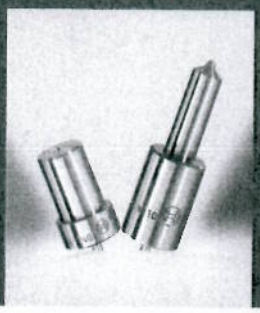
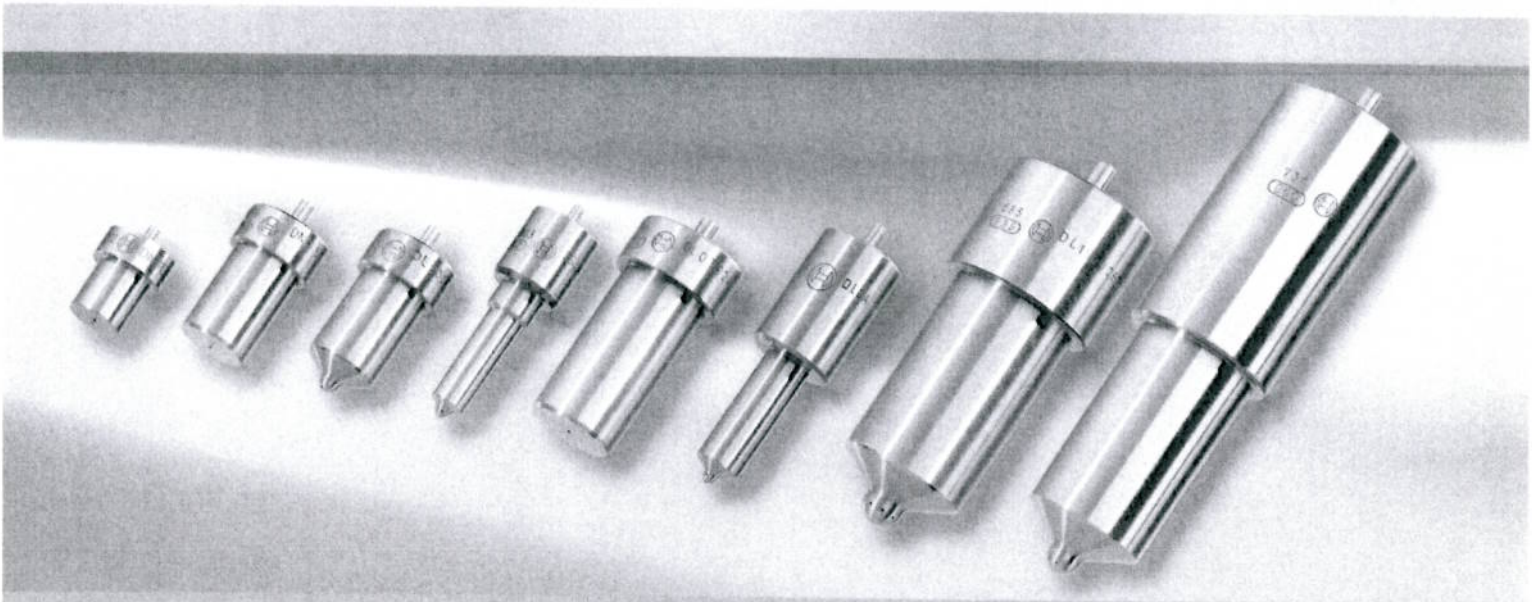
D12



Reliable, Clean, Fuel-Efficient: Original Bosch Nozzles for All Diesel Vehicles

BOSCH
Invented for life



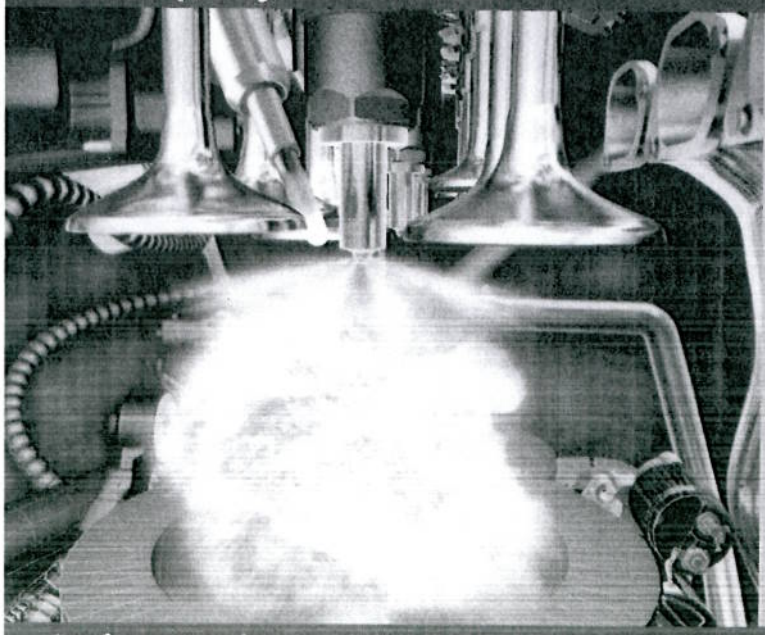
Injection nozzles are subjected to regular wear, hence must be checked at regular intervals

- In case of increased smoke development especially after cold starts
- In case of increased combustion noise when engine is cold
- In case of rough run though engine is warm
- In case of loss of performance or increased fuel consumption

Pay attention to original quality while replacing: The difference between Bosch nozzles and fake nozzles is often invisible to the naked eye. Though, it makes a big difference to the engine, as faked nozzles can negatively affect it.

Typical damage symptoms:
- Increased fuel consumption
- Loss of performance
- Reduced service life
- Failures and engine damage

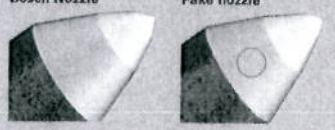
Bet on quality: bet on Bosch



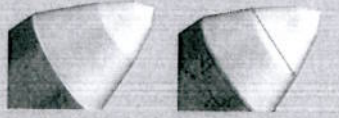
Bosch Nozzle | Fake nozzle

Characteristic: Excessively pointed nozzle pin of a fake nozzle. **Risk:** Tip of nozzle pin may break, engine damage

Bosch Nozzle | Fake nozzle



Characteristic: Rough surface of a fake nozzle. **Risk:** Uncontrolled combustion due to sealing problems



Characteristic: Wrong nozzle-seat diameter of a fake nozzle. **Risk:** Incorrect opening pressure, wrong injection timing, weakened engine performance, increased fuel consumption and emissions

Characteristic: Sharp (cone-shaft) junction of a fake nozzle. **Risk:** Nozzle may break, engine damage

Characteristic: Over-sized sack hole of a fake nozzle. **Risk:** Incomplete combustion, increased emissions, failure to comply with emissions regulations

Characteristic: Needle guide diameter of a fake nozzle is too small. **Risk:** Incorrect opening pressure, wrong injection timing, incomplete combustion, increasing emissions, weakened engine performance

Go for certainty: with original Bosch nozzles

This is how you recognize the original
Test it yourself: The fire-test makes all the difference – the nozzle-raster on the original Bosch SecurePack turns blue.

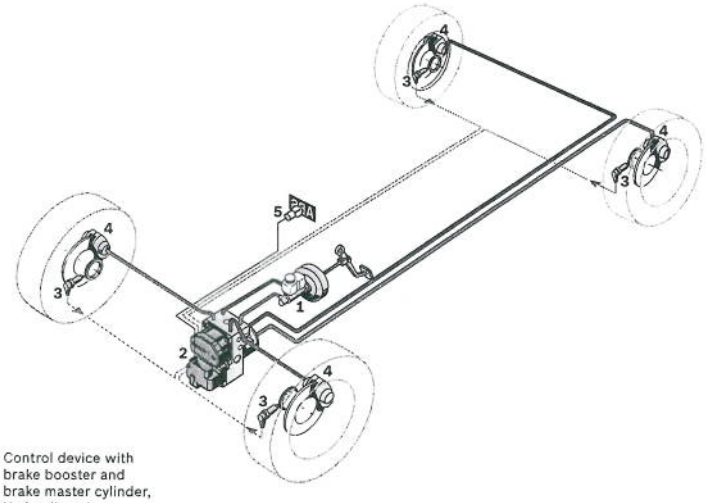
Further safety features:
- Seal ring lock technique
- Thermo imprint to prevent counterfeiting
- KeySecure Label with 15-digit code and hologram on the Bosch packing

Antilock Braking System

K1

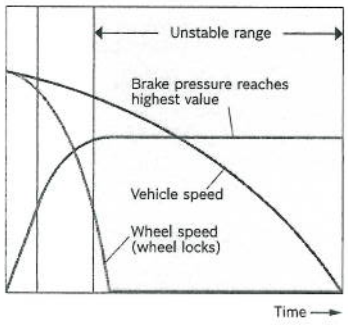
BOSCH

System overview: brake equipment with antilock braking system (ABS).

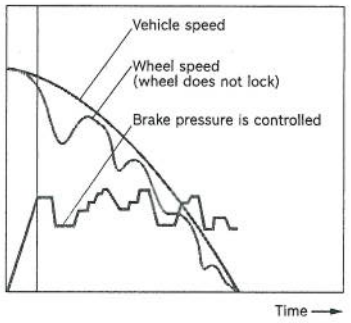


1 Control device with brake booster and brake master cylinder,
2 Hydraulic unit with add-on ECU,
3 Wheel-speed sensors,
4 Wheel brake with wheel-brake cylinder,
5 ABS indicator lamp.

Braking without ABS.

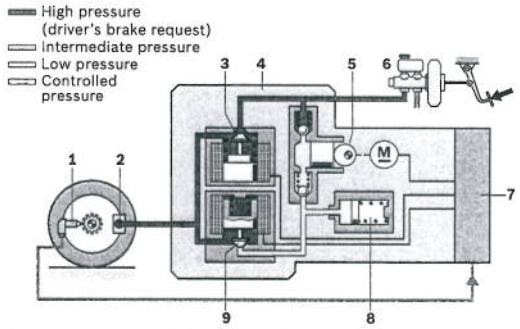


Braking with ABS.

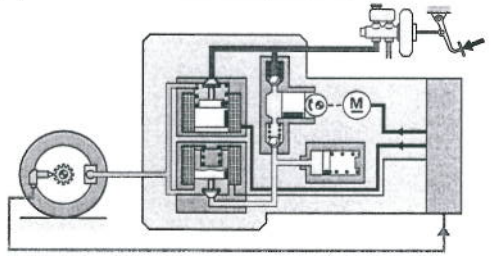


Brake pressure in the hydraulic system.

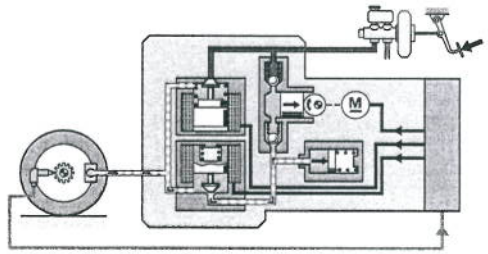
Build up pressure (normal position): inlet valve open, outlet valve closed.



Keep pressure constant: inlet valve closed, outlet valve closed.

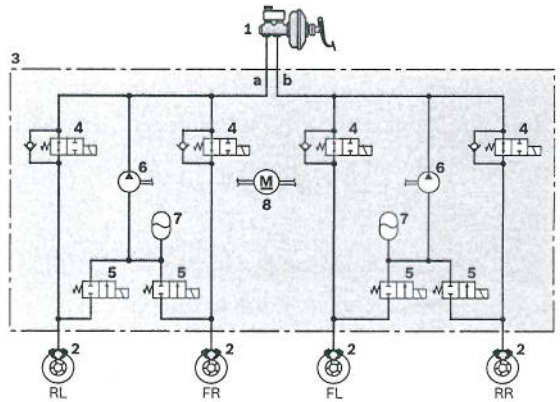


Relieve pressure: inlet valve closed, outlet valve open.



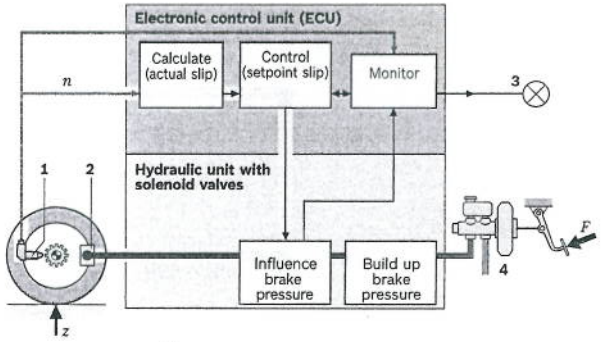
1 Wheel-speed sensor, 2 Wheel-brake cylinder, 3 Inlet valve,
4 Hydraulic unit, 5 Return pump, 6 Brake master cylinder,
7 ABS ECU, 8 Accumulator, 9 Outlet valve.

Hydraulic system of an antilock braking system.



a Brake circuit 1, b Brake circuit 2.
1 Brake master cylinder, 2 Wheel-brake cylinder, 3 Hydraulic unit, 4 Inlet valves,
5 Outlet valves, 6 Return pump, 7 Accumulator, 8 Pump motor.
F Front, R Rear,
R Right, L Left.

ABS control loop.

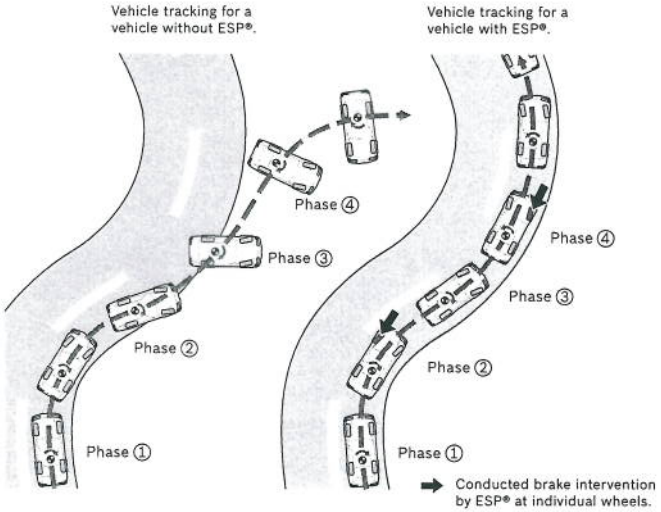


1 Wheel-speed sensor, 2 Wheel-brake cylinder, 3 ABS indicator lamp,
4 Control device with brake booster and brake master cylinder.
z Disturbance values (e. g. road condition), *n* Wheel speed, *F* Braking force.

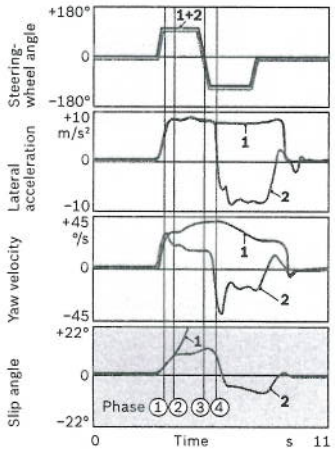
Electronic Stability Program (ESP®)

BOSCH

Right-left cornering sequence.



Curves for dynamic response parameters.



Phase 1:
Driver steers, lateral-force buildup.

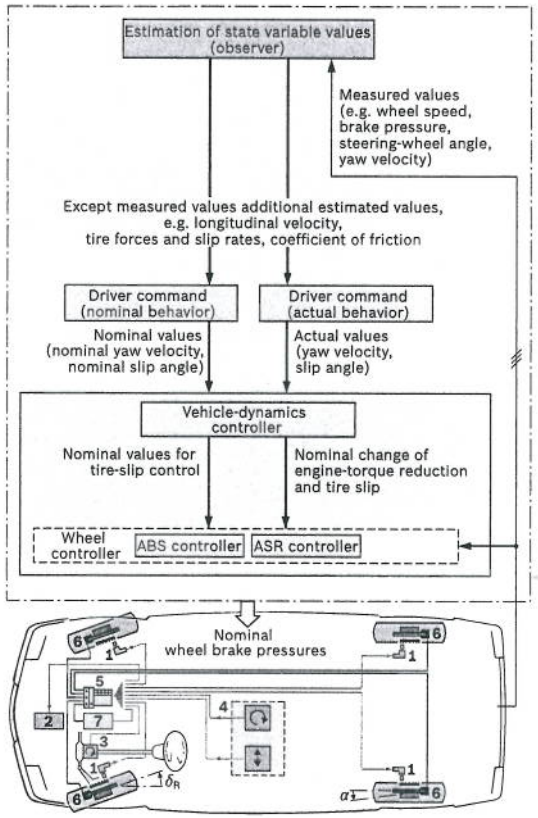
Phase 2:
Incipient instability,
ESP® intervention at left front.

Phase 3:
Countersteer;
Vehicle without ESP®: Driver loses control of vehicle.
Vehicle with ESP® remains under control.

Phase 4:
Vehicle without ESP® becomes uncontrollable.
ESP® intervention at right front, complete stabilization.

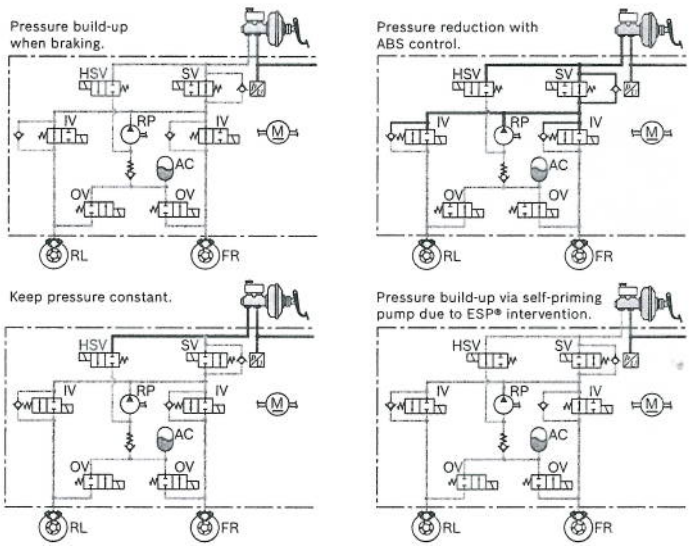
1 Vehicle without ESP®,
2 Vehicle with ESP®.

ESP® control loop in vehicle.



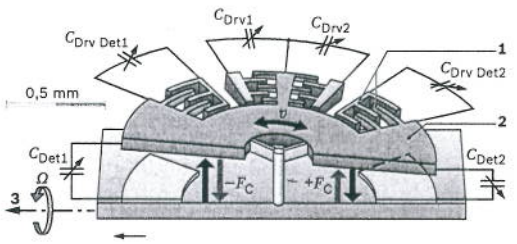
1 Wheel-speed sensors,
2 Brake-pressure sensor (integrated in the hydraulic unit),
3 Steering-wheel-angle sensor,
4 Yaw-rate sensor with integrated lateral-acceleration sensor,
5 ESP hydraulic unit (hydraulic modulator) with mounted ECU,
6 Wheel brakes,
7 Engine ECU.

Hydraulic unit of an ESP® systems.



IV Inlet valve, OV Outlet valve, SV Switchover valve, HSV High-pressure switching valve, AC Low-pressure reservoir, M Pump motor, RP Return pump.
F Front, R Rear, R Right, L Left.

Surface micromechanics yaw-rate sensor (design).



1 Comb structure,
2 Rotary oscillator,
3 Measurement axis.

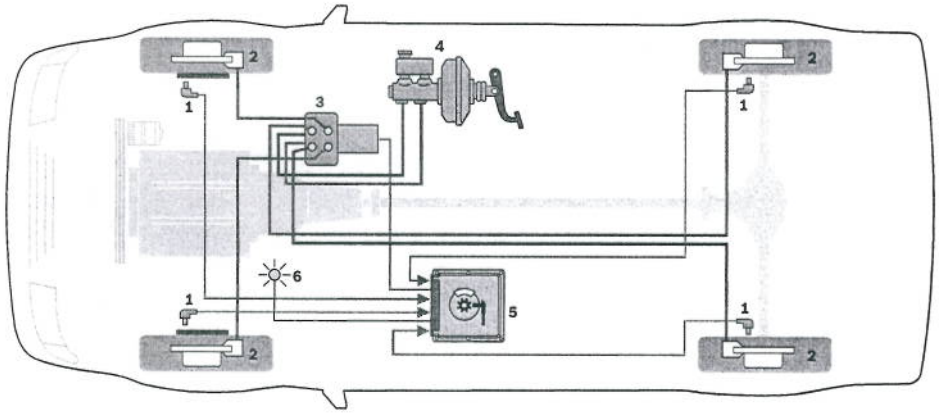
C_{Drv} Capacitance of drive electrodes,
C_{Det} Capacitive rotary-oscillation tap,
F_c Coriolis force,
v Oscillation velocity,
Ω Yaw rate to be measured ($\Omega = \text{const} \cdot \Delta C_{Det}$).

Brake Systems for Passenger Cars

BOSCH

K3

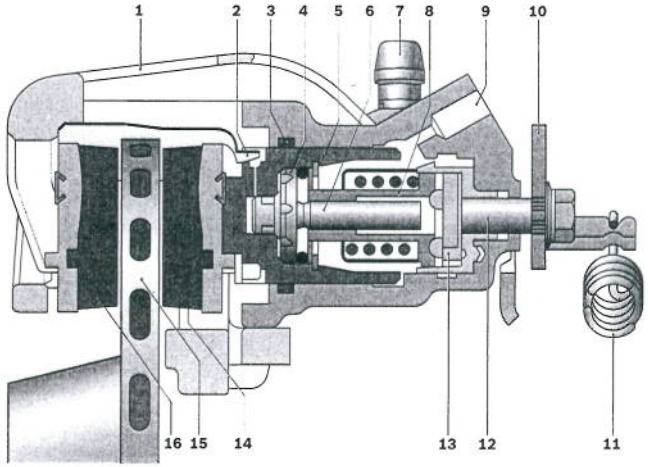
Hydraulic dual-circuit brake system with antilock braking system (ABS).



1 Wheel-speed sensors, 2 Wheel brakes (disc brakes, drum brakes also possible on the rear axle),
3 Hydraulic modulator (for antilock braking facility or driving-dynamics control system),
4 Control device with brake booster and dual-circuit brake master cylinder,
5 Control unit (can be directly mounted on the hydraulic modulator), 6 ABS warning lamp.

Wheel brakes.

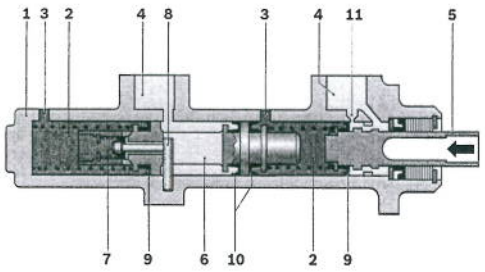
Floating-caliper brake with parking-brake mechanism.



1 Brake-caliper housing,
2 Dust-protection seal,
3 Sealing ring,
4 Coupling,
5 Piston,
6 Threaded spindle,
7 Bleeder valve,
8 Parking-brake mechanism,
9 Hydraulic port,
10 Parking-brake lever,
11 Spring,
12 Shaft,
13 Cam plate,
14 Piston-side brake pad,
15 Brake disc,
16 Outer brake pad.

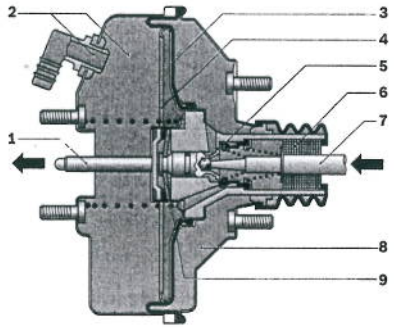
Control device.

Dual-circuit brake master cylinder with central valve in the secondary circuit.



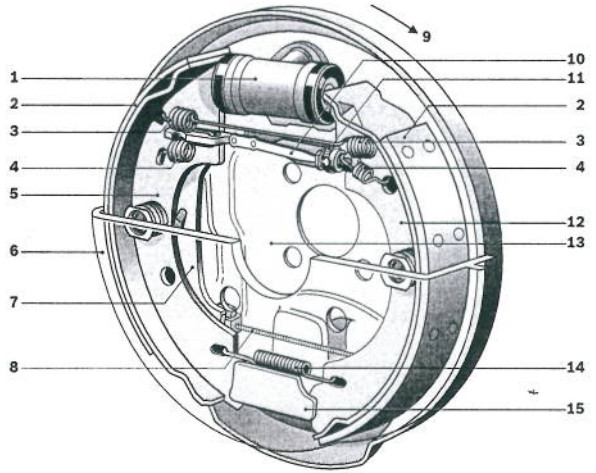
1 Cylinder housing, 2 Pressure chamber, 3 Pressure connection
4 Connection for brake-fluid reservoir,
5 Push rod (input force of the brake booster, 6 Intermediate piston,
7 Central valve, 8 Stop for central valve, 9 Primary cup seal,
10 Separating cup seal, 11 Balancing port.

Vacuum-operated brake booster.



1 Push rod (output force to brake master cylinder),
2 Vacuum chamber with vacuum connection,
3 Diaphragm, 4 Working piston, 5 Double valve, 6 Air filter,
7 Piston rod (pedal force), 8 Working chamber,
9 Backing plate.

Simplex drum brake with integrated parking brake.



1 Wheel-brake cylinder,
2 Brake lining,
3 Extension spring (brake shoes),
4 Extension spring (adjuster),
5 Trailing brake shoe,
6 Brake drum,
7 Parking-brake lever,
8 Brake cable,
9 Direction of drum rotating,
10 Thermocouple (adjuster),
11 Adjuster wheel (with elbow lever),
12 Leading brake shoe,
13 Brake anchor plate,
14 Extension spring (brake shoes),
15 Brake-shoe pin bushing.

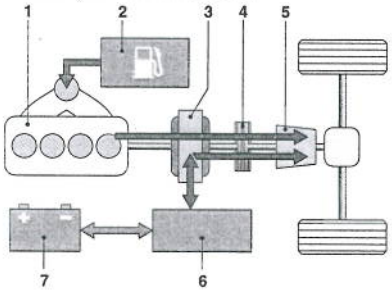
Hybrid Drives

H7

BOSCH

Drive configurations of hybrid drives.

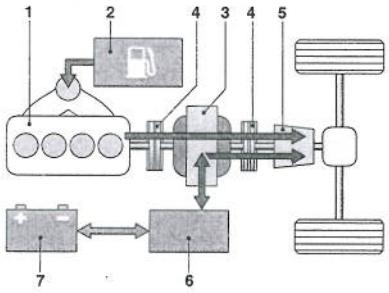
Parallel hybrid drive with one clutch.



The electric motor is rigidly connected to the internal-combustion engine (mild hybrid).

Purely electric driving is theoretically possible, but the engine must also be under coupled motion. The resulting losses prohibit this vehicle operation.

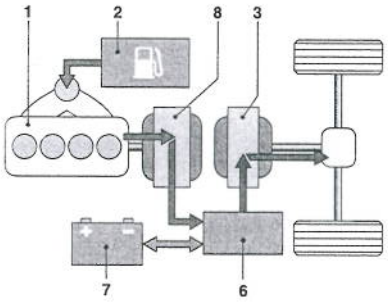
Parallel hybrid drive with two clutches.



An additional clutch facilitates the disconnection of the electric motor and the internal-combustion engine.

Purely electric driving and regenerative braking to the full extent are possible (full hybrid).

Series hybrid drive.

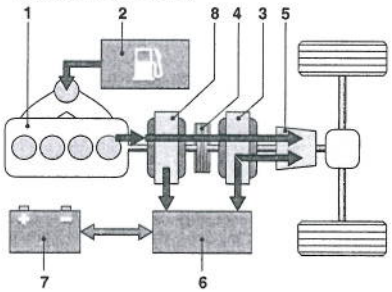


Series connection of the internal-combustion engine and two electrical machines.

The generator generates the energy for the electric motor and for charging the battery.

The internal-combustion engine is not connected to the powered axle. The engine can operate uniformly at the most efficient operating point and deliver excess energy to the battery.

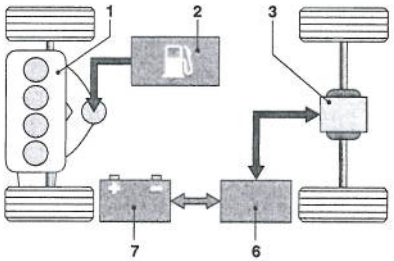
Series-parallel hybrid drive.



When the clutch is open, the system behaves like a series hybrid drive.

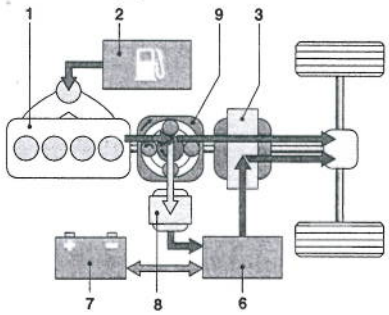
When the clutch is closed, the internal-combustion engine can deliver its power directly to the powered axle (parallel hybrid drive).

Axle-split parallel hybrid drive.



The internal-combustion engine and the electric motor act on different vehicle axles (four-wheel drive).

Power-branching hybrid drive.



In the planetary-gear set the power output of the internal-combustion engine is split into two paths.

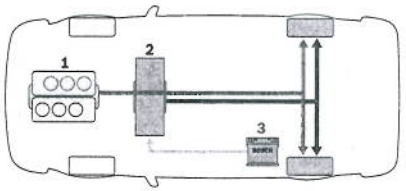
In the mechanical path, the power can be transmitted directly to the wheels by the gear teeth.

In the electrical path, the generator generates electrical power for the electric motor and the battery.

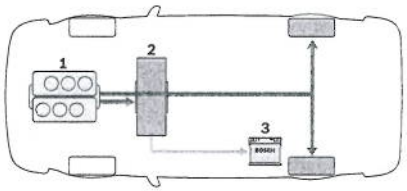
1 Internal-combustion engine, 2 Fuel tank, 3 Electric motor, 4 Clutch, 5 Transmission, 6 Inverter, 7 Battery, 8 Generator, 9 Planetary gear set.

Operating modes of hybrid drives.

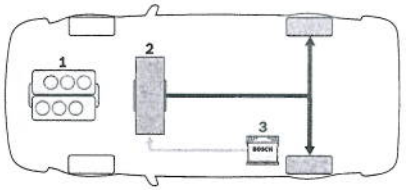
Hybrid driving.



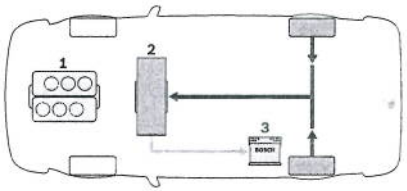
Generator mode.



Purely electric driving.

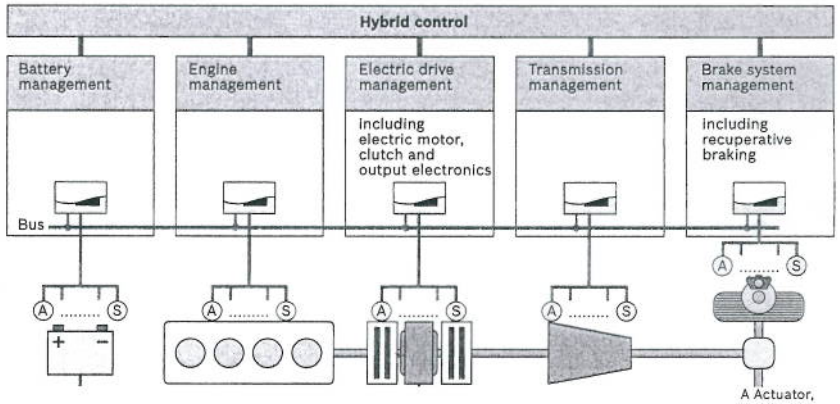


Regenerative braking.



1 Internal-combustion engine, 2 Electric motor, 3 Battery.

Networking of control systems in the drivetrain.

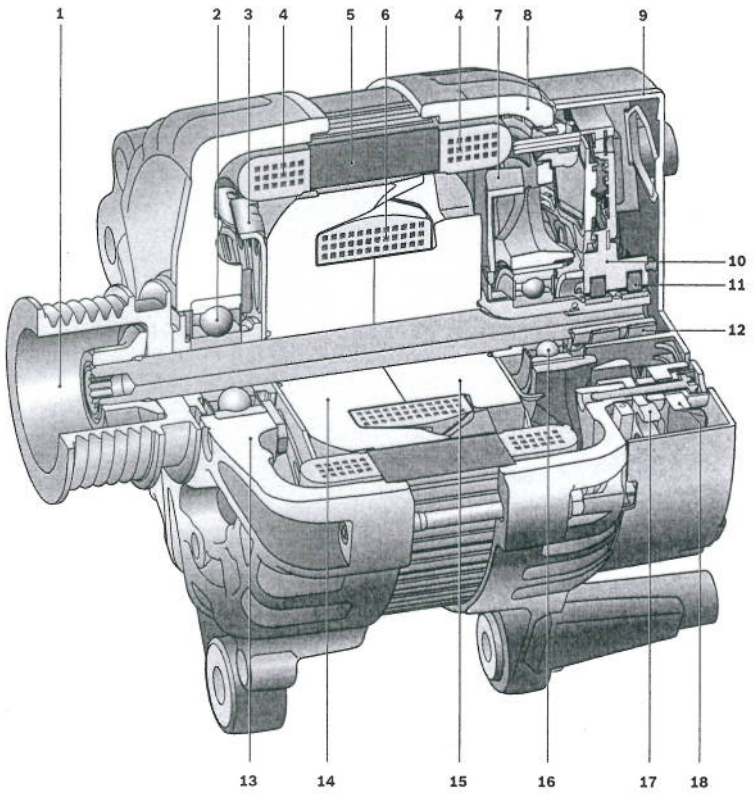


A Actuator, S Sensor.

Alternator

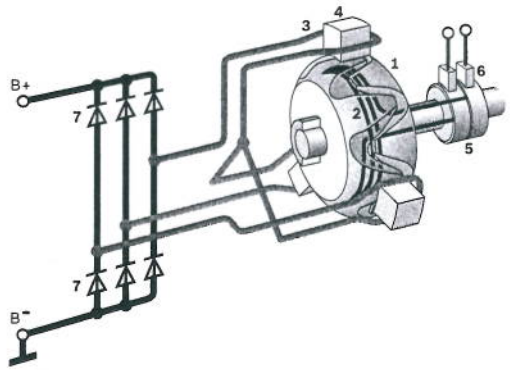
BOSCH

Bosch EL Series (Efficiency Line) compact alternator.



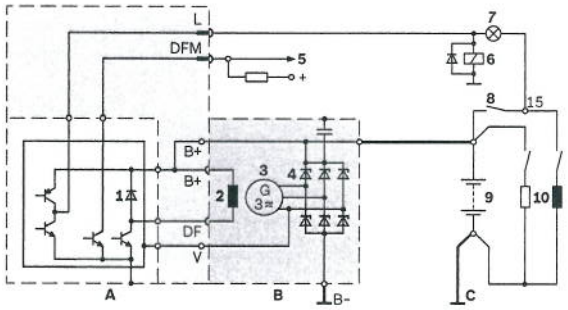
1 Belt pulley, 2 A-side (drive end) ball bearing, 3 A-side fan,
4 Stator winding heads, 5 Laminated stator core, 6 Rotor winding (excitation winding),
7 B-side fan, 8 B-side end shield, 9 Protective cap, 10 Brush holder,
11 Carbon brush, 12 Collector ring, 13 A-side end shield, 14 A-side claw pole,
15 B-side claw pole, 16 B-side ball bearing, 17 Negative heat sink of rectifier,
18 Positive heat sink of rectifier.

Basic design of a claw-pole alternator with collector rings.



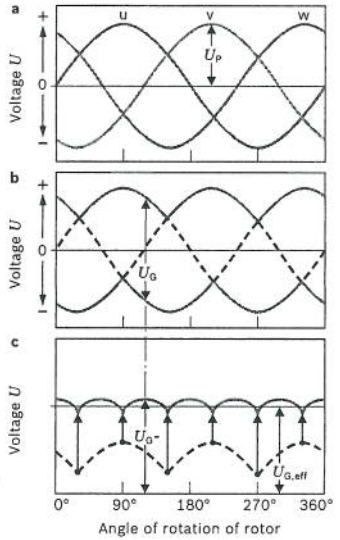
1 Rotor, 2 Excitation winding, 3 Stator winding, 4 Stator, 5 Collector rings,
6 Brushes, 7 Rectifier diodes.
B+ Battery positive terminal,
B– Battery negative terminal.

Wiring of the alternator.



A Regulator,
B Alternator,
C Vehicle electrical system.
1 Free-wheeling diode, 2 Excitation winding, 3 Stator windings,
4 Rectifier diodes, 5 Evaluation (monitoring) circuits,
6 Relay (switches equipment which is to be switched on only when alternator is active),
7 Alternator indicator lamp, 8 Ignition switch, 9 Battery, 10 Equipment.
DF Dynamo field, DFM Dynamo field monitoring, L Lamp connection,
B+ Battery positive terminal, B– Battery negative terminal, 15 Terminal 15.

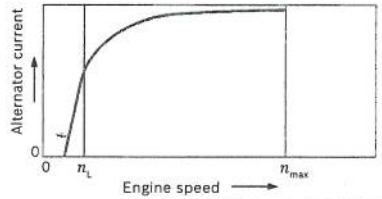
Three-phase current rectification.



a) Three-phase alternating voltage,
b) Alternator voltage formed by the envelopes of the positive and negative half-waves,
c) Rectified alternator voltage.
u,v,w Phases
U_p Phase voltage,
U_D Voltage at rectifier (negative not to ground),
U_G Alternator direct voltage (negative to ground),
$U_{G,eff}$ Effective value of direct voltage.

Characteristic curve at maximum alternator current at constant voltage.

n_L Idle speed,
n_{max} Maximum speed.

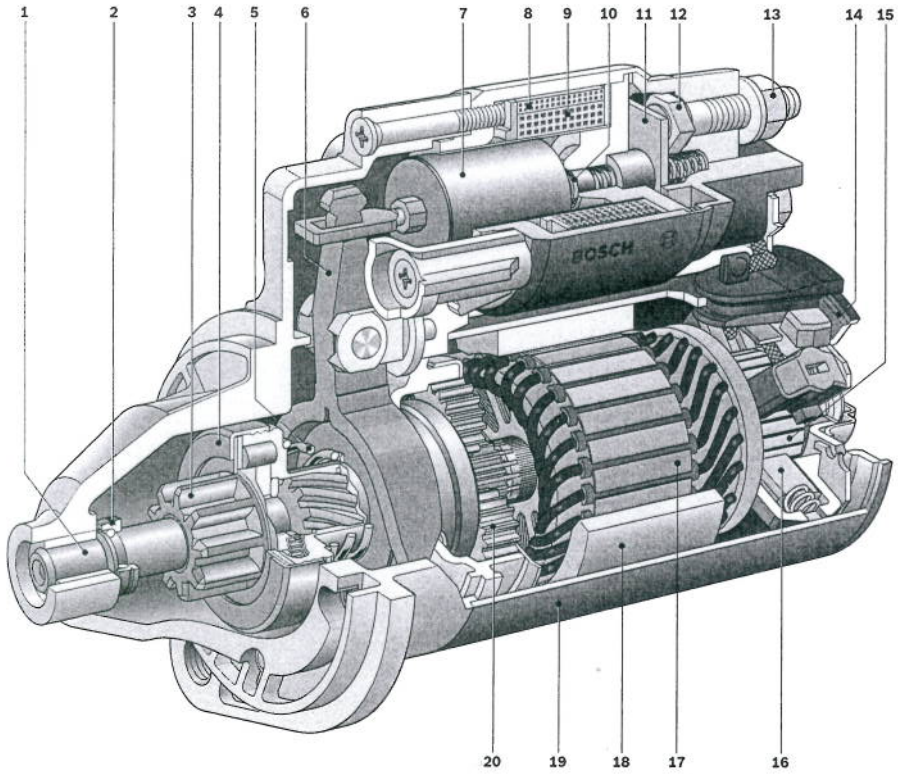


Pre-Engaged Starter Motor

A2

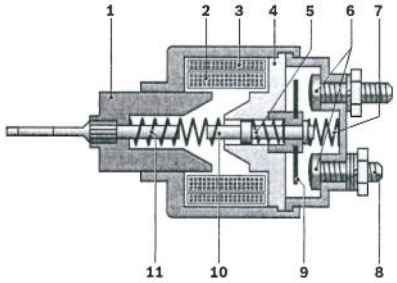
BOSCH

Pre-engaged starter motor.



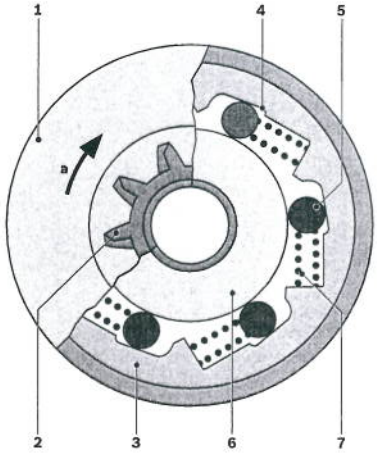
1 Drive shaft, 2 Stop ring, 3 Pinion, 4 (Roller-type) Overrunning clutch, 5 Meshing spring,
6 Engaging lever, 7 Solenoid switch, 8 Hold-in winding, 9 Pull-in winding, 10 Solenoid armature return spring,
11 Contact bridge, 12 Contact, 13 Electrical Connection, 14 Commutator end shield, 15 Commutator,
16 Brush holder, 17 Armature, 18 Permanent magnets, 19 Pole housing, 20 Planetary gear train (reduction gear).

Solenoid switch.



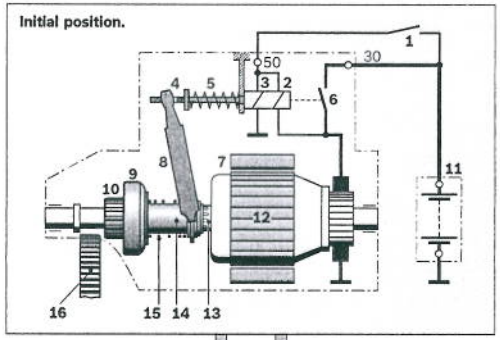
1 Solenoid armature, 2 Pull-in winding,
3 Hold-in winding, 4 Magnetic core,
5 Compression spring, 6 Contacts,
7 Contact return spring, 8 Electrical Connection,
9 Contact bridge, 10 Switching pin,
11 Solenoid armature return spring.

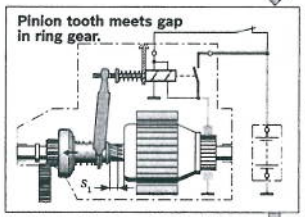
Overrunning clutch.



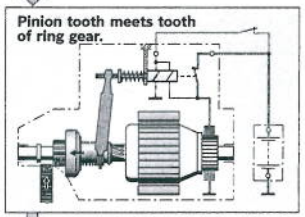
1 Sealing cap, 2 Pinion,
3 Clutch shell, 4 Roller race,
5 Cylindrical roller, 6 Pinion roll collar, 7 Spring,
a Direction of rotation.

Working phases of the pre-engaged starter.

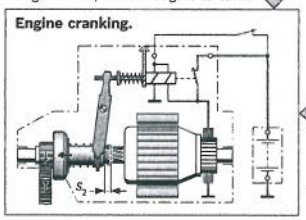




Ignition switch closed: Solenoid armature is pulled in, the pinion is pushed into the ring gear (engagement path, condition of the starter just before the main current is switched on). Contact bridge closes, starter begins to turn.



Ignition switch closed: Solenoid armature is pulled in, the pinion is pushed forward in axial direction.
The axial movement of the pinion is stopped by the ring gear (tooth on tooth), the meshing spring is compressed.
Contact bridge is closing, starter engages. Pinion tooth aligns with the gap in the ring gear. The pre-pressed meshing spring is pushing the pinion via the helical into the ring gear.



The pinion meshs fully into the ring gear.

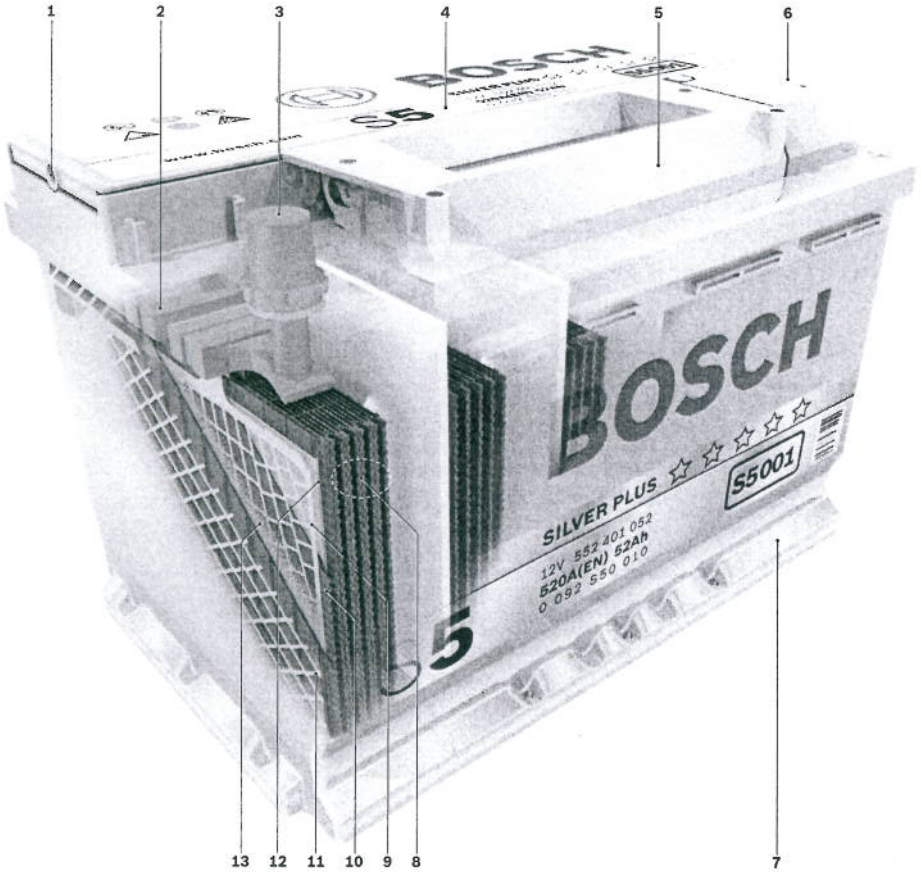
1 Ignition switch, 2 Pull-in winding of the solenoid switch, 3 Hold-in winding,
4 Solenoid armature, 5 Solenoid armature return spring, 6 Contact bridge,
7 Permanent magnets, 8 Engaging lever, 9 Overruning clutch, 10 Pinion, 11 Battery,
12 Armature, 13 Helical spline, 14 Pinion driver, 15 Meshing spring, 16 Ring gear.
Terminal identification: 30 Battery input, 50 Starter control.
s_1 Pinion path, s_2 Helical travel.

Starter Battery

A3

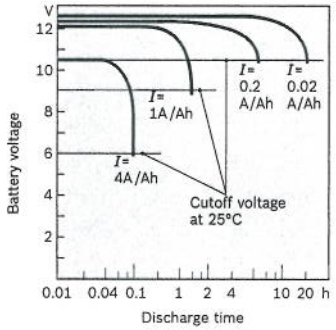
BOSCH

Basic design of a lead storage battery (Example: Maintenance-free battery).

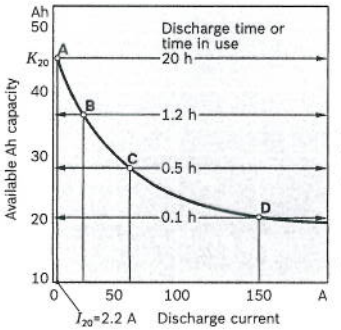


1 Gas outlet, 2 Plate connector, 3 Terminal post, 4 Double lid with labyrinth design,
5 Carry handle, 6 Terminal-post cover, 7 Base holddown,
8 Plate stack (consisting of positive plates and negative plates),
9 Stamped positive grid, 10 Pocket separator, 11 Expanded negative grid,
12 Negative active material, 13 Positive active material.

Battery-voltage curves as a function of the discharge time for various discharge currents.

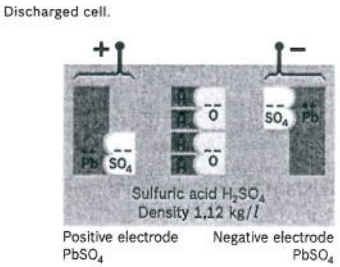


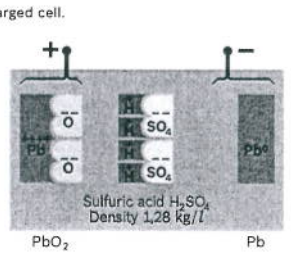
Available Ah capacity as a function of discharge current (Battery: 12 V, 44 Ah).

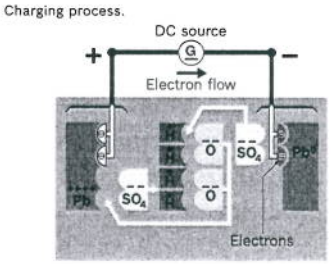


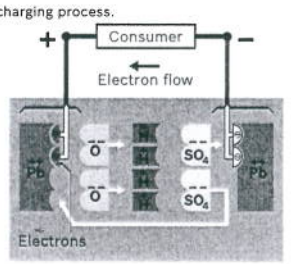
Current requirement:
A 20-hrs discharge current,
B Ignition and lighting
C In addition, fan, windshield and rear-window heating, fog lamps, wipers and radio,
D Mean starter current.

Charging and discharging processes in a lead battery.









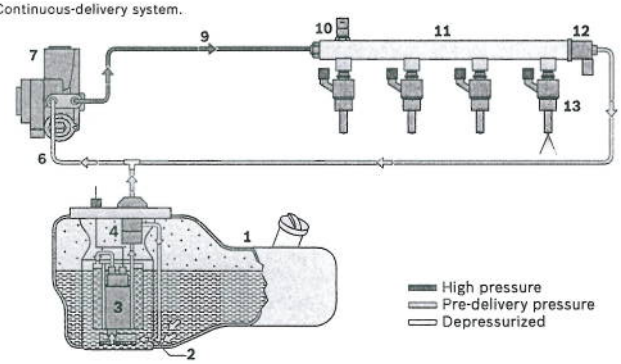
Fuel Supply and Delivery with Gasoline Direct Injection

B1

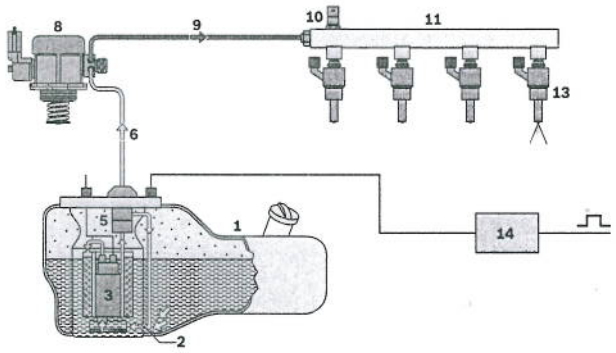
BOSCH

Fuel supply and delivery with gasoline direct injection.

Continuous-delivery system.

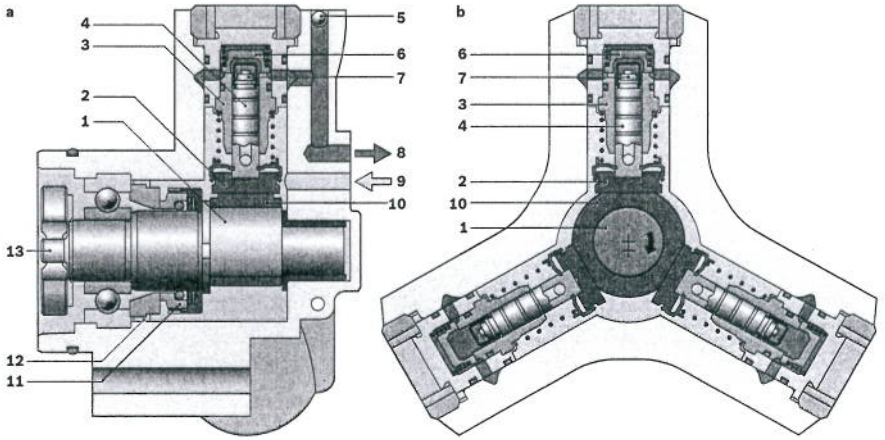


Demand-controlled system.



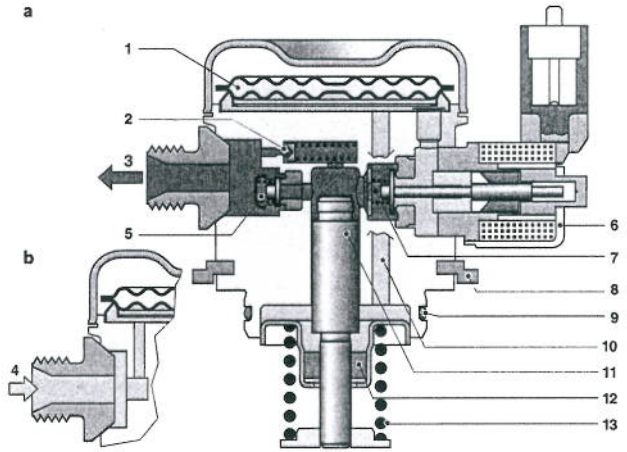
1 Fuel tank, 2 Suction-jet pump,
3 Electric fuel pump with fuel filter, 4 Pressure regulator,
5 Pressure-limiting valve and pressure sensor
(pressure sensor alternatively in the low-pressure line),
6 Low-pressure line, 7 Continuous-delivery high-pressure pump,
8 Demand-controlled high-pressure pump with integrated fuel-supply control valve and pressure-limiting valve,
9 High-pressure line, 10 Rail-pressure sensor, 11 Rail, 12 Pressure-control valve,
13 High-pressure injectors, 14 Clock module for controlling the electric fuel pump.

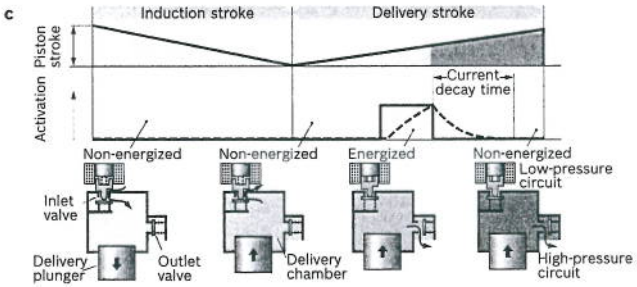
Continuous-delivery three-barrel high-pressure pump for 1st-generation gasoline direct-injection systems.



a) Longitudinal section,
b) Cross-section.
1 Eccentric element,
2 Slipper,
3 Pump barrel,
4 Pump plunger (hollow plunger, fuel inlet),
5 Closure ball,
6 Outlet valve,
7 Inlet valve,
8 High-pressure port to fuel rail,
9 Fuel inlet (low pressure),
10 Cam ring,
11 Axial seal (slide ring seal),
12 Static seal,
13 Drive shaft.

Demand-controlled single-barrel high-pressure pump for 2nd-generation gasoline direct-injection systems.





a) View with high-pressure port,
b) Detailed view with low-pressure port
(offset at angle on the same plane to the high-pressure port),
c) Activation concept of fuel-supply control valve.
1 Variable pressure attenuator, 2 Pressure-limiting valve,
3 High-pressure port, 4 Low-pressure port, 5 Outlet valve,
6 Fuel-supply control valve, 7 Inlet valve, 8 Mounting flange,
9 O-ring, 10 Passage to delivery plunger (pressure-attenuation function),
11 Delivery plunger, 12 Plunger seal, 13 Plunger spring.

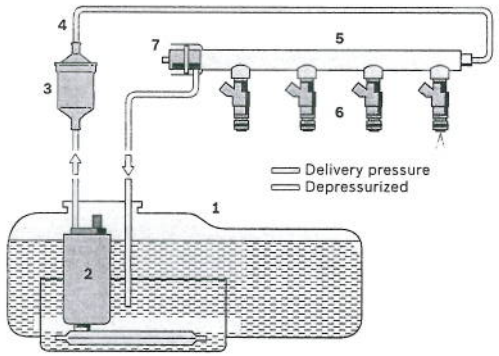
Fuel Supply and Delivery with Manifold-Injection Gasoline Engines

B2

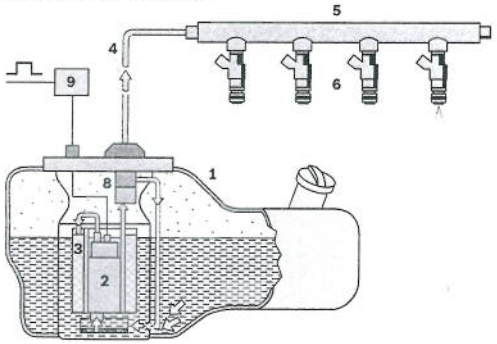
BOSCH

Fuel supply and delivery with manifold injection.

System with fuel return.

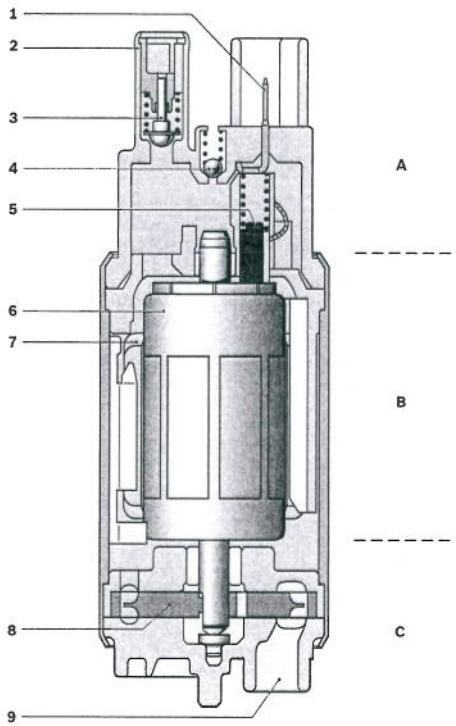


Demand-controlled returnless system.



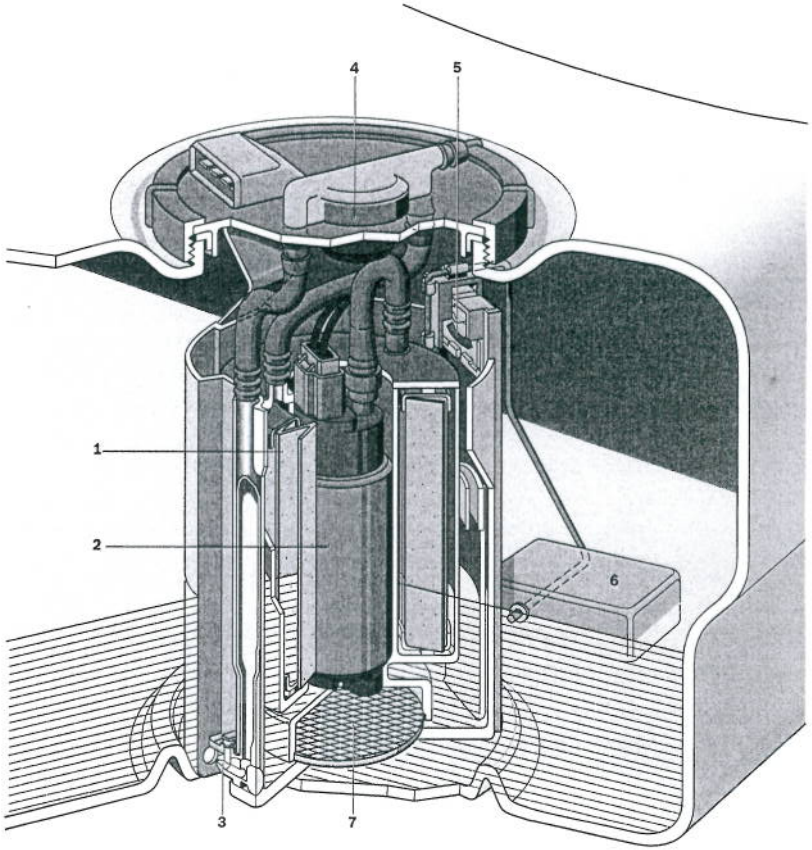
1 Fuel tank,
2 Electric fuel pump,
3 Fuel filter (outside of the fuel tank or integrated in the fuel-delivery module),
4 Pressure line,
5 Rail,
6 Fuel injectors,
7 Pressure regulator,
8 Pressure-limiting valve and pressure sensor (pressure sensor alternatively in the rail),
9 Clock module for controlling the electric fuel pump.

Electric fuel-pump design using a flow-type pump as an example.



A Fitting cover,
B Electric motor,
C Pump barrel.
1 Electrical connection,
2 Hydraulic connection (fuel outlet),
3 Non-return valve,
4 Pressure-limiting valve,
5 Commutator with carbon brushes,
6 Motor armature with windings which are energized by the commutator,
7 Magnet,
8 Impeller ring of flow-type pump,
9 Hydraulic connection (fuel inlet).

Fuel-delivery module.



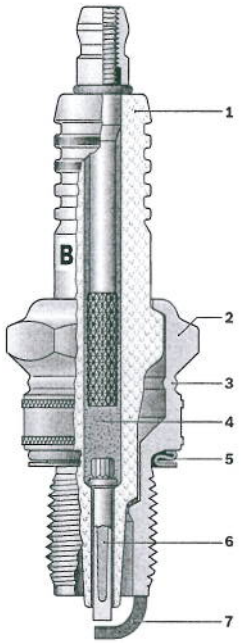
1 Fuel filter,
2 Electric fuel pump,
3 Suction-jet pump,
4 Pressure regulator,
5 Fuel-level sensor,
6 Floater,
7 Prefilter.

Spark plug

B3

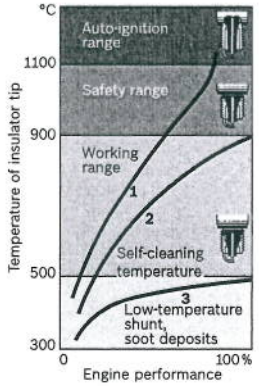
BOSCH

Spark plug design.



1 Al_2O_3 ceramic insulator,
2 Nickel-plated spark plug shell,
3 Heat-shrinkage zone,
4 Conductive glass seal,
5 Captive gasket,
6 Compound center electrode (copper and nickel),
7 Ground electrode.

Spark-plug temperature respons.



1 Spark plug with excessively high heat-range code number (hot plug),
2 Spark plug with suitable heat-range code number,
3 Spark plug with excessively low heat-range code number (cold plug).

The working range temperature should be from 500 °C to 900 °C for different engine performance ratings.

Spark plug concepts.

Air gap design:
The ignition spark travels along a direct path to the ground electrode and thus ignites the air-fuel mixture.

Surface gap design:
The layout of the ground electrodes is such that only surface air gap sparks, which are particularly long and powerful, can be formed.

Surface air gap design:
This design combines both spark paths. Both air gap sparks and surface air gap sparks ignite the air-fuel mixture.

Spark plug faces.

Normal:
Insulator nose with color between whitish or yellowish-grey and russet. Engine OK. Correct heat range. A/F mixture adjustment and timing OK, no ignition miss, cold-start enrichment functioning correctly.
No residues from lead fuel additives or engine-oil additives.
No overheating.

Soot fouling:
Insulator nose, electrodes, and spark plug shell covered with a felt-textured, matt-black coating of soot.
Cause: Incorrect A/F mixture adjustment. A/F mixture too rich, extremely dirty air filter, automatic choke defective, vehicle only used for extremely short distances, spark plug too cold, heat range too low.
Effects: Ignition miss, poor cold starts.
Remedy: Adjust A/F mixture and cold-start system, check air filter.

Oil fouling:
Insulator nose, electrodes, and spark plug shell covered with shiny oil layer of soot or carbon.
Cause: Excessive oil in combustion chamber. Oil level too high, severe wear of piston rings, cylinder walls, or valve seals/guides. Too much oil in fuel mixture (two-stroke engines).
Effects: Ignition loss. Starting difficulties.
Remedy: Overheaul engine, use correct A/F mixture, replace spark plugs.

Severly eroded center electrode:
Cause: Failure to observe spark plug replacement intervals.
Effects: Ignition miss, especially during acceleration (ignition voltage not adequate for bridging wider electrode gap). Starting difficulties.
Remedy: New spark plugs.

Severe lead deposits:
Thick, brownish-yellow glaze, thick in some places, possibly with greenish tint, has formed on the insulator nose.
Cause: Fuel additives containing lead. The glaze forms when the engine is operated at high loads after extended part-throttle operation.
Effects: At high loads the glaze becomes electrically conductive, leading to ignition miss.
Remedy: New spark plugs, cleaning them is pointless.

Ash formation:
Thick ash coating from oil and fuel additives on insulator nose, in scavenging area (annular orifice) and on ground electrode. Loose to cinder-like structure.
Cause: Alloying constituents, particularly from oil, may deposit such ash in the combustion chamber and on the spark plug face.
Effect: Can lead to auto-ignition with loss of power and engine damage.
Remedy: Repair engine. Use new spark plugs and possibly different oil.

Center electrode partially melted:
Center electrode partially melted, blistered, spongy insulator nose tip.
Cause: Thermal overload due to auto-ignition, e.g. on account of excessively advanced ignition timing. Heat range possibly too low.
Effect: Misfiring, loss of power (engine damage).
Remedy: Check engine, ignition and mixture formation. New spark plugs with correct heat range.

Center electrode melted away:
Center electrode melted away and ground electrode severely corroded.
Cause: Thermal overload due to auto-ignition, e.g. on account of excessively advanced ignition timing.
Effect: Misfiring, loss of power, possibly engine damage. Overheated center electrode may cause insulator nose to crack.
Remedy: Check engine, ignition and mixture formation. New spark plugs.

Partially melted electrodes:
Cauliflower-like appearance of electrodes. Possibly deposition of foreign matter.
Cause: Thermal overload, e.g. on account of excessively advanced ignition timing, combustion residue, defective valves or defective ignition distributors.
Effect: Loss of power prior to total failure (engine damage).
Remedy: Check engine, ignition and mixture formation. New spark plugs.

Ferrocen:
Firmly adhering reddish orange deposits coat the insulator nose, electrodes and to some extent the spark plug shell.
Cause: Fuel additives containing iron. Deposits occur in normal operation after a few thousand kilometers.
Effect: The iron in the coating is electrically conductive and causes misfiring.
Remedy: New spark plugs, cleaning has no effect.

Ground electrode wear:
Cause: Corrosive fuel and oil additives. Unfavourable flow conditions in combustion chamber, possibly on account of deposits, engine knocking. No thermal overload.
Effect: Misfiring, particularly on acceleration (ignition voltage no longer sufficient for large electrode gap). Poor starting performance.
Remedy: New spark plugs.

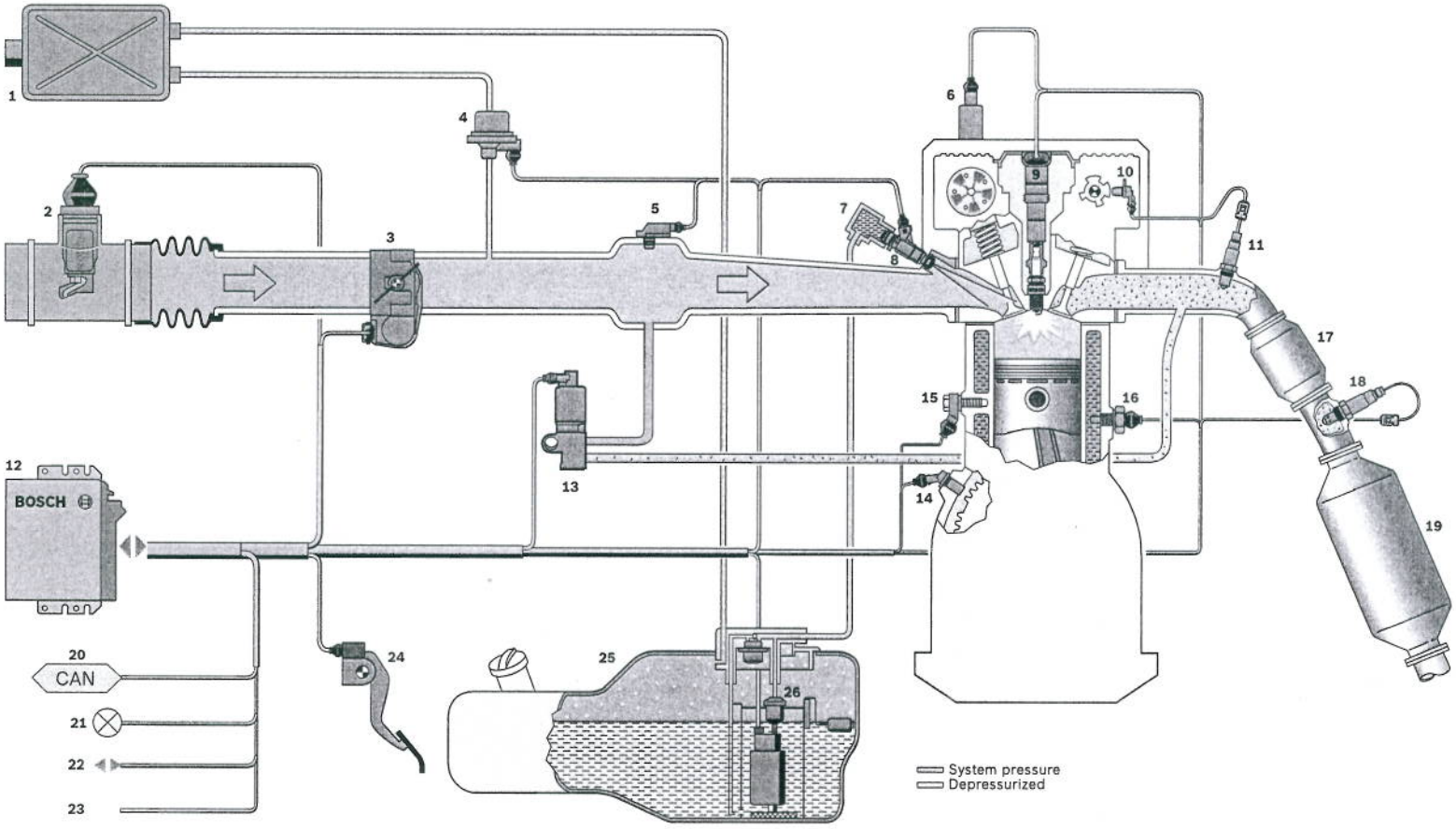
Cracking of insulator nose:
Cause: Mechanical damage due to inexpert handling. In borderline cases – particularly following excessive operating time – cracking of insulator nose may be caused by deposits between center electrode and insulator nose and by corrosion of center electrode.
Effect: Misfiring, sparkover at points not reliably supplied with fresh mixture.
Remedy: New spark plugs.

ME-Motronic Engine Management

B4

BOSCH

System overview: ME-Motronic (intake-manifold injection).



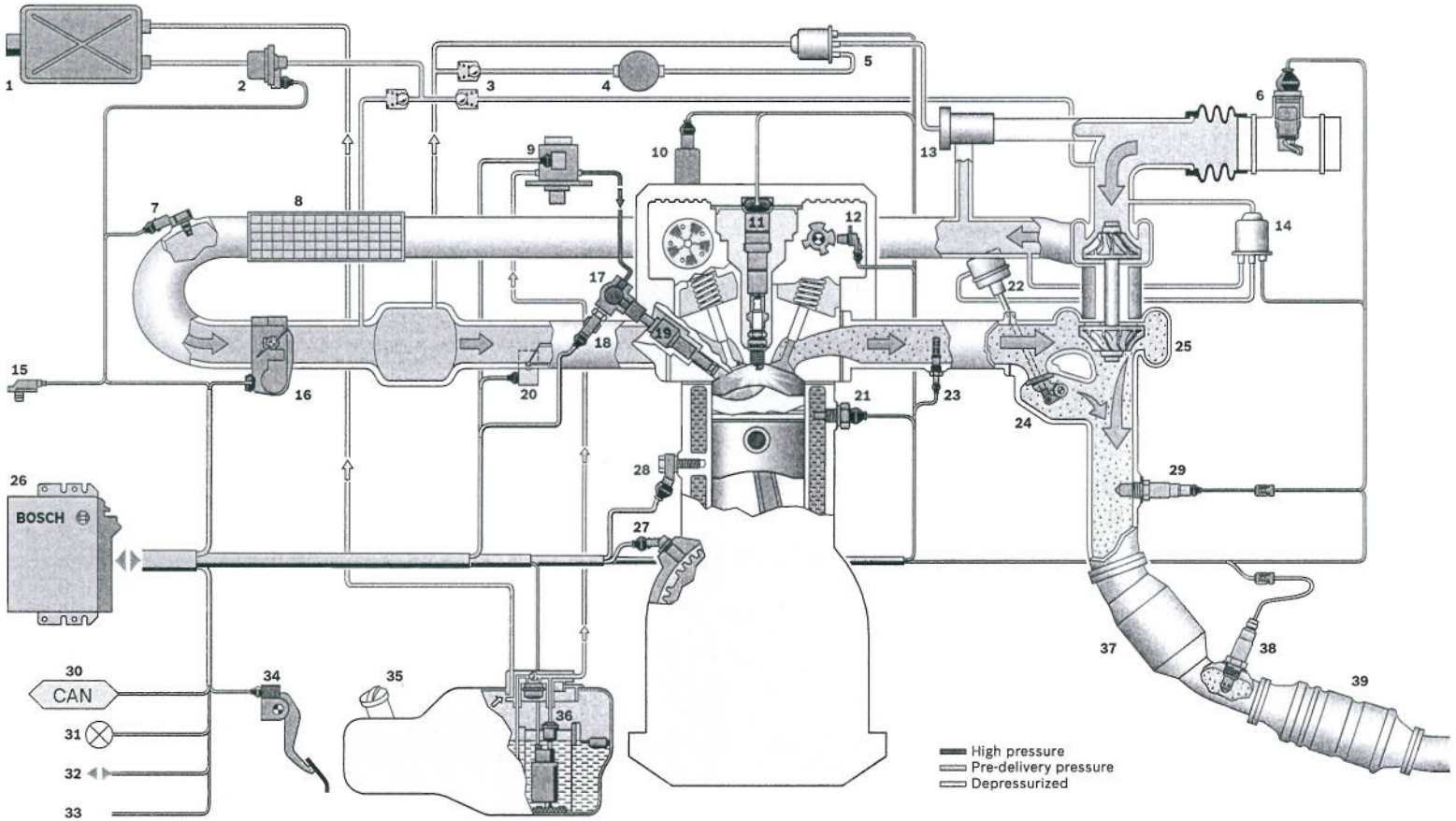
1 Activated charcoal canister,
2 Hot-film air-mass meter with integrated temperature sensor,
3 Throttle device (ETC),
4 Canister-purge valve,
5 Intake-manifold pressure sensor,
6 Actuators for variable camshaft control,
7 Fuel rail,
8 Fuel injector,
9 Ignition coil with attached spark plug,
10 Camshaft sensor,
11 λ oxygen sensor upstream of primary catalytic converter,
12 Engine ECU,
13 Exhaust gas recirculation valve,
14 Speed sensor,
15 Knock sensor,
16 Engine-temperature sensor,
17 Primary catalytic converter (three-way catalytic converter),
18 λ oxygen sensor downstream of primary catalytic converter,
19 Main catalytic converter (three-way catalytic converter),
20 CAN interface,
21 Fault lamp,
22 Diagnosis interface,
23 Interface to immobilizer control unit,
24 Accelerator-pedal modul with pedal-travel sensor,
25 Fuel tank,
26 In-tank unit with electric fuel pump, fuel filter and fuel pressure regulator.

DI-Motronic Engine Management

B5

BOSCH

System overview: DI-Motronic (gasoline direct injection) with turbosupercharging.



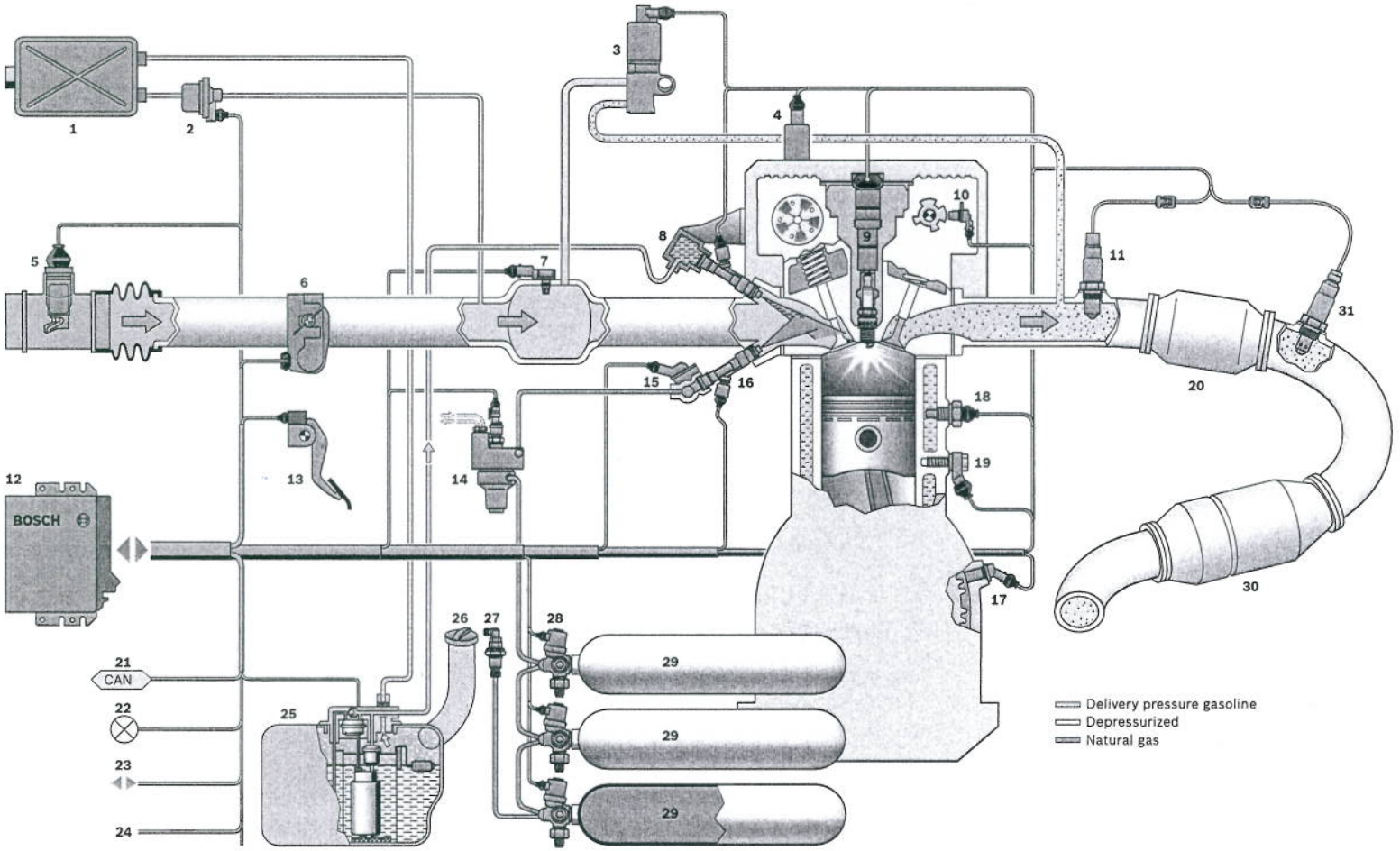
1 Activated charcoal canister,
2 Canister-purge valve,
3 Nonreturn valves,
4 Turbo-vacuum reservoir,
5 Solenoid valve,
6 Hot-film air-mass meter with integrated temperature sensor,
7 Boost-pressure sensor (optional in combination with temperature sensor),
8 Intercooler,
9 High-pressure pump with integrated fuel-supply control valve,
10 Actuators for variable camshaft control,
11 Ignition coil with attached spark plug,
12 Camshaft sensor,
13 Dump valve,
14 Solenoid valve for waste gate control,
15 Ambient-pressure sensor,
16 Throttle device (ETC),
17 High-pressure fuel rail,
18 Fuel-pressure sensor,
19 High-pressure injector,
20 Swirl-control valve,
21 Engine-temperature sensor,
22 Waste gate actuator,
23 Exhaust temperature sensor,
24 Waste gate,
25 Turbo charger,
26 Electronic control unit,
27 Engine-speed sensor,
28 Knock sensor,
29 λ oxygen sensor upstream of primary catalytic converter,
30 CAN interface,
31 Fault lamp,
32 Diagnosis interface,
33 Interface to immobilizer control unit,
34 Accelerator-pedal module with pedal-travel sensor,
35 Fuel tank,
36 In-tank unit with electric fuel pump, fuel filter and fuel pressure regulator,
37 Primary catalytic converter (three-way catalytic converter),
38 λ oxygen sensor downstream of primary catalytic converter,
39 Main catalytic converter (three-way catalytic converter).

Engines Fueled by Natural Gas

BG

BOSCH

Spark-ignition engine with bifuel operation: gasoline injection or CNG injection (Compressed Natural Gas).



1 Activated charcoal canister,
2 Canister-purge valve,
3 Exhaust-gas recirculation valve,
4 Camshaft adjuster,
5 Hot-film air-mass meter,
6 Electronically actuated throttle valve (ETC),
7 Intake-manifold pressure sensor,
8 Gasoline rail with gasoline injectors,
9 Ignition coil with spark plug,
10 Camshaft sensor,
11 λ oxygen sensor upstream of primary catalytic converter,
12 Bifuel Motronic ECU,
13 Accelerator-pedal module,
14 Natural-gas pressure-control module with integrated gas shutoff valve and high-pressure sensor,
15 Gas rail with natural-gas pressure and temperature sensor,
16 Natural-gas injector,
17 Crankshaft speed sensor,
18 Engine-temperature sensor,
19 Knock sensor,
20 Primary catalytic converter,
21 CAN interface,
22 Diagnosis lamp,
23 Diagnosis interface,
24 Interface to immobilizer ECU,
25 Gasoline tank with integrated electric fuel pump,
26 Gasoline filler neck,
27 Natural-gas filler neck,
28 High-pressure shutoff valve on natural-gas tank,
29 Natural gas tank,
30 Main catalytic converter,
31 λ oxygen sensor downstream of primary catalytic converter.

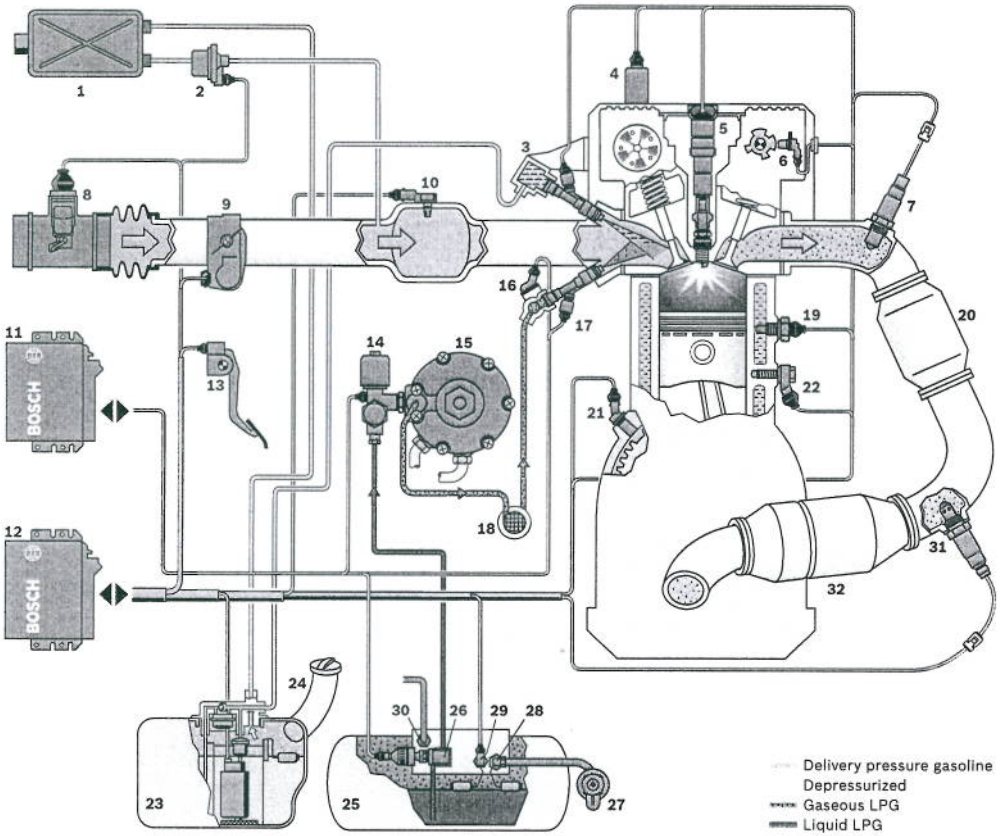
LPG Operation (Liquified Petroleum Gas)

B7

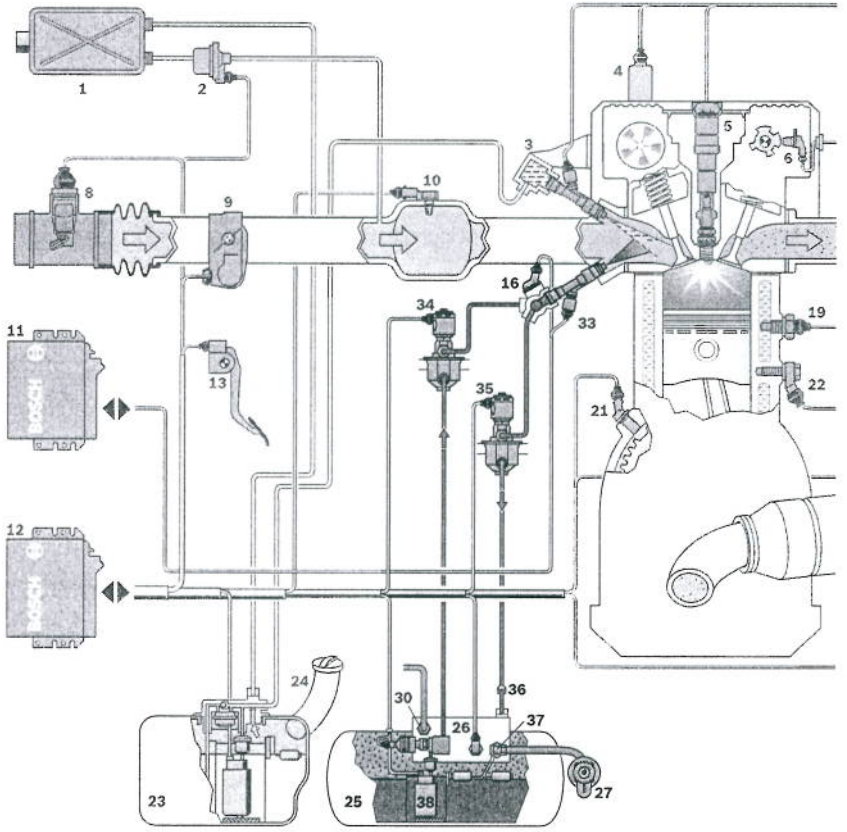
BOSCH

Spark-ignition engine with bifuel operation: Gasoline or LPG operation.

Gaseous LPG injection.



Liquid LPG injection.



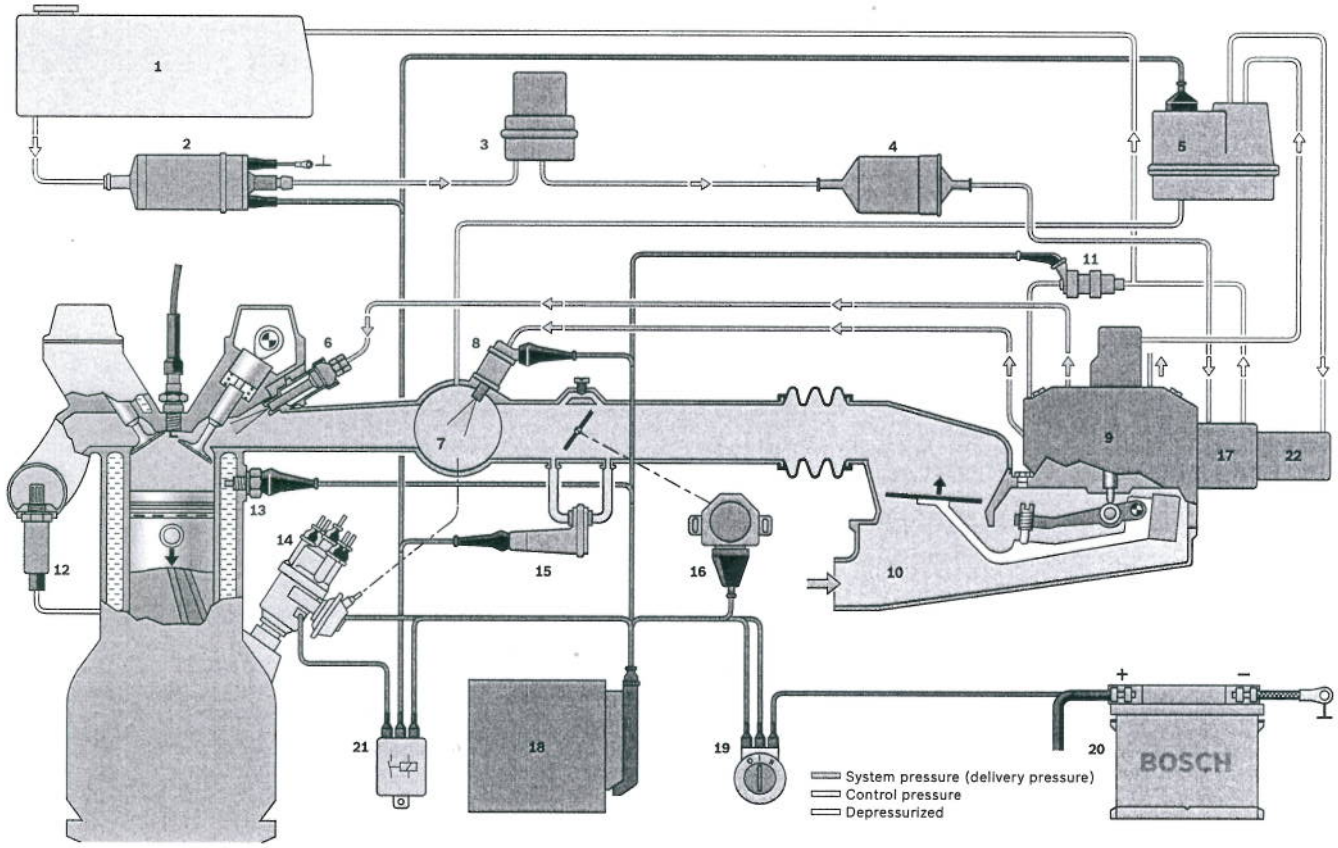
1 Activated charcoal canister, 2 Canister-purge valve, 3 Gasoline rail with gasoline injectors, 4 Camshaft adjuster, 5 Ignition coil with spark plug, 6 Camshaft sensor, 7 λ oxygen sensor upstream of primary catalytic converter, 8 Hot-film air-mass meter, 9 Electronically actuated throttle valve (ETC), 10 Intake-manifold pressure sensor, 11 LPG ECU (LPG functionality optionally integrated in a bifuel ECU), 12 Engine ECU, 13 Accelerator-pedal module, 14 Electromagnetic LPG shutoff valve, 15 Evaporator with pressure regulator, 16 Pressure and temperature sensors, 17 LPG rail with gas injectors (gaseous injection), 18 LPG filter, 19 Engine-temperature sensor, 20 Primary catalytic converter, 21 Crankshaft speed sensor, 22 Knock sensor, 23 Gasoline tank with integrated electric fuel pump, 24 Gasoline filler neck, 25 LPG tank (steel tank for pressure up to 28 bar), 26 Electromagnetic LPG shutoff valve, 27 LPG filler neck, 28 80 % filler stop valve, 29 LPG level indicator, 30 Pressure-relief valve, 31 λ oxygen sensor downstream of primary catalytic converter, 32 Main catalytic converter, 33 LPG rail with gas injectors (liquid injection), 34 Electromagnetic LPG shutoff valve for supply, 35 Electromagnetic LPG shutoff valve for return, 36 Non-return valve, 37 80 % filler stop valve with integrated LPG level sensor, 38 LPG delivery pump with filter.

K- and KE-Jetronic Gasoline Injection Systems

B8

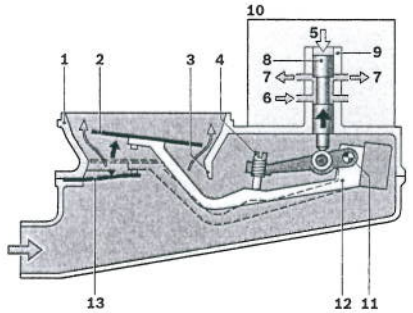
BOSCH

System overview: K-Jetronic (system with λ-control).



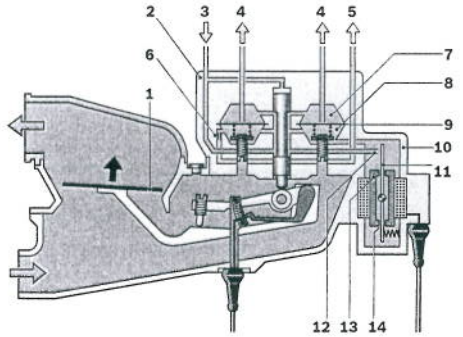
1 Fuel tank, 2 Electric fuel pump, 3 Fuel accumulator, 4 Fuel filter, 5 Warm-up regulator, 6 Fuel injector, 7 Intake manifold,
8 Cold-start valve, 9 Fuel distributor, 10 Air-flow sensor, 11 Timing valve for λ-control, 12 λ sensor, 13 Thermo-time switch, 14 Ignition distributor, 15 Auxiliary-air device,
16 Throttle valve with throttle-valve switch, 17 System-pressure regulator, 18 ECU (for version with λ closed-loop control), 19 Ignition/starting switch, 20 Battery,
21 Safety circuit, 22 check valve.

Updraft air-flow sensor (K-Jetronic).



1 Air funnel, 2 Sensor plate, 3 Relief cross-section,
4 Mixture adjusting screw, 5 Control pressure (system-pressure regulator),
6 Fuel inlet, 7 Metered quantity of fuel, 8 Control plunger,
9 Barrel with metering slits, 10 Fuel distributor, 11 Pivot,
12 Set of levers, 13 Leaf spring.

Electrohydraulic pressure actuator (KE-Jetronic).



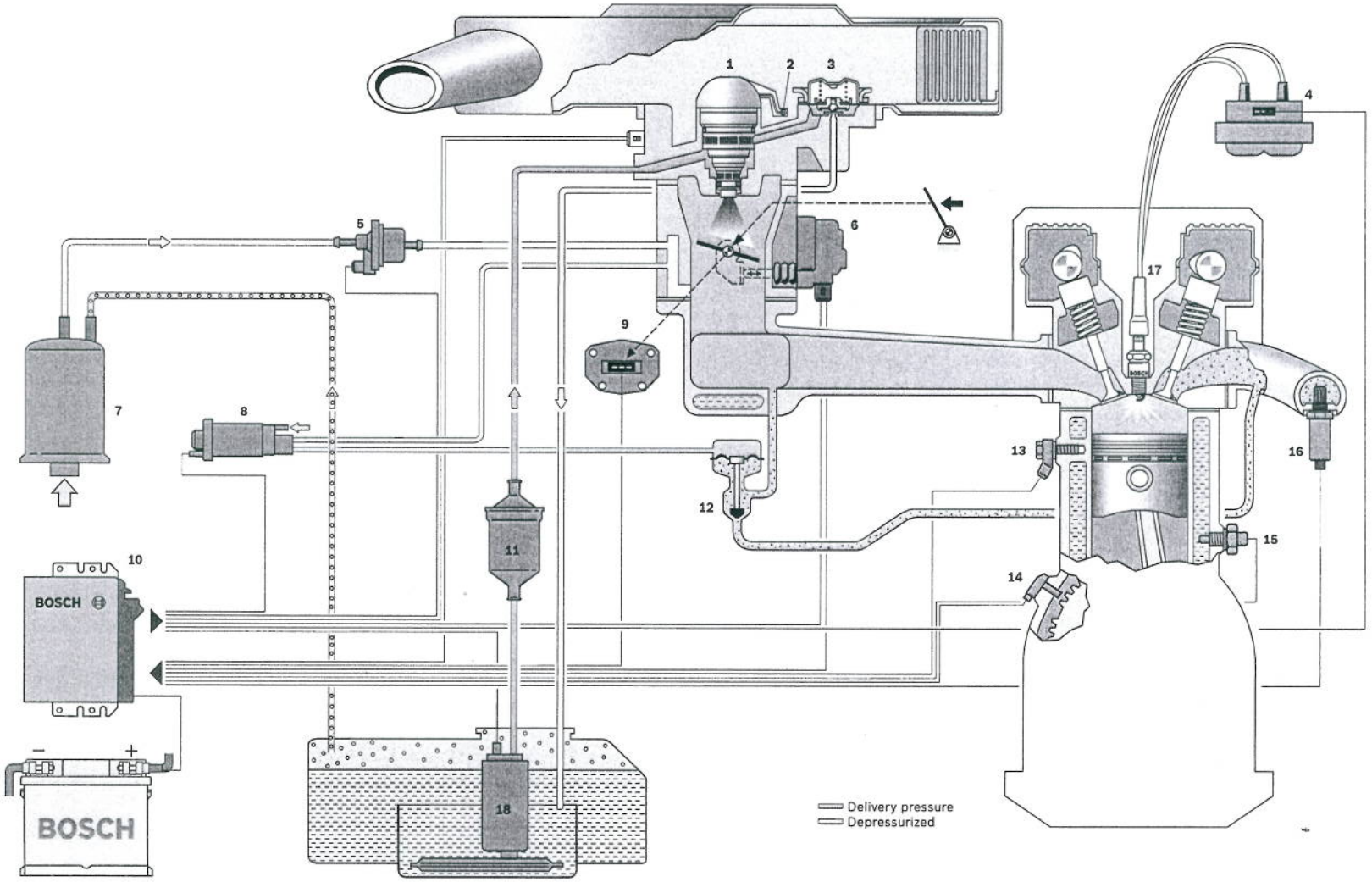
1 Sensor plate, 2 Fuel distributor, 3 Fuel inlet (system pressure),
4 Fuel to fuel injectors, 5 Fuel-return line to pressure regulator,
6 Fixed restrictor, 7 Upper chamber, 8 Lower chamber, 9 Diaphragm,
10 Pressure actuator, 11 Baffle plate, 12 Nozzle, 13 Magnetic pole, 14 Air gap.

Mono-Motronic Engine-Management System

BG

BOSCH

Mono-Motronic system overview.

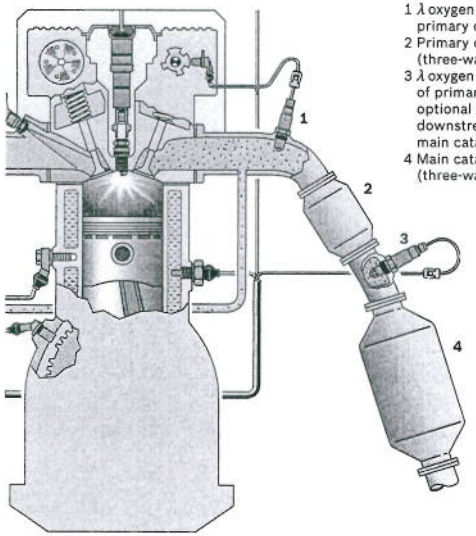


1 Fuel injector,
2 Air-temperature sensor,
3 Fuel-pressure regulator,
4 Ignition coil,
5 Canister-purge valve,
6 Throttle-valve actuator,
7 Activated charcoal canister,
8 Pressure actuator,
9 Throttle-valve potentiometer,
10 Electronic control unit (ECU),
11 Fuel filter,
12 Exhaust-gas recirculation valve,
13 Knock sensor,
14 Speed sensor,
15 Engine-temperature sensor,
16 λ oxygen sensor,
17 Spark plug,
18 Electric fuel pump.

Catalytic Exhaust-Gas Treatment on Gasoline Engines

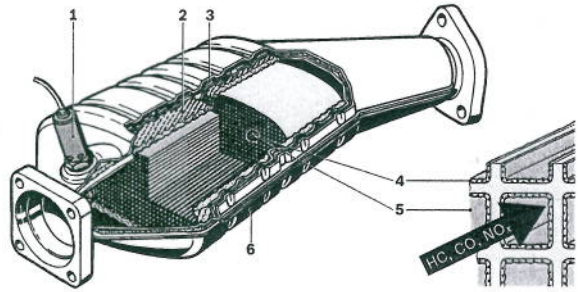
B10 BOSCH

Exhaust-gas system of a gasoline engine.



1 λ oxygen sensor upstream of primary catalytic converter,
2 Primary catalytic converter (three-way catalytic converter),
3 λ oxygen sensor downstream of primary catalytic converter, optional λ oxygen sensor downstream of main catalytic converter,
4 Main catalytic converter (three-way catalytic converter).

Three-way catalytic converter.



1 λ oxygen sensor, 2 Swell matting,
3 Thermally insulated double shell,
4 Washcoat (Al_2O_3 substrate coating) with noble-metal coating,
5 Substrate (monolith), 6 Housing.

Examples for oxidation reactions:

$2\ CO + O_2 \rightarrow 2\ CO_2$

$2\ C_3H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$

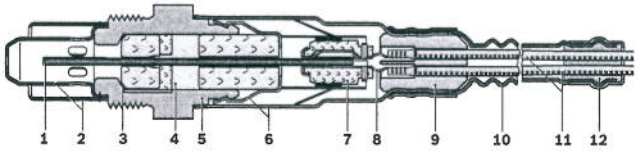
Reduction of nitrous oxides:

$2\ NO + 2\ CO \rightarrow N_2 + 2\ CO_2$

$2\ NO_2 + 2\ CO \rightarrow N_2 + 2\ CO_2 + O_2$

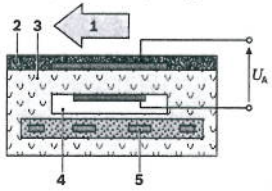
λ oxygen sensor.

Sectional view of a λ oxygen sensor (both two-step λ oxygen sensor and broad-band λ oxygen sensor).



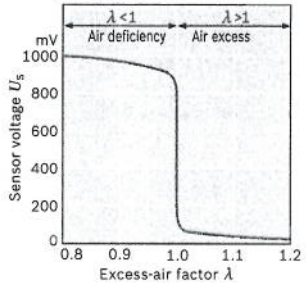
1 Measuring cell (two-step λ oxygen sensor with a planar measuring cell; planar broad-band λ oxygen sensor with a combination of a Nernst concentration cell and an oxygen pump cell), 2 Double protective tube, 3 Compensation disk, 4 Seal pack, 5 Sensor housing, 6 Protective sleeve, 7 Contact holder, 8 Contact clip, 9 PTFE grommet, 10 PTFE shaped sleeve, 11 Connecting leads, 12 Seal.

Measurement principle of a LSF4.2 planar two-step λ oxygen sensor.

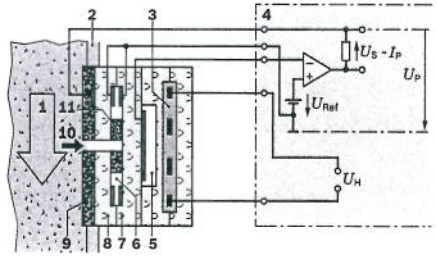


1 Exhaust gas, 2 Porous ceramic protective layer, 3 Measuring cell with microporous noble-metal coating, 4 Rererence-air passage, 5 Heater.
U_A Output voltage.

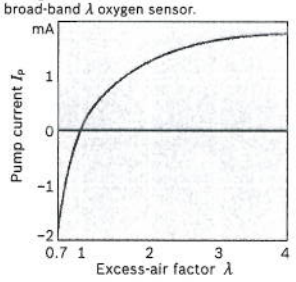
Voltage curve of a two-step λ oxygen sensor.



Measurement principle of a LSU planar broad-band λ oxygen sensor.



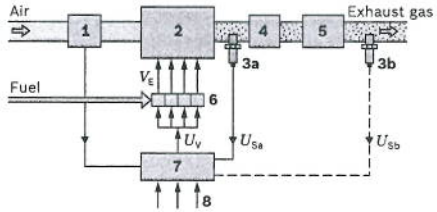
Voltage curve of a broad-band λ oxygen sensor.



1 Exhaust gas, 2 Exhaust pipe, 3 Heater, 4 Control electronics, 5 Reference cell with reference-air passage, 6 Diffusion gap, 7 Nernst concentration cell with Nernst measuring electrode (on diffusion-gap side) and reference electrode (on reference-cell side), 8 Oxygen pump cell with pump electrode, 9 Porous protective layer, 10 Gas-access passage, 11 Porous diffusion barrier.
I_P Pump current, U_P Pump voltage, U_H Heater voltage, U_{ref} Reference voltage (450 mV corresponds to $\lambda = 1$), U_S Sensor voltage.

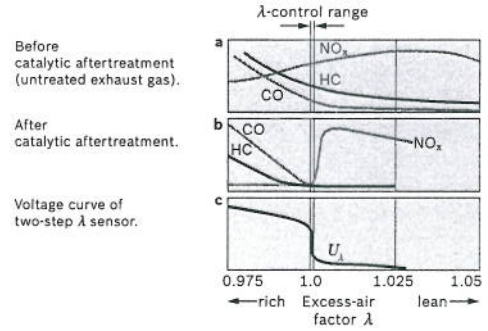
λ control loop.

Functional diagram of λ closed-loop control.

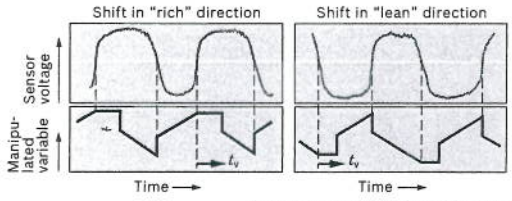


1 Air-mass sensor, 2 Engine,
3a λ sensor upstream of primary catalytic converter (two-step λ sensor, or broad-band λ sensor),
3b Two-step λ sensor downstream of main catalytic converter (for two-sensor control),
4 Primary catalytic converter (three-way catalyst), 5 Main catalytic converter (three-way catalyst), 6 Fuel injectors, 7 Engine control unit, 8 Input signals.
U_S Sensor voltage, U_V Valve control voltage, V_E Injected fuel quantity.

Pollutants in the exhaust gas.



Manipulated-variable curve of a two-step control with a λ sensor upstream of primary catalytic converter and controlled λ shift (delay time t_v) due to feed-forward control and λ control with the sensor downstream of the main catalytic converter.

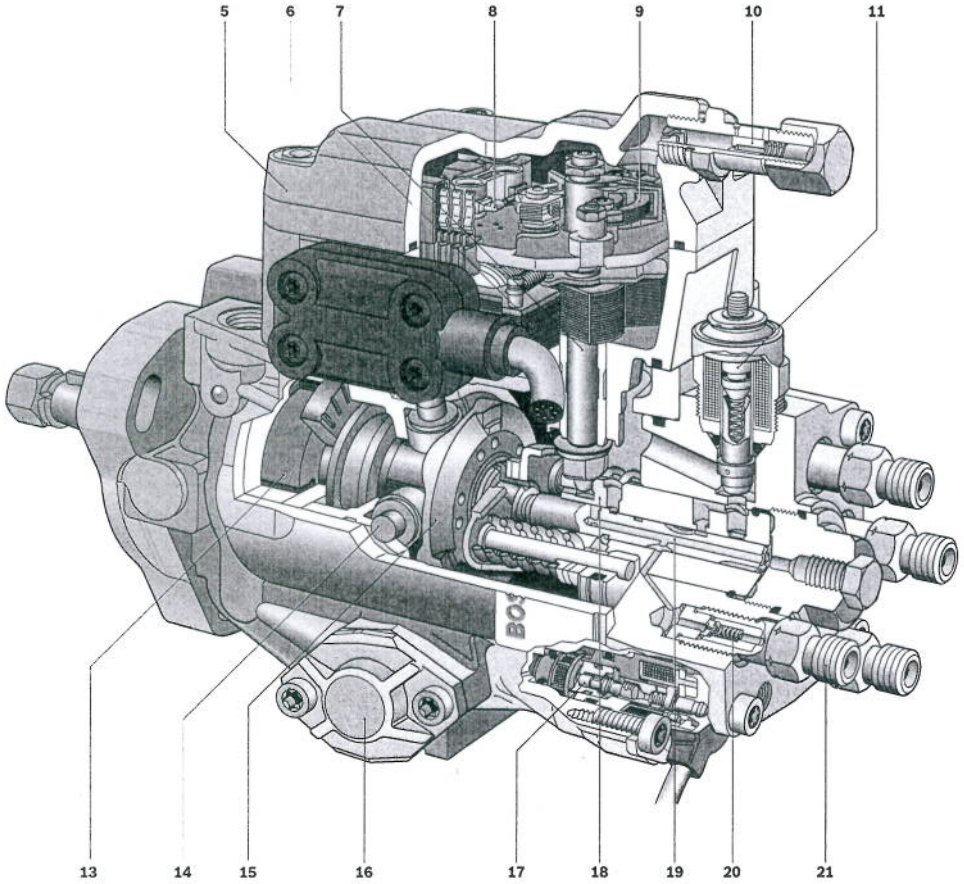


Diesel Axial-Piston Distributor Injection Pump

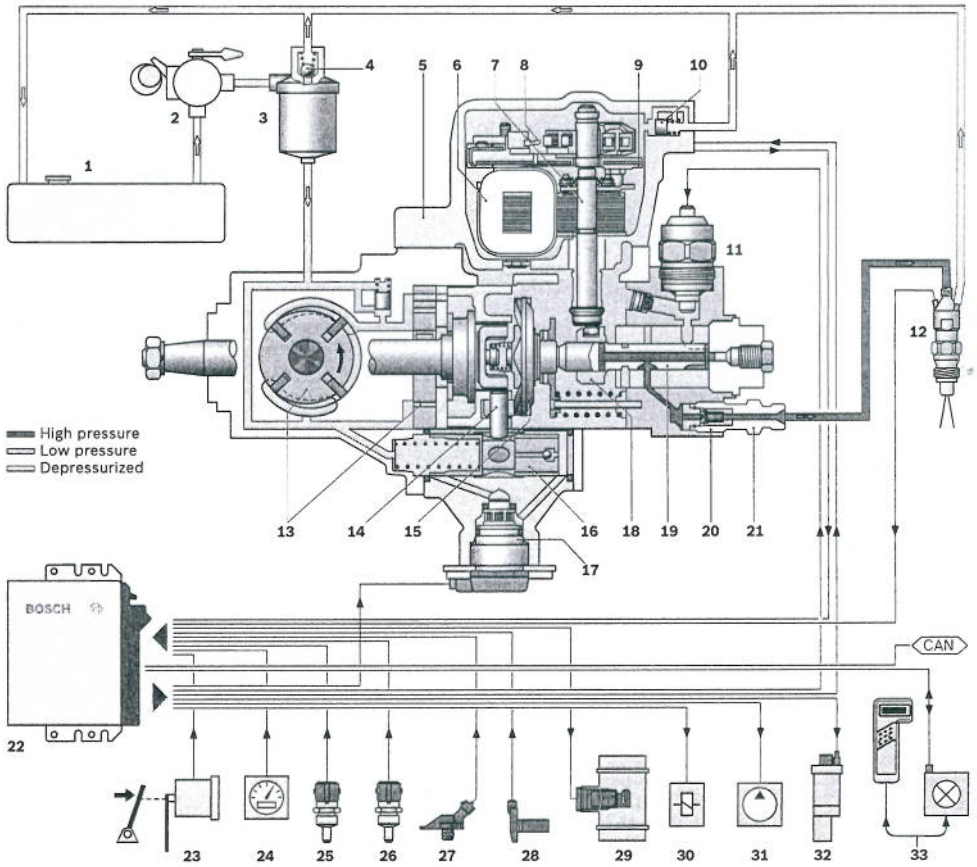
D6

BOSCH

Axial-piston distributor injection pump with electric actuator mechanism.



Electronic diesel control (EDC) for axial-piston distributor injection pumps.



1 Fuel tank, 2 Presupply pump, 3 Fuel filter, 4 Overflow valve, 5 Electrical actuator, 6 Stator, 7 Actuator shaft, 8 Temperature sensor, 9 Position sensor, 10 Overflow restriction, 11 Electrical shutoff valve, 12 Nozzle with needle-motion sensor, 13 Supply pump, 14 Roller ring with rollers, 15 Cam plate, 16 Timing device, 17 Solenoid valve, 18 Control Collar, 19 Distributor plunger, 20 Delivery valve, 21 Delivery-valve holder, 22 Electronic control unit (ECU), 23 Pedal-travel sensor, 24 Wheel-speed sensor, 25 Coolant sensor, 26 Air-temperature sensor, 27 Boost-pressure sensor, 28 Engine-speed sensor, 29 Air-mass meter, 30 Glow relay, 31 A/C compressor, 32 Exhaust-gas recirculation valve, 33 Diagnosis display with diagnostic unit.

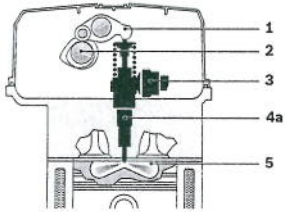
Unit Injector System (UIS) and Unit Pump System (UPS)

D5

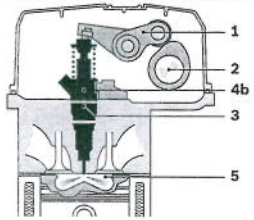
BOSCH

High-pressure injection system UIS and UPS (Motor installation).

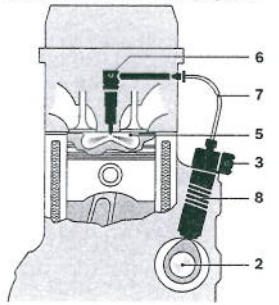
Passenger-car Unit Injector System.



Commercial-vehicle Unit Injector System.

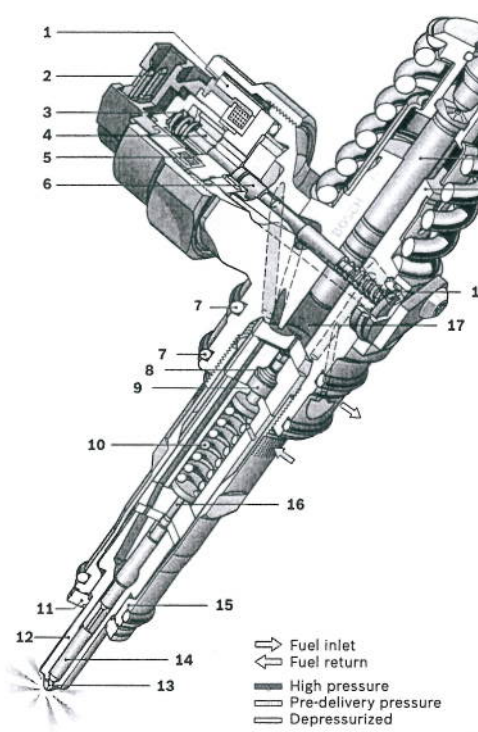


Commercial-vehicle Unit Pump System.



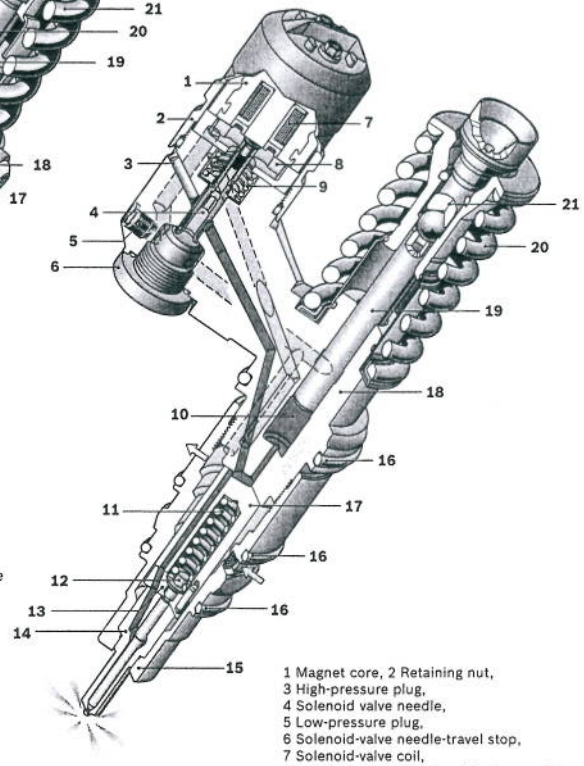
1 Rocker arm, 2 Camshaft,
3 High-pressure solenoid valve,
4a Passenger-car Unit Injector,
4b Commercial-vehicle Unit Injector (design with internal solenoid valve),
5 Engine combustion chamber,
6 Nozzle-holder assembly,
7 Short high-pressure line, 8 Unit Pump.

Passenger-car Unit Injector.



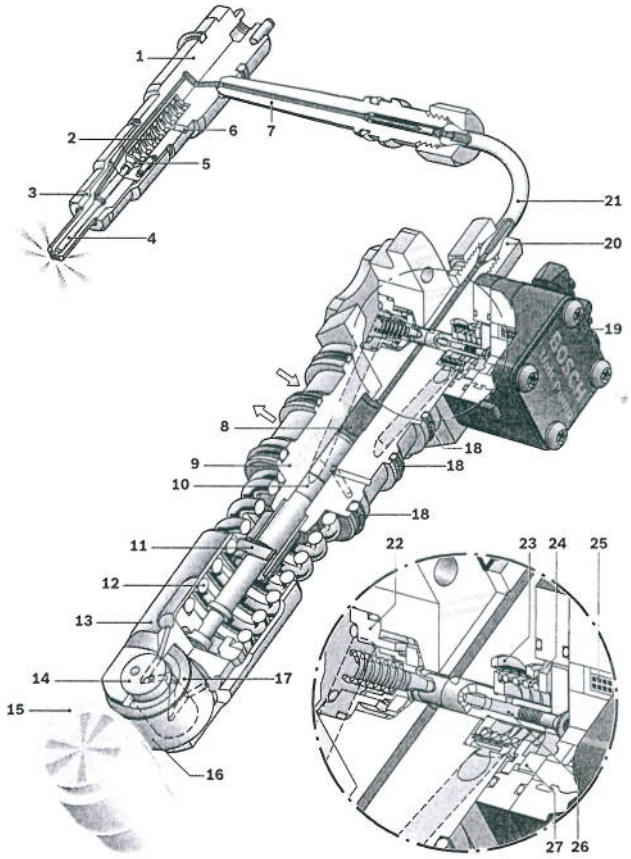
1 Magnet core, 2 Plug-in connection, 3 Compensating spring,
4 Armature, 5 Solenoid-valve coil,
6 Solenoid-valve needle, 7 Seal,
8 Accumulator chamber, 9 Accumulator plunger,
10 Needle-valve spring, 11 Sealing disc,
12 Integral nozzle assembly, 13 Needle seat,
14 Nozzle needle, 15 Retaining nut,
16 Hydraulic stop (damping unit),
17 High-pressure chamber,
18 Solenoid-valve spring, 19 Pump-body assembly,
20 Pump plunger, 21 Follower spring,
22 Ball pin.

Commercial-vehicle Unit Injector (design with exterior solenoid valve).



1 Magnet core, 2 Retaining nut,
3 High-pressure plug,
4 Solenoid valve needle,
5 Low-pressure plug,
6 Solenoid-valve needle-travel stop,
7 Solenoid-valve coil,
8 Armature plate, 9 Solenoid-valve needle,
10 High-pressure chamber,
11 Needle-valve spring,
12 Pressure pin, 13 Shim,
14 Integral nozzle assembly,
15 Retaining nut, 16 Seal,
17 Spring retainer, 18 Pump-body assembly,
19 Pump plunger, 20 Return spring,
21 Ball pin.

Commercial-vehicle Unit Pump.



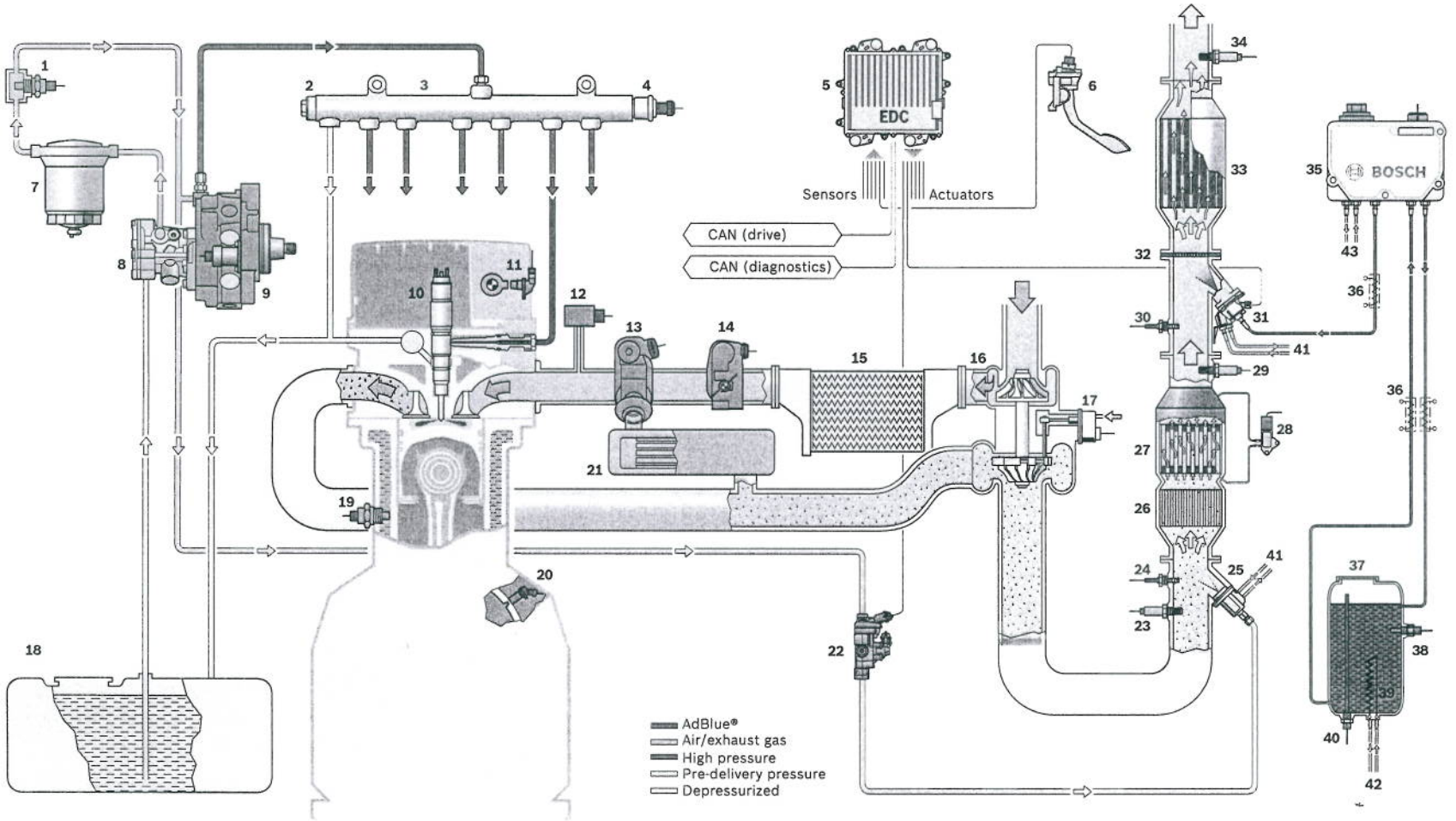
1 Nozzle-holder assembly, 2 Needle-valve spring, 3 Retaining nut, 4 Nozzle needle,
5 Pressure pin, 6 Leakage bore, 7 Pressure fitting,
8 High-pressure chamber, 9 Pump-body assembly, 10 Pump plunger,
11 Pump-plunger retention device, 12 Tappet spring, 13 Tappet body,
14 Roller-tappet pin, 15 Cam, 16 Tappet roller, 17 Roller tappet, 18 Seal,
19 Solenoid-valve housing, 20 High-pressure connection, 21 High-pressure delivery line,
22 Travel-stop, 23 Spring seat, 24 Solenoid-valve spring, 25 Solenoid-valve coil,
26 Solenoid-valve needle, 27 Armature plate.

Common-Rail System for Commercial Vehicles

D4

BOSCH

System overview: Common-rail system for commercial vehicles (example).



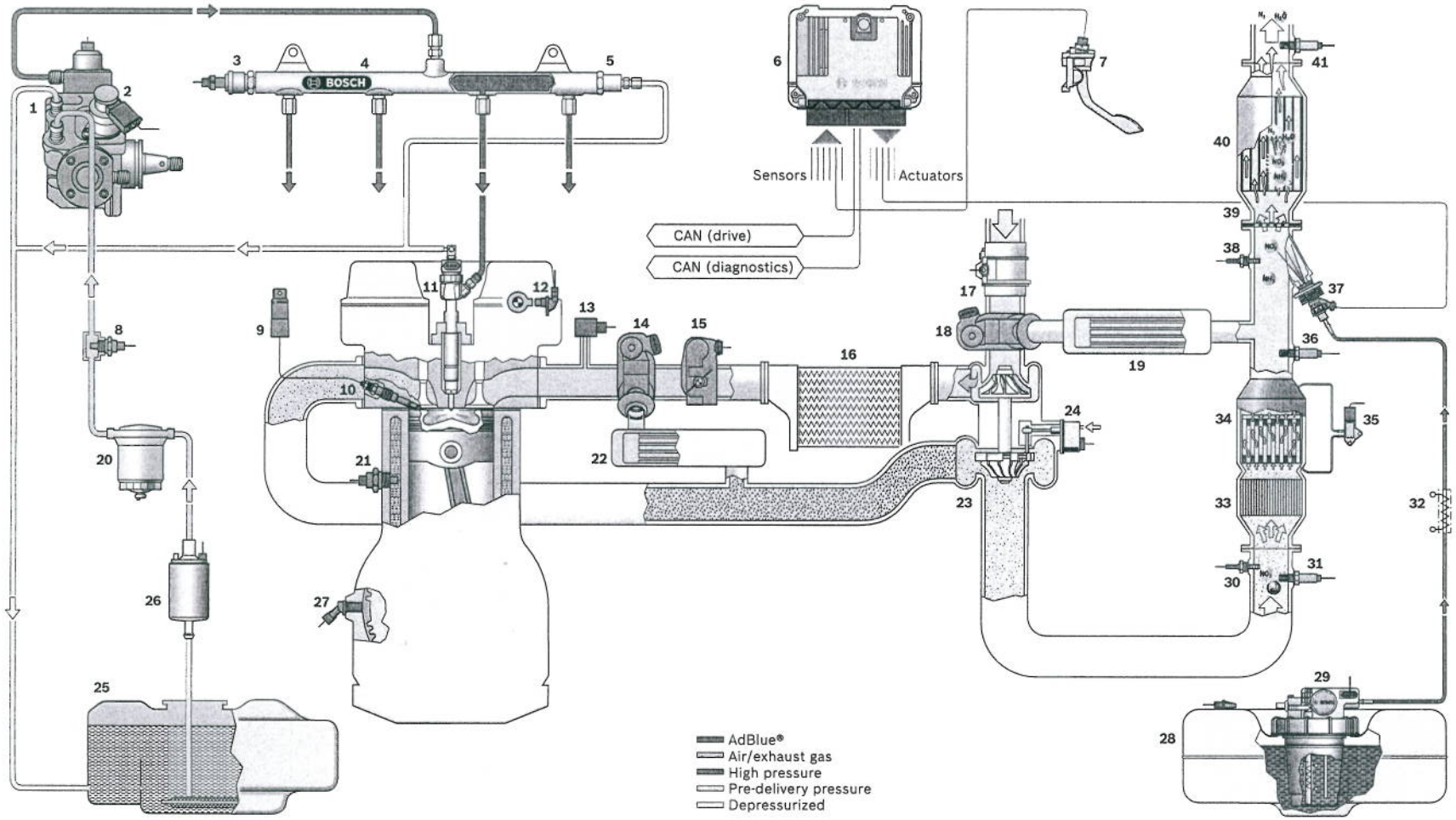
1 Fuel-temperature sensor,
2 Pressure-limiting valve,
3 Rail,
4 Rail-pressure sensor,
5 Engine control unit (electronic diesel control, EDC),
6 Accelerator-pedal sensor,
7 Fuel filter,
8 Gear presupply pump,
9 High-pressure pump with metering unit,
10 Injector,
11 Camshaft sensor,
12 Boost-pressure sensor,
13 Exhaust gas recirculation (EGR) valve,
14 Throttle valve,
15 Intercooler,
16 Turbo charger,
17 VTG actuator (variable turbine geometry),
18 Fuel tank,
19 Engine-temperature sensor,
20 Engine-speed sensor,
21 EGR cooler,
22 Dosing module Departronic,
23 λ oxygen sensor,
24 Temperature sensor,
25 Injection unit Departronic,
26 Diesel oxidation catalytic converter,
27 Diesel particulate filter,
28 Differential-pressure sensor,
29 λ oxygen sensor,
30 Temperature sensor,
31 AdBlue® dosing module,
32 Mixer,
33 SCR catalytic converter (selective catalytic reduction),
34 NO_x sensor,
35 AdBlue® supply module (Denoxtronic),
36 Heater (connection to engine cooling circuit or electric heating),
37 AdBlue® tank,
38 Temperature sensor,
39 Heater,
40 Level sensor,
41 Connection to engine cooling circuit (for cooling),
42 Connection to engine cooling circuit (for heating the AdBlue® tank),
43 Connection to engine cooling circuit (for heating the supply module, optional electric heating).

Common-Rail System for Passenger Cars and Light Commercial Vehicles

D3

BOSCH

System overview: Common-rail system for passenger cars and light commercial vehicles (example).



1 High-pressure pump,
2 Metering unit,
3 Rail-pressure sensor,
4 Rail,
5 Pressure-limiting valve,
6 Engine control unit (electronic diesel control, EDC),
7 Accelerator-pedal sensor,
8 Fuel-temperature sensor,
9 Glow control unit,
10 Glow plug,
11 Injector,
12 Camshaft sensor,
13 Boost-pressure sensor,
14 Exhaust gas recirculation (EGR) valve (high-pressure EGR),
15 Throttle valve,
16 Intercooler,
17 Air-mass meter,
18 EGR valve (low pressure EGR),
19 EGR cooler, (low pressure EGR),
20 Fuel filter,
21 Engine-temperature sensor,
22 EGR cooler (high pressure EGR),
23 Turbo charger,
24 VTG actuator (variable turbine geometry),
25 Fuel tank,
26 Electric fuel pump,
27 Engine-speed sensor,
28 AdBlue® tank,
29 AdBlue® supply module (Denoxtronic) with swirl pot, heater, level sensor, temperature sensor and pressure sensor,
30 Temperature sensor,
31 λ oxygen sensor,
32 Electric heating,
33 Diesel oxidation catalytic converter,
34 Diesel particulate filter,
35 Differential-pressure sensor,
36 NO_x sensor (optional),
37 AdBlue® dosing module,
38 Temperature sensor,
39 Mixer,
40 SCR catalytic converter (selective catalytic reduction),
41 NO_x sensor.

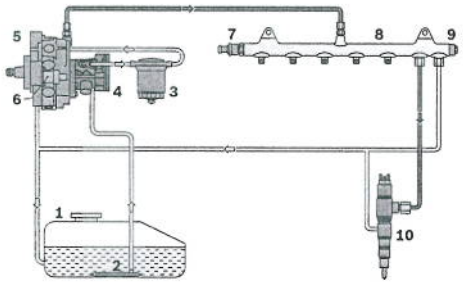
Generation of High-Pressure in Common-Rail Systems for Commercial Vehicles

D2

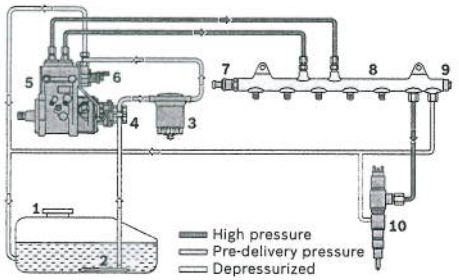
BOSCH

Common-rail systems for commercial vehicles (examples).

Demand-controlled 3-plunger radial-piston pump: pressure control on the suction side via metering unit.

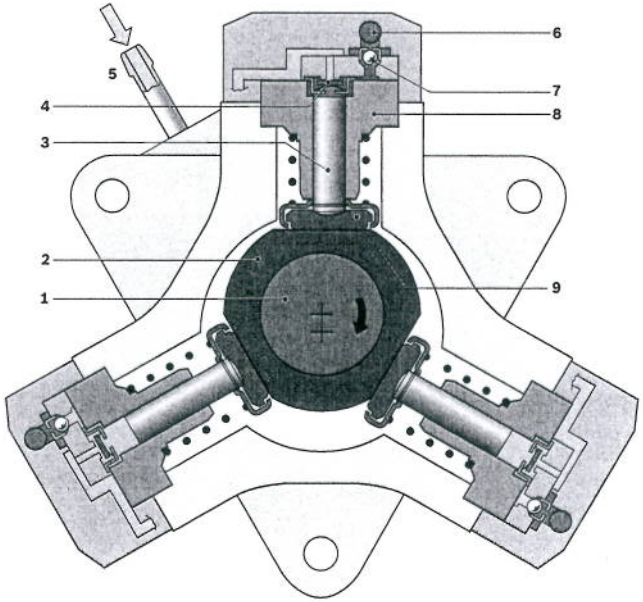


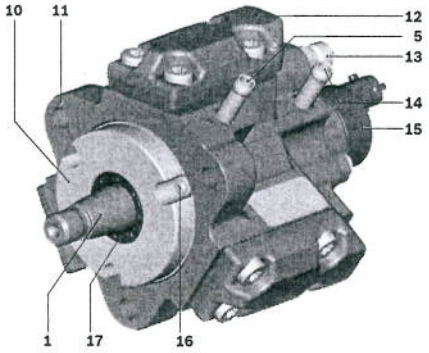
Demand-controlled 2-plunger in-line piston pump: pressure control on the suction side via metering unit.



1 Fuel tank,
2 Preliminary filter,
3 Fuel filter,
4 Gear presupply pump,
5 High-pressure pump,
6 Metering unit,
7 Rail-pressure sensor,
8 Rail,
9 Pressure-limiting valve,
10 Injector.

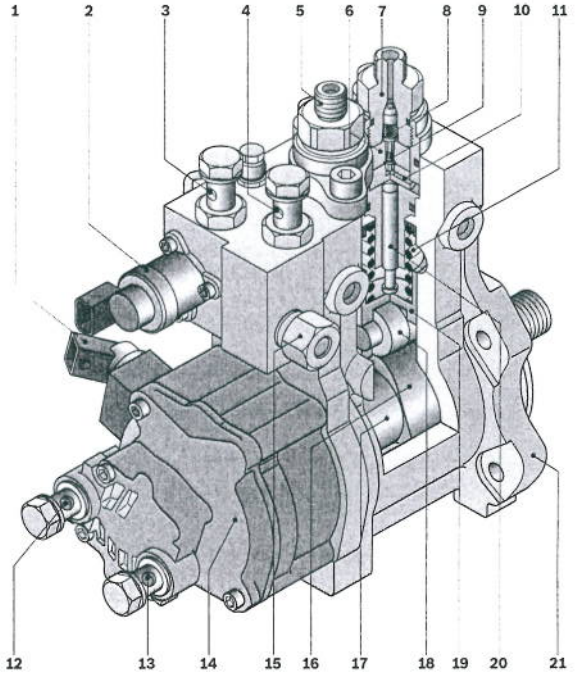
3-plunger radial-piston pump (cross section and view).





1 Eccentric shaft,
2 Polygon ring,
3 Pump plunger,
4 Intake valve (inlet valve),
5 Fuel-supply connection port,
6 High-pressure channel,
7 Outlet valve,
8 Pump cylinder,
9 Plunger base plate,
10 Flange,
11 Pump housing,
12 Cylinder head,
13 High-pressure connection port,
14 Return connection port,
15 Pressure-control valve (for continuous-delivery high-pressure pumps) respectively metering unit (for demand-controlled high-pressure pumps),
16 Barrel bolt,
17 Shaft seal.

2-plunger in-line piston pump.



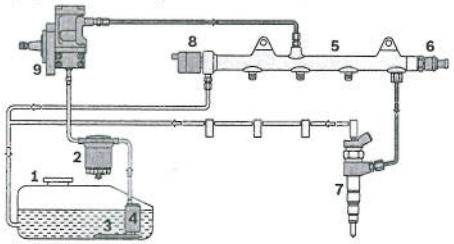
1 Speed sensor (pump speed),
2 Metering unit (for pressure control on the suction side),
3 Fuel supply for metering unit (from fuel filter),
4 Fuel return to fuel tank,
5 High-pressure connection port,
6 Valve body,
7 Valve holder,
8 Outlet valve with valve spring,
9 Inlet valve with valve spring,
10 Fuel supply to pump element,
11 Plunger spring,
12 Fuel supply (from fuel tank),
13 Fuel outlet to fuel filter,
14 Gear presupply pump,
15 Overflow valve,
16 Cam,
17 Camshaft,
18 Roller bolt with roller,
19 Roller tappet,
20 C-coated plunger,
21 Mounting flange.

Generation of High-Pressure in Common-Rail Systems for Passenger Cars

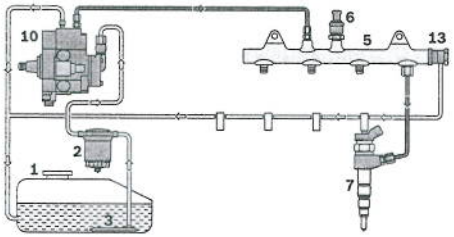
D1 BOSCH

Common-rail systems for passenger cars (examples).

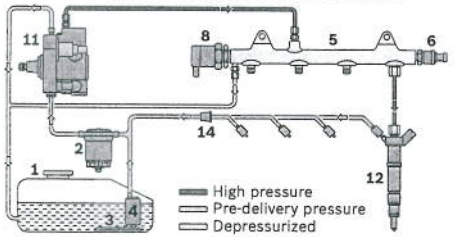
Continuous-delivery radial-piston pump: pressure control on the high-pressure side with pressure-control valve.



Demand-controlled radial-piston pump: pressure control on the suction side with metering unit flanged to the high-pressure pump.

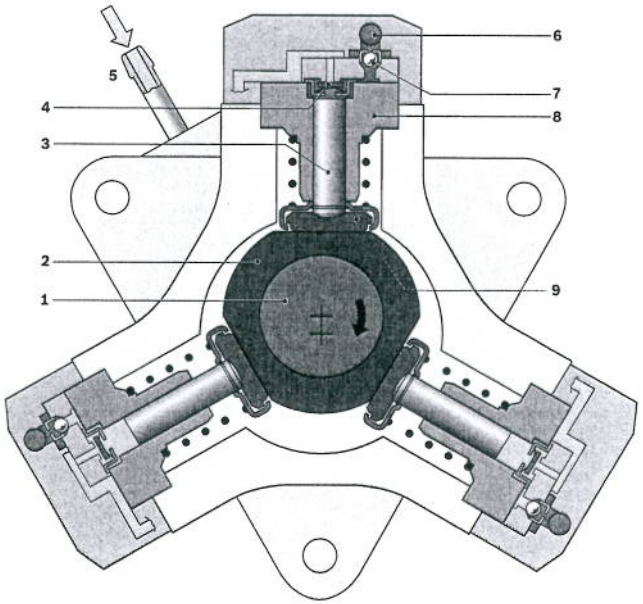


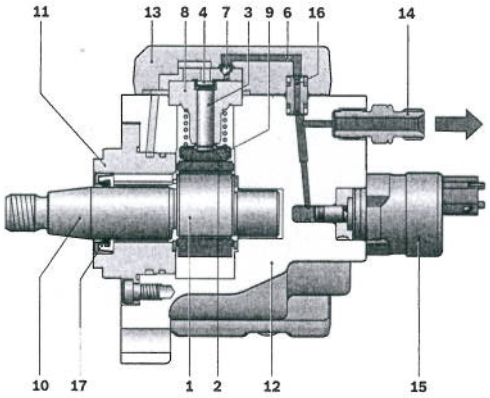
Demand-controlled radial-piston pump: two-actuator system with pressure control on the suction side via metering unit and pressure control on the high-pressure side via pressure-control valve.



1 Fuel tank, 2 Fuel filter, 3 Preliminary filter,
4 Electric fuel pump, 5 Rail, 6 Rail-pressure sensor,
7 Solenoid-valve injector, 8 Pressure-control valve,
9 Continuous-delivery high-pressure pump,
10 Demand-controlled high-pressure pump with mounted gear presupply pump and metering unit,
11 Demand-controlled high-pressure pump with metering unit,
12 Piezo injector, 13 Pressure-limiting valve,
14 Restriction.

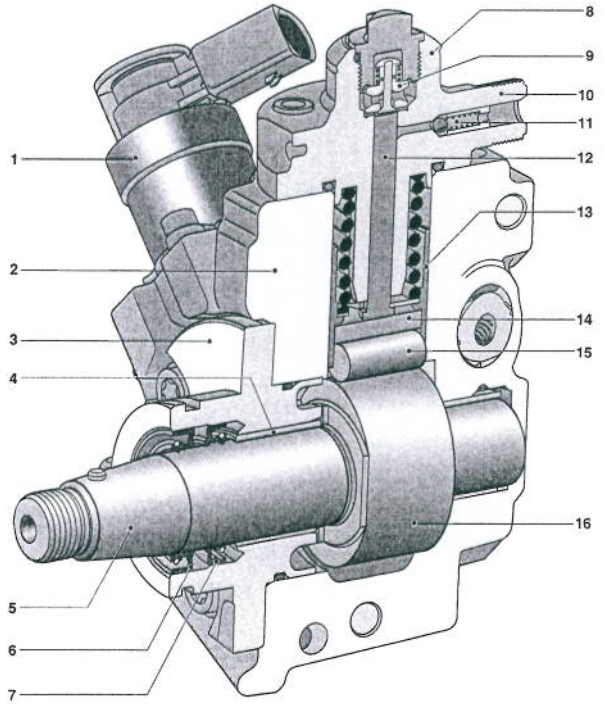
3-plunger radial-piston pump (cross section and longitudinal section).





1 Eccentric,
2 Polygon ring,
3 Pump plunger,
4 Intake valve (inlet valve),
5 Fuel-supply connection port,
6 High-pressure channel,
7 Outlet valve,
8 Pump cylinder
9 Plunger base plate,
10 Drive shaft
11 Flange,
12 Pump housing,
13 Cylinder head,
14 High-pressure connection port,
15 Pressure-control valve (for continuous-delivery high-pressure pump),
16 connector,
17 Shaft seal.

1-plunger radial-piston pump.



1 Metering unit for demand control,
2 Housing,
3 Mounting flange,
4 Friction bearing,
5 Drive shaft (camshaft),
6 Engine-side shaft seal,
7 Pump-side shaft seal
8 Cylinder head,
9 Inlet valve (suction valve),
10 High-pressure connection port, fuel-supply connection port not shown in this chart,
11 Non-return valve,
12 Pump plunger,
13 Roller tappet,
14 Roller support,
15 Drive roller,
16 Dual cam.

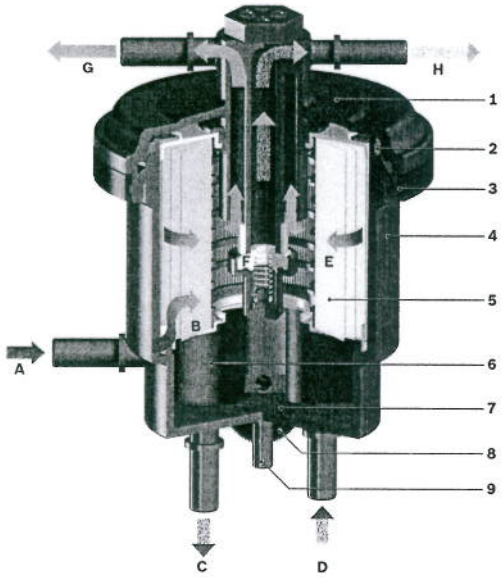
Diesel Fuel Filters

D7

BOSCH

Structure of diesel filters

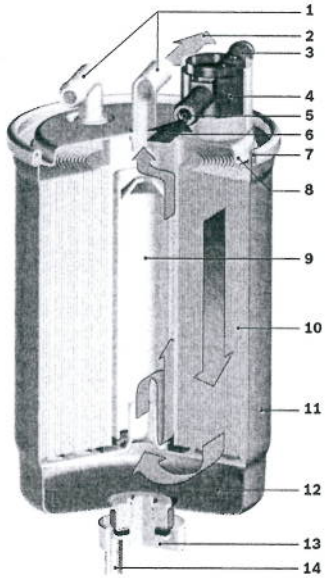
Common-rail filter



A Inflow of the contaminated diesel into the filter.
B Bimetal valve ensures optimum temperature of the diesel by redirecting the flow of warm fuel from engine to filter.
C Fuel return line to tank.
D Fuel return line from engine.
E Filtration of the diesel.
F Overflow valve opens if the pressure in the filtered diesel is higher than 1 – 1.5 bar.
G The cleaned diesel is conducted to the engine.
H The excess diesel is conducted back to the tank.

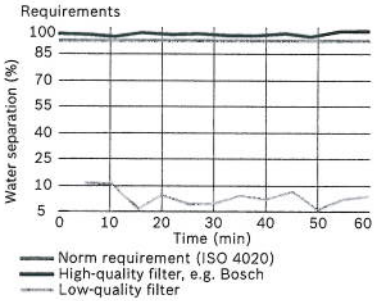
1 Filter cover of plastic,
2 Sealing ring,
3 Metal ring,
4 Pressure-resistant filter housing of plastic,
5 Filter medium (radial vee-shaped),
6 Bimetal valve (check of optimum temperature),
7 Water accumulation chamber,
8 Water drain screw,
9 Drain tube.

Diesel line filter



1 Hose connection,
2 Fuel outlet,
3 Hose connection,
4 Preheating valve,
5 Hose connection,
6 Fuel inlet (return from engine),
7 Double beading,
8 Filter cover of anodised steel plate,
9 Support tube,
10 Filter medium (spiral vee-shaped),
11 Pressure-resistant filter housing of galvanized steel,
12 Water accumulation chamber,
13 Water drain screw,
14 Drain tube.

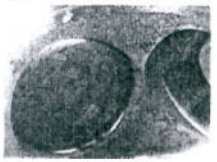
Water separation



Reasons for insufficient water separation:
Delayed exchange interval or usage of low-quality filters.

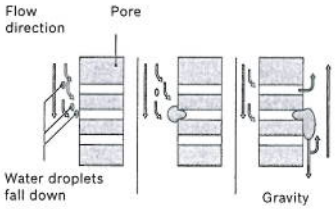
Risk: Corrosion in the fuel injection system and in the engine.

Corrosion in the high-pressure pump housing

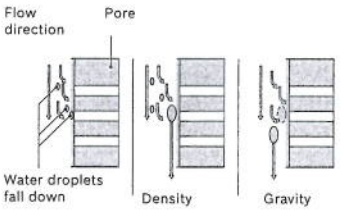


Corrosion on the injector

Principles of water separation

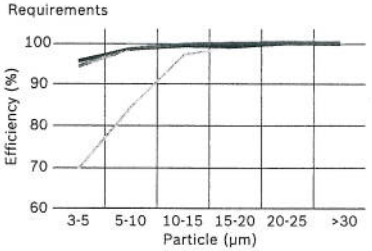


Water separation on clean side of the filter by coalescence effect.



Water separation on dirty side of the filter by hydrophobic effect.

Particle separation

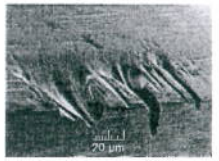


Reasons for insufficient particle separation:
Delayed exchange interval or usage of low-quality filters.

Risk: Early wear of the injectors causing engine damages.

Abrasive erosion

Wear and tear formation

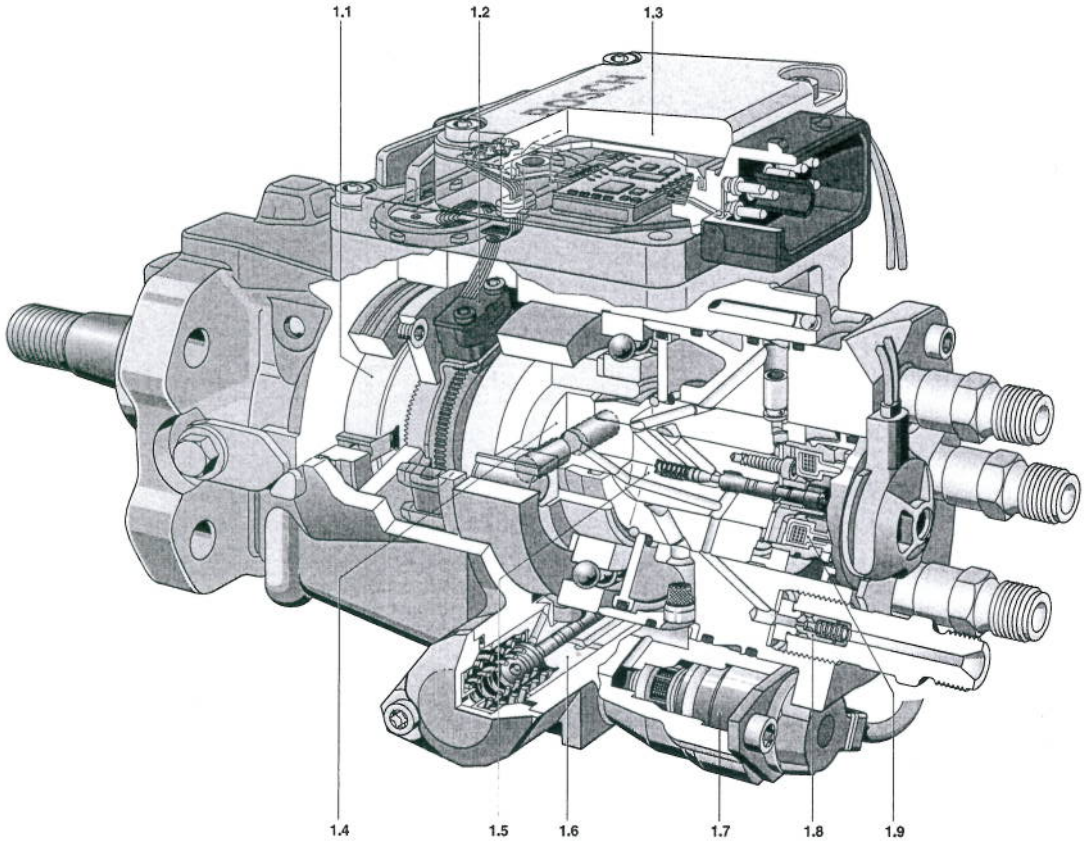


Diesel Radial-Piston Distributor Injection Pump

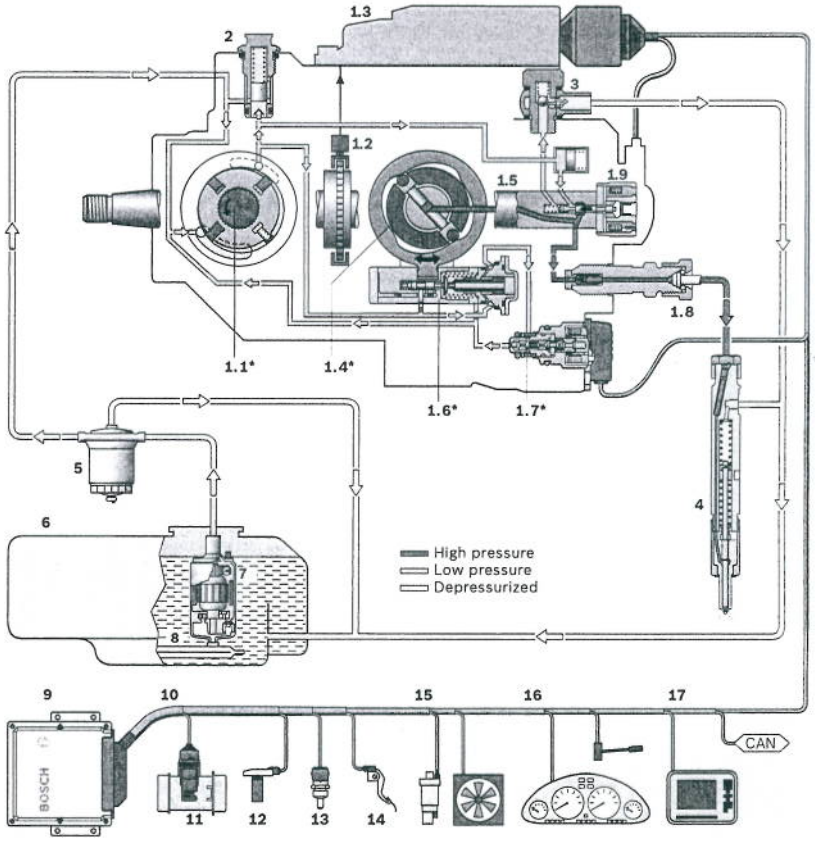
D8

BOSCH

Radial-piston distributor injection pump with pump control unit.



Electronic diesel control (EDC) for radial-piston distributor pumps.



1 Radial-piston distributor pump with pump control unit,
1.1 Vane-type supply pump (* means: view rotated 90°),
1.2 Angle-of-rotating sensor, 1.3 Pump control unit, 1.4 Radial-piston pump, 1.5 Distributor body with distributor shaft, 1.6 Timing device, 1.7 Timing-device solenoid valve, 1.8 Outlet valve, 1.9 High-pressure solenoid valve,
2 Pressure-control valve, 3 Overflow valve, 4 Injection nozzle, 5 Fuel filter, 6 Fuel tank, 7 Electric fuel pump, 8 Preliminary filter, 9 Engine control unit,
10 Choice of sensors and setpoint generators, 11 Air-mass meter, 12 Engine-speed sensor, 13 Engine-temperature sensor, 14 Accelerator-pedal sensor,
15 Choice of actuators, 16 Choice of controls and display elements, 17 Interfaces.

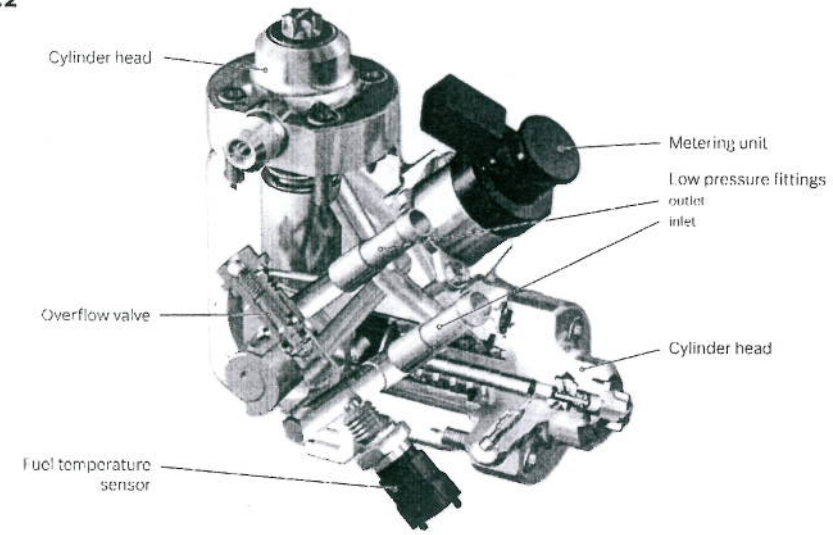
Diesel Systems – **Common Rail High Pressure Pumps PC**

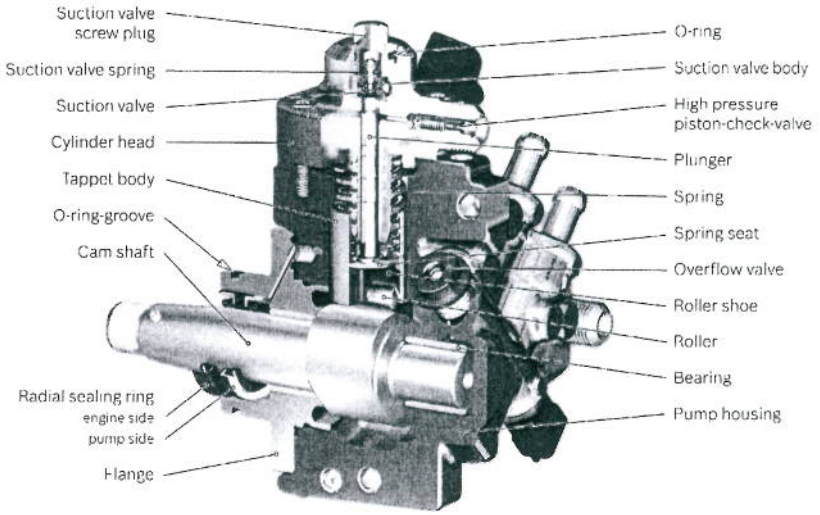
DM BOSCH

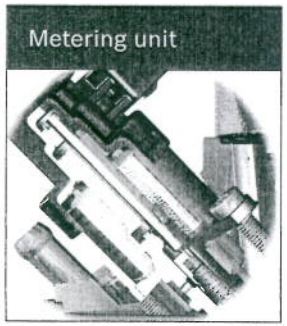
High Pressure Pumps for modern Common Rail Systems from Bosch

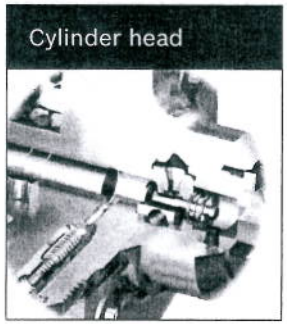
System pressure up to 2200 bar

▶ **CP 4.2**

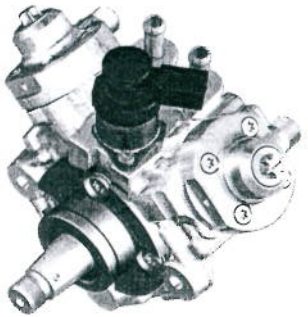








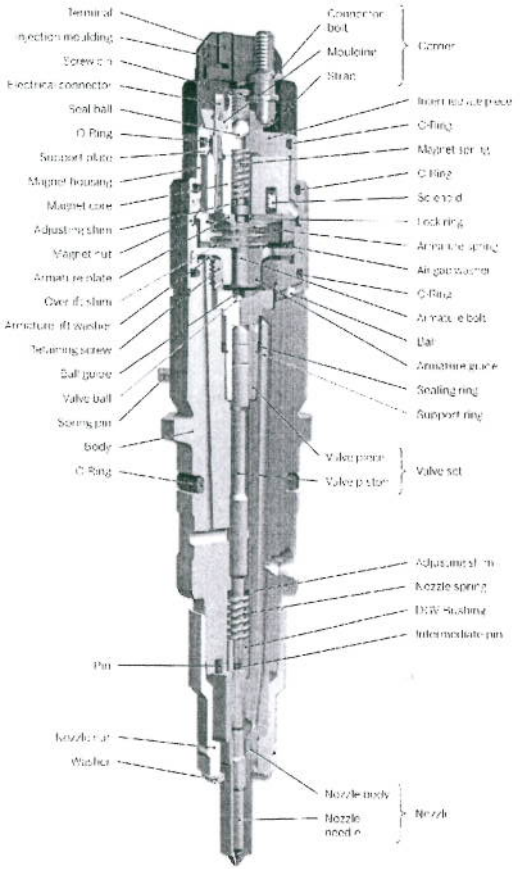
Applied by Audi, BMW, Citroën, Fiat, Hyundai, Iveco, Mercedes-Benz, Opel, Peugeot, Porsche, Renault, Seat, Skoda, Volvo, VW.



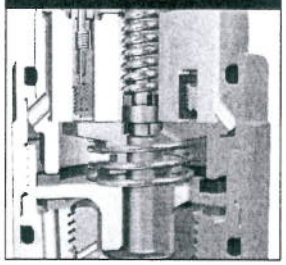
Diesel Systems – **Common Rail Injectors LCV / HCV**

D10 BOSCH

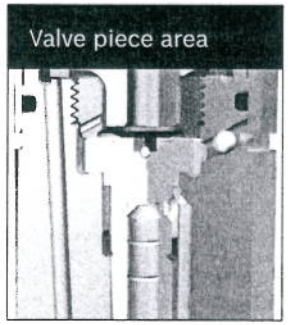
Solenoid valve controlled injector
System pressure up to 1600 bar
▶ **CRIN1**



Armature area

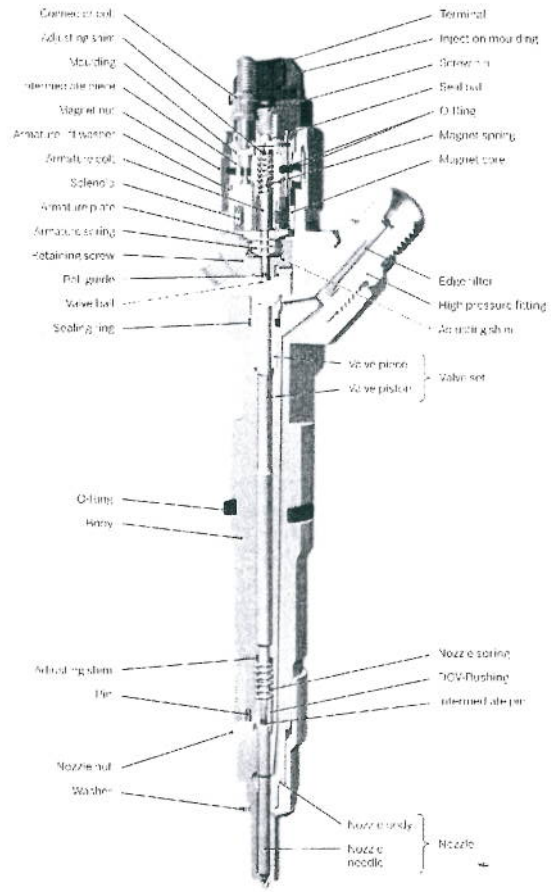


Valve piece area

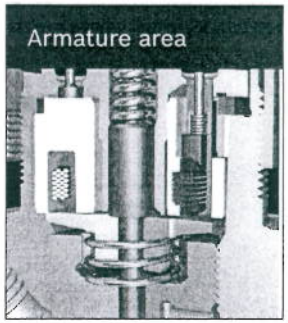


Applied by Cummins, MWM, Renault, Volvo.

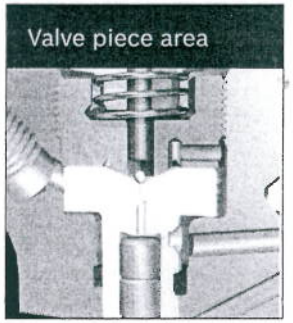
Solenoid valve controlled injector
System pressure up to 1800 bar
▶ **CRIN2**



Armature area



Valve piece area



Applied by Deutz, Iveco, MAN, Liebherr, Sisu, Volvo.