Compact and light with high torque: New V6 engine continues the great diesel tradition of the Mercedes-Benz brand

- **Successor to the previous in-line engines with five and six cylinders**
- **Output increased by up to 38 percent with exemplary fuel economy**
- **Best torque characteristics in this displacement class**
- **Third-generation common-rail injection with piezo injectors**

When the world's first car diesel engine was successfully tested exactly 70 years ago, in November 1934 at the Gaggenau plant of Daimler-Motoren-Gesellschaft and when the Mercedes-Benz 260 D celebrated its world premiere in February 1936, only very few can have imagined the importance this drive technology would also achieve for passenger cars.

The diesel pioneer Mercedes-Benz resolutely continued to refine and improve diesel technology. Highlights in this process include the first car turbodiesel engine in the Mercedes-Benz 300 SD (1977), the first diesel saloon with particulate filter in the US state of California (1985), the world premiere of four-valve technology (1997), common-rail direct injection (1997), the most powerful car diesel engine in the S 400 CDI (2000) and the maintenance-free diesel particulate filter (2003), which is now available in 20 Mercedes models.

Mercedes-Benz is continuing this tradition-laden success story in spring 2005: after a development and testing period of approx. 40 months a new CDI six-cylinder unit is entering series production, combining all the current and trailblazing technologies in diesel engine development – from the mechanical system and thermal/flow dynamics to the electronic engine management and emissions control. This guarantees outstanding results in terms of output and torque characteristics, economy, exhaust emissions and refinement.

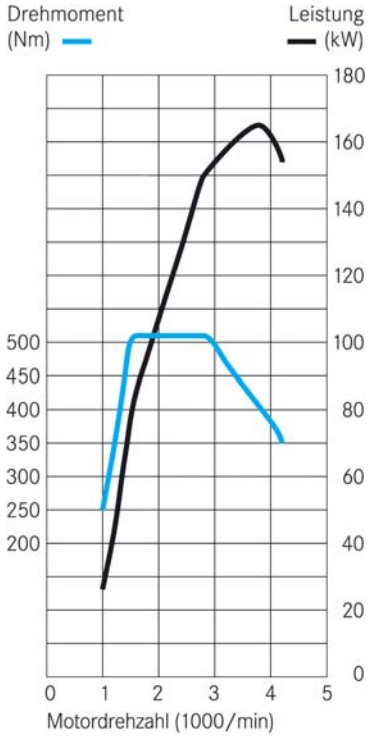
As a further special feature, the new V6 CDI is the first and only diesel power unit to be available in combination with a seven-speed automatic transmission – an advantage which heralds further benefits with respect to agility and fuel consumption.
The most important features of the new Mercedes diesel engine in brief:

- Six cylinders in a V-arrangement
- Aluminium crankcase with cast-in grey iron cylinder liners
- Third-generation common-rail injection with piezo injectors
- Four-valve technology with two camshafts per cylinder bank
- Turbocharger with electrically adjustable turbine
- Peak combustion pressure of up to 180 bar
- Exhaust gas recirculation with electrically controlled valve
- Electrically controlled intake air throttling
- Swirl control by electrically controlled intake port shut-off
- Quick-start glow system

The key data of the V6 engine at a glance:

Cylinder arrangement	V6
Cylinder angle	72°
Valves per cylinder	4
Displacement	2987 cc
Bore/stroke	83/92 mm
Dist. between cylinders	106 mm
Compression ratio	18 : 1
Output	165 kW/224 hp at 3800 rpm
Max. torque	510 Nm at 1600-2800 rpm*

*In conjunction with 7G-TRONIC



A new dimension in diesel driving pleasure

From March 2005 the new V6 will replace the current five and six-cylinder in-line engines. This means a considerable increase in output, comfort and driving pleasure. With an **output** of 165 kW/224 hp the new power unit betters the existing five-cylinder engine by up to 38 percent, and the in-line six-cylinder by nine percent. In conjunction with 7G-TRONIC, the maximum **torque** is increased to 510 Newton metres and is available between 1600 and 2800 rpm. With these torque characteristics the new Mercedes V6 is easily superior to other diesel engines in this displacement class.

The high level of driving pleasure provided by the six-cylinder diesel makes itself particularly apparent by its improved agility under acceleration and outstanding flexibility during intermediate sprints. Moreover, thanks to the latest engine technology, particulate emissions are below 0.025 grams per kilometre even without a particulate filter and therefore within the stringent EU4 limits. The fuel consumption of Mercedes passenger cars equipped with this new V6 diesel engine nonetheless remains at the previous, exemplary level.

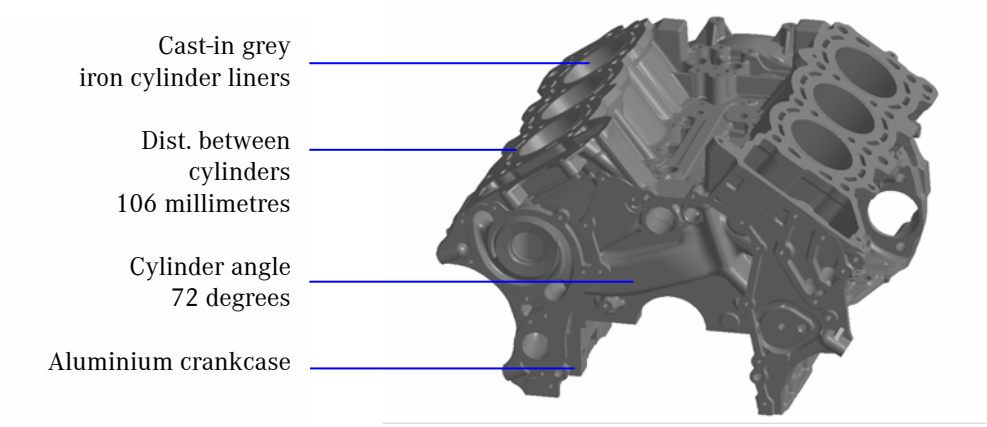
In Germany, Austria, Switzerland and the Netherlands Mercedes-Benz also equips the new six-cylinder diesel unit with a maintenance-free **particulate filter system** as standard, producing a further reduction in emissions of soot particles.

Power-to-weight ratio increased by 20 percent

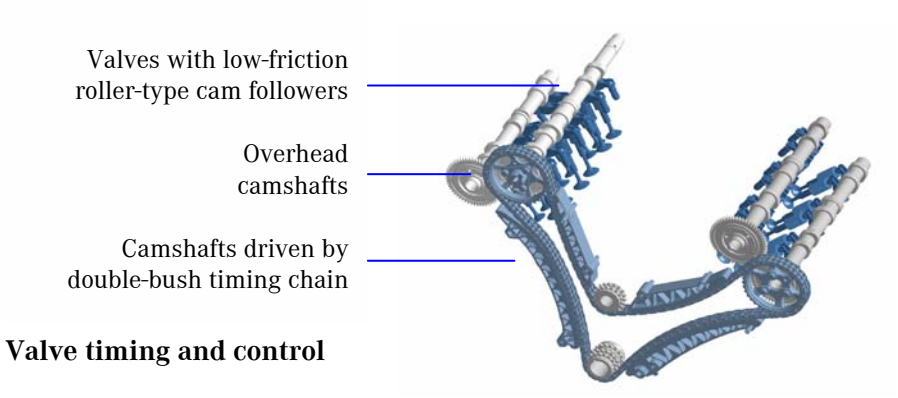
More output, more torque and lower exhaust emissions – the engineers at Mercedes approached the main objectives of their development work in various ways. For example with **lightweight construction:** owing to an intelligent choice of materials and innovative production methods, the weight of the unit according to DIN has been reduced to approx. 208 kilograms or roughly the level of the in-line five-cylinder engine. The power-to-weight ratio of the V6 engine is 0.79 kW/kg – more than 20 percent higher than for the preceding engines.

As a world first, Mercedes-Benz has developed this diesel engine with an aluminium crankcase and cast-in grey iron cylinder liners. It tips the scales at only 41 kilograms and is therefore a prime example of lightweight construction. Aluminium is also used for the cylinder heads, cylinder head covers, water pump pistons, sump and charge pressure distributor. Plastics are also used to save weight. Components in the fresh and charge air ducting systems, silencer and engine shrouding are of plastic.

Crankcase



A likewise newly developed valve control system reduces both friction and moving masses: the 24 intake and exhaust valves are controlled by an overhead camshaft for each cylinder bank, roller-type cam followers with hydraulic valve clearance compensation. The camshafts are driven by a tried-and-tested double-bush timing chain system into which the balancer shaft and the high-pressure pump for the fuel injection system are integrated.



Valve timing and control

The camshaft bearings are directly integrated into the cylinder heads and cylinder head covers. This new concept not only saves space, but also has acoustic advantages.

Compact dimensions thanks to a new "one-box concept"

Thanks to a newly developed "one-box concept", the V6 engine is among the most compact diesel power units in its displacement class worldwide. "One-box concept" means that the engine forms a single, compact entity with its components and ancillary units. The complete air filter system is directly attached to the engine and therefore occupies no additional installation space. This also simplifies the installation and use of the engine in Mercedes model series anf 4MATIC variants where no six-cylinder diesel engine was previously offered. In other words, the new V6 is even more compact than the previous 5-cylinder in-line unit.

In addition to lightweight construction, compact dimensions and low-friction valve gear, the new CDI six-cylinder would not be a Mercedes engine if it did not also meet the strict standards of the brand in terms of rigidity, vibration characteristics and long-term durability. Calculations and computer simulations provided the engineers in Stuttgart with valuable data and helped them achieve the demanding specifications. A look at the interior of the V6 engine:

- The forged **crankshaft** rotates in four bearings which have been enlarged by five millimetres versus the in-line six-cylinder engine in the interests of vibration comfort. The radii of the crank pins have been rolled to achieve high strength. The flexural and torsional rigidity of the crankshaft is more than twice that of the preceding engines.

- The **connecting rods** are also of forged steel. Mercedes engineers have further optimised their weight by using a new alloy and improving their geometry.

- Careful design of the **combustion chamber geometry**, which includes the precisely calculated recesses in the piston crowns, optimises the combustion process and helps to achieve a lasting reduction in untreated emissions.

- The free vibrations which are inherent to a V6 engine are compensated by a **balancer shaft** between the cylinder banks. This counter-rotates at the same speed as the crankshaft.

Heat exchangers for oil cooling, heating and exhaust gas recirculation

A separate roller chain is used to drive the oil pump. Via a large full-flow oil filter, the efficient and quiet external-gear pump delivers the oil to the **oil-water heat exchanger** located between the cylinder banks. The high 15-kW output of the heat exchanger ensures that even under extreme engine loads, the oil temperature does not rise above 130 degrees Celsius. The tunnel of the balancer shaft also serves as the main oil duct from which the oil flows to the main bearings, into the cylinder heads and to the piston-cooling spray units, which automatically open at a certain oil pressure and cool the pistons.

The mainstay of the **water cooling system** is a belt-driven pump on the crankcase. This is a double-helix pump which forces the coolant into the cylinder banks within the crankcase from the front, where it mainly flows to the exhaust side via special holes bored in the cylinder head gasket. Cooling is thermostat-controlled on the cross-flow principle.

The flow of coolant for the oil-water heat exchanger comes from the crankcase on the right, while the **exhaust gas recirculation** cooler and the heat exchanger for the heating system are supplied with coolant from the left cylinder head. The coolant circuit is therefore designed to ensure adequate heat dissipation under any load and engine speed conditions. Particularly high rates of flow are achieved at the valve lands, around the injector ducts in the cylinder heads, in the oil-water heat exchanger and in the exhaust gas recirculation cooler, enabling an efficient heat transfer to take place.

Turbocharger with variable turbine geometry

The new V6 diesel engine is aspirated by a **VNT turbocharger** (Variable Nozzle Turbine). This technology already enables high levels of output and torque to be achieved at low engine speeds. Thanks to electric control, VNT turbochargers are able to vary the angle of their turbine blades rapidly and precisely to suit the operating status of the engine, and can therefore use the largest possible volume of exhaust gas to compress the intake air and build up charge pressure. At low engine speeds the turbine blades reduce the flow cross-section to increase the charge pressure, while the cross-section is enlarged at high engine speeds to reduce the speed of the turbocharger. More efficient cylinder charging and therefore higher torque are the results of variable, demand-related turbocharger control. Moreover, electric VNT technology allows a precise interaction with other units which are responsible for reducing untreated emissions and exhaust gas aftertreatment.

The turbocharger is combined with a downstream **intercooler** which reduces the temperature of the compressed, heated air by up to 95 degrees Celsius, allowing a larger volume of air to reach the combustion chambers. Behind the intercooler there is an electrically controlled flap which enables the V6 engine to be throttled back precisely when the **exhaust gas recirculation** is in operation. This electrically regulated control flap allows the volume and mix of the exhaust gases added to the combustion air to be very precisely metered. To optimise the volume of recirculated exhaust gas, it is cooled down considerably in a high-performance heat exchanger. Acting in conjunction with the hot-film air flow sensors

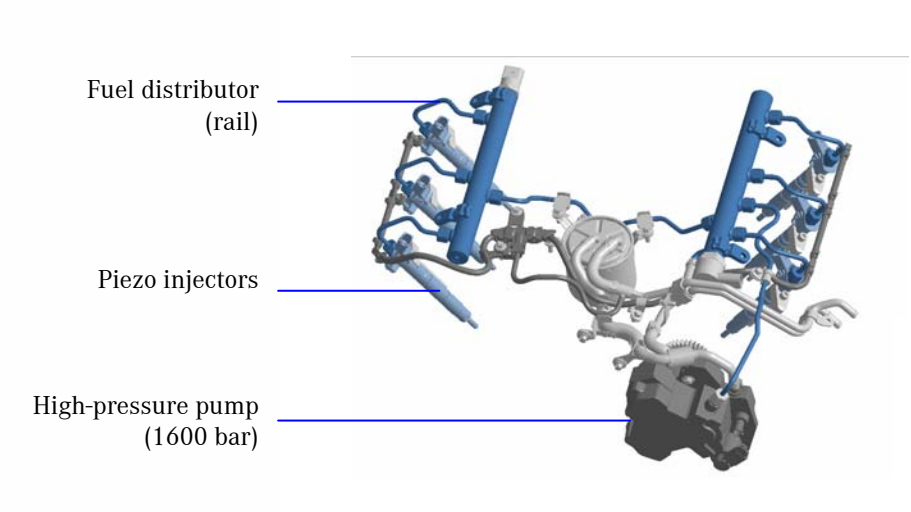
integrated into the intake air ducts, which provide the engine control unit with precise information about the current volume of intake air, this greatly reduces nitrogen oxide emissions.

The combustion air then flows into the charge air distribution module, which supplies each cylinder in equal measure. The distribution module features an integral, electrically controlled intake port shut-off function with which the intake port cross-section for each cylinder can be finely reduced. This modifies the swirl of the combustion air, ensuring that the charge flow to the cylinders is adjusted for the best possible combustion and exhaust emissions in any load and engine speed conditions.

Piezo ceramics for precisely metered injection within microseconds

The third generation of the well-proven **common-rail direct injection** system is entering series production at Mercedes-Benz with the new V6 diesel engine. This means that the injectors, high-pressure pump and electronic engine management system will operate even more efficiently, with a further reduction in fuel consumption, exhaust emissions and combustion noise.

Instead of the previous solenoid valves, the injectors are equipped with **piezo-ceramics** whose crystalline structure changes within milliseconds under an electric voltage. The engine developers have used this effect, which was discovered in 1880 by the brothers Pierre and Jacques Curie, to lift the needle jet at the tip of the injector with a precision of only thousandths of a millimetre and thereby achieve an extremely fine jet of fuel. Moreover, piezo injectors are considerably lighter and operate at twice the speed of conventional solenoid valves. With a response time of only 0.1 milliseconds, the fuel injection process can be even more precisely suited to the current load and engine speed situation, with favourable effects on emissions, fuel consumption and combustion noise. The number of fuel injections per power stroke is increased from three to five thanks to this piezo technology.



Fuel circuit and components in common-rail technology

Mercedes engineers have also made improvements to other components of the common-rail system and the injection process:

- The hydraulically optimised **injector nozzles** have eight holes (previously seven), which ensures even finer distribution of the fuel within the combustion chamber and more efficient mixture formation.

- The inlet-metered **high-pressure pump** operates with a maximum injection pressure of 1600 bar.

- The **pilot injection** process developed by Mercedes-Benz, which ensures a smoother combustion process and thereby audibly reduces the operating noise of the engine, takes place twice in succession in the new V6 engine. Small pilot quantities of fuel are injected within less than a millisecond and preheat the combustion chambers even more efficiently.

- To burn off the soot particles in the particulate filter, there is a double **post-injection of fuel** when required.

Latest-generation electronic engine management

The combustion process is managed by a newly developed electronic **control unit** which is in constant contact with other microprocessors via a databus and therefore always fully informed about the current driving situation. The range of tasks performed by the engine control unit includes the following functions:

- Common-rail injection
- Delivery control of the high-pressure pump
- Engine speed limitation
- Deceleration fuel cut-off
- Fuel pump
- Air supply
- Drive control
- Diagnosis

A separate data network links the engine management system with the generator and the glow control unit, which lies at the heart of an innovative **quick-start glow system**. This shortens the preheating time for the engine to just a moment, so that the diesel is now also the equal of a petrol engine in this respect.

Emission control with two catalytic converters and a particulate filter as standard

Two **oxidising catalytic converters** clean the exhaust gases of the new Mercedes diesel engine. One acts as what is called a light-off converter, and is ready for action very soon after a cold start thanks to its position close to the engine. This unit is accompanied by a downstream main catalytic converter. The purpose of the oxidation-type catalytic converters is to convert carbon monoxide and unburned hydrocarbons by combining them with oxygen (oxidation).

This efficient exhaust gas aftertreatment combined with the complex in engine measures already enables the V6 diesel engine to meet the stringent EU4 exhaust limits.

To lower exhaust emissions even further, Mercedes-Benz combines the new six-cylinder engine with a maintenance-free **particulate filter system** as standard for the German, Austrian, Swiss and Dutch markets, producing a further significant reduction in particulate emissions. The filter purges itself without the use of additives and remains effective over a very high operating mileage.

Like the catalytic converters, the diesel particulate filter features numerous longitudinal, rectangular ducts. In contrast to the catalytic converter ducts, these are however closed at the ends so that the incoming exhaust gases are obliged to find their way through the porous walls between the ducts. In doing so the particulates carried in the exhaust gas accumulate in the filter and are retained by the filter material.

As only a limited quantity of these tiny carbon particles can be taken up, the particulate filter needs to be purged from time to time. The necessary exhaust temperature of more than 550 degrees Celsius is achieved by heating the stream of exhaust gases at higher engine speeds, or by adjusting various engine functions to suit the pressure and temperature of the exhaust gases at the particulate filter. The variable, third-generation common-rail technology considerably assists this process, for depending on the engine operating status and filter condition it allows brief post-injections of fuel for specific increases in the exhaust gas temperature. As a result the particulates accumulating in the filter are burned off in a controlled manner, and unnoticed by the driver or other road users.