hydraulic application of gear products and has worked at Turolla/Danfoss for 12 years

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ACHIM LIECKER

Clean lines

GOOD DESIGN IS JUST AS VITAL WHEN PRODUCING NEW HOSE SOLUTIONS FOR FUEL LINES, TURBOCHARGERS AND FRONT-WHEEL DRIVES AS IT IS FOR THE LATEST STYLISH BIT OF OFF-HIGHWAY EQUIPMENT

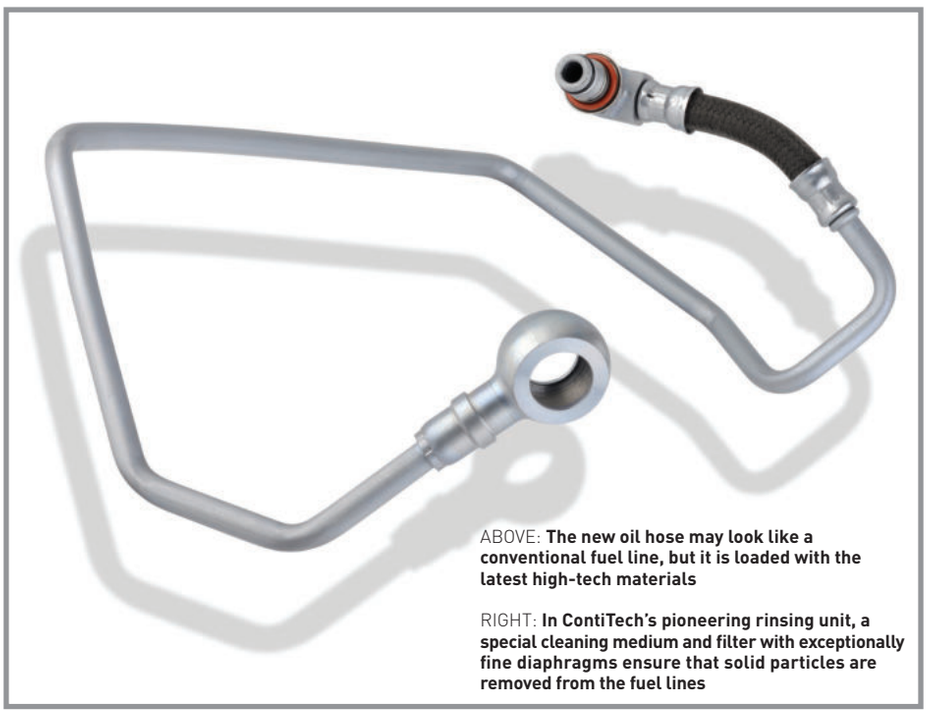
Innovations from ContiTech Fluid Technology are creating new engineering solutions for off-highway vehicles, with high-temperature hoses for turbochargers and extremely pressure-resistant lines for part-time front-wheel drives. And the company's fuel lines for modern heavy-duty engines also meet the most stringent cleanliness requirements.

"The new generation of high-temperature oil hoses for turbochargers are enabling us to venture into 250°C temperature territory," says product developer Klaus Brühne. In addition, the hose design features numerous advantages over the Teflon corrugated tubing and flat hoses used to date.

For example, the hoses benefit from much greater flexibility, thereby enabling tighter bending radii and weight reductions, as well as the accommodation of even smaller package spaces. This benefit is further amplified by lighter system integration when used in combination with aluminum tubes.

The new sheathed hoses are used on the supply and return sides of the turbocharger. The key to withstanding such high temperatures is based around the use of a braided sheath made of a plastic that exhibits high temperature and chemical resistance which – having excellent stretch ability – encloses the FKM rubber inner-lining. The hoses have a very tight bending radii with the use of a molding process, and can withstand operating pressures of 15 bar (218psi).

The hose is part of a kit, which the customer selects for each particular application, helping deliver further cost benefits. The new product can be used for lubricating turbochargers and other applications.



ABOVE: **The new oil hose may look like a conventional fuel line, but it is loaded with the latest high-tech materials**

RIGHT: **In ContiTech's pioneering rinsing unit, a special cleaning medium and filter with exceptionally fine diaphragms ensure that solid particles are removed from the fuel lines**

Continued innovation

Another example of innovation from ContiTech's engineers is the development of lines for part-time front-wheel drives. These lines are designed for trucks that spend a large proportion of their operating time on the road, but also occasionally need off-road capability. The lines carry hydraulic oil, which is pumped to motors under extreme pressure to drive vehicles' front wheels. The company supplies between 15 and 30 such lines per vehicle. Ultimately, they represent an inexpensive alternative to a permanent all-wheel-drive system, in addition to the fuel savings.

The new lines must be able to withstand pressure of 450 bar (6,527psi). This is ensured by a spiral steel sheath that forms the strength member. ContiTech offers these lines up to a nominal diameter of 25mm and can also fit them with snap-on connectors. This not only simplifies installation in the customer's plant, but also prevents torsion on the line, which is unavoidable with screw unions and detrimental to the component's pressure resistance.

"To ensure that the lines remain permanently leakproof, they are subjected to rigorous impulse and movement testing before they leave our plant," emphasizes head of R&D, Christof Kirsch. This also includes vehicle-related tests in which the applications are simulated.

Another challenge mastered by ContiTech concerns the increasing demands placed on the cleanliness of fuel lines for modern engines – even the smallest particles could damage or even destroy the extremely fine injector nozzles. That's why the company has invested some €400,000 in a unique rinsing unit at its Karben site. A special cleaning medium and filter with exceptionally fine diaphragms ensure that no solid particles are in the fuel lines, according to the latest stringent purity demands of many well-known engine manufacturers. "This means that we can satisfy the requirements for the latest generation of engines and are also ideally equipped for future developments," states Kirsch.

With its extremely resilient fuel lines for heavy-duty truck engines, the company has made a crucial contribution to new engine generations, with an offering that is both heavy-duty and environmentally friendly. The Karben site currently produces tens of thousands of these high-tech lines every week.

But the issue of cleanliness is playing an increasing role not just in relation to trucks, but also construction, agricultural and materials handling machinery. The same applies to lines for industrial applications, which are manufactured at the Hoppengarten site. Here,

too, the company ensures that hydraulic lines meet most customers' stringent cleanliness specifications.

One-stop globally

ContiTech is able to supply its commercial vehicle and industry customers worldwide using local production operations – working with the same processes and high standards as in Europe. For example, ContiTech supplies truck manufacturer Paccar with coolant lines that withstand temperatures up to 210°C and with high-temperature oil hoses for the turbocharger from Germany and Brazil. ContiTech also produces a variety of lines for Volvo from its plants in Germany, France, Brazil and China. And in 2014, ContiTech began production in Mexico, producing a range of applications from power-steering lines to heated urea lines for SCR systems and air-conditioning lines. **iVT**

Achim Liecker is head of sales industrial vehicles at Contitech Fluid Technology

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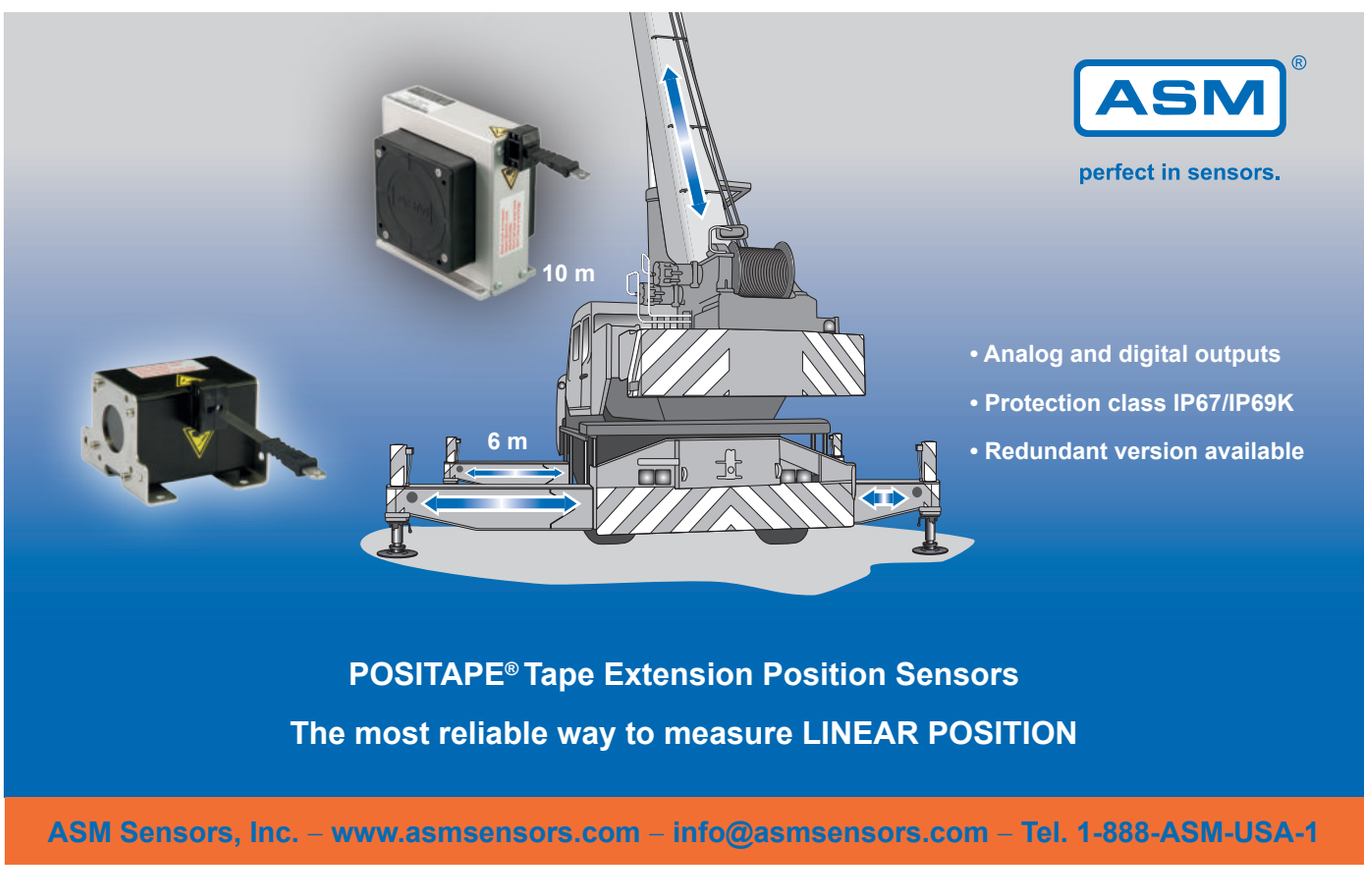

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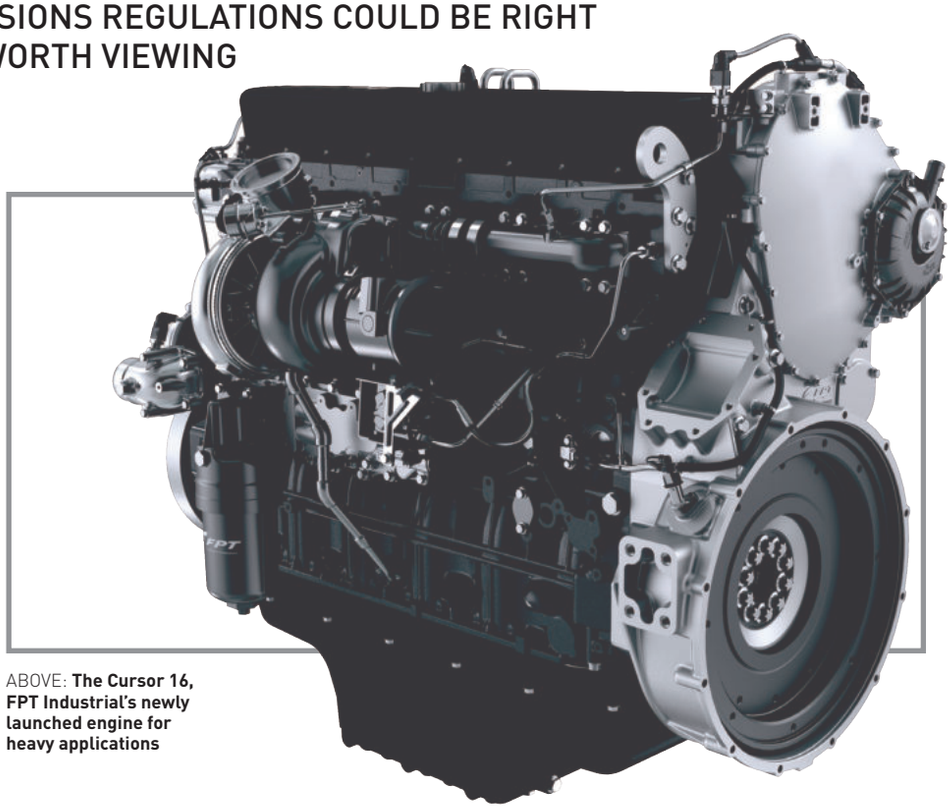
ENGINES THAT DELIVER PERFORMANCE BEYOND THEIR CAPACITY YET STILL MEET THE LATEST EMISSIONS REGULATIONS COULD BE RIGHT UP YOUR STREET AND WELL WORTH VIEWING

Across the board, engine manufacturers have had to focus their research and development efforts on emissions regulations over recent years, and FPT Industrial is no exception. Now, however, following the development of its High Efficiency Selective Catalytic Reduction (HI-eSCR) system, which reduces nitrogen oxide (NOx) levels by more than 95% to ensure alignment with the latest emissions regulations, FPT Industrial has now shifted its focus to the expansion of its product range.

With this shift, the company has made a major impact on the off-highway machinery market. The powertrain innovator's new Cursor 16 engine has been awarded the title of Diesel of the Year 2014, which was officially presented in May to Massimo Rubatto, FPT Industrial's VP of sales, at the Samoter earthmoving and construction machinery exhibition, held in Verona, Italy.

This is the second time that the company has secured the accolade: its 3.2-liter F5 engine also received the award in 2008, and is currently equipping agricultural machinery for companies such as Carraro, Case IH and New Holland.



ABOVE: **The Cursor 16, FPT Industrial's newly launched engine for heavy applications**

Well packaged

Small in size yet big in impact, the new 15.9-liter Cursor 16 provides best-in-class power and torque density, as well as rated and max power, to deliver typical 18-liter performance from a 13-liter package. Incorporating FPT Industrial's latest technology as well as the reliability and flexibility for which the Cursor Series is known, the engine excels in power management, combustion efficiency and low fuel consumption in order to considerably reduce total cost of ownership.

Designed for heavy off-highway work, the Cursor 16 is suitable for construction, agriculture and power generation applications, among others, delivering up to 570bkW and maximum torque of 3,320Nm at 1,500rpm with its single-stage turbo version, and up to 630bkW with 3,500Nm of maximum torque at 1,400rpm from its dual-stage turbo model.

Incorporating the FPT Industrial-patented HI-eSCR system, the engine adheres to Tier 4 Final and Stage IV emissions regulations. Combustion is optimized through the use of steel pistons and FPT Industrial's own double re-entrant combustion bowl. The steel pistons enable high peak cylinder pressure for higher power density and lower particulate matter (PM) production, and two turbulent vortices are created within the double re-entrant combustion bowl for the accurate control of fuel and air to further maximize performance and minimize emissions.

It is also the first engine to adopt a compact graphite iron (CGI) cylinder head for high thermal and mechanical resistance.

"Featuring the latest technical innovations that have been developed in-house at our R&D centers, the Cursor 16 delivers excellent power output while ensuring optimum efficiency and low maintenance intervals to provide end users with a cost-effective solution," says Massimo Siracusa, FPT Industrial's VP of product engineering.

"The engine represents the top level within the Cursor Series and illustrates FPT Industrial's expanding range to cater for the vast requirements of the market. Its launch follows our successful introduction to the low-displacement market with the R22 at the end of 2013," Siracusa continues.

Ahead of the game

FPT Industrial's recently launched 2.2-liter R22 engine effectively introduced the manufacturer to the low-displacement agricultural and construction sector. Developed with long-term partner VM Motori SpA, the R22 delivers power of 33-53bkW and up to 250Nm of torque. Compact and efficient, the three-cylinder engine is suitable for machinery with a gross weight of 1.6-3.1 metric tons and adheres to Tier 4 Final and Stage IIIB emission regulations.

"The R22 combines impressive torque and power density with low maintenance and operating costs, and provides considerable personalization scope to suit our customers' requirements," adds Siracusa. "These two new engines illustrate the latest direction for FPT Industrial. Our R&D had to focus on the evolving emission regulations in recent years, but now we are reviewing customer requirements and evolving to keep ahead of the market in our offering." **iVT**

With 15 years' experience, Douwe Hilarius is operational marketing and communication manager at FPT Industrial

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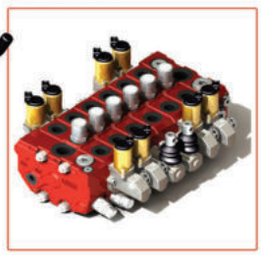

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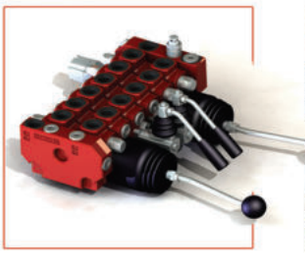

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HIGHLIGHTING NEW DRIVELINE SYSTEMS – INCLUDING HYBRID AND CVT TECHNOLOGIES – THAT ABLY MEET CONFLICTING OPERATOR DEMANDS WAS SOMETHING TO MAKE A FUSS ABOUT AT CONEXPO

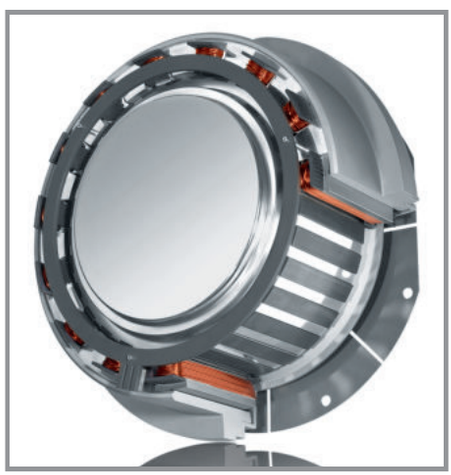
Reducing costs and fuel consumption while enhancing productivity play a key role in determining trends in the construction industry. New presentations, innovations and the highest technical performance should inspire the user of tomorrow, and so does ZF – with innovations of great value.

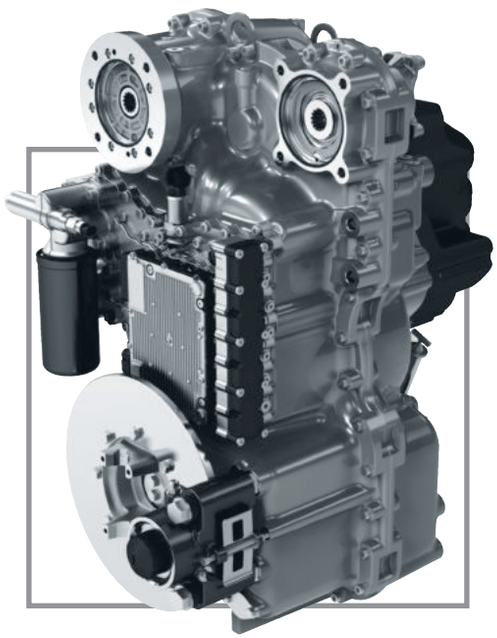
In March, ZF presented its latest product highlights at ConExpo 2014, true to the fair's motto, 'If it's new, it's here'. The ErgoPower Efficiency Package, cPower continuously variable transmission, and the ZF hybrid module, all gave a view into the future of construction equipment at the Las Vegas exhibition.

As a system supplier, ZF concentrates on the entire driveline and combines advanced software features with its transmissions and axles. The traditional areas of focus of the ZF developers include:

- Less fuel consumption and increased productivity;
- Noise reduction and ease of use;
- Increased driving comfort and safety.

For many years, ZF driveline and chassis systems have proven themselves in meeting the challenges of the off-highway market. With the perfectly matched components of the Efficiency Package, ZF offers more than the sum of their individual advantages. Such an approach makes it possible to reconcile the frequently conflicting demands highlighted above, even with fuel savings of up to 15%. Its field of application mainly comprises the important wheeled loader, motor grader, and diesel and gas lift-truck markets.





ABOVE: **ZF is hybrid ready: this modular system can be combined with a variety of transmission platforms**
ABOVE RIGHT: **cPower combines hydrostatic and mechanical drive for up to 25% reductions in fuel use**

Stepless into the future

The fully powersplit, continuously variable cPower technology benefits from the long-term experience ZF has gained in the agricultural machinery sector and offers several notable consumption benefits and productivity increases for the vehicle owner. This new technological benefit for construction machinery enables completely new drive concepts. Up to 25% less fuel consumption and up to 20% more efficiency underline the many advantages of the continuously variable transmission in typical operating cycles.

The increasing demands for fuel reduction and productivity increases require new technologies in construction machines, such as this CVT. A trend toward lower engine speeds and the demand for engine stabilization via a constant speed concept, are the future challenges in the construction machinery market. cPower meets both requirements. In wheeled loaders, hydrostatic-powersplit transmissions will often provide considerable consumption benefits compared with hydrodynamic and purely hydrostatic concepts. The CVTs clearly demonstrate their benefits over all ranges of the typical operating cycle, i.e. during bucket-filling, transporting and loading.

In this process, the percentage of hydrostatic power is kept low so that an optimal degree of efficiency can be achieved. In the start-up process, the greater part of output comes from the mechanical part of the transmission. Even in very short loading cycles, the utility of the CVT technology becomes noticeable in reduced fuel consumption.

The use of an elaborate hydraulic transmission-control unit and transmission-integrated onboard ECU optimally completes driving functions. The application of these units is made with reference to sensitivity and driving comfort, and realizes an aligned power management.

Hybrid systems

ZF also offers hybrid technology, comprising electric machines and complete hybrid systems all from one source. The ZF hybrid system is suitable for all ZF transmission forms and can be implemented for direct and separate transmission mounting.

The system works as a parallel hybrid with an efficient electric machine, providing up to 85kW or 120kW performance, depending on the size. It is possible to integrate the electric machine into the transmission. The complete system comprises power electronics for the electric machine and a lithium-ion battery, as well as a hybrid control unit. Due to the optimized energy and hybrid drive management, the interaction between an electric machine and a diesel engine is matched to avoid driving situations with poor efficiency and increased emissions.

The ZF hybrid system is a good choice for a wide range of vehicles and can also be combined with the company's cPower, HL or HC 85 transmissions. A wide range of construction machinery can be equipped with this future-oriented and environmentally friendly technology. The hybrid systems enable a considerable reduction of fuel consumption with a corresponding reduction in exhaust emissions, and an increase in work output. As a result of this innovation, the vehicle owner's operating costs can be greatly reduced. **iVT**

Alexander Eisner is head of product communication for ZF, where he is responsible for construction, agricultural and material handling machinery marketing operations

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JEAN MARC GUITTARD

Critical list

THE DAYS OF ONE-SIZE-FITS-ALL HVAC VEHICLE SOLUTIONS ARE LONG GONE. BUT WITH A VAST RANGE OF MACHINE TYPES AND SIZES TO CATER FOR, THE IMPORTANCE OF PRODUCING A SYSTEM TO MEET THEIR EXACT REQUIREMENTS IS INCREASINGLY VITAL

In the 28 years since it was founded, SNDC's role within the HVAC market has constantly evolved and transformed. Today, the main challenge confronting its customers' engineering, purchasing and service departments is providing the correct description of their HVAC requirements to ensure the most suitable technical solution is chosen.

Specifying a system that is fully compliant with standards, machine environment integration, end-user expectations and, last but not least, meeting the purchasing target price, can all be very difficult to achieve. But as a result of its customer operation environment and long history of delivering comfort, SNDC is able to back up its expert HVAC function with a role in the writing of specifications.

From a customer's initial contact to the end of a product's lifetime, HVAC development can be a long process. The growth and diversity of requirements means most OEMs are no longer able to adapt off-the-shelf units to enjoy the price benefits that result from economies of scale. Each system is now specific, meaning the long list of a customer's legitimate requirements never comes to an end.

The following paragraphs, and the next edition of *iVT International* will describe the processes that must be taken into account, as well as the tools used by SNDC to achieve this.

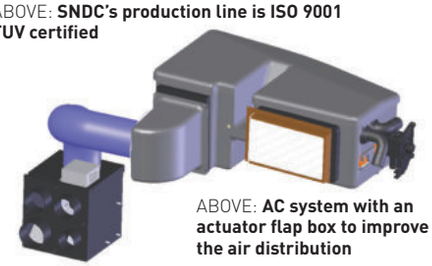
Comfort requirement support

The definition of comfort is often abstract, with standards often challenged by an end-user's comfort expectations. The desired temperature inside the cab is not the only criterion taken into account by the operator. The time taken to achieve this temperature, noise ventilation emissions, the feeling of the airflow, maintenance frequency of fresh air filters and the defrosting and defogging of windows – all this is difficult to apply criteria to when writing specification.

For this purpose – the definition of objective and subjective HVAC function criteria – the role of SNDC is twofold: the company must assist the customer in drafting the specifications, and meet and exceed those with the end results.

The preliminary stages of HVAC design involve calculation and simulation, then the finalizing of the design. Modification of just one of the input data often leads to an evolution in the calculations, which itself changes the overall results of the simulations and culminates in a product with a different volume and capacity. It is this observation that led SNDC to work all three phases of design in a single environment integrating computation, simulation and design.

ABOVE: **SNDC's production line is ISO 9001 TUV certified**



ABOVE: **AC system with an actuator flap box to improve the air distribution**

The company relies on a variety of computation tools to ensure optimum results, including:

Thermal balance: Especially developed for SNDC, the thermal modeling software must take into account various parameters to calculate exchanges between the different environments and geographic areas in which the machine operates; typically involving ambient temperature, humidity and wind-speed. But other parameters are taken into account, too, such as the desired indoor temperature, window and wall surfaces, orientation, thickness and thermal conductivity, cab color and refreshment of cab air. The thermal balance should also allow for determining the selection criteria for, and influence of, items such as wall insulation or volume fresh air renewal.

Frigorific design: On the outside, an AC system looks simple and appears to be built with identical components. SNDC's frigorific performance software stores the details of each component that plays a role in the refrigerant circle: a minor change to one parameter will create a snowball effect influencing the final cooling performance and, last but not least, the reliability and longevity.

Installing an oversized evaporator somewhere the compressor cannot deliver enough refrigerant flow is like a truck attempting to pull a heavy load uphill using a car engine. Similarly, a condenser incapable of coping with the heat rejection absorbed in the refrigerant circuit (compressor and evaporator) will reduce the efficiency. Even the use of different hoses between one vehicle and another will influence the performance of the final system.

To ensure the compressor lifetime, it is therefore of great importance to survey the running conditions, especially when they are likely to be very high or low.

In the September edition of *iVT International*, this exploration of SNDC's HVAC engineering expertise will continue with a look at its simulation tools, test resources, technologies and component choices, and production line integration. **iVT**

Jean Marc Guittard, president, founded SNDC in 1986

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All-purpose measurement system

The absolute miniature single-turn AH25S rotary encoder from **Siko** is a cost-effective solution to the task of finding a measurement system that satisfies all technical requirements, is resilient, and also offers exactly the right construction form.

It provides an ideal balance between high resolution, excellent functionality, a sturdy housing design, and a minimal construction form. OEMs can choose from several analog interfaces such as 4…20mA, 0…10V or 0.5…4.5V, which is especially well suited for agricultural equipment.

The encoder always makes use of the advantages of the wear-free magnetic measurement principle, resolving the entire 360° into 4,096 measurement steps. A redundant version is also available upon request. This innovative technology, packaged in a sturdy die-cast case of just 25mm diameter, is ideal for applications with limited installation space.

Special design measures ensure IP65 levels over the course of its long product lifetime, making it particularly suitable for positioning tasks in mechanically demanding environments and with temperatures ranging from -40° to +85°C.

Combined with resilient ball bearings, the AH25S is ideal for dependable measurement under confined spatial conditions. The 8mm blind hollow shaft enables a simple installation of the rotary encoder. The rotary encoder itself can be manufactured with a radial cable outlet with an open cable end or a corresponding customer connector.

With its zinc diecast housing and heavy-duty design, the AH25S offers many advantages, including better protection against EMC and improved impact protection. It is also better protected against environmental influences, such as UV rays, dirt, dust and water.

All these features make the AH25S single-turn encoder a perfect all-purpose tool for angle measurements in mobile machines. It is therefore used in many applications, such as angle measurement on the booms of excavators and concrete pumps; angle monitoring on forklift steering wheels and pedals; monitoring of steering angle and angle position of the front loader on agricultural machinery; and monitoring ladder elevation, angle and position/angle detection of the water gun used on municipal vehicles and fire engines.

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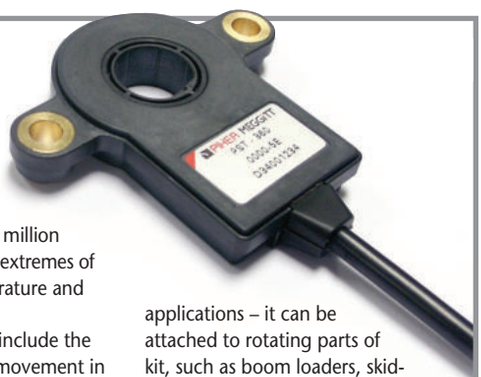
All work and no play



Designers of rugged vehicles want all the benefits of contactless rotary sensing (no wear and tear) without suffering the expense of over-engineered solutions. They want enough accuracy plus stable performance over a long lifetime, despite environmental extremes. Contactless Hall-effect specialist **Piher Sensors & Controls** has now launched two solutions that play to this requirement.

Piher's novel PST-360 'through-shaft' sensor effectively wraps around any shaft sensing directly at source. One slimline 9mm package contains two non-contacting components – a full circle magnet and an electronics module. The application-patented design can be fitted anywhere on a shaft, giving engineers the flexibility to be creative. It is easy to assemble, so production line costs are less than that of other sensor solutions.

For operators, it's all about maintenance – none is needed over the product's life. Program manager Jose Luis Macias says, "This contactless, through-shaft sensor delivers the same level of 360° precision and stability over at least 50 million rotational cycles despite extremes of vibration, shock, temperature and contamination."

Current applications include the sensing of front loader movement in some axes, sensing steering angle in ride-on scrubbers and forklifts, throttle handles, and sensing when the nose-wheel of an aircraft is in position on a tow tractor cradle.

A second solution, the MTS-360 creates immunity to radial and axial play on mobile shafts where significant misalignment usually results in poor operational performance and labor-intensive maintenance programs.

Here, Piher separates the magnet from the electronics module. This two-piece sensor uses an arc magnet (for use where 360° rotation angle is unnecessary) and is especially ideal for agricultural and construction applications – it can be attached to rotating parts of kit, such as boom loaders, skid-steer buckets and hitches arms, and the electronics module to the chassis (or vice versa). Again, over 50 million cycles, stable electrical output and the specified linearity is maintained between both sensor packages despite any radial and axial play of +/-1 to +/-1.5mm (and upward) respectively.

All Piher sensors are low-profile, yet extremely rugged, and can be custom-engineered to fit existing mechanical assemblies.

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Quote Ref: **513**

Feeling the pressure

The diversity in pressure measurement devices is derived from several variables, so a standardization that would lead to a reduction in this diversity is hardly feasible.

A building block approach is therefore an ideal solution. **STW** follows the philosophy of a "universal transmitter with configurable characteristics", and its M01 transmitter series satisfies the need for diversity and flexibility through modularization and the standardization of the interfaces between the modules. This offers maximum permutations, while ensuring cost-effective production for high and low volumes.

When selecting sensors, the customer tests the M01 just once for suitability, then defines further variants as needed, and can rely on having the same characteristics across the transmitter range. The customer can choose from an exceptionally high number of building blocks, with nine electrical output types, 1-2,000 bar pressure ranges, 10 electrical connectors, 20 different process connections, and safety options.

Combining these blocks yields 1.5 million possible transmitters with the same core characteristics. New building blocks, e.g. fieldbus systems, are continuously being added and, in case the range isn't sufficient, the customer can have its own components developed, e.g. a connector or customized data protocol, and integrated in the system.

The universal characteristics of the M01 transmitter meet the same requirements without compromise: an operating temperature range of -40° to 125°C, a high medium compatibility, extreme robustness and a small size are the basis of the building block system.

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Universal control solution

Liebherr is now offering a universal control unit specially developed for industrial vehicles. The freely programmable Compact Control Unit is guaranteed to perform well even when exposed to the most severe environmental conditions, for example vibrations, dust, water or EMI. The robust die-cast aluminum housing enables the control unit to satisfy the strict requirements of IP67 and IP6K9K, and work at operating temperatures from -40° to +85°C. This makes it ideal for applications such as controlling the working hydraulics or peripheral attachments.

The Compact Control Unit is equipped with a 32bit processor and up to 70 inputs and outputs, enabling it to perform complex and safety-critical applications. Should specific customer applications require additional inputs and outputs, there is an option for cascading further intelligent control systems or miniature controls via the CAN interface. Applications can be programmed in the high-level language 'C' and also via the development environment CoDeSys.

The provision of a library within the scope of delivery for the diagnostic identification of the performance level required in the application environment pursuant to ISO 13849 is supported with a Sistema tool.

This means control functions up to performance level 'd' can quickly be configured, enhancing the safety of both user and machine.

To connect other electronic components to the Compact Control Unit, Ethernet, CAN with connectable bus termination, RS232 and LIN interfaces are available.

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Quote Ref: **515**

Hi-spec multifunctional controller

Sontheim Industrie Elektronik has released its latest multifunctional controller – COMhawk. This high-performance ECU has numerous applications for communication and diagnostics, including its use as a CAN-to-wi-fi gateway, data server, telemetry node, datalogger, and diagnostic device, among others.

With three CAN channels, wi-fi, Ethernet, optional I/Os, built-in diagnostic functions, and a webserver, COMhawk is capable of meeting OEM needs in a variety of implementations.

Driven by a powerful 32bit microcontroller with a built-in NAND flash memory of up to 16Gb, it has a robust design capable of operating in harsh environments including exposure to dust, shock, vibration, extreme temperatures, and high-pressure water or steam jets, and meets all requirements outlined by the Automotive EMC Directive.

It is loaded with Sontheim's own flexible, modular SW architecture, along with a complete user development environment that allows for real-time operation and user programmability, making it reliable, reusable and futureproof.

For offboard applications, Sontheim produces COMfalcon, a handheld version. Similar to COMhawk, this next-gen communication controller is equipped with four CAN channels, wi-fi, Ethernet, multiplexed serial interfaces including RS232, RS422, RS485 or K-/L-Line, as well as logging capabilities and diagnostic functions.

As an expert in complete electronic systems, Sontheim also offers the Modular Diagnostic Tool Chain (MDT) software, which enables the creation of comprehensive and highly customized diagnostic applications.

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Quote Ref: **516**

Rotary sensors to the rescue

Curtiss-Wright has supplied Penny + Giles joystick controllers and rotary position sensors to BAI for use on its second-generation tunnel firefighting and rescue vehicle.

For Curtiss-Wright, the project started when BAI wanted a friction-hold joystick to control equipment installed on the VSAT 13000 S. The up/down function of each water cannon is operated using the Penny + Giles JC1500 friction-hold joystick controller, with rotational functions being provided by a Penny + Giles NRH280DP rotary position sensor fitted to the bottom of each joystick.

BAI's Enrico Callura said, "Feedback from users of the [first-gen] Janus 4000 stated that, without having to refer to the control panel's display, they wanted to easily identify the position of the joystick. The decision to specify Penny + Giles was based on our requirement for a joystick completely compatible with the rotary sensor and featured a low-profile design so the sensor could be fitted to its base."

The non-contact NRH280DP Hall-effect rotary position sensor is provided with a housing activated by a separate magnet, offering a small 6.5mm profile. The NRH280DP is designed for operation in extreme temperatures and has been factory-configured to provide OEMs with a wide selection of parameter options, including measurement range and clockwise or anti-clockwise direction output. This high level of flexibility provides a greater amount of control to configure the sensor to best suit the needs of vehicle manufacturers and achieve maximum performance.

For example, the sensor can be configured so that one signal can be used in a control function, while the other is used for position monitoring or display purposes.

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Quote Ref: **517**

J4F joystick plays it safe

elobau's robustly designed J4F joystick incorporating safe electronics has been developed in accordance with the Machinery Directive ISO 13849-1:2008 to PL 'd', and certif ied to DIN EN IEC 61508:2010 and SIL2.

It provides an interface that represents a comfortable, integral part of a machine's safety architecture. The J4F can be quickly and easily installed from above the mounting panel using four screws. Due to its very compact design with a directly flanged CAN electronic module and a 90° angled Deutsch connector, it requires minimal installation space in the console. With direct connection to the vehicle CANbus, no additional CAN electronic module is required. The typical robust design of the J4 series also withstands a high static load on the x/y-axis of 2,000 N and on the z-axis of up to 700 N.

To ensure reliable switching, the electronics provide redundant signals from both the axis of the joystick base and the thumbwheels. Furthermore, the push buttons are equipped with NAMUR circuitry that can reliably detect any malfunction. The contactless Hall sensor and reed switch technology ensure long life and high reliability.

The interface to the vehicle CANbus is based on the CAN SAE J1939 protocol and includes some safety-related adjustments. The electronics are fully sealed to IP67, and with its wide temperature range of -25° to +85°C, and the ability to withstand extreme vibration, it is ideal for use in telehandlers and wheeled loaders.

The multifunction handle has three analog thumbwheels and 65 nano push buttons as standard, or an optional eight-button handle variant. Integrated microbuttons can also help prevent frost damage, and night illumination is available.

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Gripping stuff

J.R. Merritt's new ultra-rugged CS3HD joystick was designed from the company's industry-proven CS3 joystick. The CS3HD provides a Hall-effect sensor in a compact, yet heavy-duty package. The company offers this unit with 1-, 2- or 3-axis control, as well as with a variety of standard and custom options, including a Hall-effect twist third axis with smooth high-life non-biasing compression-style spring return to center and a variety of standard handle options and custom multifunction grips.

Features include proprietary blend, ultra-tough boot, and environmentally sealed mounting and corrosion-resistant components.

The durable 10mm diameter operating shaft and robust internal mechanism of the CS3HD make this device especially ideal for use with the company's new FG-5 universal hand grip. This large, multifunction grip is used for left-hand or right-hand operation. The FG-5 includes a longer barrel for operators with large hands or gloves, and a removable face plate can be configured with a wide combination of buttons, thumbwheels, rocker switches and toggles.

The CS3HD joystick and the FG-5 universal grip make an ideal combination for reliable operator control in both on- and off-highway industrial vehicles.

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High-pressure multiconnections

Constantly focusing on continuous improvement activities and new product development, **Faster** has recently developed and launched a new high-pressure Multifaster range named PH406 for very high-pressure ranges in industrial heavy-duty applications.

These multiconnections have been developed to offer the best connection solution for hydraulic equipment working at very high pressures up to 46MPa (6,671psi).

With over 25 years' experience with multiconnections, the Italian company has combined the new product with its recent FFH high-pressure technology.

The main application fields of this new product are in industrial and heavy-duty construction equipment such as special demolition machines, grapple cranes, heavy-duty cranes, high-pressure power units, trailers and other special applications.

General technical features of the PH406 include:

- Connectable under pressure;
- Maximum working pressure of 46MPa (6,670psi);
- Outstanding impulse pressure resistance;
- High resistance to severe conditions and dirt environment;
- Mate1000 zinc-nickel coating treatment;
- FFH technology experience;
- Available sizes: 06-3/8in.

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A cluster that counts

Bauser's counting, visualizing and supervision panel instrumentation clusters for industrial vehicle cockpits, some with TFT color displays, provide high functionality and user-orientation, high quality, and good value. The company's quick reaction speed also enables OEMs working to short lead times to be first to market.

Recent development has focused on instrument clusters for diesel-driven machines, which work within standardized CANbus protocols, such as CANopen or SAE J1939. CAN messages, such as PDOs or PGN/SPNs, can be received from an engine or hydraulic ECU and then indicate warnings through LED lamps or error codes on the display. Emissions control is also indicated.

Warning LEDs can also be triggered via digital input or CANbus protocol. A particular threshold to the input of the instrument can be connected, to activate the warning LED – e.g. for fuel level, battery charging, cooling water indication, oil pressure, handbrake and direction indicator.

As part of this, Bauser can design a diagnostics tool according to client requirements, although most adopt its pre-existing diagnostics tools, ensuring a quicker, more seamless transition.

Even after production of an instrument cluster, changes as a result of future vehicle modifications can be made using a PC configuration tool – for instance, installation of a new sensor, tank encoder or CAN connection – making it easy and straightforward to re-parameterize various analog inputs, to upgrade firmware, to set a clock, or to update service interval values.

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Save money when switched off

The automated start/stop system has become a standard feature in all energy-saving automotive vehicles. According to OEMs, 2-6% of fuel can be saved when the engine is automatically switched off at traffic lights or in traffic jams, depending on the driving cycle.

Linde Hydraulics has been examining this issue in great detail, investigating ways that diesel engines can be switched off and restarted in line with demand in machines such as wheeled loaders, for example. The solution is a new type of hydraulic start-stop system.

The basis of the automated start/stop system is the electrically controlled MPR 50 medium-pressure pump, which works as a system component to supply oil to the hydraulic work functions.

The pump has also now taken on an additional task: when the engine is in operation, the pump charges a compact hydraulic accumulator. When the Linde Hydraulics LINC ECU detects that the driving and working functions have come to a standstill, the IC engine is switched off. When the operator touches the pedal or moves the steering wheel or joystick, power is fed from the accumulator via a valve block back to the MPR pump, which then functions as a starter motor. The engine then ramps up to a pre-set engine speed.

This starting procedure is four times quicker than starting using an electric starter motor, ensuring that the machine is ready for operation without any noticeable delay.

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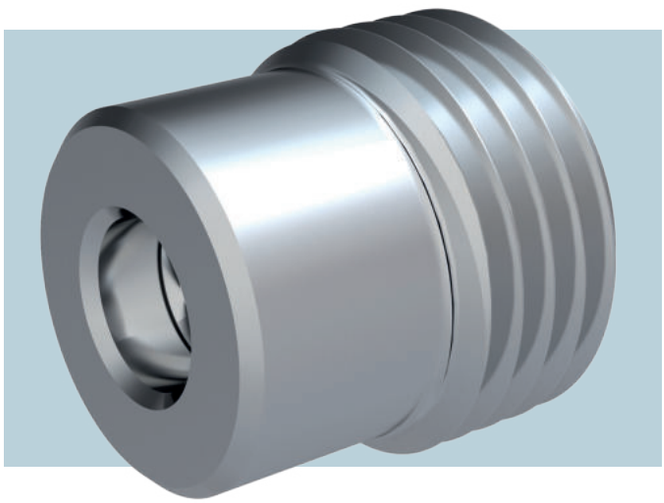
Hydraulic check valves with extra flow

When it comes to the concept of 'ECOdraulics', the engineers at **Bucher Hydraulics** have certainly done their homework.

The new-generation series RKVE-G…-VD hydraulic check valves provide 50% higher flow at the same pressure differential than the previous version. Not only does this design save energy, but in many applications, will enable OEMs to select smaller valves. This saves mounting space as well as lowering build costs.

The design does away with soft packings so that the valves can now operate at temperatures between -30° and +120°C. The new generation can be used with cavity type REG-02 (118°) and is interchangeable in this cavity type with the previous versions.

RKVE series check valves belong to Bucher's family of non-return valves. These enable a free flow in one direction, while preventing oil flow in the opposite direction. The spring-loaded poppet valves are rugged, reliable and insensitive to dirt. The body and seat have a positive fit, while the valve seat, ball and body are hardened, and the sealing faces precision machined.



The check valves are available in nominal sizes 04 (12 l/min); 06 (25 l/min); 08 (50 l/min); 10 (80 l/min); and 16 (120 l/min); with opening pressures of 0.2, 0.5 and 1 bar.

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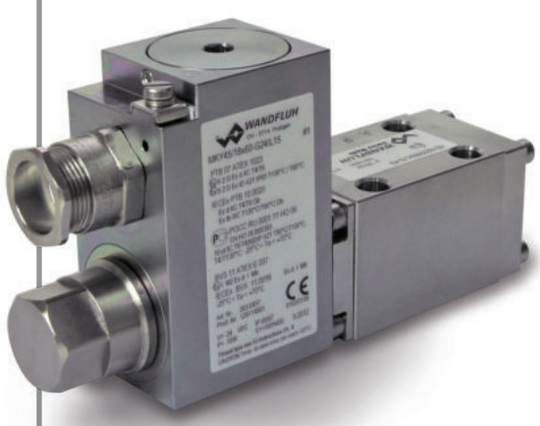
Adapting to the conditions

The ambient conditions surrounding oil and gas production make for high demands on installations and tools. The installations have to reliably operate at temperatures of up to 60°C or withstand the climate and the seawater on offshore production or transportation facilities.

Many drive functions are performed hydraulically in these installations and therefore provide the necessary power within a small installation space. **Wandfluh** produces a wide range of hydraulic valves that have been especially tailored to the requirements of these ambient conditions. In the field of surface protection, the external valve components are manufactured from seawater-resistant stainless steel.



With this K9 standard, Wandfluh provides all-important valve functions – from the directional valve via the leakage-free poppet valve, right up to the pressure- and flow-control valves. The adjustment of the valve may take place manually or through a solenoid. If movements are to be made with changing speeds or with variable forces, the necessary valves are also available with a proportional function.

In oil and gas applications in particular, electrically actuated valves are naturally used in explosion hazard areas. A corresponding protection therefore has to be provided for the solenoid, which encapsulates possible sparks and limits surface temperatures, to exclude any ignition source. For this purpose, Wandfluh provides a solenoid with many international and national certifications and corresponding certificates. With the zinc nickel surface coating, a maximum degree of corrosion protection is assured (>800h salt-spray test according to EN ISO 9227), which also enables problem-free use of the solenoid in a corrosive atmosphere.

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Connection problem?

In many mobile applications, quick-action couplings are used to connect and disconnect the hydraulic circuit between the machine and the attachments or other parts of the machine that need to be disassembled for whatever reason.

With closed circuits full of oil after disconnection, the separated parts of the machine suffer from a notable increase of the internal pressure due to the thermal expansion, which creates problems for the next connection. To proceed with their work, many operators try to solve this problem in an unsafe way, by releasing the pressure acting on the valves of the couplings or unscrewing the couplings from their fittings.

To deal with this problem, for several years **Stucchi S.p.A** has been developing and researching new solutions dedicated to each of the applications in order to help operators carry out the connection and disconnection of the hydraulic circuit with internal residual pressure, without effort and in safe conditions.

In addition, these clever solutions provide other benefits such as reducing the connection operation time, savings on the total installed cost of the products due to their longer life, and even removing the risk of fines for inadvertently releasing hydraulic oil into the environment.

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Diffusing the atmosphere

Several OEMs began their partnership with **Kalori** after finding the ideal air diffuser for their application in the company's product range.

Its accessories are now grouped together under a label that clearly differentiates them from the heating and air-conditioning product range, Kalori Trim Line, and are frequently chosen for their greatest quality – elegance.

Since the production of the first air vent in 2000, the product range has expanded to become one of the most comprehensive on the market. It has today reached the third generation of KB vents – the best-seller in the range. This air diffuser is a huge success: its sober design, excellent construction and pleasant handling give the standard accessory a perceived quality that enhances the general appearance of the cab and the machine.

More upmarket versions have enriched the offer: the KB vent is available with a chromium-plated fixed part as a standard feature or matt chromium-plated on demand.

This vent is attached in the dashboard using the multiclip system invented by the Kalori design office. This clever yet simple system ensures effective fastening, even in dashboards that have an irregular thickness. This air diffuser can be fitted with couplings for ducts of 40-70mm diameter, and there is also a 90° curved coupling of 55mm diameter.

The product range is constantly improved with the creation of new grilles, vents of different sizes, connection accessories, or damper or butterfly valve systems, enabling the forming of more automotive-style units from standard elements.

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Seat combines conformity and comfort

KAB Seating has announced the launch of its new Sentinel seat family for material handing and small construction machine applications. The Sentinel has been cleverly designed for the material handling sector, where the seats conform to all applicable regulations including EN13490 and vibration classes IT1 and IT2; as well as for the construction sector, where the seats conform to classes EM 6 and EM 7 for mechanical suspension and EM 6-9 for the air suspension. The Sentinel offers an SIP of 200mm and is available in 12V and 48V versions.

It has been thoughtfully designed with comfort in mind, and with an emphasis on easy-to-use, intuitive adjustments. The Sentinel Air version features the ingenious KAB Autoride system. By sensing when a person sits on the seat, this automatically sets the suspension to the correct ride height. This is of particular benefit when a truck is used by different drivers, as it self-adjusts to suit various heights and weights.

Other Sentinel variants offer a mechanical suspension as well, along with a range of trims – including an option with leather bolsters to improve entry/exit and reducing wear when used in forklift trucks.

Onboard features include operator presence switches, multipositional lumbar support and heaters. Optional accessories also include armrests, backrest extensions, head rests and seatbelts.

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New casters add birthday cheer

Superior Tire & Rubber Corp has been celebrating its 50th anniversary with the unveiling of additional members of its famed STR5000 family of easy-adjustment stabilizer casters for electric pallet trucks. These casters are available just in time to add to its golden anniversary proceedings that include doubling the size of its engineering team, as well as adding 60,000ft² of advance polyurethane molding lines and steel fabrication.

As well as the most popular top-adjustable STR5500 Series designed for 8,000 lb pallet trucks and the side-adjustable STR5200 Series for 6,000 lb trucks, the company also launched three additional casters: the side-adjustable STR5100 Series for 4,500 lb walkie trucks, the side-adjustable STR5400 Series for 8,000 lb rider trucks, and the top-adjustable STR5600 Series for extra-heavy rider trucks. These casters require less than 10 minutes to adjust the height, some including the spring rate adjustment, without having to lift the truck – compared with almost half hour for traditional casters.

"We are completing our caster product road map that will enable us to solve the age-old problem of the casters foregoing adjustment," said Dr Arun Kumar, head of the engineering team. "The process of adjusting a stabilizer caster was so cumbersome that it was almost never practiced. These improperly adjusted casters were rendering the new and expensive trucks ultimately no better than their predecessors [in terms of] performance deterioration."

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Versatile drivetrain options

Dana offers new drivetrain options for mid-sized front-end loaders that illustrate its ability to meet a diverse range of market needs, from value-driven solutions to premium configurations with advanced technologies.

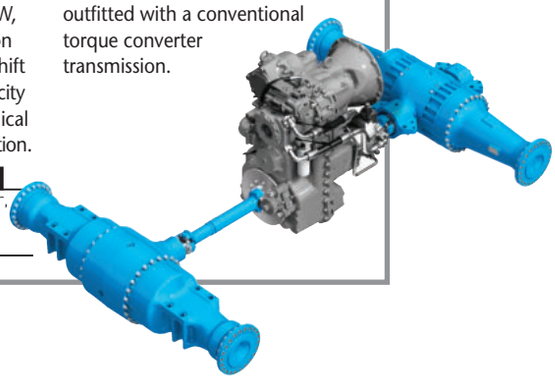
Its drivetrain for 21 metric ton front-end loaders can be configured with the new Spicer TE18 powershift transmission or with the latest HVT (hydromechanical variable transmission) from Dana Rexroth Transmission Systems, the 50:50 JV with Bosch Rexroth.

The new Spicer TE18 powershift transmission is specially engineered to supply front-end loaders with higher input power capability, reduced maintenance, and smoother, quieter operation. Rated from 150-195kW, the TE18 is a 4-speed transmission platform that provides superior shift quality through high-energy-capacity forward and reverse clutches, helical gears and adaptive clutch modulation.

The HVT R2 uses a modular platform to deliver a full suite of configuration options and software controls. Designed to maximize efficiency and reduce overall vehicle ownership and operating costs, it is ideal for off-highway applications requiring 135-195kW of engine output power.

The HVT optimizes the operating point of the IC engine by decoupling engine speed from drive speed, and maintenance costs are reduced by utilizing hydrostatic braking and wear-free directional reversing.

Initial tests on front-end loaders with Dana Rexroth's HVT powersplit systems demonstrate fuel savings in the drivetrain of up to 25% when compared with the same vehicle outfitted with a conventional torque converter transmission.



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LOOKING TO ENHANCE YOUR CORPORATE SOCIAL RESPONSIBILITY CREDENTIALS? YOU COULD DO WORSE THAN DESIGN A SMALL, CHEAP COTTON HARVESTER...

Man is by nature a hunter gatherer species; our forebears once led a nomadic life, taking food where they could and hunting game where necessary. The agricultural processes that developed as man became more organized as a species led to there being a regimentation dictated by the seasons, meaning that during certain times of the year, depending on our particular location on the planet, we would sow a crop during one part of the year and harvest it as soon as it had properly matured.

Illustration: Julie Welby

Many look back nostalgically to a golden age before the mechanization of agriculture, reveling in the idyllic simplicity of a life carved from nature without the drone of machinery. But make no bones about it: even in the 19th and early 20th centuries, when huge chunks of common processes had been taken away by powerful threshing machines and steam engines, agricultural work still remained a back-breakingly hard life where many often starved or lived in abject poverty.

THERE ARE A FEW CROPS THAT STILL ELUDE MECHANICAL HARVESTING THESE DAYS

To a large extent though, the further development of machinery in the off-highway sector has meant that nowadays almost all agricultural processes can be undertaken from the ergonomically designed ventilated and suspended seats of cutting-edge machines that result in a lot less effort and involve fewer people.

With certain crops, however, these processes have been harder to properly mechanize – for example, only in the last decade or so have there been really effective harvesters for sugar cane – in fact, even now harvesters produce chopped cane that begins to deteriorate much quicker than cut cane. For farmers though, there is simply no going back. Whereas in the past there were many hands ready and willing to take to the fields armed only with a straw hat and a machete, a new generation of people who've never experienced manual labor are somewhat less eager to engage in this work.

It is unlikely that OEMs will come up with a machine process that delivers the cane in cut poles so I guess that loss will have to be factored in by the producers when they calculate pricing, because, to most, the evolution is irreversible as manual tasks increasingly become a thing of the past.

Surprisingly, however, there are a few crops that still elude mechanical harvesting processes these days. The harvesting of oil palm fruit remains ostensibly manual, and, while the mechanized retrieval of soft fruits such as blackcurrant seems to be practical, it is also expensive.

Ignoring economics for a moment though, my thoughts are that from one particular standpoint, cotton harvesting is where we might well consider channeling some resources. A recent BBC news report addressed the plight of child laborers in the Indian cotton industry. Although illegal in India, more than 500,000 children are known to be employed by the companies that provide the raw crop to be processed into the 'homespun' cotton that Sir Ben Kingsley was always banging on about when he played Gandhi in the movie of the same name.

According to one interviewee, "The children are quicker and more productive than adults."

It seems the fact that kids should be playing or learning, rather than working long hours in the fields, had somehow escaped his logic. The report cited the cost of mechanization as a factor, and it is largely true that the mechanical harvesters on the market tend to be huge behemoths developed in the West and aimed at prairie conditions, rather than small affordable units that might suit these farmers.

Another challenge to the OEM looking at this seriously is that the children are used to hand-pollinate the flowers, as a way of increasing the yield. So we really need a small and economically priced cotton harvester/pollinator to be developed so these youngsters can be released from their servitude.

The interviewee then went on to explain (with a weird sort of pride, really) that the children's families relied solely on their offspring's wages for support, somehow giving this sordid exploitation some sort of twisted nobility.

Morally, governments should be pushing for full mechanization in situations like this to alleviate the potential for this slavery to continue by subsidizing and supporting better and cheaper machinery.

We, as engineers, can probably do our part if the will is there. But in the 'economic miracle' that is modern India, I seriously doubt that anyone over there is even bothered. **iVT**

Comments: theinsider@ukipme.com