

**MANN+HUMMEL Diesel Particulate Filter CRT®**  
**New filter technology for diesel engines**



# Diesel particulate filtration – trends

## The engine with a future

In recent years the robust and economic nature of the diesel engine has increased its popularity as a drive unit. Today diesel engines are the standard choice for mobile machinery used in the construction industry and agriculture. Yet despite the most modern engine technology, particle emissions remain an issue for the diesel engine. Scientific research indicates that engines without a diesel particulate filter are a health risk.

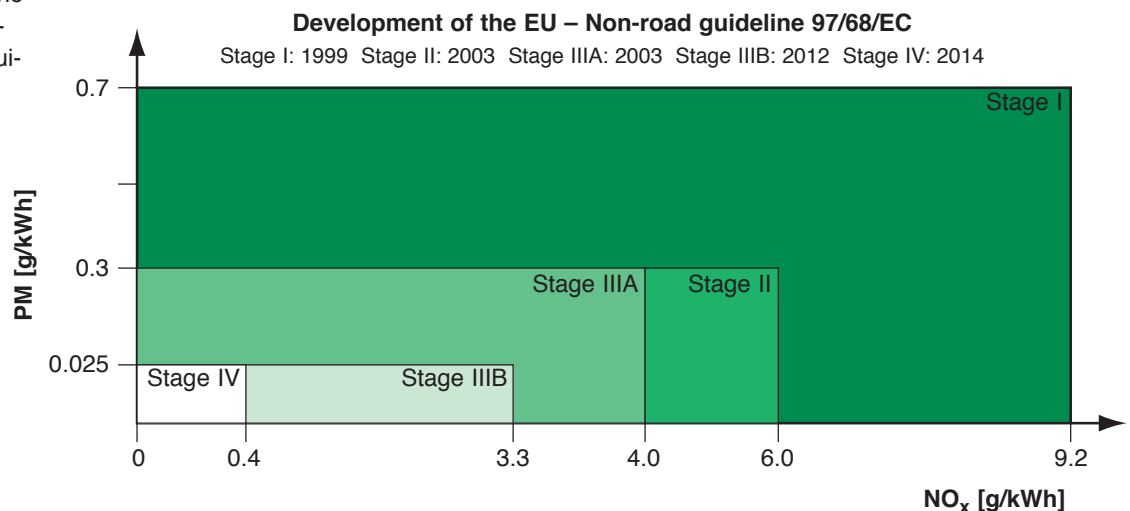
According to the World Health Organisation (WHO) and the US Environmental Protection Agency, particulates from diesel engines are today responsible for 5% of all respiratory cancer. Environmental and political pressure and regulations governing the workplace have therefore made it a top priority to use diesel particulate filters to remove the fine particulates from exhaust emissions created by diesel engines.



## Market development

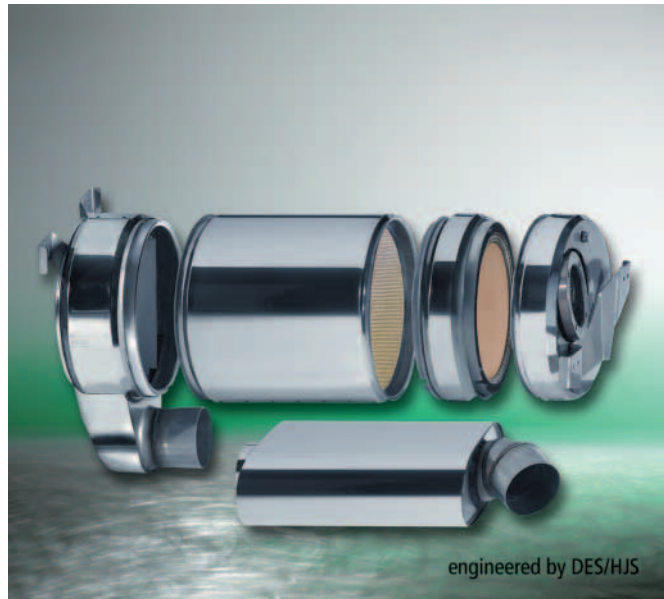
Diesel engines make an invaluable contribution towards achieving environmental protection targets. In contrast to petrol engines, due to their low fuel consumption they produce approximately 20% less carbon dioxide. However, for many years it has been clear that the soot particles generated by diesel engines contribute towards environmental pollution and are a risk to health. The European 97/68/EC guideline for engines installed in non-road mobile machinery requi-

res a value of 0.025 g/kWh for the particle emissions of diesel engines. Today, Swiss legislation already requires installation of a filter in each construction machine. In order to achieve the emission values, MANN+HUMMEL recommends use of a diesel particulate filter.



# Modular CRT® system: A clean solution

The MANN+HUMMEL CRT® system (continuous regeneration trap) is an efficient cleaning system which reduces diesel particulates in exhaust gas. It reduces the number of particles in the exhaust gas and also considerably reduces the component of ultra-fine particles ( $<1 \mu\text{m}$ ). The CRT® system traps the diesel particulates and burns them off continuously.



CRT® combines the effect of the diesel particulate filter with that of an oxidation catalytic converter. The nitrogen dioxide ( $\text{NO}_2$ ) formed in the catalytic converter enables continuous burning of trapped diesel particulates in the filter in a temperature range of 250 to 450 °C.

The modular CRT® system from MANN+HUMMEL reduces pollutant emissions by 90%. The resulting concentrations can barely be detected using modern emission measurement techniques. This enables the diesel engine to be more environmentally friendly. The modular system consists of a diesel particulate filter preceded by an oxidation catalytic converter. The system with its OXI-CAT and diesel particulate filter is integrated in the stainless steel exhaust silencer

so that fitting to the existing exhaust gas system can be made easily without changing the connections. Numerous tests on engine test benches, including the Rhineland Westphalia technical inspection authority (TÜV) in Essen, Germany, confirm a reduction of more than 90% of the carbon monoxide (CO), hydrocarbons (HC) and particulate matter (PM) emissions.

The CRT® is suitable for OEM products and can also be retrofitted.

## Advantages of the CRT® Systems

- 99% filter efficiency, no regeneration aids necessary
- Modular design enables flexible integration in existing installation space
- Reliable function
- Low maintenance
- High ash holding capacity
- Easy to clean
- Suitable for new vehicles and possible to retrofit
- Certification according to VERT

## Adaptation criteria

- Engine output
- Installation space
- Pollution classification
- Permissible exhaust back pressure
- Particle/ $\text{NO}_x$  ratio

## System requirements

The following conditions are required to ensure correct function of the modular CRT® system:

- Sulphur-free diesel DIN EN 590 with max. 50 ppm S (0.005% sulphur content)

- Suitable application conditions, i.e. a temperature range of 250 - 450 °C at the filter
- Engine maintenance according to the manufacturer's recommendation
- For use with Euro 1, Euro 2 and Euro 3 engines

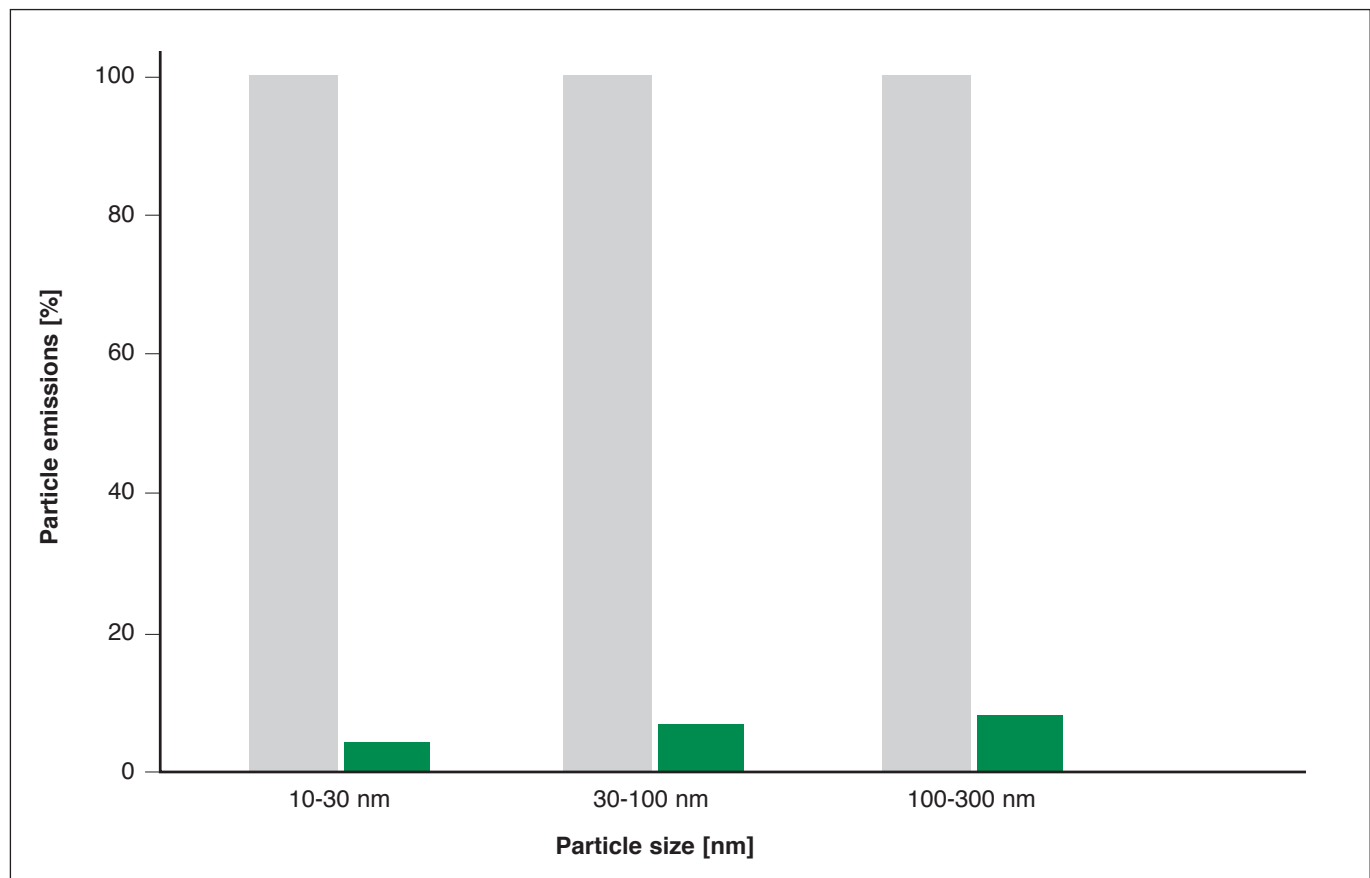
# Modular CRT® system: A clean solution

## The pollutant emissions

- CO (carbon monoxide): colourless and odourless gas, after 1000 ppm causes acute symptoms of poisoning, MAK value 30 ppm
- Saturated HC (hydrocarbon): odourless, the concentration present in the exhaust is usually insignificant
- Unsaturated HC (hydrocarbon): a slightly sweet odour, a component of smog, harmful
- Aromatic HC (hydrocarbon): neurotoxic substance, highly carcinogenic (e.g. 3,4 benzopyrene)
- NO (nitrogen monoxide): reacts with air to become NO<sub>2</sub>, after 25 ppm causes damage to the lungs, MAK value 25 ppm
- NO<sub>2</sub> (nitrogen dioxide): a gas with an irritating odour similar to chlorine gas, MAK value 5 ppm
- PM (particles): In particular, fine particulates are made responsible for cancer

## Particle emissions

### Influence of the modular CRT® system on particle size distribution

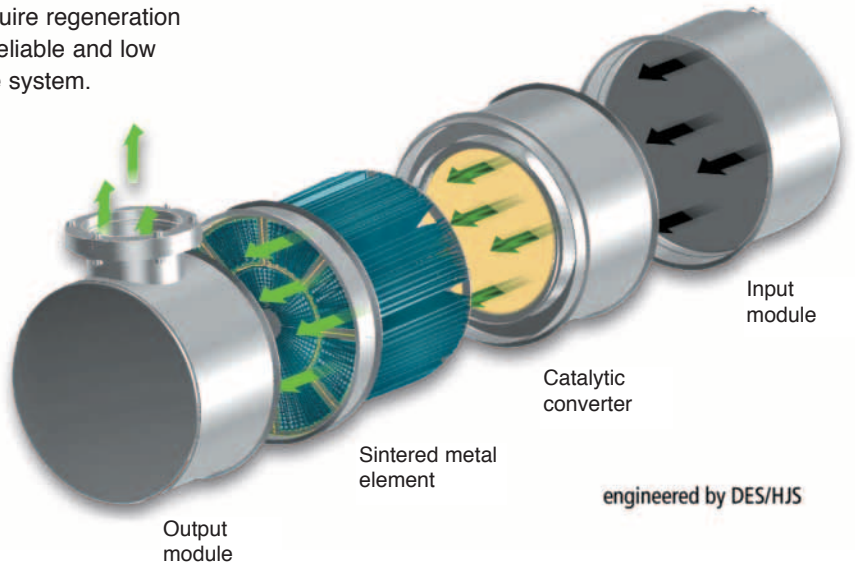


The use of a CRT® system considerably reduces the quantity of diesel particulates.

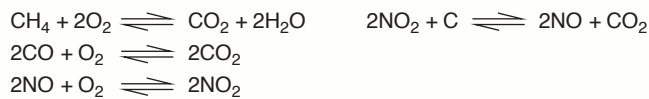
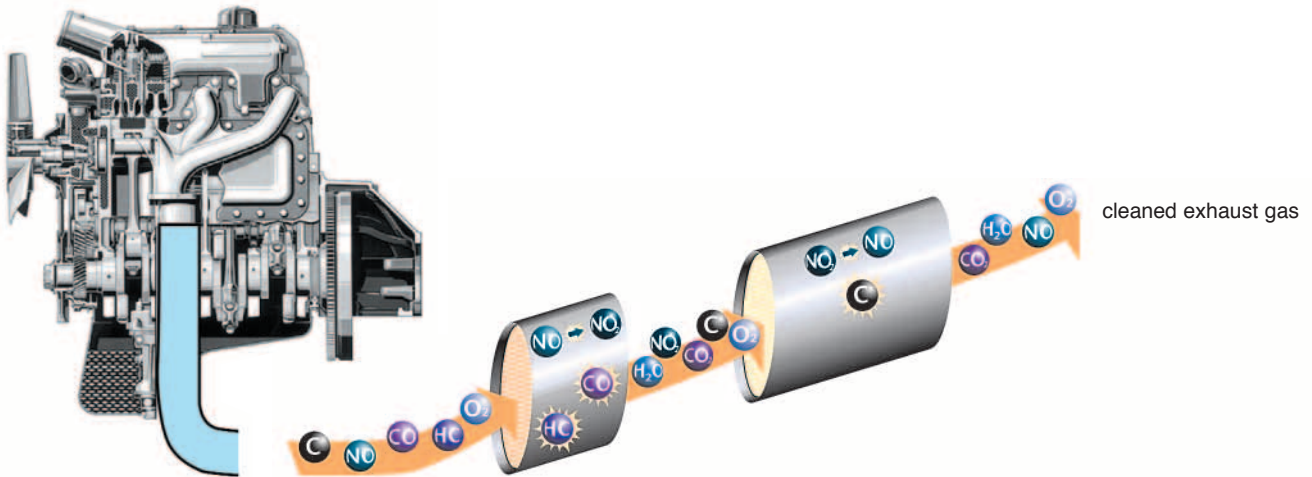
# Modular CRT® system: working principle

A highly efficient oxidation catalytic converter is fitted upstream of a diesel particulate filter. The catalytic converter oxidises the hydrocarbons and carbon monoxide. Nitrogen reacts with air to form nitrogen dioxide. The diesel particulates trapped in the filter are continuously burned off through the nitrogen dioxide formed in the catalytic converter upstream. The catalytic converter is adjusted to minimise the necessary surplus of nitrogen oxide. The nitrogen oxide emissions of the engine are reduced to an insignificant extent.

The modular CRT® system does not require regeneration aids. It is a reliable and low maintenance system.



# Chemistry of the exhaust cleaning



engineered by DES/HJS

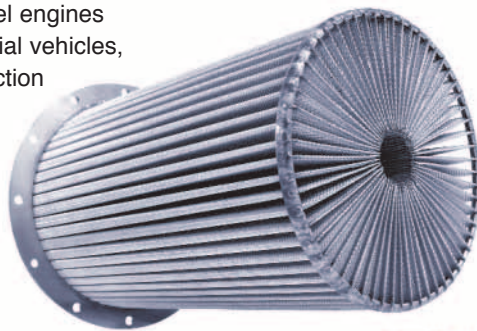


# Modular CRT® system with sintered metal element

## Diesel particulate filter made from sintered metal (SMF®)

The design of the sintered metal filter and the material used offer considerable advantages over previous filter concepts. The modular design of the system and the use of several modules per filter system enable generation of filters in the size and form required by the customer.

In future MANN+HUMMEL will offer systems with filter surface areas of 1.8 to 10.2 m<sup>2</sup>. This will enable the use of MANN+HUMMEL filter technology in all diesel engines in cars, commercial vehicles, buses or construction machines.



## CRT® with SMF® filter

### Advantages:

- 99% filter efficiency
- Excellent inflow and flow through
- Low exhaust back pressure
- High ash holding capacity
- Modular, self-supporting design
- Easy adaptation to different installation spaces
- Easy to clean
- Low cost canning
- Easy recycling
- Low costs for cleaning and maintenance

## Modular CRT® system: requirements

### Long-term tests

- In Europe, there are currently around 20,000 commercial vehicles and approx. 5,000 off-road machines in use fitted with CRT® systems
- CRT® system have been available on the market since 1995
- Most vehicles are driven with fuel which is almost free of sulphur (max. 50 ppm S)

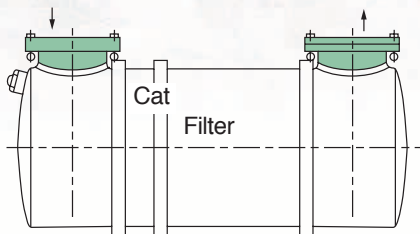
### Service and maintenance

The combustion of engine oil and additives contained in the oil create oil ashes which are also trapped by the filter. The oil ashes cannot be regenerated and therefore the filter has to be cleaned. Cleaning is carried out by blowing out carefully with compressed air. The ashes are collected and disposed of.

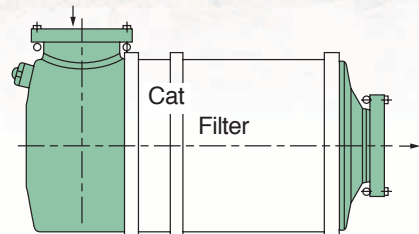
# Modular CRT® system: module combinations

The modular design of the off-highway CRT® system allows the configuration of different systems to meet the individual requirements of the installation space. This allows, for example, inlet and outlet modules with a radial or axial configuration. After we receive your engine specifications and a corresponding CRT® system has been dimensioned, MANN+HUMMEL makes a detailed drawing available for design modifications.

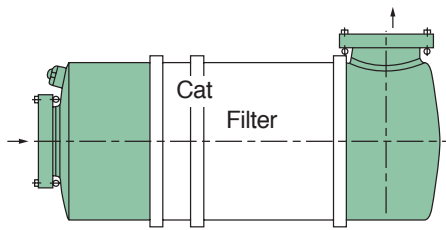
## Combination possibilities



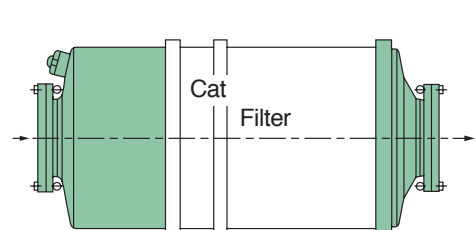
radial-radial



radial-axial



axial-radial



axial-axial





# Glossary

## Canning

Canning is used to describe the manufacture and provision of casings for diesel particulate filters (DPF<sup>®</sup>) as a component part of a complete exhaust gas system, partly including the necessary exhaust pipes.

## CRT<sup>®</sup>

CRT<sup>®</sup> stands for Continuously Regeneration Trap – and describes a combination of a diesel oxidation catalytic converter (DOC) with a diesel particulate filter (ceramic or sintered metal).

## DPF<sup>®</sup>

DPF<sup>®</sup> stands for diesel particulate filter. DPF<sup>®</sup> is a registered trademark of the German company HJS Fahrzeugtechnik.

## EPA

The US environmental protection agency, often abbreviated to EPA or also US EPA is an organisation of the US government dedicated to environmental protection and protection against risks to human health. It develops and enforces implementation of the environmental protection regulations.

## Fine particulates

Airborne contaminant particles with an aerodynamic diameter of fewer than 10  $\mu\text{m}$  (PM<sub>10</sub>).

## NO<sub>x</sub>

Nitrogen oxide (NO<sub>x</sub>) is generated in combustion processes with high temperatures, for example in vehicles, power stations and industry. Nitrogen oxide is dangerous to human health. A special aspect of nitrogen oxide in connection with modern engine technology is the conflict between reduced consumption and reduction of NO<sub>x</sub> emissions. Efficient engines have a high combustion temperature and therefore produce more NO<sub>x</sub>.

## Off-highway

Off-highway refers to the use of systems in vehicles not registered to drive on roads (e.g. construction machines, forklifts, special vehicles).

## Particles

Since the US introduced limits for particle emissions in 1972, particles are defined by the method of measurement. According to the measurement technique defined by the US EPA and EU directive 88/77/EEC, particles are solid and gaseous exhaust components which can be separated from exhaust gas diluted with filtered ambient air using a test filter at a defined maximum temperature of 51.7 °C.

## PM<sub>10</sub>

Particles that pass a size-selecting air inlet with an aerodynamic diameter of 10  $\mu\text{m}$  are characterised by a separation efficiency of at least 50%. Similarly, "particulate matter" = fine dust or aerosols.

## Retrofit

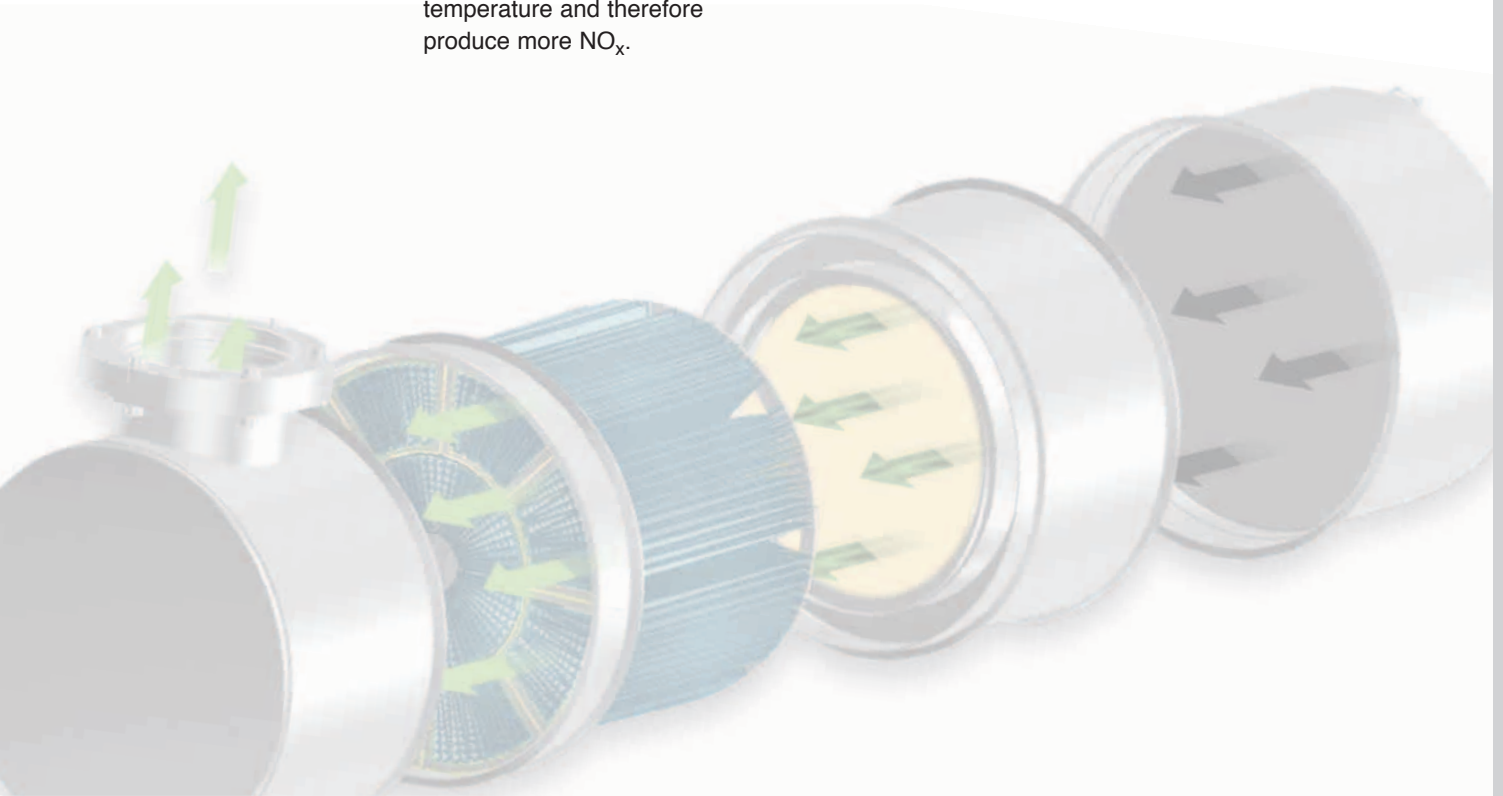
Exhaust gas cleaning system fitted after the system with the diesel engine has been delivered (e.g. bus, construction machine) to the customer.

## SMF<sup>®</sup>-AR

SMF<sup>®</sup> with active regeneration, whereby active regeneration currently refers to so-called "thermoelectric regeneration". This is a regeneration process specially developed for the SMF<sup>®</sup> which uses a heating unit, an additive dosing system and a customised electronic control unit (ECU).

## VERT

VERT stands for the reduction of emissions from machines used in tunnel construction. VERT is a project conducted by the Swiss institute for accident protection (SUVA), the Munich civil engineering association (TBG), the Austrian general accident insurance institute (AUVA) and the Swiss federal office for the environment, forest and countryside (BUWAL).





## MANN+HUMMEL Industrial Filters

The MANN+HUMMEL Group is an international company with its headquarters in Ludwigsburg, Germany. The group employs approx. 9,500 people worldwide at more than 40 locations.

The company develops, produces and sells technically complex components for the

automotive industry and many other fields. A key area is high quality filtration products for vehicles, engines and industrial applications. The OEM business with global market leaders and producers of vehicles, machines and installations defines the quality and performance of the group. Filters for the

international aftermarket are sold under numerous international brands as well as under the MANN-FILTER brand.

The Industrial Filters Business Unit with its headquarters in Speyer, Germany is specialised in meeting the requirements of off-highway vehicle

and - engine applications, compressed air and vacuum technology, mechanical engineering and plant construction. For these and other industrial fields MANN+HUMMEL Industrial Filters offer high performance products for the filtration and separation of air, gases and liquids.



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