Service.

Self-Study Programme 230

Motor Vehicle Exhaust Emissions

Composition, emission control, standards, etc.

Basics

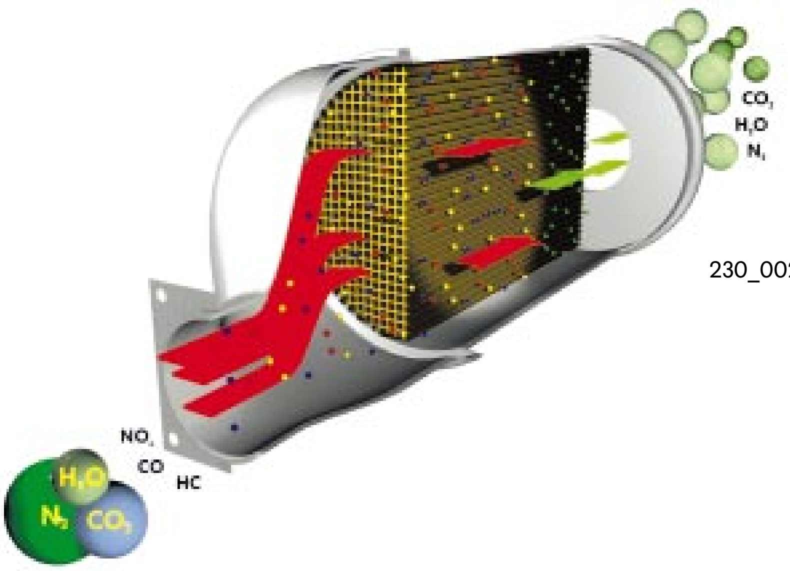
The exhaust emissions of various engines, systems and vehicles are mentioned and analysed in training documents more often now. The Lupo 3L TDI in particular reflects the topic's relevance to the modern day, and has shown that not only legislators are pushing forward development but also the car industry, in particular Volkswagen AG.

The environmental policy debate on the automobile of the next millennium will centre on three topics:

- Exhaust emissions
- Fuel consumption
- Noise emission

In this Self-Study Programme, therefore, we will provide you with detailed information about motor vehicle exhaust emissions.
In addition to automotive technology, this SSP will contain further information on such subjects as measuring methods and standards.

The standards and laws laid down by the government are changing continuously. We will inform you about the latest developments in supplementary training documents.



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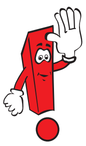
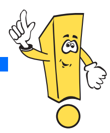
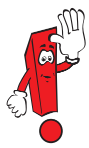


The data specified in this Self-Study Programme, referred to the growth in private cars and freight transport, as well as fuel consumption in the Federal Republic of Germany, reflect the trends that are already apparent in other European countries.

New



Important Note



This Self-Study Programme explains the design and function of new developments.

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

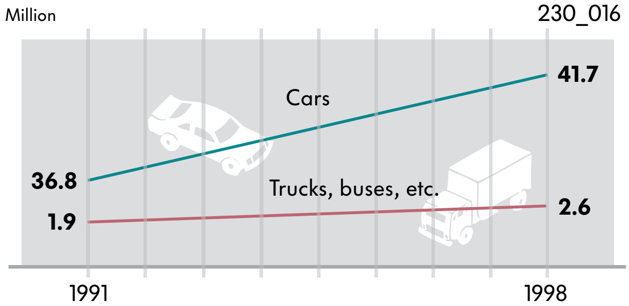
Table of Contents

Traffic growth

Mobile and flexible

The car has becomes more and more important. It is now a key factor in the "quality of life". It gives us personal mobility and sometimes expresses our social standing. On the other hand, it has also become a tool which we use to carry out everyday things.
It gives people the advantages of flexibility and locational freedom.

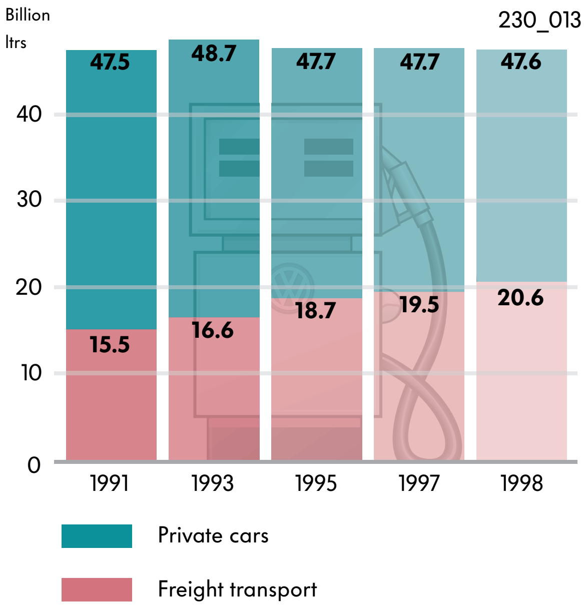
Registered vehicles (Germany)

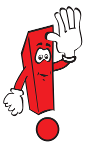


Similar requirements are also resulting in an increase in road freight transport.
Today, goods need to be transported and supplied just-in-time. Also, the road still offers the most flexible infrastructure despite its heavy use.

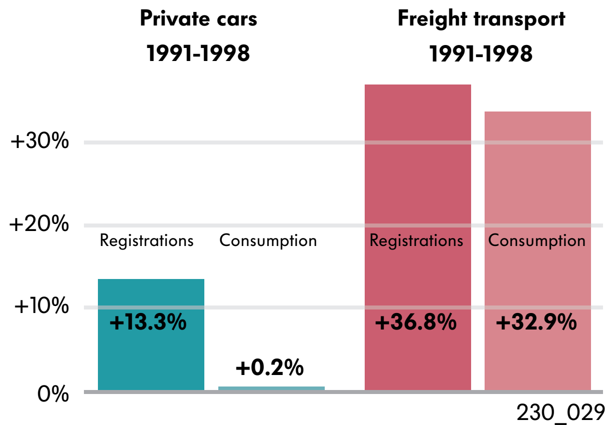
However, the interaction between the motor vehicle and the environment has become an increasingly important consideration.
Therefore, the onus is on the car industry to counteract the growing volume of traffic by developing new products in ever quicker succession. It will be necessary to continue to reduce globally the emission of environmentally toxic exhaust gas constituents in future.

Fuel consumption of private cars and freight transport (Germany)





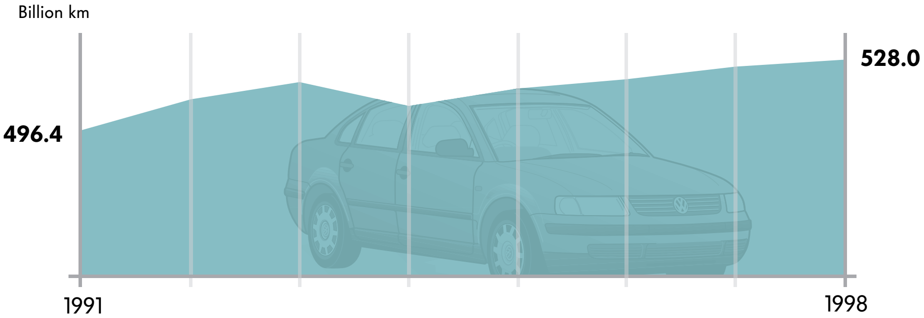
The comparison between registrations and fuel consumption with regard to private cars shows that fuel consumption has only risen minimally even though the number of registrations is rising.



Private cars

As mentioned already, the motor vehicle stock is growing constantly. In 1996, every second person in Germany owned a car.
This development has prompted legislators to by set more stringent standards and tax laws as an incentive for the car industry and consumers alike to develop and buy more environmentally-friendly products.

Mileage of passenger cars (in km)
(Federal Republic of Germany)



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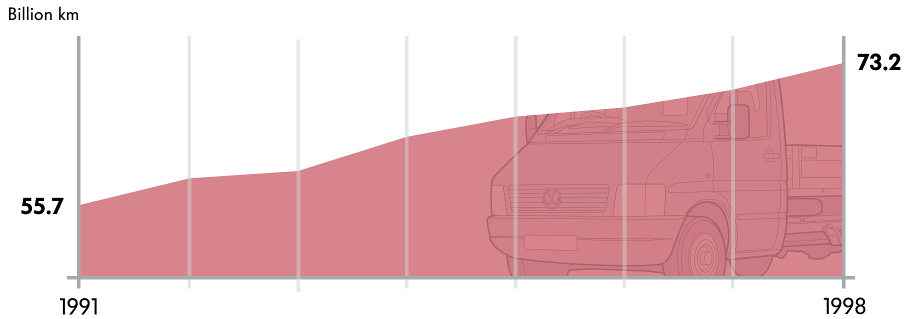
Freight transport

Road freight transport is also growing constantly and is still taking market share away from other means of transport. In 1998, the competing transport modes (rail and shipping) had a share of only 29% in total freight traffic volume, compared with a share of 67% by road freight transport. In this sector, too, there is a need for eco-friendly developments.

Mileage of road freight transport (trucks, buses, etc.)(in km)
(Federal Republic of Germany)



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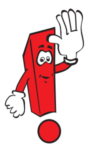
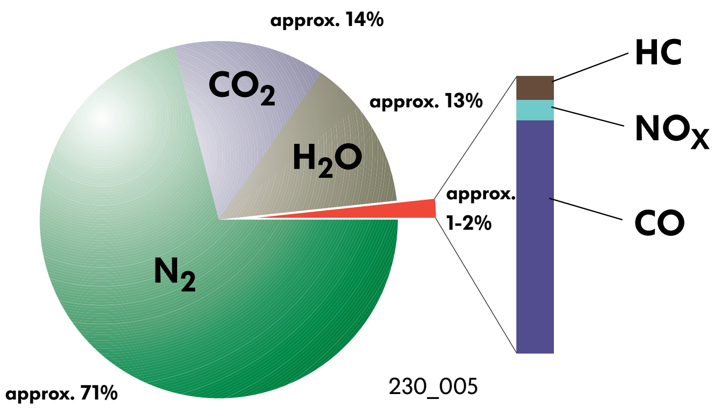


With regard to private transport, consumption figures have risen by only 0.2% even though mileage has risen by 6%.

Exhaust components

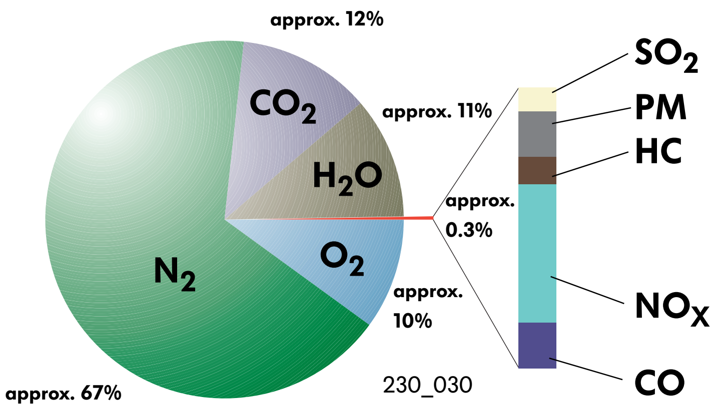
Summary

In the discussions on the constitution of motor vehicle exhaust emissions, the same terms are used repeatedly: carbon dioxide, nitrogen oxide, particulate matter or hydrocarbons. In this connection, mention is rarely made of the fact that these substances constitute only a fraction of total exhaust gas emissions. Therefore, we will show you the approximate composition of the exhaust emissions of diesel and petrol engines before describing the individual exhaust gas components.



Composition of exhaust emissions of petrol engines

Petrol engines may also emit small quantities of sulphur dioxide SO_2 .



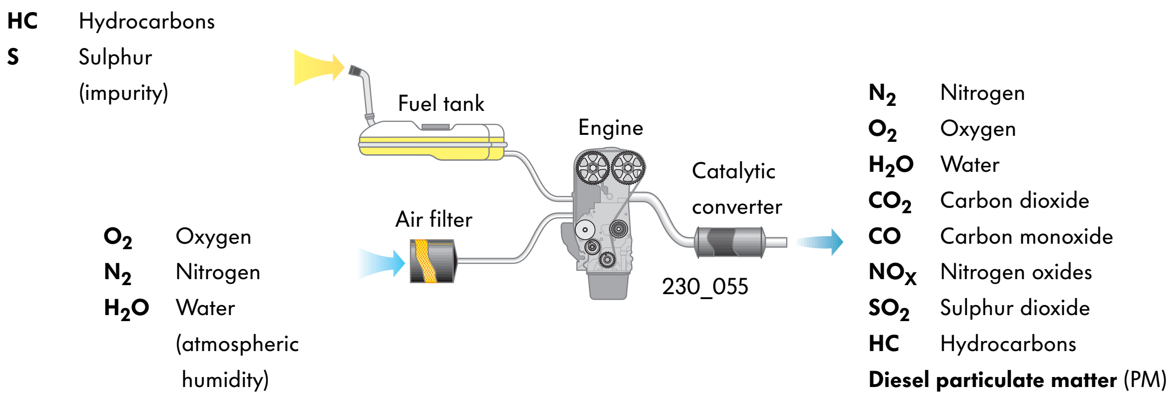
Composition of exhaust emissions of diesel engines

N_2	Nitrogen
O_2	Oxygen
H_2O	Water
CO_2	Carbon dioxide
CO	Carbon monoxide
NO_X	Nitrogen oxides
SO_2	Sulphur dioxide
Pb	Lead
HC	Hydrocarbons

Particulate matter (PM)

Intake and exhaust components of combustion

The following diagram shows a summary of the intake and exhaust components of the combustion cycle which takes place in the engine.



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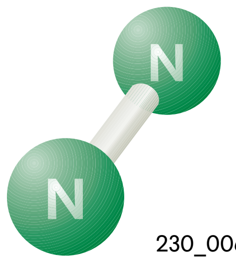
Description of exhaust gas components

● N_2 – Nitrogen
is a non-flammable, colourless and odourless gas.
Nitrogen is an elementary constituent of the air we breathe (78% nitrogen, 21% oxygen, 1% other gases), and is transported into the combustion chamber in the intake air. The largest proportion of the nitrogen induced is again discharged in pure form in the exhaust gases. Only a small proportion of the nitrogen combines with oxygen O_2 to form oxides of nitrogen NO_X.



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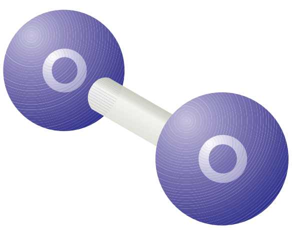

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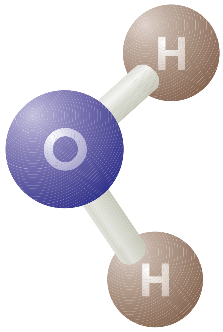
● O_2 – Oxygen
is a colourless, odourless and tasteless gas. It is the primary constituent of the air we breathe (21%).
Oxygen, like nitrogen, is drawn in through the air filter.

Composition

● H_2O – Water
is partly induced by the engine (atmospheric humidity) or occurs during low-temperature combustion (warm-up period).
Water is a harmless exhaust gas component.



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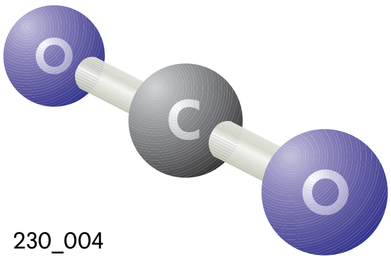
● CO_2 – Carbon dioxide
is a colourless, non-flammable gas. It is produced by the combustion of fuel containing carbon (e.g. petrol, diesel). Carbon combines with oxygen induced into the engine.
The debate on climatic change (global warming) has increased public awareness to the subject of CO_2emissions.
Carbon dioxide CO_2 depletes the ozone layer which protects the earth against the sun's UV rays (greenhouse effect).



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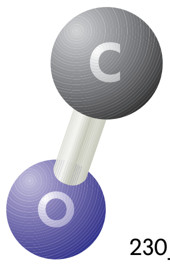
● CO – Carbon monoxide
results from the incomplete combustion of combustibles containing carbon. It is colourless, odourless, explosive and highly toxic. Carbon monoxide prevents red blood corpuscles (erythrocytes) from transporting oxygen. Even a relatively low concentration of carbon monoxide in the air we breathe is fatal. In normal concentrations in the open, carbon monoxide will oxidise to carbon dioxide CO_2 within a short period of time.



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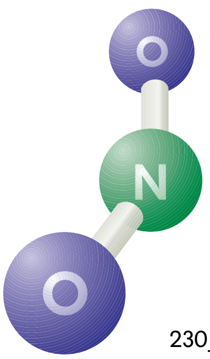
● NO_X – Nitrogen oxides
are compounds of nitrogen N_2 and oxygen O_2 (z. B. NO, NO_2, N_2O, etc.). Nitrogen oxides are produced by high pressure, high temperature and a surplus of oxygen in the engine during the combustion cycle. Several oxides of nitrogen are harmful to health.
Action taken to reduce fuel consumption has, unfortunately, often led to a rise in nitrogen oxide concentrations in exhaust emissions because a more effective combustion process generates higher temperatures. These high temperatures in turn mean higher nitrogen oxide emission.



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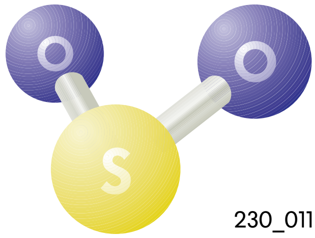
- SO_2 – Sulphur dioxide

is a colourless, pungent and non-flammable gas.
Sulphur dioxide causes respiratory illness, but only occurs in very low concentrations in exhaust gases.
Sulphur dioxide emission can be curbed by reducing the sulphur content in the fuel.



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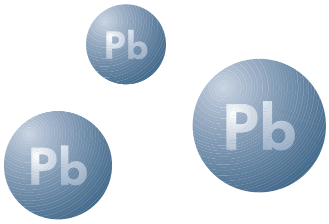
- Pb – Lead

has been completely eliminated from motor vehicle exhaust emissions. 3000 t were still released into the atmosphere in 1985 by the combustion of leaded fuel.
Lead in fuel prevents engine knock, which is caused by spontaneous ignition, and had a damping effect on the valve seats.
By using environmentally-friendly additives in unleaded fuel, it is now possible to largely preserve knock resistance.



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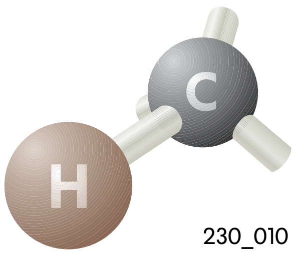
- HC – Hydrocarbons

are unburnt fuel components which occur in the exhaust emissions after incomplete combustion.
Hydrocarbons (HC) occur in a variety of forms (e.g. C_6H_6, C_8H_{18}) and each has different effects on the human organism. Some hydrocarbons irritate the sensory organs while others are carcinogenic (e.g. benzene).



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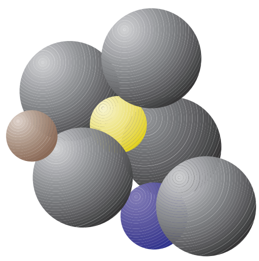
- Particulate matter PM

is mainly produced by diesel engines.

Research into the effects of particulate matter on the human organism is still inconclusive.



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Exhaust gas constitution

Development of exhaust gas composition

Development in general

In recent years, resolutions and laws aimed at curbing the emission of air pollutants have been passed, not only in the Federal Republic of Germany but also throughout Europe and the world. In this context, it has of course been necessary to place special emphasis on road traffic.
The more stringent exhaust emission standards which came into effect in the USA and Europe prompted the car industry to develop new and improved technologies for reducing and avoiding pollutants in exhaust gases.

Emissions of main exhaust gas components in road traffic from 1990 - 1998 (Federal Republic of Germany)

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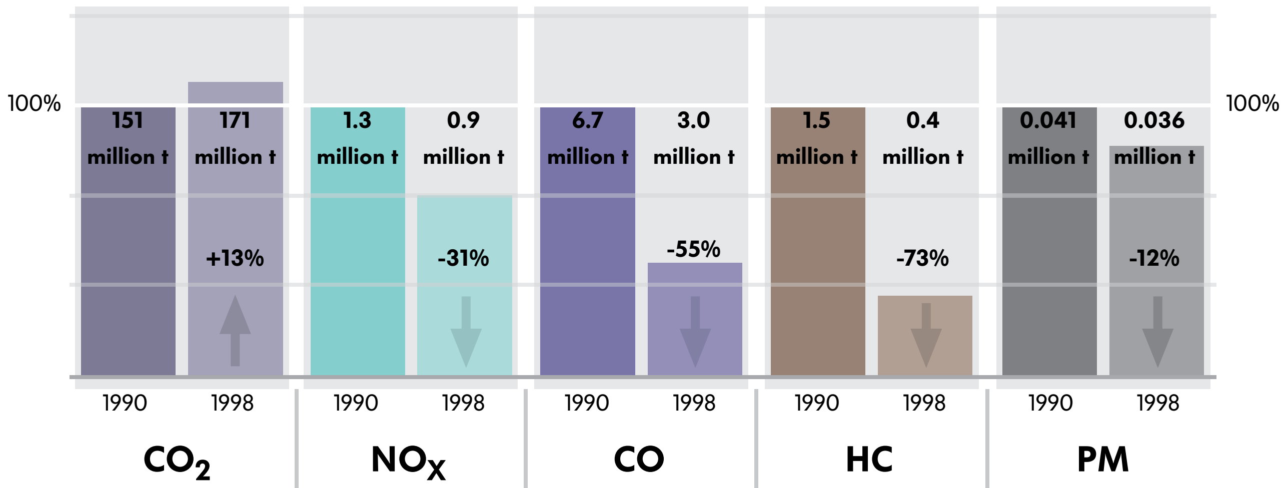


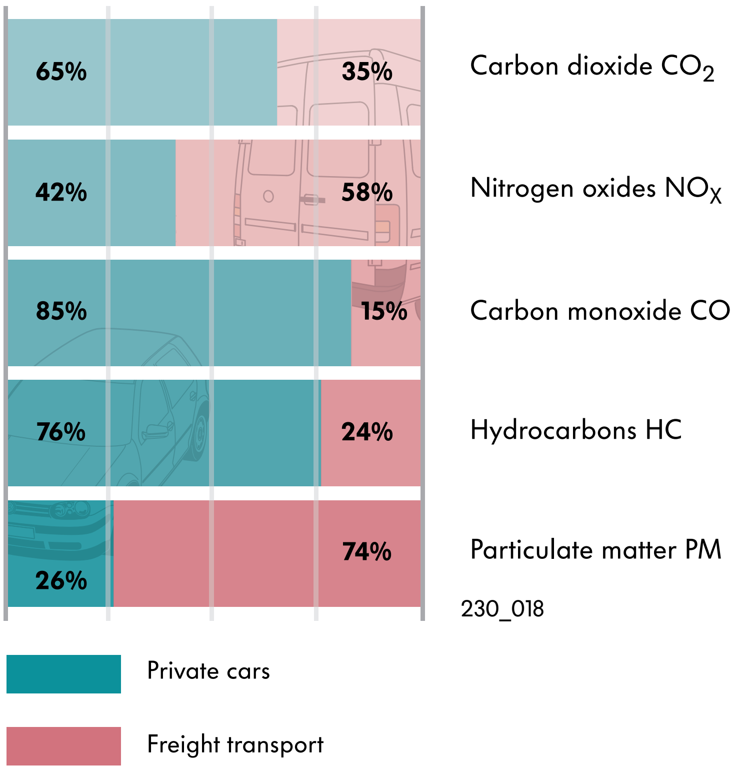
The development of exhaust gas quantity shows that air pollution attributable to road traffic decreased sharply between 1990 and 1998. The goals set by the government were in part even exceeded, and these reductions are expected to continue in the years ahead.

However, there is one exception: the growth in the amount of carbon dioxide CO_2. The emission of carbon dioxide CO_2 is proportional to the fuel consumption of a vehicle. Although new technologies have reduced fuel consumption, the increase in new vehicle registrations and the trend towards more powerful and heavier vehicles has cancelled out any positive developments in the recent past. The rate of growth in CO_2 emissions is now decreasing and it looks as though the rising curve may be reversible in future.

Comparison between car and trucks

To develop future vehicles, it is important among other things to examine what vehicle group produces what exhaust gas components. Although freight transport can no longer match the new registration figures and mileage of private cars, trucks are largely responsible for the production of certain exhaust gas components. Through the use of heavy diesel engines, freight transport accounts for a large proportion of nitrogen oxide (NO_X) and particulate matter (PM) emissions.

Proportions of main exhaust gas components in road traffic in 1998 (Federal Republic of Germany)



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Reduction

Nowadays, the development of individual automotive technologies alone is not enough to reduce certain exhaust gas components and fuel consumption. The answer, therefore, is to look at vehicles as an integral whole and match all the automotive components to one another. Taking this holistic approach to vehicle development as a basis, three main exhaust emission control strategies can be defined:

- Reduction of consumption
- Exhaust gas treatment
- Performance monitoring

The following sections will explain these terms and what action they entail.

Reduction of fuel consumption

Aerodynamics

The drag coefficient of aerodynamic vehicle shapes is low. Lower drag means lower fuel consumption.
In the past few decades, Volkswagen has succeeded in reducing the drag coefficient of its vehicles to less than 0.30 from over 0.45. This is a major step forward especially when you consider that approximately 70% of input power is required to overcome the aerodynamic drag when travelling at 100 kph.

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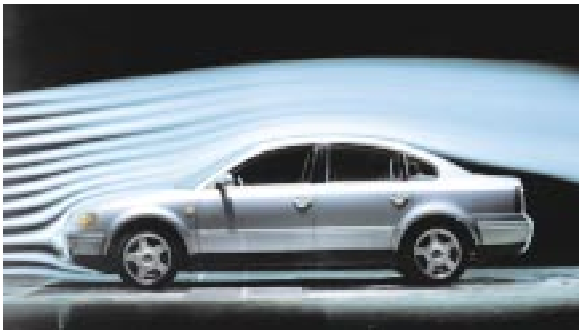

Weight savings

Safety standards and rising comfort levels offset weight savings.
However, weight savings are necessary in order to reduce fuel consumption.
Take the Audi A8/A2 (Space Frame) and the Lupo 3L TDI for example. In these vehicles, light-weight materials (aluminium, magnesium) are used in body construction.

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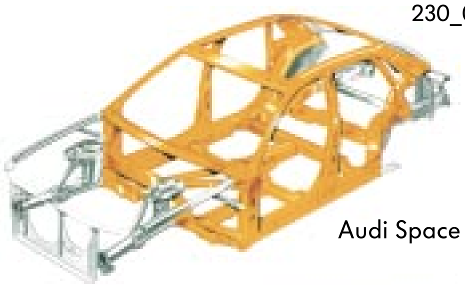

Audi Space Frame

Lupo 3L TDI

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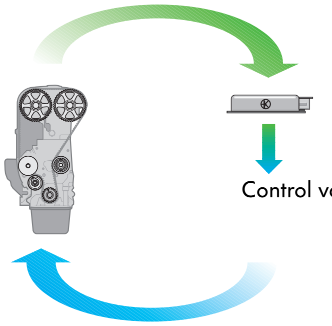
Engine management control loop



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Engine management system

Today's engine management systems have the ability to influence all controllable components (final control elements) of an engine. This means that all signals from the sensors (e.g. engine speed, air mass, charge pressure) are evaluated in the engine control unit and form control values for the controllable components (e.g. fuel injection quantity, injection timing, ignition advance angle). As a result, the engine can be controlled as a factor of load and the combustion process can be optimised.

Engine and gearbox optimisation

Engine and gearbox construction has a major bearing on vehicle fuel efficiency.
In engines, for example, modern injection systems are important for fuel-efficient combustion:
- Pump injector-technology used in the diesel (TDI)
- Direct injection in the petrol engine (FSI)
In the gearbox, it is necessary to adapt the gear ratios to the size and weight of the vehicle. In addition, 6-speed gearboxes are now in use. They allow the engine to operate in its optimal RPM range most of the time to obtain the best fuel economy.


230_021

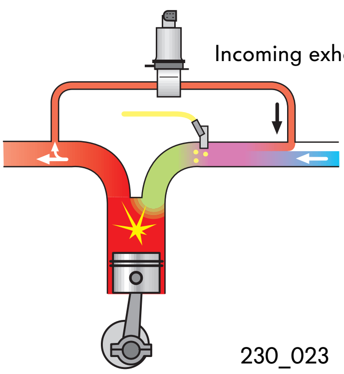
Engine-gearbox assembly used in the Lupo 3L TDI

Fuel tank purging

To prevent petrol vapour (hydrocarbons) from escaping into the environment, the evaporated petrol from the fuel tank is accumulated in an activated charcoal canister and combusted in a controlled manner.

Exhaust gas recirculation

In modern engines, the exhaust gas recirculation system is used firstly to reduce engine air intake and, secondly, to utilise the positive effect of the exhaust gas on the combustion process in defined driving situations.



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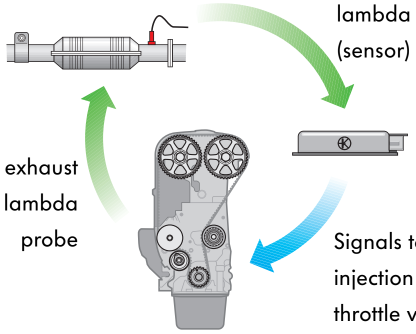
Reduction

Exhaust gas treatment

Catalytic converter (petrol engine)

Nowadays, the exhaust gases of petrol engines are treated by catalytic converters.
The catalytic cleaning process is controlled by the engine control unit.
The lambda probe signals to the engine control unit the oxygen content in the exhaust gases, and the engine control unit adjusts the fuel/air mixture to a ratio of lambda=1.

Lambda control loop



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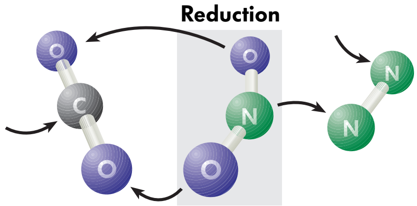
The catalytic converter is able to clean the exhaust gases at a temperature of approximately 300°C or higher and needs a certain amount of time to heat up after a cold start. To shorten the warm-up phase and clean exhaust gases more quickly, primary catalytic converters are used in modern exhaust systems. They are located near to the exhaust manifold. They are normally small in size, and so reach their operating temperature more quickly.

The catalytic cleaning processes involves two chemical reactions:
1. Reduction – Oxygen is withdrawn from the exhaust gas components.
2. Oxidation – Oxygen is added to the exhaust gas components (secondary combustion).

Reduction



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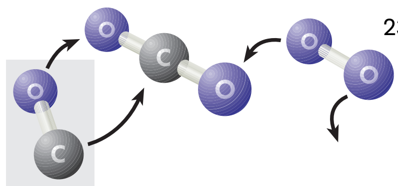
Nitrogen oxides NO_X are reduced to form carbon dioxide CO_2 and nitrogen N_2.

Oxidation



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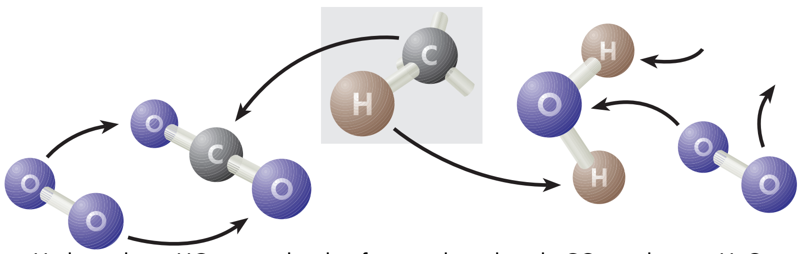
Carbon dioxide CO is oxidised to form carbon dioxide CO_2.

Oxidation



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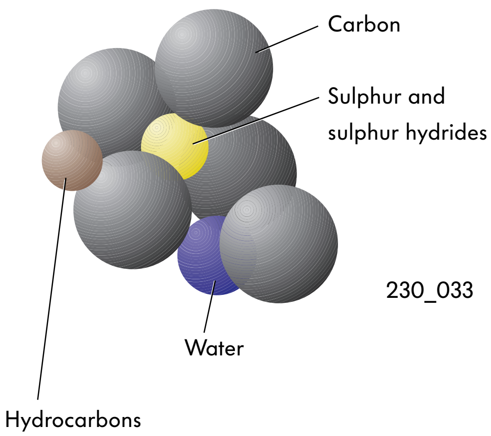
Hydrocarbons HC are oxidised to form carbon dioxide CO_2 and water H_2O.

Catalytic converter (diesel engine)

The diesel engine operates with a surplus of oxygen in the fuel/air mixture. Therefore, oxygen content need not be controlled by the lambda probe, and an oxidation catalytic converter undertakes the task of catalytic cleaning by using the high residual oxygen level in the exhaust gas.

This means that catalytic exhaust gas treatment is not controlled in the diesel engine and that the oxidation catalytic converter can only convert oxidisable exhaust gas components.
As a result, the concentrations of hydrocarbons (HC) and carbon dioxide (CO) are substantially reduced. However, the nitrogen oxide components in the exhaust gas can only be reduced by design improvements (e.g. combustion chambers and injection systems).

The main constituents of particulate matter (PM)



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The particulate matter typically emitted by a diesel engine comprises a core and several attached components, of which only the hydrocarbons (HC) are oxidised in the oxidation catalytic converter. The residues of the particulate matter can only be collected by special particulate filters.

Performance control

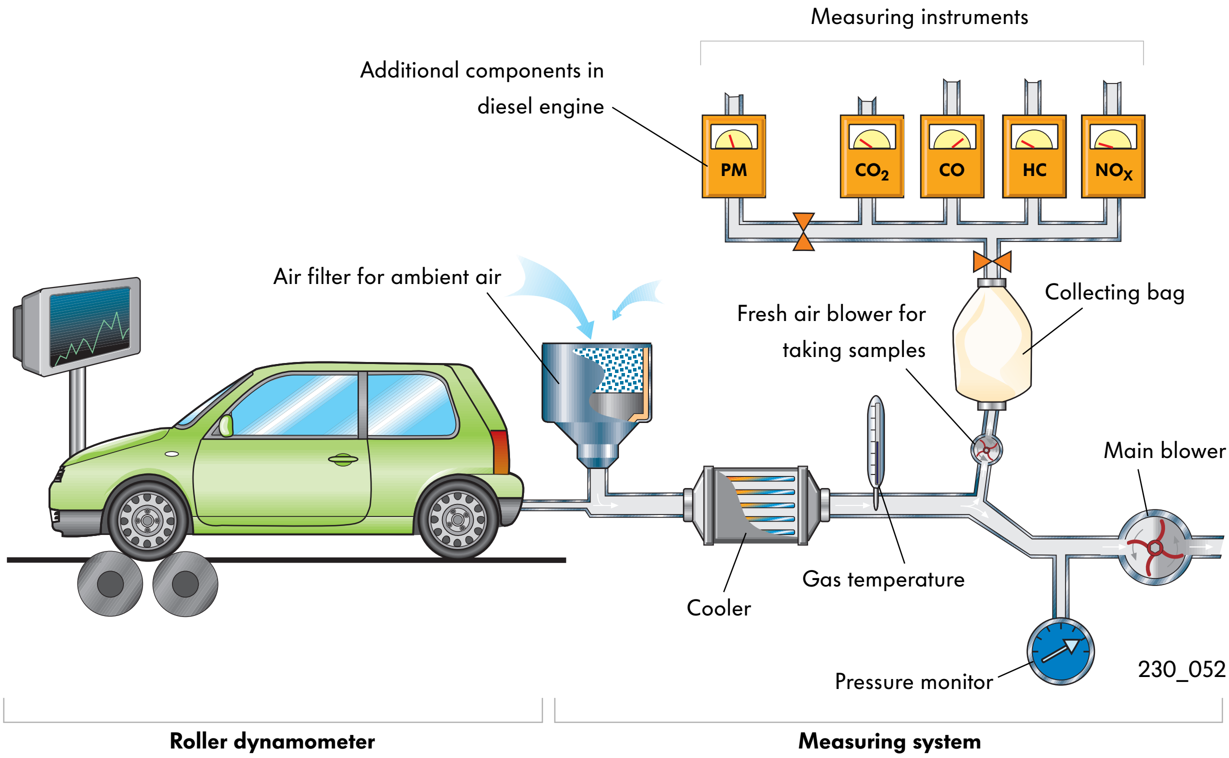
You will already be familiar with the performance control of all automotive components and systems relevant to exhaust emissions under the term "On-Board Diagnosis“. This concept was coined in California in 1988. The European variant of this diagnosis concept is called "Euro On-Board Diagnosis (EOBD)“ and is required by the government for homologating new vehicles of the automobile industry since the start of 2000.

Faults which impair the emission behaviour of a vehicle are indicated by self-diagnosis fault warning lamp K83. Faults and various other items of information can be read out at the diagnosis interface using a generic OBD visual display unit or Vehicle Diagnostic, Testing and Information System VAS 5051.

Measuring methods

Implementation

For homologation purposes, the exhaust emissions of a vehicles are determined on a roller dynamometer by using a prescribed measuring system. For this purpose, a defined driving cycle is implemented on the roller dynamometer and the measuring system records the quantity of exhaust gas components. Type approval must be performed by the automobile industry before it brings a new vehicle onto the market.



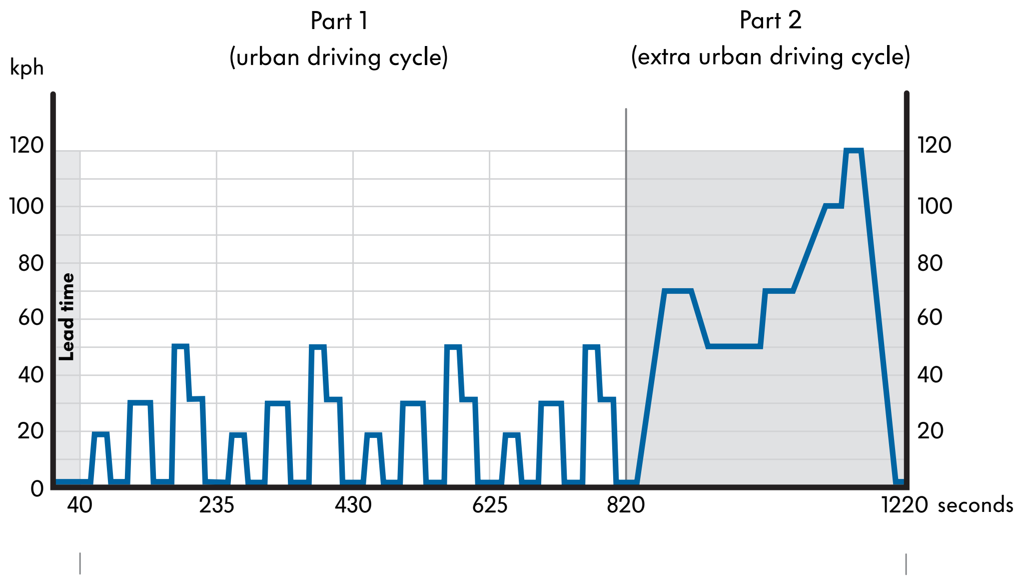
Function

- The driving cycle is executed on the roller dynamometer.
- While this cycle is under way, the main blower induces exhaust gas together with the filtered ambient air in a steady air mass flow. This means that the amount of air-exhaust gas mixture induced stays constant. When the vehicle produces higher exhaust emissions (e.g. during an acceleration phase), less ambient air is induced. When the vehicle produces lower exhaust emissions, more ambient air is drawn in.
- A constant quantity of this air-exhaust gas mixture is withdrawn continuously and pumped into one or more collecting bags.
- The collected exhaust components are measured, referred to the total distance covered and output in grammes per kilometre.

Driving cycles

Europe: NECC (New European Driving Cycle) <u>with 40-second lead time</u>

This driving cycle was introduced in 1992 and will be replaced by a modified cycle on Jan. 1, 2000. A striking feature of this driving cycle is the 40-second lead time before measurement of the exhaust emissions begins. This lead time can also be described as a "warm-up period".



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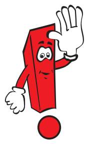
Characteristics

Cycle length:	11,007 km
Average speed:	33.6 kph
Maximum speed:	120 kph



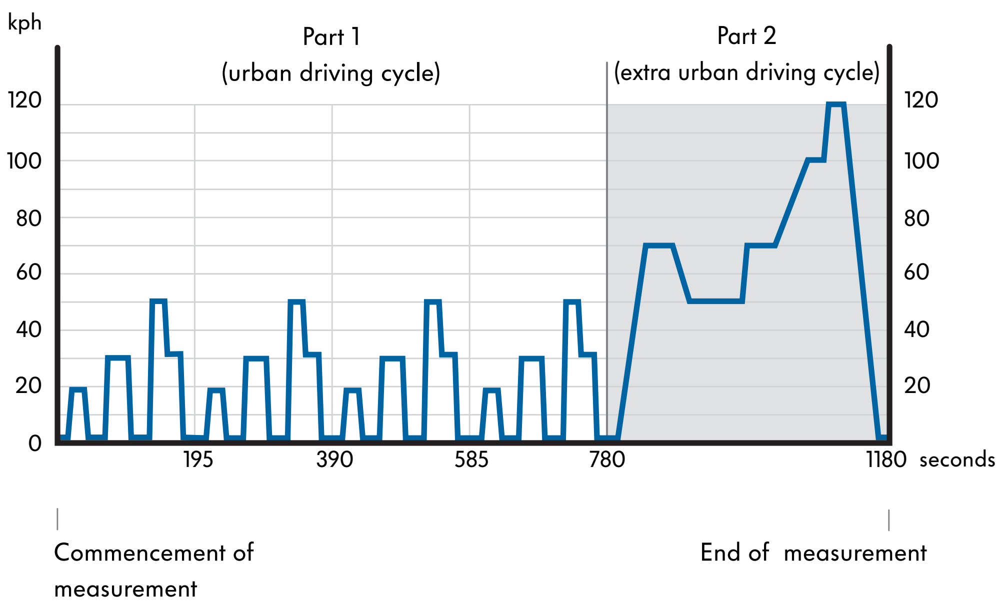
With regard to the NECC, the following terms have also come into use:

- **MVEG**-driving cycle
  The "**M**otor **V**ehicle **E**mission **G**roup" is a technical working party of the European Commission in charge of developing driving cycles.
- **ECE/EU** driving cycle

Measuring methods

Europe: NECC <u>without 40-second lead time</u>

When the EU III exhaust emission standard came into effect on Jan.1, 2000, the 40-second lead time was eliminated from the current driving cycle. The measuring cycle begins as soon as the engine is started.
The elimination of the lead time intensifies the measuring method because allowance is made in the test results for all exhaust components produced after a cold start while the catalytic converter heats up.



230_035

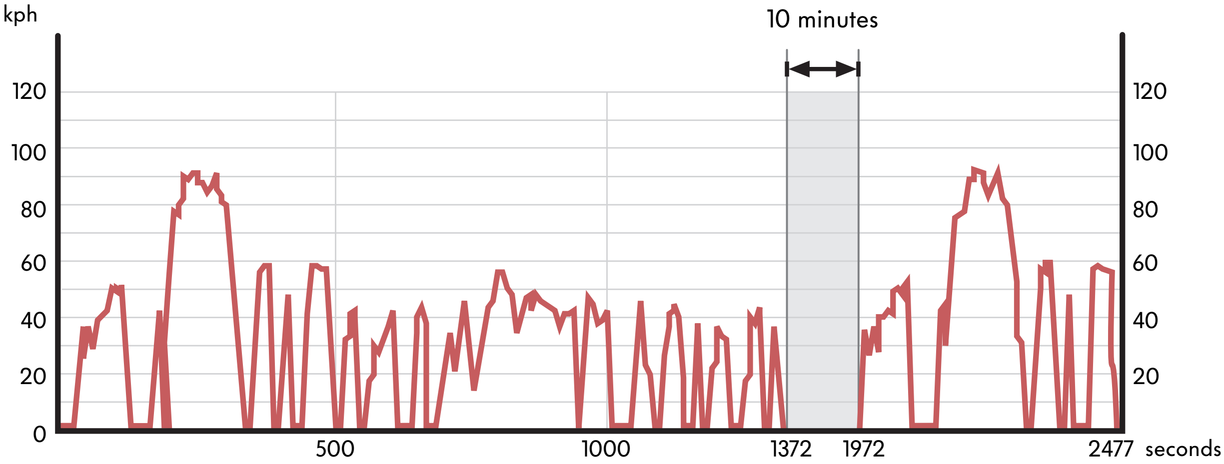
Characteristics

Cycle length:	11,007 km
Average speed:	33.6 kph
Maximum speed:	120 kph

USA: FTP 75 driving cycle

European exhaust emission limits are frequently compared with US exhaust emission limits because the USA has played a precursory role in the statutory reduction of exhaust emissions.
However, the following comparison of driving cycles shows that it is not possible to draw a direct comparison. Besides, test results in Europe are specified in grammes per kilometre (g/km) while test results in the USA are specified in grammes per mile (g/mile).

FTP 75 driving cycle

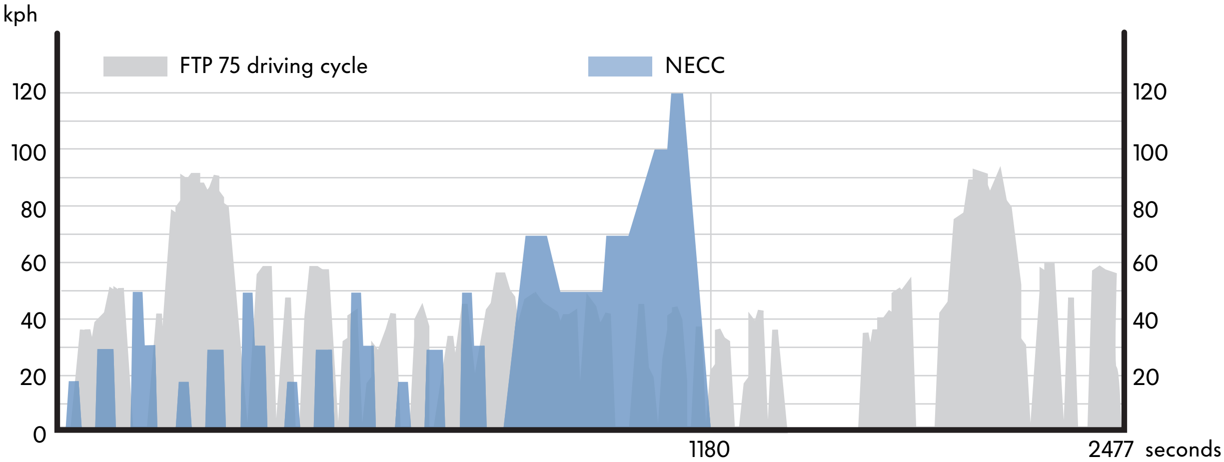


230_036

Characteristics

Cycle length:	17.8 km
Average speed:	34.1 kph
Maximum speed:	91.2 kph

To highlight the differences between the European NECC and the US FTP 75 driving cycle, the two curves are shown superimposed in the following diagram. The two cycles differ in respect of test duration, top speed, average speed, speed intervals and start-up phase.
The start-up phase in the FTP 75 driving cycle in particular is more intensive than in the NECC cycle because the vehicle can be driven at higher speeds after a cold start while the catalytic converter is heating up.



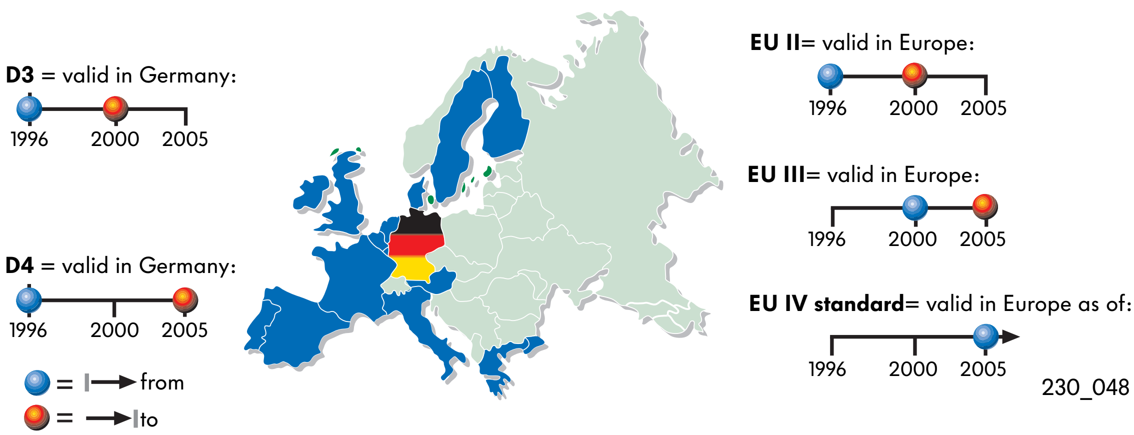
230_037

Standards and taxes

Standards for exhaust emissions

Having explained the measurement methods, we will now show you the limit values which vehicles are required to obtain type approval or be eligible for tax relief.

This Self-Study Programme is limited in scope to the standards of the European Union and the Federal Republic of Germany.



230_048

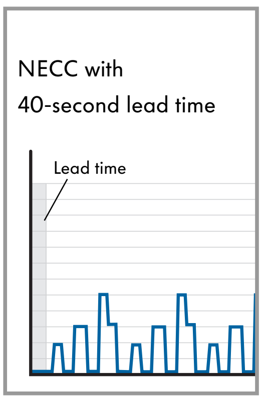
European standards

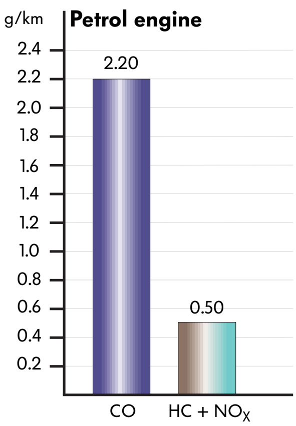
The European standards prescribe the limit values for type approval of new models in the car industry.

● EU II standard

The EU II standard includes the limit values valid for Europe up until 31.12.1999. These values were determined using the "NECC <u>with 40-second lead time</u>".

The exhaust components nitrogen oxides (NO_X) and hydrocarbons (HC) are still specified together.





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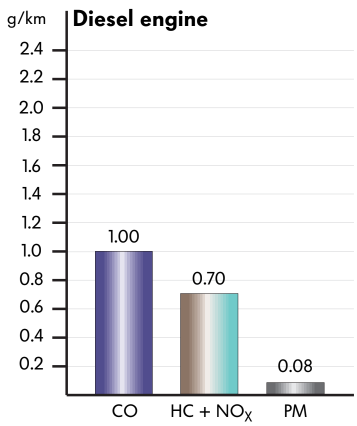
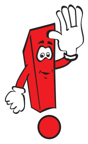


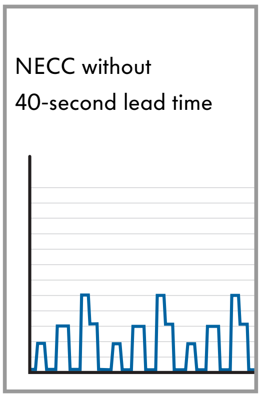
230_039

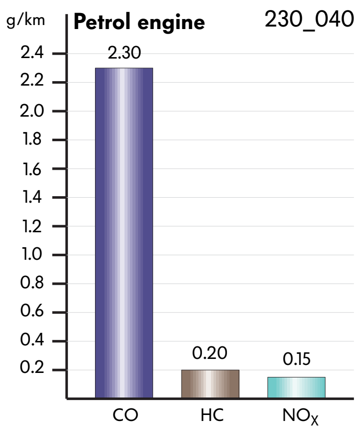
- EU III standard

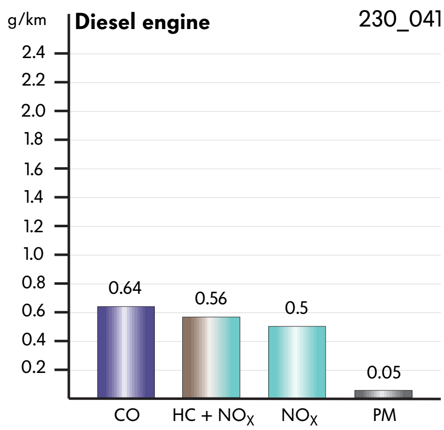
The EU III standard measured with the "NECC without 40-second lead time" came into force on Jan.1, 2000. The EU III standard replaced the EU II standard.
The exhaust components nitrogen oxides (NO_X) and hydrocarbons (HC) are included in the standard as separate limit values.



The carbon monoxide limit value (CO) seems to be higher than the limit value in the EU II standard. As the lead time has been eliminated from the driving cycle, the emissions are below the EU II level.

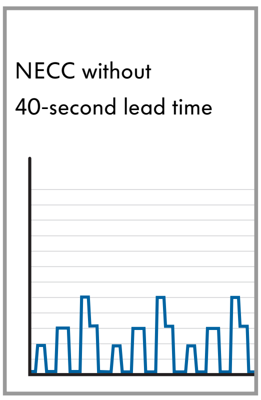


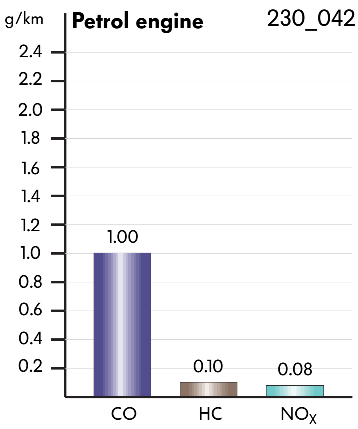


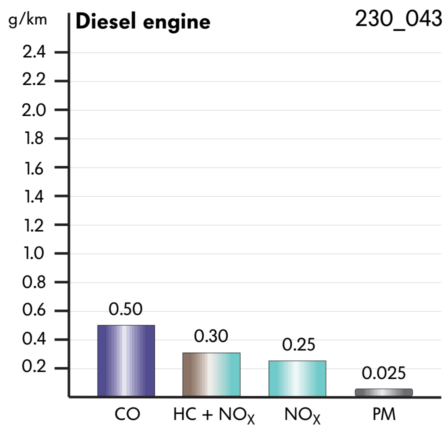


- EU IV standard

A further reduction in limit values will become effective in the year 2005 in connection with the EU IV standard. The EU IV standard supersedes the EU III standard.







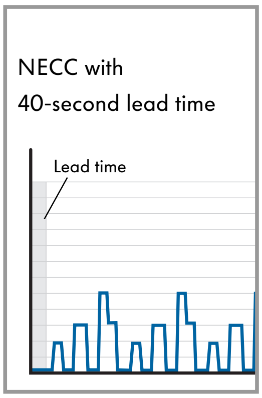
Standards and taxes

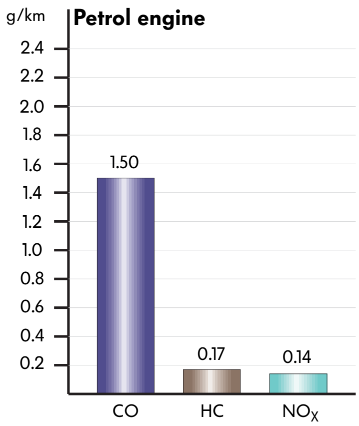
German standards

The German standards were introduced on a voluntary basis in order to promote the fulfilment of limit values which exceed the EU standards. This means that, if the customer buys a new vehicle that meets not only the current EU III standard but also the D4 emission standard, the state will provide tax assistance in the form of motor-vehicle tax relief (prior to Jan.1, 2000: EU II and D3, D4).

- D3 standard

The D3 standard, valid up until 31.12.1999, tightens up the EU II standard at national level. This standard is measured with the older cycle "NECC with 40-second lead time".





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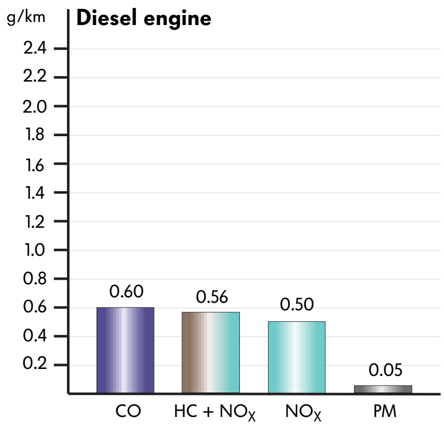

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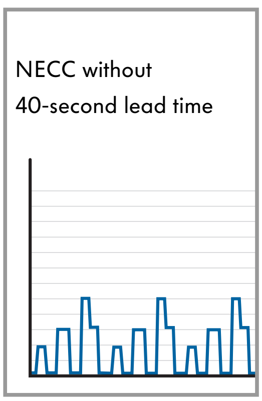
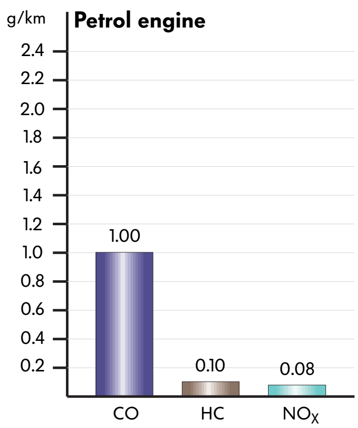
- D4 standard

The D4 standard is valid up until 31.12.2004. It stipulates more stringent limit values than the EU III standard and makes tax assistance possible. To homologate new models to the D4 standard, the automobile industry is required to perform the "NECC without 40-second lead time". This requirement came into effect on 31.01.1999.





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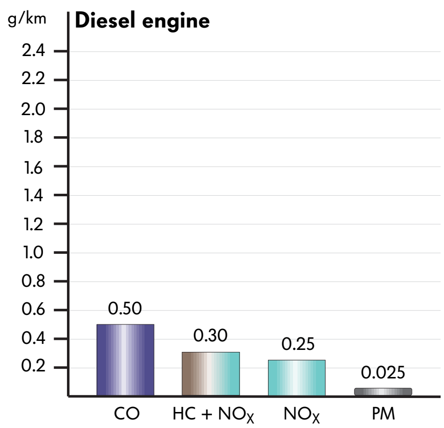


230_043

Tax relief in Germany

In addition to meeting defined exhaust emission standards, there is a second possible way to obtain eligibility for favourable tax treatment: CO_2 tax relief (3- and 5-litre cars).
Both possibilities for tax relief are described in the table below.

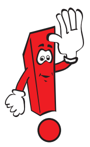
The code number in field 1 on the vehicle registration document denotes the exhaust emission standard which the vehicle meets.

Tax benefit for low emissions

Standard	Petrol engine	Diesel engine
D3 standard		
- Rate of taxation until December 31 2003 (per 100 cc)	DM 10.00	DM 27.00
- Rate of taxation as from January 1 2004 (per 100 cc)	DM 13.20	DM 30.20
D4 standard		
- Once-only tax benefit until December 31 2005	DM 600.00	DM 1200.00
- Rate of taxation until December 31 2003 (per 100 cc)	DM 10.00	DM 27.00
EU I standard		
- Rate of taxation until December 31 2000 (per 100 cc)	DM 13.20	DM 37.10
- Rate of taxation as from January 1 2001 (per 100 cc)	DM 21.20	DM 45.10
EU II standard		
- Rate of taxation until December 31 2003 (per 100 cc)	DM 12.00	DM 29.00
- Rate of taxation as from January 1 2004 (per 100 cc)	DM 14.40	DM 31.40
EU III & EU IV standard		
- Once-only tax benefit (UE IV) until December 31 2004	DM 600.00	DM 1200.00
- Rate of taxation until December 31 2003 (per 100 cc)	DM 10.00	DM 27.00
- Rate of taxation as from January 1 2004 (per 100 cc)	DM 13.20	DM 30.20

Tax benefit for low CO_2 emission

Designation	Petrol engine	Diesel engine
5-litre car Emission < 120g CO_2/km	DM 500.00	DM 500.00
3-litre car Emission < 90g CO_2/km	DM 1,000.00	DM 1,000.00



If both conditions - the exhaust emission standard and the CO_2 emission limits - are met, then the vehicle will be eligible for both types of tax relief.
The tax relief period definitely ends on 31.12.2005.

Standards and taxes

Example 1: Golf

2.0-litre 85 kW (115 bhp) petrol engine conforming to the D4 standard.

A customer buys this Golf on Jan. 1, 1999 and registers it in the Federal Republic of Germany. As the vehicle meets the D4 standard, the customer is entitled to DM 600.00 in tax relief. The Golf in our example has a 2-litre engine, i.e. the engine displacement is 2000 ccm. According to exhaust emission standard D4 (DM 10.00 per 100 cc), DM 200.00 is payable per annum for this vehicle.

In total, the customer is exempted from paying motor vehicle tax for 3 years (3 x DM 200.00 = DM 600.00).

Example 2: Lupo 3L TDI

1.2-litre 45 kW (60 bhp) diesel engine to D4 standard.

A customer purchases a Lupo 3L TDI on Jan. 1, 2000 and registers it in the Federal Republic of Germany. As the vehicle meets the D4 exhaust emission standard and is entitled to tax benefit for low CO_2 emission (3-litre car), the customer will be eligible to receive a tax relief of DM 1,200.00 (D4 standard) plus DM 1,000.00 (tax relief for low CO_2 emission). This makes a total of DM 2,200.00. The engine displacement of the Lupo in our example is 1,200 cc. According to exhaust emission standard D4 DM 27.00/as from Jan. 1, 2004: DM 30.20 per 100 cc), an annual sum of DM 324.00 or DM 362.40 is due for this vehicle.

In total, the customer should normally be exempted from payment of motor vehicle tax for a period of 78 months. Because the tax relief period definitely ends on 31.12.2005, there are only 72 months until the tax relief period expires.

Example 1: Golf

Level of tax relief = DM 600.00		
1999	**2000**	**2001**
Motor vehicle tax = DM 200.00	Motor vehicle tax = DM 200.00	Motor vehicle tax = DM 200.00

230_049

Example 2: Lupo 3L TDI

Tax relief = DM 2,020.80					
2000	**2001**	**2002**	**2003**	**2004**	**2005**
Motor vehicle tax DM 324.00	Motor vehicle tax DM 324.00	Motor vehicle tax DM 324.00	Motor vehicle tax DM 324.00	Motor vehicle tax DM 362.40	Motor vehicle tax DM 362.40

230_050

1. What are the differences between the exhaust components of diesel and petrol engines?

☐ a) Exhaust gases of a diesel engine contain more oxides of nitrogen (NO_X).

☐ b) Exhaust gases of a petrol engine contain no hydrocarbons (HC).

☐ c) Diesel engines run with an oxygen surplus and therefore have a higher level of residual oxygen O_2 in their exhaust gases.

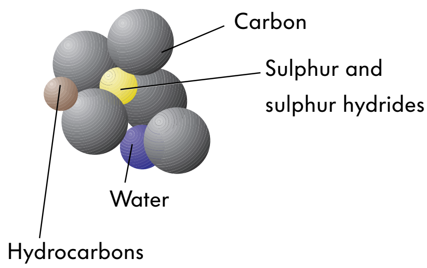
2. What are the basic strategies for the reduction of exhaust emissions?

_ _

3. What chemical reactions are responsible for exhaust gas treatment in a catalytic converter (petrolengine)?

_ _

4. What constituent(s) of the particulate matter (PM) is/are converted in the catalytic converter (diesel)?
Please underline the applicable constituent(s).



230_033

Test your knowledge

5. What exhaust emission standards currently apply in the Federal Republic of Germany?

☐ a) EU II

☐ b) EU III

☐ c) D3

☐ d) D4

6. What exhaust emission standards currently apply in Europe?

☐ a) EU II

☐ b) EU III

☐ c) D3

☐ d) D4

Notes

Solutions:

1.) a, c

2.) Reduction of fuel consumption,
exhaust gas treatment,
performance monitoring

3.) Oxidation and reduction

4.) Hydrocarbons (HC)

5.) b, d

6.) b

230

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