

## Siemens VDO drives toward the future

**Siemens VDO Automotive** engineers are involved in a project in which the drivetrain, steering, shock absorbers, and brakes are directly integrated into the wheels of future vehicles. The company says that this kind of by-wire integration will help to improve the flexibility and durability of off-highway equipment. The concept, called eCorner, replaces the conventional wheel suspension with hydraulic shock absorbers, mechanical steering, hydraulic brakes, and conventional internal-combustion engines.

Due to fuel and energy uncertainties, Siemens projects the traditional engine architecture will be replaced by electric wheel hub motors, which act directly on the wheels to accelerate the vehicle. The possible elimination of the internal-combustion engines burning gasoline or diesel fuel will reduce emissions and satisfy the extremely strict regulations anticipated for the future. eCorner will make it possible to develop drive-by-wire vehicles on which the drivetrain, steering, and brakes provide common support for the driver in critical driving situations, thus helping to avoid potential accidents.

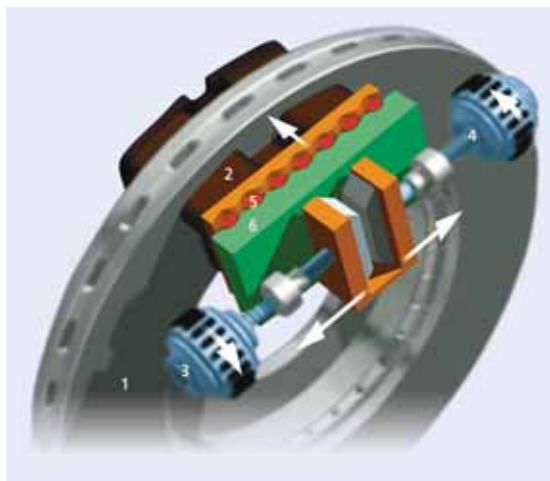
Although Siemens VDO says it will continue to invest in optimization of conventional internal-combustion engines in an effort to completely exhaust their potential, the perspectives for the future are even more important. "Hybrid drives are only an in-



*In Siemens VDO's eCorner concept, the wheel rim (1) remains the same. Beneath the rim is the wheel hub motor (2). Braking is via the electronic wedge brake (3). The active suspension (4), like the electronic steering (5), replaces the conventional hydraulics.*



*Siemens is currently getting the electronic wedge brake (EWB) ready for series production, which includes tests on the brake test bench.*



*In the EWB, the brake disc (1) is braked by a pad (2), which is moved by electric motors (3, 4) via several rollers (5) along wedge-shaped inclined faces.*

termediate step along the path to future propulsion solutions," said Klaus Egger, Group Vice President of Siemens VDO. "We consider the electric motor to be the actual long-term drive solution for fulfilling even the most stringent emissions laws of the future."

With eCorner, a tire containing a sensor (Tire Guard) for monitoring the inflation pressure will be in contact with the ground. While often complex mechanical wheel suspension systems with oil-pressure spring elements ensure a comfortable ride for the operators and permanent, reliable contact with the ground, electronic circuits will play an increasingly significant role in the future, says Siemens. Within eCorner, electric motors will take over the task of

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ensuring contact between wheel and ground. With this new suspension, hydraulic steering can be eliminated, allowing each individual wheel to be moved at its own specific steering angle.

When the speed is reduced, the wheel hub motors will act as auxiliary brakes using a generator effect. The energy reclaimed in this manner can be used to charge the vehicle battery. Finally, in addition to the generator brakes, the electronic wedge brakes (EWB) can decelerate each wheel separately with maximum precision and braking power to match the need of the situation.

Under optimum conditions, a future full hybrid system uses approximately 85% of the theoretically available energy, while today's gasoline and diesel engines use less than 50%, says Siemens. Wheel hub motors are projected to use up to 96% of the provided electrical energy for vehicle propulsion.

Integration of various vehicle components into the wheels will also allow further modularization of vehicles and more options for equipping very different vehicle concepts.

Siemens believes the start of mass production of EWB as a completely electric brake system will be an important milestone on the way to eCorner realization, opening the door for other elements to be integrated into the wheel. The greatest intermediate step toward eCorner will be the integrated corner module in cars. During the next decade, this system will integrate all systems into the wheel with the exception of electronic shock absorbers and electronic steering. The combustion engine will not disappear completely for the time being; it will be able to provide the necessary electrical power for long-distance vehicles.

Jean L. Broge

## Hydraulics serve as system integrator

Traditional hydraulic systems have rapidly evolved well beyond hydraulic power. While it is true that hydraulic pumps, motors, cylinders, and valves have all improved individually over the



*The performance of the hydraulic rotator used in AGCO's Challenger 525 RMS is an example of how a hydraulic component has evolved into a dual role of structurally connecting two systems together for productive operations, yet hydraulically isolating the two systems from damaging forces and component failure.*



*The Sauer-Danfoss valve uses electrohydraulics for precise hydraulic flow control, and at the other end of the spectrum, features manual flow control valves so the operator can adjust flow to personal preferences.*



*A grounded stainless steel shielded wiring harness, coupled to a four-axis proportional joystick, enables the operator to have precise control without the worry of unexpected boom movements due to outside electronic frequencies from power lines and other machinery.*

years, the real value is the supporting role they now play in pulling other unrelated systems together, to perform as one very powerful and reliable integrated package.

With **AGCO's** Challenger 525 RMS (roadside mowing system), three very different systems are pulled together with a hydraulic system designed to blend the best of three systems into one. The first system, the Challenger MT525, is essentially formed of the engine, axles, transmission, and cab to provide a reliable platform of power, stability, and operator safety.

The second system is an integrated frame structure consisting of 10 major frame components. The formed and welded structure is designed to capture and control all of the dynamic forces created by a roadside boom mower. The structure not only supports the articulated boom mower but evenly distributes those forces safely throughout the integrated frame, while isolating any harmful or excessive loads from the tractor.

The third system consists of a mid-mounted articulated boom, stick, and mower cutting head. The single purpose of this system is to give an operator a way to safely deliver 80 hp (60 kW) of hydraulic roadside-mowing performance to the overgrown vegetation along the roadside.

Unique to the RMS series is a hydraulic system that enhances the performance benefits of each system, yet blends all three systems into one that is said to be both balanced and operator-friendly. Helping to accomplish this is a large hydraulic rotator that replaces the traditional frame swing post and hydraulic cylinder that swings the boom. Traditional swing post and cylinder designs can magnify side breakaway forces and directly transfer possibly damaging torsion loads directly into the frame and tractor.

Challenger RMS's hydraulic rotator functions both as a structural frame member connecting the boom to the inte-

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As one of the largest independent manufacturers of diesel and gas engines in the world, offering an output range from 4 to 4,000 kW, DEUTZ also sets the standard in the construction trade. Whether installed in excavators, wheel loaders, road finishing or grooving machines, or compressors, DEUTZ engines have good prospects for securing a sizeable share of the market now and in the future.

The engine company.



grated frame, and also as a hydraulic component delivering fluid power to create 83,333 lb·ft (113,000 N·m) of swing torque. AGCO says the real value of the hydraulic rotator is how it “dramatically reduces” torsion loading to the frame and tractor by buffering the integrated frame and tractor from those loads. And if the torsion loading becomes too great, the hydraulic rotator has internal relief both fore and aft.

At the heart of the Challenger RMS hydraulic system is a large, high-flow hydraulic pump. Designed to efficiently transfer power from the tractor PTO, the pump has its own dedicated 60-gal (227-L) hydraulic tank. Because the high-flow pump operates at 55 gal/min (208 L/min), it does not rely on high pressure to generate power. AGCO claims the high-flow, low-pressure system creates the most power of any roadside mower, but does so without creating excessive heat or high pressure spikes that shorten the life of hydraulic components.

While there have been numerous electrohydraulic valves on the market for some time, many have gotten a reputation as offering erratic control problems and poor reliability. A high-performance electrohydraulic valve from **Sauer-Danfoss** that uses “the latest design in electronic voltage control modules” and represents “the best marriage of electricity and oil” is used in the Challenger RMS.

A grounded stainless steel-shielded wiring harness, coupled to a pistol grip four-axis proportional joystick, enables the operator to have precise control without the worry of unexpected boom movements due to outside electronic frequencies from power lines and other machinery. The Challenger RMS valve is coupled directly to the tractor’s independent hydraulic pump system for an uninterrupted flow of oil, regardless of mowing operations.

While tractor oil flow is proportionately controlled with the joystick and valve, the operator is able to adjust the speed on every boom and head movement with individual oil flow valves. Different operators, different skill levels, and different work applications can be accommodated due to manual flow control valves on every circuit. The operator simply turns a knob on each valve to speed up or slow down each function.

The Challenger RMS hydraulic system has been engineered to qualify for the **Parker Hannifin** GPP Leak-Free Program. Verification of oil flows, operating pressures, and pressure spikes were all verified by Parker technicians. AGCO says this is the only hydraulic system in the roadside-mowing industry to be warranted leak-free for three years.

Jean L. Broge

## Deere warms to the idea of Modine EGR coolers

**John Deere Power Systems’** new line of Tier 3 185- to 600-hp (138- to 448-kW) off-highway diesel engines feature exhaust-gas recirculation (EGR) coolers produced by **Modine** Manufacturing, which designs and develops heating and cooling solutions for the agricultural, automotive, truck, heavy-duty, and industrial markets. The EGR coolers recirculate a portion of the exhaust gas to burn and remove NOx and particulates.



John Deere Power Systems’ new line of Tier 3 off-highway PowerTech Plus engines have exhaust-gas recirculation (EGR) coolers produced by Modine Manufacturing.

“The integration of our EGR coolers helps Deere comply with new regulations while continuing to meet the challenging engine application needs of their customers,” said Rick Behrend, Director of Engine Products Group, Modine.



Modine is shipping the EGR coolers from its Joplin, MO, plant to Deere locations in Iowa, Mexico, and France.

Modine began shipping EGR coolers last fall from its Joplin, MO, plant to Deere locations in Iowa, Mexico, and France. The coolers will be used on the Deere PowerTech Plus engines for agricultural and construction equipment.

“The wide range in power, duty cycles, and packaging constraints presented some interesting challenges for us,” said Tod Kerscher, Heavy-Duty Division Program Manager, Modine. “Our early involvement with Deere’s Advanced Technology group several months prior to the official kickoff of this project enabled us to guide the up-front development activities and optimize the total system for each engine family. We were able to effectively leverage our on-highway EGR product knowledge and manufacturing experience to design, validate, and produce a reliable, high-performance series of EGR coolers for John Deere.”

“Modine has worked with Deere for more than 85 years,” said Behrend. “We understand their thermal needs.”

Jean L. Broge



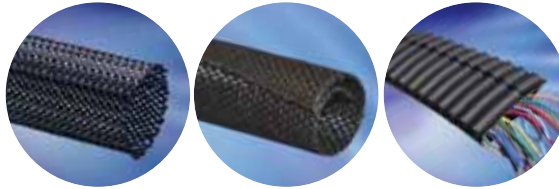
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## Deutz has modular ideas for emissions reduction

With a design philosophy that states, "As much technology as necessary, but not as much as possible," **Deutz** offers what it terms DVERT (Deutz variable emissions reduction technology), a modular system strategy to reduce both exhaust and noise emissions in diesels ranging from 5 to 500 kW (6.7 to 670 hp). The elements that make up the DVERT concept can be combined to provide the required level of engine performance, emissions compliance, and market competitiveness. A variety of design choices are available within the four elements of DVERT, which include fuel-injection systems, engine-control technologies, combustion management, NOx-reduction technology, and exhaust aftertreatment.



*The six-cylinder Deutz 2013 engine is equipped with the DCR (Deutz common rail) system, in which electronically controlled injectors deliver fuel to the combustion chambers.*

For diesels up to 100 kW (134 hp), Deutz offers either direct or indirect mechanical injection systems in junction with either internal or external uncontrolled exhaust-gas recirculation (EGR), without any electronics. However, that diesel range can be integrated with an electronic management system by adapting Deutz's electronic engine governor, EMR. The EMR is a programmable speed governor that duplicates the features of full-authority electronics without the ability to move the timing point.

Between 100 and 250 kW (134 and 335 hp), Deutz combines controlled EGR with both mechanically and electronically controlled high-pressure injection systems, via either inline in-



*In the upper portion of the four-cylinder 2013 are the two feed pump elements with the rail and in the lower part is the electronic control unit, between the compressor and oil filter.*

jection pumps for PLD (pump-line-diesel) injection or Deutz common-rail (DCR) technology. The DCR features two high-pressure feed-pump elements that are integrated into the crankcase and driven by the camshaft to provide fuel to the rail. Different degrees of sophistication are available in this range depending on torque shaping, transient performance, and power demands of the specific application.

Beyond 250 kW (335 hp), Deutz uses four-valve cylinder heads and a combination of a PLD system with a solenoid-controlled injection valve, what it calls the MVS (magnetic valve system). Engines using DCR and MVS communicate with the machine via CAN bus, allowing for features such as drive-by-wire and full integration of the engine controls with electronically controlled hydraulic drivelines.

*Jean L. Broge*

## Parker's integrated digital electronic-control system

**Parker Hannifin's** Hydraulic Pump Division (HPD) has introduced a new version of its 75-cm<sup>3</sup>/rev P1/PD Series medium-duty variable piston pumps, featuring an integrated digital electronic control (IDEC) capability that it says provides the ability to control pump functions in real time.

New P1-075 IDEC pumps take advantage of **Microsoft** Windows-based software to enable users to control proportional pressure, proportional displacement, electronic torque limiting, anti-stall, and constant flow settings to optimize pump performance under a full range of operating conditions.

"IDEC is fully integrated into the pump," said David Knight, HPD Marketing Manager. "There are no external wires or plumbing, other than the single wire that commands the flow and pressure output. Sensors for pressure, speed, temperature, and displacement are all built into the pump and calibrated at the factory."

The sensors work with the software to allow for optimized pressure and flow output, even under the varying speed, temperature, viscosity, and load-pressure conditions that are typical of actual working pump applications. "Sensor outputs also

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*Parker Hannifin's P1/IDEC Series pumps are variable displacement, axial piston pumps for open-circuit applications in both mobile and industrial equipment. The pumps allow proportional control of the pump itself.*

give users a sophisticated hydraulic system monitoring capability for onboard diagnostics, which can mean extended life and reduced maintenance downtime for the pump and other system components," said Knight.

In addition to greater operating efficiency, P1/PD-IDEC pumps also reduce the number of proportional valves required in a system by allowing proportional control of the pump itself. It also offers on-the-fly electronic changes in the type of control, allowing the pump to function as a load sense, pressure comp, and power control during the operation of different functions in the same system. This feature allows for efficient control by acting as three different pumps in the same system.

Parker claims that the increased operating efficiency made possible by the IDEC system can produce significant savings in

design, manufacturing, and operating costs for mobile and industrial equipment using the new P1/PD pumps.

In one example cited by the company, a wheel loader OEM could save \$83,000 through shortened design time, \$1000 per unit through lower installed cost vs. a previously used pump and valve system, and \$100 per unit through a smaller cooling system made possible by the P1-075 IDEC's efficiency and consequent smaller thermal load.

Users of the wheel loader would also realize significant savings, including up to \$2000 per year in fuel-cost reductions by eliminating load sensing losses and recovering energy during bucket lowering, and an additional \$1000 by eliminating one service call per year using the system's "in-pump" diagnostic capabilities.

"These savings are typical of what we found in our field testing of IDEC-equipped pumps," said Knight. "The \$83,000 figure represents a month's worth of engineering development that can be saved because the IDEC pumps let users avoid load sensing instability problems."

Parker's P1 (mobile) and PD (industrial) series pumps are variable displacement, axial piston pumps for open-circuit applications. The P1/PD pumps operate at pressures up to 280 bar (4060 psi) and provide compact and quiet control for the most demanding mobile and industrial environments. The IDEC system will be available on other Parker pump models in the future.

Parker's Hydraulic Pump Division was formed in 2003 when Parker Hannifin acquired **Denison Hydraulics**. It manufactures hydraulic components and systems for earthmoving and construction vehicles; mining equipment; for pulp and paper, chemical, and other processing equipment; ships and ordnance equipment; and in-plant machines such as machine tools, plastic molding, die casters, and stamping presses.

*Jean L. Broge*

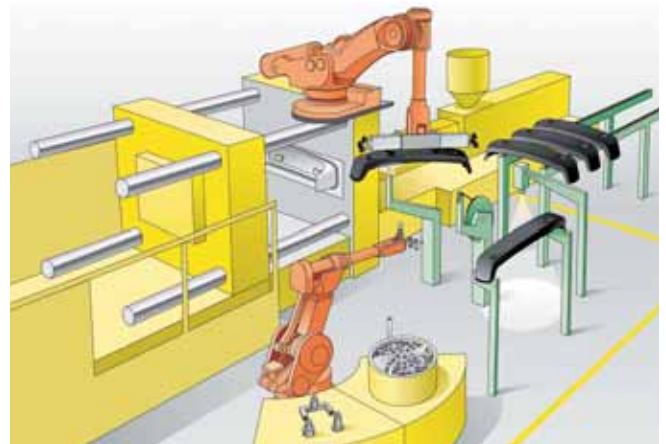
## On the shelf with ABB

A new six-axis shelf robot from **ABB**, designated IRB4450S, is designed to operate in conjunction with midsize injection-molding machines (IMM). The main working envelope of shelf robots is below the foot: the 4450S, which can handle workpieces up to 30 kg (66 lb), can reach more than 1 m (3.3 ft) below ground level. ABB describes it as being particularly suitable for use in areas where space is limited, a constraint often experienced in plastic-injection-molding applications.

The company regards the IRB4450S as a highly practical alternative to a three-axis robot typically used for IMM tending, explaining that it can achieve post-process tasks in parallel during each "sheet," avoiding the typical problem of three-axis types remaining idle at times because of their purely linear move-



The ABB IRB4500S shelf robot has foundry applications.



ABB's new IRB4450S shelf robot tending an injection-molding machine.

ment. Post-processes can include cleaning, flaming, quality control, punching, and assembly, allowing plant designers to reduce the number of downstream stations and cut plant throughput times.

ABB has also introduced the IRB4500S with similar reach and payload performance to that of the 4450S, but with particular applications within the foundry industry. It is available as the FoundryPlus with protection for the complete robot to service various applications within foundries and other harsh environments including machine tending, die-casting operations, core handling, cleaning, and spraying.

*Stuart Birch*

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## JDPS boasts of emissions and economy

Key to meeting current (and future) emissions requirements and fuel-economy expectations, **John Deere Power Systems** (JDPS) leveraged three technologies in its current line of PowerTech Plus engines whose use may not necessarily raise eyebrows, including cooled exhaust-gas recirculation (EGR), a variable-geometry turbocharger (VGT), and a "state-of-the-art" engine control unit (ECU). It seems nearly everyone is using them, but it is how everyone is using them that appears to be the differentiator.

It is through the adoption of cooled EGR and VGT technologies in particular that JDPS says it was able to maintain, and in some cases increase, the power density of its engines. The increased power density also allows for smaller displacement engines.



*John Deere Power Systems offers 4.5-, 6.8-, 9.0-, and 13.5-L (shown) engines in the PowerTech Plus family, all of which include cooled exhaust-gas recirculation and a variable-geometry turbocharger to meet Tier 3/Stage IIIA regulations.*

The greater an engine's peak combustion temperature, the greater the amount of NOx that is created. Cooled EGR allows measured amounts of cooled exhaust gas to mix with incoming fresh air, lowering peak combustion temperature and reducing NOx. The VGT works in conjunction with EGR by tailoring the amount of recirculated exhaust gas that mixes with the fresh air. This step is accomplished through the ECU, which changes the pitch of the VGT vanes to increase or decrease the measured amount of exhaust gas mixed with the incoming fresh air depending on load and speed. When the exhaust flow is low, the vanes are partially closed. This increases the pressure against the turbine blades, making the turbine spin faster and generating more boost.

Depending on the power rating, standard or wastegated turbochargers are matched to the power level and application. Transient smoke is controlled by using higher-boost turbo-



*JDPS says its 9.0-L PowerTech Plus engine offers increased performance and power density, higher levels of power bulge, increased levels of peak and low-speed torque, and better transient response time than its Tier 2/Stage II counterpart.*

chargers, including using wastegated turbos that increase low-speed torque and prevent over-boosting at high speed.

The VGT minimizes the impact on engine envelope size and provides enhanced performance across the entire operating range of the engine, including transient response and fuel economy. It also allows a wider power range using common engine performance hardware—reducing the number of engine configurations for OEM customers and distributors.

The patented JDPS ECU controls the air-to-fuel ratio, multiple fuel injections, injection timing, the amount of EGR, and VGT output. It is a 32-bit, Power PC-based ECU with twice the memory and five times the computing power of units found on Tier 2/Stage II engines. This ECU also features snapshot diagnostics, which can record and store up to seven different sets of diagnostic data.

When JDPS began selecting technologies to meet Tier 3/Stage IIIA regulations, it said it did so with the understanding that different markets have different needs. In performance markets, for example, machines require more power, more torque, and higher performance overall. Other markets simply do not have the need for high-performance features.

With that in mind, JDPS developed three distinct solutions, including PowerTech Plus, which consists of 4.5-, 6.8-, 9.0-, and 13.5-L engines certified to Tier 3/Stage IIIA. PowerTech E uses a high-pressure common rail fuel system for its 4.5- and 6.8-L engines, an electronic unit pump fuel system for the 2.4-

and 3.0-L engines, and full-authority electronic controls. PowerTech M features economy of design and mechanical.

To offset the increase in particulate matter caused by the reduction of NOx in PowerTech Plus engines, JDPS increased fuel injection pressure through high-pressure common-rail fuel systems and electronic unit injectors, improved power cylinder components for reduced oil consumption, adopted the VGT to control transient smoke, and improved the shape of the combustion bowl to maximize air/fuel mixing and optimize the combustion process.

PowerTech E two-valve per cylinder engines offer electronically controlled fuel systems with improved cold-start performance, precise engine-speed control, torque-curve shaping,

and turbocharged or air-to-air aspirations. Because these systems have less need for redundant sensors, add-on electronic governors, and shutdown devices, they result in a lower installed cost.

The 2.4- and 4.5-L engines in the PowerTech M category are suitable for lower-power applications and are equipped with a new fuel system that creates higher injection pressures. The 2.4 L, starting at 30 kW (40 hp) and 4.5 L starting at 60 kW (80 hp) will be available in advance of EPA regulations—Tier 3 and Interim Tier 4—beginning in January 2008, and Stage III A EU regulations beginning in January 2007.

Jean L. Broge

## Grammer seats get sentenced to the climate chamber

The Actimo XXL seat for construction equipment and all other Grammer products endure testing under extreme conditions in the company's competence center. With the click of a mouse, technicians can simulate a Siberian winter; followed by a cold, moist European autumn; and then a scorching equatorial sun. A relative humidity of up to 95% can be produced, and the possible temperatures range from -40 to +90°C (-40 to +194°F).

The climate chamber at Grammer's Amberg, Germany, competence center is one of many setups for testing the company's products—seats for off-highway equipment, buses, trucks, and



*Grammer takes seriously the need for its off-highway seats to meet the needs of operators in the market, a philosophy that includes tormenting seats with dynamic endurance tests.*



*The Actimo XXL seat for construction equipment and all other Grammer products undergo testing in extreme conditions in the company's competence center.*

trains—under extremely severe conditions because, as Grammer says, it would be nearly impossible to subject the seats to the actual, unpredictable forces of nature, at least not within a reasonable amount of time. The company therefore simply shifts such tests out of nature and into artificial or virtual worlds while developing new products.

In the competence center, seat prototypes are subjected to dynamic endurance tests in special setups and rigs, some of which the company has developed itself. The tests check the overall structural integrity, cushions, and controls of the seats.

The goal of such torture is “flawless long-term quality, even after thousands of kilometers traveled and hours of actual use,” says Grammer, because the seat essentially constitutes the direct interface between the driver and the vehicle.

Off-highway work requires top performance not only of the machine but of the operator. The more effectively vibrations and jolts are dampened, the easier it is to do the job without harming one’s back. The Actimo XXL features a pneumatic suspension specifically designed to cope with the typical vibrations of construction equipment. The low natural oscillation frequency of the seat allows it to absorb nearly all vertical vibrations, says Grammer.

In field tests, another of the procedures conducted by Grammer at its competence center, the prototype Actimo XXL was tested to make sure that its design met the necessary requirements to operate under the rough conditions of actual use. The “body block” underwent testing on a six-axis rig. The test program ran for 200 hours, which in the case of truck seats corresponded to up to 6000 km (3730 mi) on poor roads, and with tractor seats about 3000 hours of operation.

The seats were completely checked and measured both before and afterward to determine among other things their lat-

eral and longitudinal stability and the natural oscillation frequency of the suspension system. The behavior of defined assemblies was also observed and documented during the entire test. All Grammer test programs are recorded in actual vehicles and then simulated in real time on the six-axis test rig. The competence center has implemented this approach on a special rig, two of which are available for testing purposes.

Lateral and longitudinal stability are checked in a separate test rig. Force/travel diagrams are derived for the various forces affecting a seat. Data is digitally captured and included as a component of test documentation.

Grammer also used a special rig for accelerated endurance testing. The loads were changed no fewer than 10 million times to quickly find out how a product is affected by stresses over its entire service life.

The suspension system’s response to vibrations was tested on a two-axis vibration rig. The test cycle conformed to the requirements of standards applicable to the various driver seats (ISO, EN, EEC, and **SAE** standards). The test was carried out with a 55- and 98-kg (120- and 216-lb) operator.

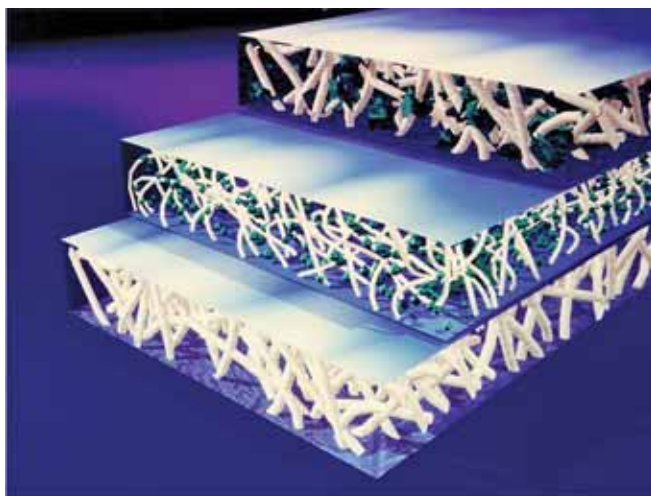
Jean L. Broge

## Equipment operators can breathe easy with micronAir

Well-established in the automotive market, **Freudenberg Nonwovens** is making a fresh-air foray into the off-highway industry with its micronAir cabin air filtration product.

“When you think about the product and what it does, it’s a perfect fit for off-highway,” said Dave Lester, General Manager of micronAir Cabin Air Filtration, Freudenberg Nonwovens, North American Filtration Division. “You definitely want to have some sort of protection for the operator of that equipment. This market will be one of our growth initiatives for next year.”

Freudenberg’s presence in the North American off-highway market—indeed the entire cabin air filtration industry’s—is currently tiny. Outside of North America, it is essentially nonexistent. Freudenberg, the leader in cabin air filtration for the automotive market, currently supplies micronAir products to **John Deere** through one of the OEM’s suppliers, **Modine**, and it has submitted quotes on other applications to several manufacturers.



There are many places for particles to be trapped within a micronAir nonwoven cabin air filter. With paper filters, particles are trapped on the surface, forming a dust cake and degrading efficiency.



micronAir cabin air filters come in whatever shape, size, and filtering capability desired by the customer.

The company also sells micronAir aftermarket product for use in **Kenworth**, **International**, **Volvo**, and other heavy-duty truck makes. Lester, who has a bachelor’s degree in mechanical engineering, said the company is considering an entry into the aerospace sector and is “looking at some military applications that we cannot comment on at the moment.”

Lester noted that the automotive is a more mature cabin air filtration market than is off-highway in terms of specifications for cabin air filters. “In some cases,” he said, “they [off-highway companies] are just using fly catchers, which are media pads with a lot of open air throughout them; you can see through them. But we’re seeing more and more of a drive toward traditional cabin air filtration, which is pleated media with no holes that you can see through.”

The advantage of micronAir technology over others, according to Lester, is his company’s use of nonwovens vs. paper. The

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This new closed-circuit video system is part of the HydraForce family of electronic systems and components providing full vehicle electronic control and security for heavy duty off-highway applications.

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Off-highway will be one of Freudenberg Nonwovens' growth initiatives next year, said Dave Lester, General Manager of micronAir Cabin Air Filtration, Freudenberg Nonwovens, North American Filtration Division.

basic nonwoven technology is the same across industries but with different specifications.

"One of our strengths is that we are the inventor of nonwovens, beginning in the 1900s," Lester said. "We have that experience, we brought that technology to marketplace, and we have strong core expertise on media development and meeting specifications."

Paper filters are one-dimensional, in a sense. Even though they may be pleated, paper filters collect dust only on the surface of the paper, resulting in a dust cake and a loss of efficiency. In contrast, nonwoven media have an open structure, so a dust particle "can al-

ways go and find another place," Lester explained.

Large dust-holding capacity is a special requirement for off-highway applications, Lester noted. And some in the industry have inquired about filters that can be cleaned and reused. Reuse is not a problem for nonwovens, but it is for paper, he said. Nonwovens, he added, lend themselves particularly well to "tuning" for different applications.

A major difference between automotive and heavier-duty applications such as off-highway is the shape of filters: in automotive, they are basically flat, whereas in heavier-duty applications they are often cylindrical.

Freudenberg offers what it calls combination cabin air filters to the automotive market. These filters, in addition to filtering particles, also capture various gases and odors. But currently there is no demand for such multipurpose filters in off-highway, Lester said.

The largest cabin air filter in production for an off-highway customer has a mass of 160 g (5.6 oz), "But we're looking at one that would be 330 g for an unnamed customer," said Lester.

Engineers at Freudenberg are always busy trying to develop new filter media and new production methods for building the filters, according to Lester.

The company is moving away from ultrasonic welding and toward adhesives for filter construction said Donald Pedigo, Applications Engineering Manager, micronAir Cabin Air Filtration, Freudenberg Nonwovens, North American Filtration Division. Freudenberg's plant in Hopkinsville, KY, already is using the adhesive method, and plants around the world are in the process of switching over.

Lester noted that engineers also are focused on commonizing production processes for greater manufacturing efficiency. And they are investigating ways to mold the filter material in such a way that it can form its own seal with the plastic surround. "A lot of design alternatives are being looked at," Lester said. Some of this work is being done at Hopkinsville, but the bulk of research is carried out at Weinheim, Germany, home of Freudenberg Nonwovens.

Patrick Ponticel

## Aspex helps detect, characterize micro debris

OEMs and vendors around the world, with those in Germany leading the way, are discovering that manufacturing debris as small as a few microns can wreak havoc on the performance of precision assemblies, resulting in everything from clogged fuel-injection systems to malfunctioning electronic sensors.

In their efforts to fight contamination at the micron-level, manufacturers have experimented with a variety of testing and quality-control approaches, including gravimetry and optical microscopy. Both methods can detect particles larger than 25  $\mu\text{m}$  (980  $\mu\text{in}$ ). But manufacturers have discovered that even smaller particles can still lead to major product failures.

There is another limitation to such conventional methods: they cannot determine the elemental composition of particles. To prevent contamination, it is important to know the composition of a particulate so that its upstream source in the manufacturing process can be located and eliminated.

Finally, to be of use in a production environment, the ideal detection and identification system must lend itself to automation. Manufacturers demand a solution that can process high volumes of production samples, using established cleansing and filtering methods, on a 24/7 unattended basis.

Initially, manufacturers focused their "micro-attention" on diesel-injection systems. But, with the ever-increasing tolerances on precision components and increased use of electronic sensors, the need for automated contamination analysis is becoming widespread across the factory—in the production of everything from brake systems, powertrains, compressors, and transmissions to diesel components, steering cylinders, and electronic sensors.

Working in conjunction with several leading OEMs and vendors in the United States and Germany, **Aspex** developed an automated solution to factory-floor microanalysis integrating scanning electron-beam and energy-dispersive X-ray technologies with automated control and statistical analysis software.

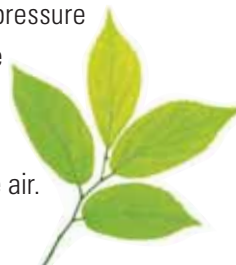


The Aspex AQC system integrates scanning electron-beam and energy-dispersive X-ray technologies with automated control and statistical analysis software. The system is capable of identifying and characterizing debris as small as 0.1  $\mu\text{m}$  (4.0  $\mu\text{in}$ )

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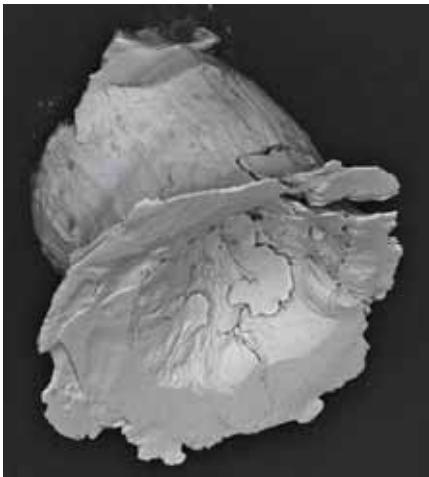
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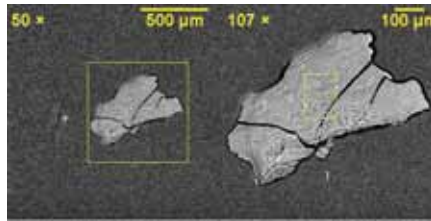
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This low-alloy-steel particle of 120  $\mu\text{m}$  (4700  $\mu\text{in}$ ) diameter was found in a diesel-injection nozzle. Forensic examination of various components in the system after rinsing led to the conclusion that the debris originated in the high-pressure pump.



This is an example of a "killer" particle as displayed on the Aspex AQC system. More than 1.0 mm (0.04 in) in diameter, it was found in a steering cylinder. Utilizing its energy-dispersive X-ray capabilities, the system was able to identify the particle as a piece of hard rubber containing sulfur and residual steel particles. The particle is from a coated spring mechanism inside a connector.

The system is capable of identifying and characterizing debris as small as 0.1  $\mu\text{m}$  (4.0  $\mu\text{in}$ ).

While zero contamination remains the ideal vision, manufacturers are just beginning to understand what levels of cleanliness are acceptable for different components. They are utilizing the Aspex AQC system to develop a process of continuous improvement that allows the cleanliness effort to improve as information is generated and studied over time.

The process begins with the testing of baseline samples from all phases of manufacturing—from the receipt of materials through final assembly. This step determines the representative

sizes, shapes, and compositions of debris particles. The technique of passing a cleaning fluid through a membrane filter is the established method for ensuring a representative population of residual particles. Samples can also be obtained from other fluids such as motor oil, gasoline, and hydraulic fluid.

The Aspex ASC system incorporates a dedicated interface that performs time-consuming micro-navigational searching, measuring, and elemental analysis in a completely unattended manner.

One of the first applications was in a new high-pressure common-rail diesel-injection system. The technology was developed by German engineers attempting to build diesel engines with improved fuel performance, reduced hammering, and enhanced acceleration. With these improvements came new challenges, including new types of system failures. Using ASPEX AQC, quality-control engineers determined that microcontamination was causing many of these failures.

VDA, the leading German automotive trade association, together with other regulatory bodies in Europe, is evaluating a new set of specifications on particulate cleanliness. Once these are finalized they are expected to become new ISO standards for all important aspects of cleanliness analysis. This will allow precise purchasing specifications to be established by manufacturers. The new ISO bin size table, including size histogram tables, is available at [www.vda.de/en/vda](http://www.vda.de/en/vda).

David C. Castaldo of ASPEX and Bernhard Heneka of RJL Micro Analytics wrote this article for *SAE Off-Highway Engineering*.

## Eaton extends motor family

A new dedicated high-torque, low-speed wheel motor that Eaton has named Delta is designed to be a direct, drop-in replacement for Parker Hannifin's TF, TG, and TL and White Hydraulics' RE and HB motors. The company says the design is entirely new, but it uses many proven techniques.



The main applications for Eaton's new Delta motor are lawn and garden maintenance vehicles, scissor lifts, sweepers, winches, and other equipment where there is a need for a compact, efficient drive motor with high side-load capability.

The Delta is a wheel motor that can generate 1355 N·m (1000 lb-ft) of torque. The motor is based on Eaton's disc valve technology, which allows for improved volumetric efficiency and lower pressure drop. A reduction in "no load pressure drop" on drive applications is important because it offers design engineers a lower temperature of operation and thus saves on the life of the entire hydraulic system as well as improving vehicle efficiency and reducing harmful emissions.

The bearing capacity of the motor is 20 to 30% higher than most of its competitors, claims Eaton. The side-load capacity is therefore significantly higher, allowing the motor to be used with bigger and heavier equipment. If replacing product, Eaton says it will show life improvements over the existing motor. A related benefit is the availability of bigger shaft sizes due to the bigger bearing pack. Delta can have up-tapered, splined, or straight shafts to a maximum of 38.1 mm (1.5 in), with the tapered shaft available at 41.3 mm (1.6 in).

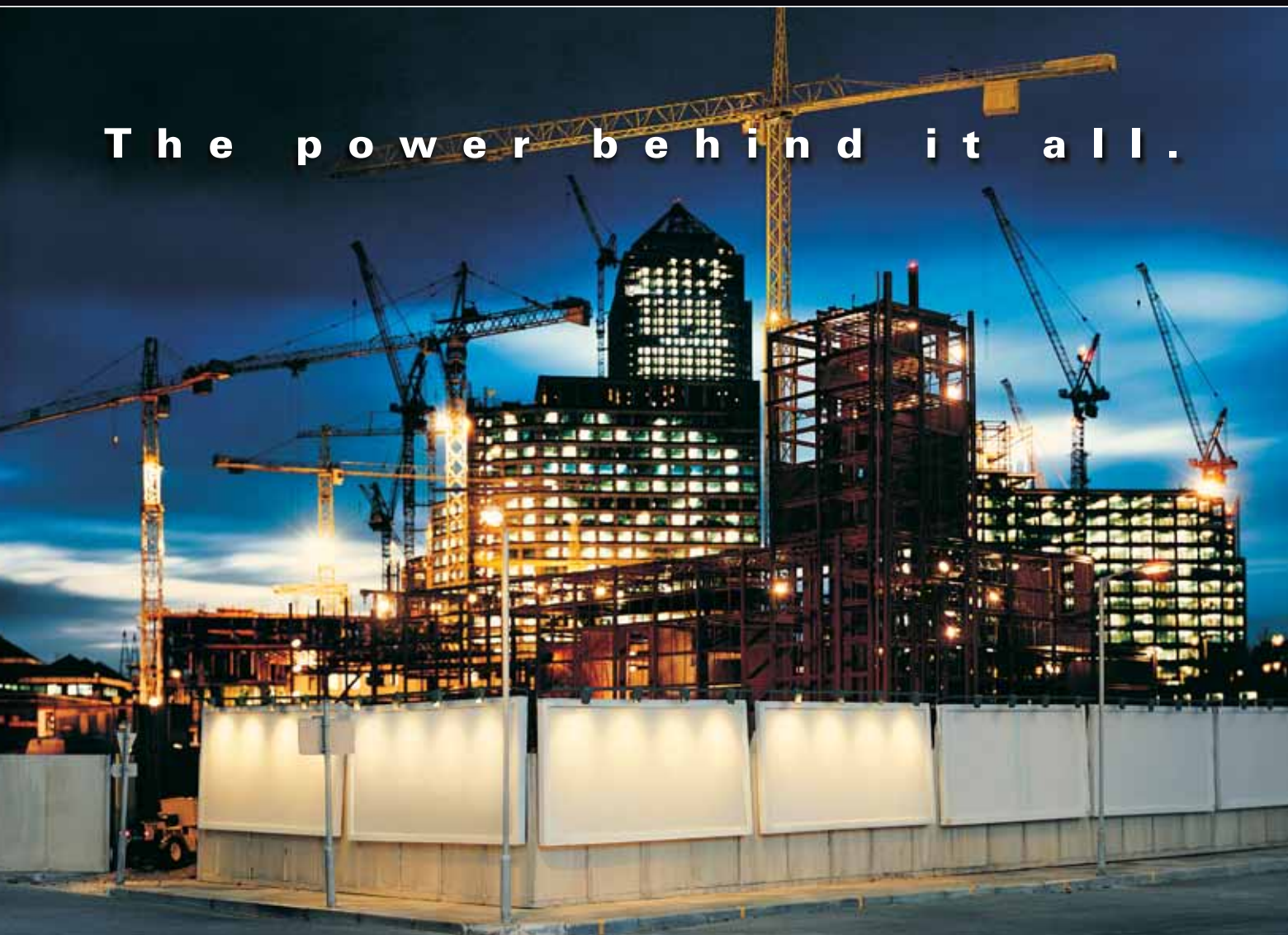
Delta is available in displacements from 113 to 754  $\text{cm}^3/\text{rev}$ , with a maximum intermittent pressure of 280 bar (4060 psi). A case drain is not required.

Jean L. Broge



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