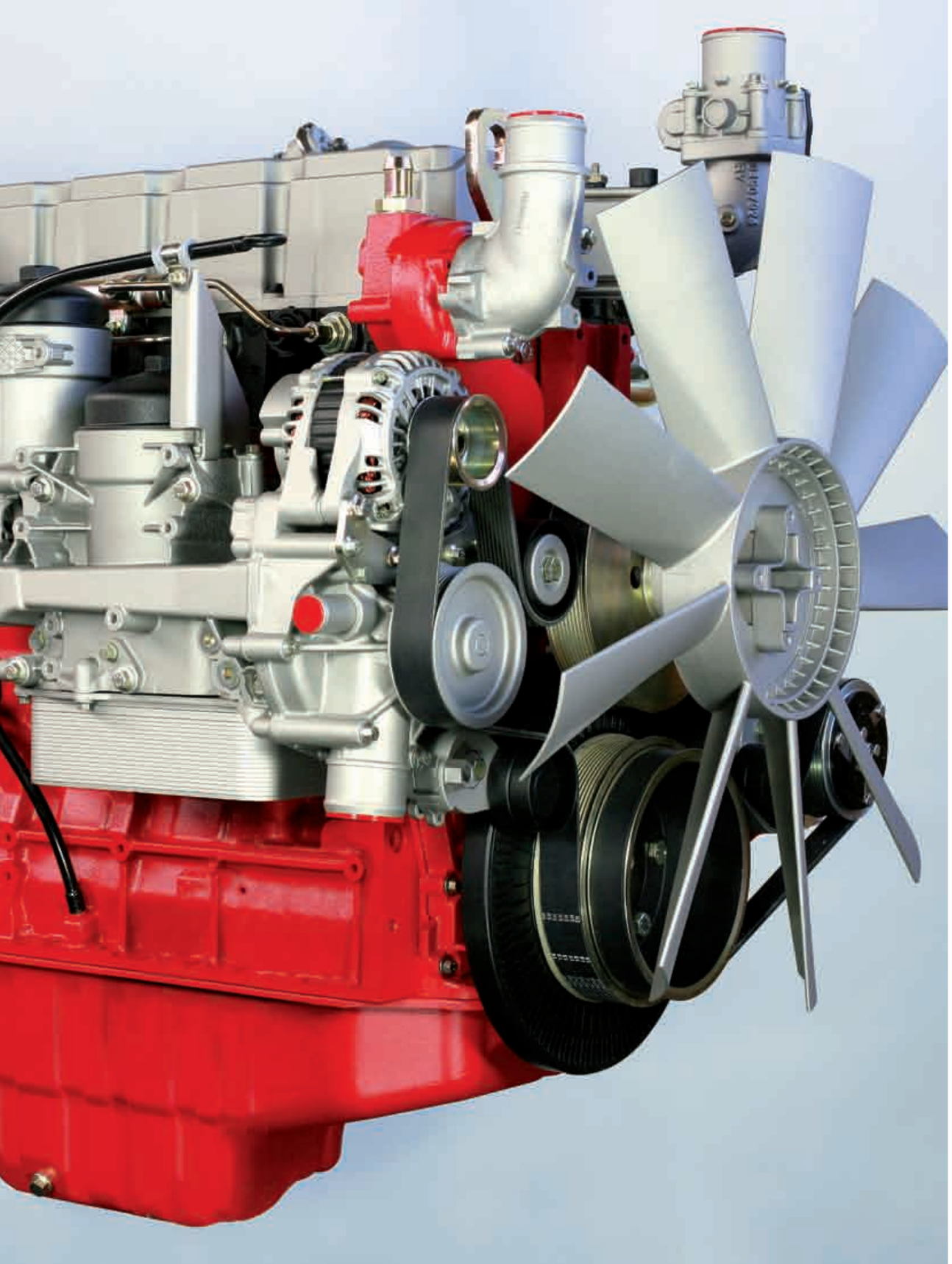
DEVERT®

DEUTZ Variable Emission Reduction Technology

Tier 4 – our driving force, your advantage.

The engine company.

DEUTZ®



Challenges are what drives us.

One of the great challenges facing the diesel engine manufacturers is the implementation of the future exhaust emission laws. Regulations for the systematic reduction of pollutant concentrations in the exhaust gases of diesel engines have been introduced in Europe and the USA since 1996.

Air contaminating substances caused by the combustion of fossil fuels are responsible for a number of negative influences on the environment and health, for example acid rain, smog and greenhouse gases which are seen in connection with global warming and respiratory complaints.

The exhaust gases of diesel engines consist primarily of water, NO_X, CO, HC, PM and CO_2.

NO_X: Nitric oxide: A combination of nitrogen monoxide NO and nitrogen dioxide NO_2 which contributes to smog and is a major factor in the development of acid rain when fuels with a high sulphur content are used.

CO: Carbon monoxide: Is tasteless, odourless and toxic and is produced at high combustion temperatures or when too little oxygen is available in the combustion.

HC: Hydrocarbons: These are the result of complete and incomplete combustion and occur as many different pollutant varieties. The main reaction products in the diesel engine are carbon dioxide, water or carbon monoxide and carbon (soot) among other things.

PM: The particle emission is spart of the complex diesel emissions. The main components are metal attrition products from the engine, carbon (soot) and hydrocarbons from the fuel and lubricating oil as well as watery sulphuric acid produced from the sulphur in the fuel.

CO_2: Carbon dioxide: Familiar as greenhouse gas. The CO_2 emission values of diesel engines are below those of petrol engines.

The topic of exhaust emission limiting and reduction is extremely complex. Increasingly profound measures in the engine design, the injection, combustion and charging technology and the use of exhaust post-processing are necessary to keep the permissible emission limits.

After successfully implementing the first steps of the European and US emission reduction we have now turned our attention to the future European and US exhaust stage 4. This is the greatest challenge to the engine manufacturers so far and will lead to the application of further technology modules.

The basic philosophy of DEUTZ: We will only introduce technical modifications to the engine design and the complexity where this is necessary for safe implementation of the legal provisions or customer requirements. In the meantime we will keep our sights set firmly on the economy and reliability of the diesel engine.

The way to a clean environment.

The European exhaust stage III B or the US exhaust Tier 4 interim (start 2011) initially concern engines with a performance of above 130 kW | 174 hp. The NO_X/HC and particle emissions will be reduced considerably in comparison with the previous exhaust emission Tier. Different techniques are available to achieve these values.

The particles can be reduced by a particle filter system. The NO_X values are reduced by internal engine measures, e.g. with the aid of the cooled exhaust gas feedback.

An alternative measure is the reduction of the NO_X/HC emission with the aid of the SCR technology at the same time as optimised combustion for particle emission reduction.

With the introduction of the exhaust EU stage IV, US EPA Tier 4 the limit values for engines > 56 kW | 75 hp are so low that exhaust post-processing of the nitric oxides (NO_X) and the diesel soot (PM) will be necessary.

Although the European emission regulations of stage III B/IV are very similar to the American EPA Tier 4 interim/Tier 4, there are a few important differences, above all with regard to the transitional stage EPA Tier 4 interim. The exhaust post-processing conditions of the European stage IV will also be subjected to various technological revisions before their introduction dates.

European directive RL 2002 / 88 / EC

kW	hp	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
18–36	24–48	(7.5) / 5.5 / 0.6									
37–55	49–74	(4.7) / 5.0 / 0.4						(4.7) / 5.0 / 0.025			
56–74	75–99					3.3 / 0.19 / 5.0 / 0.025			0.4 / 0.19 / 5.0 / 0.025		
75–129	100–173	(4.0) / 5.0 / 0.3				3.3 / 0.19 / 5.0 / 0.025					
130–560	174–751	(4.0) / 3.5 / 0.2			2.0 / 0.19 / 3.5 / 0.025			0.4 / 0.19 / 3.5 / 0.025			

(NO_X + HC) / CO / PM (g/kWh) NO_X / HC / CO / PM (g/kWh)

Stage III A Stage III B Stage IV

US directive EPA NONROAD, 40 CFR Part 89

kW	hp	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0–7	0–10	(7.5) / 8.0 / 0.40									
8–18	11–24	(7.5) / 6.6 / 0.40									
19–36	25–48	(7.5) / 5.5 / 0.30					(4.7) / 5.0 / 0.03				
37–55	49–74	(4.7) / 5.0 / 0.30*									
56–74	75–99	(4.7) / 5.0 / 0.40				3.3 / 0.19 / 5.0 / 0.02			0.40 / 0.19 / 5.0 / 0.02		
75–129	100–173	(4.0) / 5.0 / 0.30									
130–224	174–301	(4.0) / 3.5 / 0.20			2.0 / 0.19 / 3.5 / 0.02			0.40 / 0.19 / 3.5 / 0.02			
225–449	302–602	(4.0) / 3.5 / 0.20									
450–560	603–751	(4.0) / 3.5 / 0.20									
> 560	> 751	(6.4) / 3.5 / 0.20			3.1 / 0.19 / 3.5 / 0.10			0.40 / 0.19 / 3.5 / 0.02			

(NO_X + HC) / CO / PM (g/kWh) NO_X / HC / CO / PM (g/kWh)

Tier 2 Tier 3 Tier 4 interim Tier 4

Post-processing of the diesel soot (PM) is necessary for engines with a performance for USA >19 kW | 25 hp and EU > 37 kW | 50 hp.
*Takes »Option 1« into account in transition stage Tier 4 interim

All options, one principle.

DVERT® is our answer to the problem of harmonising future emission regulations with our customers' requirements. DVERT® stands for a modularly structured system of technology modules which are incorporated into the many different configurations of our engines. The basic principle is:

"As much technology as necessary and not as much as possible."

Almost all the elements of the DVERT® system kits can be combined with each other to ensure the desired result with regard to engine performance, observance of emission limits and competitivity. We have a number of techniques which meet the specified emission limits. With our flexible module system we can ensure that a "overtechnification" is avoided and only as much technology as is necessary and useful is used.

Our driving force, your advantage.

Improved engine performance
- More power – more dynamics
- Lower consumption – lower emissions

Flexible installation possibilities
- System kits for all engine series

Individual customer support
- Partners in system selection, design and integration into the device

Minimal operating costs
- DEUTZ Xchange® competence

DVERT®-System Kits

EU STAGE III A / US EPA TIER 3

FUEL INJECTION
- Mechanical pump line and nozzle
- Mechanical distributor injection pump
- DEUTZ Common Rail (DCR®)
- Solenoid valve system (MVS®)

ENGINE CONTROL TECHNOLOGY
- Mechanical fuel injection and regulation
- Mechanical fuel injection with electronic speed control and engine data recording (EMR®3)
- Fully electronic engine control with electronic fuel injection systems from DEUTZ

COMBUSTION MANAGEMENT
- Direct and indirect injuection systems
- Aspirated engines
- Turbochargers
- Turbochargers with charge air cooling
- 2-valve and 4-valve systems

NO_X REDUCTION TECHNOLOGY
- Simple, uncontrolled internal exhaust gas feedback (EGR)
- Controlled exhaust gas feedback with valve stroke management (VLM®)
- Controlled and cooled exhaust gas feedback

EU STAGE III B / US EPA TIER 4 INTERIM

EXHAUST POST-PROCESSING
- Reduction of diesel soot by means of diesel particle filters
- NO_X reduction by means of the selective catalytic reduction (SCR). Particle reduction inside the engine
- Omission of mechanically controlled engines, VLM, uncontrolled EGR, …

EU STAGE IV / US EPA TIER 4

EXHAUST POST-PROCESSING
- Combination of the technologies introduced in Tier 4 interim.
- Reduction of diesel soot by means of diesel particle filters, NO_X reduction by selective catalytic reduction (SCR).

TECHNOLOGICAL VISION – EMISSIONLESS DIESEL ENGINES

From theory to practice.

There are a number of frequently asked questions for choosing a Tier 4 engine. We would like to answer the most important of these here.

Installation situation

The higher the exhaust stage, the more components and therefore installation space is required to achieve the desired result. However, since the available installation space cannot be extended infinitely, a problem which particularly affects our customers, the device manufacturers, other solutions have to be found. We solve the problem by configuring the engine and the exhaust system together with our customers already in the planning phase of a new device and therefore optimally exploit the available space.

DVERT®'s modular structure makes this easier.

Performance

DEUTZ engines with modern exhaust technology have equal or often even better performance density than engines without advanced exhaust gas processing. The "downsizing" familiar from the automotive industry is also used for many DEUTZ engines. For you as customers this may mean equal performance at largely consistent installation dimensions because the extra effort fort cooling or exhaust gas cleaning can be compensated by the higher performance density of the drive module.

Consumption

A large proportion of the operating costs of an engine are determined by its fuel consumption. DEUTZ engines are traditionally distinguished by low levels of diesel consumption. This applies to our new Tier 4 engines in particular. With the latest engine and combustion management, performance and torque are optimised while at the same time fuel consumption is reduced. The slightly higher mechanical and thermal expenses are always more than compensated for. Depending on the application, the amount of fuel saved can be up to 5%.

Complexity

Of course, Tier 4 engines are more complex and technically more demanding than their predecessors but that is only natural. However, it is familiar ground for DEUTZ because the SCR technology, for example, has long been proven with our automotive customers. It has proved suitable and reliable for the daily routine in hundreds of thousands of diesel-powered vehicles.

Service effort

Engines from exhaust EU stages III B/US EPA Tier 4 interim do not generally require more service than comparable engines with a lower exhaust stage. All the relevant components of the DVERT® system kits have the same life endurance as the engine itself. The only, technologically related exceptions are the closed diesel particle filters. These have to changed and cleaned at the earliest in standard applications in the class below 130 kW | 174 hp, due to ash deposits in the filter and depending on the engine load after 3,000 h and in the class above 130 kW | 174 hp at the earliest after 4,500 h. A warning signal alerts the owner that the filter is due for a change in good time.

To enable our customers to change the filter easily and quickly, the proven DEUTZ Xchange® program has had the diesel particle filter product range added.

Regeneration

Particle filter systems are expected to achieve optimum regeneration results without significant extra consumption in addition to good filter-specific performances such as a high separation factor at low backpressure, low maintenance costs, simple design and long life. Two systems have established themselves in practice.

a. Passive regeneration
These systems feature regeneration of the filter under certain operating conditions, i.e. without targeted introduction of the oxidation process. This includes: Diesel particle filters with continuous regeneration (CRT) and coated particle filters (CSF). Advantage of the passive regeneration is the fact that these systems operate without a supply of external energy. Their disadvantage is that they are not suitable for all load profiles.

b. Active regeneration
In the active systems the exhaust gas is brought up to the necessary oxidation temperature (> 600 °C | > 1112 °F) by an external energy source, this introduces targeted regeneration.

DEUTZ offers all the above processes but concentrates on the solution with one burner installed close to the engine and an air pump (application-optimised regeneration). The advantages of this solution are:

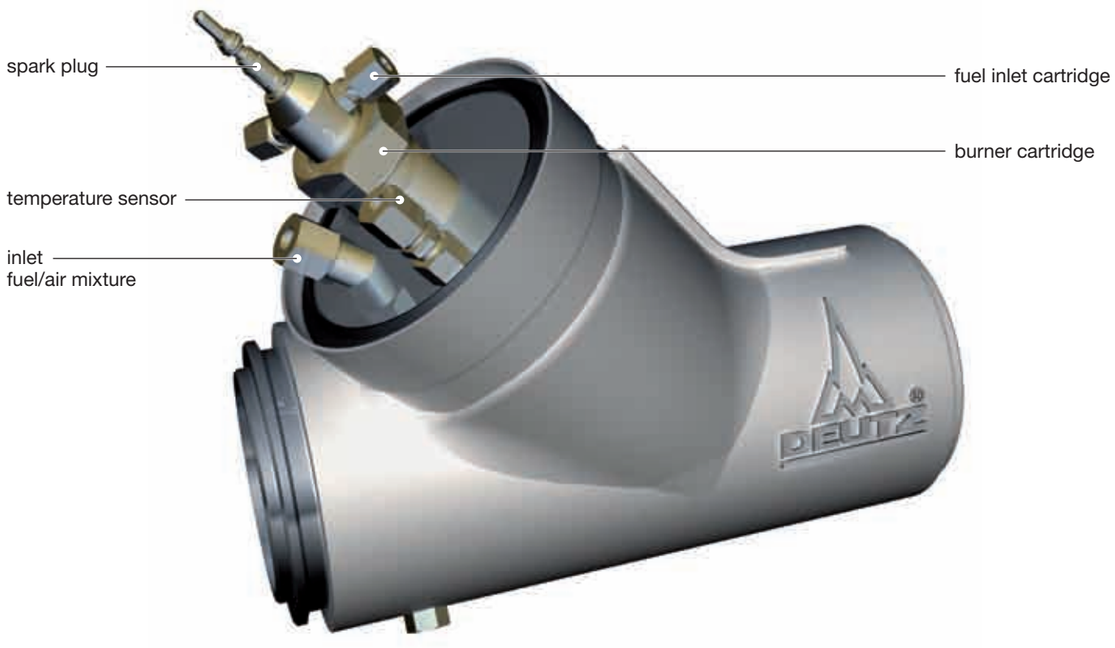
- the regeneration takes place by requirement control by additional combustion in the exhaust gas,
- regeneration also takes place automatically in applications with a low engine load,
- overloading of the particle filter and therefore a rise in the gas backpressure are reliably prevented,
- the engine efficiency is not impaired,
- the maximum engine performance is always available.

With the modular DVERT® system kits this solution can be implemented cost effectively and with only slight design changes by the equipment manufacturer.

DVERT®-SYSTEM KITS

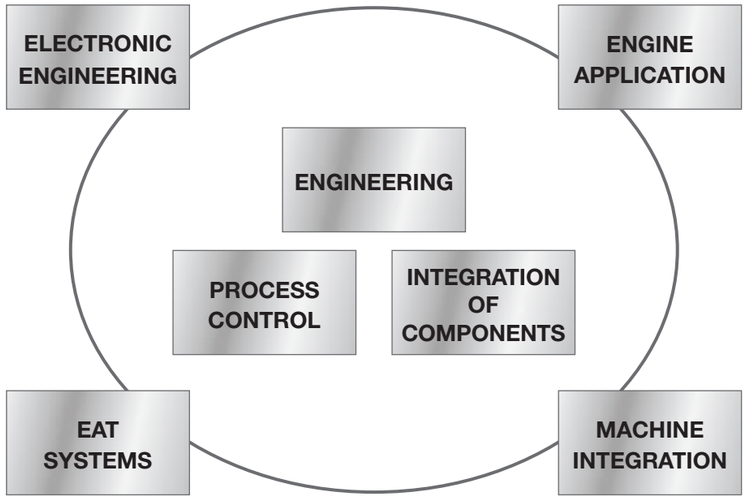
Series	2009	2010	2012 4V	2012 4V	2013 4V	2015 4V
Power	15–50 kW 20–67 hp	50–85 kW 67–114 hp	70–115 kW 94–154 hp	130–180 kW 174–241 hp	160–250 kW 214–335 hp	300–520 kW 402–697 hp
EU Stage III B / US EPA Tier 4 interim						
Particle Oxidation Catalyst		●				
Burner			optional	●	●	
Diesel Particle Filter			●	●		
Selective Catalytic Reduction						●
EU Stage IV / US EPA Tier 4						
Particle Oxidation Catalyst	●					
Burner		●	●	●	●	●
Diesel Particle Filter		●	●	●	●	●
Selective Catalytic Reduction		●	●	●	●	●

● = standard solution



The leading competence in emission technology.

DVERT® is so valuable for our customers because it is a completely integral part of DEUTZ technology competence. All components, from engineering to the integration of the engine and exhaust aftertreatment system in the equipment are carefully matched together. For our customers, this proves our claim to leadership in all areas of engine construction.



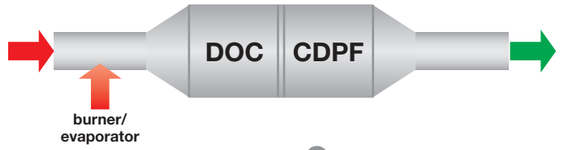
PARTICLE OXIDATION CATALYST (OPEN FILTER)

- ⊕ HC and CO are oxidised
- ⊕ low exhaust gas backpressure
- ⊖ internal engine measures necessary for limiting emissions (especially particles)

CONTINUOUS REGENERATION TRAP (CRT®)

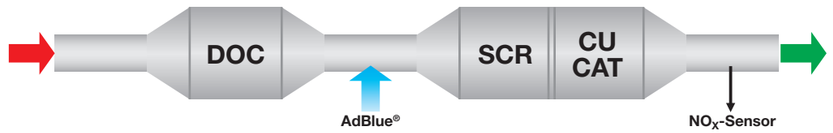
- ⊕ HC and CO are oxidised
- ⊕ > 90 % particle reduction by DPF filter
- ⊕ regeneration by CRT® effect
- ⊖ effort for load connection, e.g. hydraulic
- ⊖ sensitivity to weak load operation, active measures necessary:
  load connection
  speed increase
  throttling

DEUTZ BURNER-EVAPORATOR FOR DPF SYSTEM



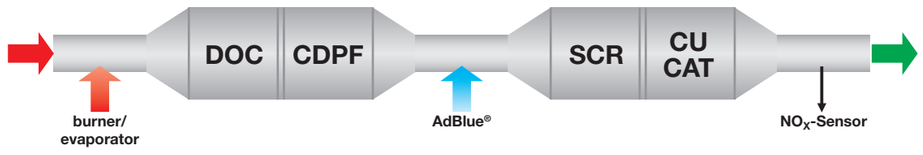
- ⊕ HC and CO are oxidised
- ⊕ > 90 % particle reduction by DPF
- ⊕ NO_2-free system
- ⊕ no engine measures necessary for raising the temperature
- ⊕ active components are mounted on the engine

SELECTIVE CATALYTIC REDUCTION (SCR)



- ⊕ up to 85 % NO_X reduction possible
- ⊕ HC and CO are oxidised (also without DOC)
- ⊕ particle reduction by HC oxidation (approx. 30 % at EU IV/V)
- ⊖ operating media (AdBlue®) necessary

SCRT (EU STAGE IV AND US EPA TIER 4)



- ⊕ up to 85 % NO_X reduction possible
- ⊕ HC and CO are oxidised
- ⊕ > 90 % particle reduction by DPF
- ⊕ filter regeneration by CRT® effect
- ⊖ operating media (AdBlue®) necessary

DOC = Diesel oxidation catalyst; POC = Particle oxidation catalyst; CDPF = Coated diesel particle filter; SCR = Selective catalytic reduction; CU CAT = Clean up catalyst

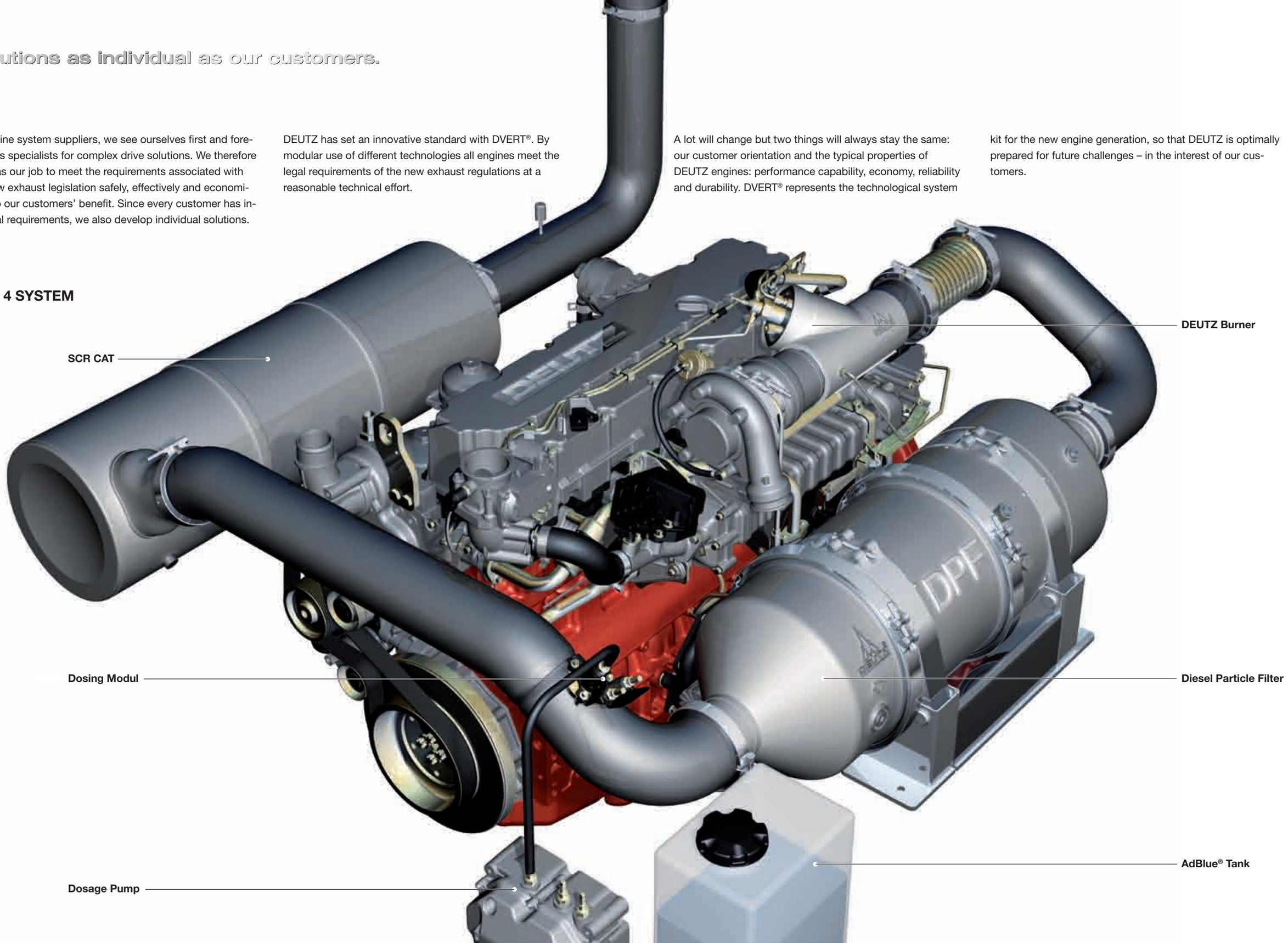
Solutions as individual as our customers.

As engine system suppliers, we see ourselves first and foremost as specialists for complex drive solutions. We therefore see it as our job to meet the requirements associated with the new exhaust legislation safely, effectively and economically to our customers' benefit. Since every customer has individual requirements, we also develop individual solutions.

DEUTZ has set an innovative standard with DVERT®. By modular use of different technologies all engines meet the legal requirements of the new exhaust regulations at a reasonable technical effort.

A lot will change but two things will always stay the same: our customer orientation and the typical properties of DEUTZ engines: performance capability, economy, reliability and durability. DVERT® represents the technological system kit for the new engine generation, so that DEUTZ is optimally prepared for future challenges – in the interest of our customers.

TIER 4 SYSTEM



Fuel injection systems

In addition to distributor injection pumps, Bosch-Common-Rail systems and our pump-line-nozzle systems we have developed the DEUTZ Common-Rail-System (DCR®).

In this method, two high-pressure pumps are used which are driven by the engine camshaft and feed fuel into the pressure line. As in all Common Rail systems electronically controlled injectors ensure that the right amount of fuel is injected into the combustion chamber with the required pressure. By means of this concept we can retain the external dimensions of the basic engine and offer all the ancillary power takeoffs to meet our customers' needs.

Engine and machine control

Engines with DCR® communicate with the machine via a CAN-Bus protocol. This enables functions such as "drive by wire" and the full integration of the engine control in the electronically controlled hydrostatic powertrains of vehicles or machines. Another advantage of these fully automatic, electronic controllers is the integrated engine diagnosis and safety system. If the engine controller registers an unusual state, such as engine overheating, during operation, the engine performance is reduced to emergency mode and is necessary down to shutdown. This avoids cost-intensive repairs and increase the operational reliability/operating availability of the work machines.

We will use our present mechanical control systems for engines in the lower performance range as far as possible. These systems feature the simplest mechanical centrifugal force controllers and closed, torque-controlling centrifugal force controllers which are partly common in engines up to 7 litre capacity nowadays.

Cases exist in which a machine benefits from the uncomplicated nature of a mechanical injection system but still requires the control complexity of an electronic engine controller. We satisfy this need by using the DEUTZ EMR® control system. EMR® is a programmable speed controller which imitates the functions of fully automatic electronic controllers but without the ability to change the ignition time. Functions such as "drive by wire", continuous speed control, multiple saved torque curves, torque control and engine safety control are also provided by the EMR® control system.

Combustion management

Our engine range includes combustion systems with indirect diesel injection for the smaller engines and direct fuel injection for all other engines. We will continue to offer both systems.

We will retain aspirated and turbocharged engines for the range below 56 kW | 75 hp. The choice of these two combustion management types is performance-dependent. In the class above 56 kW | 75 hp where the NO_X emission limits are stricter, the engines additionally have a turbocharger and a charge air cooler.

For some engines we also offer optional 2-valve and 4-valve variants. The larger the inlet valve cross-section, the more aspirated air is available for the combustion. This leads to a better engine filling and combustion and thus a higher power density. Similar applies for the outlet valve related to the conbustion gas outlet. Since the valve size is defined by geometric restrictions, this problem can be solved by using the multi-valve technique.

A 4-valve engine supplies a higher power over the entire speed range and a higher torque in comparison with a conventional 2-valve engine with the same capacity.

NO_X reduction technology

NO_X is produced when the oxygen and the nitrogen in the air react with each other in a high-temperature environment. Diesel engines operate with high compression ratios and lean fuel mixtures. This results in rich oxygen and nitrogen atmosphere in the combustion chamber which leads to formation of NO_X.

This feedback of part of the exhaust gases into the combustion chamber (exhaust gas recirculation, EGR) reduces the quantity of excess air so that a condition with fewer available oxygen and nitrogen molecules is created which can bond as NO_X in a chemical reaction.

An exhaust gas feedback can be produced in different ways.

Internal EGR

The simplest way is either to open the outlet valve during the aspiration stroke or the inlet valve during the outlet stroke. Both methods can be implemented by simple modification of the camshaft but have the disadvantage that they cannot be deactivated. This means that the EGR always operates regardless of the engine load and speed. The internal, uncontrolled EGR has a slight disadvantage at some engine operating points with regard to the torque acceptance which depends on optimised camshaft profiles.

Controlled internal EGR

Another EGR method is the electronic control of the opening point of the outlet valve. The outlet valve stroke for the EGR is implemented by hydraulic connection with the inlet cam. The connection can be broken by means of a solenoid valve which deactivates the EGR. The advantage is that this system is controlled by the engine management system without having the disadvantage of cooled external EGR, corrosive materials. Other advantages are an improved driving behaviour and a faster response of the engine. The system is mainly used in high-performance equipment such as tractors, factory floor vehicles and building machinery.

Cooled EGR

A third EGR method is to feed a defined amount of exhaust gas through an external cooler and then feed it back into the combustion system through a clack valve. This method is known as external, cooled EGR. The system enables a higher power density and better torque control because the switching valve can be controlled electronically by the engine management system (definition of the EGR amount). The temperature of the aspirated air is reduced by feeding back cooled exhaust gases which leads in turn to a higher power density. The disadvantages are higher cooling requirements and, more important, the transformation of sulphur from the fuel to corrosive sulphuric acid. This is one of the reasons why all manufacturers of high performance diesel engines are demanding the distribution of sulphur-free diesel fuel for this solution. DEUTZ uses especially suitable materials to avoid corrosion.

Diesel particle filters

Modern diesel particle filters are in use as closed or open versions. In the closed particle filters, also known as surface filters, the exhaust gases flow through a filter unit of a porous ceramic material. While the filter gradually fills with particles, the engine managment system monitors the rise in the exhaust backpressure. Thermal regeneration of the filter takes place at an exactly defined time.

The particle oxidation catalysts, also known as open filters, have a lower separation rate (< 50 %) and the filtration takes place inside a metal structure. No active regeneration is necessary for this filter type but it is unsuitable for high specific engine performances.

SCR technology

The selective catalytic reduction (SCR) is a method of reducing the NO_X emissions. The basis of this technology is a watery, 35 % urea solution (AdBlue®) which is sprayed into the exhaust gas flow by a spezial exhaust gas catalyst. This catalyst has a vanadium or zeolith coating.

The urea produces ammonia (NH_3) in a passive transformation which reacts with the NO_X and oxygen to form nitrogen and water. This technology has been on the European lorry market since 2006 and is being introduced in the USA as well.

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The engine company.

DEUTZ®