Service Training

Self-study programme 322

The 2.0l FSI engine with 4-valve technology

Design and function

The 2.0l engine is based on the tried and tested 827/113 series.

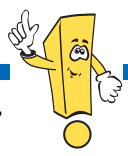
Thanks to FSI technology (Fuel Stratified Injection), the 2.0l petrol engine has taken on a new dimension. FSI engines are more economic, cleaner and more responsive than multi-point injection engines.
They also meet today's requirements in terms of low consumption, environmental issues and increased driving fun.

The Volkswagen 1.4-litre/77kW FSI engine, the pioneer in this new generation of petrol engines, demonstrated these advantages at the end of 2000 when it was used in the Lupo. It was then followed by the 1.6-litre/81kW FSI and 1.4-litre/63kW FSI in the Polo.

This self-study programme should familiarise you with the new technical features of this engine.

S322_015

NEW



Important Note

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

For current testing, adjustment and repair instructions, refer to the relevant service literature.

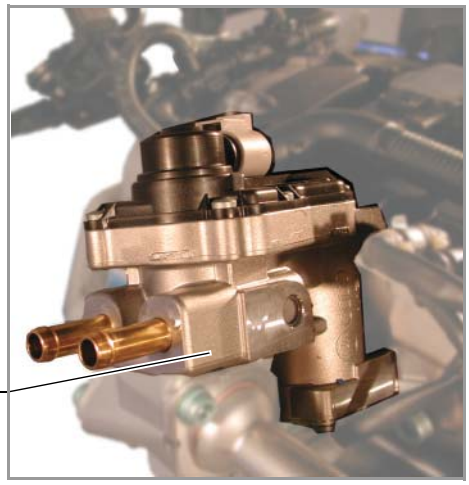
Contents

Introduction

Description of engine

Using the Volkswagen Audi platform, the 2.0-litre FSI engine appeared for the first time in the Audi A4, longitudinally mounted with the engine code AWA. In February 2003, the 2.0l FSI engine with the code AXW, identical with the Volkswagen version, was installed transversely in the Audi A3.
The following components have been further developed to meet the high demands for engine performance and economy:

- An aluminium engine block with cast-iron liners
- A water-cooled exhaust gas recirculation valve (EGR)
- An exhaust system with two starter catalytic converters fitted close to the engine



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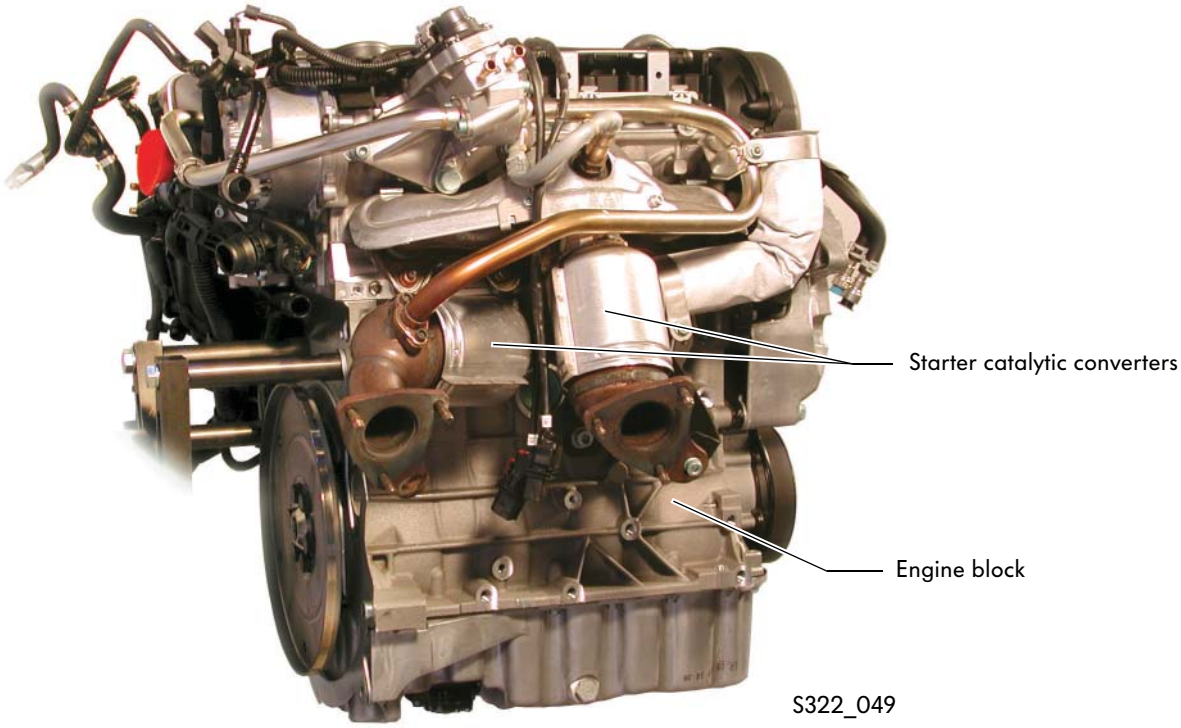


S322_049

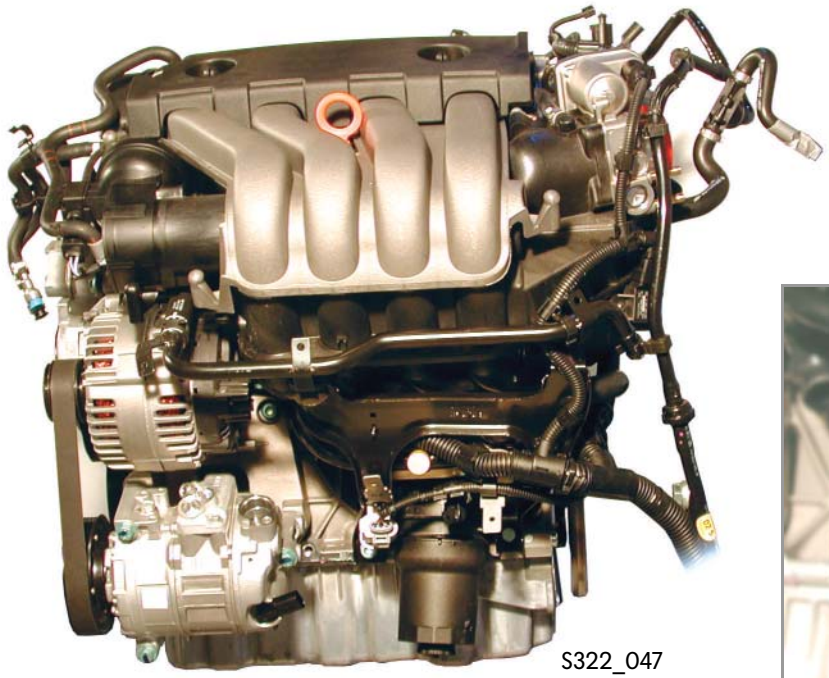
- An intake manifold with change-over barrel for switching between the torque and power channels
- A new oil filter module
- Bosch Motronic MED 9.5.10
- Four valves per cylinder, operated via roller rocker fingers with upright hydro-elements
- Aluminium cylinder head with two overhead camshafts and continuous inlet camshaft timing adjustment
- Direct fuel injection with demand-regulated high-pressure pump

S322_069

S322_073

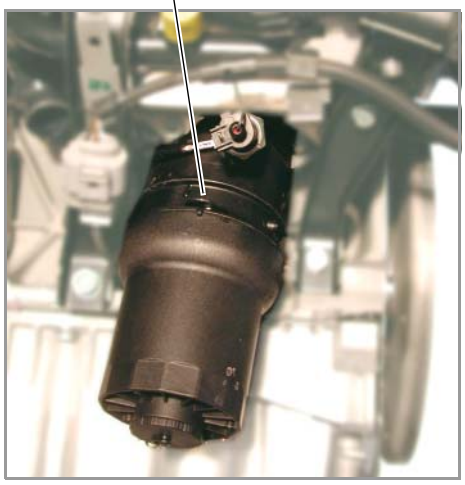
Change-over barrel

Intake manifold



S322_047

Oil filter module



S322_071

The 2.0l/110kW FSI engine with 4-valve technology

The 2.0l/110kW FSI engine was used in the Audi A3 in February 2003. Volkswagen used the engine for the first time in October 2003 in the Touran. It will be available for the Golf from the start of 2004.

Technical features

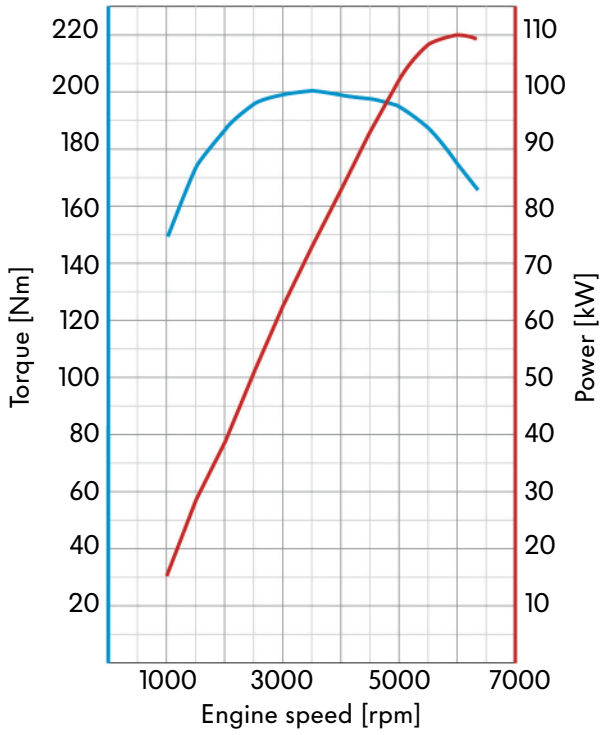
- Single-piston high-pressure pump
- Plastic variable intake manifold
- Intake manifold with continuously adjustable charge direction flaps/ intake manifold flaps
- Water-cooled exhaust gas recirculation valve
- Roller rocker finger with hydraulic support element
- Two overhead camshafts with continuous inlet camshaft adjustment
- Balancer shaft gear assembly in sump
- Air-guided combustion method

S322_011

Technical data

Engine code	AXW
Type	4-cylinder in-line engine
Displacement [mm³]	1984
Bore [mm]	82.5
Stroke [mm]	92.8
Valves per cylinder	4
Compression ratio	11.5:1
Maximum output	110kW at 6000rpm
Maximum torque	200Nm at 3500rpm
Engine management	Bosch Motronic MED 9.5.10
Fuel	Unleaded 98 RON (Unleaded 95 RON with reduction in performance)
Exhaust gas treatment	NO_x storage catalytic converter and 2 starter catalytic converters
Emissions standard	EU 4

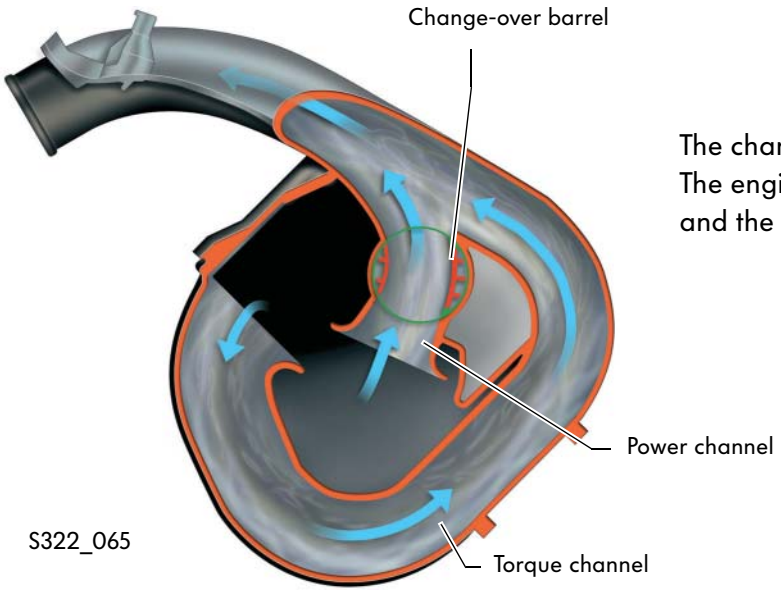
Torque and power diagram



S322_012

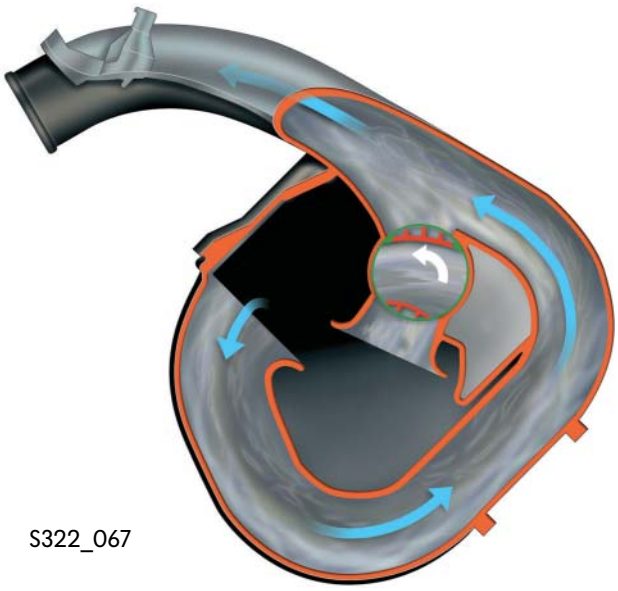
Intake manifold with change-over barrel

The two-stage variable intake manifold helps provide the required power and torque characteristics. The pneumatic switching of the change-over barrels from torque to power position is map-controlled. The load, speed and temperature are the relevant variables for this process.



S322_065

The change-over barrel in power position. The engine draws in air via the power channel and the torque channel.



S322_067

The change-over barrel in torque position. The engine draws in air only via the torque channel.

Intake manifold lower part

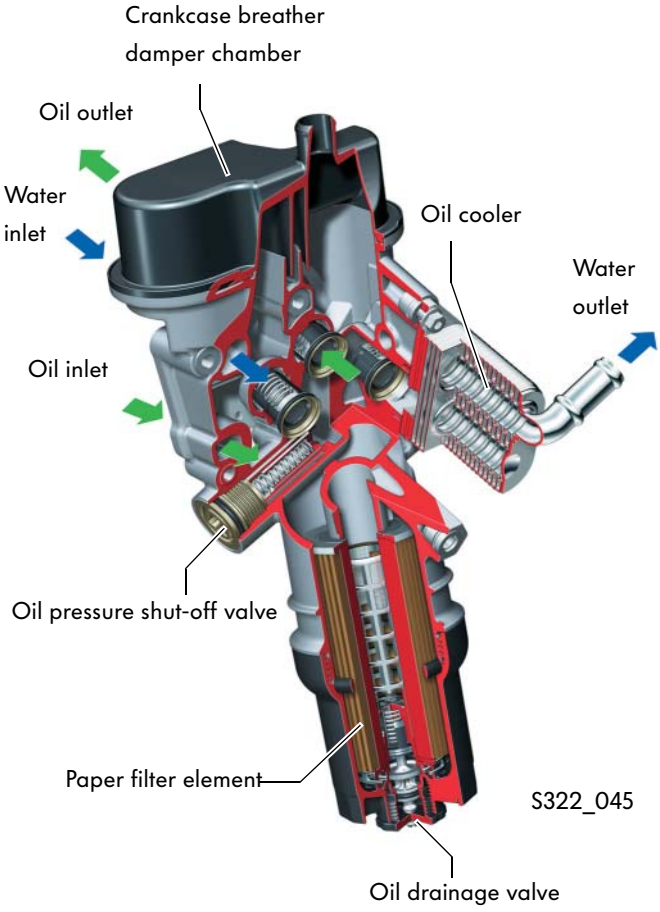
The lower part of the intake manifold contains four intake manifold flaps that are adjusted by the V157 control motor via a common shaft. The G336 potentiometer integrated in the control motor is used to indicate the flap position to the J220 engine control unit.

S322_061

The oil filter module

The new oil filter module was developed as a highly integrated plastic unit. Its components include:

- An oil pressure shut-off valve
- A paper filter element to filter the oil
- An integrated water-cooled oil cooler
- A damper chamber on the crankcase breather for the liquid-vapour separator



S322_045

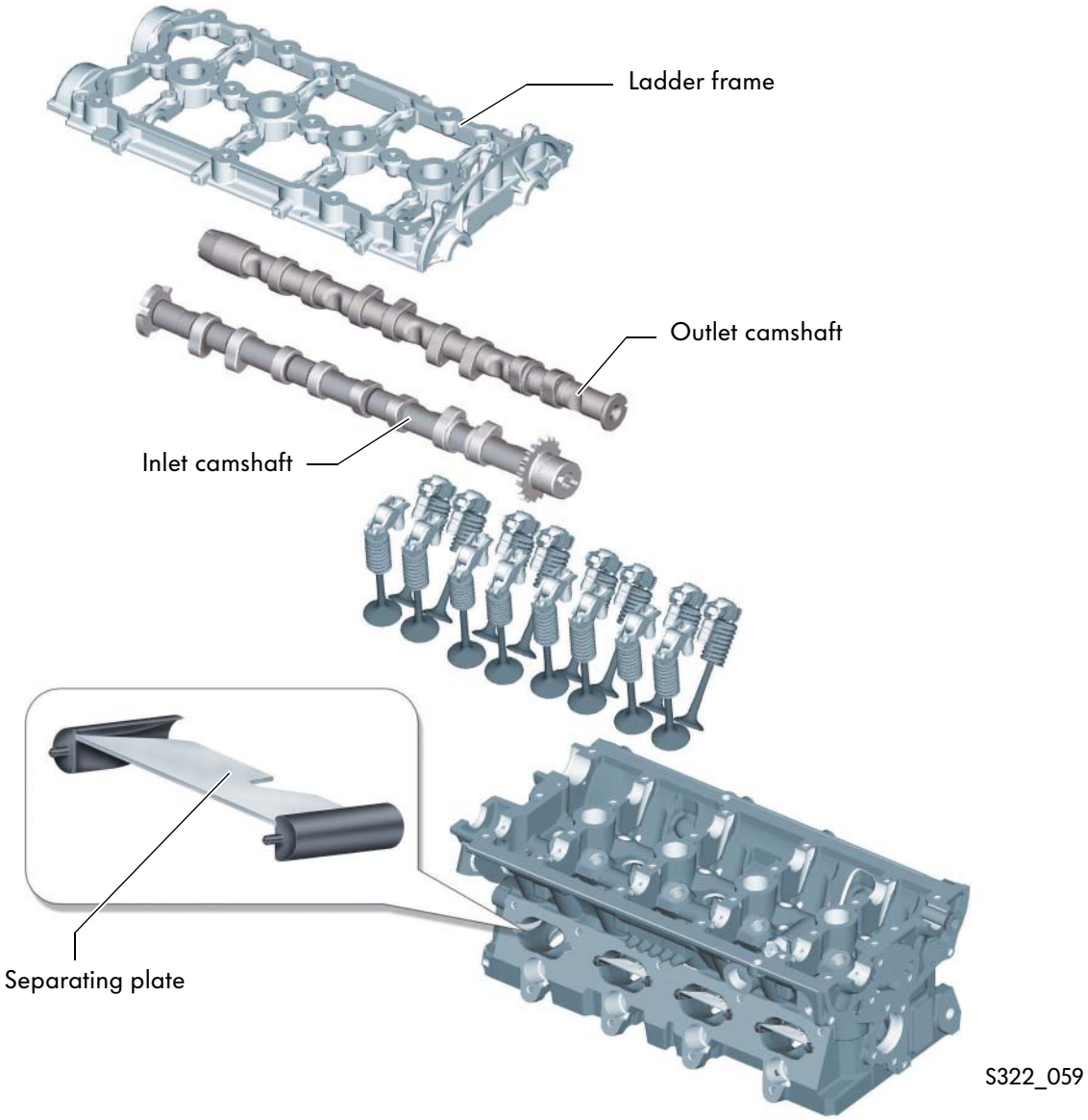
The cylinder head

The 2.0l FSI engine with 4-valve technology has an aluminium cylinder head.

The valves are operated by two overhead camshafts mounted on bearings in a ladder frame to ensure torsional stiffness.

The outlet camshaft is driven by toothed belts. The inlet camshaft is driven via the outlet camshaft by a simplex chain.

Each intake channel is divided into an upper and lower half by a separating plate. The plates have been shaped so that they can only be fitted in the correct position.



Engine management

System overview

G71 Intake manifold pressure sender
G42 Intake air temperature sender

G299 Intake air temperature sender 2

G28 Engine speed sender

G40 Hall sender

J338 Throttle valve module
G187 Throttle valve drive angle sender 1
G188 Throttle valve drive angle sender 2

G79 Accelerator pedal position sender
G185 Accelerator pedal position sender 2

F Brake light switch
F47 Cruise control system brake pedal switch

G247 Fuel pressure sender, high pressure

G410 Fuel pressure sender, low pressure

G61 Knock sensor
G66 Knock sensor 2

G62 Coolant temperature sender

G83 Radiator outlet coolant temperature sender
G336 Intake manifold flap potentiometer

G212 Exhaust gas recirculation potentiometer

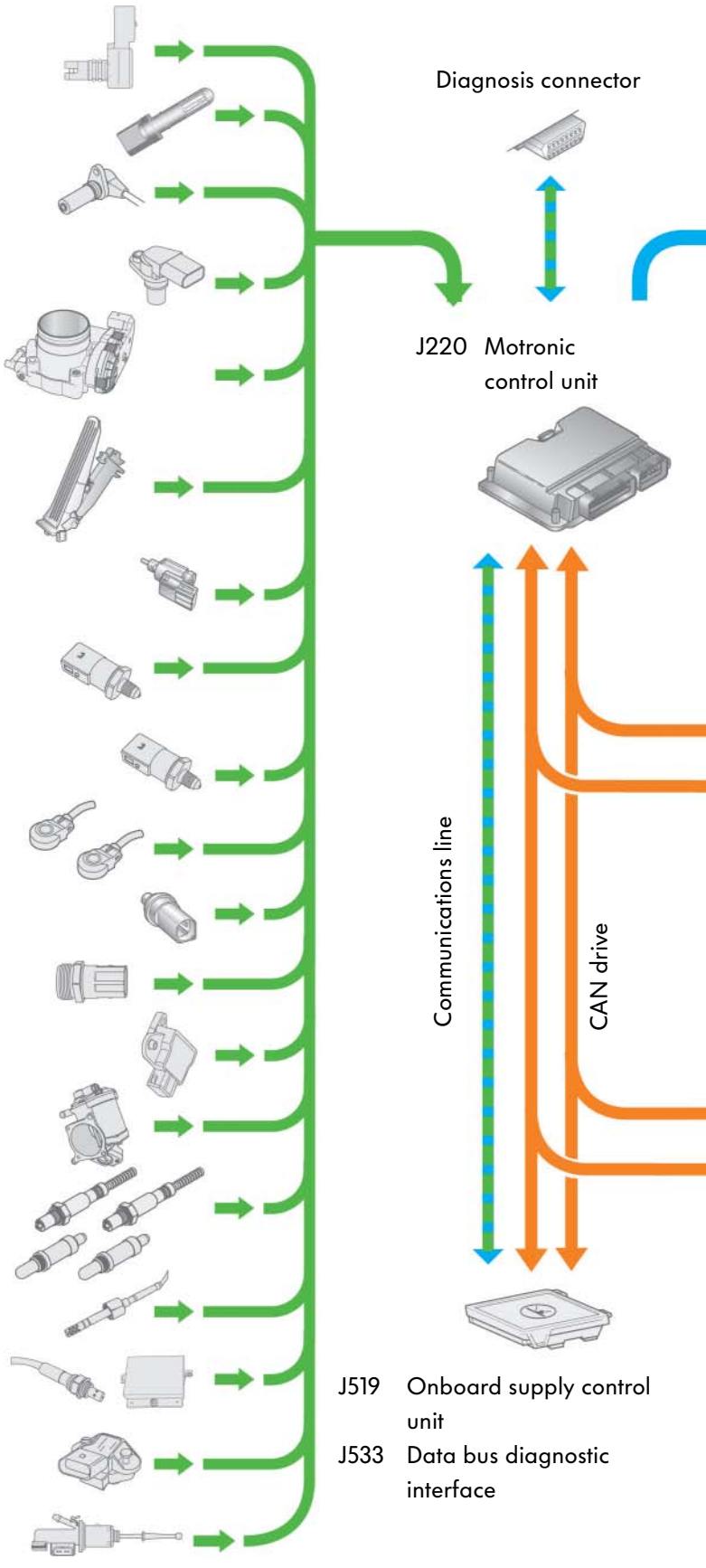
G39 Lambda probe
G108 Lambda probe II
G130 Lambda probe after catalytic converter
G131 Lambda probe II after catalytic converter

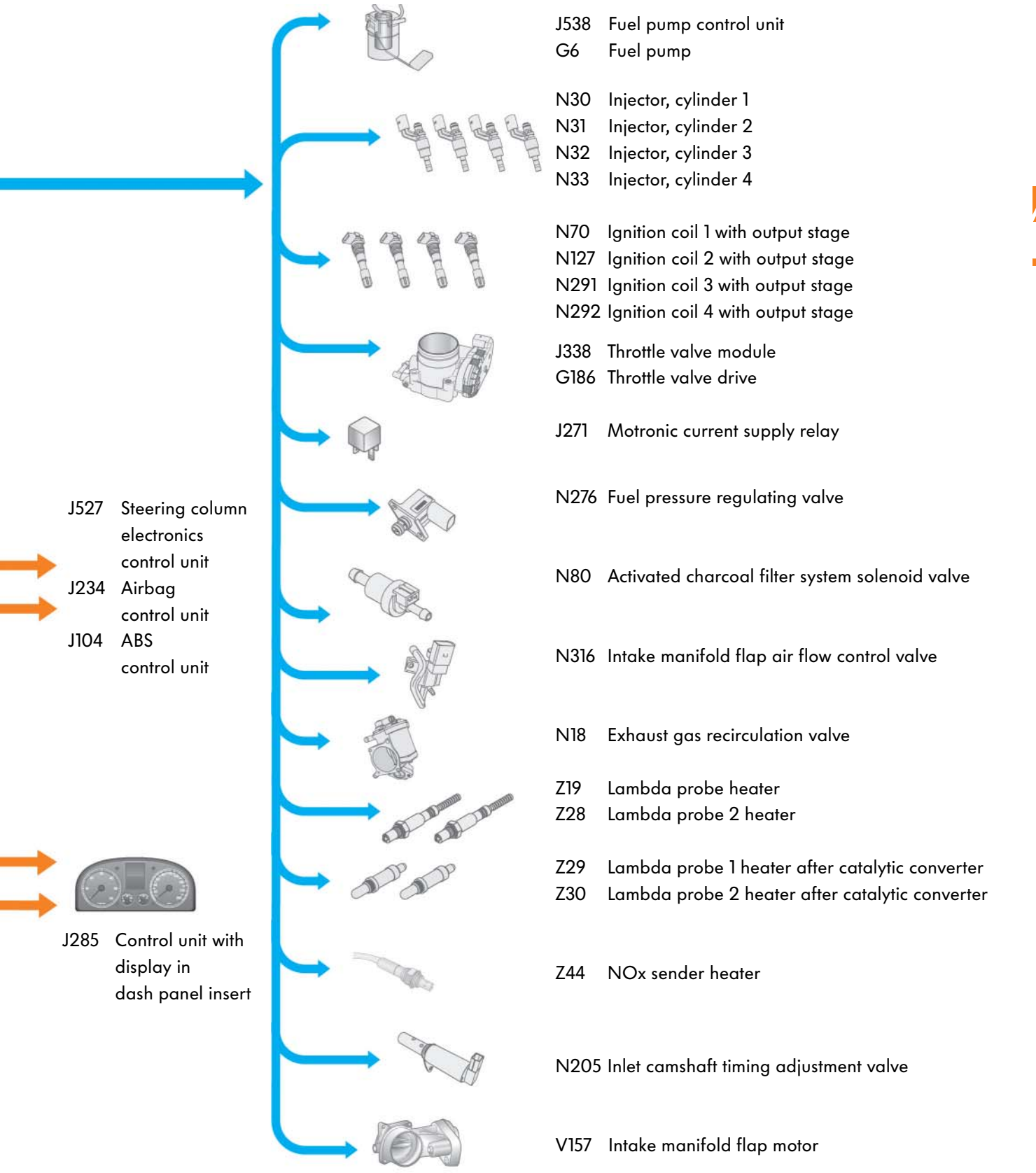
G235 Exhaust gas temperature sender

G295 NOx sender
J583 NOx sensor control unit

G294 Brake servo pressure sensor

G476 Clutch position sender




J538 Fuel pump control unit
G6 Fuel pump
N30 Injector, cylinder 1
N31 Injector, cylinder 2
N32 Injector, cylinder 3
N33 Injector, cylinder 4
N70 Ignition coil 1 with output stage
N127 Ignition coil 2 with output stage
N291 Ignition coil 3 with output stage
N292 Ignition coil 4 with output stage
J338 Throttle valve module
G186 Throttle valve drive
J271 Motronic current supply relay
N276 Fuel pressure regulating valve
N80 Activated charcoal filter system solenoid valve
N316 Intake manifold flap air flow control valve
N18 Exhaust gas recirculation valve
Z19 Lambda probe heater
Z28 Lambda probe 2 heater
Z29 Lambda probe 1 heater after catalytic converter
Z30 Lambda probe 2 heater after catalytic converter
Z44 NOx sender heater
N205 Inlet camshaft timing adjustment valve
V157 Intake manifold flap motor
J527 Steering column electronics control unit
J234 Airbag control unit
J104 ABS control unit
J285 Control unit with display in dash panel insert

S322_042

Engine management

Exhaust system

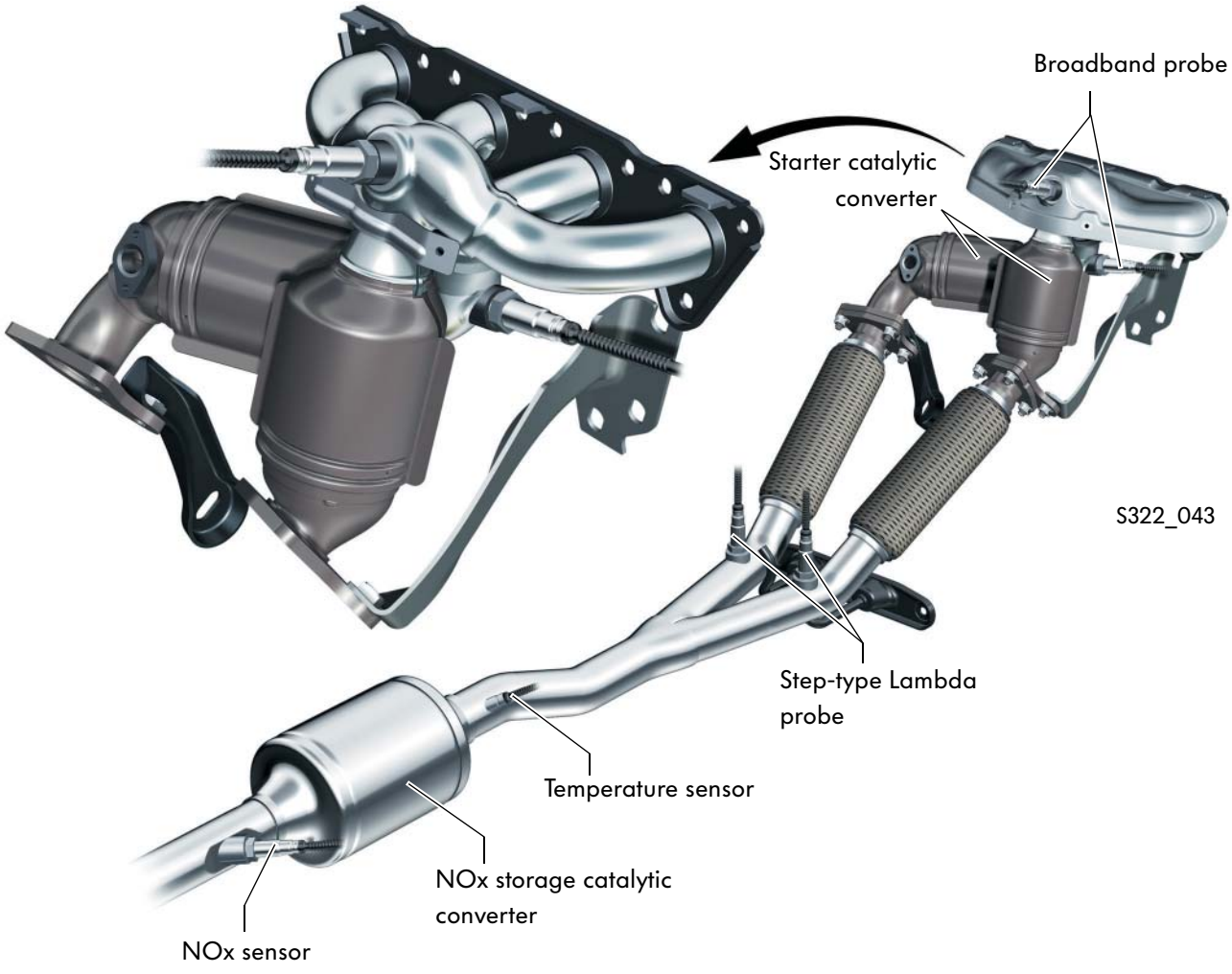
The front section of the exhaust system is split into dual pipes to increase the torque in the lower rev range. Both exhaust sections are equipped with starter catalytic converters.

The starter catalytic converters have been permanently fixed to the two exhaust manifolds.

Two broadband probes monitor the mixture composition for the starter catalytic converters. Two step-type Lambda probes come after the starter catalytic converters (planar Lambda probes). These monitor the efficiency of the starter catalytic converters.

The two exhaust sections then join together at the NOx storage catalytic converter.

In lean mix operation, the storage catalytic converter temporarily stores nitric oxide (NOx). The NOx sensor monitors the degree of saturation and triggers regeneration of the storage catalytic converter.



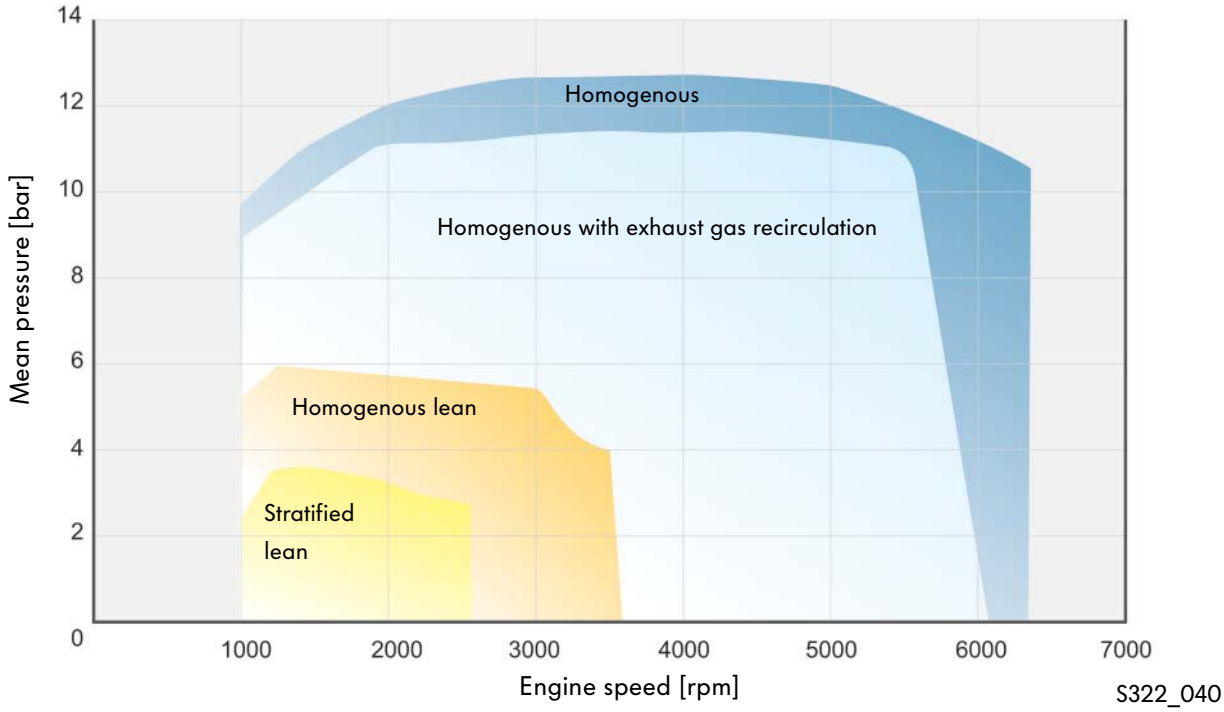
Operating modes

The air-guided combustion method allows use of homogenous and stratified charge modes.

The engine electronics select the best operating mode depending on the load and the position of the accelerator pedal.

There are 4 main modes:

- Stratified lean
  with exhaust gas recirculation (EGR)
- Homogenous lean without EGR
- Homogenous with Lambda = 1 and EGR
- Homogenous with Lambda = 1 without EGR



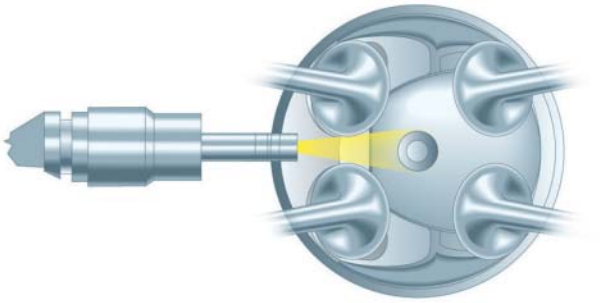
You will find further information in the self-study programme SSP 253 “The petrol direct injection system with Bosch Motronic MED 7”.

Engine management

Stratified charge mode

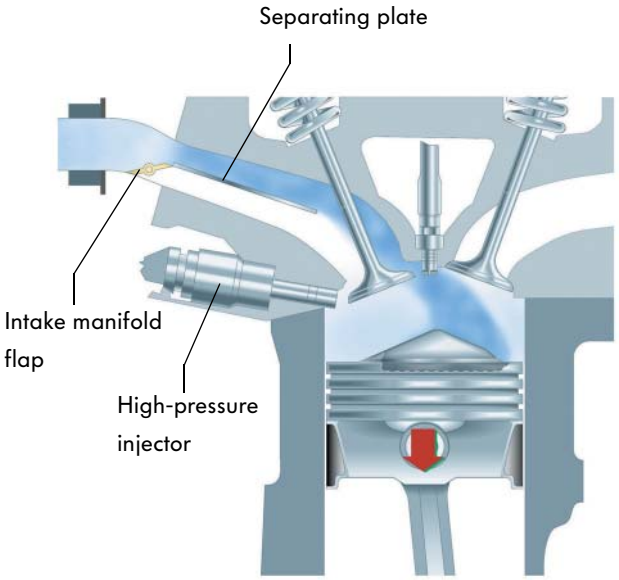
The fuel injection, the combustion chamber geometry and the flow inside the cylinder need to be fine-tuned to make stratified charge mode possible. The following requirements also need to be met:

- The engine should be in the appropriate load and rev range.
- There cannot be any exhaust gas-related errors in the system.
- The coolant temperature should be above 50 °C.
- The temperature of the NOx storage catalytic converter should be between 250 °C and 500 °C.
- The intake manifold flap should be closed.



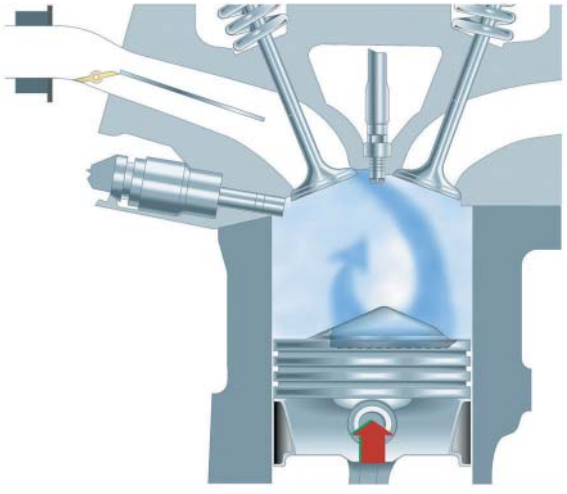
S322_021

The intake manifold flap closes the lower intake duct according to the engine map. As a result, the increased incoming mass of air has to flow through the upper intake duct and starts a tumbling charge movement in the cylinder.



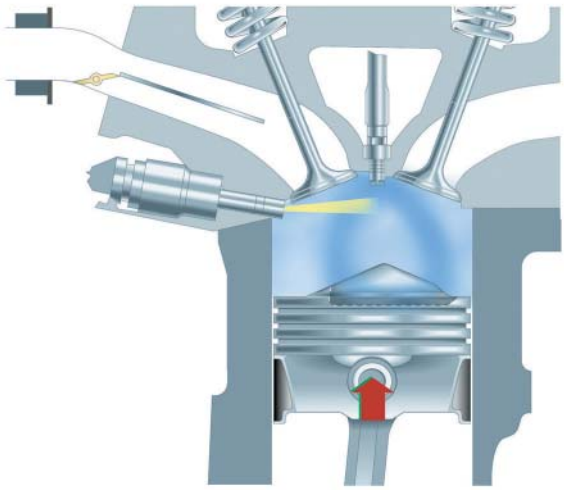
S322_023

The tumbling air flow is enhanced in the cylinder by the air-flow recess in the piston and the upwards movement of the piston.



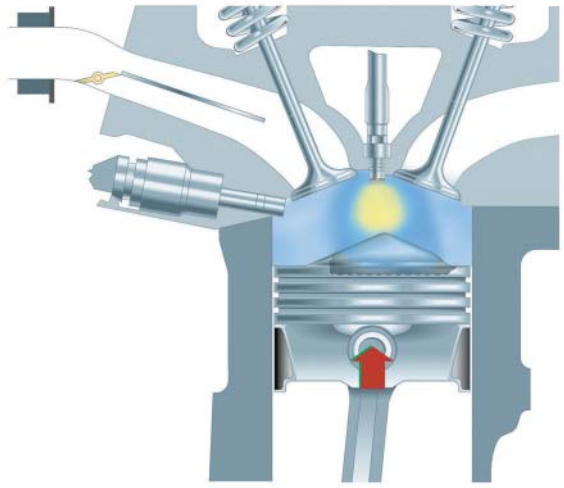
S322_025

The fuel is injected during the compression stroke just before the ignition point. The fuel is injected at high pressure (40-110 bar) into the flow of air. The air flow then carries the ignitable mixture to the spark plug.



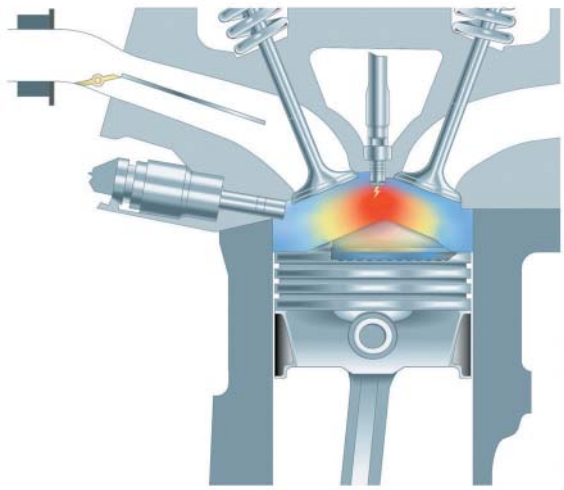
S322_027

As the injection angle is quite flat, the fuel mist virtually does not come into contact with the the piston head. This is known as an “air-guided” method.



S322_029

Upon combustion, there is a layer of insulating air between the ignited mixture and the cylinder wall. This reduces the amount of heat transferred via the engine block and thus improves efficiency.

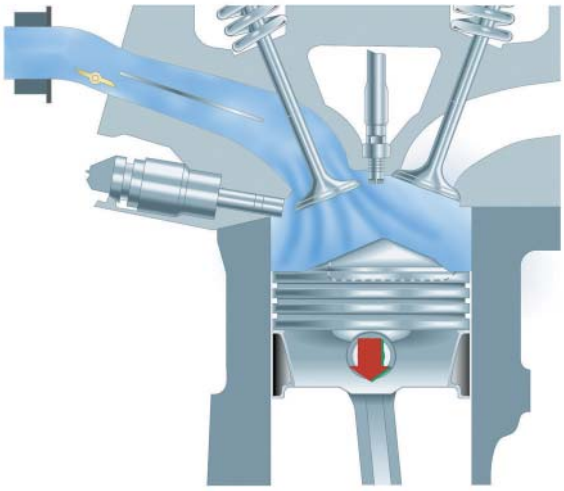


S322_031

Engine management

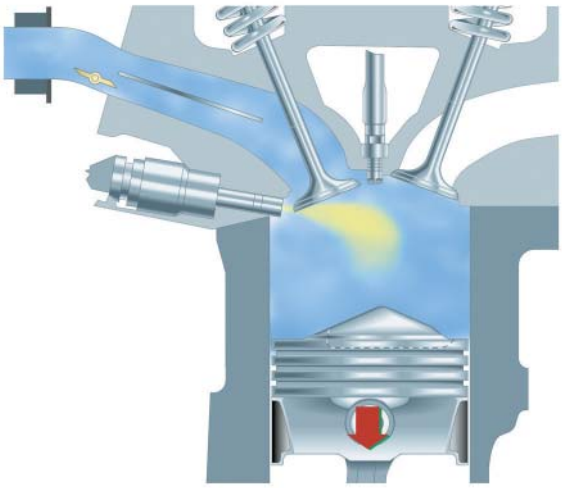
Homogenous mode

In homogenous mode, the intake manifold flap is moved to an intermediate position according to the engine map.
In the combustion chamber, an optimum air flow for achieving lower fuel consumption and emissions is created.



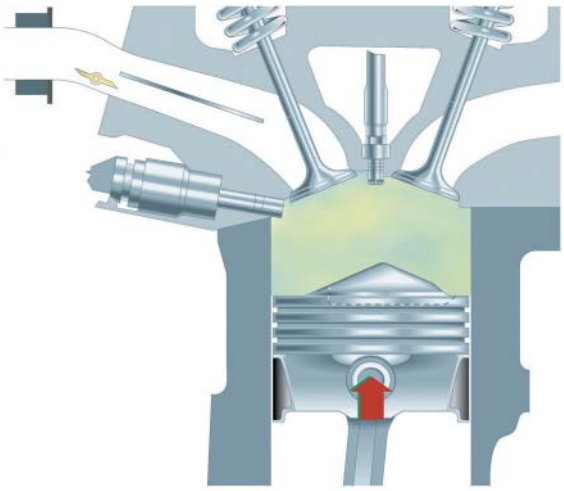
S322_033

In homogenous mode, the fuel is injected during the intake stroke and not in the compression phase as with stratified charge mode.



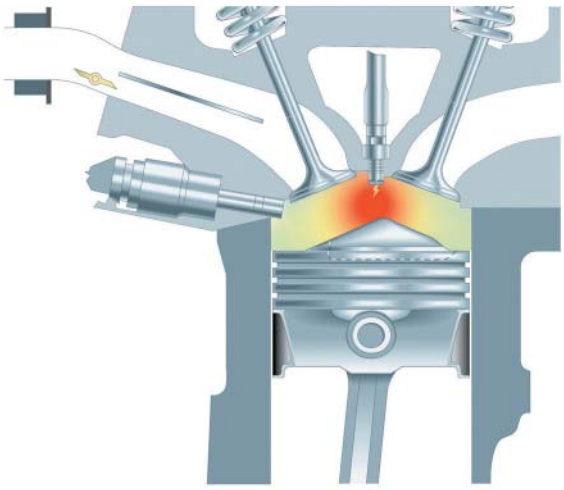
S322_035

As the fuel is injected during the intake stroke, the fuel-air mixture has more time to mix thoroughly before ignition.



S322_037

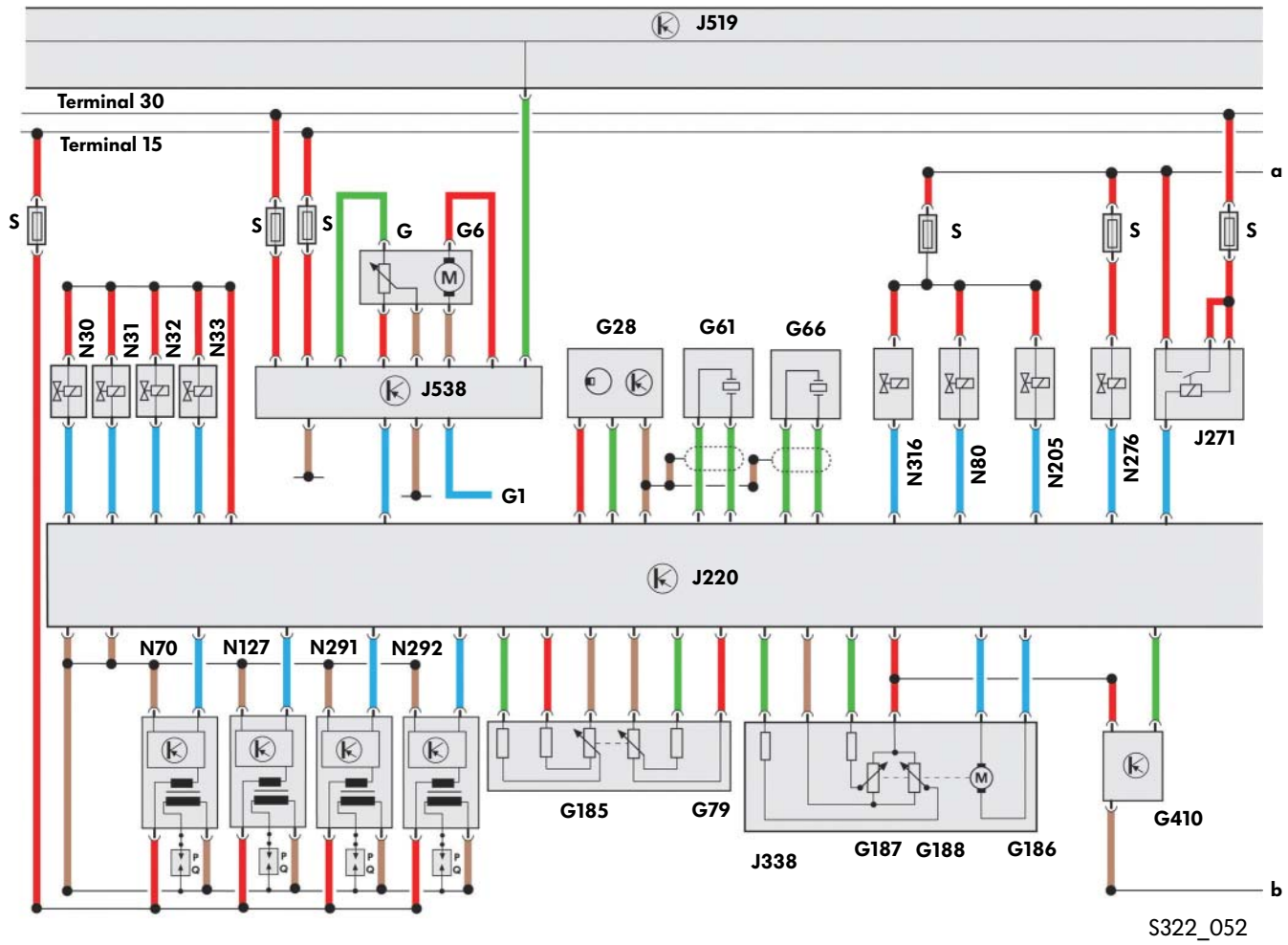
Combustion takes place in the whole combustion chamber without an insulating air layer or recirculated exhaust gases.



S322_039

The advantages of homogenous mode are brought about by direct injection during the intake stroke. The fuel evaporation removes some of the heat from the incoming air. Cooling the interior reduces the knocking tendency and thus increases the engine compression and efficiency.

Functional diagram

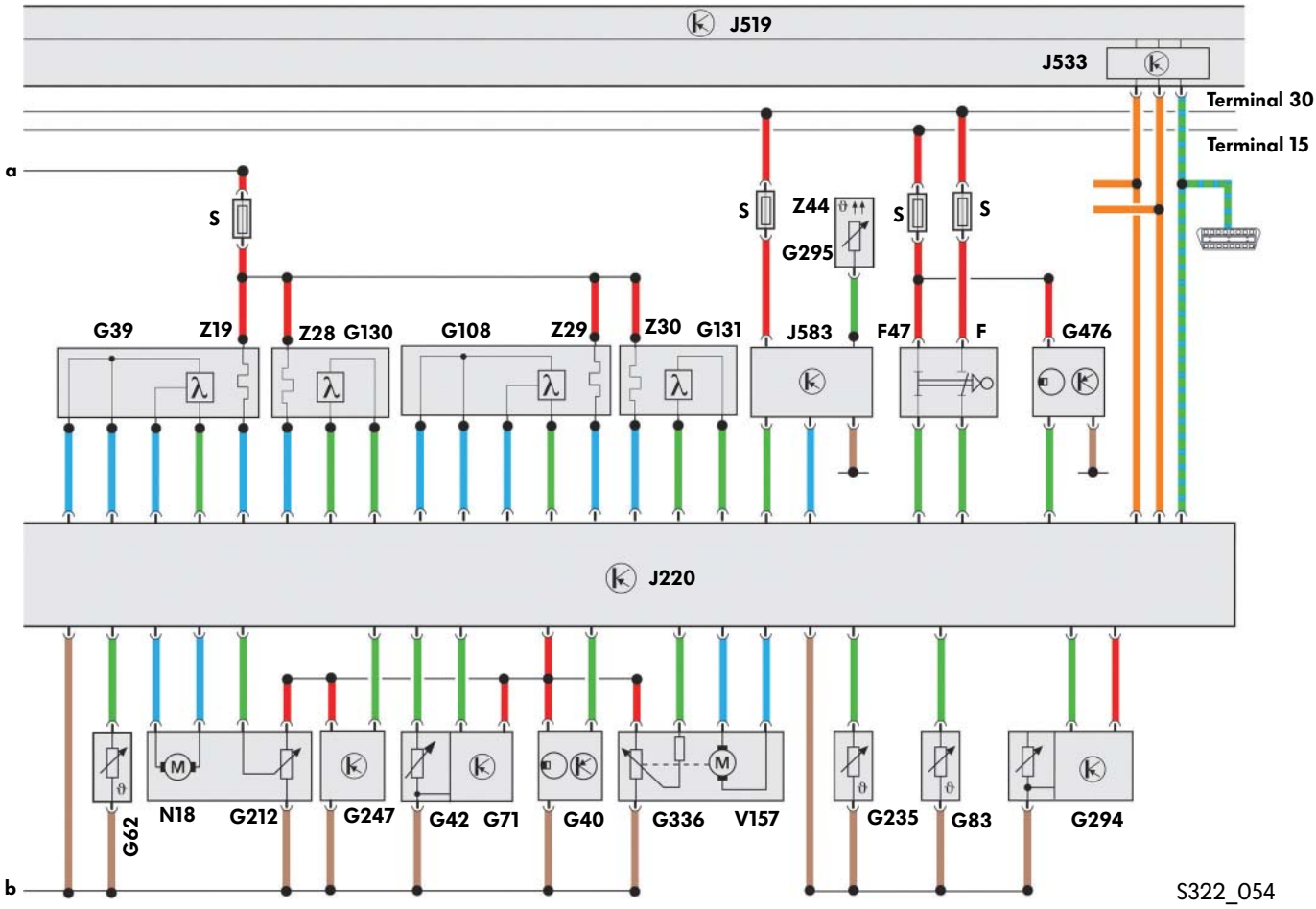


S322_052

F Brake light switch
F47 Cruise control system brake pedal switch
G Fuel gauge sender
G1 Fuel gauge
G6 Fuel pump
G28 Engine speed sender
G39 Lambda probe
G40 Hall sender
G42 Intake air temperature sender
G61 Knock sensor
G62 Coolant temperature sender
G66 Knock sensor 2
G71 Intake manifold pressure sender
G79 Accelerator pedal position sender
G83 Radiator outlet coolant temperature sender
G108 Lambda probe II
G130 Lambda probe after catalytic converter
G131 Lambda probe II after catalytic converter
G185 Accelerator pedal position sender 2
G186 Throttle valve drive
G187 Throttle valve drive angle sender 1
G188 Throttle valve drive angle sender 2
G212 Exhaust gas recirculation potentiometer
G235 Exhaust gas temperature sender
G247 Fuel pressure sender, high pressure

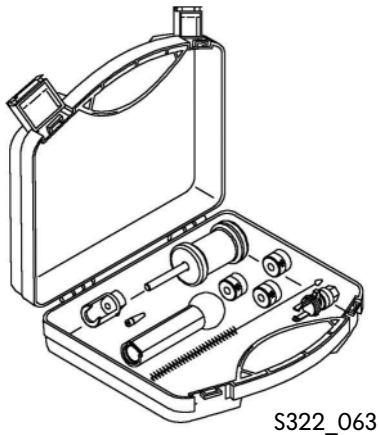
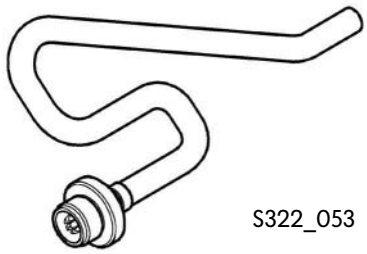
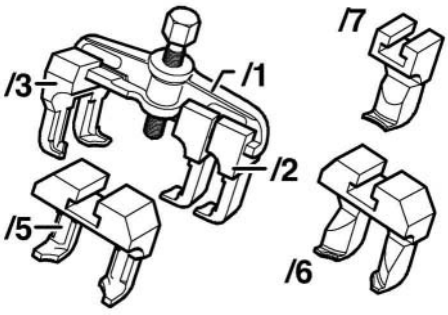
Colour code/legend

= input signal
= output signal
= positive
= earth
= CAN data bus



G294 Brake servo pressure sensor
G295 NOx sender
G299 Intake air temperature sender 2
G336 Intake manifold flap potentiometer
G410 Fuel pressure sender, low pressure
G476 Clutch position sender
J271 Motronic current supply relay
J338 Throttle valve module
J519 Onboard supply control unit
J533 Data bus diagnostic interface
J538 Fuel pump control unit
J583 NOx sensor control unit
N18 Exhaust gas recirculation valve
N30 Injector, cylinder 1
N31 Injector, cylinder 2
N32 Injector, cylinder 3
N33 Injector, cylinder 4
N70 Ignition coil 1 with output stage
N80 Activated charcoal filter system solenoid valve
N127 Ignition coil 2 with output stage
N205 Inlet camshaft timing adjustment valve
N291 Ignition coil 3 with output stage
N292 Ignition coil 4 with output stage
N276 Fuel pressure regulating valve
N316 Intake manifold flap air flow control valve
V157 Intake manifold flap motor
Z19 Lambda probe heater
Z28 Lambda probe 2 heater
Z29 Lambda probe 1 heater after catalytic converter
Z30 Lambda probe 2 heater after catalytic converter
Z44 NOx sender heater

New special tools

Designation	Tool	Application
T10133 FSI special tool case	 S322_063	Familiar special tools for repairing FSI engines. Also for use with 2.0l FSI engines.
T40057 Oil drainage adapter	 S322_053	For draining the engine oil from the oil filter housing
T40001 Puller T40001/6 Claw attachments for puller T40001/7 Claw attachments for puller	 S322_055	For removing the camshaft wheel

Notes

Test yourself

1. The engine electronics select the best operating mode depending on the load and the position of the accelerator pedal. Which 4 main modes are used by the 2.0l FSI engine?

a) _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

b) _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

c) _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

d) _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

2. What is meant by the "air-led" method used in stratified charge mode?

☐ a) The fuel is injected in the direction of the piston head. The fuel mist is then transported to the spark plug together with the tumble-shaped air flow.

☐ b) The fuel is injected into the tumble-shaped air flow at a flat angle and transported to the spark plug.

☐ c) The fuel directly injected during the intake stroke evaporates in the cylinder and draws part of heat from the incoming air mass.

3. Where is the NOx sensor located in the exhaust system?

☐ a) In front of the NOx storage catalytic converter.

☐ b) In front of the step-type Lambda probes.

☐ c) After the NOx storage catalytic converter.

☐ d) In front of the starter catalytic converters.

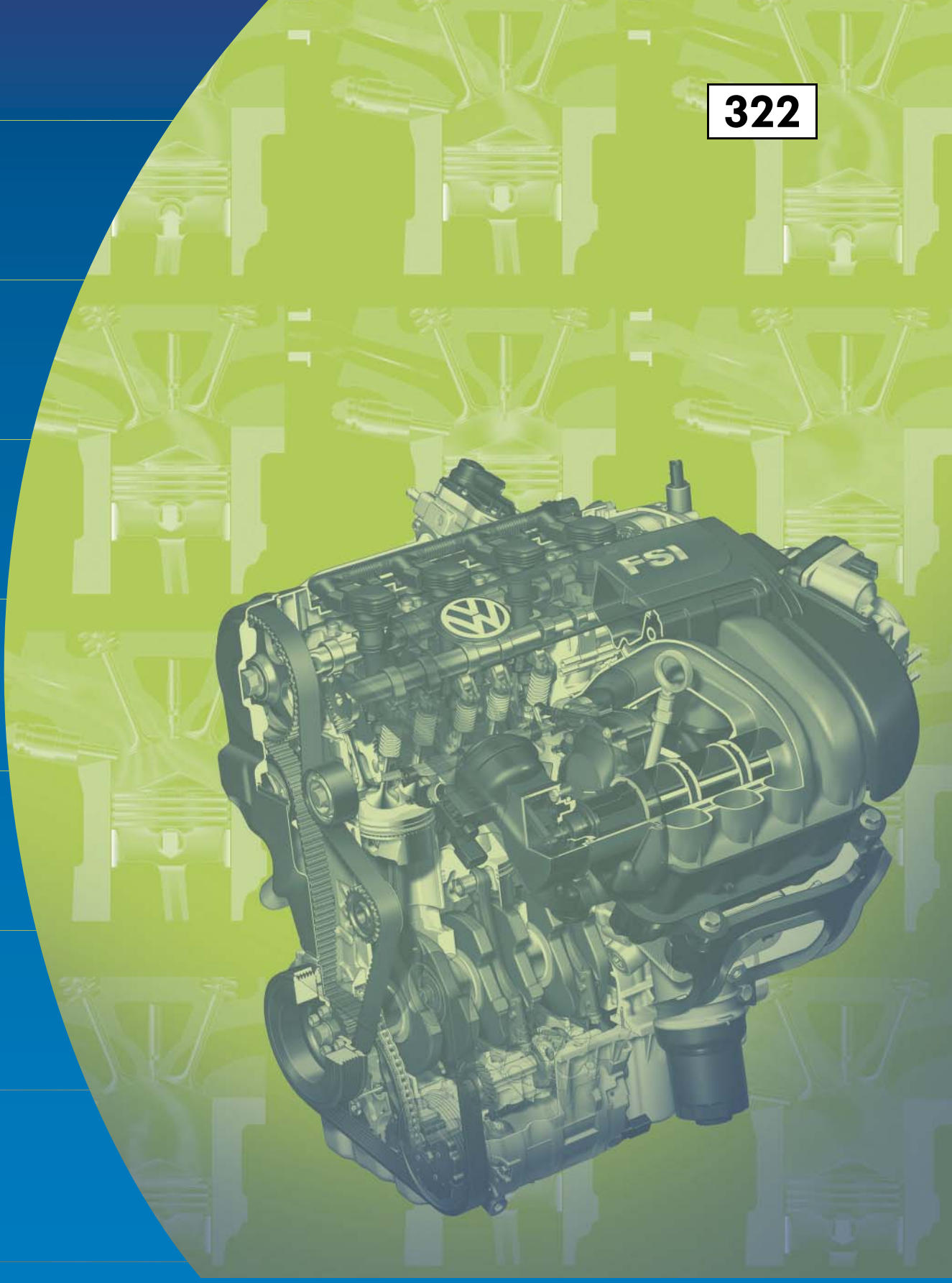
Answers

1.) a) Stratified injection with exhaust gas recirculation (EGR)
    b) Homogenous lean without EGR
    c) Homogenous with Lambda = 1 and EGR
    d) Homogenous with Lambda = 1 without EGR

2.) b

3.) c

322



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