

Innovative exhaust emissions control for construction machines**Reducing operating costs *and* exhaust emissions**

- **Highly efficient SCR systems for Stage IIIB and Stage IV**
- **Engine tuned for minimum fuel consumption**
- **Meets future emissions control requirements**

The low emission limits for nitrogen oxides (NO<sub>x</sub>), which were introduced with EU Stage IIIB and IV, create a conflict of objectives in the development of engines because the laws of physics dictate that engines adjusted for low NO<sub>x</sub> emissions must have higher fuel consumption. Highly effective NO<sub>x</sub> emission control is able to resolve this conflict so that the engine can be tuned for maximum fuel efficiency. The SCR process (**S**elective **C**atalytic **R**eduction) is used for NO<sub>x</sub> control; and special catalysts and system configurations have been developed to achieve the objectives of lower operating costs and lower emissions at the same time.

The EU Stage IIIB limit for regulated particulate matter (PM) emissions can be met by in-cylinder improvements. In this case the engine does not require exhaust recirculation and needs less cooling. Fuel injection mapping is tuned for optimum combustion and fuel consumption. All of these measures result in fuel savings of up to 5 – 10% compared to in-cylinder NO<sub>x</sub> control. Advanced engine technology means that the SCR system typically has to reduce engine-out NO<sub>x</sub> emissions by between 75 and 85%.

The pressure loss of highly effective metal substrate catalysts is low and so maintains full engine performance and optimum fuel consumption. Flexible shapes and the turbulence-generating structures of the catalyst substrates provide maximum efficiency at minimum installation space. As a result, SCR catalysts can be installed close to the engine – ideally inside the engine compartment – so that unrestricted driver/operator visibility is maintained since no additional components in the exhaust aftertreatment system impede the view.

EU Stage IV further increases the demands of exhaust emissions control. While the maximum PM limit remains unchanged, stricter NO<sub>x</sub> limits mean that the efficiency of the exhaust gas treatment with regard to NO<sub>x</sub> emissions has to be raised to > 90 – 95% if PM emission limits are to be met via engine-based measures alone.

Emitec has developed a new SCR process to meet these very strict NO<sub>x</sub> limits. The process, which rightly deserves to be described as advanced, has been termed SCR advanced (SCRa) and exploits the potential offered only by metal catalyst substrates:

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- Turbulence-generating structures for maximum performance with minimum installation space
- Mixing and flow equalisation inside the catalyst
- Numerous, flexible designs that can adapt to the existing installation space

SCRa is a multi-stage process concept and consists of a close-coupled module that comprises oxidation catalyst, AdBlue injection and an initial small SCR catalyst. A ring-shaped oxidation catalyst offers particular advantages in this area as the exhaust gas is deflected and flows back through an inner tube. AdBlue is injected into the deflection chamber so that, given an optimum mixture, hydrolysis already occurs inside the component. The first, small SCR stage is fitted downstream, still close to the engine. Depending on installation space this SCR catalyst can have a round or oval cross-section. The close-coupled design of these compact metal components ensures rapid heating for catalyst light-off and is highly effective also under transient load collective commonly found in non-road applications.

NO<sub>x</sub> emissions are already substantially reduced in the first SCR stage. In combination with a second SCR stage the system is able to achieve extremely high overall NO<sub>x</sub> conversion rates of 90 – 95%. This SCR catalyst can be installed wherever there is sufficient installation space in the vehicle or the machine.

With NO<sub>x</sub> conversion rates of 90 – 95% NO<sub>x</sub> engine-out emissions can exceed 5 – 6 g/kWh and still meet the requirements of EU Stage IV. As a result of this additional degree of flexibility, fuel efficiency can be further improved; easily by more than 5% compared to other concepts. Modern engines with high-pressure fuel injection systems and highly effective turbocharging require no further emission control technology in addition to the SCRa system to comply with stage IIIB or even stage IV.

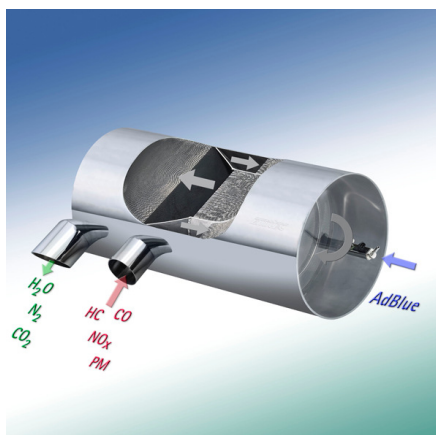
Emitec has already integrated the first production-ready compact SCRi<sup>®</sup> systems for combined PM and NO<sub>x</sub> reduction in non-road mobile machines and is presenting model examples at bauma 2010.

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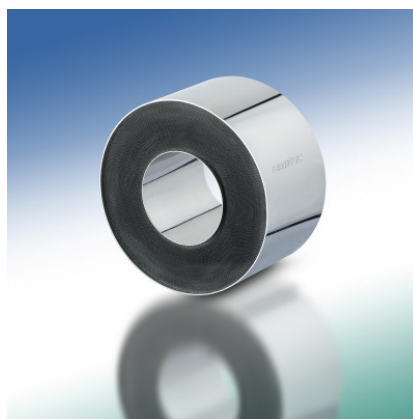
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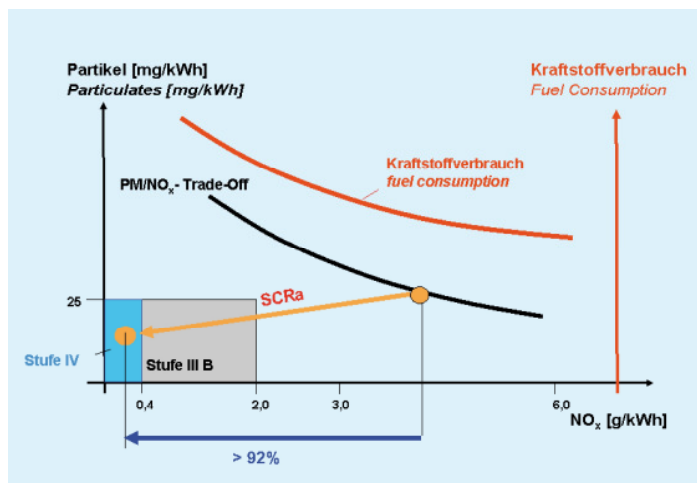
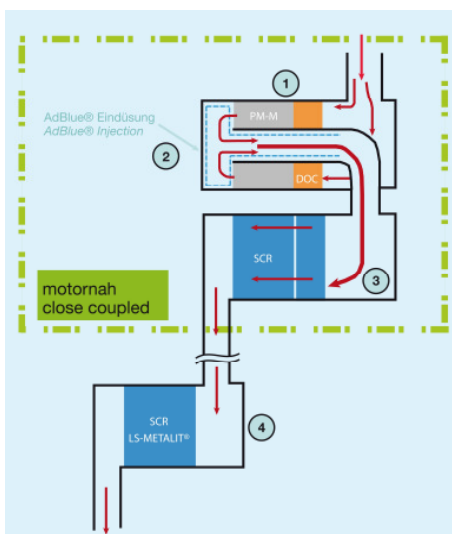
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**Compact SCR-System**



**Donut-shape Catalyst**



**SCRa: 2-stage high performance SCR system**

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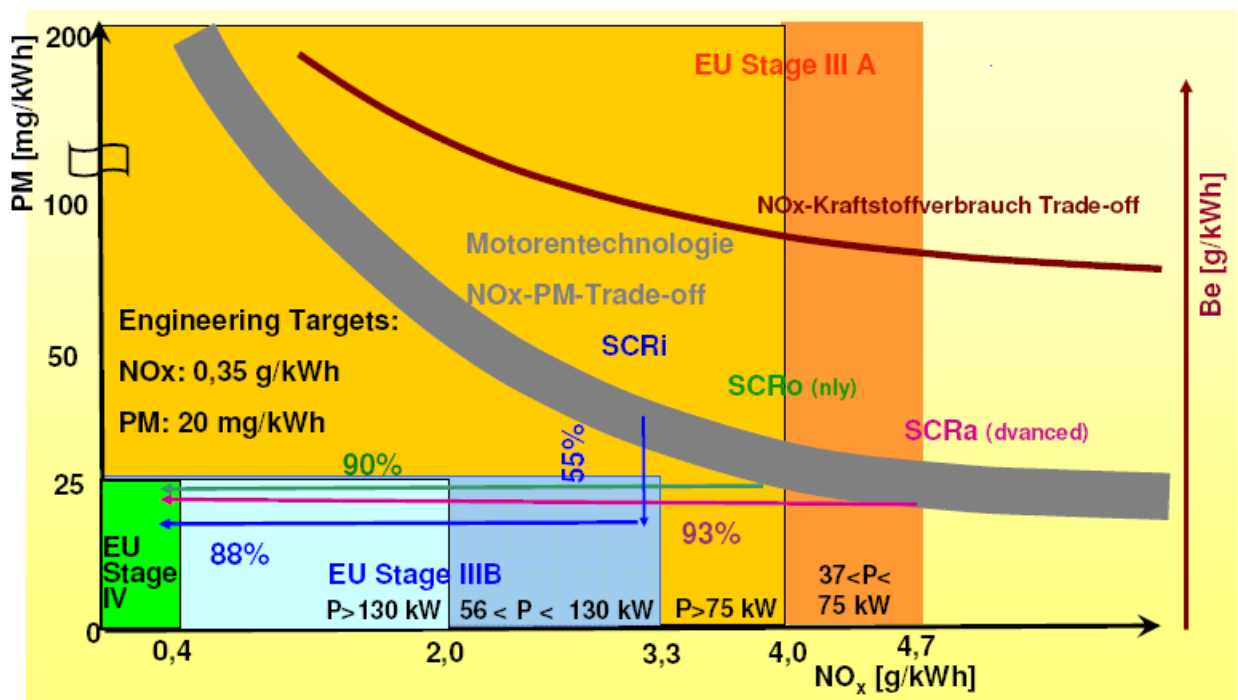
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## Case Study SCRa for 200 kW-Engine



**Fig.: NO<sub>x</sub>-PM- and NO<sub>x</sub> - fuel consumption (Be) Trade-off-Curves**  
 Curves for given engine technology  
 Emissions control technologies designed according to the required demand specific to engine technology and tuning: SCR, SCRi or SCRa

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