



Self-study programme 336

The catalytic coated diesel particulate filter

Design and function

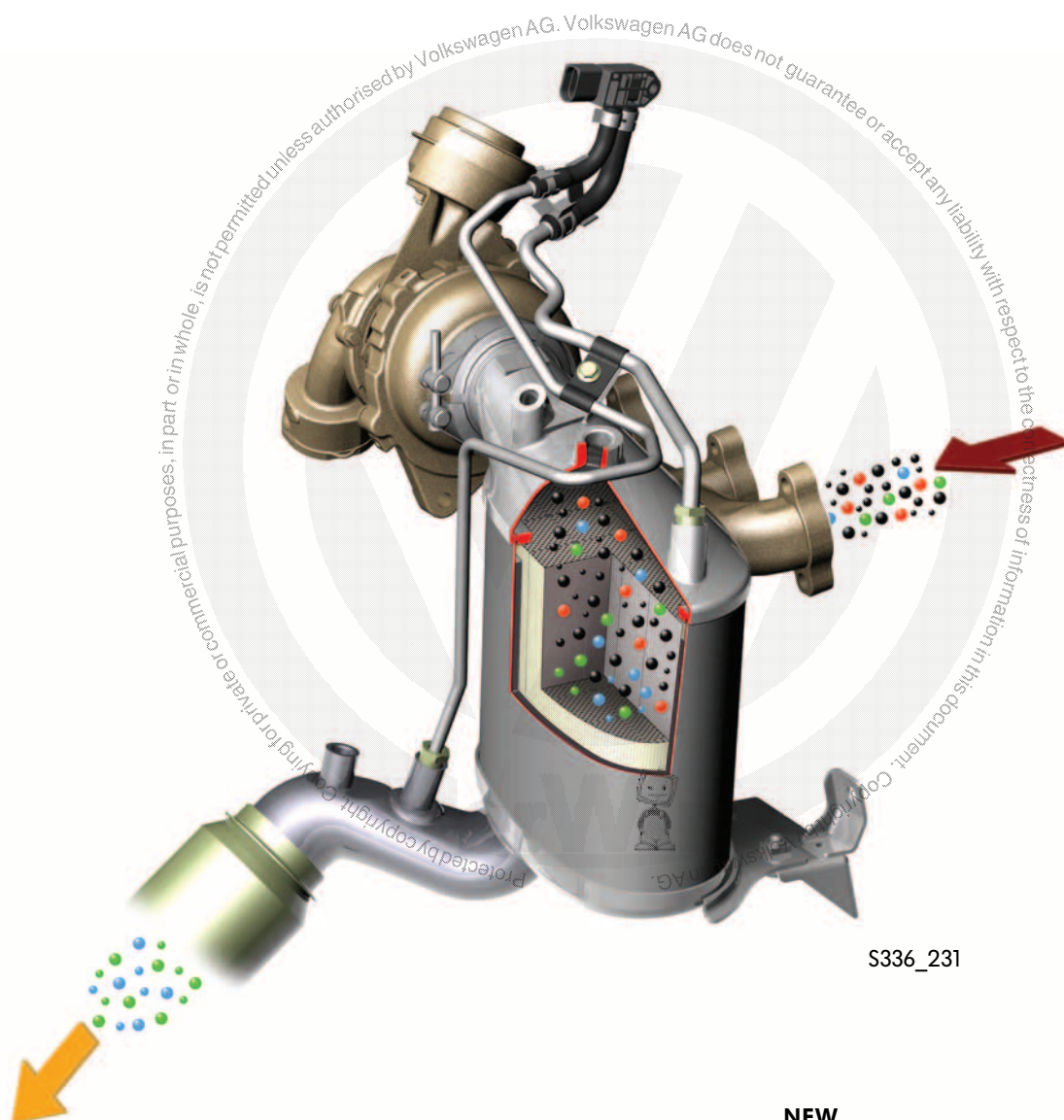
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The reduction of particulate emissions from diesel engines is a great challenge in this day and age. In addition to engine measures, exhaust gas treatment is of particular importance to help achieve this.

The particulate filter is an effective method to remove carbon soot particles that are inherent in diesel emissions.

The most common filter systems comprise of an oxidation catalyst and a particulate filter. On the catalytic coated particulate filter from Volkswagen, the catalyst and filter have been combined to form one single unit. With this particulate filter system, the particulates can be burnt off continually without the addition of a fuel additive, thanks to the design and installation position close to the engine.



S336_231

NEW



Important
Note



**This self-study programme shows the design and function of new developments!
The contents will not be updated.**

Please always refer to the relevant Service Literature for all inspection, adjustment and repair instructions.



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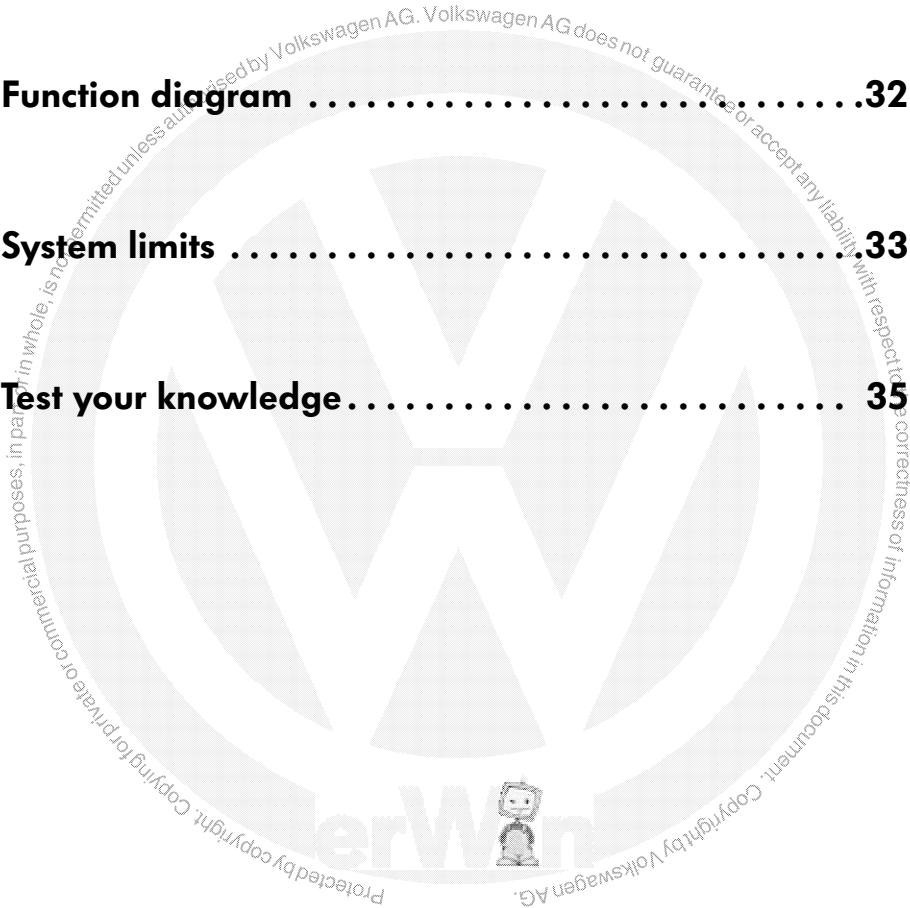
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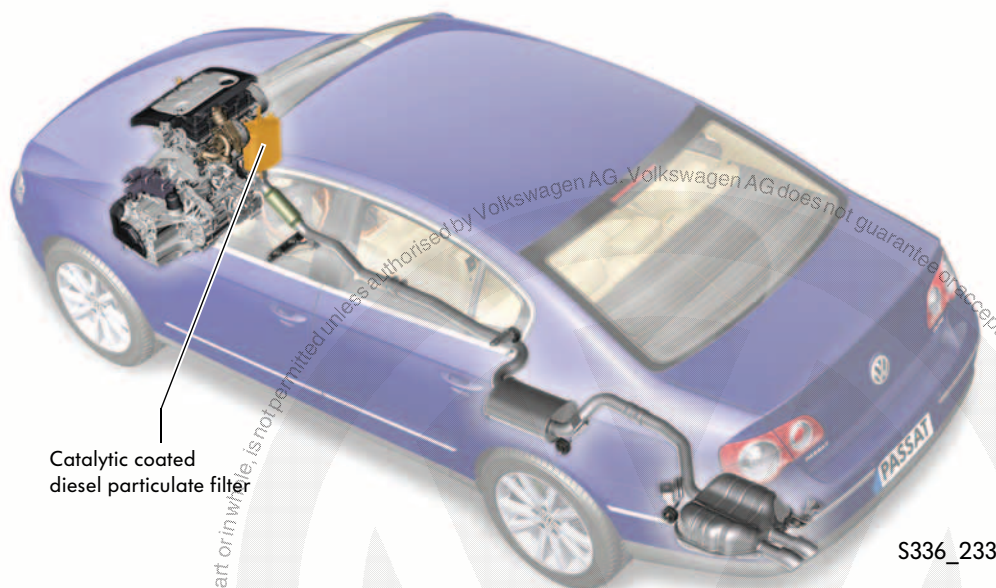


Introduction

General

During combustion of diesel fuel, all sorts of different deposits are built up. Those that can be perceived directly as exhaust components on a cold engine are non or partly oxidised hydrocarbons in droplet form as white or blue smoke and strong smelling aldehyde.

In addition to harmful gaseous substances, particles of solid substances are emitted with the emissions from diesel engines, which have been included under the main heading of particulates with regards to substances that are damaging to health and the environment.



Volkswagen follows a long-term strategy with the aim of reducing exhaust emissions – not only in the area of diesel particulates but also for all other emissions components, such as hydrocarbons and nitrogen oxides. Some years ago, Volkswagen undertook tough measures on a continual basis to optimise the internal combustion processes and to reduce the emission of carbon soot particles from diesel engines.

And with success: In 1999, Volkswagen was able to offer the Lupo 3L TDI on the market as the first vehicle to meet the strict Euro 4 exhaust emissions standard – six years before the standard was established as a legal requirement in 2005.

Volkswagen played an important role in driving on the development for clean diesel fuel and thereby faced the responsibility of protecting the environment. Examples of this are the efficient, economical and low noise generating TDI technology and also the unit injector system. Volkswagen will continue to selectively improve internal combustion processes in the future to further bring down fuel consumption and reduce emissions directly at source. In addition, Volkswagen will enhance these efforts step-by-step by the introduction of diesel particulate filter systems.

The exhaust gas

Emissions standards

In the Republic of Germany, across Europe and throughout the world, laws have been passed in recent years to reduce the emission of harmful substances in the air. In Europe, the emissions standards are categorised from EU1 to EU4. These prescribe emission limits to the automobile industry for type approval of new vehicle models.

EU3

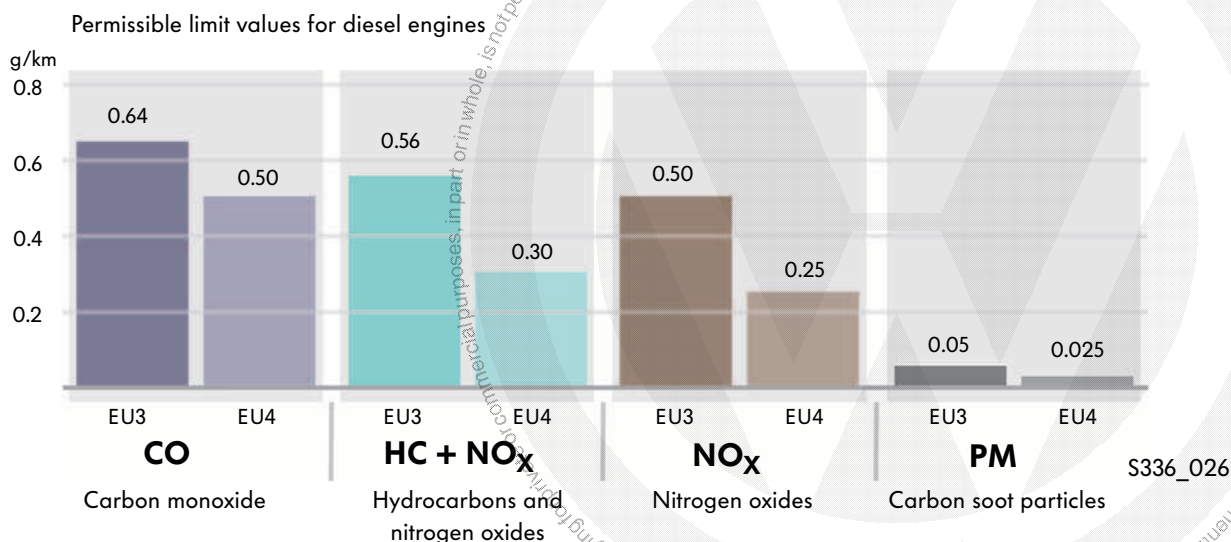
From the year 2000, newly registered vehicles have to fulfil emissions standard EU3.

It differs from its predecessor EU2 by more stringent conditions on the test bed and by a reduction in the limit values.

EU4

The EU4 standard will come into force in 2005 and will supersede EU3. The consequences are a further reduction in permissible limit values.

Even now, more than 65 percent of all newly registered Volkswagens with a diesel engine fulfil emissions standard EU4 in Germany.



Outlook

In the future, the more stringent EU5 standard will come into force. The limit values for this standard have as yet not been established, but acceptable emission levels will be lowered even further. There are plans to markedly reduce the particulate limit value for diesel passenger vehicles even further. Therefore, all diesel passenger vehicles must be fitted with a particulate filter in the future.

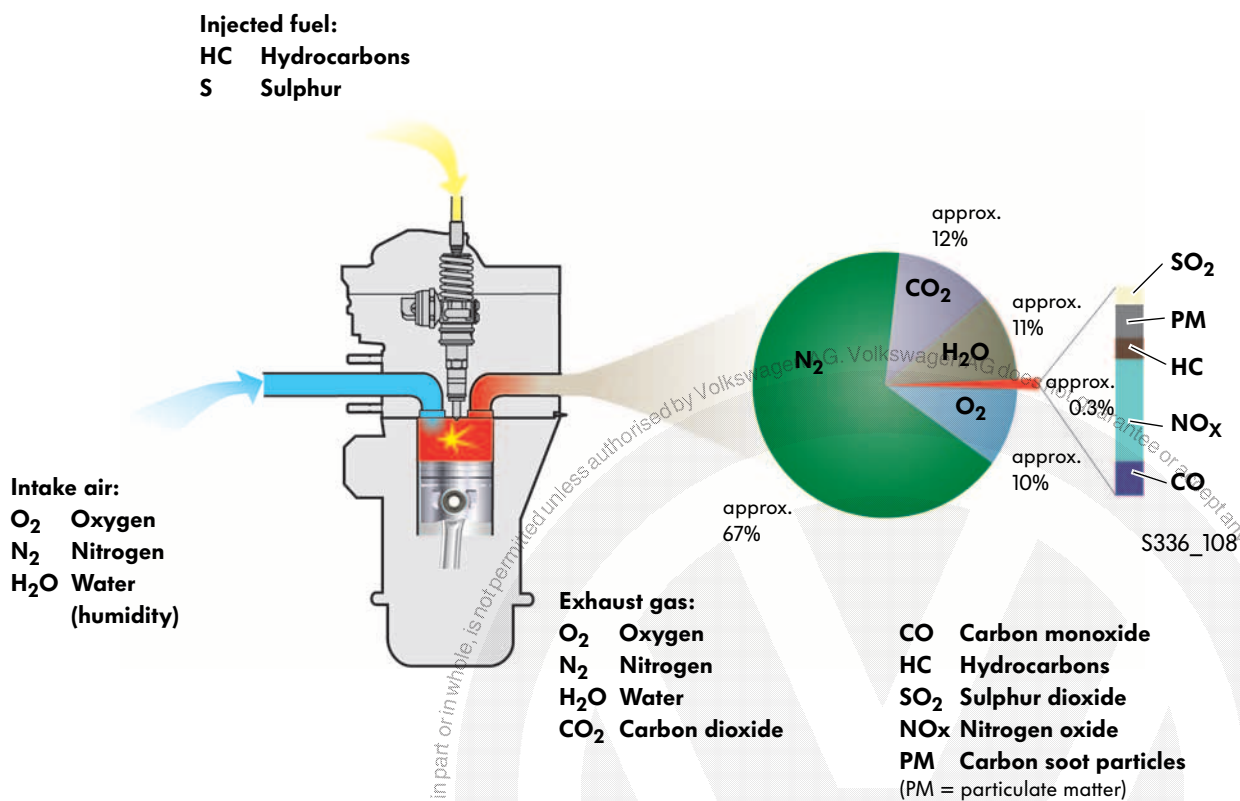


Introduction

Harmful substances caused by combustion

The harmful substances, and particulate emissions in particular, are influenced in a diesel engine by the combustion process. This process is affected by many factors relating to the construction, the fuel itself and the atmosphere.

The following illustration shows an overview of the inlet and exhaust components of a diesel engine during combustion.



With regards to the damaging effect on the environment and health, the emissions from a diesel engine have various components that require different analyses.

Those components that are already present in the atmosphere (oxygen, nitrogen and water) can be categorised as safe.

Carbon dioxide, which is present in the atmosphere as a natural gas, is at the limit between safe and harmful due to its categorisation. It may not be poisonous, but in higher concentrations it can contribute towards the greenhouse effect.

Carbon monoxide, hydrocarbons, sulphur dioxide, nitrogen oxide and particulates are categorised as harmful.

Harmful substances in the exhaust gas



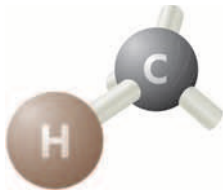
CO
Carbon
monoxide



S336_014

Carbon monoxide (CO) is generated from oxygen deficiency as a result of the incomplete combustion of fuels containing carbon. It is a gas and has no colour, smell or taste.

HC
Hydrocarbons



S336_016

Hydrocarbons cover a wide range of different compounds (for example C_6H_6 , C_8H_{18}), which occur as a result of incomplete combustion.

SO₂
Sulphur dioxide



S336_018

Sulphur dioxide is generated by the combustion of fuel containing sulphur. It is a gas without colour but with a pungent smell. The amount of sulphur added to fuel is decreasing.

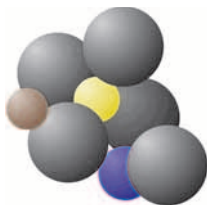
NO_x
Nitrogen oxides



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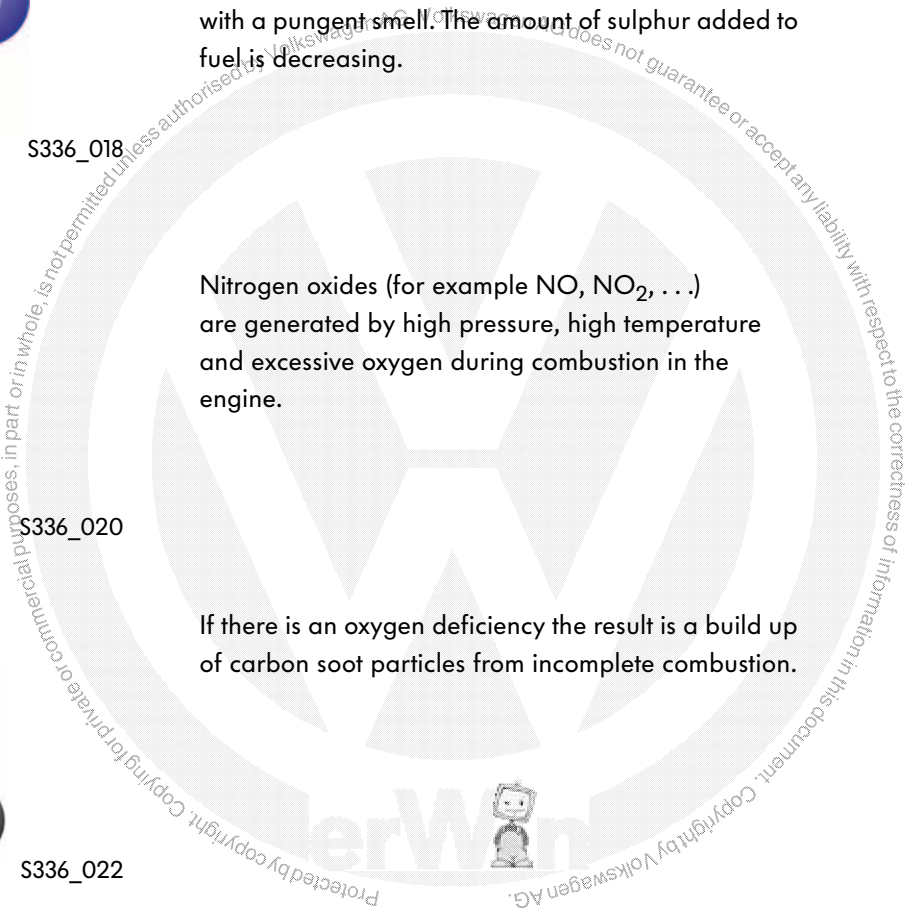
Nitrogen oxides (for example NO, NO₂, ...) are generated by high pressure, high temperature and excessive oxygen during combustion in the engine.

Carbon soot particles



S336_022

If there is an oxygen deficiency the result is a build up of carbon soot particles from incomplete combustion.



Introduction



The particulates

Particulates is a term that covers all particles, solid or liquid, that are generated from friction, breakdown of components, erosion, condensation and incomplete combustion.

These processes create particulates in different shapes, sizes and structures.

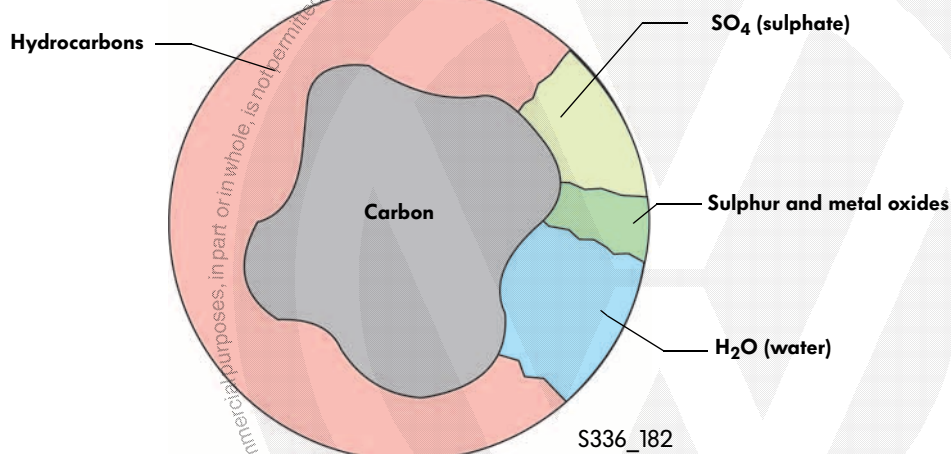
Particulates have the same character as harmful substances in the air if, due to their small dimensions, they can float around in gaseous substances and damage organisms.

The carbon soot particles

Carbon soot particles are generated from the combustion process in a diesel engine. Carbon soot particles are microscopic balls of carbon with a diameter of about $0.05\text{ }\mu\text{m}$. Their core consists of pure carbon. Around the core are deposits of different hydrocarbon compounds, metal oxides and sulphur.

Some hydrocarbon compounds are categorised as potentially hazardous to health.

The exact composition of carbon soot particles depends on the engine technology, the conditions of use and the type of fuel.



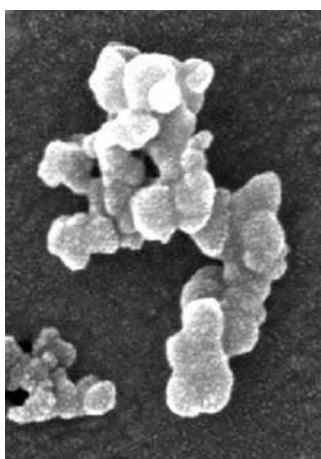
Cause of carbon soot particles

The build up of carbon soot particles in a diesel engine depends on the individual processes of diesel combustion, such as air intake, injection, flame spread.

The combustion quality depends on how well the fuel is mixed with the air.

The mixture in some areas of the combustion chamber could be too rich because not enough oxygen is present.

Combustion will then be incomplete and carbon soot particles will be formed.



S336_013

Typical particle of carbon soot caused by combustion in a diesel engine

The mass and number of particles are therefore affected generally by the quality of the engine combustion process. With high injection pressure and an injection pattern based on the requirements of the engine, the unit injector system ensures efficient combustion and thereby reduces the formation of carbon soot particles during the combustion process. High injection pressure and associated fine atomisation of the fuel, however, does not necessarily lead to smaller particles.

Tests have shown that the difference in particle sizes in the exhaust gas is very similar regardless of the combustion principle of the engine, whether swirl chamber, common rail or unit injector technology.



Introduction



The measures to reduce particulates

The reduction of exhaust emissions in a diesel engine is an important aim in further development. There is a range of different technical solutions to reduce exhaust emissions. Here, a difference is made between internal and external engine measures.

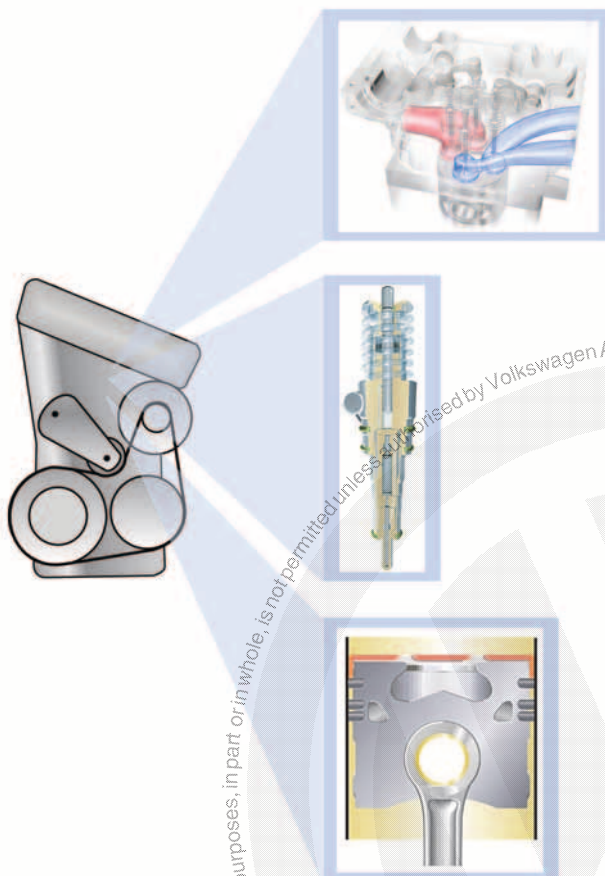
Internal engine measures

A reduction in emissions can be achieved by measures to the internal workings of an engine.

Effective optimisation of the combustion process can ensure that harmful substances are not produced at all.

Examples of internal engine measures are:

- the design of the inlet and exhaust ports for optimal flow properties,
- high injection pressures, for example from unit injector technology,
- the combustion chamber design, for example reduction in the size of the area where harmful substances are produced, design of the piston crown.



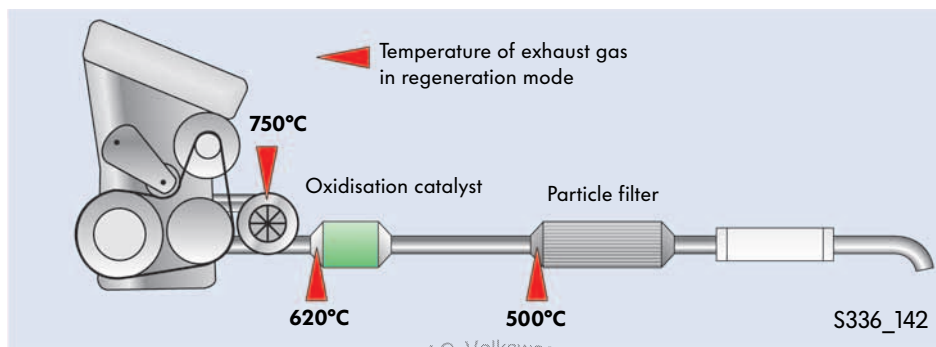
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External engine measures

The release of carbon soot particles that are produced during combustion can be prevented by external engine measures. This can be seen as the reduction of carbon soot particles by means of a particulate filter system. To do this, it is necessary to differentiate between two systems – the diesel particulate filter with additive and the catalytic coated diesel particulate filter. On the next few pages the design and function of just the catalytic coated diesel particulate filter will be described.

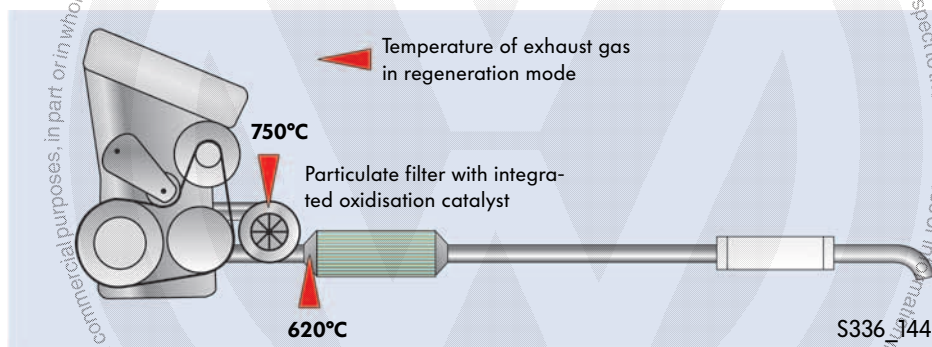
System with additive

This system is used on vehicles where the particulate filter is installed away from the engine. Due to the distance the exhaust gas has to make from the engine to the particulate filter, the required ignition temperature for combustion of the particulates can only be reached with the introduction of an additive.



Catalytic coated system

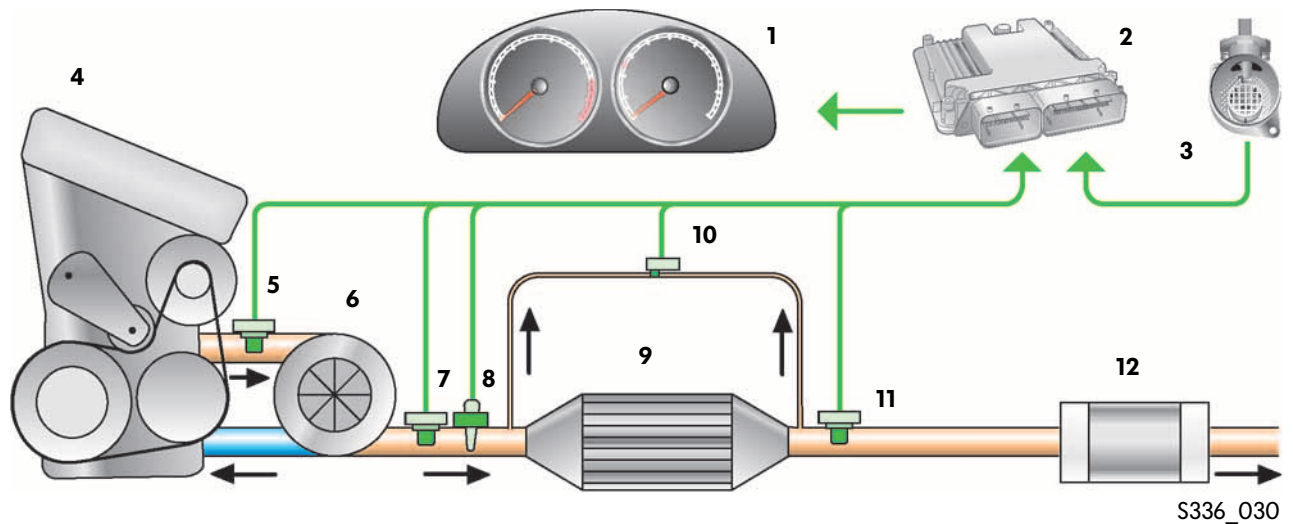
This system is used on vehicles where the particulate filter is installed close to the engine. Due to the short distance exhaust gas has to take from the engine to the particulate filter, the temperature of the exhaust gas is sufficiently high enough to burn off the carbon soot particles.



Design and function

The system of the catalytic coated diesel particulate filter

Shown in the overview below are the components of the diesel particulate filter system.

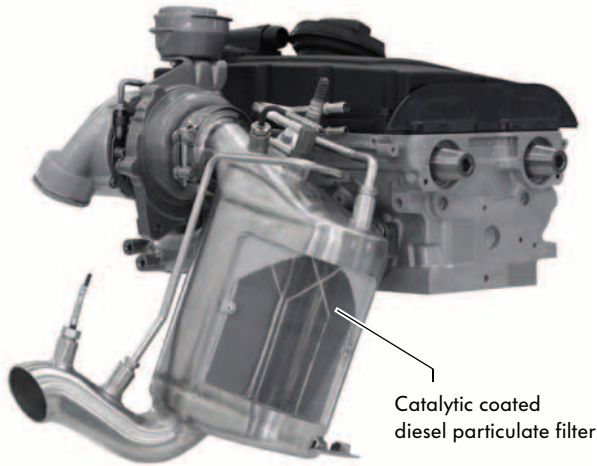


- | | |
|---|---|
| 1 Control unit in dash panel insert J285 | 7 Temperature sender before particulate filter G506 |
| 2 Engine control unit | 8 Lambda probe G39 |
| 3 Air mass meter | 9 Particulate filter |
| 4 Diesel engine | 10 Exhaust gas pressure sensor 1 G450 |
| 5 Temperature sender before turbocharger G507 | 11 Temperature sender after particulate filter G527 |
| 6 Turbocharger | 12 Silencer |



The overview shows a system with single exhaust pipe. On multi-pipe exhaust systems the particulate filter and the sensors on the exhaust system are installed for each set of cylinders.

The particle filter

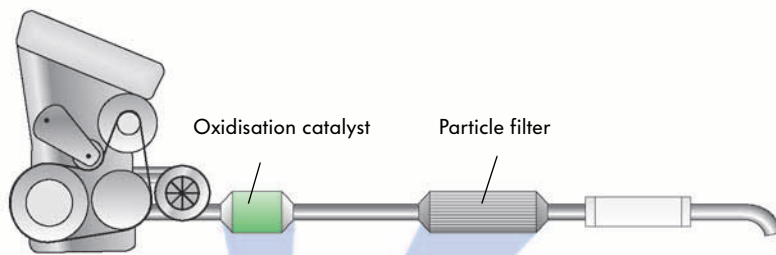


Catalytic coated
diesel particulate filter

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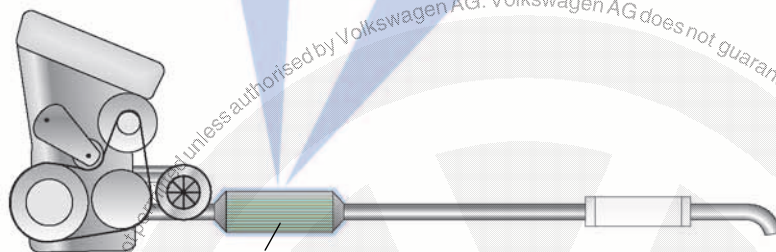
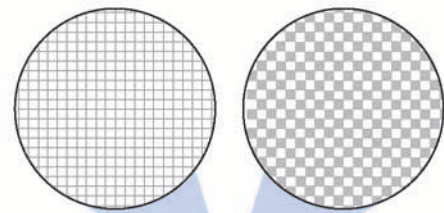
The catalytic coated diesel particulate filter is located in the exhaust system after the turbocharger, within close proximity of the engine.

Two components, the oxidation catalyst and the particulate filter, have been combined to form one unit, the catalytic coated diesel particulate filter. It joins the functions of the oxidation catalyst and the diesel particulate filter in one single component.



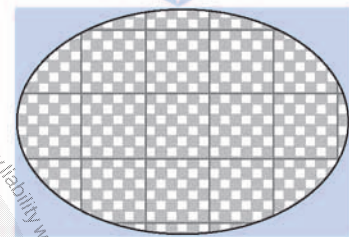
Oxidisation catalyst

Particle filter



S336_212

Catalytic coated
diesel particulate filter



Catalytic coated
diesel particulate filter

As a diesel particulate filter it filters out the carbon soot particles from the exhaust gas. In its function as oxidation catalyst, it cleans the exhaust gas of hydrocarbons (HC) and carbon monoxide (CO). They are converted into water (H₂O) and carbon dioxide (CO₂).



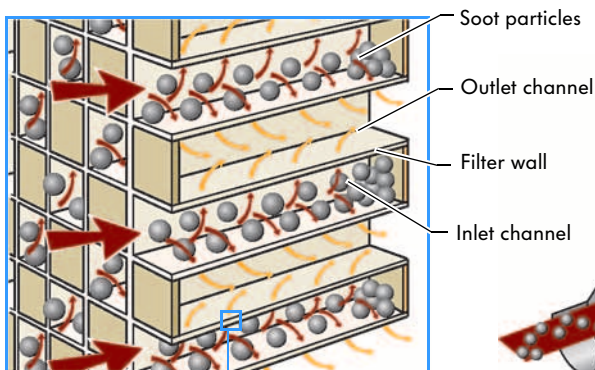
Detailed information about oxidation catalysts can be found in self-study programme no. 124 "Diesel engine catalysts".



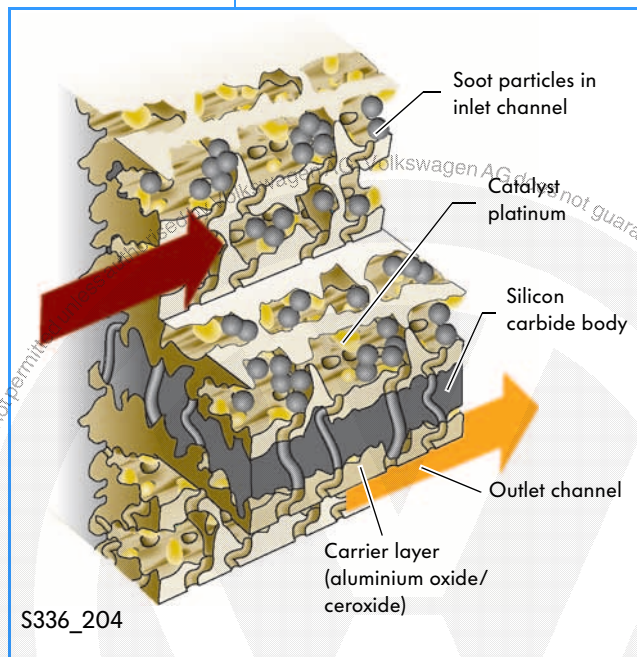
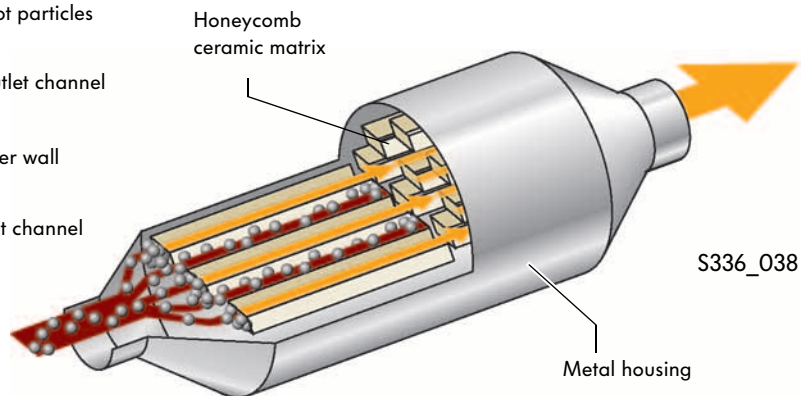
Design and function

Design

The diesel particulate filter comprises of a honeycomb ceramic matrix made from silicon carbide, which can be found in a metal housing. The ceramic matrix itself has many small channels that run parallel to each other and are alternately connected. In this way, inlet and outlet channels are created that are separated by filter walls.



S336_154



The filter walls made from silicon carbide are porous. The silicon carbide body is coated with a mixture of aluminium oxide and cerioxide.

This mixture serves as a carrier layer for the catalytic converter. The carrier layer is coated with a precious metal, platinum, which acts as the catalyst.

A catalyst is a substance that promotes or hinders a chemical reaction without changing itself.

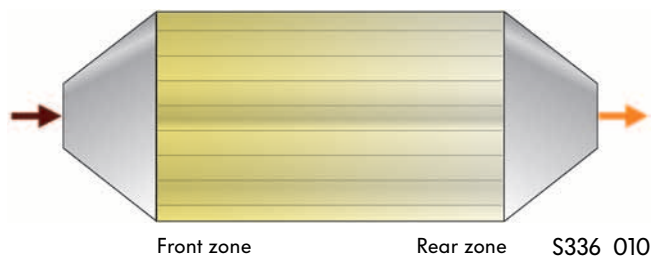
Function

Since the channels are sealed alternately in the direction of flow from the inlet and outlet side, the carbon soot contaminated exhaust gas must flow through the porous filter walls made from silicon carbide. When this happens, the carbon soot particles and not the gaseous components are retained in the inlet channels.

The coated zones in the diesel particulate filter

The diesel particulate filter requires a certain length in order to provide a large storage volume for the carbon soot. In addition, it must be coated with a certain amount of platinum in order to attain the desired catalytic effect.

The catalytic coating of the diesel particulate filter is separated into zones across the length of the filter.



In the front zone there is a large quantity of platinum and in the rear zone there is less platinum.

The following are advantages from the zone-like coating:

- In normal operating mode of the engine the diesel particulate filter heats up quickly in the front area. Due to the high concentration of platinum in this front zone of the catalyst, the filter has a very fast catalytic effect. In other words, the diesel particulate filter responds quickly.
- In regeneration mode, the rear area of the diesel particulate filter becomes very hot as the carbon soot is burnt off. Due to these high temperatures the platinum gets broken down over a period of time. Therefore, the expensive raw material is not used as intensively in the rear zone.
- A further reason for reduced use of platinum in the rear zone is ageing of the diesel particulate filter. During operation, more and more deposits are built up in the rear area from combustion, which impair the catalytic effectiveness of the platinum.

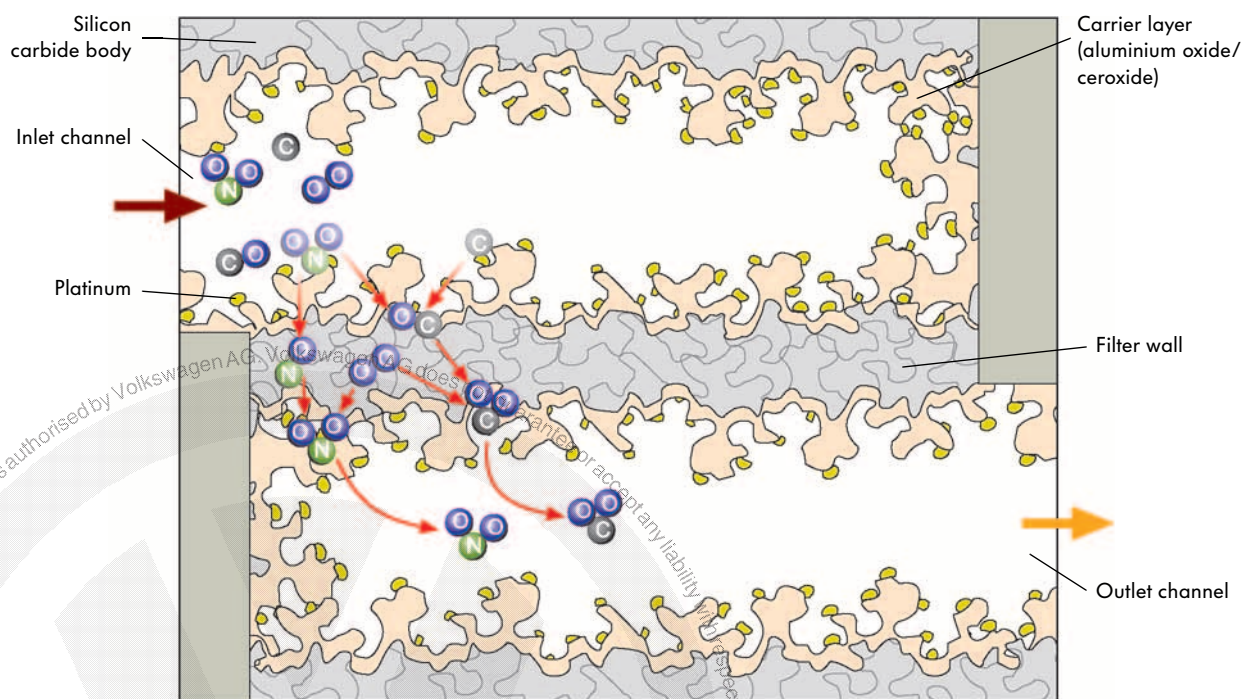
Regeneration

The diesel particulate filter must be cleaned of the particles of carbon soot regularly to prevent it from becoming blocked and its function thereby being affected. During the regeneration phase, the particulates that have accumulated in the particulate filter are burnt off (oxidised). With regeneration of the catalytic coated particulate filter, passive regeneration and active regeneration are separated. There are no signs to the driver that regeneration is occurring.

Design and function

Passive regeneration

With passive regeneration, the carbon soot particles are burnt off continually without intervention from the engine management system. The particulate filter is positioned in close proximity to the engine. This assures that exhaust gas temperatures of 350-500 °C are reached on motorways, for example. The carbon soot particles are thereby converted into carbon dioxide by a reaction with nitrogen oxide. This gradual process occurs slowly and continually through the platinum coating, which works as a catalyst.



S336_184

Function

From the nitrogen oxides present in the exhaust gas (NO_x) and oxygen (O₂), nitrogen dioxide (NO₂) is produced via the platinum coating.



The nitrogen dioxide (NO₂) reacts with the carbon (C) of the carbon soot particles. As a result, carbon monoxide (CO) and nitrogen monoxide (NO) are formed.

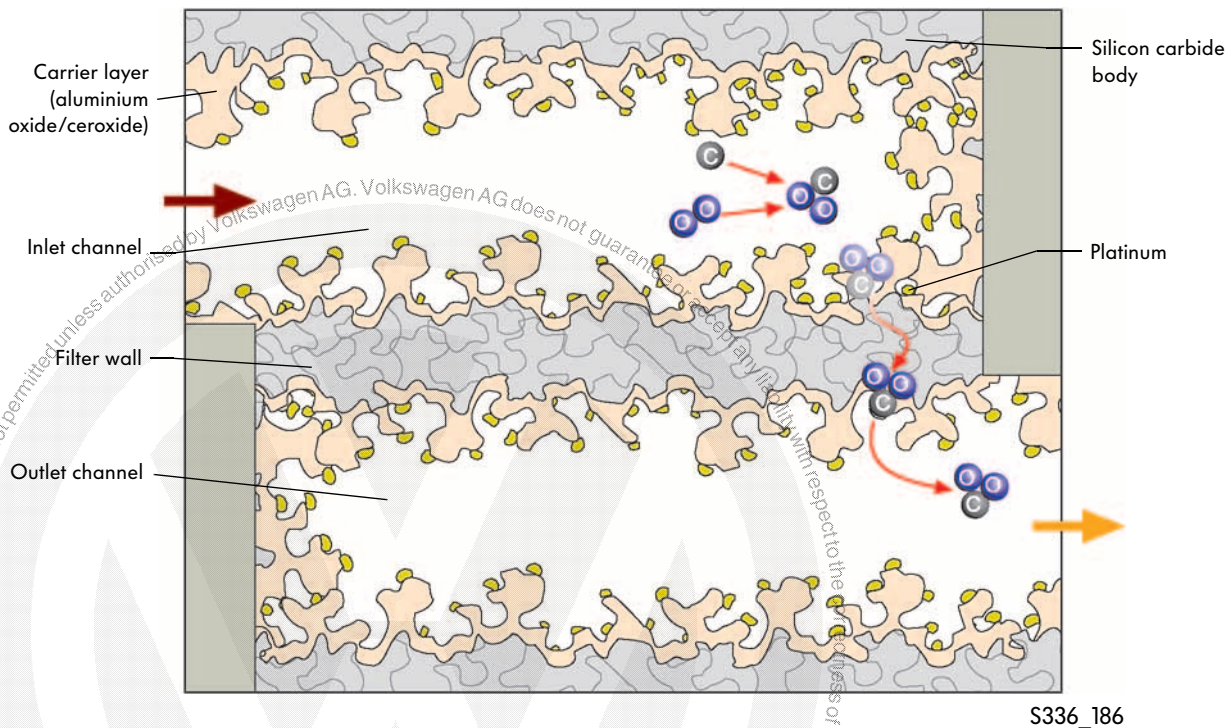


The carbon monoxide (CO) and nitrogen monoxide (NO) combine with oxygen (O₂) and form nitrogen dioxide (NO₂) and carbon dioxide (CO₂).



Active regeneration

With active regeneration, the carbon soot particles are burnt off through a targeted increase in the exhaust gas temperature by the engine management system. In urban traffic with low loads on the engine, the exhaust gas temperatures for passive regeneration of the particulate filter are too low. Since the carbon soot particles cannot be broken down, deposits build up in the filter. As soon as a certain level of carbon soot deposits is reached in the filter, active regeneration is initiated by the engine management system. This process lasts for approximately 10 minutes. The carbon soot particles are burnt off to carbon dioxide at an exhaust gas temperature of 600-650 °C.



Function

With active regeneration, the carbon soot particles are burnt off by high exhaust gas temperatures. When this happens, the carbon from the soot particles oxidises with oxygen and forms carbon dioxide.

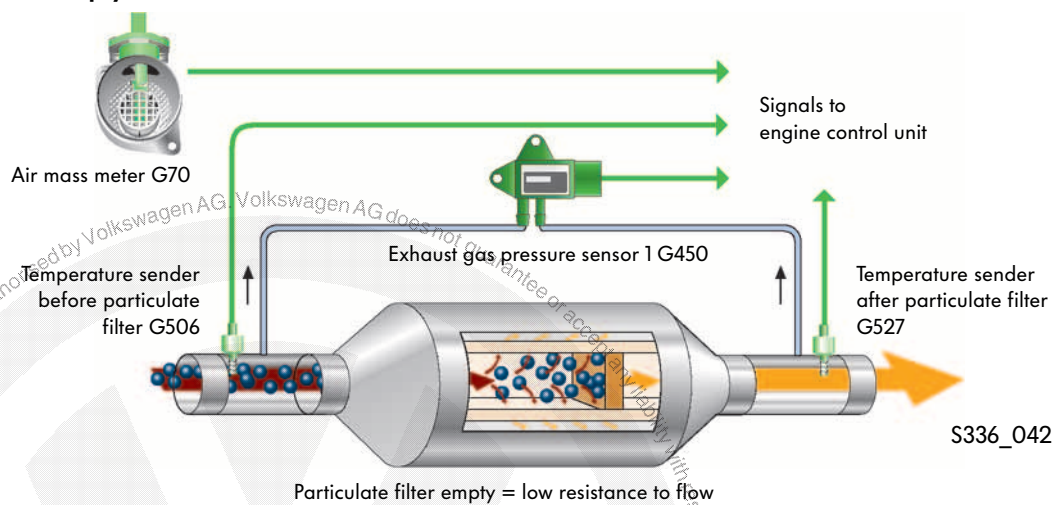


Design and function

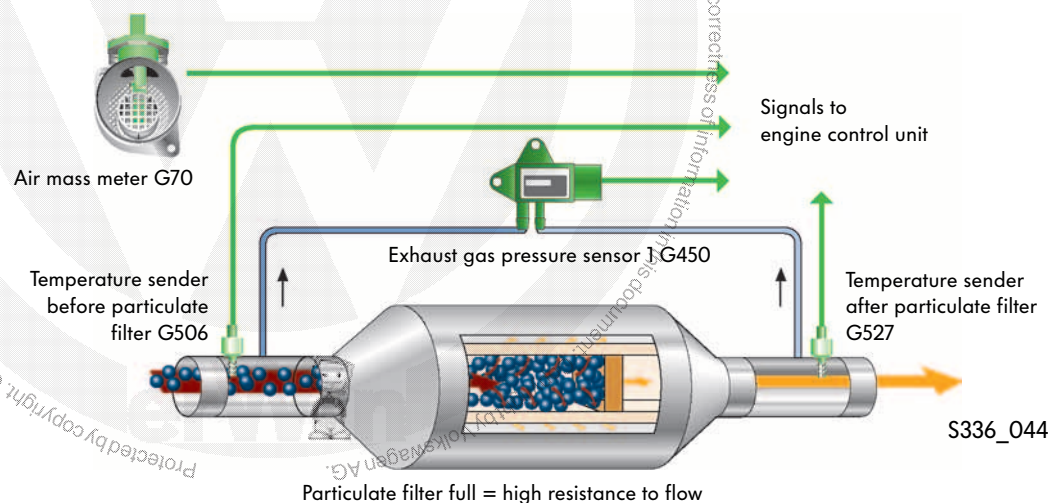
Function of active regeneration

The carbon soot particles are retained in the inlet channels. The engine control unit can detect the level of carbon soot in the particulate filter by evaluating the signals from the air mass meter, the temperature sender before and after particulate filter and the exhaust gas pressure sensor 1.

Particulate filter empty



Particulate filter full

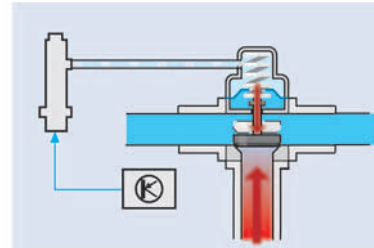


When the carbon soot level reaches a predetermined limit, the engine management system initiates active regeneration.

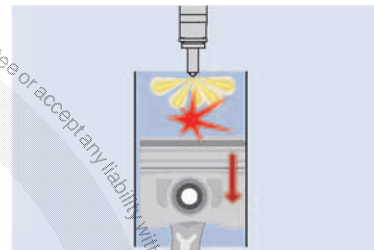
Engine management during initiation of active regeneration

From the flow resistance of the filter, the engine control unit can detect the level of carbon soot deposit in the filter. A high flow resistance indicates that the filter is in danger of becoming blocked. The engine control unit initiates an active regeneration process. To do this:

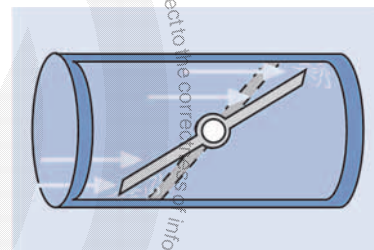
- exhaust gas recirculation is switched off to raise the combustion temperature,
- an extended injection period is initiated, after a period of main injection with reduced quantity at 35° crankshaft angle after TDC, in order to increase the exhaust gas temperature,
- the supply of intake air is regulated by an electric throttle valve and
- the charge air pressure is adapted so that the torque during regeneration does not change noticeably by the driver.



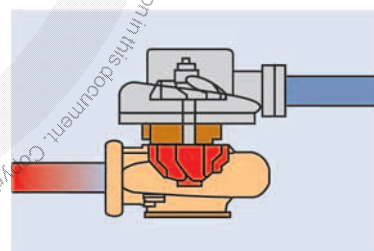
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S336_126



S336_120



S336_122

These measures lead to a targeted, brief increase in the exhaust gas temperature to approximately 600 °C to 650 °C. In this temperature range, the collective carbon soot oxidises to carbon dioxide. After this active regeneration period, the particulate filter is ready for operation again and can begin filtering carbon soot out of the exhaust gas.

Design and function

Level of carbon deposit in particulate filter

The level of carbon deposit in the particulate filter is constantly monitored by the engine control unit, which calculates the flow resistance of the filter. To determine the flow resistance, the exhaust gas volume before the particulate filter is compared with the pressure difference before and after the particulate filter and recorded as a ratio.

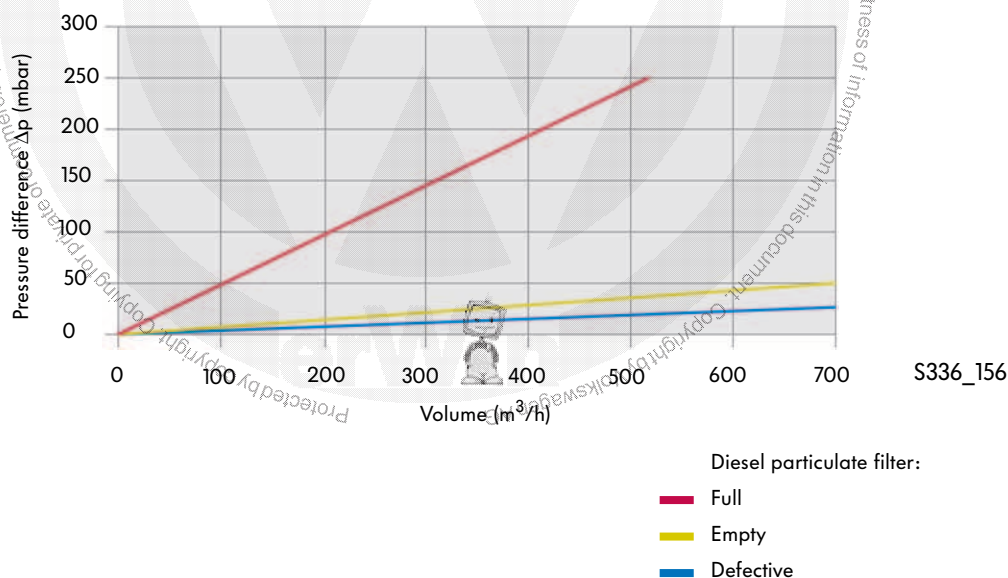
Pressure difference

The pressure difference of the air flow before and after particulate filter is calculated by exhaust gas pressure sensor 1.

Exhaust gas volume

The exhaust gas volume is calculated by the engine control unit from the air mass in the exhaust manifold and the exhaust gas temperature before the particulate filter. The mass of exhaust gas is roughly equivalent to the mass of air in the intake manifold, which is calculated by the air mass meter. The volume of exhaust gas depends on the respective temperature. The temperature is calculated from the senders before and after particulate filter. Using the exhaust gas temperature reading, the engine control unit can calculate the exhaust gas volume from the mass of air in the exhaust gas.

Flow resistance of particulate filter

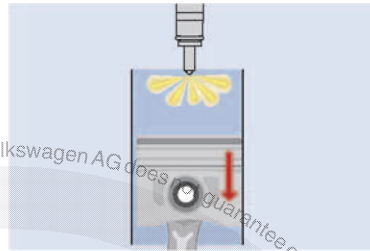


The engine control unit creates a ratio from the pressure difference and the volume of exhaust gas and can thus calculate the flow resistance of the particulate filter. From the flow resistance, the engine control unit can detect the level of carbon soot deposit.

Extended injection period at overrun

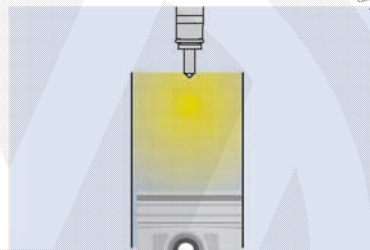
In heavy urban traffic with strong changes in engine load and a high percentage of overrun operation, particular measures are necessary for cleansing of the filter. Normally, no more fuel is injected in the cylinders at overrun, therefore the exhaust gas cannot reach the necessary temperature for purposes of particulate filter regeneration.

A small amount of fuel is injected at overrun, at approx. 35° crankshaft angle after TDC.



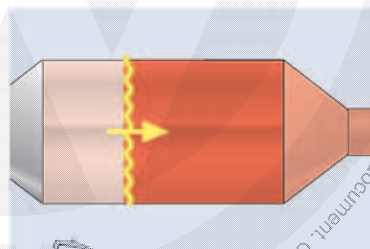
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Since there is no main injection at TDC, the fuel does not combust but vaporises.



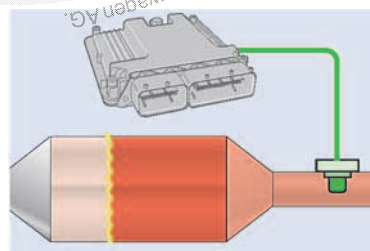
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This fuel vapour combusts in the particulate filter. The heat generated as a result means the required temperature of the exhaust gas is assured for regeneration of the particulate filter.



S336_202

The temperature sender after particulate filter monitors the exhaust gas temperature after particulate filter. This regulates the extended injection volume at overrun.



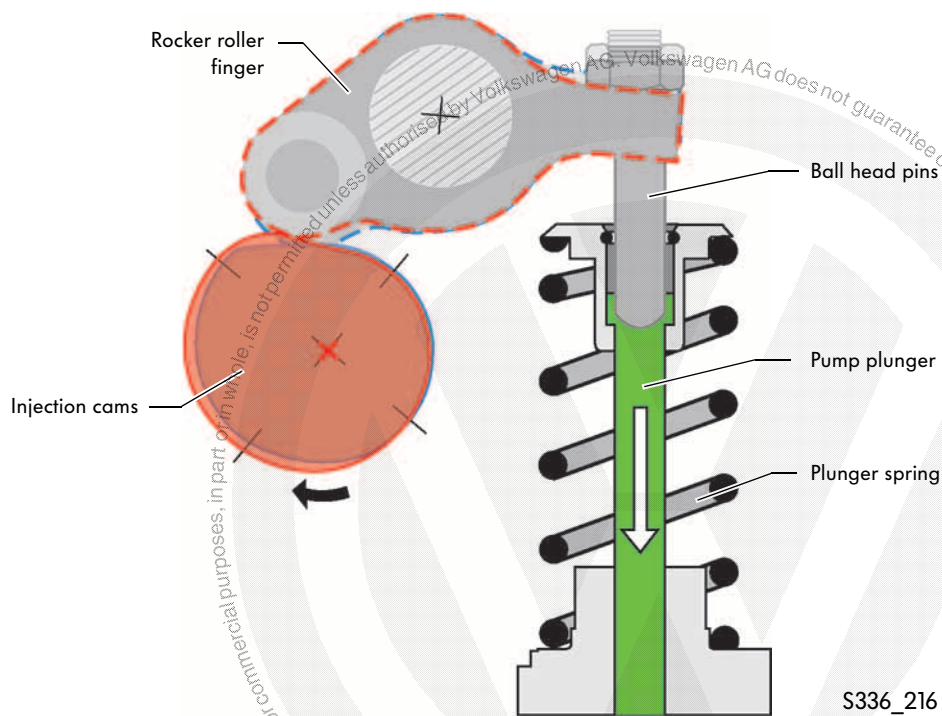
S336_200

Design and function

The injection cams

On diesel engines with unit injector technology and diesel particulate filter, the contour of the injection cam has been modified for the extended injection period.

Compared to an engine without diesel particulate filter, the injection cam is designed so the downwards motion of the pump plunger is longer. In this way, there is enough stroke available to allow extended injection at a later stage.

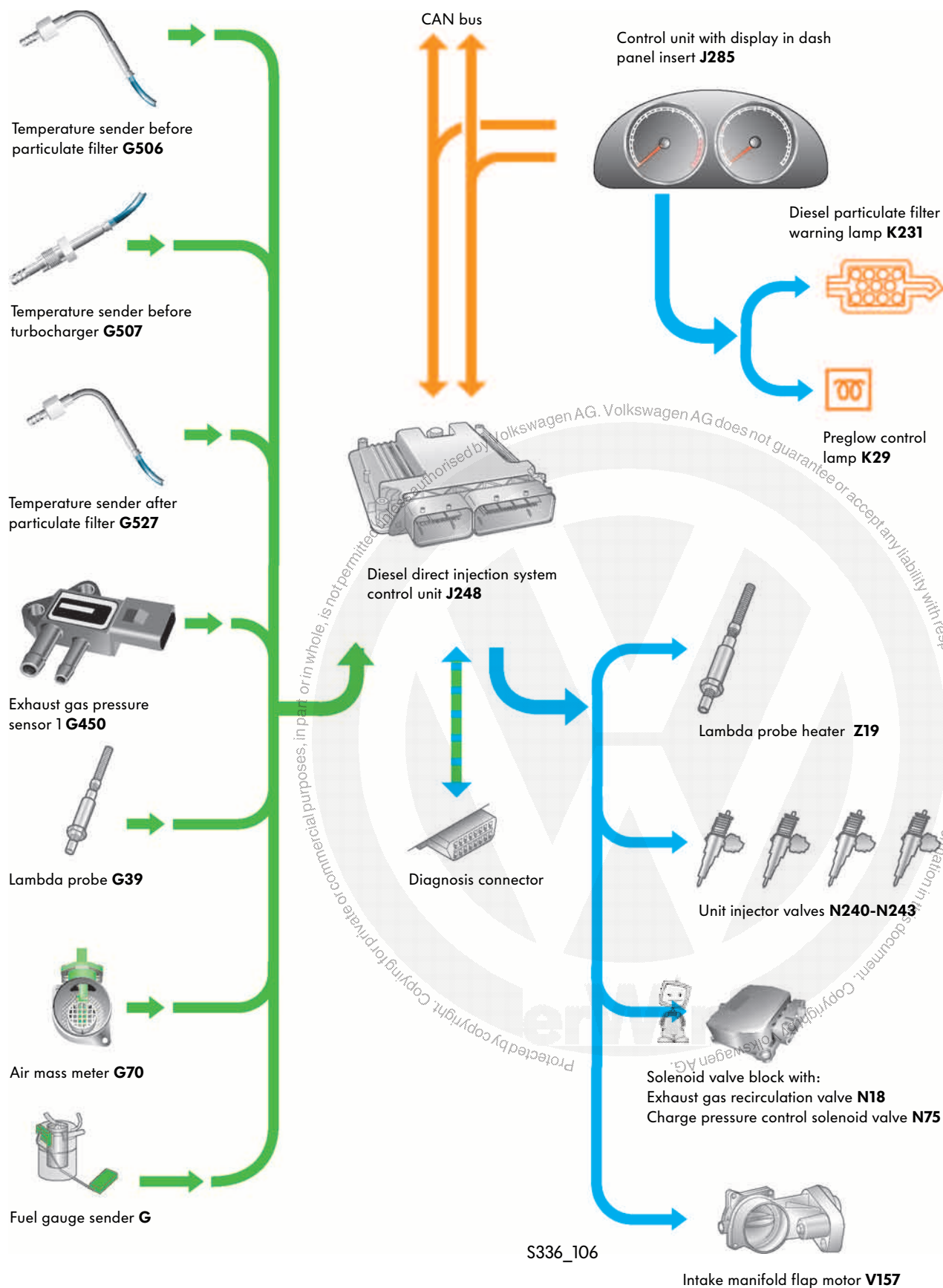


- Contour of cam on diesel engines with unit injector system and no diesel particulate filter
- Contour of cam on diesel engines with unit injector system and diesel particulate filter



Please refer to setting specifications in workshop manual when installing unit injector.

System overview

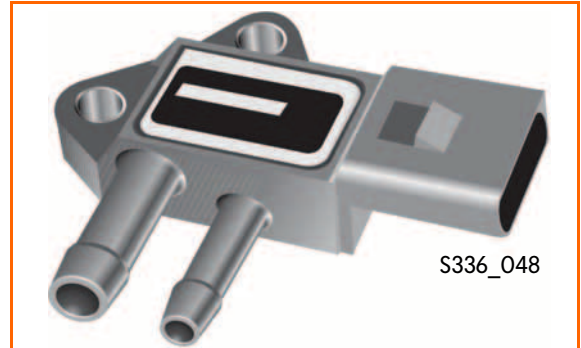


Sensors and actuators

Exhaust gas pressure sensor 1 G450

Signal application

Exhaust gas pressure sensor 1 measures the pressure difference in the flow of exhaust gas before and after the particulate filter. The signal from the exhaust gas pressure sensor, the signal from the temperature sender before and after particulate filter and the signal from the air mass meter form an inseparable unit during calculation of the level of carbon soot deposit in the particulate filter.



Effects of signal failure

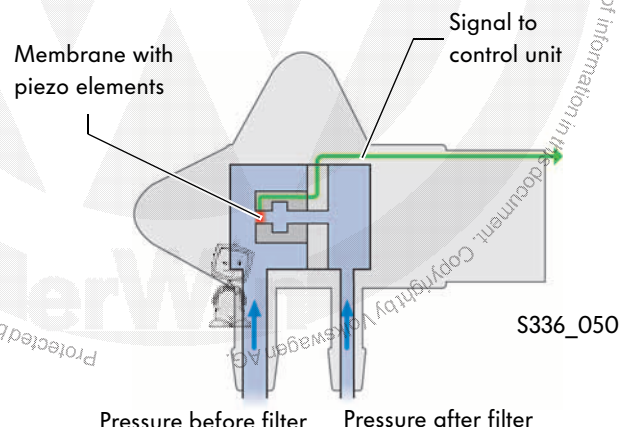
In the event of signal failure from the exhaust gas pressure sensor, the particulate filter regeneration cycle will be based on the distance travelled or the number of hours in operation. This cycle for particulate filter regeneration, however, is not effective over a long period of time.

After a predetermined number of cycles, the diesel particulate filter warning lamp will light up and the preglow control lamp will then flash in the dash panel insert. This informs the driver that the vehicle must be driven to a workshop.

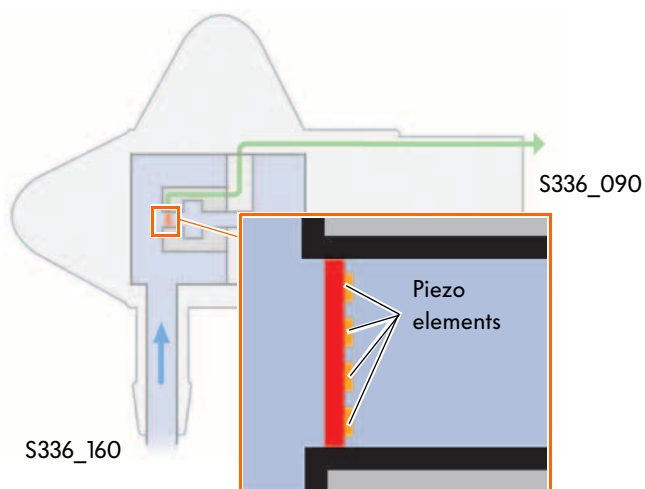
Design

Exhaust gas pressure sensor 1 features two pressure connections. Leading from one is a pressure line to the flow of exhaust gas before particulate filter and from the other to the flow of exhaust gas after particulate filter.

Installed in the sender is a membrane with piezo elements, which effect the respective exhaust gas pressures.



This is how it works:

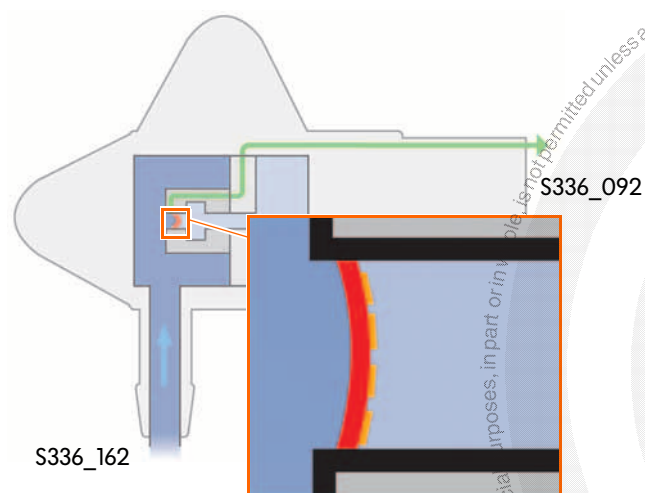


Pressure before filter = pressure after filter

Particulate filter empty

If the particulate filter has a very low carbon soot deposit level, the pressure before and after the filter is almost the same.

The membrane with the piezo elements is in a position of rest.



Pressure before filter > pressure after filter

Particulate filter full

If there is a build up of carbon soot in the particulate filter, the exhaust gas pressure rises before the filter due to a lower flow volume.

The exhaust gas pressure behind the filter remains almost the same. The membrane changes its shape depending on the difference in pressure.

This deformation alters the electrical resistance of the piezo elements, which are connected to form a test bridge. The output voltage of this test bridge is processed, amplified and sent by the sensor electronics as a signal voltage to the engine control unit. From this signal, the engine control unit calculates the level of carbon soot deposit in the particulate filter and initiates regeneration to clean the filter.

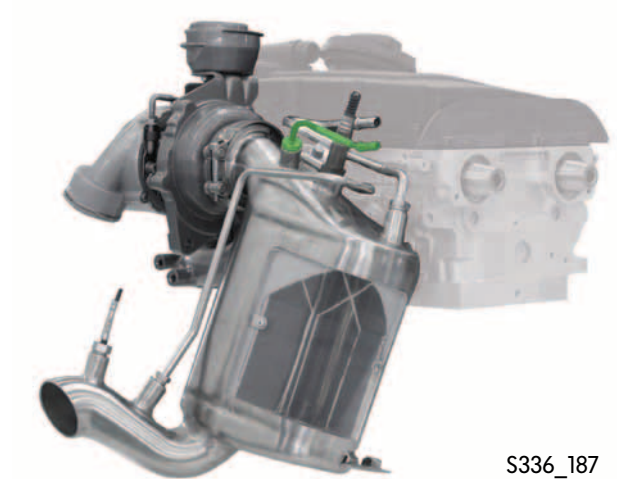


The level of carbon soot deposit in the particulate filter can be checked using vehicle diagnosis, testing and information system VAS 5051 in a measured value block as "particulate load coefficient".



Sensors and actuators

Temperature sender before particulate filter G506



The temperature sender before particulate filter is a PTC sensor. On a sensor with PTC (positive temperature coefficient), resistance rises as temperature increases.

It can be found in the exhaust system before the diesel particulate filter. There it measures the temperature of the exhaust gas.

Signal application

Using the signal from the temperature sender before and after particulate filter, the engine control unit calculates the exhaust gas volume in order to determine the level of carbon soot deposit in the particulate filter.

The signals from the temperature senders before and after particulate filter, the signal from the air mass meter and the signal from the exhaust gas pressure sensor form an inseparable unit during calculation of the level of carbon soot deposit in the particulate filter.

Furthermore, the signal is used as a form of component protection to protect the particulate filter against high exhaust gas temperatures.

Effects of signal failure

In the event of signal failure from the temperature sender before particulate filter, the particulate filter regeneration cycle will be based on the distance travelled or the number of hours in operation.

This cycle for particulate filter regeneration, however, is not effective over a long period of time. After a predetermined number of cycles, the diesel particulate filter warning lamp will light up and then the preglow control lamp will flash in the dash panel insert. This informs the driver that the vehicle must be driven to a workshop.

Temperature sender after particulate filter G527



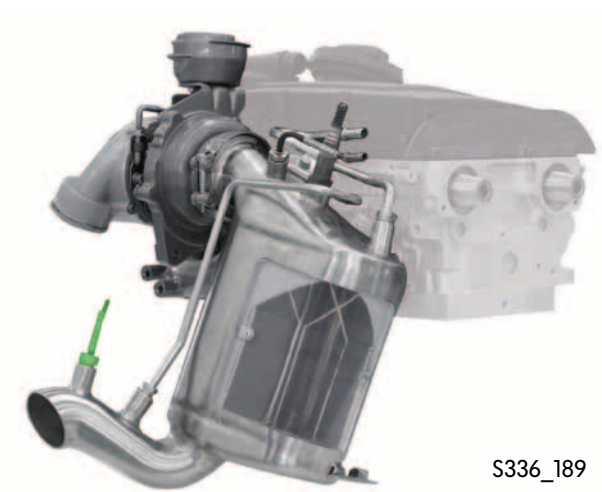
The temperature sender after particulate filter is a PTC sensor.

Signal application

The engine control unit uses the signal from the temperature sender after particulate filter to regulate the injection volume for extended injection at overrun.

The higher the exhaust gas temperature after particulate filter, the lower the injection volume.

The signal from the temperature sender is used as a form of component protection to safeguard the particulate filter against high exhaust gas temperatures.



It can be found in the exhaust system after the diesel particulate filter. There it measures the temperature of the exhaust gas.

Effects of signal failure

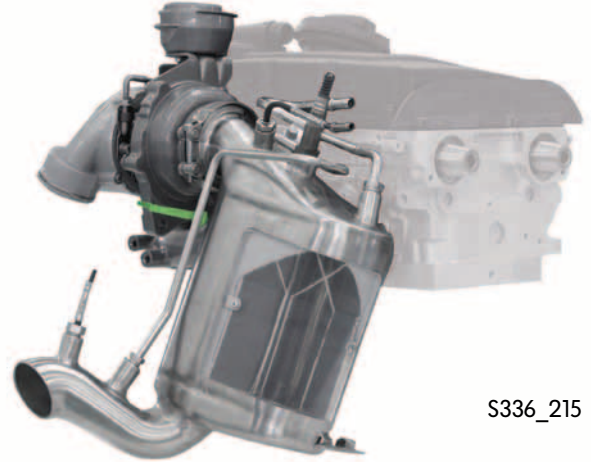
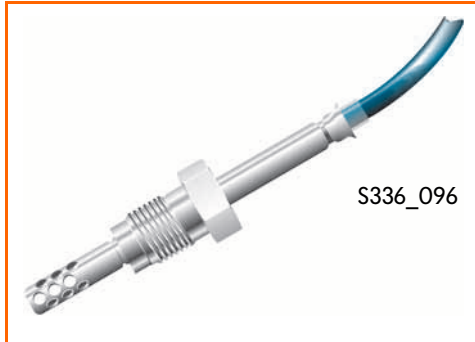
In the event of signal failure from the temperature sender after particulate filter, the particulate filter regeneration cycle will be based on the distance travelled or the number of hours in operation.

This cycle for particulate filter regeneration, however, is not effective over a long period of time. After a predetermined number of cycles, the diesel particulate filter warning lamp will light up and then the preglow control lamp will flash in the dash panel insert. This informs the driver that the vehicle must be driven to a workshop.



Sensors and actuators

Temperature sender before turbocharger G507



The temperature sender before turbocharger is a PTC sensor. It can be found in the exhaust system before the turbocharger. There is measures the temperature of the exhaust gas.

Signal application

The engine control unit requires the signal from the temperature sender before turbocharger to calculate start of injection and the quantity of extended injection for regeneration. In this way, the required temperature increase for combustion of the carbon soot particles is reached. In addition, the signal is used to protect the turbocharger against excessively high temperatures during regeneration.

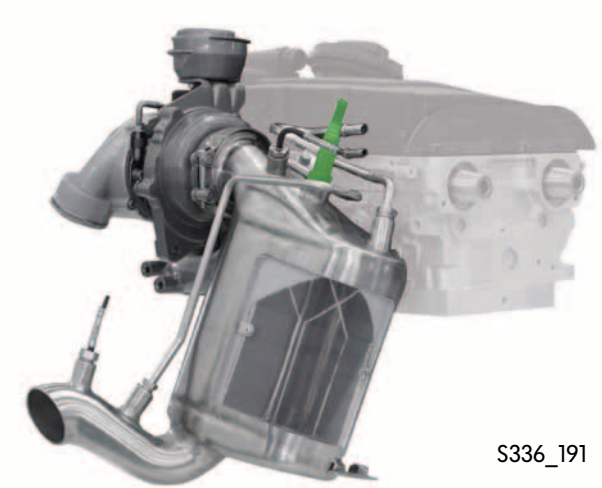
Effects of signal failure

In the event of failure from the temperature sender before turbocharger, the turbocharger can no longer be protected against excessively high temperatures. Regeneration of the diesel particulate filter is stopped. By means of the preglow control lamp, the driver is informed that the vehicle should be driven to a workshop. To reduce the carbon soot emissions, exhaust gas recirculation is switched off.

The lambda probe G39



The lambda probe is of the broadband type. It can be found in the exhaust manifold before the oxidising catalytic converter.



Signal application

With the lambda probe, the percentage of oxygen in the exhaust gas can be determined across a wide measuring range. In conjunction with the diesel particulate filter system, the engine control unit uses the signal from the lambda probe for precise calculation of the quantity and start of extended injection for regeneration. For effective regeneration of the particulate filter, a minimal percentage of oxygen in the exhaust gas is required at a continually high exhaust gas temperature. This regulation is made possible by the signal from the lambda probe in conjunction with the signal from the temperature sender before turbocharger.

Effects of signal failure

Regeneration of the particulate filter is not as efficient but remains functional.
In the event of lambda probe failure, there could be an increase in nitrogen oxide emissions.



Detailed information about the broadband lambda probe can be found in self-study programme no. 231 "Euro onboard diagnosis for petrol engines".



Sensors and actuators

Air mass meter G70

The hot film air mass meter is installed in the intake manifold. Using the air mass meter, the engine control unit can determine the actual mass of intake air.



S336_220

Signal application

In conjunction with the diesel particulate filter system, the signal is used for calculation of the exhaust gas volume in order to determine the level of carbon soot deposit in the particulate filter.

The signal from the air mass meter, the signals from the temperature senders before and after particulate filter and the signal from the exhaust gas pressure sensor form an inseparable unit during calculation of the level of carbon soot deposit in the particulate filter.

Effects of signal failure

In the event of signal failure from the air mass meter, the particulate filter regeneration cycle will be based on the distance travelled or the number of hours in operation.

This cycle for particulate filter regeneration, however, is not effective over a long period of time. After a predetermined number of cycles, the diesel particulate filter warning lamp will light up and then the preglow control lamp will flash in the dash panel insert. This informs the driver that the vehicle must be driven to a workshop.

Exhaust emissions warning lamp K83 (MIL)

The emissions relevant components of the diesel particulate filter system are checked for faults and malfunctions within the scope of the Euro onboard diagnosis (EOBD).

The exhaust emissions warning lamp (MIL = malfunction indicator lamp) shows the faults detected by EOBD.

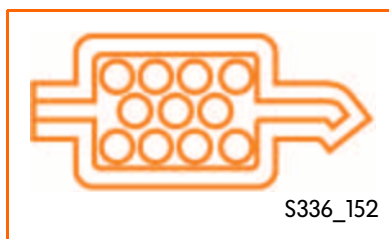


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Detailed information about the exhaust emissions warning lamp and the EOBD system can be found in self-study programme no. 315 "Euro onboard diagnosis for diesel engines".

Diesel particulate filter warning lamp V231



The diesel particulate filter warning lamp can be found in the dash panel insert. It lights up if the diesel particulate filter is subject to many short journeys, thus preventing regeneration.

Task

If the vehicle is driven frequently over short distances, regeneration of the diesel particulate filter can be impaired because the exhaust gas temperature does not reach the necessary level. Since regeneration cannot take place, there is a risk of the filter becoming damaged or blocked by carbon soot deposits. In order to avoid this, the diesel particulate filter warning lamp lights up in the dash panel insert if the carbon soot level reaches a certain threshold.

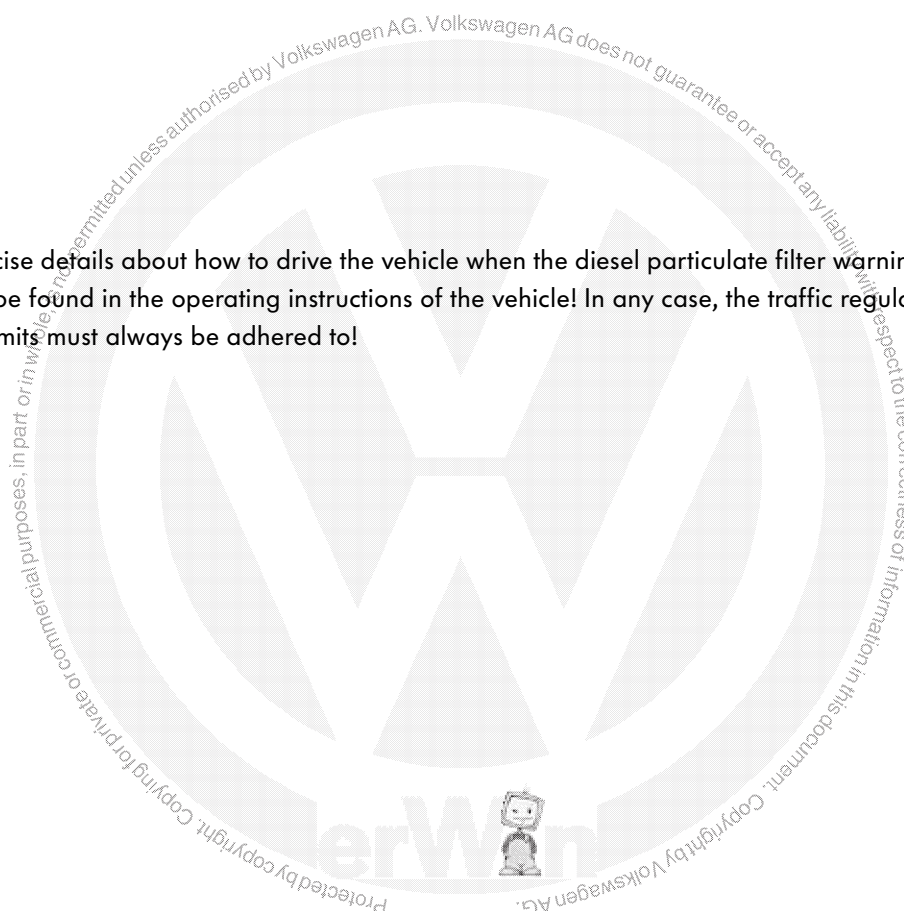


With this signal, the driver is requested to drive at more than 60km/h at a constant rate for a period of about 15 minutes. The filter can be cleaned most effectively if the vehicle is driven in 4th or 5th gear in a speed range of approximately 2000 rpm. The warning lamp must go out after this measure.

If the diesel particulate filter warning lamp does not go out after this measure, the preglow period warning lamp will light up and a message will be displayed in the dash panel insert saying "Engine damage - workshop" (or words to that effect). This informs the driver that the vehicle must be driven to the next workshop.

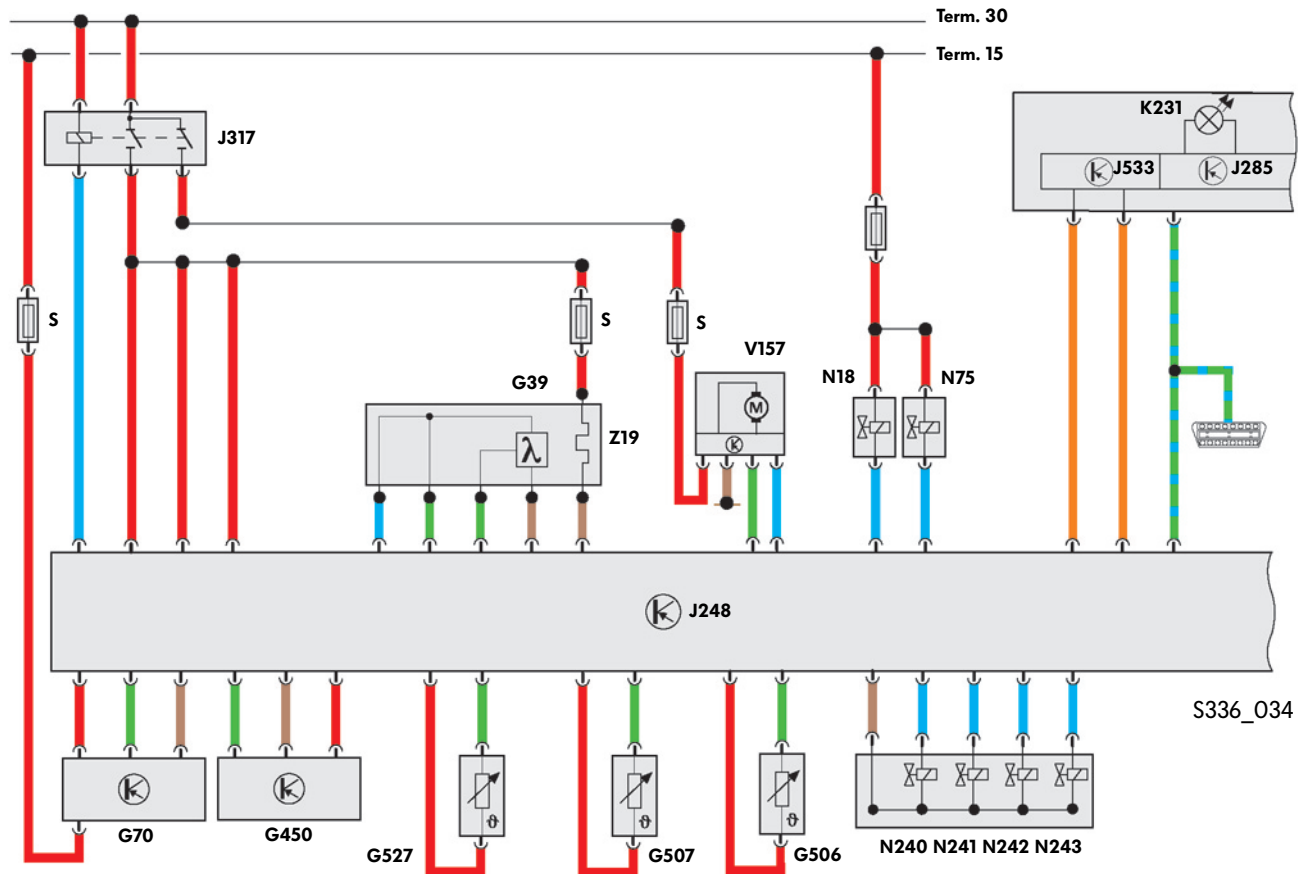


The precise details about how to drive the vehicle when the diesel particulate filter warning lamp lights up can be found in the operating instructions of the vehicle! In any case, the traffic regulations and speed limits must always be adhered to!



Functional diagram

Functional diagram



- | | | | |
|-----------|--|------|--|
| G39 | Lambda probe | N18 | Exhaust gas recirculation valve |
| G70 | Air mass meter | N75 | Charge pressure control solenoid valve |
| G450 | Exhaust gas pressure sensor 1 | V135 | Particulate filter additive pump |
| G506 | Temperature sender before particulate filter | V157 | Intake manifold flap motor |
| G527 | Temperature sender after particulate filter | Z19 | Lambda probe heater |
| G507 | Temperature sender before turbocharger | | |
| J248 | Diesel direct injection system control unit | | |
| J285 | Control unit in dash panel insert | | |
| J317 | Term. 30 voltage supply relay | | |
| J533 | Data bus diagnosis interface | | |
| K231 | Diesel particulate filter warning lamp | | |
| N240-N243 | Unit injectors | | |

Colour codes/key

- | | |
|---------------------------------------|-----------------|
| ■ | = Input signal |
| ■ | = Output signal |
| ■ | = Positive |
| ■ | = Earth |
| ■ | = CAN data bus |

Frequent short trips

For the regeneration process to be initiated in the diesel particulate filter, the exhaust gas temperature is increased by the engine management system.

In the event of frequent short trips, the exhaust gas temperature cannot reach a sufficient level. Regeneration cannot be carried out successfully. Subsequent regeneration procedures that are carried out with excessively high levels of carbon soot deposit can lead to overheating and damage to the particulate filter. The filter could become blocked due to a high level of carbon deposit. This blockage in the filter could cause the engine to fail.

In order to prevent these cases from happening, a diesel particulate filter warning lamp will be activated in the dash panel insert once a specific limit is reached in the filter storage capacity or after a certain number of unsuccessful regeneration procedures.

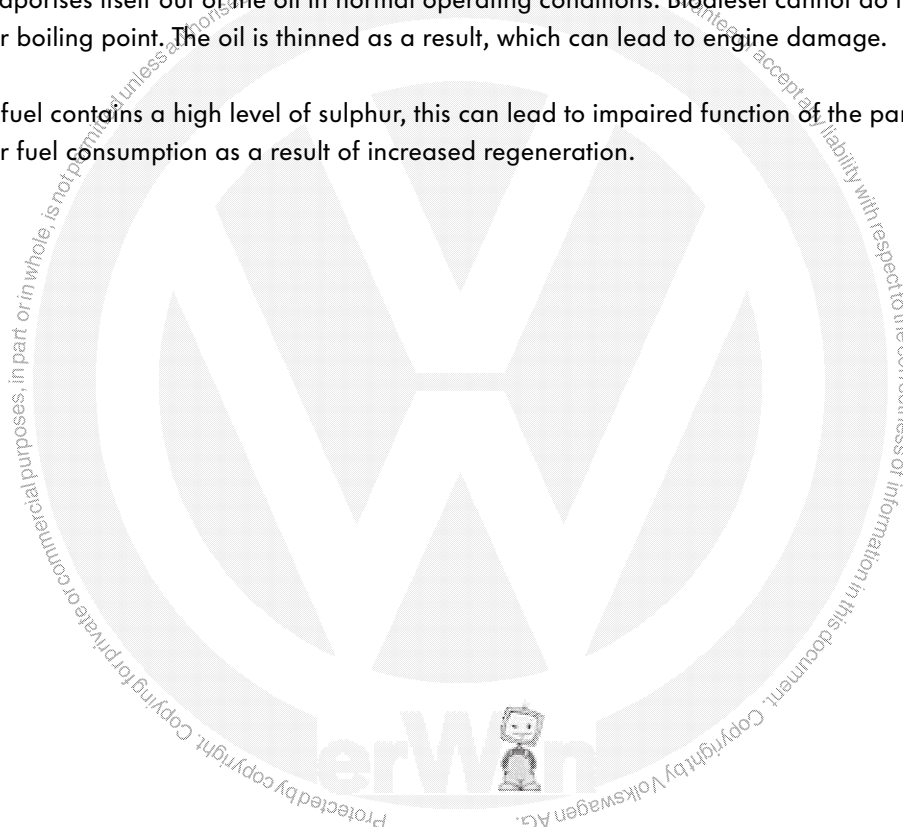
The driver is thereby requested to drive the vehicle at increased speed for a short period of time in order that the required exhaust gas temperature can be reached for purposes of diesel particulate filter regeneration.

The fuel quality

It should be noted that the quality of the fuel must meet the DIN standard as stipulated in the instruction manual.

Operation with biodiesel is not possible. The extended injection period for regeneration of the diesel particulate filter can lead to unburnt fuel on the cylinder wall entering the engine oil from the piston movement. Normal diesel fuel vaporises itself out of the oil in normal operating conditions. Biodiesel cannot do this effectively due to its higher boiling point. The oil is thinned as a result, which can lead to engine damage.

If the fuel contains a high level of sulphur, this can lead to impaired function of the particulate filter system with higher fuel consumption as a result of increased regeneration.



System limits

The emissions

When the regeneration cycle is active, there could be an increase in emissions. During regeneration, there is an oxidation process from carbon soot to carbon dioxide (CO₂). If there is not enough oxygen available during this process, carbon monoxide (CO) will also be formed.

By switching off the exhaust gas recirculation, the nitrogen oxide emissions increase slightly.

To determine the emissions content, an emissions test is carried out (NEDC - New European Driving Cycle). During this test, the values from the cycle are evaluated with and without regeneration. With the mean values, the vehicle must meet the EU4 emissions standard.



1. What is meant by "passive regeneration" of the diesel particulate filter?

- ☐ a) The carbon soot particles are collected and burnt off by induced combustion via VAS 5051 at the next service interval.
- ☐ b) The carbon soot particles are burnt off through targeted increase in the exhaust gas temperature by the engine management system.
- ☐ c) The carbon soot particles are burnt off continually without intervention by the engine management system.

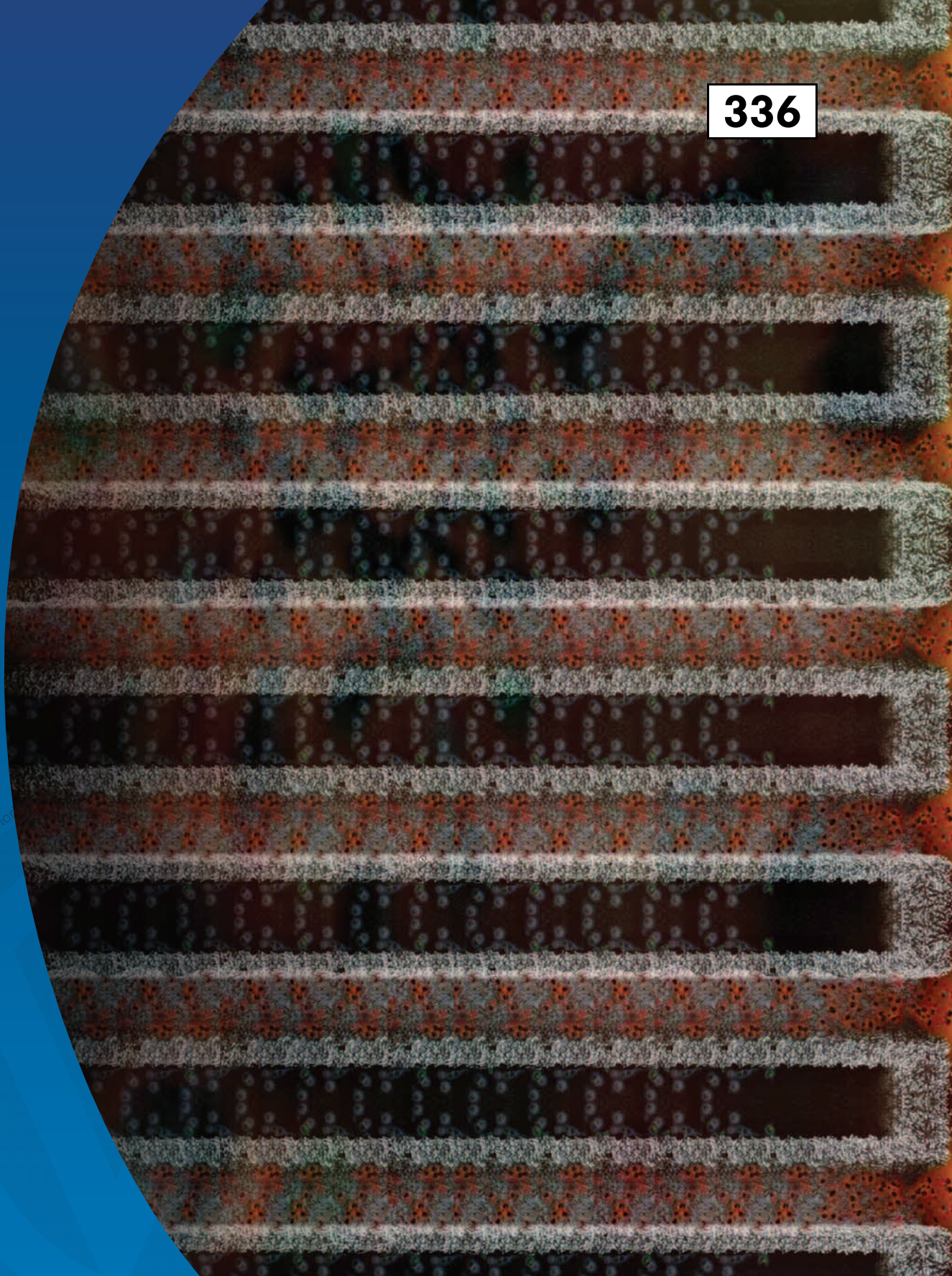
2. What role does the temperature sender after particulate filter G527 have?

- ☐ a) The engine control unit uses the signal from the temperature sender after particulate filter to regulate the injection volume for extended injection at overrun.
- ☐ b) The engine control unit calculates the pressure difference before and after particulate filter from the temperature sender signal.
- ☐ c) The signal from the temperature sender is used by the engine control unit to determine the rate of exhaust gas recirculation.

3. Which substance promotes combustion of the carbon soot particles in the catalytic coated diesel particulate filter during passive regeneration?

- ☐ a) Additive
- ☐ b) Platinum
- ☐ c) Aluminium oxide
- ☐ d) Sulphur dioxide
- ☐ e) Silicon carbide





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000.2811.51.20 Technical status 02/05

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