No One-Size-Fits-All Solution

Offering a range of modular aftertreatment options key to Deutz diesel engine emissions strategy

The EU Stage 4/U.S. EPA Tier 4 final emissions legislation are the most stringent engine exhaust emission requirements for nonroad mobile machinery to date. These steps are leading to emissions reductions of up to 90% compared to the Tier 3 emissions levels introduced in 2006. Having reduced nitrogen oxide (NO₃) emissions to close to zero levels (400 mg/kWh) for engines larger than 75 hp, the most recent emission legislation is focusing on particulate emissions.

This gained additional momentum in June 2012 when the International Agency for Research on Cancer (IARC), part of the World Health Organization (WHO), classified diesel engine exhaust as carcinogenic to humans. Furthermore, in October 2013 the IARC also classified outdoor air pollution and particulate matter as carcinogenic.

In looking at Deutz’ EAT strategy, according to Deutz’ Michael Wellenzohn, board member for sales/marketing and service.

“We are observing a trend to introduce specific local or regional regulations requiring closed particle filters even earlier,” Wellenzohn said. “This is leading to very heterogeneous or varied market requirements, which is worrying for diesel engine makers and machine OEMs alike.”

Wellenzohn said that besides markets or applications where particulate filters were already encouraged or required — such as Switzerland or tunnel construction sites — new specific requirements are being introduced or are in discussion in London, Leeds, Birmingham, Berlin, New York and other urban areas, as well as for German railway construction sites.

“This will be a major challenge for equipment manufacturers since they will require engines which are suitable for all regional needs — in a market environment where there has so far never been a ‘one-concept-fits-all’ requirement in the past,” Wellenzohn said.

As such, Wellenzohn said flexibility and application-specific solutions for engines and exhaust aftertreatment systems (EAT) are required to provide the optimum solution for each case.

“To face these challenges, Deutz has developed a modular kit of EAT options to enable a high degree of flexibility in machine integration for our OEMs,” he said. “We call this the Deutz Variable Emission Reduction Technology (DVERT).”

Whether the EAT is engine-mounted or installed separately in the machine, DVERT is designed to provide the optimum solution for each installation. “DVERT meets the customer requirements for easy, maintenance-free EATs and also offers system solutions which comply with more stringent local emission requirements,” Wellenzohn said.

In looking at Deutz’ EAT strategy, continued on page 26.
Fuel may leave the refinery process clean, but fuel quality can degrade significantly during transport and storage. Sophisticated and more efficient high pressure common rail engines designed with extremely tight fuel injector tolerances place increasing demands on having clean dry fuel. Velcon and Racor brand diesel filtration solutions have been tested and proven to help meet the demand at every stage from refinery to injector. A complete filtration program is essential to ensure clean dry fuel is available on demand. Parker Hannifin provides the solutions to fuel your success.

Together, we can protect your fuel from the refinery to the injector.

Fuel may leave the refinery process clean, but fuel quality can degrade significantly during transport and storage. Sophisticated and more efficient high pressure common rail engines designed with extremely tight fuel injector tolerances place increasing demands on having clean dry fuel. Velcon and Racor brand diesel filtration solutions have been tested and proven to help meet the demand at every stage from refinery to injector. A complete filtration program is essential to ensure clean dry fuel is available on demand. Parker Hannifin provides the solutions to fuel your success.

Together, we can protect your fuel from the refinery to the injector.
for engines smaller than 134 hp, Wellenzohn said the market is dominated by equipment such as aerial work platforms, forklift trucks, telehandlers or small loaders. Further, the rental business has a dominant share in this power range.

“Typically, such applications have lower annual usage than bigger machines,” Wellenzohn said. “As a consequence, such machines are very sensitive to product cost. Rental also means that there are many different operators using the machines, who have typically very little interest in maintenance.”

Thus it is Deutz’ view that a simple, cost-effective and robust solution is the key criteria for this power range. Deutz’s sub-4 L engines, the TCD2.9 and TCD3.6 diesels, are equipped with an open DVERT oxidation catalyst (DOC) that is optionally mounted to the engine. The DOC is a flow-through honeycomb substrate with a catalytic coating formulated to reduce gaseous emissions.

Above 75 hp, the regulated NO\textsubscript{x} emissions level is 10 times lower than in the power range from 50 to 75 hp. To reach these extremely low emissions levels an additional EAT system is necessary, Wellenzohn said, adding that Deutz believes the most effective technology to reduce NO\textsubscript{x} emissions is selective catalytic reduction (SCR) which reaches efficiencies of up to 95\% NO\textsubscript{x} reduction within the stringent nonroad transient testing cycles.

The SCR catalyst used is a flow-through honeycomb substrate with a catalytic coating where ammonia gas (NH\textsubscript{3}) converts NO\textsubscript{x} to nitrogen and water. To generate ammonia gas upstream of the catalyst, an aqueous ammonia solution — urea, DEF or AdBlue — is injected into the mixing pipe to the exhaust. SCR systems are applied to all Deutz Tier 4 engines at ratings above 75 hp.

For more stringently regulated markets or environmental urban areas with particulate number limit values, Deutz offers a DVERT particulate filter (DPF) as an option. The DPF consists of a wall-flow honeycomb substrate with alternately blocked channels. Particles are trapped on the surface of the inlet channels and are continuously burned to regenerate the filter.

Particulates are removed at a high efficiency of more than 99\%, Wellenzohn said. Within one unit, the DPF contains the functionality of a DOC to raise the exhaust temperature to support the continuous regeneration of the downstream particulate filter.

Deutz said that for most engine types originally delivered as DOC or DOC+SCR variants, there will be a DPF retrofit kit available for most engines, in case customers want to upgrade their machines. At the same time, if customers want to resell their used machines into export markets, there will be downgrade kits available.

Within the power range from 134 to 335 hp, the off-highway market is characterized by equipment such as wheel loaders, crawler excavators and road-building machines. Deutz said here the main market drivers are dynamic response and low fuel consumption, as well as high equipment availability and lowest cost of ownership.

These main drivers are the reason for the Deutz technology decision to use DPF+SCR aftertreatment systems in the 4 to 8 L range. “This EAT solution enables highest performance and lowest fuel consumption without the need for complex turbocharging technology,” Wellenzohn said.

In the power range above 335 hp, a market Deutz said is dominated by...
larger high-performance equipment and special niche-market vehicles, Wellenzohn said that modifications of the engine installation are even more complex and expensive than for smaller equipment.

“For bigger machines at lower volumes, it is a huge advantage to keep the engine installation as it was with the previous emission stages,” Wellenzohn said. Here, the Deutz V-engines, the TCD12.0 and TDC16.0, come with an SCR-only system, where two SCR catalysts in series are applied to the engine.

“This DVERT concept is the logical continuation of the DVERT SCR solution for EU Stage 3B/EPA Tier 4 interim,” Wellenzohn said. “There is no need to apply EGR, which is very complex for V-engines in particular and leaves the installation and connecting points and the heat balance unchanged.

“Further, this larger equipment is mainly used outside of urban areas or in harvesting machines where a DPF is not required. However, for applications where a DPF is necessary, such as tunnel construction or railroad track construction, the existing Stage 3 add-on DPF solutions from external DPF suppliers can be retrofitted according to Deutz technical guidelines.”

For operation under all operating conditions, DVERT contains a heat management system that combines intake air throttling, optimized combustion and sophisticated control strategies to optimise the efficiency of the DVERT SCR system and to support the regeneration of the DVERT particulate filter.

With our model-based and validated software strategy, no standstill regeneration was necessary under test conditions, with all known and tested load profiles,” Wellenzohn said. “In summary, Deutz feels there is no individual technology for off-highway mobile machinery that outweighs all others. Depending on the application and power range, different solutions have their benefits and drawbacks.

“Furthermore, ‘fit for all markets’ and ‘fit for future’ technologies become more and more important in times where regional approaches lead to wide-ranging market requirements. And that is why the Deutz Variable Emission Reduction Technology has different solutions for various applications and power ranges — each technology being what we feel are the best choices for the highest performance, lowest fuel consumption and lowest total cost of ownership.”