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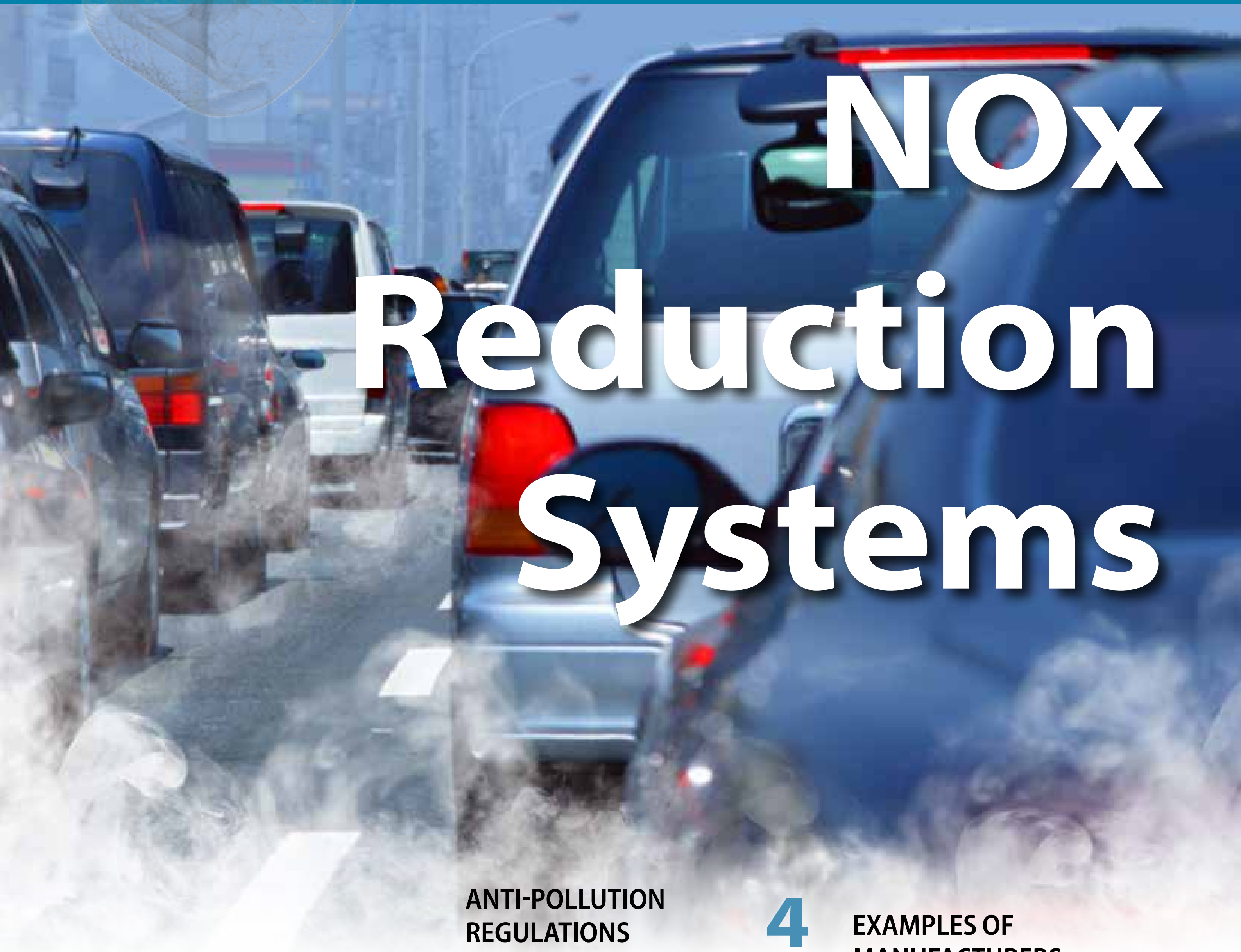
Eure!TechFLASH

THE UP-TO-DATE TECHNICAL INSIGHT IN AUTOMOTIVE TECHNOLOGY & INNOVATIONS

EDITION 16



NOx Reduction Systems

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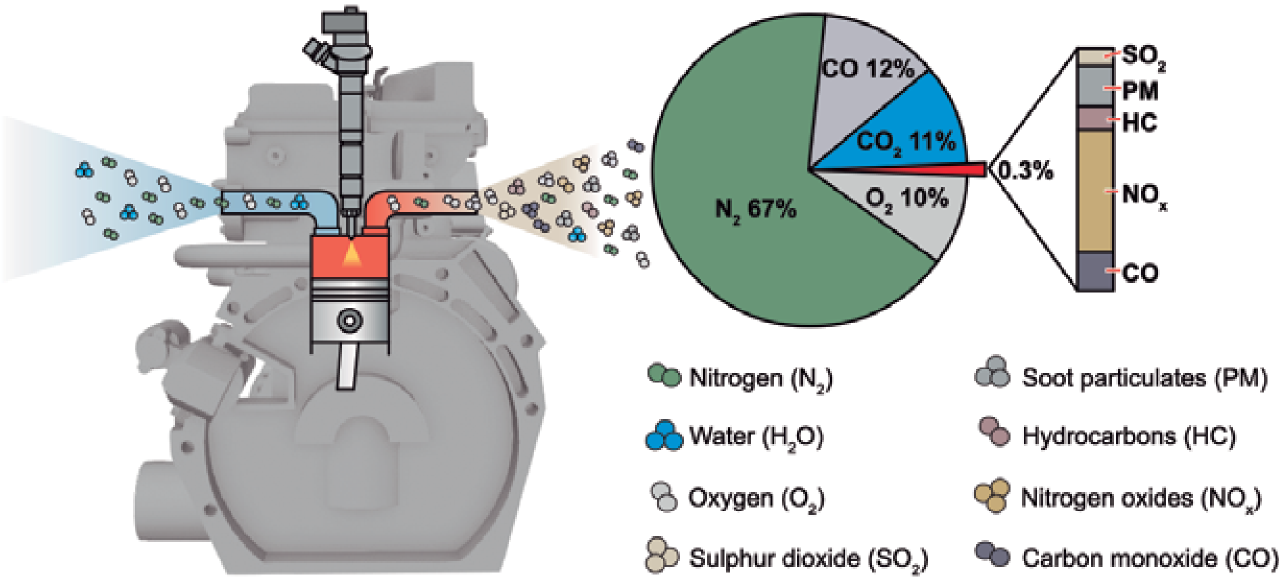
INTRODUCTION

One of the substances produced by combustion engines that is most harmful to people and the environment are the **nitrogen oxides and their derivatives**. According to the maximum environmental pollution levels established for cities, nitrogen dioxide, NO2, must not exceed 200 mg/m3.

In reality, these levels can often triple in adverse weather conditions, which is a serious threat to public health. Nitrogen oxides are mainly produced during combustion in the diesel engine at low engine speeds when the amount of diesel injected is small. As the engine works with unrestricted aspirated air, under these conditions the air/fuel mix is lean, so there is a large amount of air that does not participate directly in combustion. As the air mainly consists of nitrogen (78%) and oxygen (21%), the remainder of these elements that have not been involved in the combustion react due to the high temperatures in the combustion chamber. They pollute the air by forming nitrogen oxides (NOx), which cause serious problems relating to pollution in large cities.

Consequently, car manufacturers have developed different solutions for reducing, converting and controlling nitrogen oxide emissions. One of these solutions is the use of the AdBlue agent, which reduces emissions by converting the nitrogen oxides.

AdBlue is a registered brand under which the product technically called AUS32 (Aqueous Urea Solution, a 32.5% urea solution) is marketed. Its purpose is to reduce the nitrogen oxide (NOx) emissions from diesel engines. For this, a process is applied called SCR (Selective Catalytic Reduction). This process is carried out in a catalytic converter that is specifically for the storage and reduction of the NOx.

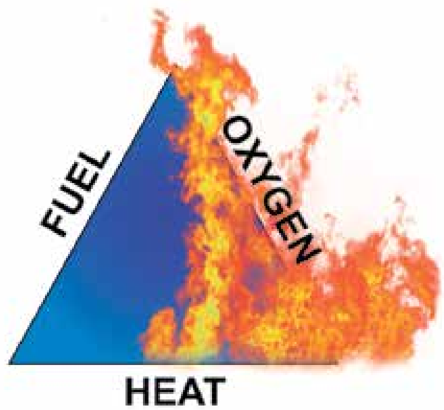


COMBUSTION AND EXHAUST GAS

Combustion

Combustion is a continuous chemical reaction in which a combustible element, in this case diesel oil, reacts and combines with an oxidising agent (oxygen). During the rapid combination of the fuel with the oxygen, heat and light energy is released, and an oxide is produced at the same time. Combustion is an exothermic reaction because heat is generated during the process. The most frequent types of fuel are organic, which contain carbon and hydrogen.

In a diesel engine, ideal combustion occurs when all the fuel reacts with the oxygen giving as the only resulting products: nitrogen (N2), carbon dioxide (CO2) and water (H2O). This means that the fuel has been fully oxidised, i.e. it has been completely burnt. However, in reality, due to the inherent characteristics of the nature of combustion, and the fact that dur-



ing combustion there is a continuous variation of the air/fuel mix ratio, ideal combustion does not occur in practice.

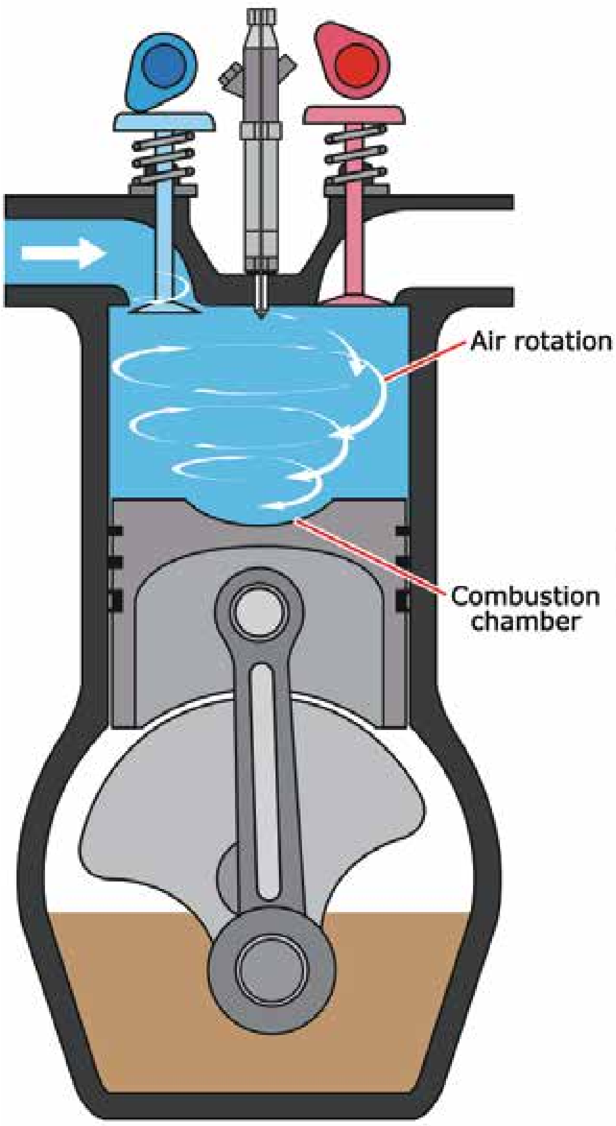
Actual combustion (incomplete), results in, in addition to O_2, N_2, CO_2 and H_2O, several toxic sub-products, such as: partially oxidised carbon PM (soot), carbon monoxide CO, unburnt hydrocarbons HC, nitrogen oxides NOx resulting from the oxidisation of nitrogen, and sulphur dioxide SO_2 as a sub-product of partial combustion of sulphur contained in the diesel fuel.

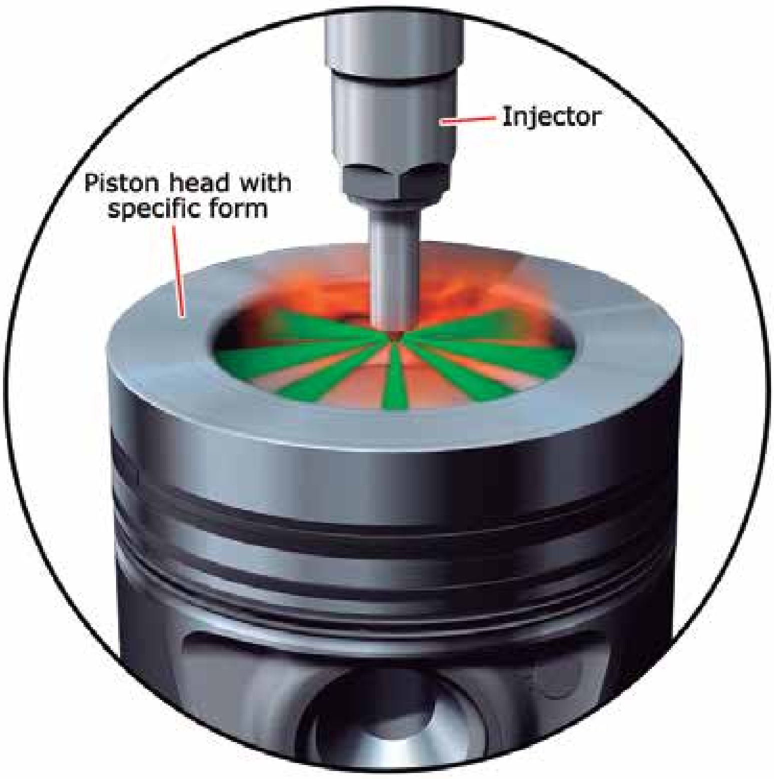
Diesel engine manufacturers have studied and worked hard on the design of each component that participates directly in combustion (inside the engine), with the aim of achieving combustion as close as possible to the ideal. The mechanical components and processes that have been most studied and optimised are: the combustion chambers, the valves, the pistons, the intake and exhaust manifolds, the exhaust gas recirculation systems, the preheating systems, the injectors and the injection process. The result of this work has led to the improvement of the factors that most influence the development of combustion:

- **Fuel metering:** The better the atomisation of the fuel, the better the combustion. This is because the fuel particles will be smaller and there will be a larger contact surface area between them and the oxidising agent (oxygen). For this, the injection pumps have been made more powerful and are capable of supplying more than 2000 bar of pressure. The injectors have also been improved by increasing the number of injection holes and redesigning the orientation of the injection jets, the number of injections, and the precision of the injection times and duration. This is possible thanks to the speed of calculation of the electronic injection management systems and the evolution of the component machining systems.

- **Residence time:** This is the time that the air-fuel mixture remains in the combustion chamber machined on the head of each piston. During this time, the mixture must be oxidised as much as possible. This is directly related to the temperature of the combustion chamber, compression ratio and the geometry of the combustion chambers.

- **Swirl:** This is one of the determining factors in producing good combustion. The speed of entry of the air into the combustion chamber and its movement in the shape of the swirl are decisive for achieving good homogenisation of the air and the fuel. This ensures that a maximum number of fuel droplets are surrounded by fresh air. Manufacturers attempt to improve the swirl through the design of the valves and the intake ducts.





Exhaust gas

In spite of all the measures adapted by the manufacturers to improve the influencing factors and the combustion conditions by redesigning the aforementioned components, the truth is that the development of **actual combustion** is still a long way from **ideal complete combustion**.

There are numerous influencing variables that are virtually impossible to control: variation of the working temperature, variation of the engine speed, the quality of the diesel, the variation of the injection flow rate according to the torque demand, etc. Consequently, the engine produces noxious exhaust gas that depends on its operating conditions:

Engine emissions at low acceleration and low loads

Under these conditions, there is a large amount of air (O2 and N2) and little diesel. Consequently, there is excess oxygen (O2) and a large amount of nitrogen N2. The peak combustion temperature causes these elements to react and form nitrogen oxides NOx. As there is little diesel, only a small amount of CO and unburnt hydrocarbons (HC) are produced.

Engine emissions at high rpm and high loads

To accelerate, the injected fuel is increased in the diesel engine, more heat is released which creates more pressure, and this pushes the piston with more force. There is a higher proportion of diesel with respect to the air that enters the cylinder (N and O2). During combustion, nearly all the oxygen (O2) is consumed which generates more carbon monoxide (CO) and unburnt hydrocarbons (HC) and less nitrogen oxides (NOx), because there is hardly any oxygen (O2) left over from combustion.

The large amount of fuel and the short time available for combustion when the engine load and speed are high leads to the formation of solid particulates. The solid particulates are formed by the fuel that has not initiated oxidation. The hydrogen from the hydrocarbons is disassociated from the carbon and is combined with the oxygen of the air to form water (H2O). The carbon clusters together with the water to form conglomerates that, due to their size, are solid. A smaller proportion are visible particulates (10 – 20 %) and the rest are invisible to the human eye.

The fact that the proportion of polluting gases is different at high and low engine speeds and, at the same time, different at high and low load, means that the diesel engine requires specific anti-pollution supplements for each situation, which makes the purification technology for the exhaust gas more complex.

The performance increase of diesel engines over recent years has influenced the composition of the exhaust gas. The higher pressure and temperature during combustion means higher production of NOx.

The NOx are produced due to combustion with a lean fuel and excess oxygen mix under high pressure and temperature conditions. They are toxic and very radioactive gases whose concentration is limited to a maximum of **200 mg/m3**.

They are some of the gases that cause acid rain. Moreover, they produce what is called "**photochemical smog**" in large cities. This is a **brown haze** that has different effects on people: irritation of the respiratory system and eyes after short exposures. And in the case of prolonged exposures it causes chronic respiratory, cardiovascular and cerebrovascular diseases.

ANTI-POLLUTION REGULATIONS

The European legislation on polluting emissions is a set of standards that regulates the acceptable limits for gas emissions emitted by internal combustion engines. All new vehicles sold in the Member States of the European Union must comply with these standards. The emissions standards are defined in a series of directives that the European Union is implementing progressively and the restrictions of which are increasingly severe due to the incessant increase of environmental pollution.

In 2001, the European Commission launched the CAFE (Clean Air For Europe) programme. One of its conclusions was the need to reduce the emissions of the transport sector, as part of a global strategy to improve air quality. In this regard, the European Community has been issuing, by way of directives, various orders to its member countries to meet certain commitments as regards polluting emissions. These directives have been called EURO I, EURO II, EURO III, EURO IV, EURO V and EURO VI; each one more restrictive than the last.

Compliance with regulations is determined by monitoring the operation of the engine during a standardised test cycle prior to its marketing. Emissions of nitrogen oxides (NOx), hydrocarbons (HC), carbon monoxide (CO) and soot particles (PM), are regulated for most vehicles and different standards are applied depending on their characteristics.

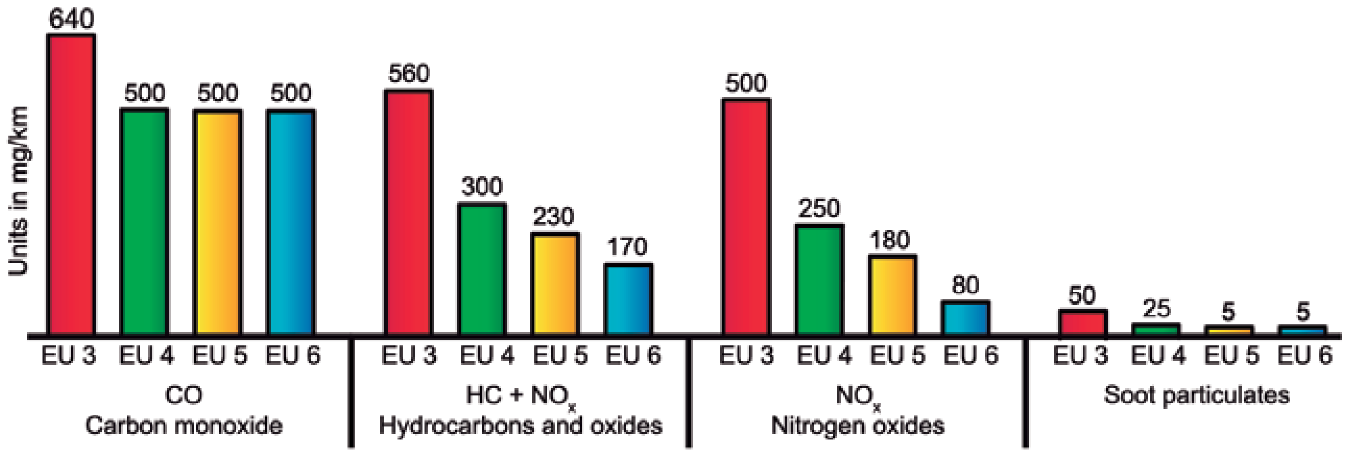
The maximum permissible amount of sub-products existing in the emissions of gases from passenger vehicles is summarised in the following tables according to the type of gas emitted, the date of entry into force of the regulation and the corresponding restriction level, and depending on whether the engine is petrol or diesel. They are expressed in grams per km:

DIESEL						
Type	**Date**	**CO**	**HC**	**HC + NOx**	**NOx**	**PM**
Euro 1	July 1992	2.72	-	0.97	-	0.14
Euro 2	January 1996	1	-	0.7 (*) – 0.9 (**)	-	0.08 (*) – 0.10 (**)
Euro 3	January 2000	0.64	-	0.56	0.50	0.050
Euro 4	January 2005	0.50	-	0.30	0.23	0.025
Euro 5	September 2009	0.50	-	0.23	0.18	0.005
Euro 6	September 2014	0.50	-	0.17	0.08	0.0045

*** Indirect injection engine** **** Direct injection engine**

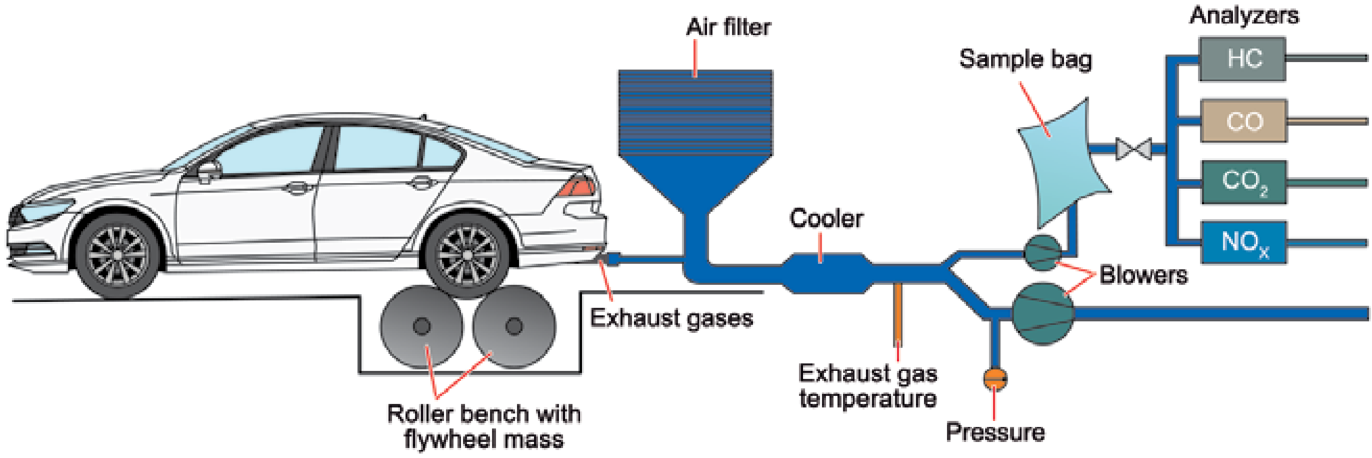
PETROL						
Type	**Date**	**CO**	**HC**	**HC + NOx**	**NOx**	**PM**
Euro 1	July 1992	2.72	-	0.97	-	-
Euro 2	January 1996	2.2	-	0.5	-	-
Euro 3	January 2000	2.3	0.2	-	0.15	-
Euro 4	January 2005	1	0.1	-	0.08	-
Euro 5	September 2009	1	0.1	-	0.06	0.005
Euro 6	September 2014	1	0.1	-	0.06	0.0045

The graphic shows the progressive reduction according to the type of gas emitted and the applicable Euro directive.



To simulate the emissions of a vehicle on the road, a roller test bench is used where it is attempted to reproduce real driving conditions.

By means of this test, measurements are obtained that are representative of the polluting elements. For this, a driving cycle has been established that simulates the normal conditions of vehicle use.



Various petrol and diesel engine gas analysers are available from different manufacturers which are used for analysing exhaust gas emissions.

The most common analysers for **petrol engine**s are capable of analysing **four or five gases**. Connecting a sensor at the rear silencer outlet allows emissions tests to be carried out and to check that the values for the polluting substances are correct.

Also, for **diesel engine**s an **opacity analyser**, called an **opacimeter**, is used.

MEASURES FOR THE REDUCTION OF POLLUTING EMISSIONS

Based on the information that has been explained up until now, we can sum up by saying that manufacturers are implementing two types of measures for reducing polluting gases. These can be classified into external- and internal-engine measures.

External-engine measures

These are the technical modifications and additions that are applied to elements external to the engine. The most important are described below:

Oxidation catalytic converter

Its main function is to oxidise the carbon monoxide (CO) and convert it into carbon dioxide (CO2) and the unburnt hydrocarbons (HC) into carbon dioxide (CO2) and water (H2O). For this reason, they are called **"two-way"** (CO + HC). There are also **"three-way"** oxidation catalytic converters (mainly fitted to petrol engines) which, in addition to converting the CO and HCs, also convert the nitrogen oxides (NOx) into oxygen and nitrogen. However, **only two-way catalytic converters are used for diesel engines** as these engines work with excess air and, therefore, emit exhaust gas with a high concentration of oxygen (O2) that prevents the reduction of the nitrogen oxides to nitrogen (N2) and oxygen (O2).

Consequently, to reduce the NOx in diesel engines, manufacturers have developed **a special catalytic converter called SCR which stores and converts the nitrogen oxides**.

Diesel Particulate Filter (DPF)

The purpose of this filter is to r**etain the soot particles** (solids) in the exhaust gas produced by diesel engines. When the volume of particulates is sufficiently high, they are removed by burning the soot in the filter itself by means of regeneration cycles. Some manufacturers use **additives** to raise the particulate filter to the necessary temperature (+450ºC) in order to oxidise the particulates so that they convert into CO2 (gas).

Another solution is to locate the particulate filter next to the oxidisation catalytic converter immediately behind the exhaust manifold and the turbocharger turbine. This makes the use of additives unnecessary as the required temperature for burning the soot particles is achieved due to proximity to the combustion chambers. On the other hand, an excessive temperature in the exhaust and the combustion chamber **increases the formation of NOx.**

Internal-engine measures

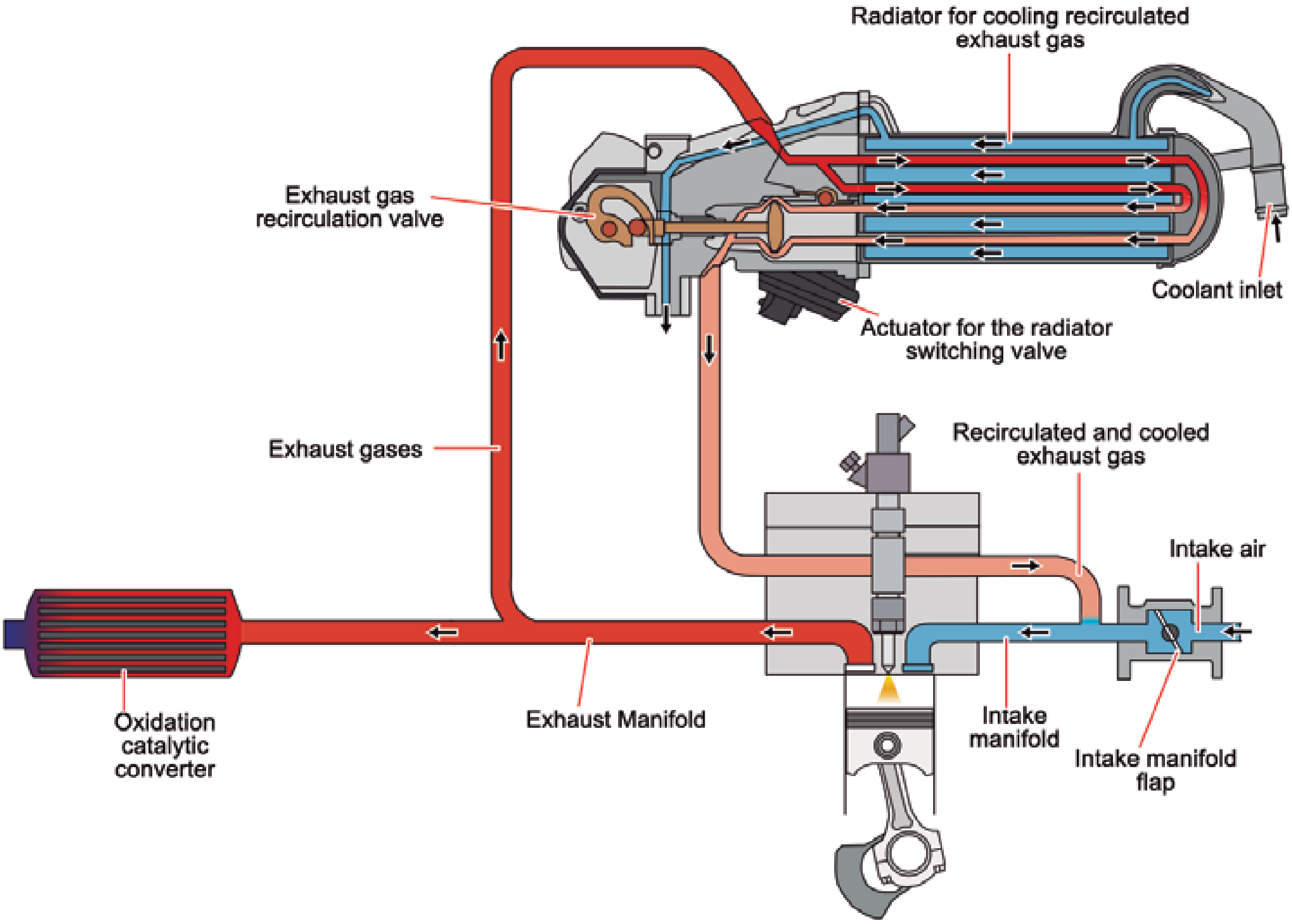
These are the technical modifications and additions that are applied to the internal elements of the engine intended to prevent the production of pollutants. The most important in diesel engines are:

Exhaust gas recirculation EGR

The main purpose of this system is to reduce the effective volume of air filling the cylinders, reducing the amount of excess oxygen in combustion, and to reduce the peak temperature during combustion. This **contributes to reducing the formation of nitrogen oxides (NOx)** to a large extent, but only when the engine load is low.

To improve the performance of the exhaust gas recirculation system, a **heat exchanger** is added to reduce the gas temperature. The cooled gases absorb more heat during combustion, therefore, they reduce the maximum combustion temperature.

However, this recirculation system has some **disadvantages**. Increasing the rate of recirculated exhaust gas reduces the amount of exhaust gas that reaches the turbocharger turbine, which worsens its response. This means that the boost pressure will be lower than that required for the engine to respond adequately. Furthermore, the dirty exhaust gas is allowed to directly access the intake manifold inlet, which causes an accumulation of soot in the intake system.



High and low-pressure exhaust gas recirculation

To meet the Euro 6 emissions standards, some manufacturers have opted to incorporate a more comprehensive exhaust gas recirculation system in their vehicles, which can function by combining the recirculation of the gas in two different ways:

High-pressure exhaust gas recirculation

In this mode, the gas from the exhaust manifold is redirected to the intake manifold by means of an external duct, in a similar way to conventional recirculation systems. The difference here is that an exhaust gas cooler is not required, because when its temperature is too high, the low-pressure exhaust gas recirculation mode is used. A valve actuated by a servomotor and monitored by sensors is responsible for controlling the flow of the high-pressure exhaust gas according to the engine working conditions (in some cases this valve is cooled by means of a coolant).

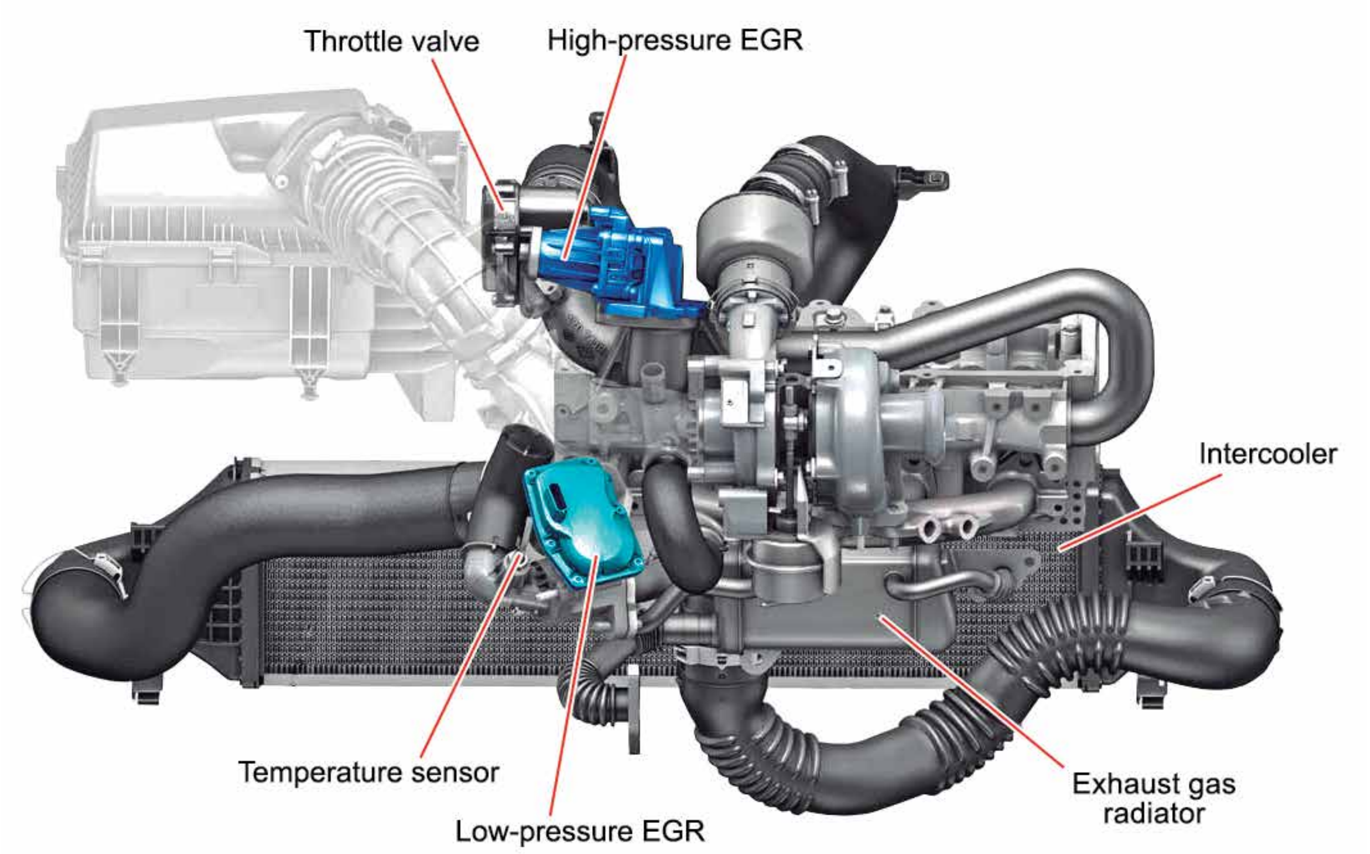
This mode is principally applied when the exhaust gas temperature is not very high and the motor is idling or working at low load.

Low-pressure exhaust gas recirculation

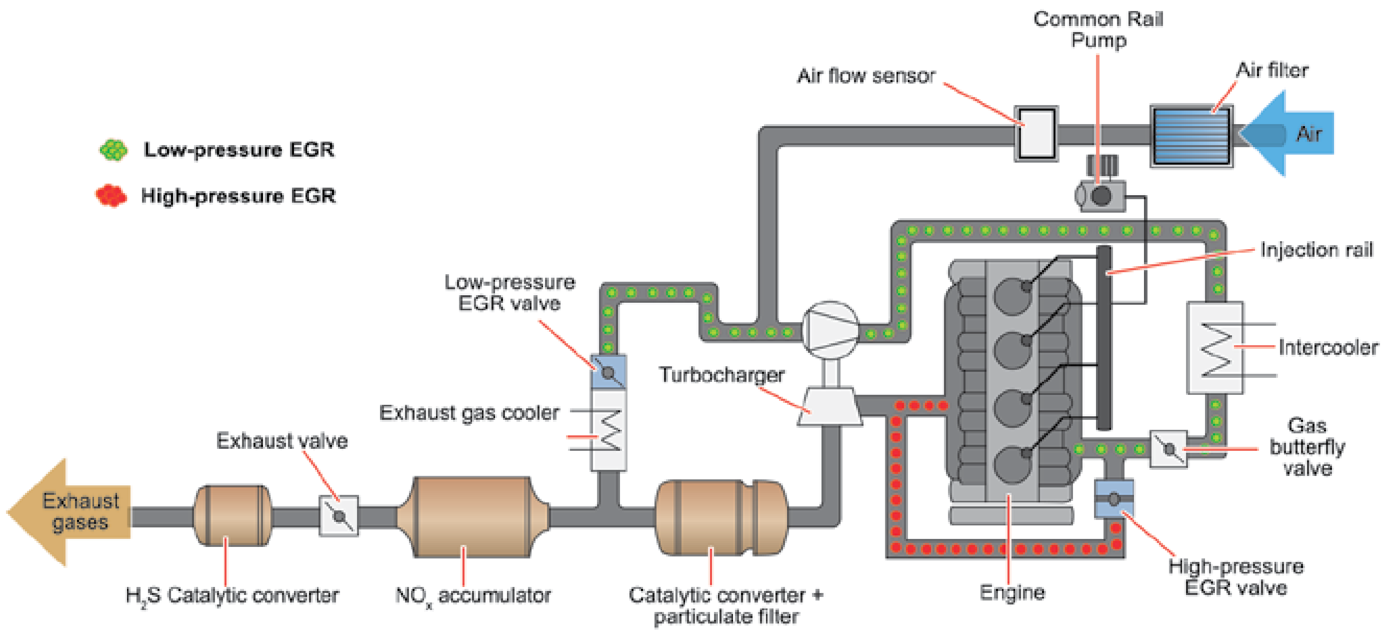
In this mode, the gas from the particulate filter is redirected externally to the turbocharger intake area. For this, first it crosses a heat exchanger cooled by coolant and located at the outlet of the DPF. Then, a valve actuated by a servomotor and monitored by means of sensors is responsible for regulating the intake of low-pressure exhaust gas according to the engine working conditions. The decarbonised and reduced oxygen content exhaust gas is redirected to the suction side of the turbocharger to be mixed with the intake air and returned to be cooled in the intercooler (which sometimes uses coolant to reduce the temperature of the gas). Finally, a butterfly valve control unit regulates the overall air plus exhaust gas flow entering the intake manifold.

Benefits:

- The exhaust gas is free of solid particulates and is recirculated at a lower temperature.
- It does not reduce the flow of exhaust gas into the turbo, so that the engine responds better in situations of high recirculated exhaust gas flow and high boost pressures.
- The exhaust gas redirected to the turbocharger contributes to maintaining its speed during changes of engine load and it contains less oxygen, which has been combined in the catalytic converter.



The engine control unit decides to combine the exhaust gas recirculation mode based on signals received for the engine speed, torque demand, the temperature and pressure of the exhaust gas in the purification module and information from the oxygen sensors. This **reduces the excess oxygen from combustion and lowers the temperature of the combustion** chambers over a wider engine operating range in comparison with conventional EGR systems. Consequently, exhaust gas recirculation is not only possible under low load or idling engine working conditions, but also at medium loads at medium and high speeds.

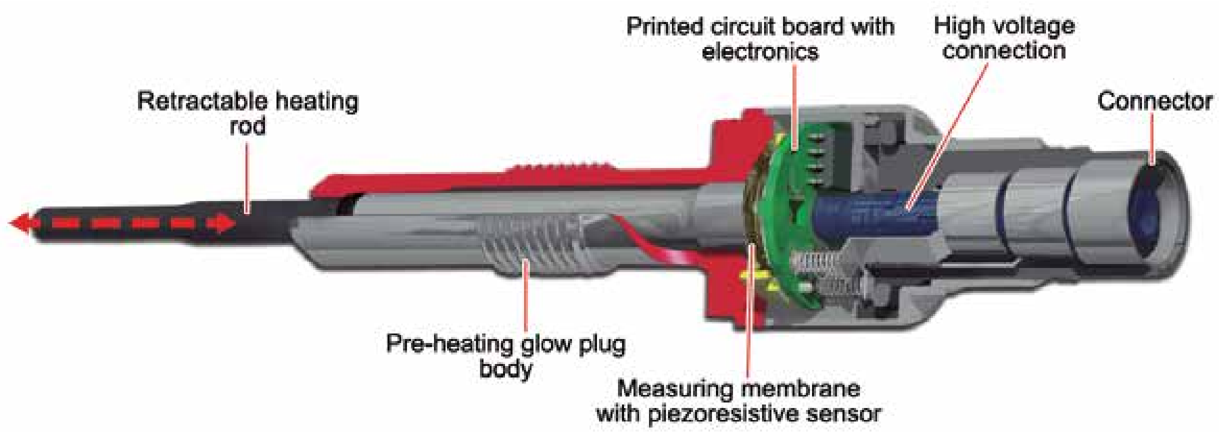


In short, this complex exhaust gas recirculation system reduces nitrogen oxides (NOx) to a great extent as it quantitatively reduces the amount of air (N2 + O2) taken in by the engine.

Pre-heating glow plugs with pressure sensor

These components are fitted in the combustion chamber of diesel engines to facilitate cold starting. The pre-heating glow plugs with pressure sensor, in addition to heating the combustion chamber, also add the capacity to measure the prevailing pressure in that chamber to prevent the formation of polluting emissions.

The heater function is achieved with a resistor that allows a high power flow when it is cold and rapid heating is required.
The mechanical structure of this glow plug is characterised by the incorporation of a retractable heating rod. One end of this rod or electrode is exposed to the combustion chamber and it retracts according to the pressure within the cylinder. On the other end of the rod, the internal part of the top heater, a piezoresistive type sensor detects the pressure value in the combustion chamber in real-time through the deformation of a measuring membrane that receives the movement of the rod.



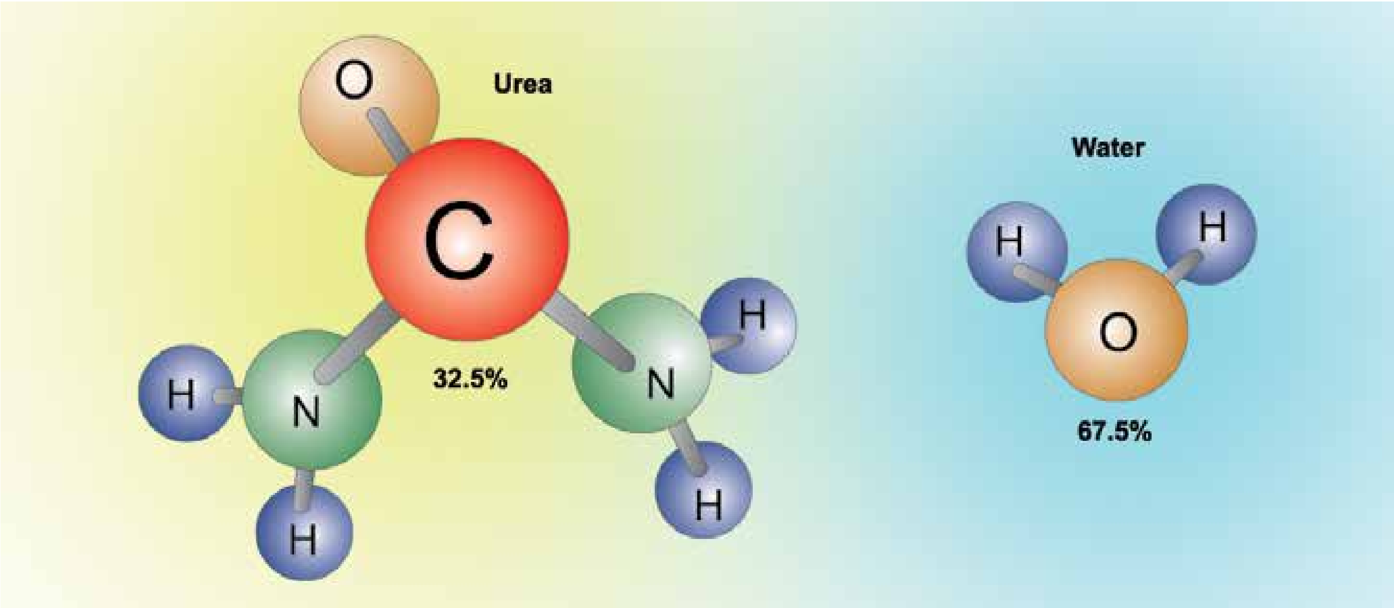
After filtering, the information obtained from this sensor is transmitted to the engine control unit, which then adapts the injection flow and advance throughout the engine rpm range. This optimises the combustion process to prevent the formation of **particulates and nitrogen oxides** in the exhaust gas, thus extending the regeneration period of the particulate filter.

SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEMS

To further reduce the **nitrogen oxides (NOx)** in diesel engine exhaust gas, they are converted into innocuous substances. For this, a **catalytic converte**r is used that has been designed **solely for reducing** the **NOx. SCR** stands for **Selective Catalytic Reduction**. The SCR catalytic converter converts the nitrogen oxides from the exhaust gas into nitrogen (N2) and water (H2O). To achieve this, a **reducing agent** is introduced into the exhaust gas flow upstream of the reduction catalytic converter. The reducing agent that is used is a **urea aqueous solution** which, during the combination process with the nitrogen oxides, will be converted into ammonia (NH3). It adds carbon, nitrogen, hydrogen and oxygen to the exhaust gas.

AdBlue reducing agent

This is a reducing agent made up of a solution of 32.5% u**rea, CO (NH2)2, diluted in water, H2O, called AUS32** (Aqueous Urea Solution 32.5%). During the reduction process in the catalytic converter, the urea is converted into CO2 and ammonia NH3. This is the compound that will actually convert the NOx into N2 and H2O. The reason for using water diluted urea is to have a safer agent for handling, as ammonia is an irritant to the skin and mucous membranes. In this way, AdBlue is able to comply with standards DIN70070 and ISO 22241.



Principal properties of the AdBlue agent

- It freezes at -11 ºC or below.
- It decomposes at a temperature between 70 ºC and 80 ºC, producing ammonia, which causes olfactory discomfort.
- It can break down in the presence of impurities and bacteria.
- Electrical connectors must be protected, as it is very corrosive.
- If it is spilt, the urea content may crystallise and produce white marks on the surface where it has been spilt.

Instructions for the use and handling of the AdBlue agent

- Only use reducing agent that comes in packaging that complies with regulations.
- Do not inhale or ingest reducing agent.
- If it has been taken out of the tank, do not reuse the reducing agent, as it may have decomposed.
- When adding or refilling the reducing agent tank, use containers and adapters that are authorised by the manufacturer.
- If you come into contact with the reducing agent, it is recommended to rinse the affected area immediately with plenty of water, as it can irritate the skin, eyes and air ways.
- In the event that it is spilt, clean with a cloth and plenty of cold water. If the agent has crystallised, clean with a sponge and hot water.

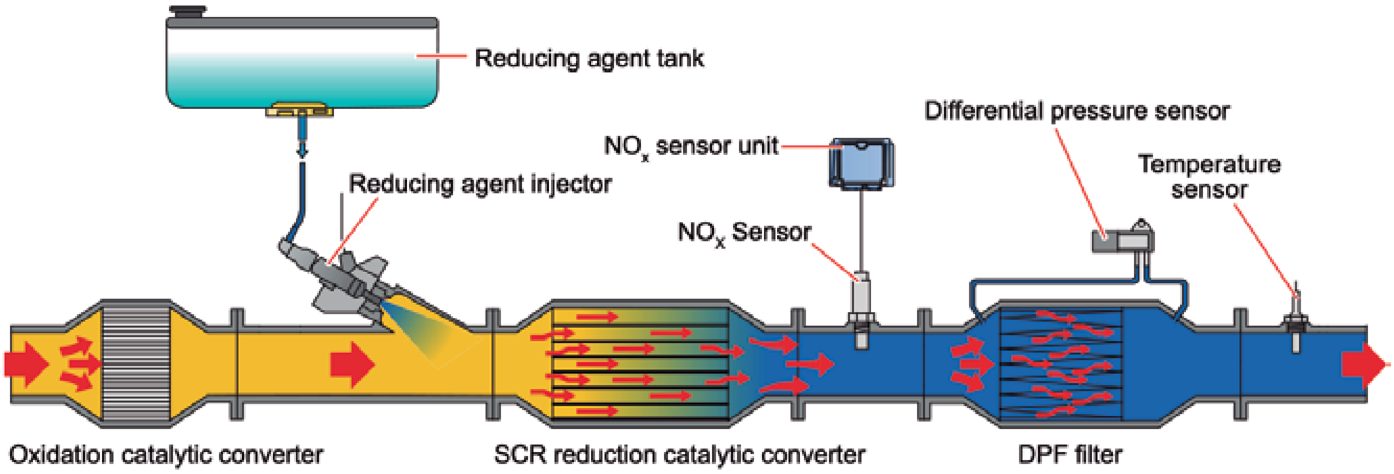
Architecture of the exhaust gas system with SCR catalytic converter

The incorporation of the SCR catalytic converter in the exhaust line has led to manufacturers choosing different combinations when positioning it together with the other exhaust gas purification elements. Consequently, three differential treatment blocks are obtained, whose combination and arrangement may vary:

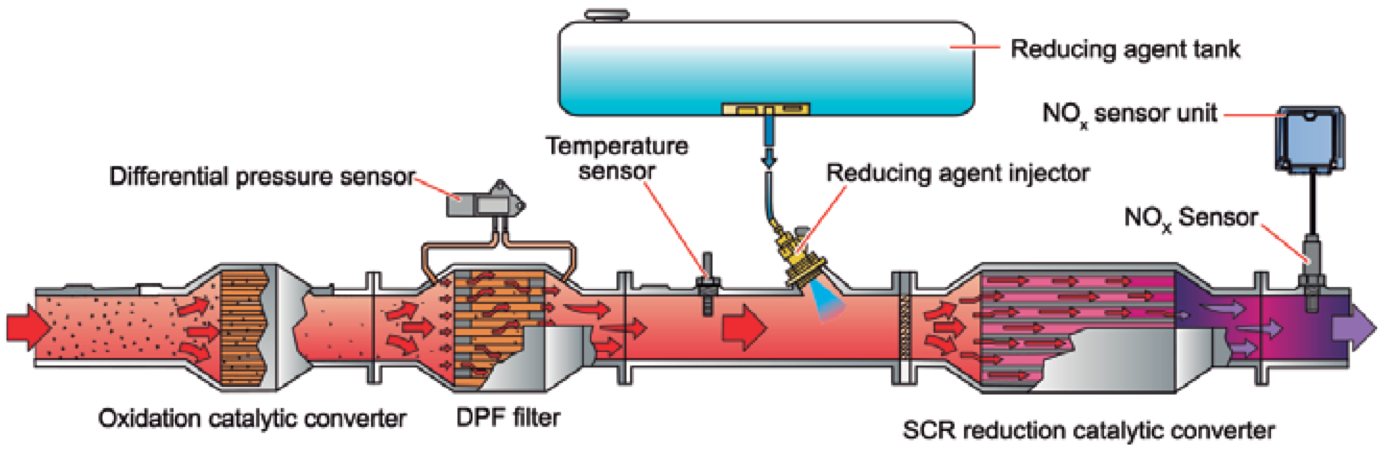
- Oxidation catalytic converter
- Particulate filter
- SCR reduction catalytic converter

When an SCR system is installed to reduce nitrogen oxides, a reduction catalytic converter is incorporated to the exhaust system. Depending on the manufacturer of the vehicle, it may be installed upstream or downstream of the particulate filter.

System with the catalytic converter upstream of the particulate filter



System with the catalytic converter downstream of the particulate filter



SCR system components

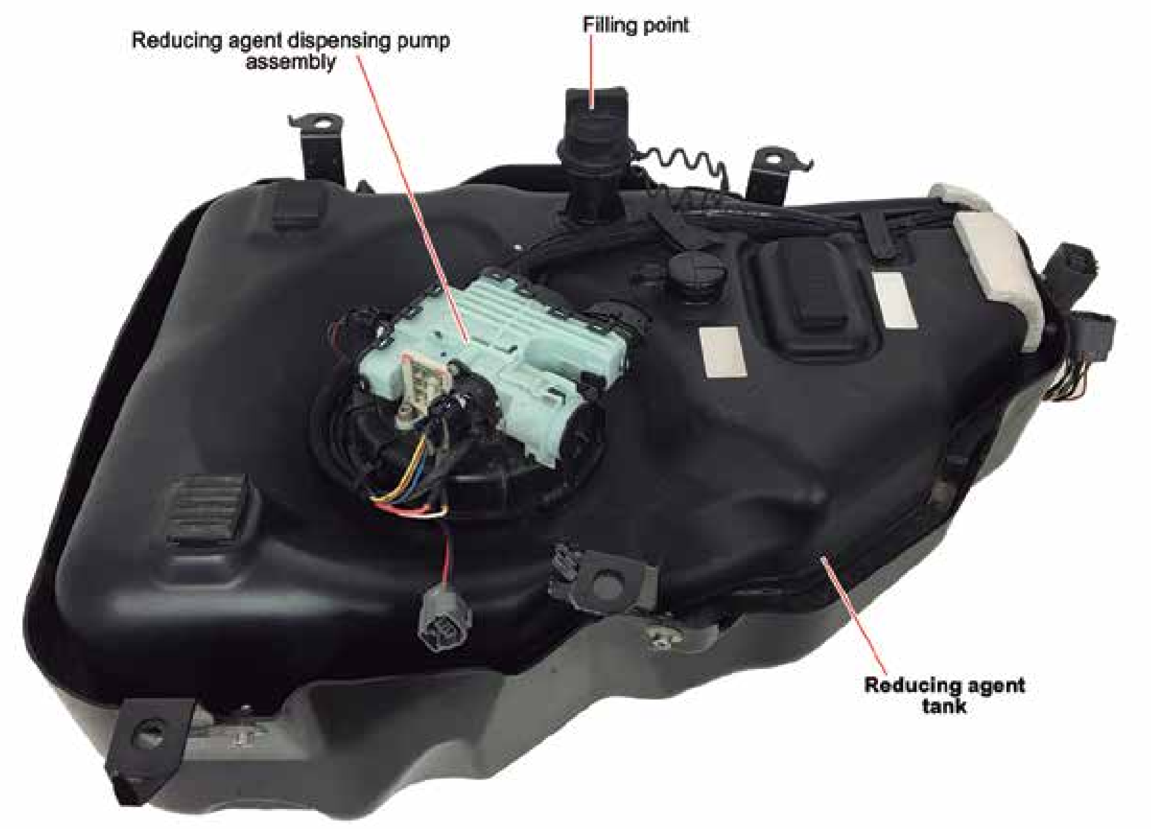
Generally, the SCR system has the following elements:

- Reducing agent tank
- Reducing agent injector
- Hydrolytic section
- Reduction catalytic converter
- NOx sensor
- NOx sensor control unit

Reducing agent tank

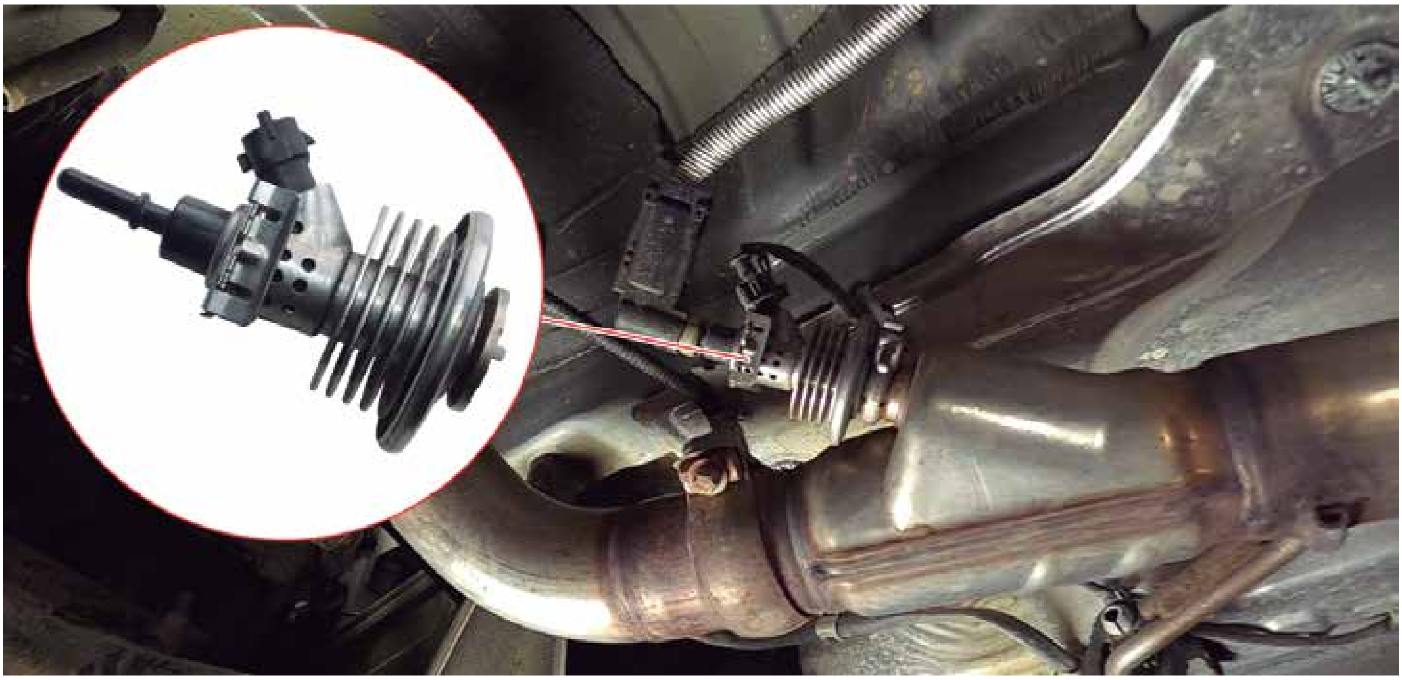
It is usually located at the rear of the vehicle and near the fuel tank. It has an approximate capacity of 17 to 19 litres depending on the manufacturer and the engine cylinder capacity. It is made of a plastic material and has a filler neck. If necessary, it is possible to add reducing agent using a specific adapter.

Several devices are installed in the tank for heating, for detecting the level of reducing agent, and sometimes a module that incorporates other components of the reducing agent dispensing system.



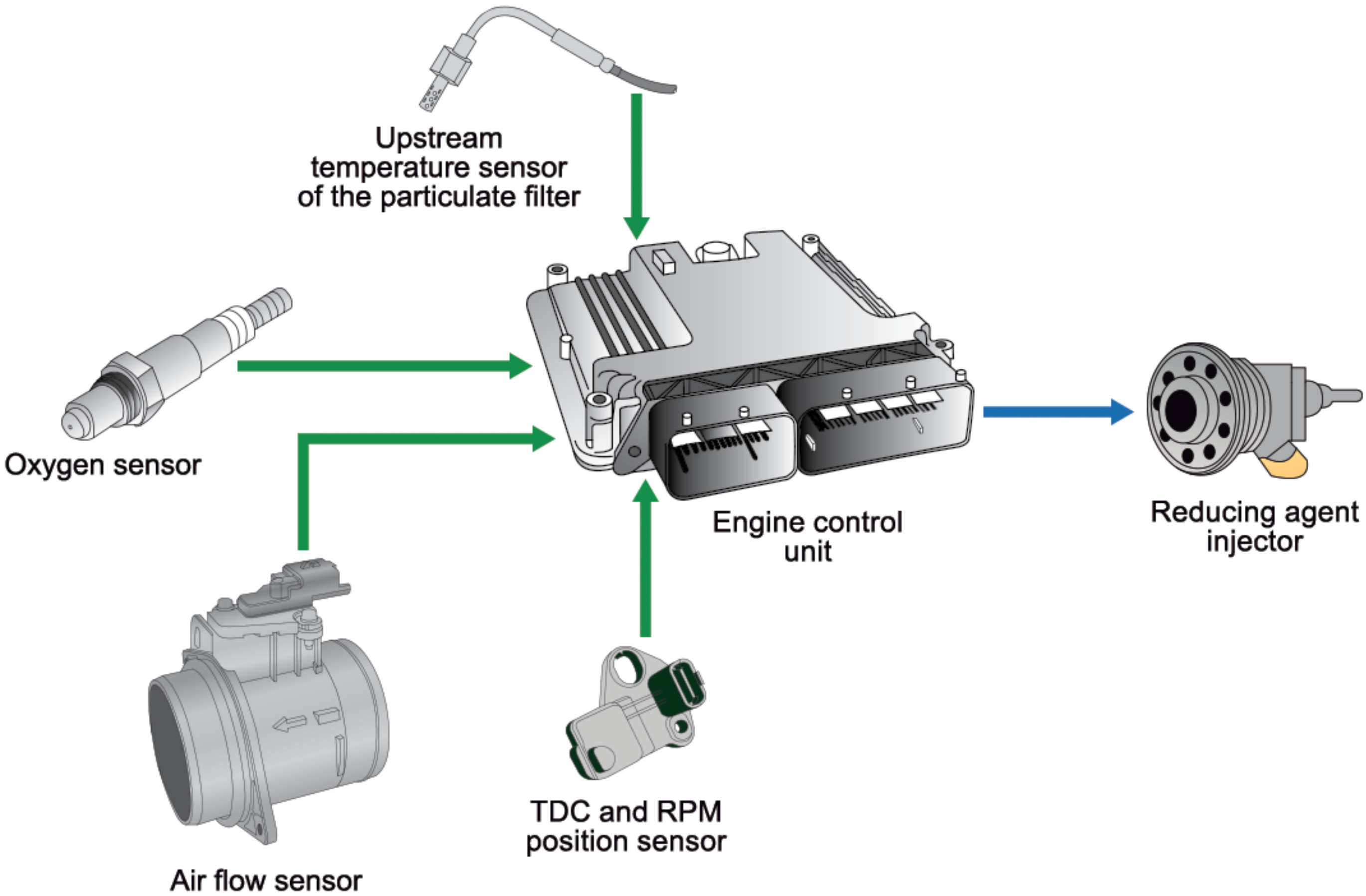
Reducing agent injector

This has the function of injecting the reducing agent into the flow of exhaust gas, upstream of the mixer. To ensure good mixing, it is orientated so that the reducing agent is injected in the same direction as the flow of exhaust gas.



Calculating the quantity of reducing agent to inject

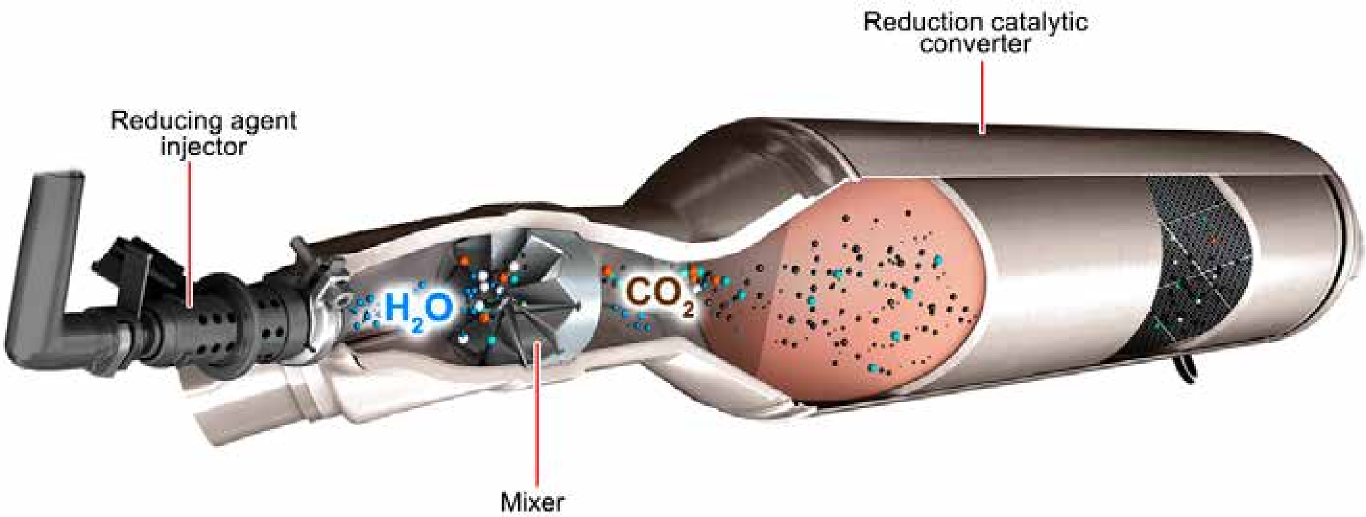
The engine control unit calculates the amount of reducing agent to inject based on three basic functions. These are: the operating status of the engine; the temperature of the exhaust gas; and the concentration of nitrogen oxides downstream of the reduction catalytic converter.



Hydrolytic section

This section of the system is from the reducing agent injector to the reduction catalytic converter. There is a mixer installed in the hydrolytic section. When the reducing agent is injected, the water in the reducing agent evaporates as a result of the heat from the exhaust gas. Thermolysis of the reducing agent occurs, converting it into ammonia and isocyanic acid.

Thermolysis: Reaction where a compound separates from at least two others as a result of an increase in temperature.

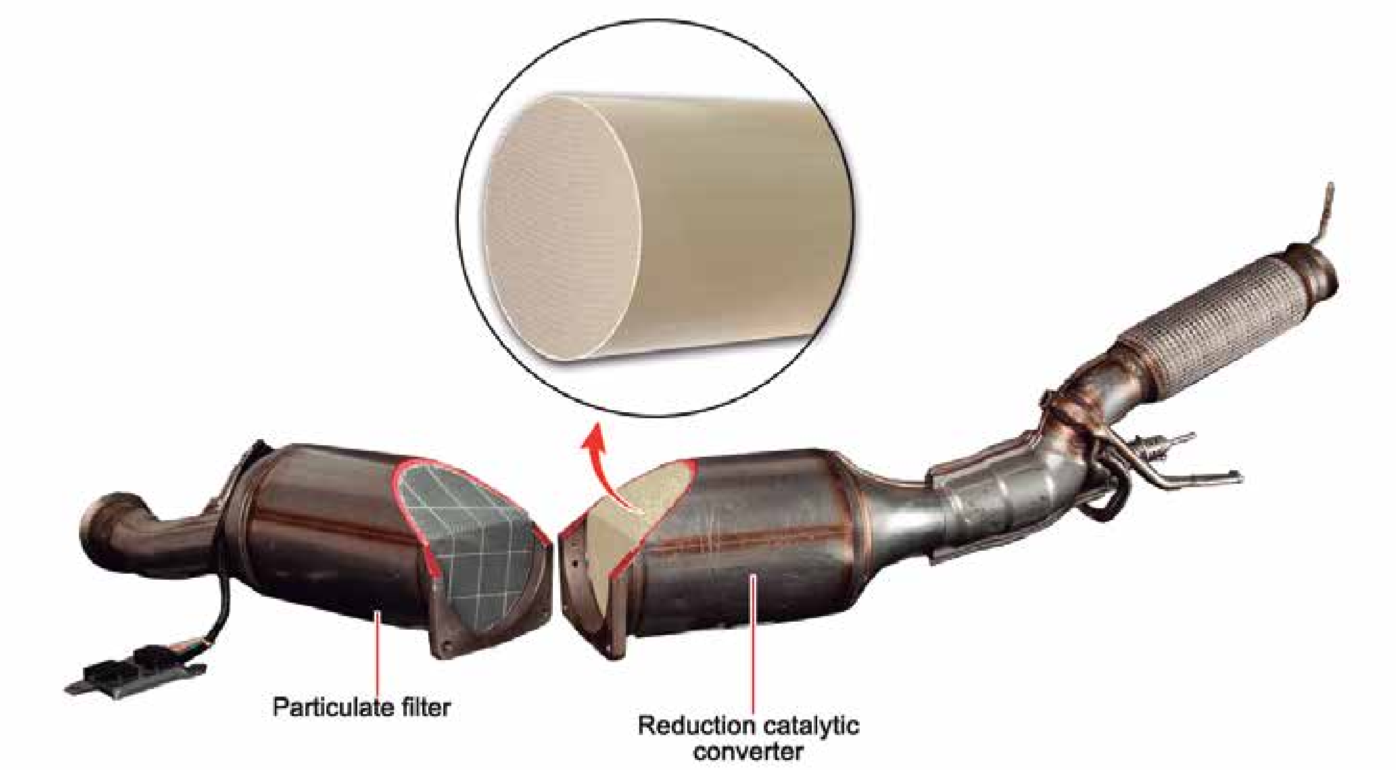


Next, the isocyanic acid undergoes thermal decomposition when it reacts with water. At the end of the hydrolytic section, the reducing agent decomposes and forms carbon dioxide and ammonia. Ammonia is the substance that reacts with the nitrogen oxides in the reduction catalytic converter. CO2 is a non-toxic gas.

Hydrolysis: Chemical reaction between a water molecule and another molecule.

Reduction catalytic converter

This can be located upstream or downstream of the particulate filter. The reduction catalytic converter comes into operation from 200°C. Inside, it has a ceramic body with a coating of copper zeolite that forms a porous structure composed of aluminium, silicon and copper. The exhaust gas and the ammonia that has been formed in the hydrolytic section of the system enter the catalytic converter, where the ammonia reacts with the nitrogen oxides, forming nitrogen and water. This reaction is produced by the copper zeolite coating and, consequently, the gas at the outlet of the reduction catalytic converter is composed of carbon dioxide (CO2), water (H2O), oxygen (O2) and nitrogen (N2) which are all elements naturally present in the atmosphere.



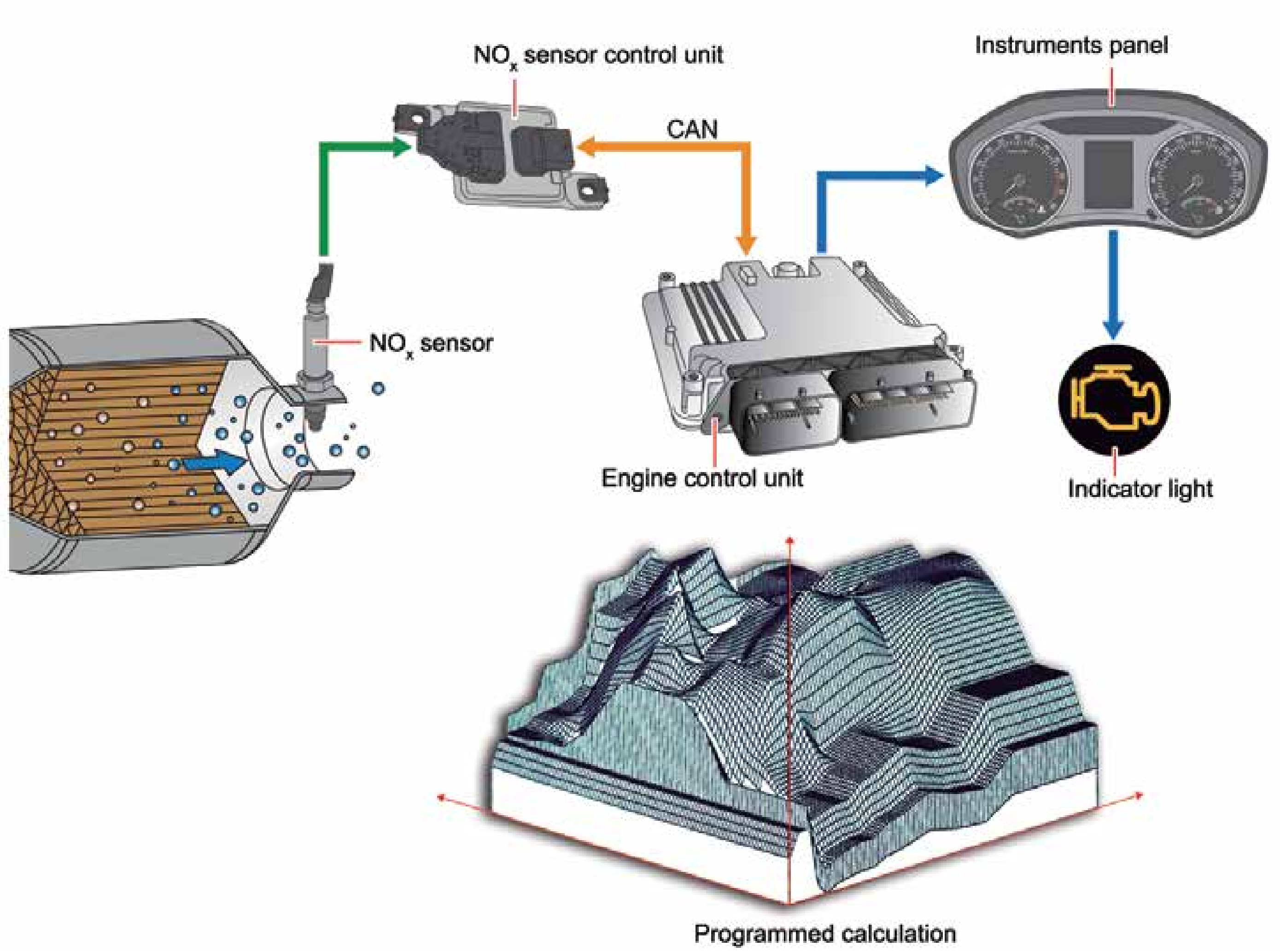
NOx sensor

This is located at the outlet of the reduction catalytic converter. Its function is very similar to that of a broadband oxygen sensor and the electrical current it generates is of the order of microamps. Therefore, it is joined to the NOx sensor control unit, which is nearer to the engine control unit. The length of sensor cable influences the intensity of the signal.

NOx sensor control unit

This unit manages the NOx sensor signal and transmits it to the control unit via the CAN-Bus. The unit can then calculate the performance of the reduction catalytic converter and monitor the operation of the SCR system as another function of the EOBD system, which controls the anti-pollution devices.

The engine control unit compares the average value with the value in the programmed calculation model. If the performance is not as expected by the programmed model, the exhaust emissions indicator warning light is activated.



EXAMPLES OF MANUFACTURERS THAT INCORPORATE THE ADBLUE NOX REDUCTION SYSTEM

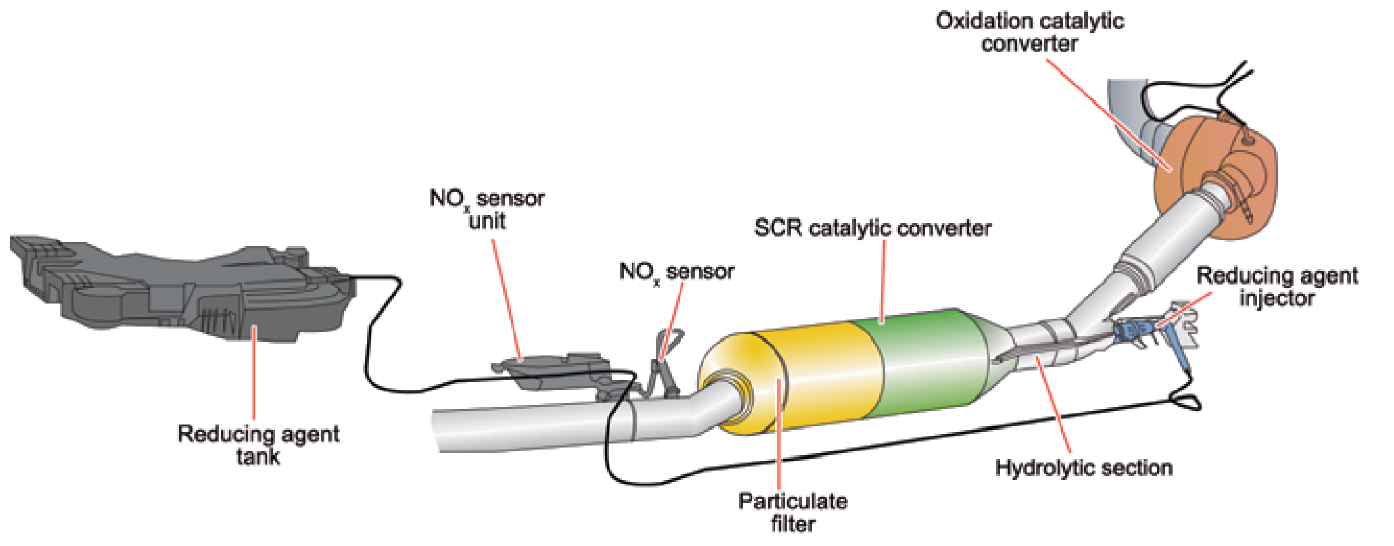
Many manufacturers have incorporated the system into their diesel vehicles in order to pass the approval standards, each use a different name:

- PSA Group “BlueHDi”
- Mercedes Benz “BlueTEC”
- BMW “Blue Performance”
- Bosch “DENOXTRONIC”

The first two examples are described below.

PSA Group, BlueHDi

This is an initiative of the PSA group for meeting the Euro 6 standard by incorporating a **selective catalytic reduction (SCR)** system that uses reducing agent to reduce **nitrogen oxide** emissions. Commercially called **BlueHDi**, the first model to incorporate this system was the Citroën Grand C4 Picasso. The structure of the exhaust gas purification line consists of a **diesel oxidation catalyst (DOC), the SCR catalytic converter and the particulate filter (FAP)**.



The functioning of the BlueHDi system is basically as explained in previous sections.

- The AdBlue liquid is injected into the exhaust line.
- The injected AdBlue liquid is mixed with the exhaust gas in a mixer that homogenises the exhaust gas with the atomised agent.
- The homogenised mixture flows through the SCR reduction catalytic converter where, on meeting the stored nitrogen oxides, it is converted into water vapour (H2O) and nitrogen (N2).

The tank that is used to store the AdBlue reducing agent is normally 17 litres.

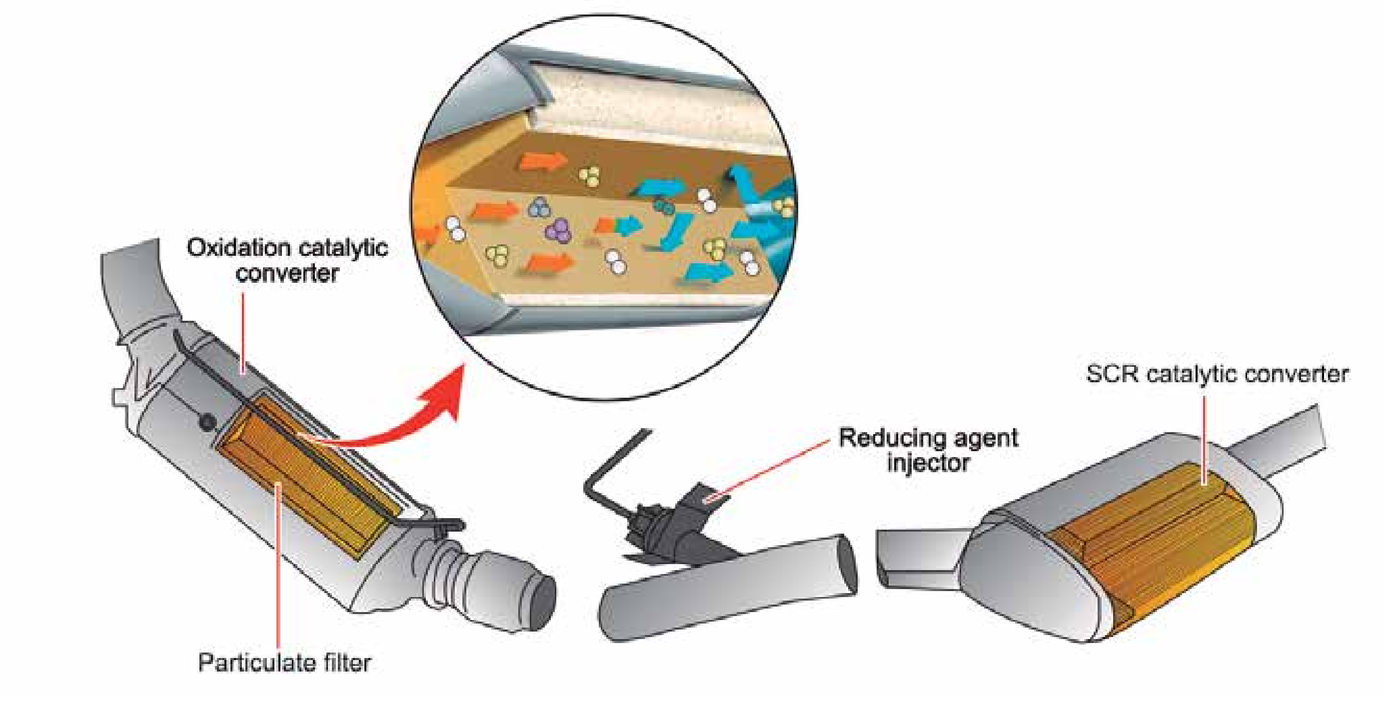
In this case, the PSA group has opted to locate the **SCR reduction catalytic converter** before the particulate filter and near the exhaust manifold, so that it can quickly reach its working temperature. In this way, it can start to work effectively from the first stages of engine heating. The aim is for it to be fully operational during urban driving.

Furthermore, the PSA group offers some of its BlueHDi models with the option of combining the engine with the SCR system together with the **Stop & Start system** and a more efficient **automatic gearbox** called theEfficient Tronic Gearbox ETG6. These models can reduce nitrogen oxide NOx emissions from 180 mg/km to 80 mg/km.

The BlueHDi technology is available in the Peugeot, Citroën and DS ranges. Overall, they have managed to reduce NOx by 90% and CO2 emissions between 2% and 4% compared with conventional diesel vehicles.

Mercedes Benz, BlueTEC

Mercedes Benz has introduced the SCR selective catalytic reduction system using AdBlue reducing agent into the engine range applicable to the following models: E350, ML350, GL350 and R350. The structure of the system is made up of an oxidation catalytic converter, together with a particulate filter, a reducing agent injector and the SCR reduction catalytic converter at the end of the exhaust line.



Before using the reducing agent injector, an NOx storage catalytic converter (DeNox) was added between the oxidation catalytic converter and the particulate filter on the first vehicles with BlueTEC. This is a **non-selective** nitrogen oxide reduction method that uses the appropriate chemical compounds of the catalytic converters. The **DeNOx catalytic converter**, together with the **SCR reduction catalytic converter**, is responsible for reducing the oxides resulting from incomplete combustion.

When operating with a lean mixture, the DeNOx collects NOx gases which are then converted into N2 and H2O in the regeneration stage. With a rich mixture, ammonia is generated which is stored in the SCR catalytic converter where it is later consumed during lean mixing. The particulate filter is responsible for collecting soot particulates. During lean mixing, the NOx which could not be collected in the DeNOx are converted into molecular nitrogen and water in the SCR catalytic converter using the stored ammonia.

Since this system is not sufficient to comply with the Euro 6 standards and is more expensive, a more economical and effective option has been chosen. This option involves omitting the DeNOx catalyst and using the AdBlue injector to inject the substances needed to reduce NOx directly into the SCR catalytic converter.

MAINTENANCE OF THE NOX REDUCTION SYSTEMS WITH ADBLUE

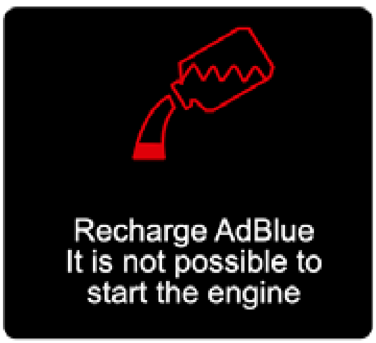
In order to ensure that the NOx reduction system with AdBlue functions correctly, the reducing agent must be periodically topped up. This operation can be carried out by the vehicle user without the need to go to a garage, provided there is no fault related to the system. Neither is any form of reset or zeroing by diagnostic equipment required, as there is a real level sensor.

The **Euro 5 emissions standards** require a vehicles that use an **agent or additive** for the treatment of exhaust gas to have a system for **blocking engine starting** in the absence of this agent or if there is a fault that increases the emissions levels above that stipulated in the standard.

The system is programmed to give an acoustic and visual warning to the driver in good time and persistently through the instrument panel. In this way, the user can refill the reducing agent before the control unit prevents the engine starting.

Indications on the dashboard

- **AdBlue reducing agent low-level indication.** It also includes the range in kilometres that the reducing agent remaining in the tank will allow.
- **AdBlue reducing agent tank empty indication.** This indicates the need to refill the AdBlue agent. If the reducing agent is not refilled, the vehicle cannot be started after stopping. There is diagnostic equipment that allows the engine start lock to be overridden in order to travel up to 50 kilometres.
- **Indications relating to possible faults in the SCR system.** Depending on the nature of the fault, the SCR system is programmed to allow the motor to operate in a limited way before preventing the starting of the engine or directly prohibiting the starting of the engine once it has stopped.

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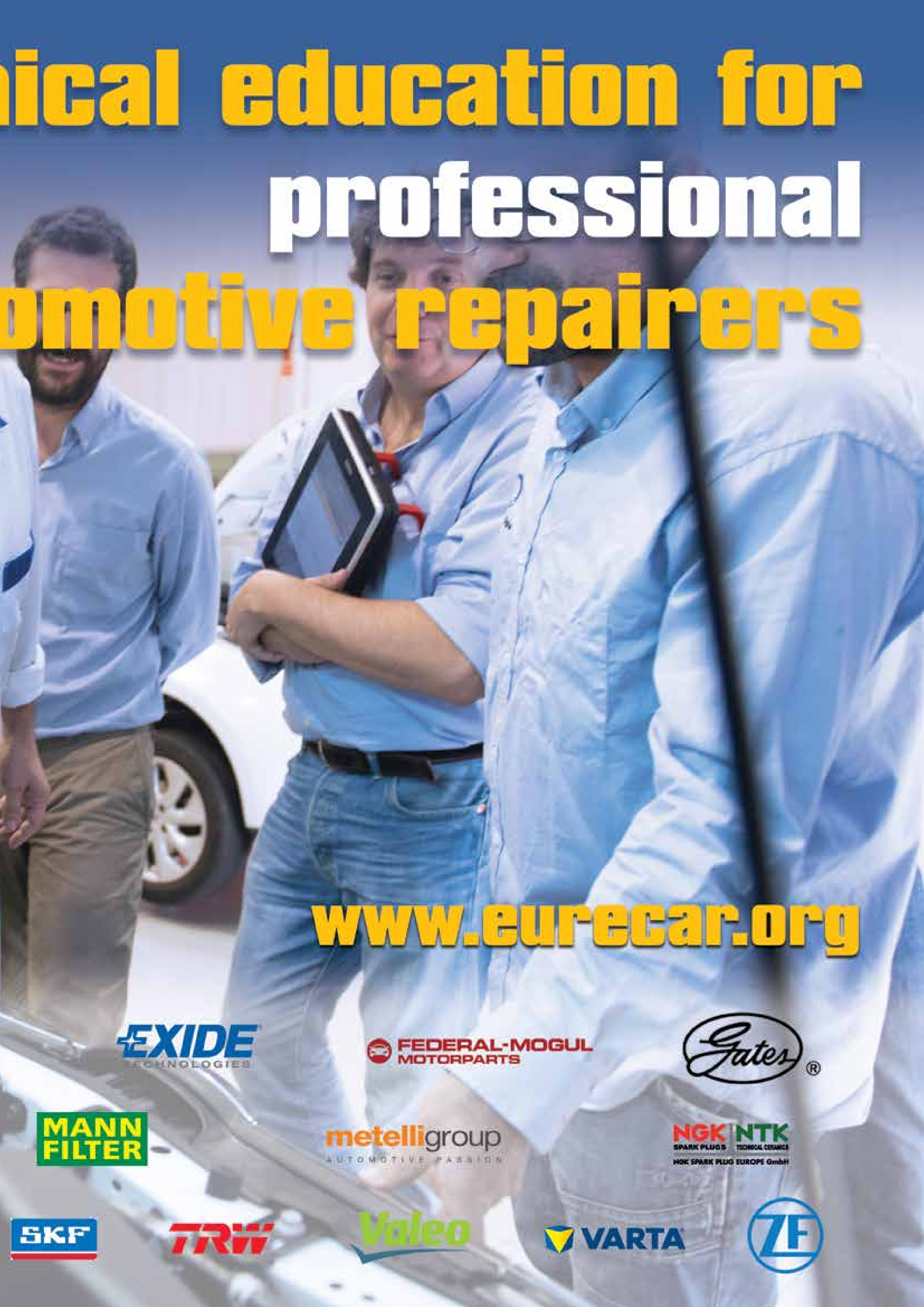
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