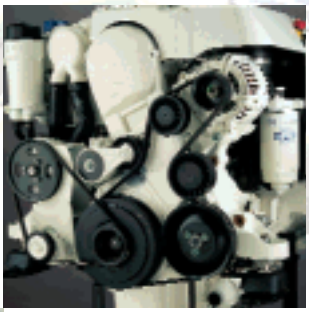
Self-study programme M001

Design and function

Boat engines from Volkswagen Marine



TDI 100-5
TDI 120-5
TDI 150-5
TDI 150-5D

SDI 55-5
SDI 75-5

VOLKSWAGEN marine
SUPERIOR TECHNOLOGY

Foreword

Volkswagen diesel engines have been providing dependable service in passenger vehicles and transporters since 1976.

The development of TDI engines is a significant step in the direction of high technology.

With their sophisticated mechanical and electronic systems, low fuel consumption values and outstanding power ratings, these diesel engines represent peak performance in diesel technology.

MSSP_001_002

Boat engines from Volkswagen are developed by skippers for skippers.

The easy-to-service components as well as a worldwide parts organisation ensure reliable and efficient operation over many years.

NEW **Attention Note**

The self-study programme is not a workshop manual!

Please refer to the corresponding service literature for inspection, adjustment and repair instructions.

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Fundamentals

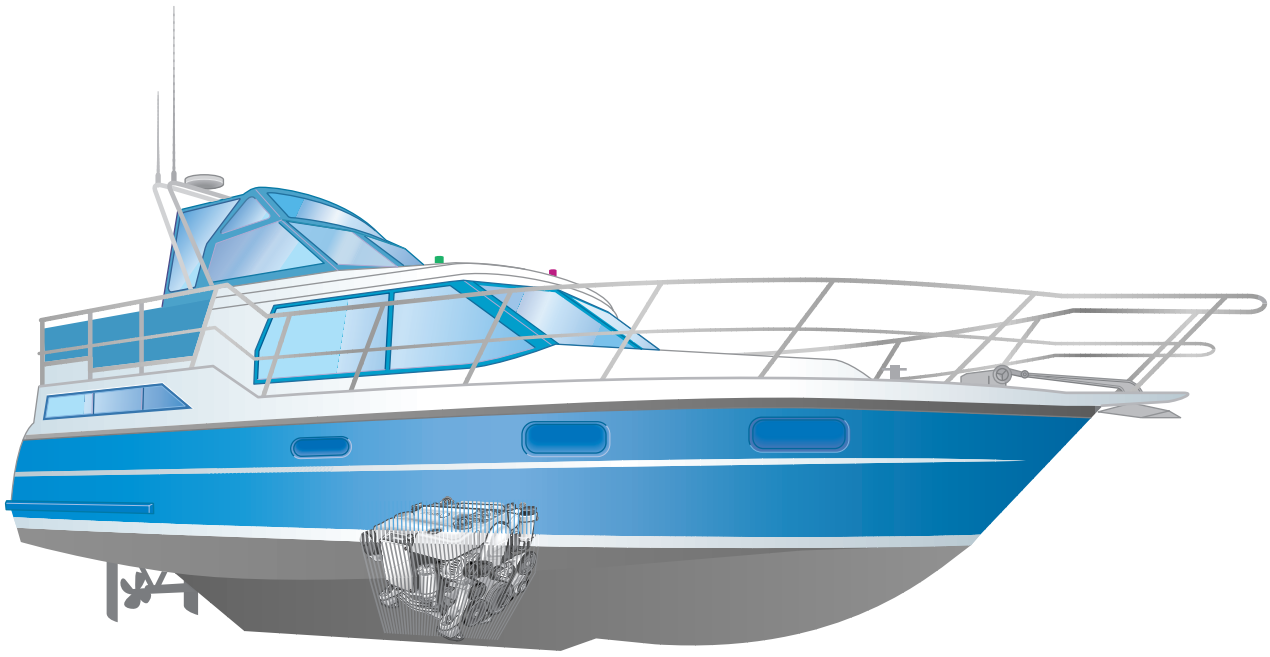
Features

- Quiet-running 5-cylinder engines
- Low weight and compact dimensions
- 2-pole electrical system:
  To avoid galvanic corrosion, the engine is not connected to ground
- Electric oil intake pump and upright cup-type oil filter for clean and efficient oil change at the push of a button
- Oil pan with support feet and baffle plates for increased protection when listing and in rough seas
- Low-maintenance belt drives with automatic tensioning elements to ensure long service life of belts and components
- Ultramodern electronics for monitoring engine functions
- Warnings with visual and acoustic alarm
- Water-cooled turbocharger with **V**ariable **T**urbine **G**eometry (VTG) for high propelling power in a wide speed range
- Powerful three-phase alternators for reliable power supply and fast battery charging
- All engines comply with the currently valid and most stringent pollution standard, the Bodensee Schifffahrtsverordnung (Lake Constance Shipping Ordinance) BSO II also with twin motorisation
- Complete instrumentation with economy control
- Suitable for PME/RME fuel

Particular care must be taken to ensure that the fuel tank and the fuel hoses leading to the engine are also suitable for PME/RME fuel.

The Volkswagen Marine boat engines feature

- a special **M**arine **D**iesel **C**ontrol (MDC) system specifically adapted to boat operation and which is characterized by maximum reliability. An emergency running program with a regeneration function ensures reliable engine operation should, contrary to expectations, a malfunction occur.
- a wide effective engine speed range with high propelling power.
- extensive corrosion protection for the engine housing and all add-on components.
- a dual-mass flywheel to absorb drive and transmission vibrations.



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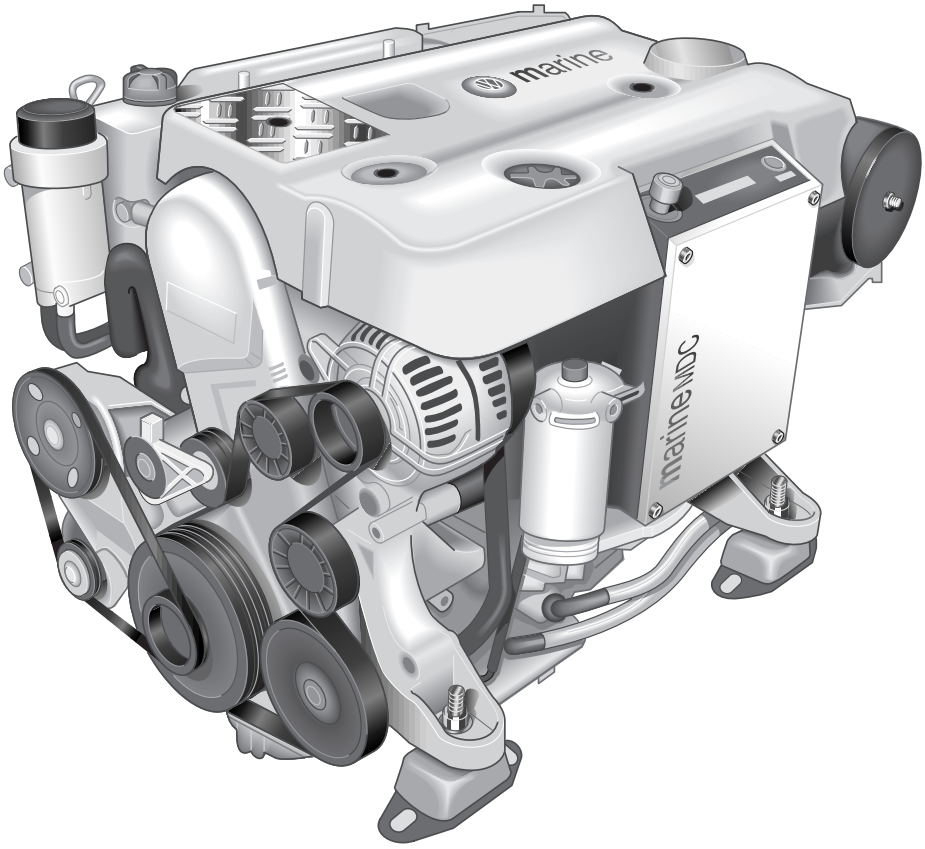
The SDI engine

The Volkswagen Marine boat engines are designed as naturally aspirated diesel engines with direct injection for use in displacement boats.

The engines, well-proven a million times over, offer:

- Quiet operation despite high pressure direct injection
- Low engine speed level and low-vibration operation
- High torque and low fuel consumption
- Low pollutant emission
- Compact installation dimensions
- Ease of maintenance and
- Ultramodern technology



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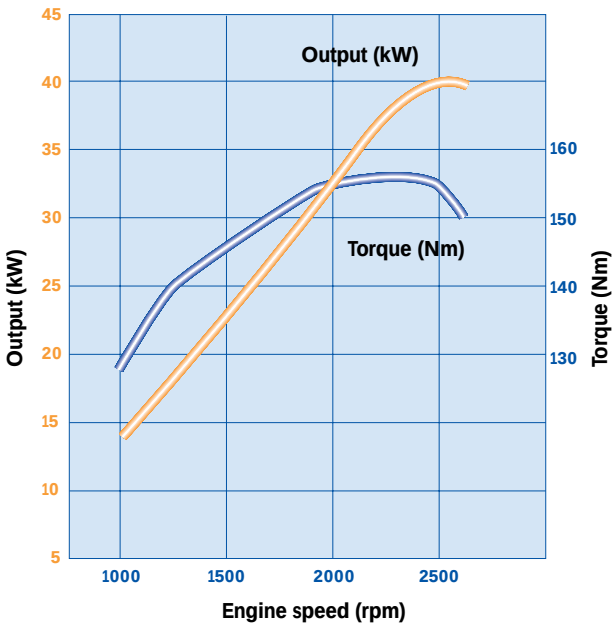
Engine data

Marine Type	SDI 55-5	SDI 75-5
Engine code letter	BCT	ANF
Engine design	5-cylinder in-line naturally aspirated diesel engine	
Fuel injection system	Diesel direct injection with electronically controlled distributor-type injection pump	
Displacement	2461 cm^3	
Compression ratio	19.0 : 1	
Power rating at engine speed	40 kW (55 bhp) 2500 rpm	55 kW (75 bhp) 3600 rpm
Max. torque at engine speed	155 Nm 2250 rpm	155 Nm 2250 rpm
Specific power output	16.3 kW/l	22.3 kW/l
Min. specific fuel consumption	233 g/kWh	233 g/kWh
Weight (dry, with ancillary components, cooling system and clutch flange) not including gearbox	260 kg	260 kg
Alternator	120 A	
Electrical system	12 V not earthed	
Exhaust emission legislation, certified in accordance with	Bodensee Schifffahrtsverordnung Stufe 2 (Lake Constance Shipping Ordinance, Stage 2)	

SDI 55-5



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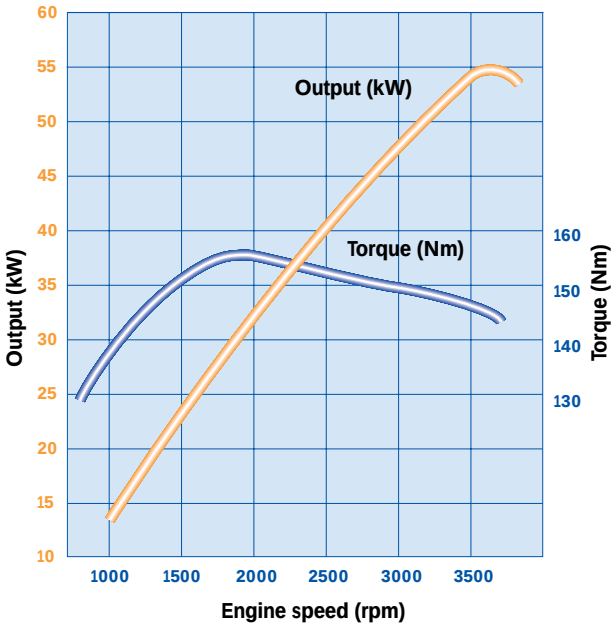
SDI 75-5



MSSP_001_110

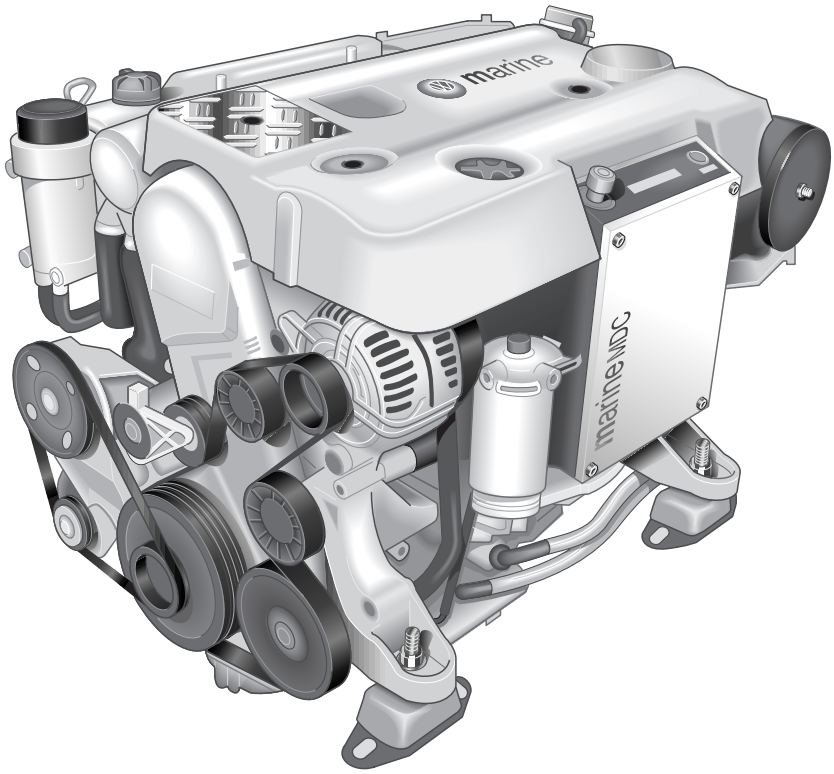
The TDI engine

Volkswagen Marine boat engines are designed as direct injection engines with turbocharging for use in displacement and hydroglider boats.

The TDI 150-5 is particularly suitable for use in fast hydroplanes. The TDI 150-5D variant is certified for use as twin motorisation in compliance with BSO II.

The TDI 100-5 and 120-5 engines are perfectly adapted to use in touring and sailing boats. They are both also certified for use as twin motorisation in compliance with BSO II.

The TDI engines feature a turbocharger with a water-cooled VTG turbocharger (**V**ariable **T**urbine **G**eometry).



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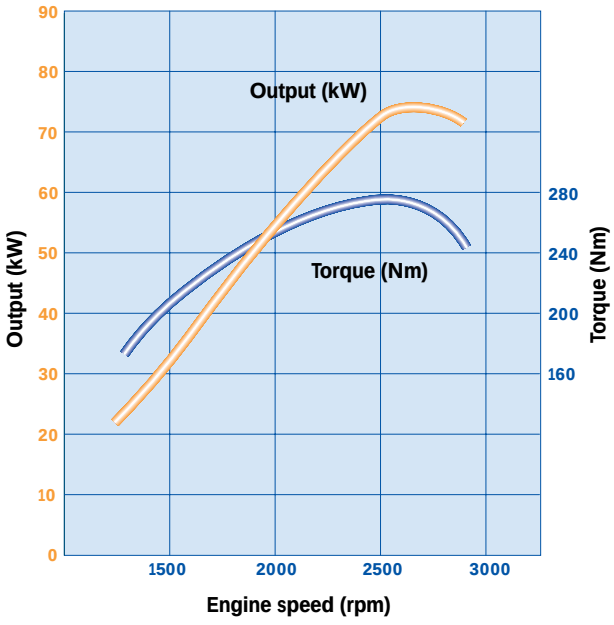
The engines develop a wide effective speed range offering high propelling power without the characteristic propulsion weakness of turbocharged engines in the lower engine speed range.

TDI 100-5

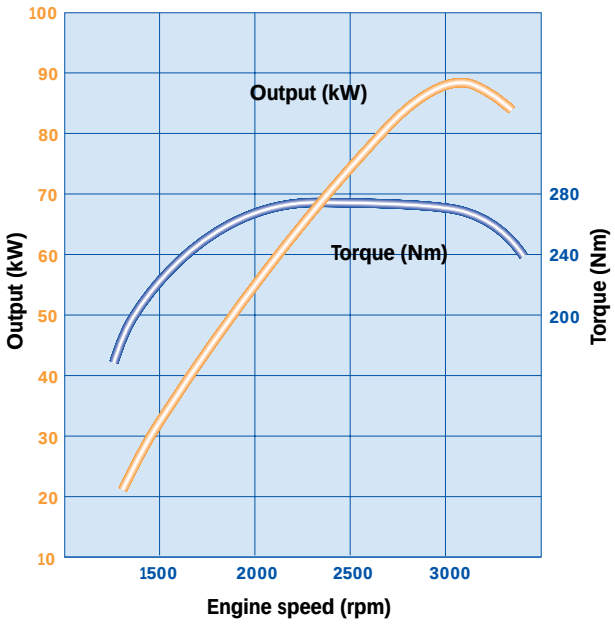


MSSP_001_111

Engine data

Marine Type	TDI 100-5	TDI 120-5	TDI 150-5	TDI 150-5D
Engine code letter	BCU	ANG	ANH	BCV
Engine design	5-cylinder in-line turbocharged diesel engine			
Fuel injection system	Diesel direct injection with electronically controlled distributor-type injection pump			
Supercharging	Variable turbocharger (VTG)			
Displacement	2461 cm^3			
Compression ratio	19.0 : 1			
Power rating at engine speed	74 kW (100 bhp) 2600 rpm	88 kW (120 bhp) 3250 rpm	111 kW (150 bhp) 4000 rpm	108 kW (147 bhp) 4000 rpm
Max. torque at engine speed	270 Nm 2500 rpm	275 Nm 2500 rpm	310 Nm 1900 rpm	310 Nm 1900 rpm
Specific power output	30.1 kW/l	35.8 kW/l	45.1 kW/l	43.9 kW/l
Min. specific fuel consumption	217 g/kWh	217 g/kWh	203 g/kWh	203 g/kWh
Weight (dry, with ancillary components, cooling system and clutch flange) not including gearbox	275 kg	275 kg	280 kg	280 kg
Alternator	120 A			
Electrical system	12 V not earthed			
Exhaust emission legislation, certified in compliance with	Bodensee Schifffahrtsverordnung Stufe 2 (Lake Constance Shipping Ordinance, Stage 2)			

TDI 120-5



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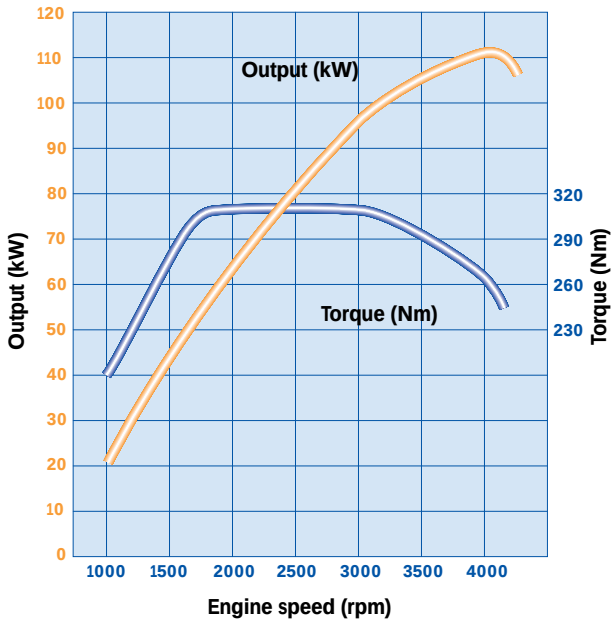
TDI 150-5



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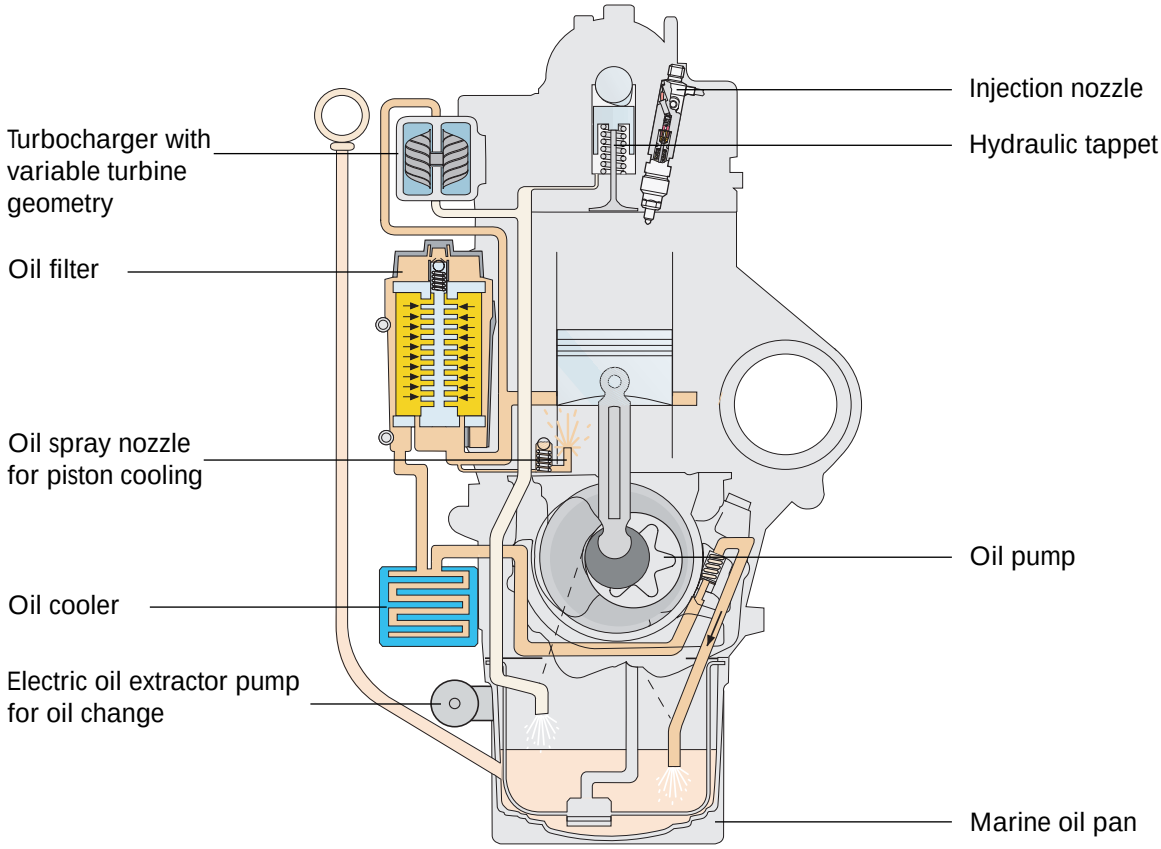
Engine oil circuit



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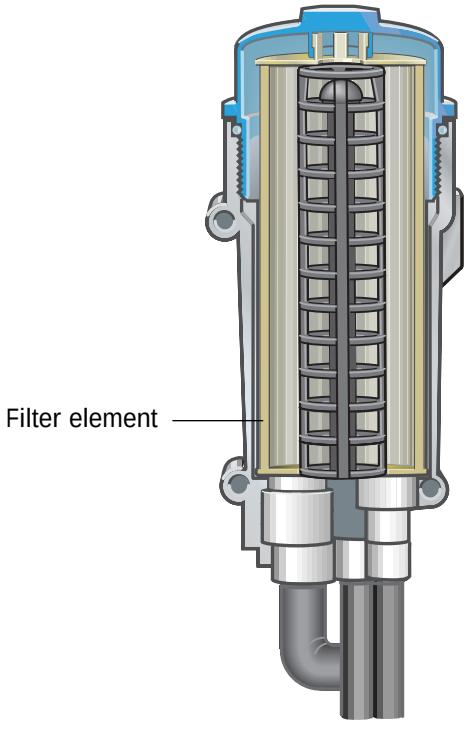
Cup-type oil filter

The cup oil filter is arranged upright. The paper filter that can be replaced from the top ensures the filter is easy to service and environmentally compatible.

When the oil filter cover is opened, a valve also opens so that the oil can flow out of the filter housing through a separate line back into the oil pan.



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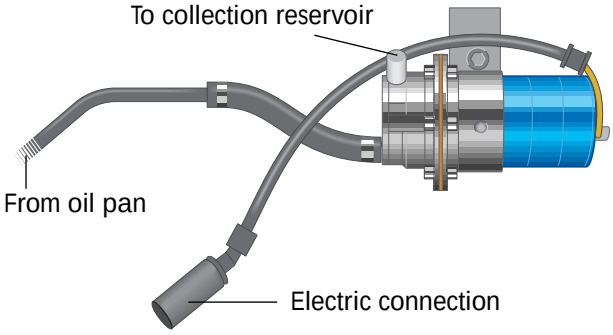
Electric oil extractor pump

The electric oil extractor pump can be used to extract the engine oil in an environmentally friendly manner and free of drips.

The pump is switched on by the switch on the central electrics unit.



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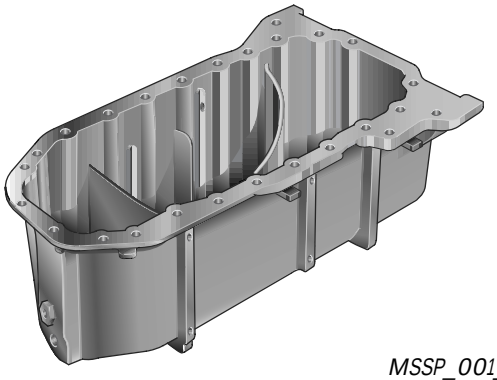
Oil pan

The oil pan is designed specially for use in Volkswagen Marine boat engines. Baffle plates ensure reliable oil supply to the engine also when listing heavily and in rough seas.



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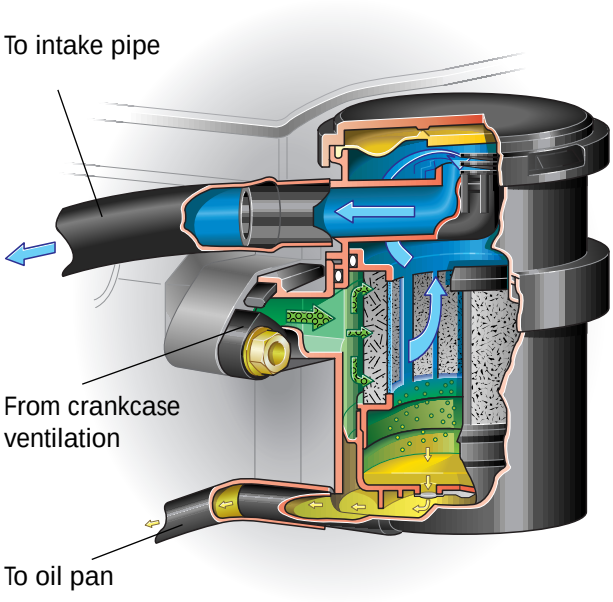
Crankcase ventilation with oil separator

The crankcase ventilation system with oil separator serves the purpose of keeping the air clean (to minimize oil burning) and prevents oil deposits forming on the intercooler.

The oil vapours pass through the crankcase ventilation system into the oil separator. The fabric element contained in the oil separator separates oil droplets and blow-by gas. The oil droplets are collected on the base and returned to the oil pan. The blow-by gas is routed back into the intake manifold of the engine.

The fabric element need not be replaced.



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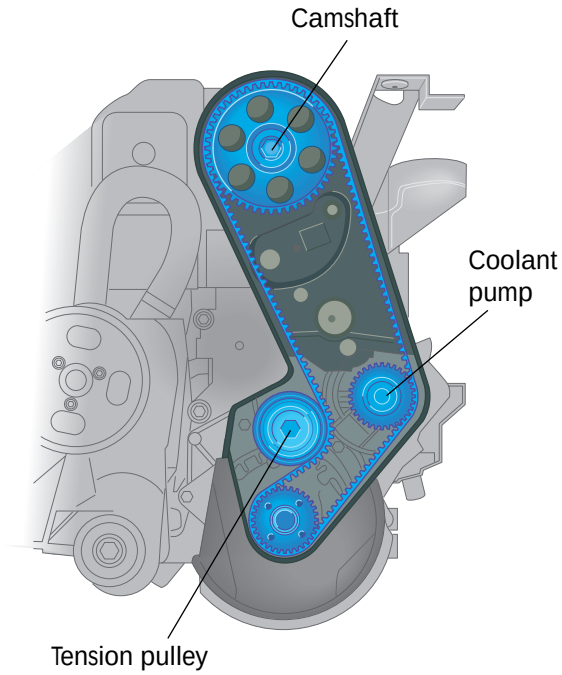
Belt drives

Toothed belt drive for the camshaft

The toothed belt drives

- the camshaft and
- the coolant pump.

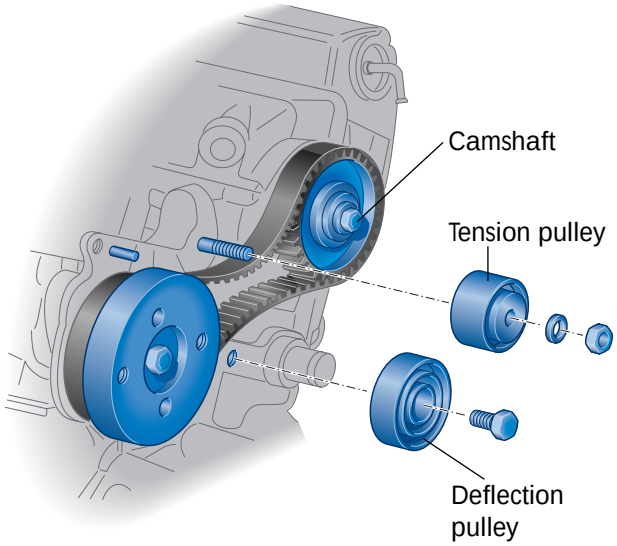
The mechanical tension of the toothed belt is controlled by a tension pulley.



MSSP_001_006

Toothed belt drive for the distributor injection pump

The toothed belt drive for the distributor-type injection pump consists of the tension pulley, deflection pulley, drive gearwheel that is driven by the camshaft, injection pump gearwheel as well as the toothed drive belt.



MSSP_001_007

Ribbed V-belt drives for ancillary components

The ancillary components are driven by ribbed V-belts.

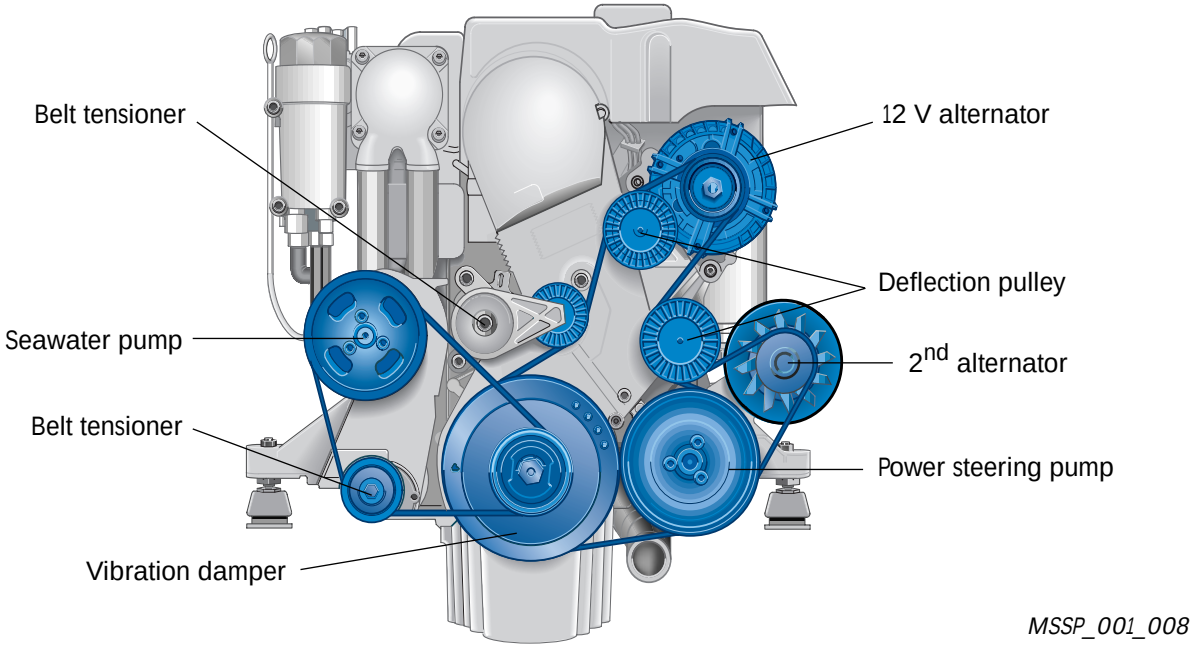
The following components are driven:

- The alternator (12 V) for engine operation and battery charging
- *Optional*
  The power steering pump for boats with Z-drive
- *and optional*
  An additional 12 V, 24 V or 230 V alternator
- The seawater pump via a separate ribbed V-belt drive

The belt drives are equipped with automatic belt tensioners and therefore require little maintenance.

To avoid damage to the vibration damper and the engine, the engine must not be run without the alternator belt drive.

Please refer to the current Workshop Manual for instructions on all adjustment and repair work.



MSSP_001_008

Dual-mass flywheel

Due to irregularities in combustion, displacement engines produce torsional vibrations at the crankshaft and the flywheel.

The use of a dual-mass flywheel prevents these torsional vibrations being transmitted into the drive train where they would produce resonance, resulting in disturbing noise in the boat. The dual-mass flywheel therefore also avoids excessive stress in the subsequently connected gearbox.

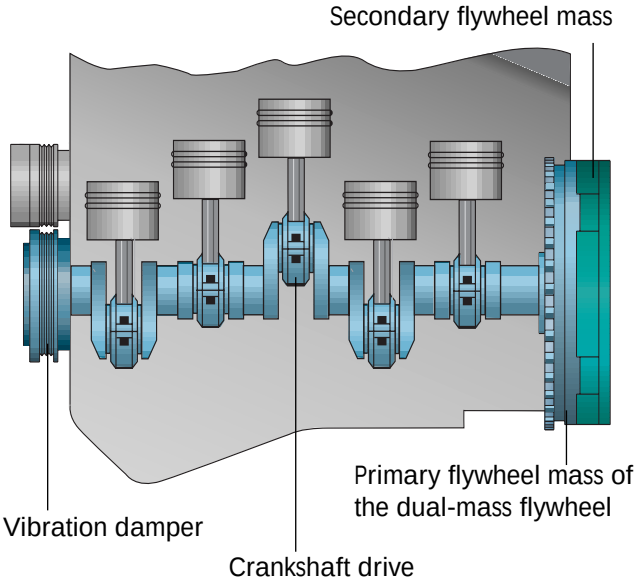
The dual-mass flywheel divides the flywheel mass into two parts.

One part is the primary flywheel or centrifugal mass; it belongs to the mass moment of inertia of the engine.

The other part, the secondary mass, increases the mass moment of inertia of the drive.

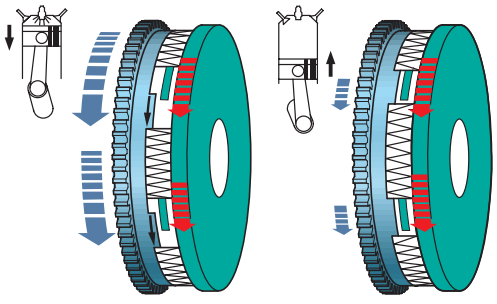
Connected by means of a spring damping system, both decoupled masses isolate the vibrations.

They absorb the vibrations at low engine speeds thus ensuring "drive rattle" no longer occurs.



MSSP_001_010

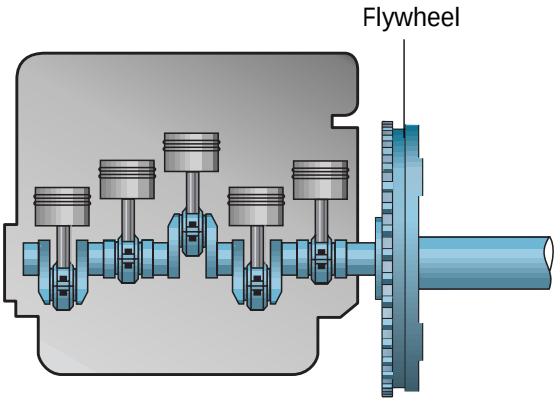
Vibration insulation



MSSP_001_063

Conventional power transmission structure without dual-mass flywheel

Engine and drive train vibrations at low engine speed



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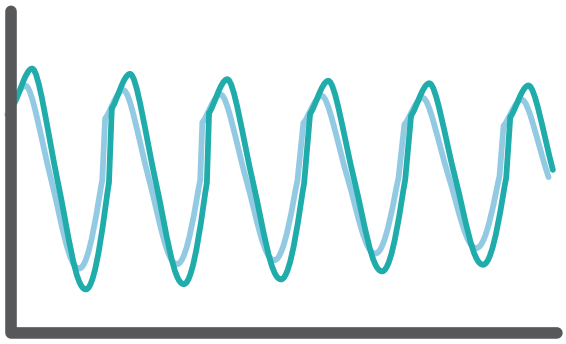
Engine and drive train vibration in idle speed range



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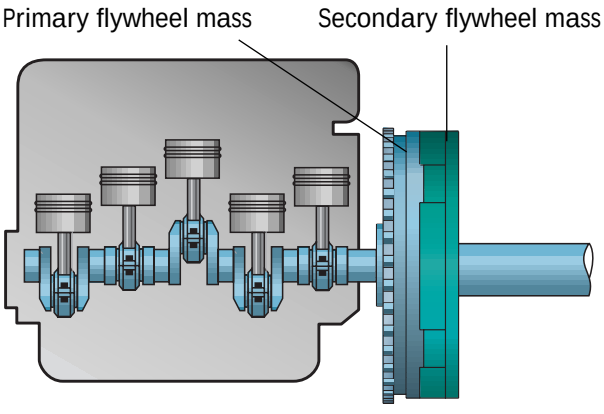
Power transmission with dual-mass flywheel

Engine and drive train vibrations at low engine speed



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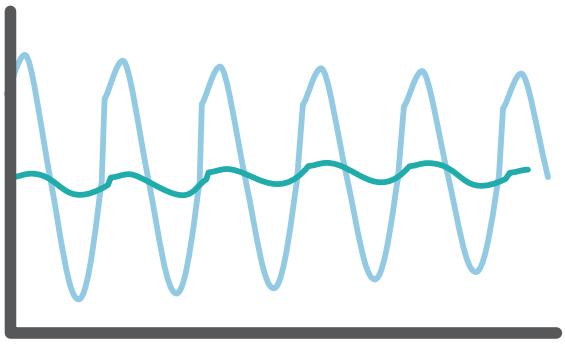
Engine and drive train vibration in idle speed range



Vibrations generated by the engine

Vibrations absorbed by the drive train

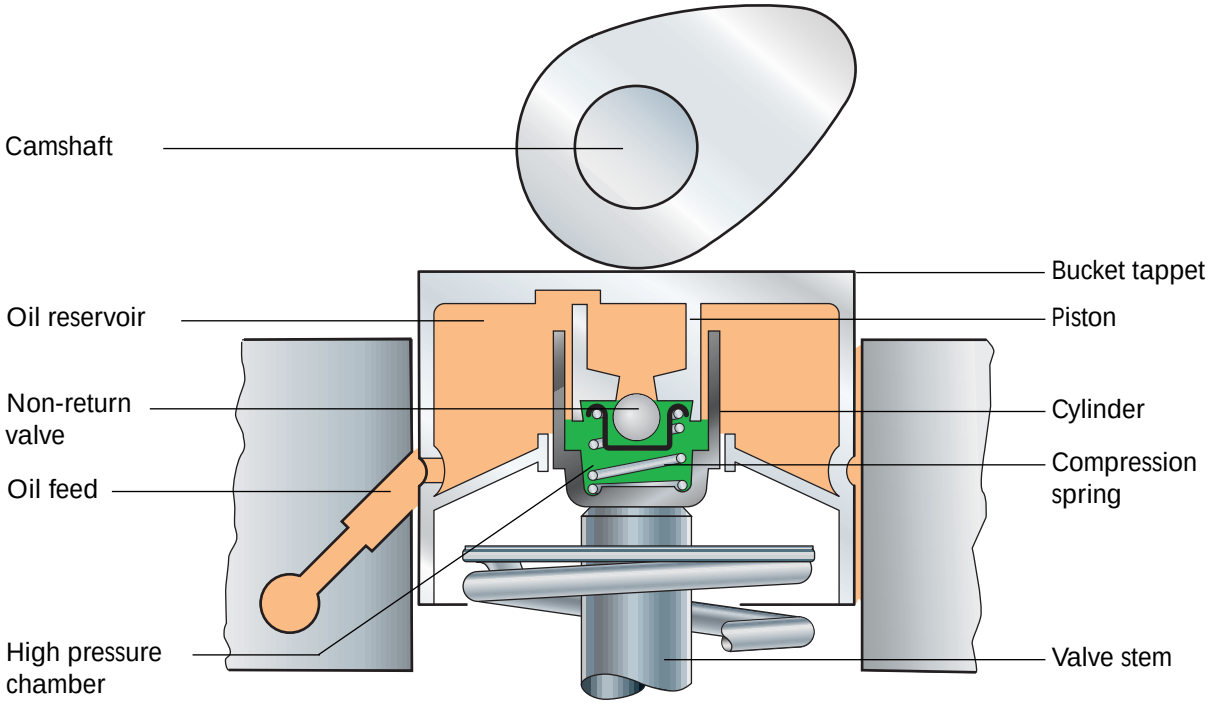
MSSP_001_084

Hydraulic bucket tappet

All Volkswagen Marine boat engines are equipped with hydraulic bucket tappets.

In addition to reducing noise, they also simplify servicing:

- No need to check and adjust valve clearance
- Precision valve timing



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The hydraulic bucket tappets essentially comprise:

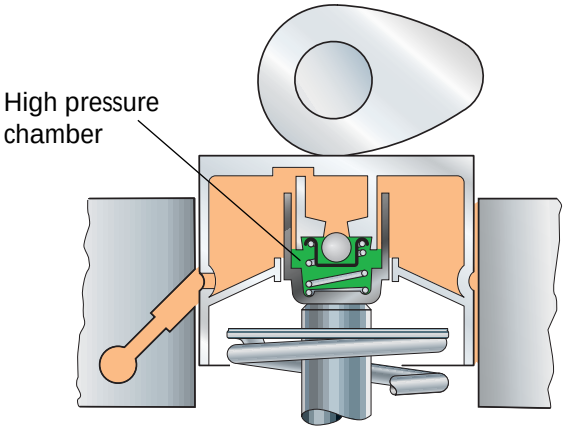
- Bucket tappet with piston
- Cylinder
- Non-return valve

Valve noise after starting the engine is a normal occurrence. Oil is forced out of the bucket tappet while the engine is inoperative. As soon as the engine is running, the high pressure chamber is filled with oil again and the valve noise disappears.

Functional description

Beginning of valve stroke

The cam turns on the bucket tappet, the non-return valve closes and pressure builds up in the high pressure chamber. The oil trapped in the high pressure chamber cannot be compressed. The bucket tapped acts as a rigid element.



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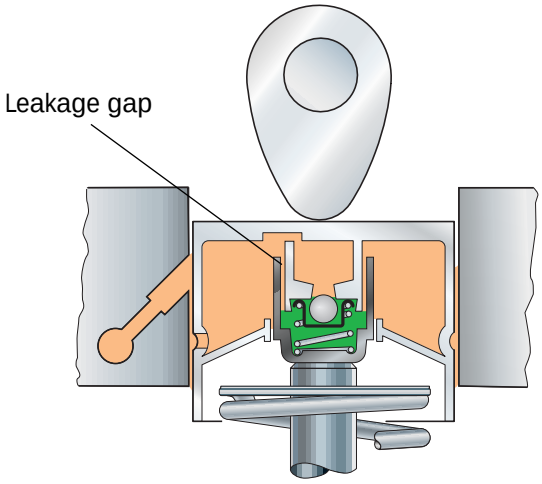
Valve stroke

The pressure in the high pressure chamber increases due to the force the cam exerts on the tappet. A little oil escapes via the leakage gap so that the tappet compresses by max. 0.1 mm.



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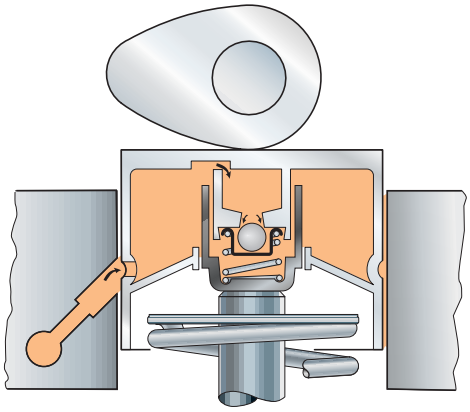
Valve clearance compensation

Compensation of the valve clearance (lash) begins after the valve has closed. The pressure in the high pressure chamber drops as the cam no longer presses against the tappet. The spring forces the cylinder and bucket apart to such an extent that there is no clearance between the bucket tappet and cam. Oil flows out of the supply reservoir through the now opening non-return valve into the high pressure chamber.



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Combustion system

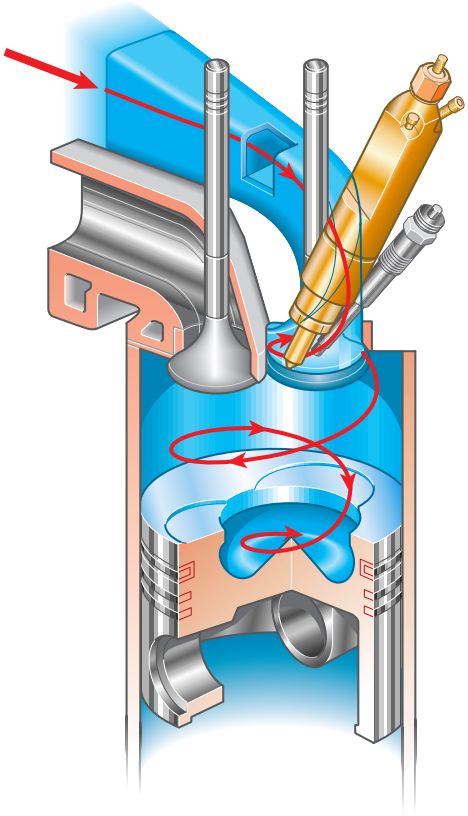
The combustion system

In Volkswagen Marine boat engines, the fuel is injected directly into the main combustion chamber.

The advantages include:

- More efficient combustion
- Improved fuel utilization
- Lower fuel consumption and
- Low pollutant emission

The special design of the pistons, injection nozzles and of the intake port optimises the combustion process with regard to noise development, smooth operation and pollutant emissions.



Intake swirl port

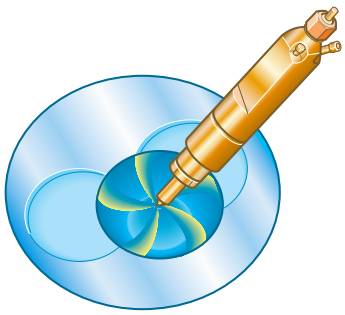
The special design of the intake port induces a swirling motion in the drawn-in air.

Piston recess

The swirling motion of the intake air is continued in the piston recess that is optimally adapted to this engine.

Injection nozzle

The five-hole injection nozzle (fuel injector) injects the fuel in two stages into the piston recess where it ignites on the hot air.
The two-stage injection prevents a "harsh" increase in pressure thus avoiding the characteristic diesel "knock".



MSSP_001_016

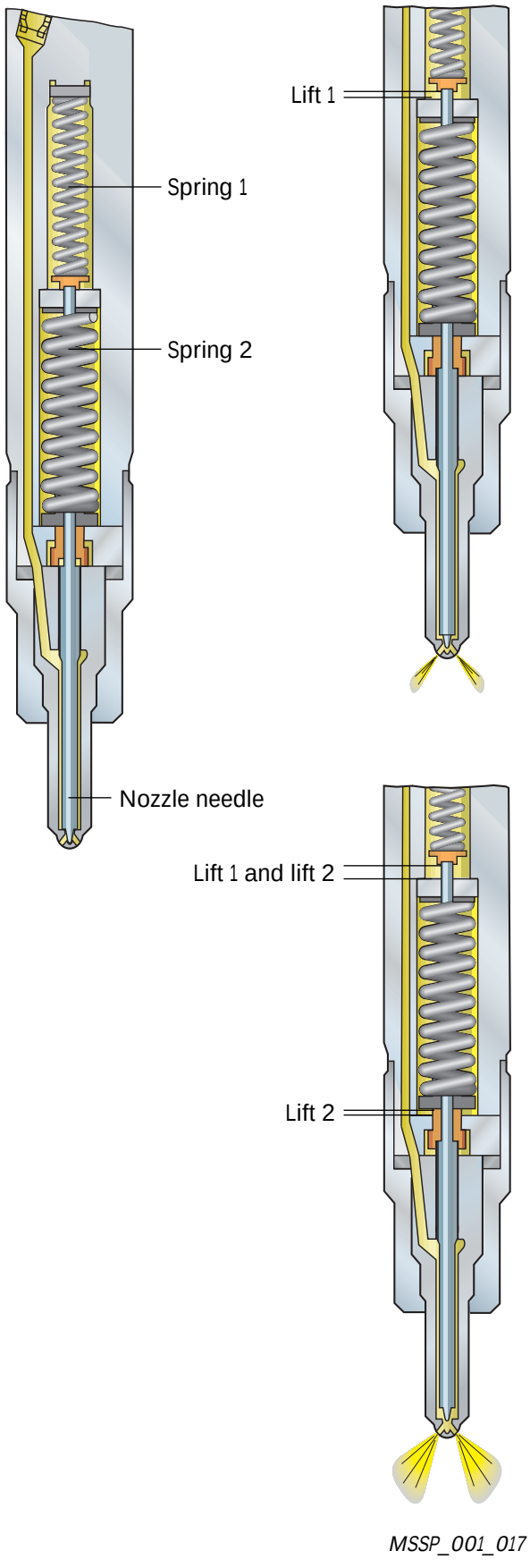
Two-spring nozzle holder

Smooth increase in pressure in the combustion chamber reduces combustion noise and mechanical stress.

The two-spring nozzle holder developed for the Volkswagen direct injection diesel engines enables fuel injection in two stages. As a result, it plays an important part in ensuring "smooth" combustion.

Functional description

There are two springs of different thickness fitted in the nozzle holder. Due to the geometry of the springs, the nozzle needle is raised only against the force of the first spring at the start of injection. A small gap is produced, allowing a small quantity of fuel to be pre-injected at low pressure. This pre-injection ensures a smooth increase in the combustion pressure and creates the ignition conditions for the main volume of fuel. The pressure in the injection nozzle increases due to the fact that the injection pump delivers more fuel than escapes through the small gap. The nozzle needle is further raised against the force of the second spring. The main injection now takes place at high pressure.



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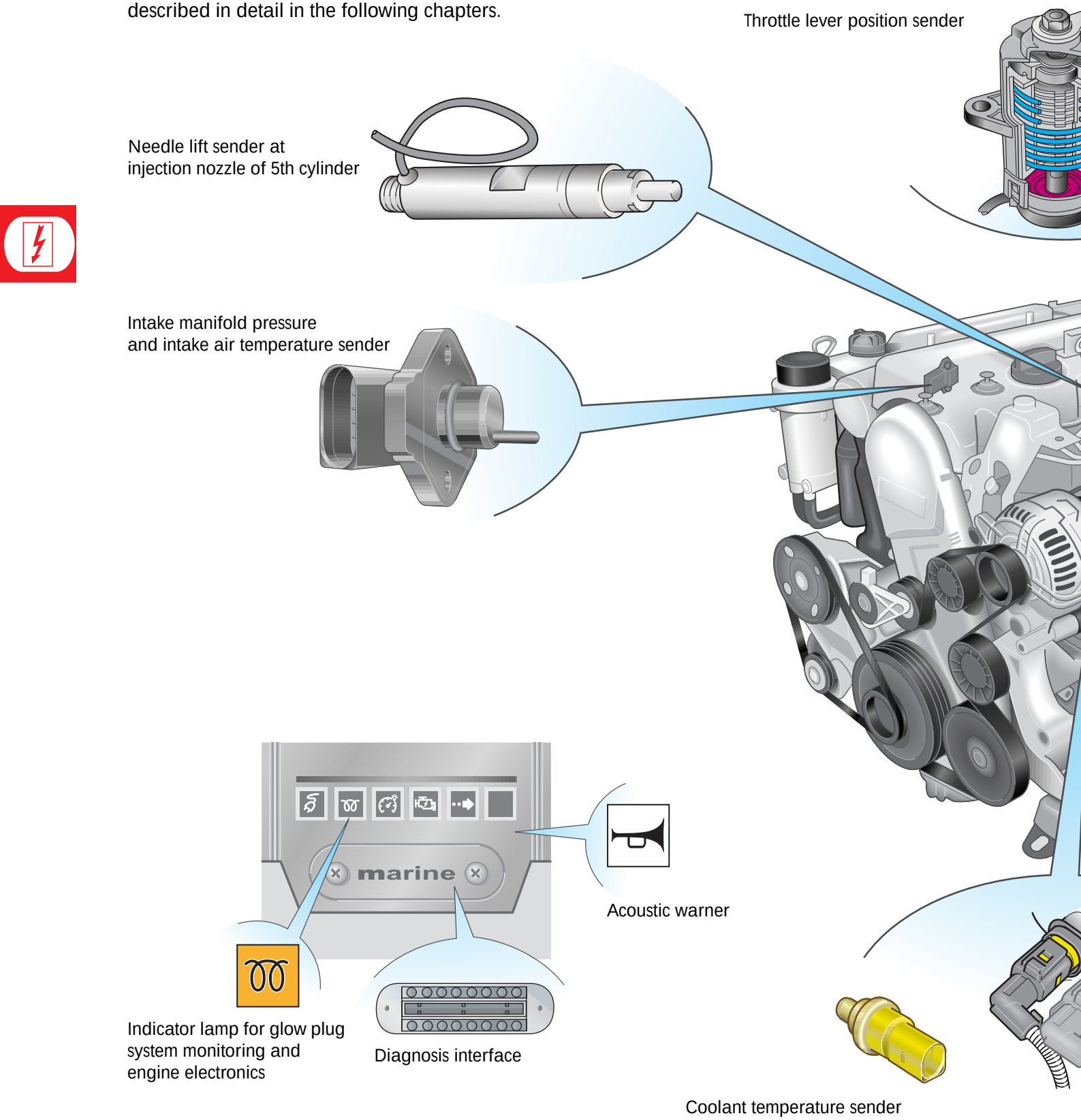
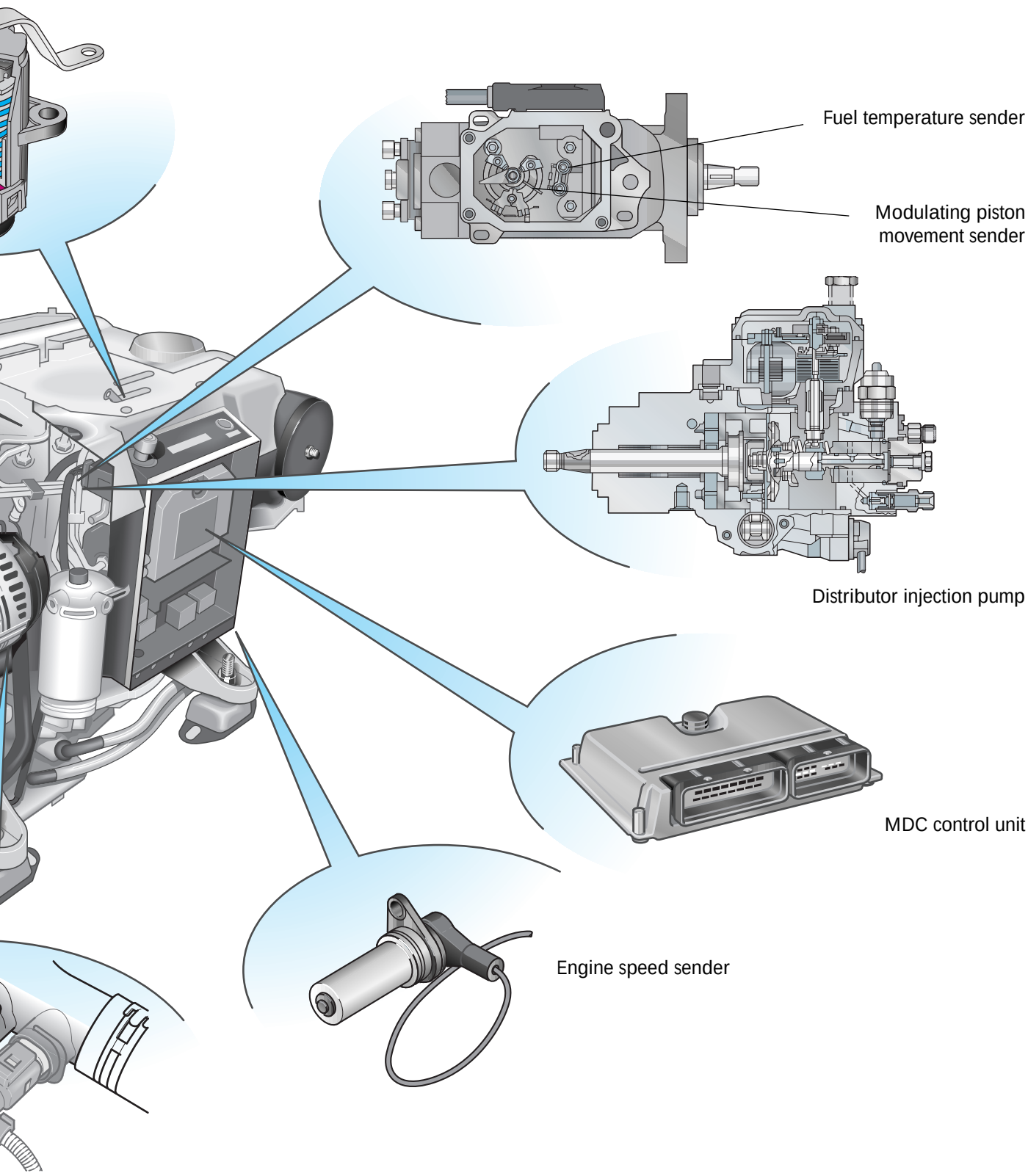
Engine electronic systems

Overview of installation locations

This general layout provides an overview of the components of the MDC. The components are described in detail in the following chapters.

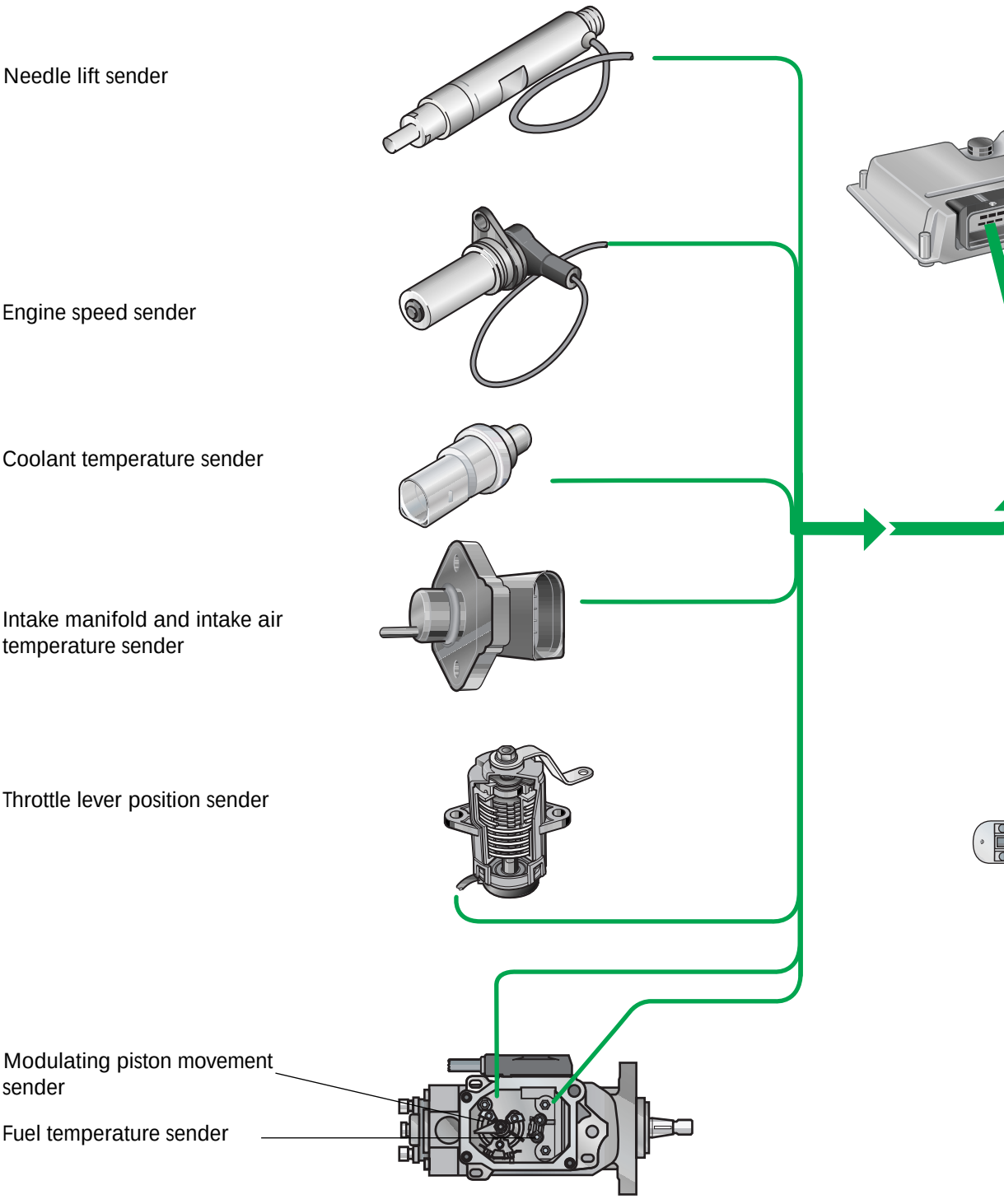



Fuel temperature sender
Modulating piston movement sender
Distributor injection pump
MDC control unit
Engine speed sender

MSSP_001_019

System overview

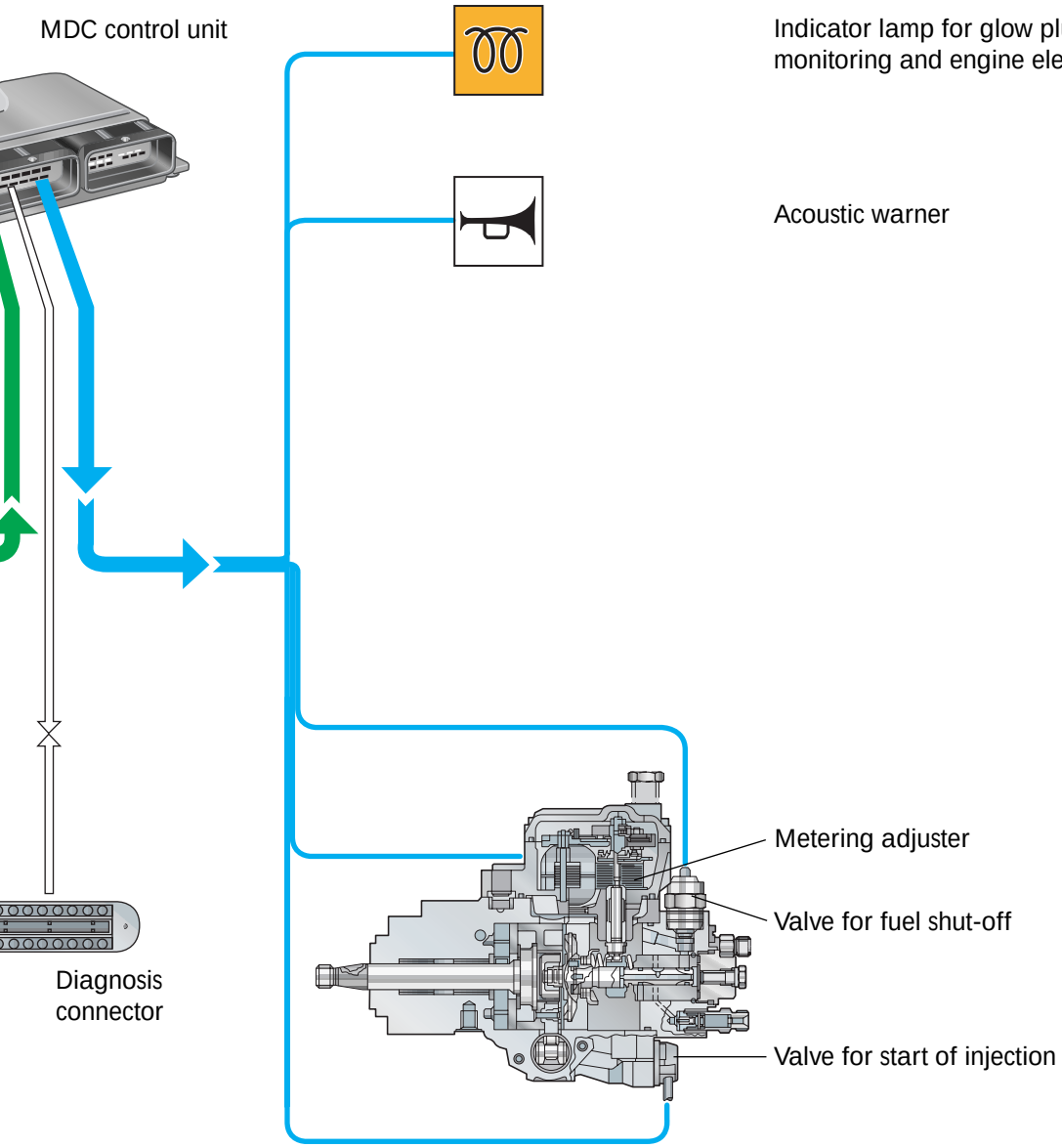
Sensors supply the engine control unit with information on the current operating status of the engine.



The corresponding actuators are activated following evaluation of the sensor information in the engine control unit.

The injection volume and start of injection as well as the preheater system are controlled and monitored in this way.

For monitoring purposes, the engine control unit makes use of several characteristic maps and characteristic curves while ensuring the best torque output, the most favourable fuel consumption and the best exhaust emission characteristics for every operating situation.



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Glow plug system

A glow plug system control is integrated in the Volkswagen Marine engine control unit.

The glow plug control contains the following functions:

- Preheating
- Post-heating
- Standby heating

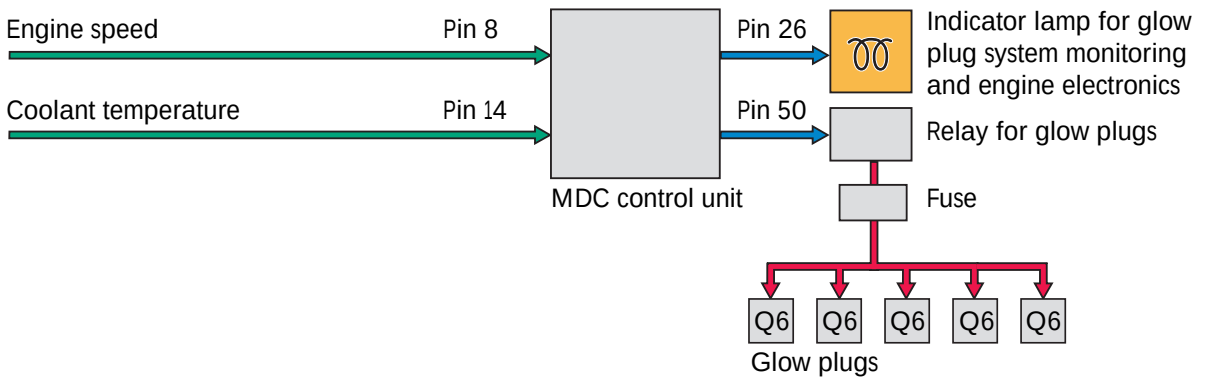
Functional description

Preheating

In view of the outstanding starting characteristics of the Volkswagen Marine direct injection boat engines, preheating (glow plug) is only activated at temperatures below +9 °C. The engine control unit receives the signal for the engine temperature from the coolant temperature sender.

The preheating procedure is started automatically. The preheating time depends on the current engine temperature.

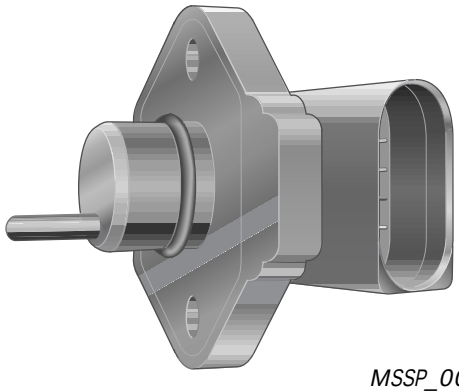
An indicator lamp in the panel informs the skipper that preheating is active.



MSSP_001_045

Intake manifold pressure and intake air temperature sender

The intake manifold pressure and intake air temperature sender is located in the intake manifold. From the signal, the engine control unit recognizes the pressure and temperature of the intake air. The signal is required for limiting smoke in the dynamic range and to monitor the function of the turbocharger (TDI only).



MSSP_001_098

Functional description

The piezoelectric crystals in the intake manifold pressure sender are changed by the pressure of the air drawn in and thus send a voltage signal to the engine control unit.

Substitute function

None

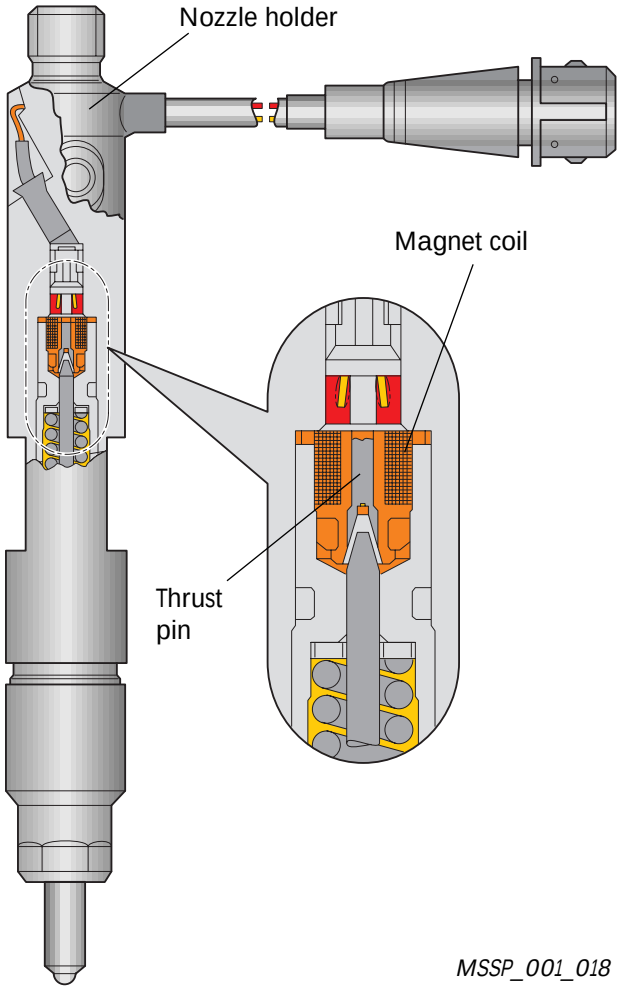
Effect

In the event of failure, there are no malfunctions in engine operation

Needle lift sender

The needle lift sender is located on the injection nozzle of the 5th cylinder.

It signals the actual start of injection to the engine control unit. The signal is used to ensure the characteristic map for start of injection is adhered to.



Functional description

The voltage applied at the magnet coil of the needle lift sender is controlled by the engine control unit such that a constant current always flows. In this way, a magnetic field is generated in the magnet coil (solenoid). The magnetic field changes with the movement of the nozzle needle that is connected to the thrust pin. The change distorts the applied voltage; a pulse peak is created. The engine control unit calculates the actual start of injection from the time difference between the pulse peak and the TDC signal from the engine speed sender. The actual start of injection is compared with the set start of injection specified in the characteristic map of the engine control unit and is corrected by the control unit in the event of deviations.

Substitute function

An emergency operation program is started in the event of the needle lift sender failing.

The start of injection is controlled according to fixed setpoints from the characteristic map. In addition, the injection volume is reduced.

Effect

The power output of the engine is reduced.

Modulating piston movement sender

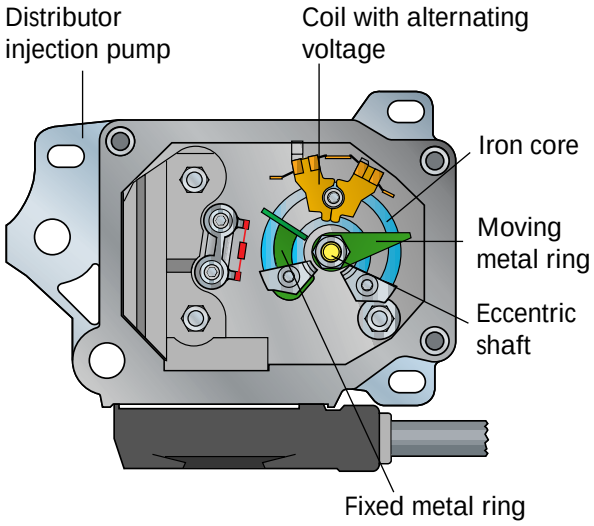
The modulating piston movement sender signals to the engine control unit the current position of the metering adjuster in the injection pump.

Functional description

An alternating voltage generates an alternating magnetic field in a special iron core. A metal ring that is secured to the eccentric shaft moves along the iron core.

This movement influences the magnetic field.

The engine control unit evaluates this change and thus obtains the current position of the metering adjuster.



MSSP_001_021

Substitute function

If the engine control unit receives no signal from the modulating piston movement sender, the engine will be shut down for safety reasons.

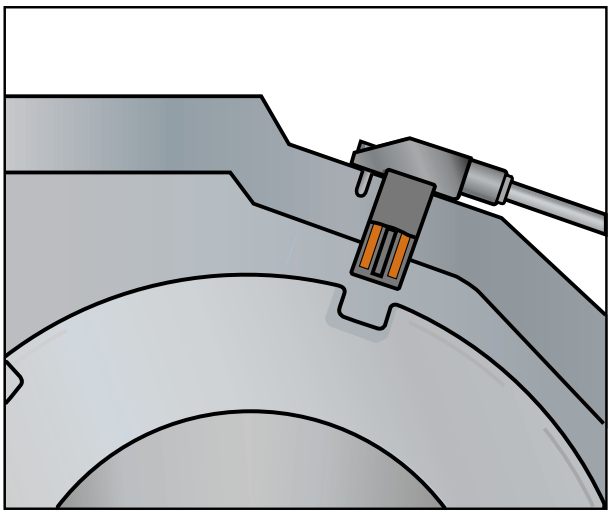
Effect

Engine operation is not possible.

Engine speed sender

The engine speed sender is located in the vicinity of the starter crown gear. It scans five marks on the sender wheel for engine speed.

The engine control unit uses the signal to detect the engine speed.



MSSP_001_022

Functional description

The sender operates in accordance with the induction principle.

The marks on the sender wheel generate an alternating voltage in the sender coil. From this signal, the engine control unit can accurately calculate the angular position and the current engine speed.

Substitute function

If the engine control unit receives no signal from the engine speed sender, an activated emergency operation program uses the signal from the needle lift sender as a substitute signal.

Effect

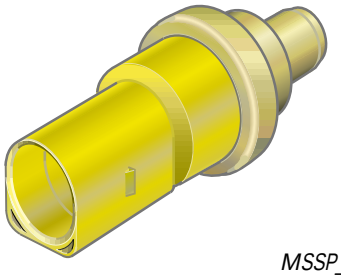
The injection volume is reduced thus also reducing the engine power output. The engine is shut down if the signal from the needle lift sender also fails.

Coolant temperature sender

The coolant temperature sender is located on the connection coupling for the coolant above the coolant pump.

Its signal serves as a variable for determining the engine temperature and for detecting whether preheating, post-heating, standby heating or increased idle speed is required when the engine is cold (90 sec).

The signal is additionally used in the event of engine overheating to reduce the power output.



MSSP_001_023

Functional description

The coolant temperature sender features an NTC bead. An NTC (**N**egative **T**emperature **C**oefficient) changes its resistance corresponding to temperature. When the temperature increases the resistance value drops. When the temperature drops the resistance values increases.
The engine control unit can detect the current engine temperature from this resistance value.

Substitute function

If the engine control unit receives no signal from the coolant temperature sender, a fixed value stored in the engine control unit is used as the substitute signal.

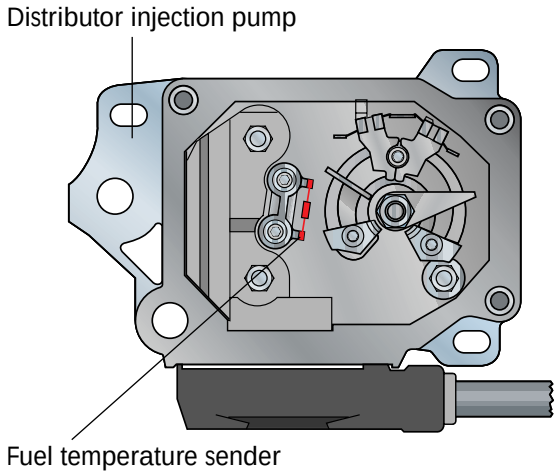
Effect

The MDC control unit receives no engine temperature value from the coolant temperature sender.

Fuel temperature sender

The fuel temperature sender is located in the upper housing of the distributor-type injection pump.

Its signal informs the engine control unit of the coolant temperature and the control unit adapts the fuel volume accordingly.



MSSP_001_024

Functional description

The fuel density changes with the change in the fuel temperature. The injection volume must be correspondingly adapted to ensure an optimum combustion process.

Substitute function

In the event of the fuel temperature sender failing, the last temperature value is stored in the MDC control unit.

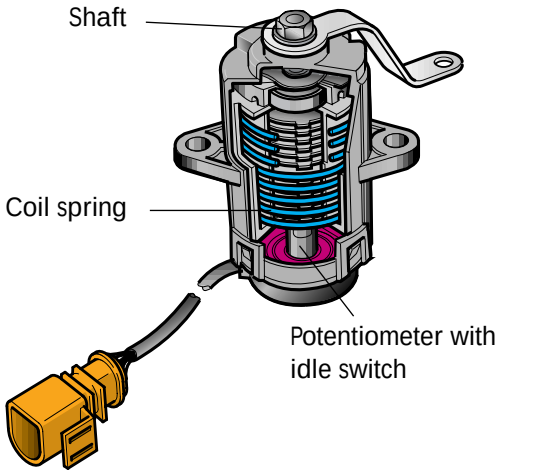
Effect

The injection volume can no longer be determined correctly. The MDC now determines the injection volume according to the value last stored.

Throttle lever position sender

The throttle lever position sender is located in the vicinity of the central electronics unit.

Its signal informs the engine control unit of the throttle lever position. This signal is also used to determine the injection volume.



MSSP_001_025

Functional description

The shaft in the sender is turned when accelerating. The potentiometer mounted on the end of the shaft sends to the engine control unit a voltage value corresponding to the throttle position. From this value, the engine control unit recognizes the throttle lever position and the skipper's choice. In connection with the fuel volume control of the distributor injection pump, the control unit regulates the fuel volume to be injected.

Substitute function

If the engine control unit receives no signal, a fixed stored value is used as the substitute signal.

Effect

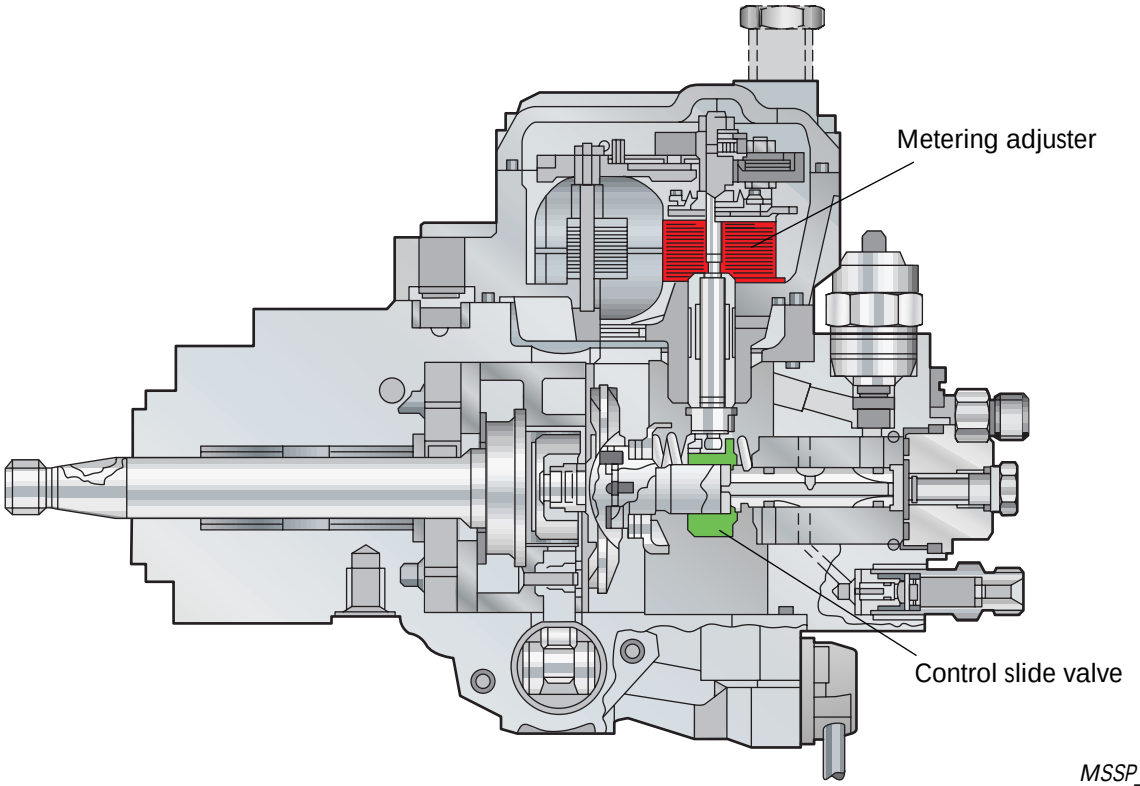
The engine runs at increased idle speed (1400 rpm) so that the skipper can reach the next mooring. Acceleration is no longer possible.

Metering adjuster

The metering adjuster with an electromagnetic actuator for controlling the injection volume is located in the distributor-type injection pump.

Functional description

With the aid of a control shaft, the electromagnetic actuator changes the position of the control slide valve. When activated by the engine control unit, the position of the control slide valve is changed axially thus constantly varying the injection volume between "minimum" (idle speed) and "maximum" (full throttle).



MSSP_001_026

Substitute function

None

Effect

If the metering adjuster fails due to a defect, the engine is shut down by means of the fuel shut-off valve.

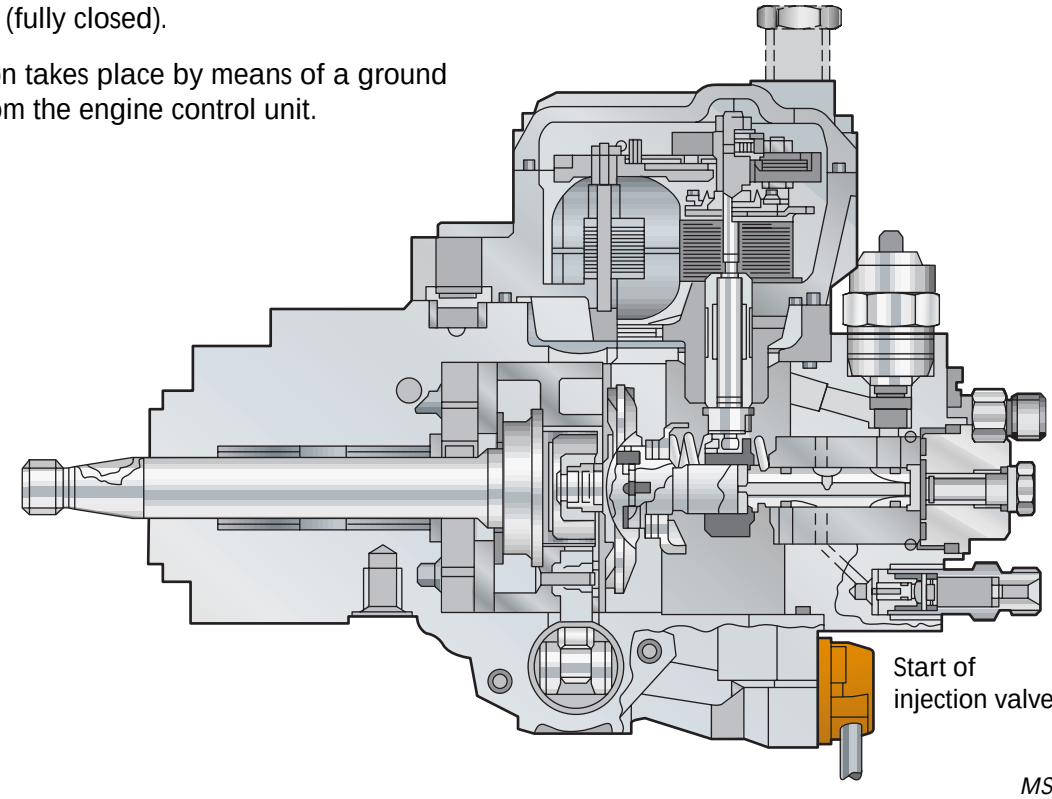
Start of injection valve

The start of injection valve is positioned on the underside in the housing of the distributor-type injection pump. The inner chamber pressure of the pump acts on the injection control piston via this cyclically clocked solenoid valve.

Functional description

The start of injection is controlled depending on the clock pulse (pulse duty factor) of the start of injection valve. The engine control unit can adjust infinitely variable between retarded start of injection (fully open) and advanced start of injection (fully closed).

Activation takes place by means of a ground pulse from the engine control unit.



MSSP_001_030

Substitute function

Control is no longer possible in the event of the start of injection valve failing.

A fixed value is used.

Effect

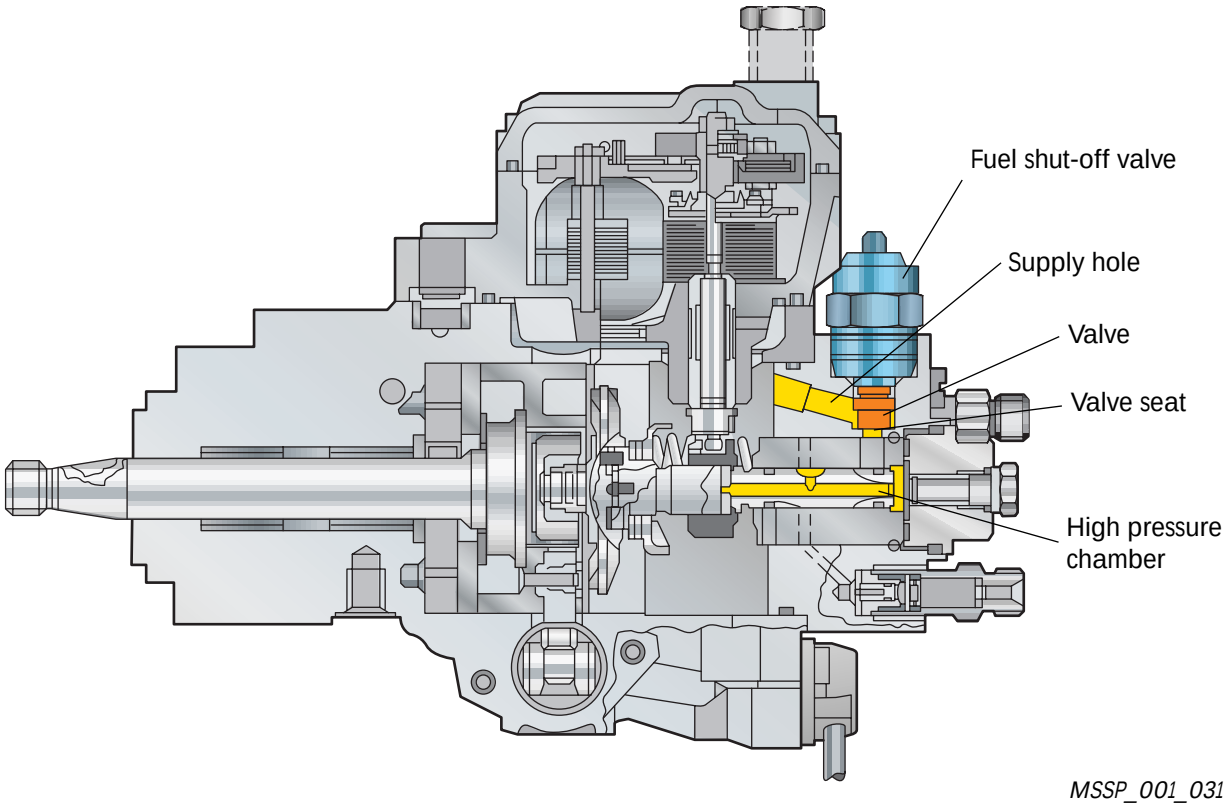
The engine runs with reduced power output due to the now limited volume of fuel.

Fuel shut-off valve

The fuel shut-off valve is installed on the upper side of the distributor-type injection pump in the vicinity of the fuel injection lines. This solenoid valve interrupts the fuel supply when the engine is shut down.

Functional description

The valve is open when no power is applied. In this way, it keeps the inlet hole to the high pressure chamber open. When power is applied to the solenoid, the valve closes the inlet hole. The fuel supply is shut off so that the high pressure piston can no longer deliver fuel.



MSSP_001_031

Substitute function

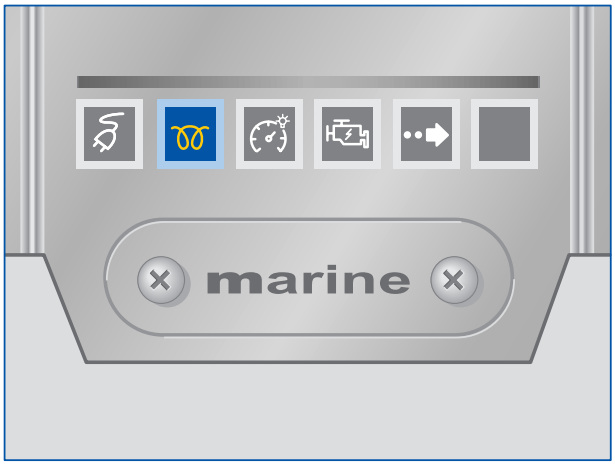
None

Effect

The engine is shut down by the metering adjuster.

Indicator lamp for glow plug system monitoring and engine electronics

The self-diagnosis concept of Volkswagen Marine boat engines comprises a self-monitoring function for sensors, actuators and mircoprocessors by the engine control unit.



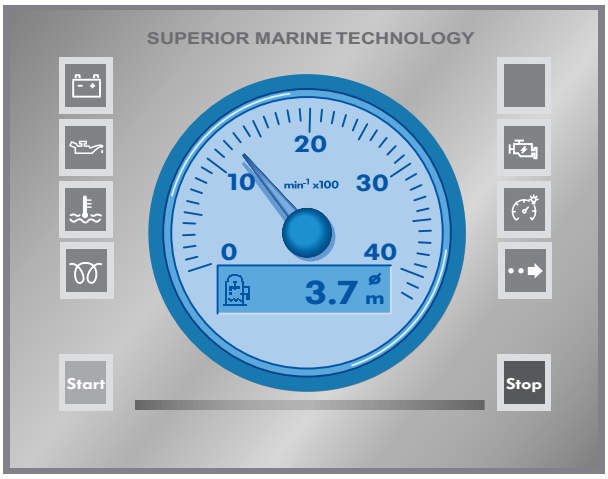
MSSP_001_032

Functional description

The self-diagnosis system uses an indicator lamp to inform the skipper of any malfunctions. In this way he is requested to call at the nearest service centre.

A warning is given in the event of a malfunction in the following components:

- Needle lift sender
- Engine speed sender
- Modulating piston movement sender
- Metering adjuster
- Start of injection valve
- Turbocharger: Boost pressure outside set range (TDI only)



MSSP_001_067

Substitute function

None

Effect

The effect depends on the type of component that has failed.

Activation

The engine control indicator lamp is activated by the engine control unit.

When the indicator lamp is activated by the engine control unit, an acoustic warning signal additionally sounds. This signal can be turned off after pressing the acknowledging button.

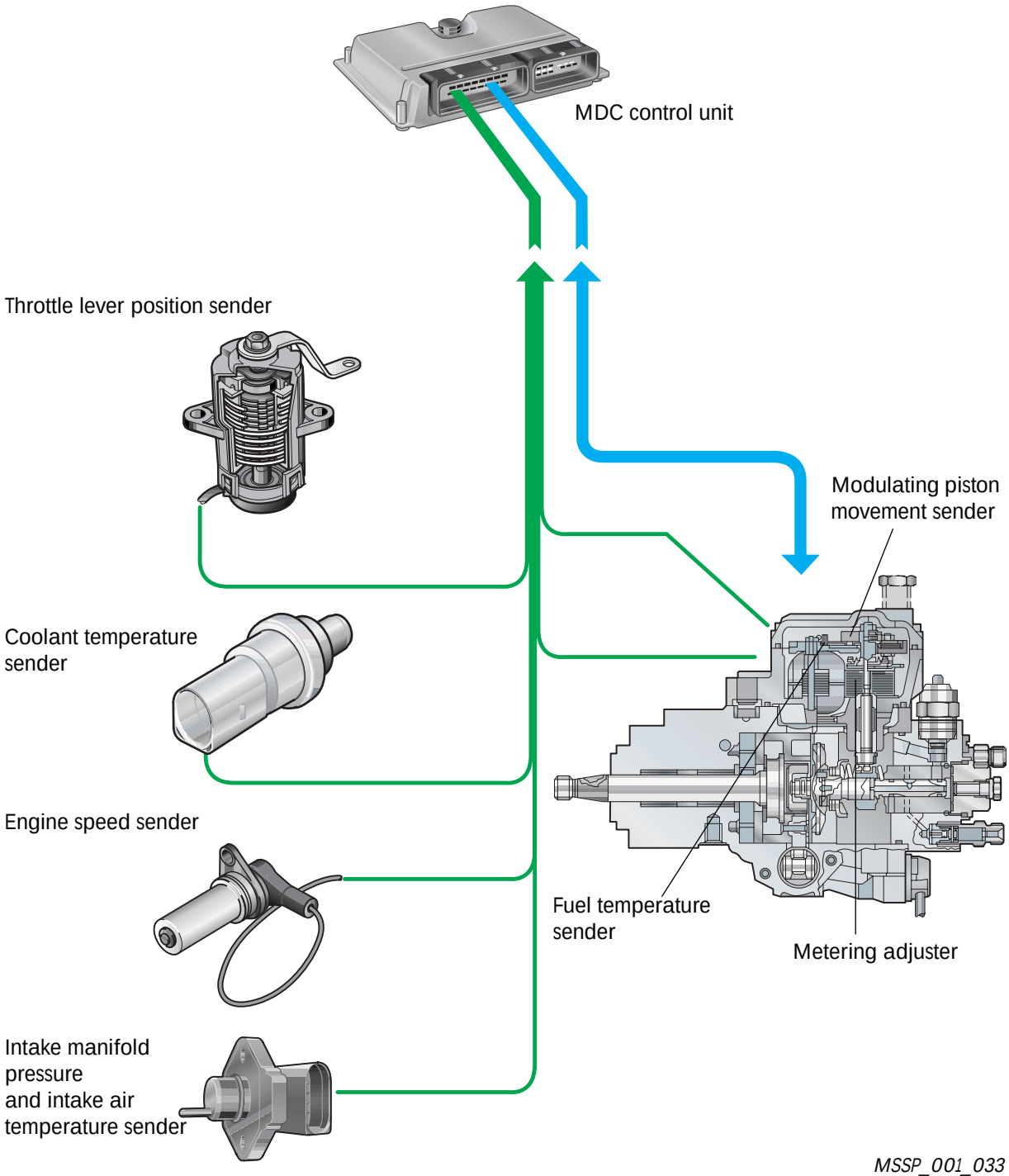
Fuel volume control

Following evaluation of the received sensor signals, the correct injection volume is determined in the engine control unit and an electrical signal is sent to the metering adjuster in the injection pump. The metering adjuster varies the position of the control slide valve corresponding to the electrical signal.

The engine control unit monitors the change in the valve position with the aid of the modulating piston movement sender.

If there is insufficient air in the system, the injection volume is limited by the smoke characteristic map.

Overview of sensors and actuators



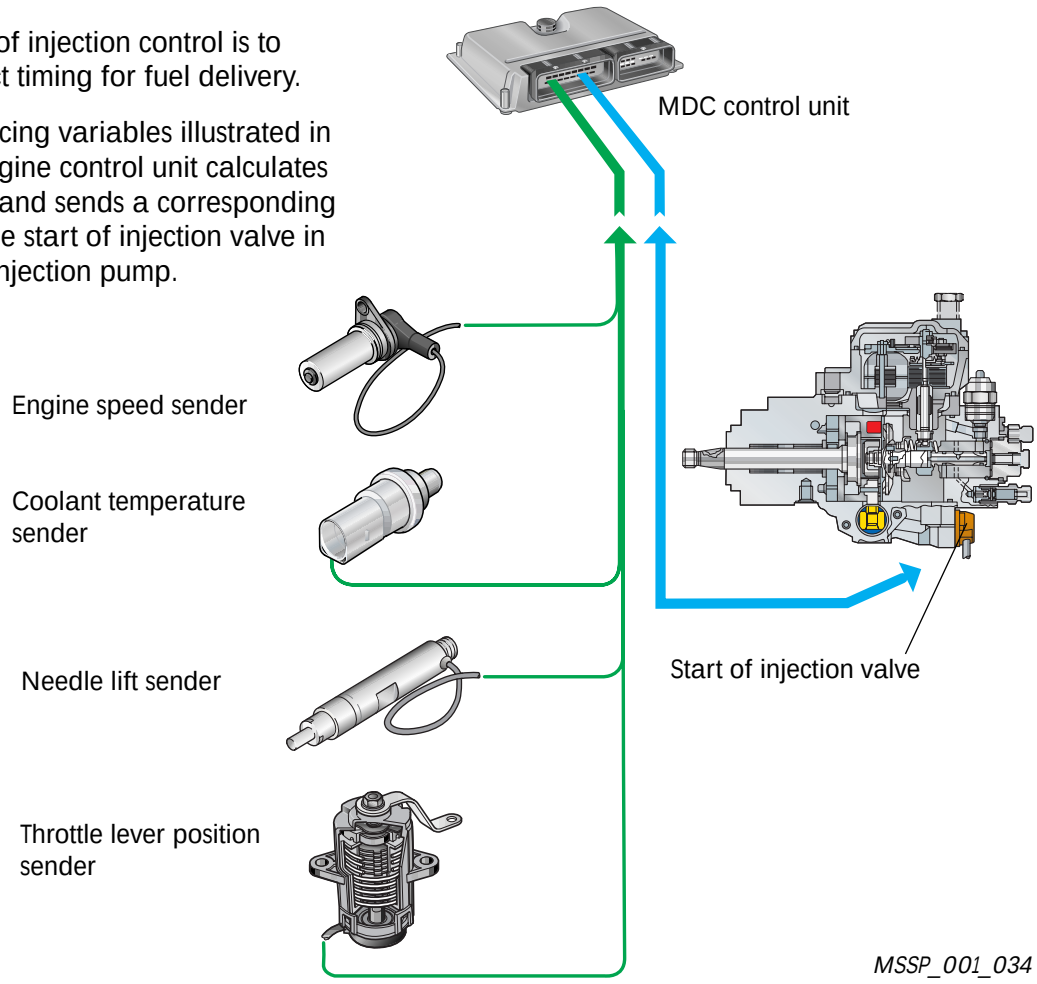
MSSP_001_033

Start of injection control

A large number of engine properties such as the starting characteristic, fuel consumption, engine output, smooth engine operation as well as exhaust emission are influenced by the start of injection.

The task of the start of injection control is to determine the correct timing for fuel delivery.

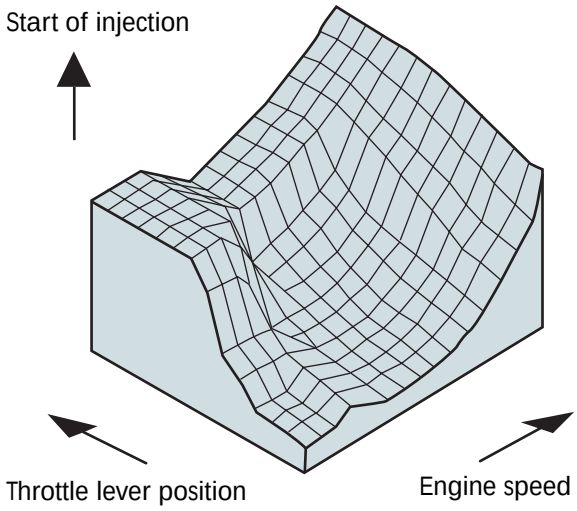
Based on the influencing variables illustrated in the following, the engine control unit calculates the start of injection and sends a corresponding electrical signal to the start of injection valve in the distributor-type injection pump.



MSSP_001_034

Start of injection characteristic map

The engine control unit calculates the optimum start of injection from the stored start of injection characteristic map and the input variables.



MSSP_001_046

Functional description

Injection timing device

The mechanical injection timing device in the distributor-type injection pump operates with the aid of the speed-dependent fuel pressure in the pump interior.

It is necessary to inject fuel earlier as the engine speed increases. The start of injection is varied by the turning movement of the rolling ring. This is controlled by the change in the fuel pressure in the pump interior. The fuel pressure increases as the engine speed increases. The control unit controls the start of injection valve by means of a clock pulse (pulse duty factor). The pressure in the pump interior changes corresponding to the pulse duty factor. One start of injection operation is assigned to each clock pulse. This facilitates infinitely variable control of the start of injection from maximum advance to retard setting.

Engine control unit

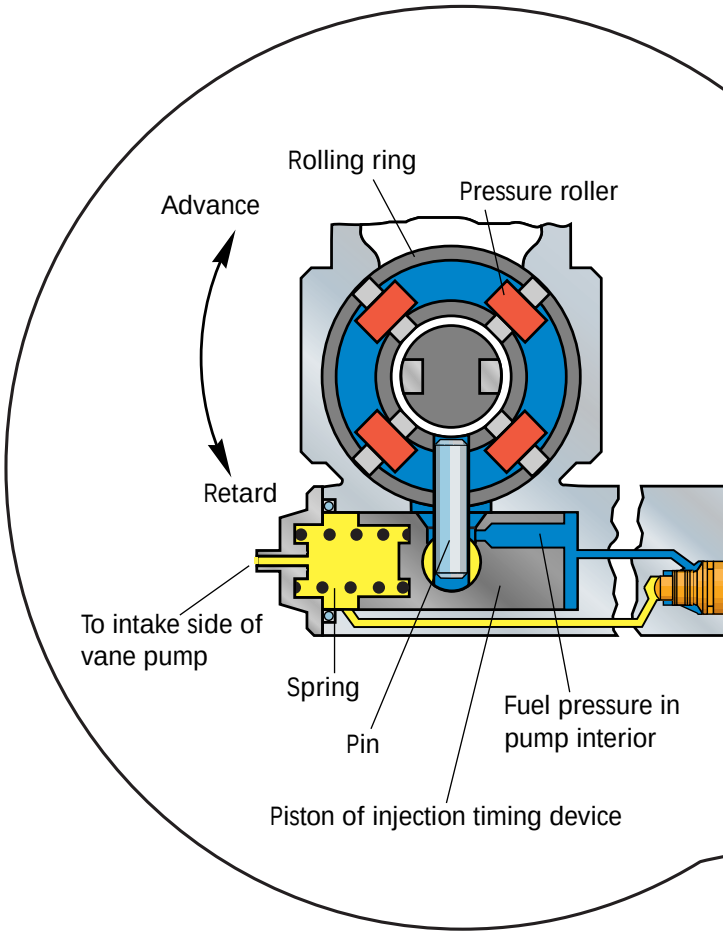
From the incoming sensor signals, the engine control unit calculates the set start of injection and sends the signals for the necessary pulse duty factor to the start of injection valve.

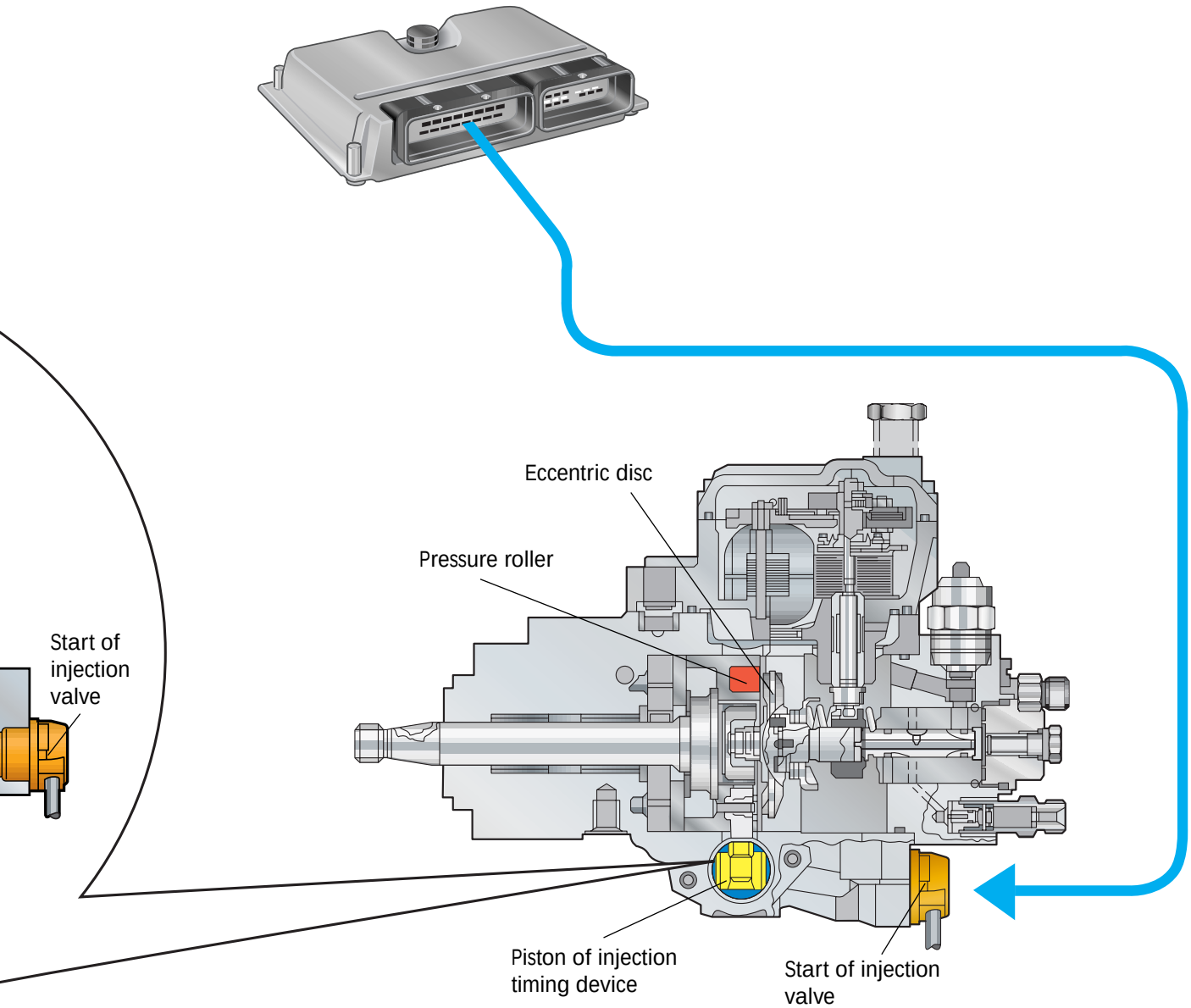
Start of injection valve

The valve converts the pulse duty factor into a change in the pump interior pressure (control pressure).

Note

To provide a clear illustration, the objects in the enlargements have been turned through 90°!

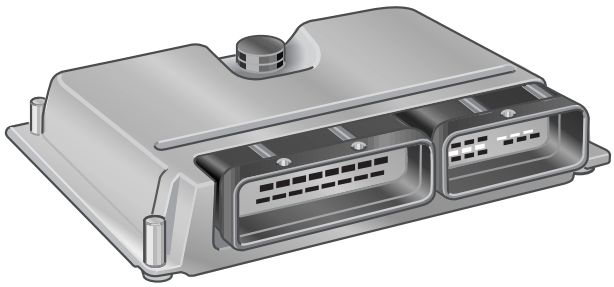



Eccentric disc
Pressure roller
Start of injection valve
Piston of injection timing device
Start of injection valve

MSSP_001_035

Internal functions in the engine control unit

With additional functions, the engine control unit ensures the engine runs smoothly during operation.



MSSP_001_106

Idle speed control

Based on the engine speed signal that is supplied 5 times per crankshaft revolution, the engine control unit recognizes even the smallest deviation from the specified idle speed.

By way of changes in the metering adjuster control, the engine control unit can maintain a constant idle speed under all operating conditions.

Smooth running control

In order to achieve particularly smooth, uniform engine operation, the injection volume of each cylinder is controlled in such a way as to avoid output differences between the individual cylinders.

This function is monitored by means of the signal from the engine speed sender that supplies the engine control unit with five signals per crankshaft revolution. If the signals are received in uniform rhythm this means all cylinders are performing the same amount of work. If the output of one cylinder is weaker, the crankshaft will be accelerated to a lesser extent. If the output of one cylinder is higher, it will accelerate the crankshaft to a greater extent.

Once the engine control unit has recognized an irregularity, a higher or lower injection volume is immediately supplied to the corresponding cylinder until the engine runs smoothly and uniformly again.

The injection volume deviation is indicated in the measured value block.

Maximum engine speed governing

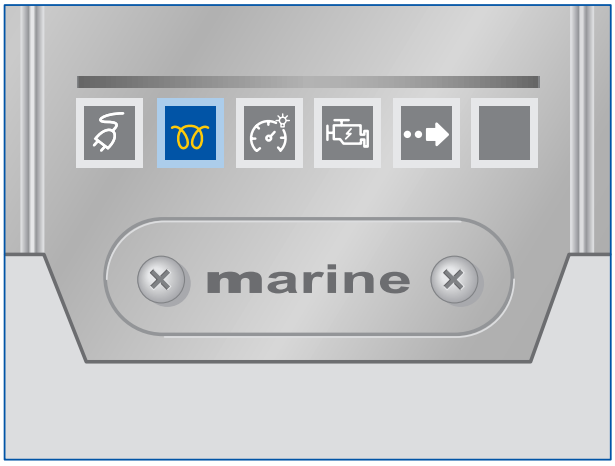
On reaching the maximum engine speed, the engine control unit reduces the injection volume in order to protect the engine.

Start volume control

The injection volume required for starting is determined by the engine control unit corresponding to the coolant temperature. As a result, exhaust emission is kept low while still ensuring very good starting characteristics.

Signal monitoring

During operation, the engine control unit monitors itself as well as the functions of the sensors and actuators. Occurrence of a malfunction is indicated visually by the indicator lamp illuminating and acoustically by a warning tone.



MSSP_001_032

Engine electronic systems

Function diagram

E190 - Emergency stop button
E354 - Oil extractor pump button

F36 - Neutral switch
F60 - Idling switch

G6 - Fuel pump (presupply pump)
G28 - Engine speed sender
G62 - Coolant temperature sender
G71 - Intake manifold pressure sender
G72 - Intake manifold temperature sender
G79 - Throttle lever position sender
G80 - Needle lift sender
G81 - Fuel temperature sender
G149 - Modulating piston movement sender

J17 - Fuel pump relay
J 52 - Glow plug relay
J248 - Diesel direct injection system control unit
J317 - Terminal 30a voltage supply relay
J593 - Fuel shut-off valve control relay

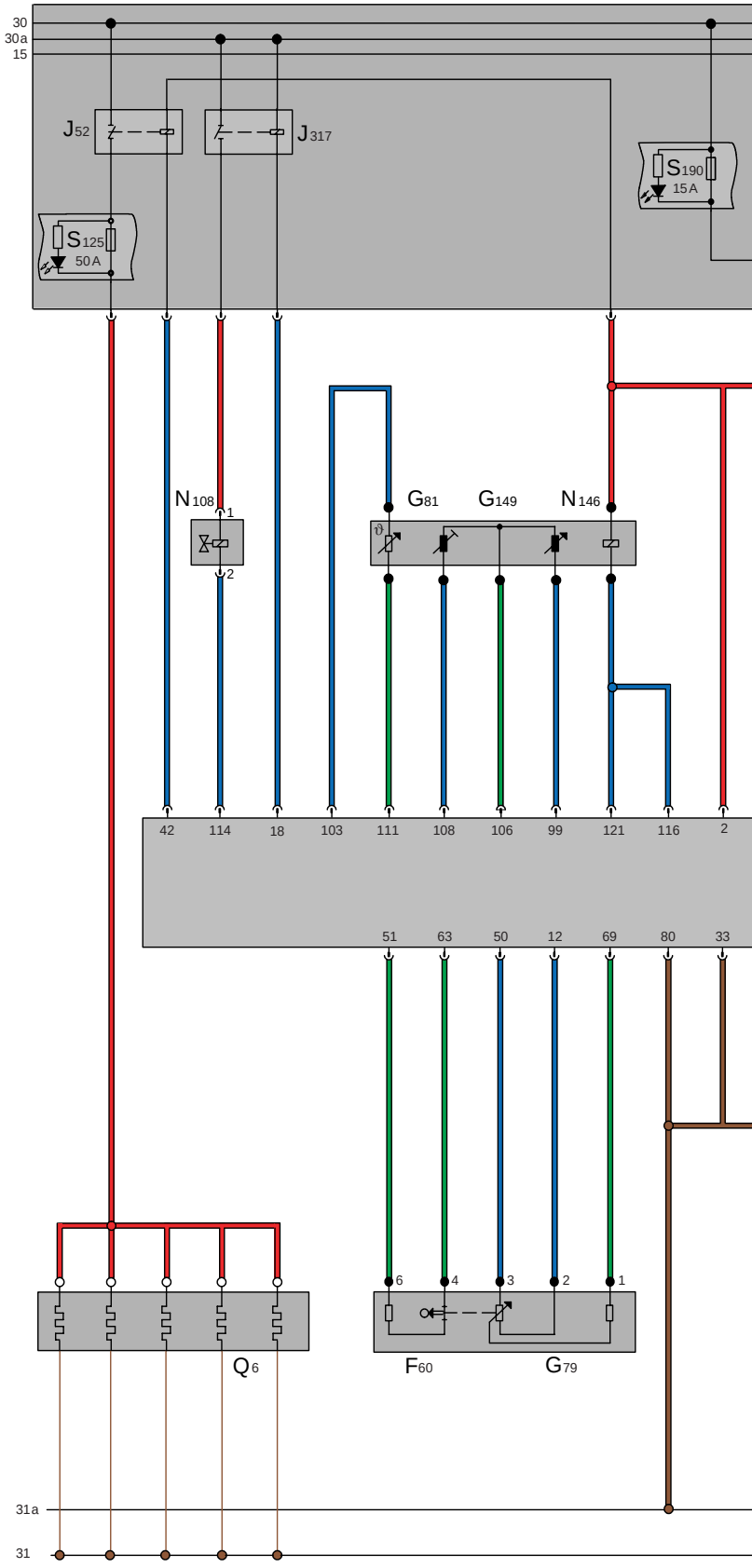
K29 - Glow period indicator lamp

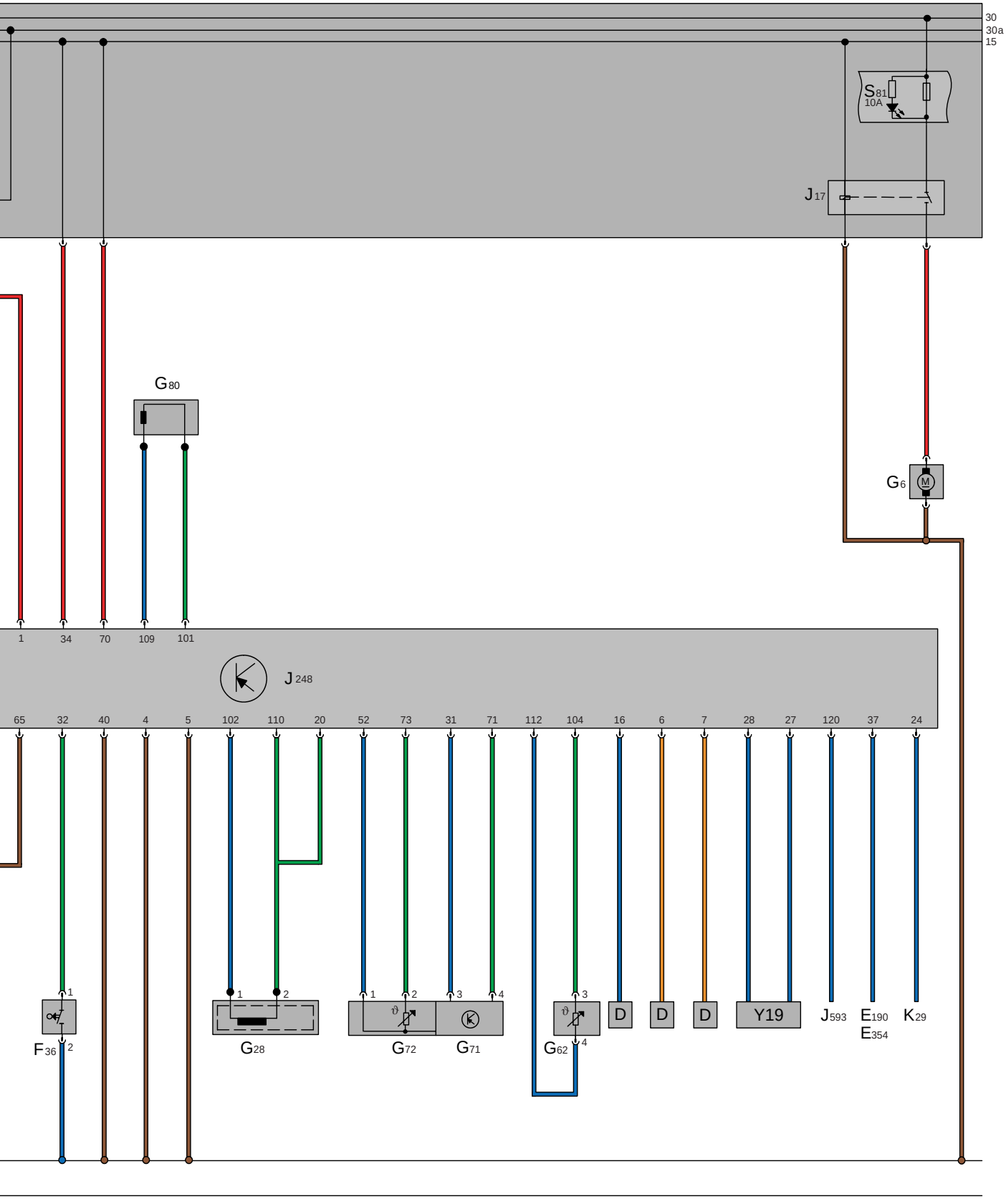
N108 - Start of injection valve
N146 - Metering adjuster

Q6 - Glow plugs (engine)

S81 - Fuel pump fuse
S125 - Glow plug fuse
S190 - Terminal 30 voltage supply fuse

Y19 - Multifunction display with engine speed




30
30a
15
S81
10A
J17
G80
G6
M
1
34
70
109
101
J248
65
32
40
4
5
102
110
20
52
73
31
71
112
104
16
6
7
28
27
120
37
24
F36
G28
G72
G71
G62
D
D
D
Y19
J593
E190
E354
K29

MSSP_001_048

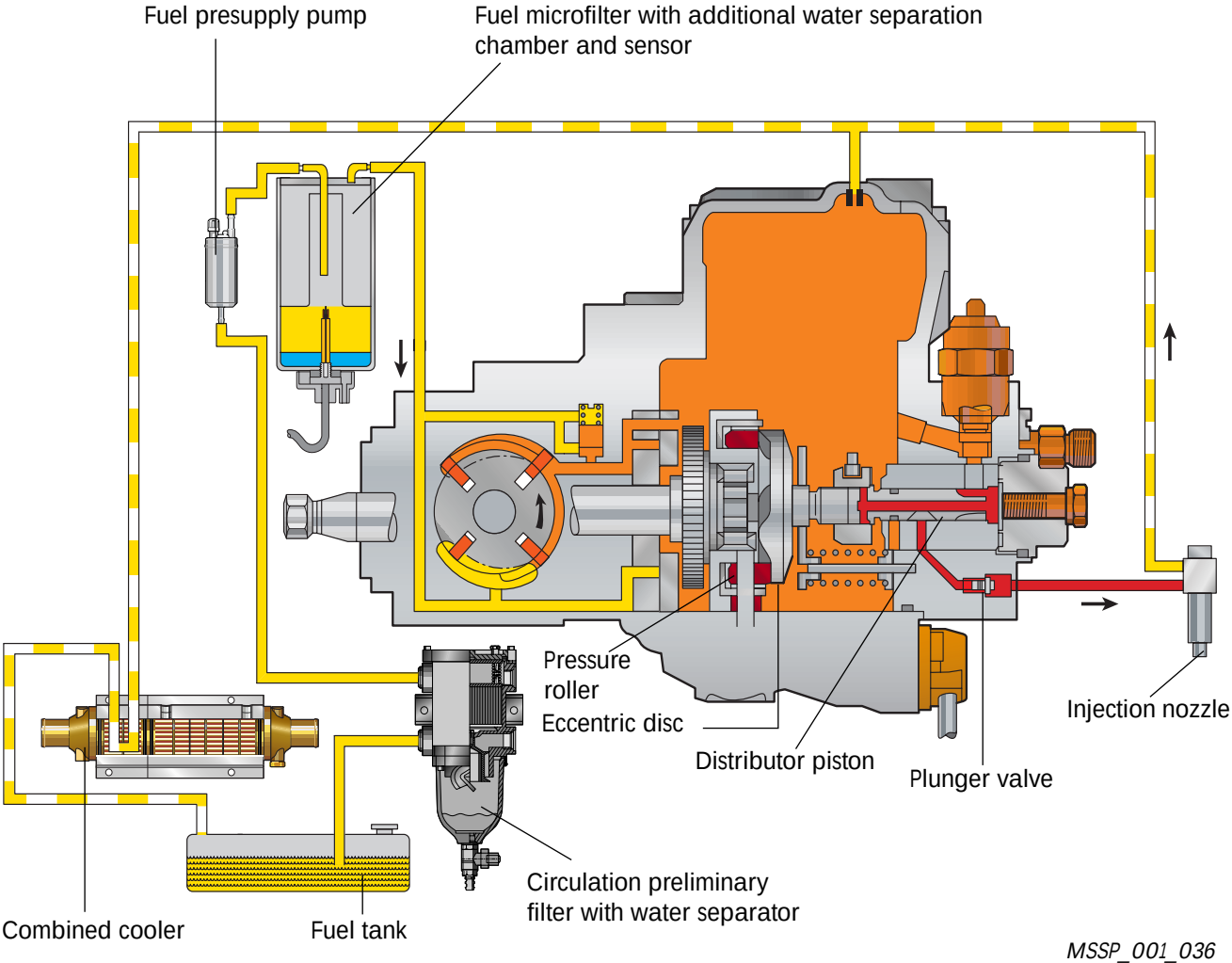
Fuel system

Fuel supply

The fuel pump sucks the fuel out of the fuel tank directly via the circulation preliminary filter. The electric presupply pump supports the fuel pump located in the injection pump housing.

The fuel presupply pump is mounted on the engine below the central electrics.
It is arranged between the circulation filter and the fuel microfilter.

The fuel return is routed via the combined cooler. In this way, the return fuel is cooled and the fuel temperature in the fuel tank kept low.

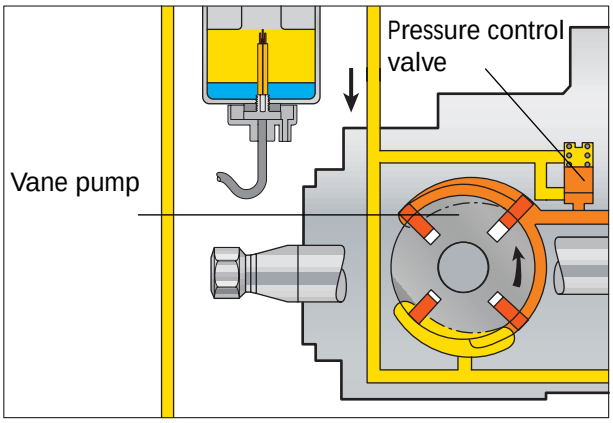


MSSP_001_036

Functional description

Fuel intake

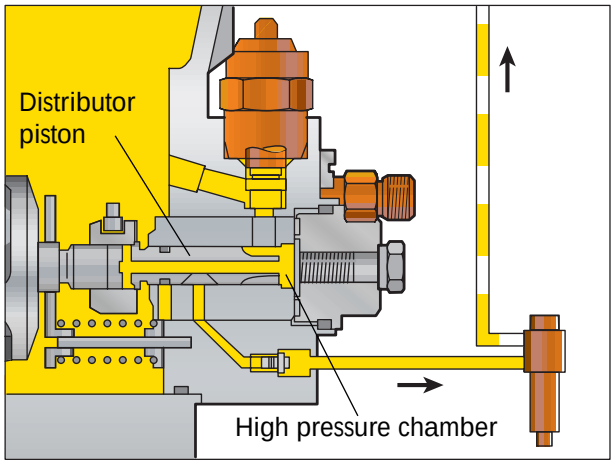
The vane pump sucks in the fuel and forces it into the pump housing. The rotor is mounted directly on the drive shaft. A pressure control valve is fitted for the purpose of maintaining the pressure increase within the permissible range as the engine speed increases.



MSSP_001_037

Filling high pressure chamber

With the aid of a claw clutch, the drive shaft of the vane pump causes the distributor piston to rotate and lift by means of an eccentric disc. The eccentric disc executes one lift movement per cylinder. During the delivery phase, the control slot opens the feed channel as the result of the rotary motion of the distributor piston and allows fuel to flow into the high pressure chamber.

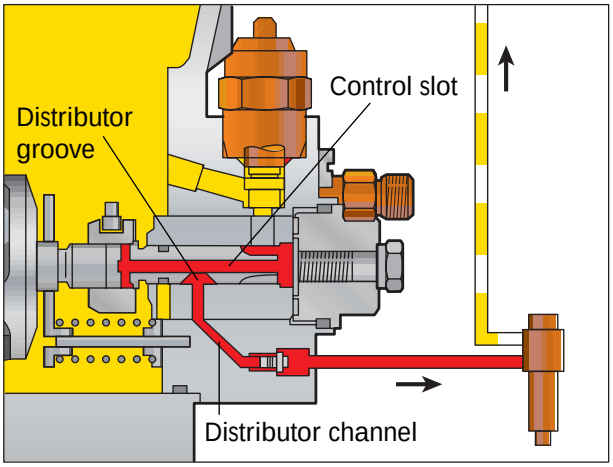


MSSP_001_038

Start of injection

The distributor piston continues to turn so that the control slot closes the feed hole.

The following list movement exerts pressure on the fuel. As the distributor piston continues to rotate, the distributor groove is aligned flush with the outlet hole. The fuel under high pressure is forced to the injection nozzle.



MSSP_001_039

Fuel system

Diesel fuel microfilter with water warning facility

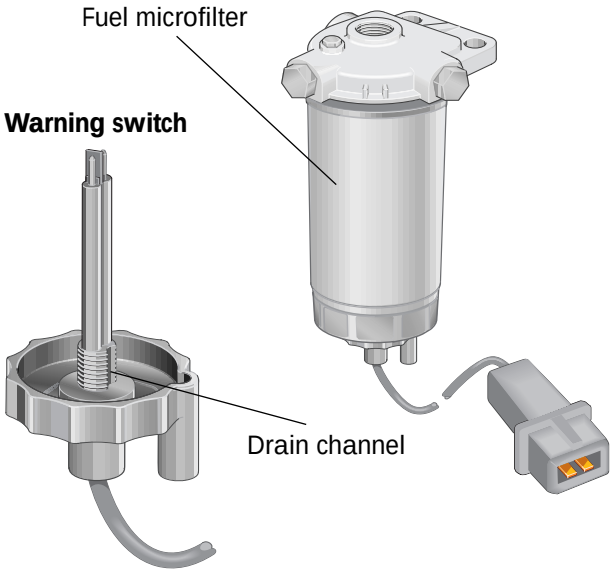
The task of the fuel microfilter is to filter out the finest impurities in the fuel.

Thoroughly filtered fuel is of great significance for ensuring reliable operation.

Condensation water or water that enters the system while refuelling must be filtered out. Owing to its higher weight, water collects in the base of the filter.

A high proportion of water in the diesel fuel poses the risk of the water entering the fuel injection system. This would lead to internal corrosion and engine failure.

For this reason, diesel fuel microfilters in Volkswagen Marine boat engines feature a water warning facility. It informs the skipper of high water level in the fuel microfilter before it can place operational reliability at risk.

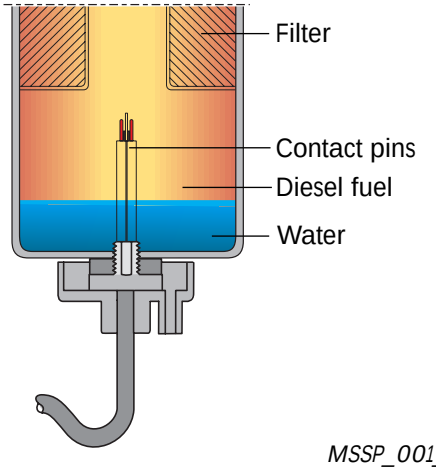


MSSP_001_040

Functional description

Water level safe

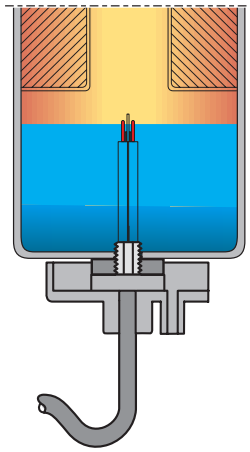
The engine control unit sends a voltage to the contact pins of the warning switch located in the fuel microfilter. Only a low current flows if the contact pins are surrounded by diesel fuel.



MSSP_001_041

Water level dangerous

If the water level rises up to the contact pins, a higher current flows due to the better conductivity of the water. The engine control unit detects the higher current flow and by way of the indicator lamp in the control panel signals the high water level to the skipper.

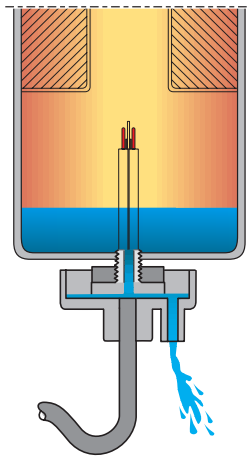


MSSP_001_042

Drain fuel microfilter

A drainage facility is located on the underside of the fuel microfilter.

Water drain valve



MSSP_001_043

Please refer to the Owner's Handbook or the current Workshop Manual for the exact description of the water drainage procedure.

Fuel system

Circulation preliminary filter with water separator (optional)

The circulation water separator is installed between the fuel tank and fuel presupply pump. The exact installation location depends on the type of boat.

Functional description

The fuel flows through the inlet opening and an internal system of guide vanes. An intensive rotary motion is induced which forces the fuel into the bowl section.

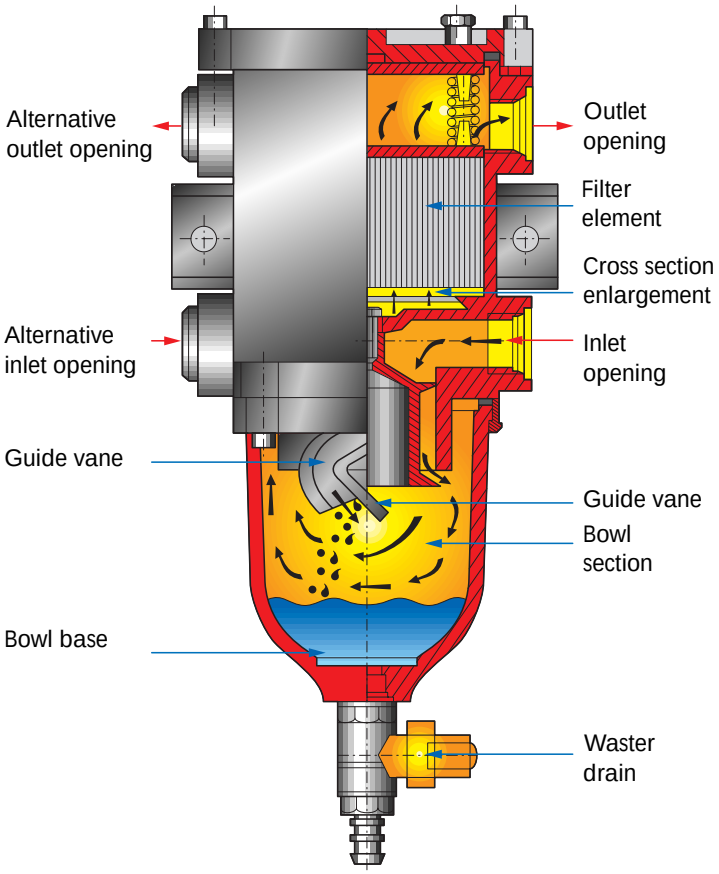
Water droplets and heavy particles are expelled by the centrifugal force, they collect on the bowl walls and finally settle on the base of the bowl.

During the further course of the filter process, the fuel must pass through the guide vane system positioned on the outer housing.

Due to the different lengths of the deflection vanes and the double change in direction of flow, smaller water droplets and fine particles are expelled and also collect on the base of the bowl.

The considerable increase in cross section below the filter element causes the fuel to settle while the finest water droplets and particles are expelled.

The remaining particles and water are subsequently filtered out by a replaceable filter element.



MSSP_001_044

Please refer to the Owner's Handbook or the current Workshop Manual for instructions on the maintenance and water draining procedure.

Notes

Emission characteristics

Emission characteristics

The lowest possible level of environmental pollution renders necessary sophisticated design as well as extensive matching and tuning work.

In doing so, it is often necessary to consolidate conflicting requirements such as low pollutant emission and high engine power output.

All Volkswagen Marine boat engines comply with the Bodensee Schifffahrtsverordnung Stufe 2 (Lake Constance Shipping Ordinance, Stage 2) (BSO II).

Pollutants in exhaust gas

The following exhaust gasses mainly occur in the exhaust emissions of diesel engines:

- **Carbon monoxide (CO)**
  Carbon monoxide is produced by combusting fuels containing carbon. It is odourless and colourless, explosive and highly toxic. Carbon monoxide inhibits erythrocytes (red blood corpuscles) from transporting oxygen and is lethal even in small concentrations in breathing air. In the open it oxidizes to form carbon dioxide within a short space of time. Carbon dioxide is a constituent part of air.
- **Gaseous hydrocarbons (HC)**
  They occur in the exhaust gas following incomplete combustion. Hydrocarbons irritate the sense organs and, depending on the type, can also cause cancer.
- **Soot particles**
  Soot particles are produced by the combustion process in a diesel engine. The effects on the human body are currently not fully clarified.
- **Nitrogen oxide (NOx)**
  Nitrogen oxide is produced by high pressure, high temperature and surplus oxygen during combustion.

Reducing pollutants

Measures designed to reduce soot particles and the formation of HC increase the percentage of nitrogen oxides. Attempts to reduce the nitrogen emission increase the proportion of other exhaust gas constituents.

In Volkswagen Marine boat engines, the lowest possible exhaust emission has been achieved by specific design of the combustion chamber and of the piston recess as well as the matching and coordination of the injection nozzles.

Electronically controlled and monitored engine management and variable start of injection control further ensure optimum combustion and low exhaust emissions.

MSSP_001_075

Exhaust turbocharging

Fundamental principle of exhaust turbocharging

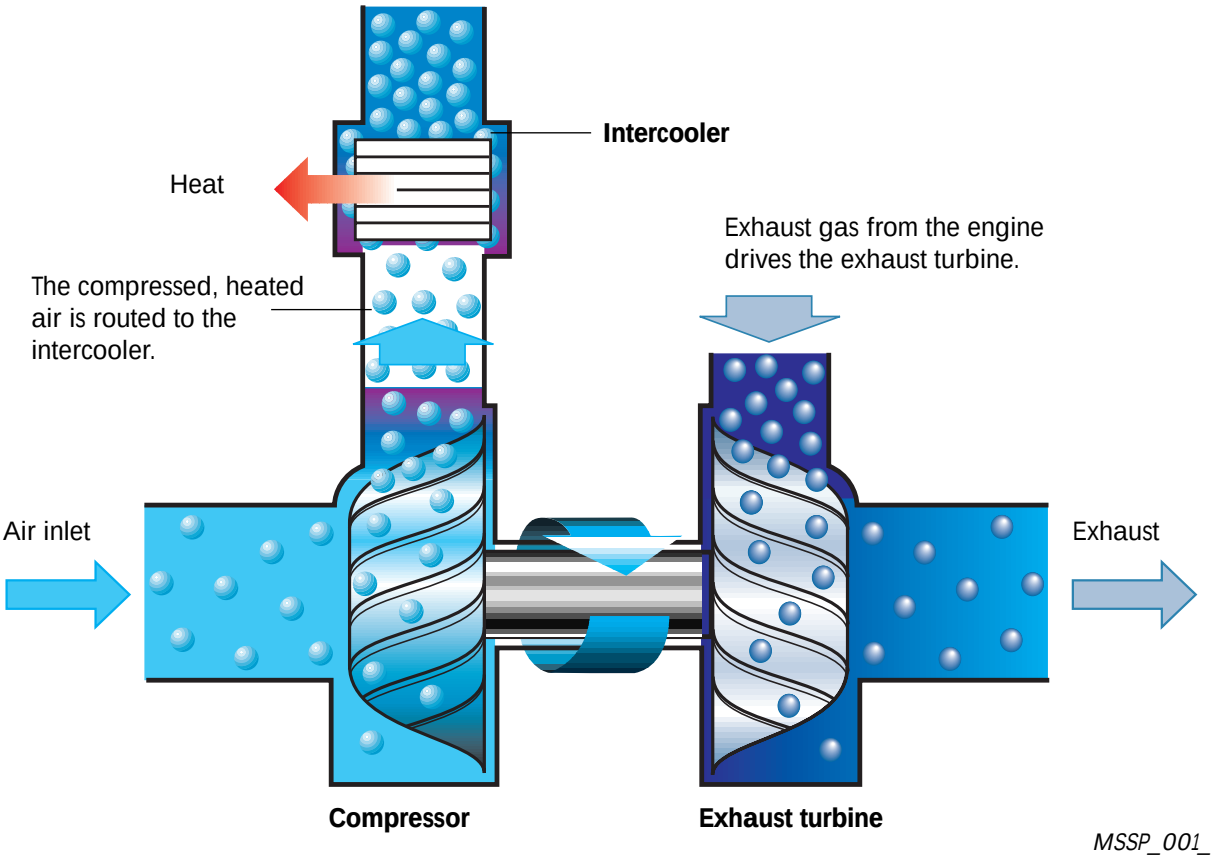
The aims of supercharging by means of a turbocharger are:

- Higher torque and
- Increased engine output

By compressing the intake air, more air and thus increased levels of oxygen enter the combustion chamber with each intake stroke. The higher share of oxygen enables improved combustion. The power output is increased.

The movement and pressure energy contained in the exhaust gas is used to drive the turbine wheel of the turbocharger that is connected via a shaft to the compressor wheel.

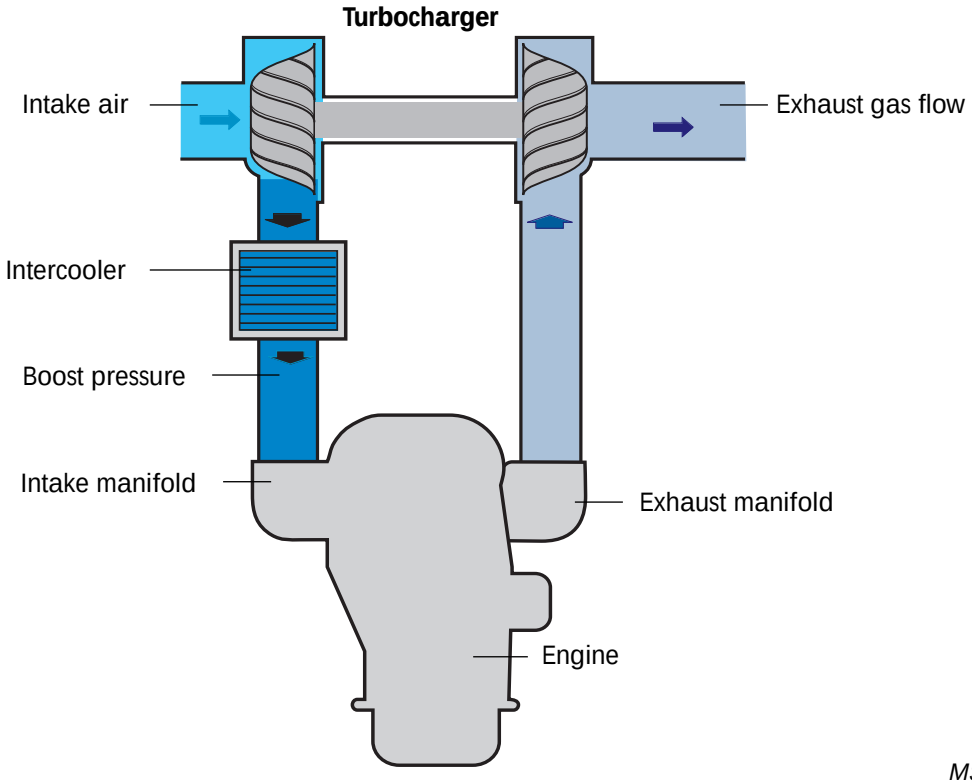
The compressor wheel compresses the air and forces it into the combustion chamber. Since the air temperature increases during compression and the density thus decreases, the engine output can be further increased by cooling the air in an intercooler. The air density increases again.



MSSP_001_051

There are two specific problems involved in the use of a conventional turbocharger.

- The energy of the exhaust gas is too low in the lower engine speed range. The turbine wheel does not reach the rotary speed necessary to sufficiently compress the air.
- The exhaust gas energy is very high in the upper engine speed range. The speed of the turbine wheel is therefore higher than necessary. The air is compressed too much.



MSSP_001_052

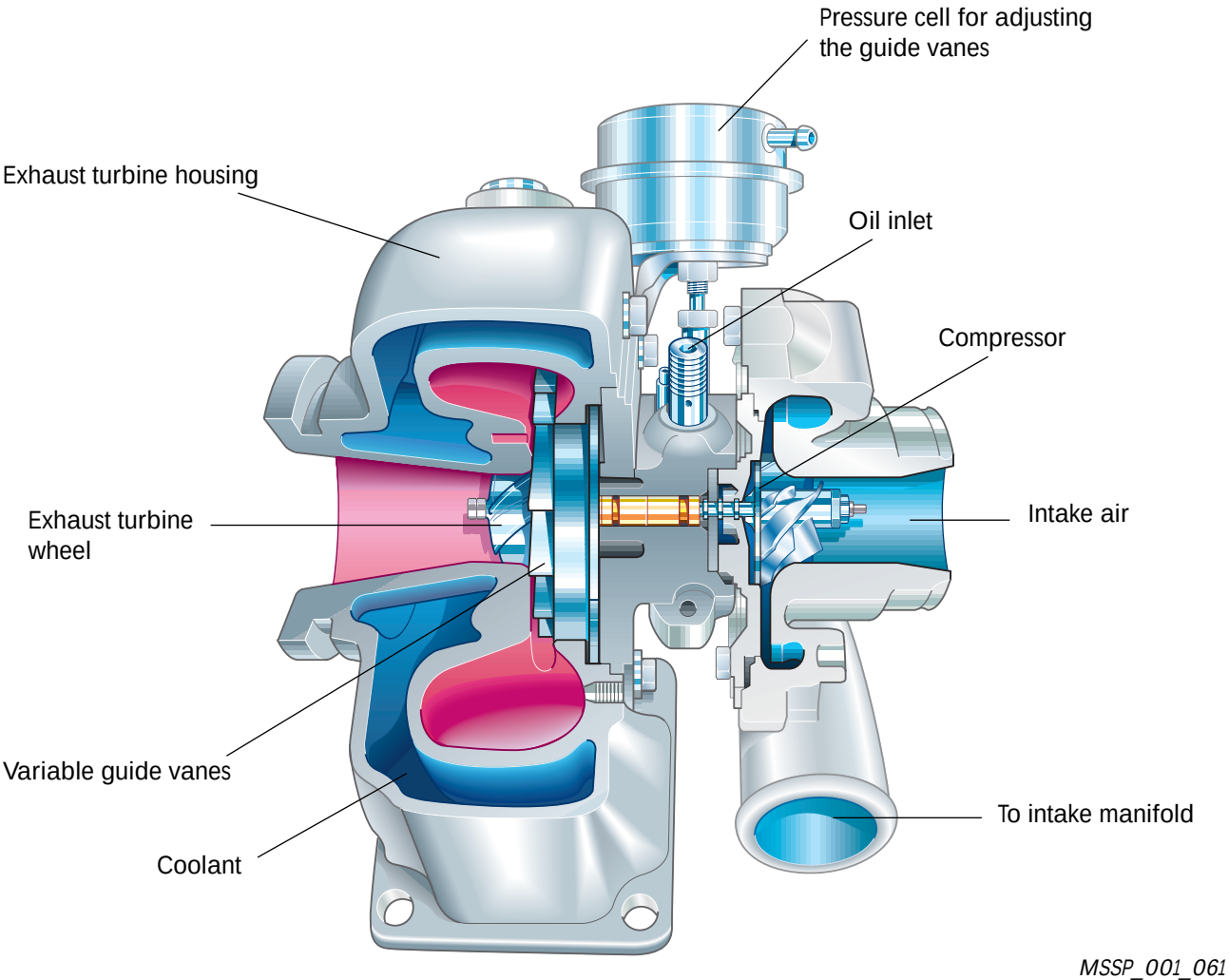
Exhaust turbocharging

Turbocharger with variable turbine geometry

The turbocharger installed in Volkswagen Marine boat engines operates with variable guide vanes.

Advantage

- By correspondingly influencing the exhaust flow, the optimum boost pressure is made available virtually over the entire engine speed range. This ensures improved combustion and lower exhaust emission values as well as high propelling power over the entire engine speed range.



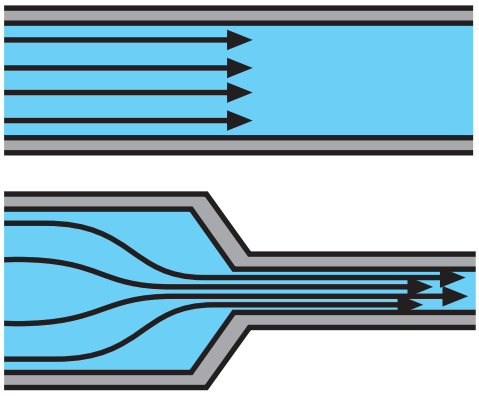
MSSP_001_061

Functional description

Fundamental principle

A gas flows through a narrow pipe faster than through a pipe without a constriction. The prerequisite is that the same pressure is applied in both pipes.

This physical principle is utilized by the turbocharger with variable turbine geometry for the purpose of achieving a constant boost pressure in virtually all engine speed ranges.

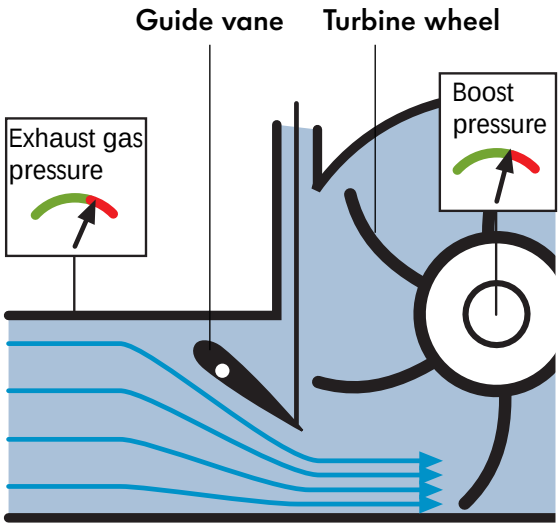


MSSP_001_053

Low engine speed

The volume and speed of the exhaust gas are low. The cross section of the exhaust pipe is constricted before the turbine wheel by the guide vanes. The narrowed cross section forces the exhaust gas to flow faster thus increasing the speed of the turbine wheel.

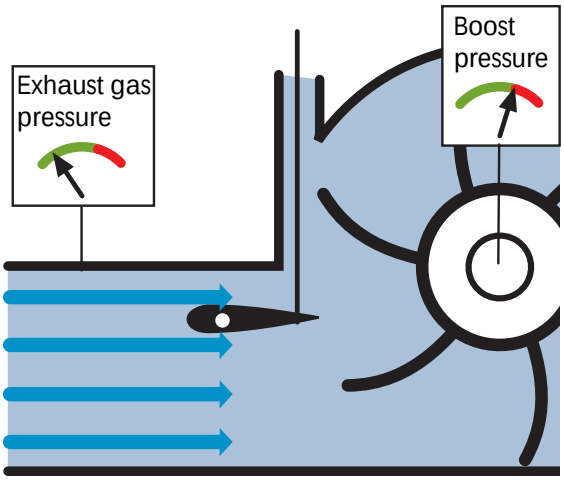
The high rotary speed of the turbine guarantees optimum boost pressure also at low engine speed.



MSSP_001_054

High engine speed

The exhaust volume and speed are high. The guide vanes enable a larger cross section. The maximum boost pressure is not exceeded.



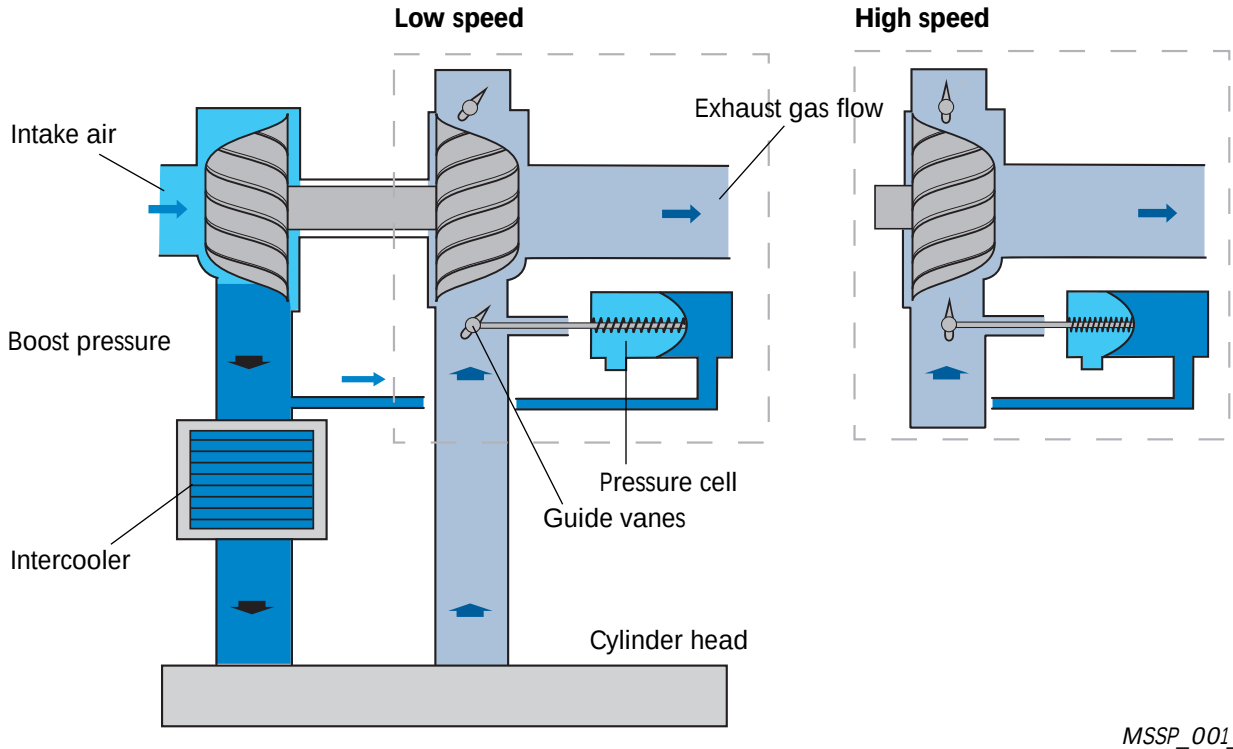
MSSP_001_055

Exhaust gas turbocharing

Control of variable guide vanes

The pressure cell is connected via a hose line to the intake pipe. The pressure in the pressure cell changes depending on the intake manifold pressure.

Turbocharger with variable guide vanes



MSSP_001_057

At **low intake manifold pressure,** the diaphragm of the pressure cell is pushed back by the force of the spring. The guide vanes are set to a small inlet cross section.

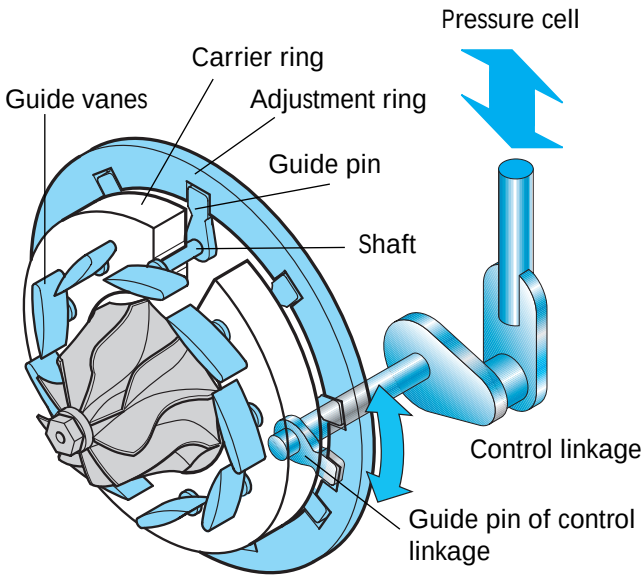
At **high intake manifold pressure,** the pressure acting on the diaphragm in the pressure cell increases.
The guide vanes are set to a large inlet cross section.

This control always makes available the boost pressure necessary for ensuring optimum power output.

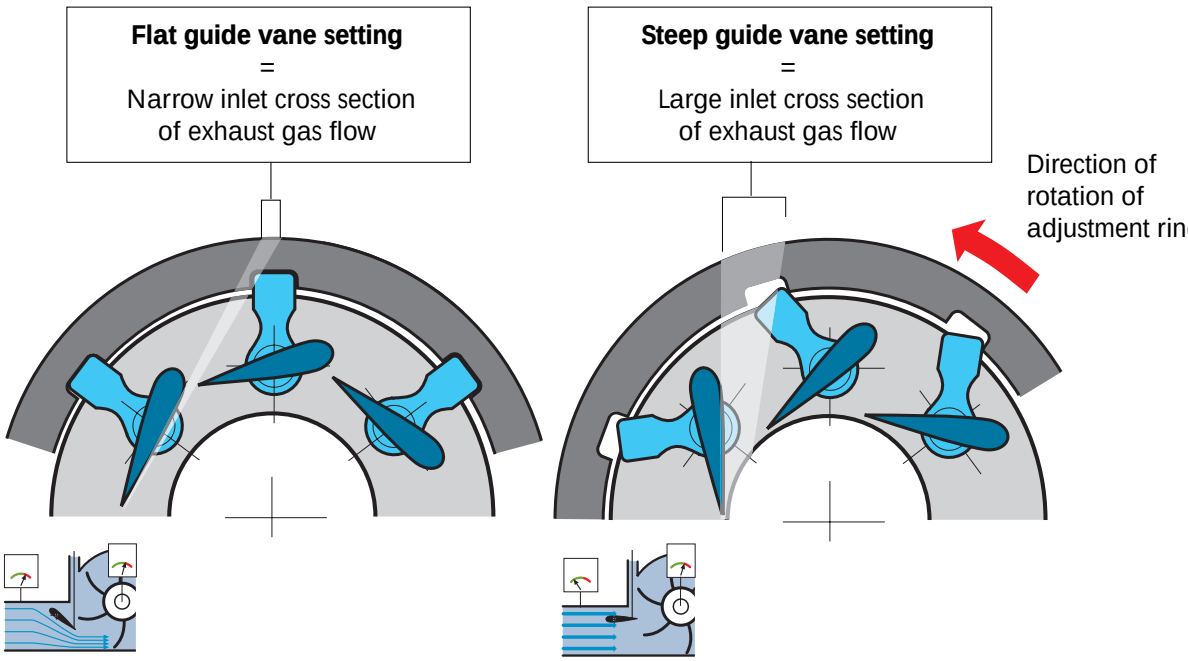
Guide vane adjustment

The guide vanes together with their shafts are mounted on the carrier ring. The guide vanes are connected by means of a shaft to the guide pin. This guide pin engages in the adjustment ring such that all guide vanes are adjusted simultaneously as the adjustment ring rotates.

The adjustment ring is turned by the vacuum cell in connection with the control linkage.



MSSP_001_049



MSSP_001_074

In connection with the acceleration in the flow of the exhaust gas, the constricted inlet cross section results in a higher turbine speed.

The flow rate of the exhaust gas increases as the engine speed increases. The inlet cross section becomes larger so that the boost pressure and turbine output remain constant over a wide speed range.

Cooling system

Introduction to cooling system

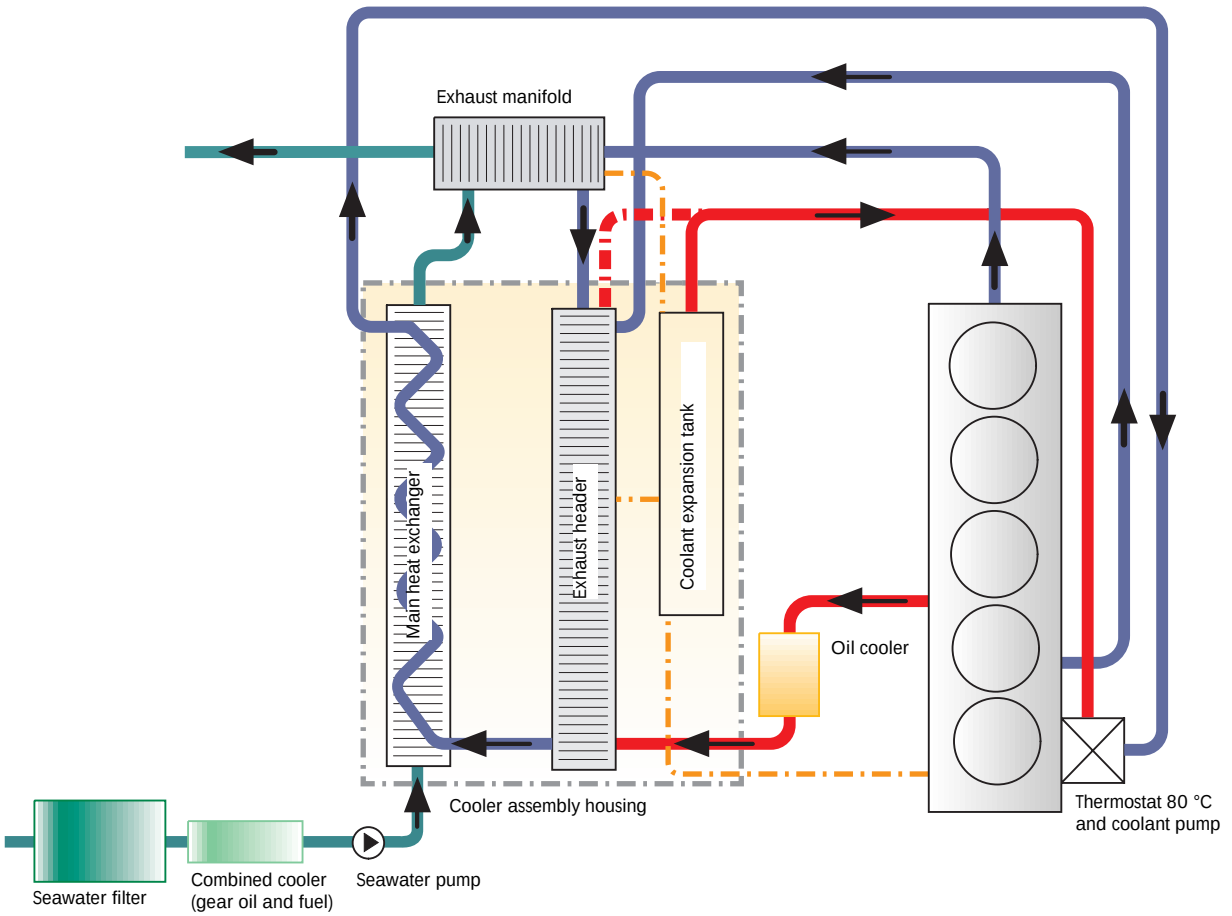
While in a road vehicle the engine heat is given off via the cooling water to the air drawn in on the airstrain, the engine heat in a boat is transferred to the seawater.

In order to keep the engine clear of aggressive media such as saltwater, the Volkswagen Marine boat engines feature a dual-circuit cooling system.
In the same way as in passenger vehicles, the coolant in the primary circuit is made up of antifreeze, corrosion inhibitor and water and is designed as a closed circuit. The heat is transferred in a heat exchanger through which seawater flows.
The seawater circuit (secondary circuit) is an open circuit in which the seawater is drawn in and after having flowed through the heat exchangers, it is expelled again.

The coolant circuit consists of

- Small coolant circuit (primary) – red closed freshwater circuit
- Large coolant circuit (primary) – blue closed freshwater circuit
- Seawater circuit (secondary) – green

Overview of cooling circuit for SDI engines



MSSP_001_058

Seawater circuit

Drawn in by the seawater pump, the seawater enters the system via the boat's hull. The seawater filter filters the impurities out of the incoming seawater.

The downstream combined cooler is a two-piece assembly. It cools the fuel flowing back to the fuel tank. On boats with power-assisted steering, the other part cools the hydraulic oil in the steering system as well as the gearbox oil on boats with a reversing gearbox.

In the heat exchanger, the seawater absorbs the heat of the coolant circuit and thus cools the engine. The seawater outlet takes place in the exhaust gas flow through the exhaust manifold (wet exhaust).

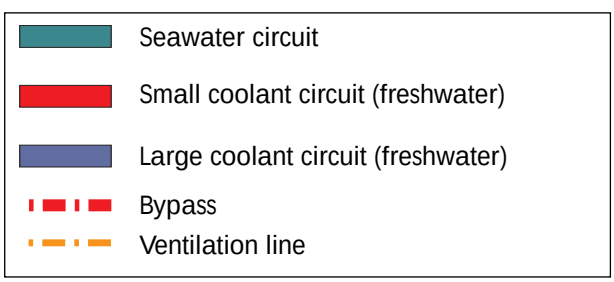
Provided the engine is running, the seawater always flows through the main heat exchanger and the exhaust manifold.

Small coolant circuit

Driven by the coolant pump during the warm-up phase, the coolant circuit passes through the engine block, oil cooler, exhaust header and via the bypass back to the coolant pump. This ensures the engine quickly reaches its operating temperature.

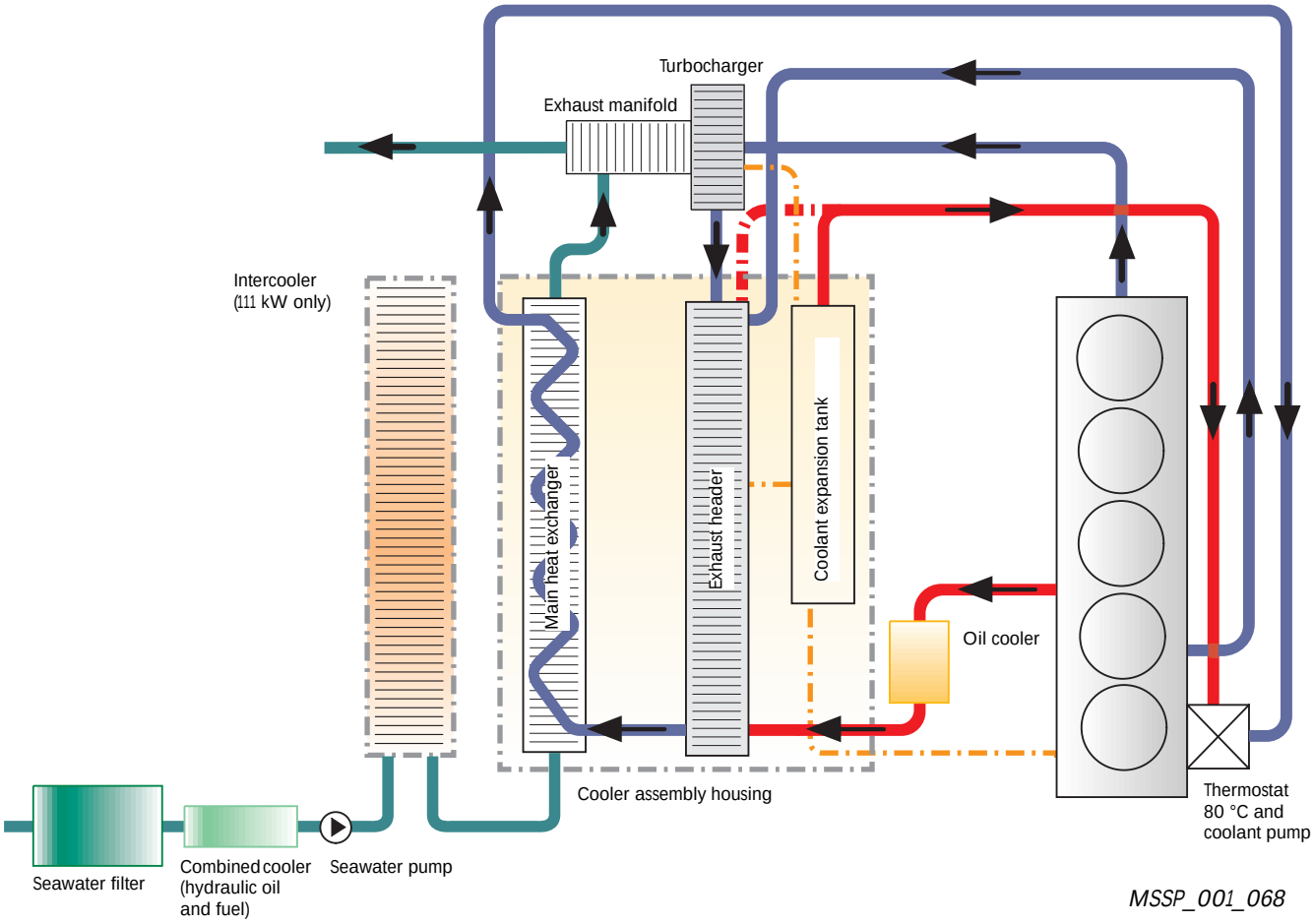
Large coolant circuit

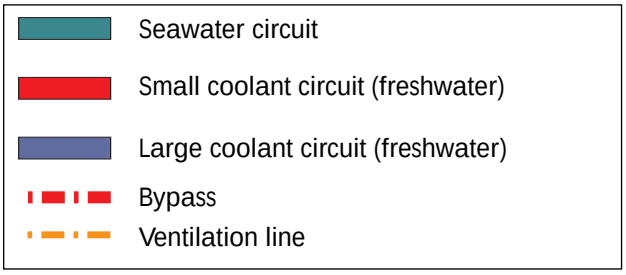
Once the engine has reached its operating temperature, the thermostat opens the "large coolant circuit". The coolant now additionally flows through the main heat exchanger where it gives off the heat to the seawater.



Cooling system

Overview of cooling circuit for TDI engines





Seawater circuit

Apart from the following changes, the seawater circuit of the TDI engines is the same as that of the SDI engines.

Changes

On the TDI 150-5/150-5D, 108 kW and 111 kW TDI engines, the intercooler is located between the seawater pump and the main heat exchanger. In order to increase the air density, the compressed charge air from the turbocharger is cooled by the seawater.

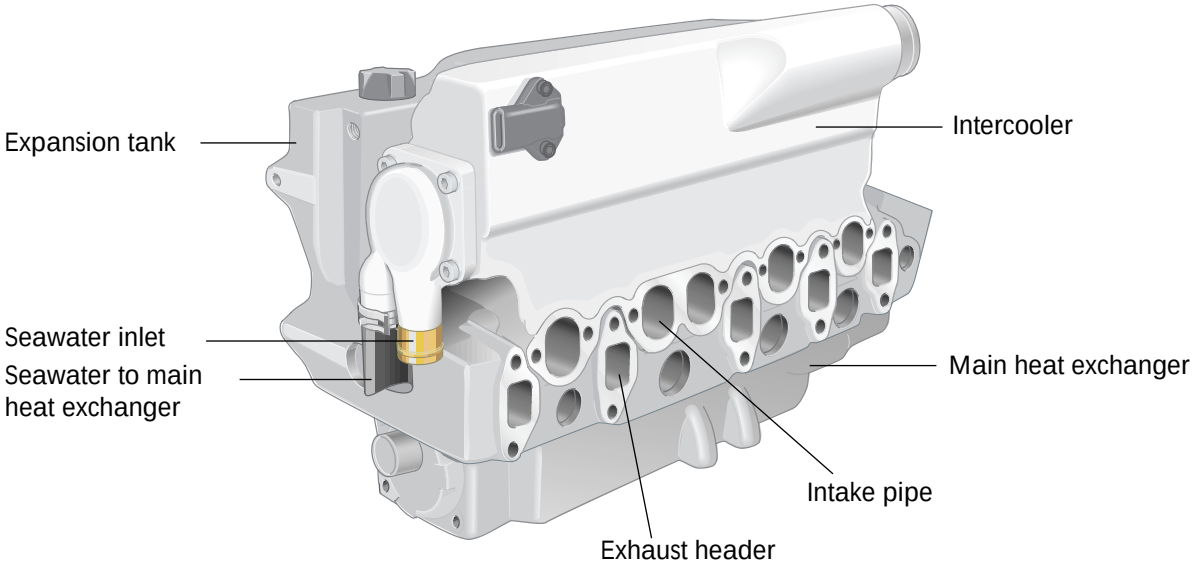
The TDI 120-5, 88 kW engines as well as the TDI 100-5, 74 kW engines are not equipped with an intercooler.

Large coolant circuit

High temperatures occur at the turbocharger during engine operation. For this reason, the "large coolant circuit" cools the turbocharger instead of the exhaust manifold as on the SDI.

Cooling system

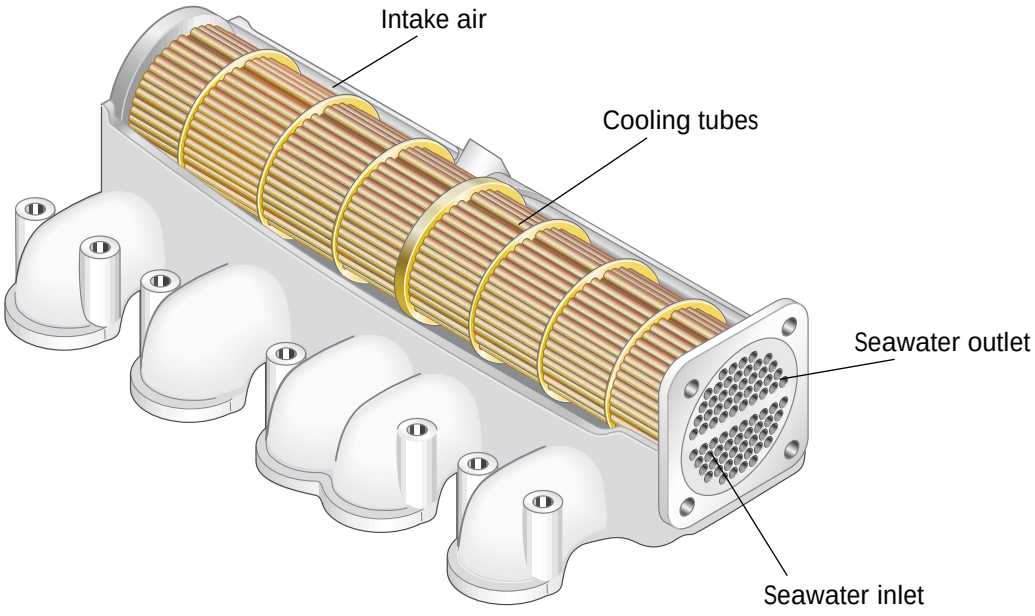
Design of cooler assembly



MSSP_001_100

Intercooler (TDI 150-5/150-5D only)

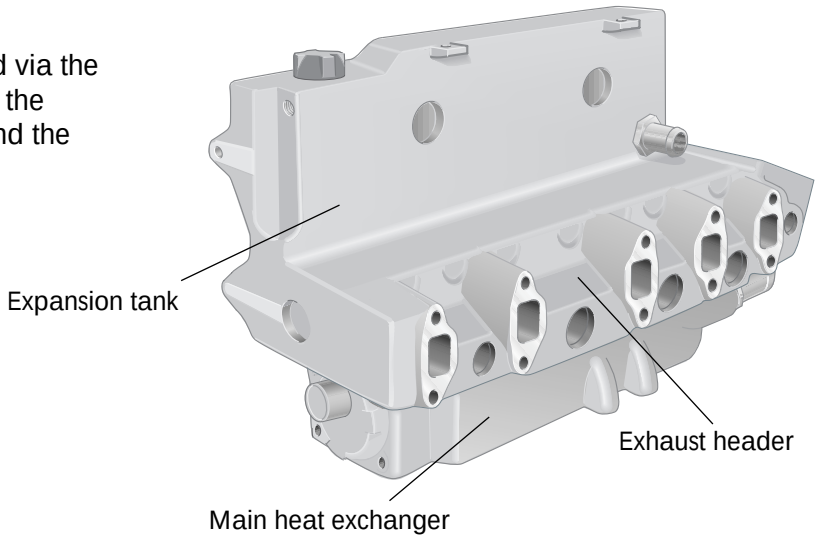
The intercooler consists of the cooling pipe assembly and the housing. The seawater pump pumps the seawater through the intercooler, thus cooling the air compressed by the turbocharger. The air density increases.



MSSP_001_072

Main heat exchanger

The heat from the engine is transferred via the coolant in the main heat exchanger to the seawater. The main heat exchanger and the expansion tank form one unit.



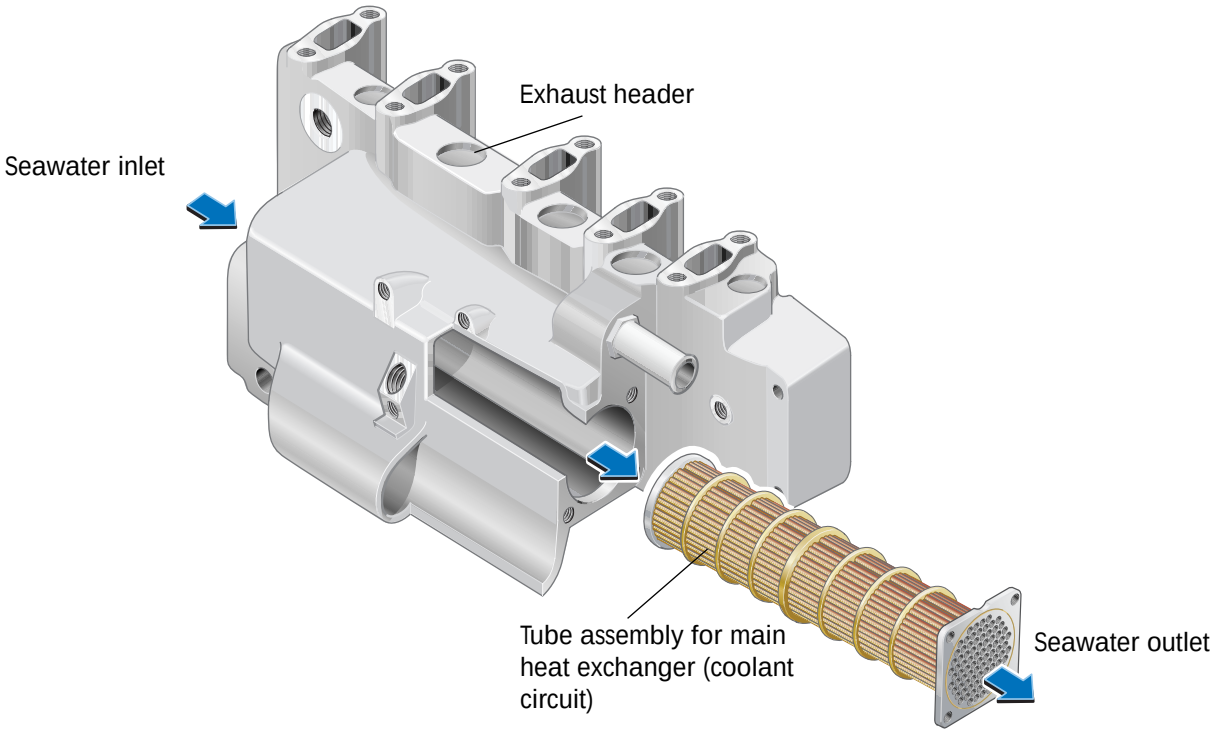
MSSP_001_105

Exhaust header

Exhaust gas temperatures of a diesel engine can reach up to 800°C.

In order to keep the surface temperature at a low level, the exhaust header in Volkswagen Marine boat engines is cooled by the coolant circuit.

The dissipated heat is then transferred in the main heat exchanger to the seawater.

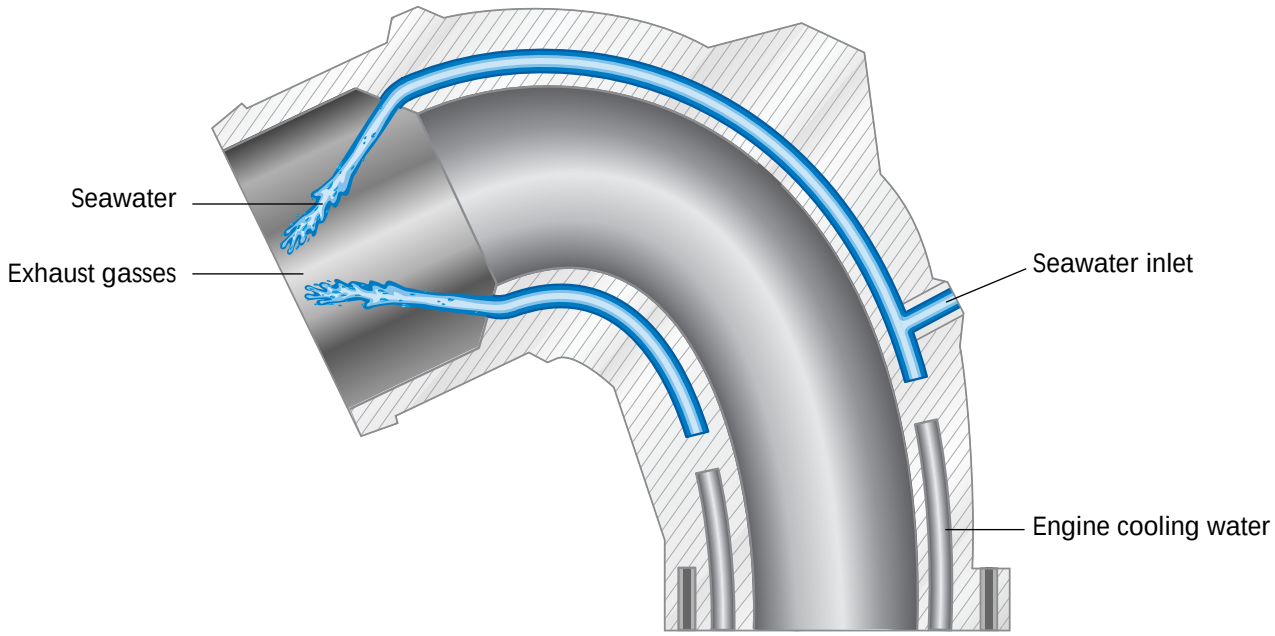


MSSP_001_099

Cooling system

Exhaust manifold

In the exhaust manifold, the seawater required for cooling is fed to the exhaust gas and routed via the exhaust system out of the boat (wet exhaust).

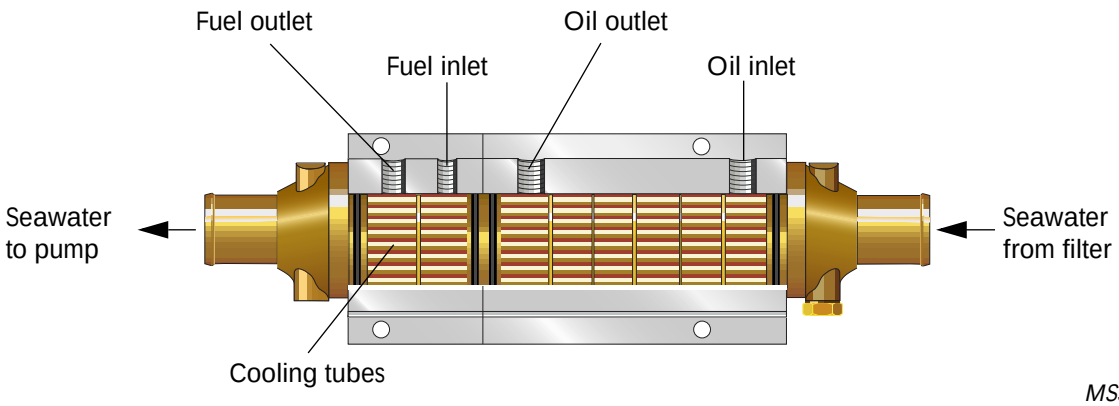


MSSP_001_102

Combined cooler

The combined cooler is located below the central electrics on the engine on the side of the oil pan.

Due to its split design, it cools the fuel flowing back to the fuel tank and, depending on the boat's equipment, the hydraulic oil of the power-assisted steering or the gear oil of the reversing gearbox.



MSSP_001_069

Seawater pump

The seawater pump is driven by a ribbed V-belt. The star-shaped impeller pumps the seawater into the seawater circuit.

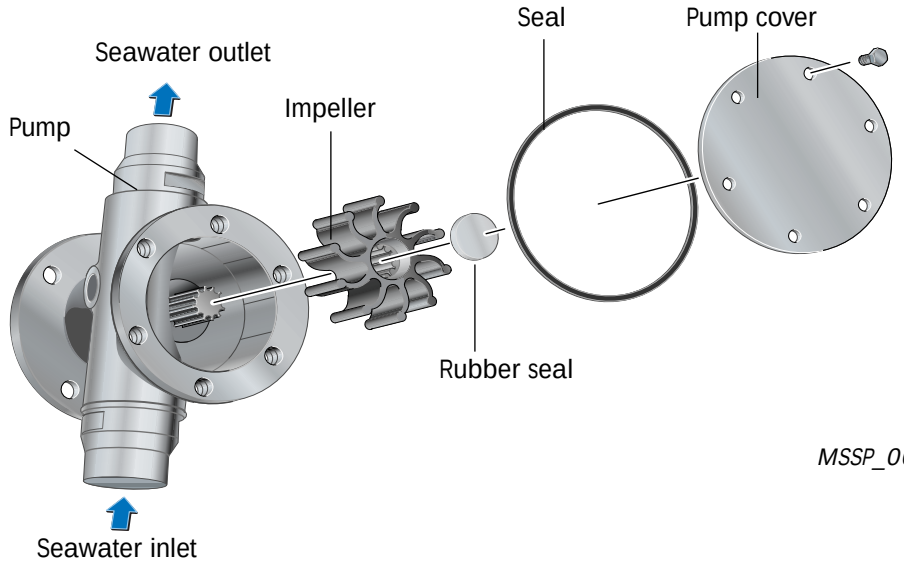
Quick-release coupling of seawater hoses

The design of the hose couplings ensures easy assembly and disassembly.

The retaining springs on the connection pieces need only be unclipped in order to disconnect the seawater hoses from the pump.

The springs lock in again automatically when reconnecting the hoses.

The pump is made up of the following components:



MSSP_001_060

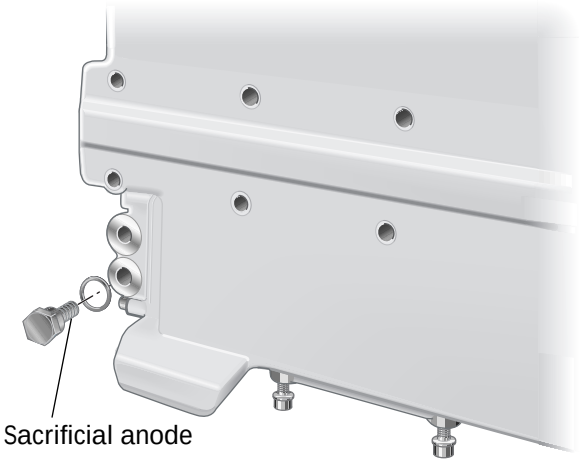
The rubber impeller of the seawater pump should be inspected at the end of the season and replaced as required.
Please refer to the Owner's Handbook and the current Workshop Manual.

Cooling system

Sacrificial anode

Due to the incoming seawater, disintegration in accordance with electrochemical series can occur on the materials with which the seawater comes in contact.

To ensure no engine component is affected, a reactive or sacrificial anode is located in the main heat exchanger. It disintegrates (sacrifices) itself, thus protecting the other components.



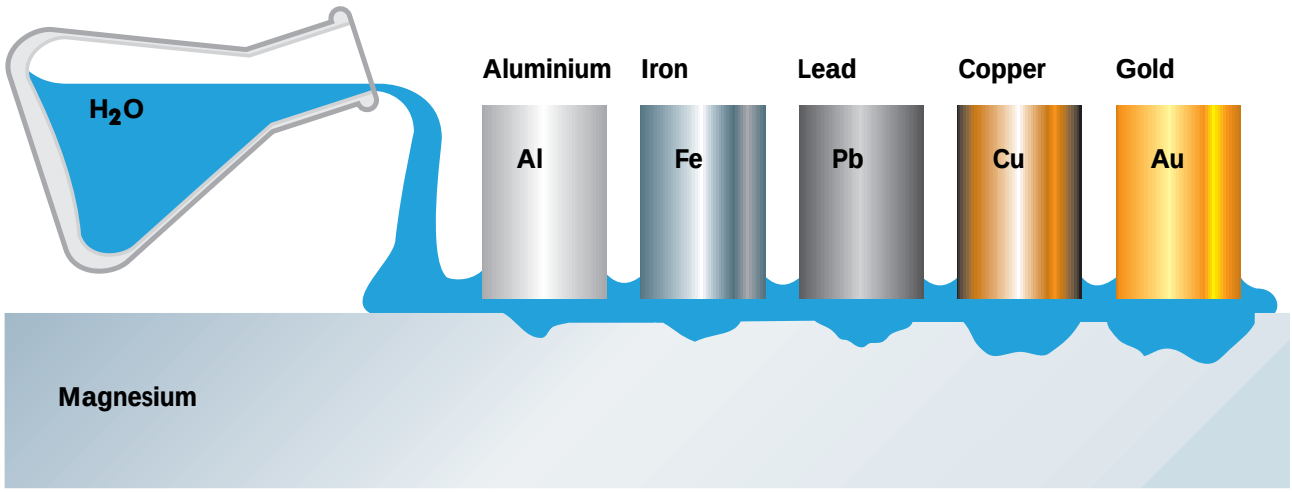
MSSP_001_070

Electrochemical series

Charge carrier exchange occurs between different metals in the presence of water. As the result of this exchange, the lower grade of both metals disintegrates.

The electrochemical series is obtained by arranging the metals in a series from the lower grade to the higher grade metal.

The further the metals are apart in the series the higher the charge carrier exchange and thus the disintegration.



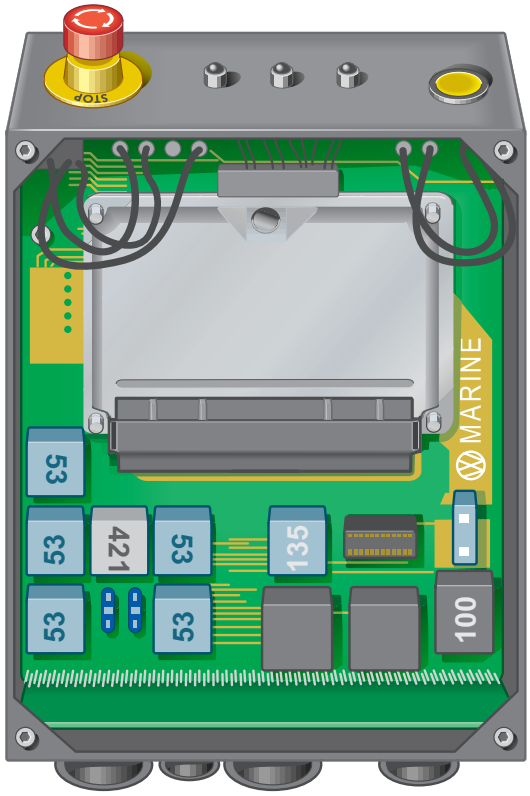
MSSP_001_071

Please refer to the Owner's Handbook or the current Workshop Manual for instructions on how to replace the sacrificial anode.

Central electrics unit

The central electrics unit based on pc-board design is located on the engine. It accommodates the engine control unit, relays, diode group, fuses for the glow plugs and the fuse for the fuel pump as well as the MDC main fuse.

Two electrical terminals connect the unit to the engine. In addition, there is also an oil and water resistant connecting cable leading to the control panel.

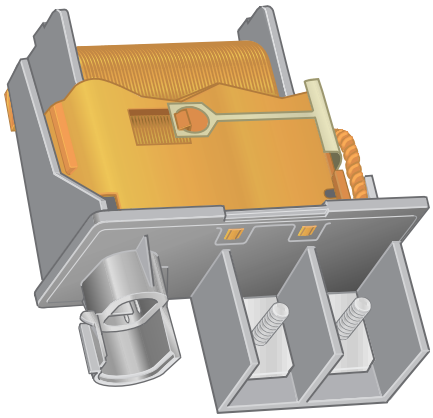


MSSP_001_050

Earth cutout relay

The engine is earth-free in order to protect the drive train from galvanic corrosion.

The earth cutout relay closes when the engine is started. The engine is thus temporarily connected to earth for the purpose of powering the starter.



MSSP_001_101

Multifunction display

The rev counter in the control panel is equipped with a multifunction display.

MSSP_001_077

It contains the following information:

- **Operating hours**
- **Gearbox in neutral position**
- **Distance**
  It can be displayed in
  - Kilometres (km)
  - Nautical miles (nm)
  - Miles (m)

- **Fuel consumption**
  Can be displayed in
  - Litres (l)
  - Gallons (g)

- **Current fuel consumption/average**
  It can be displayed in
  - l/km
  - l/nm
  - l/m
  - g/km
  - g/nm
  - g/m

- **Range**
  It can be displayed in
  - Kilometres (km/l)
  - Nautical miles (nm/l)
  - Miles (m/l)

- **Speed**
  It can be displayed in
  - Kilometres per hour (km/h)
  - Knots (kn)
  - Miles per hour (mph)

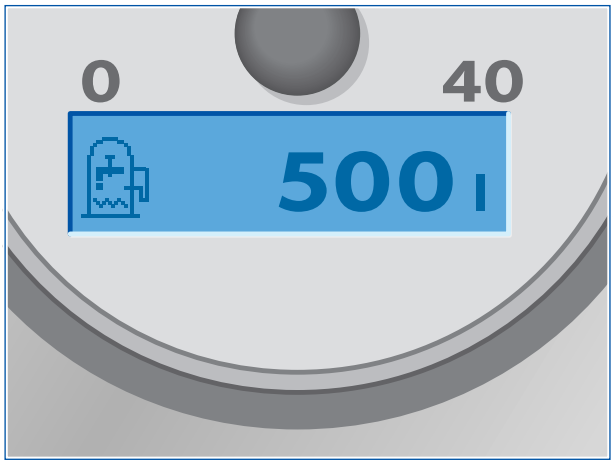
Memory

The multifunction display is also equipped with an automatic memory.
It stores information relating to:

- Operating hours
- Distance covered
- Amount of fuel consumed
- Fuel consumption
- Range
- Speed

The memory collects the data of any number of individual journeys up to

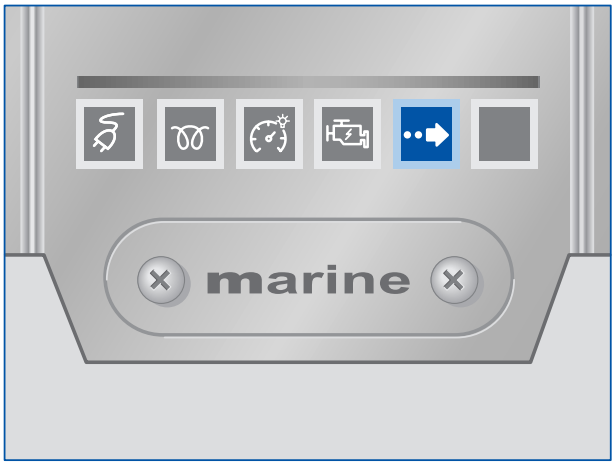
- 9999 operating hours
- 9999 nautical miles
- 9999 litres fuel consumed



MSSP_001_079

The individual functions can be selected via the control switch.

All memory data are deleted (except for total operating hours) when the control switch is pressed for longer than 5 seconds or when the battery is disconnected.

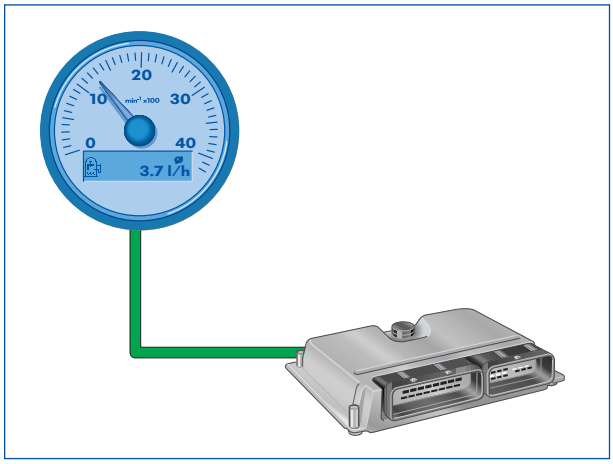


MSSP_001_078

Displays / indicators

Rev counter

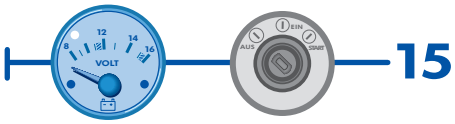
The rev counter provides information on the current engine speed. It receives the engine speed signal from the engine control unit.



MSSP_001_080

Voltmeter

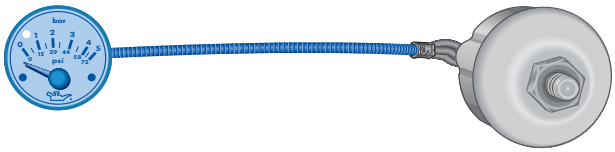
The voltmeter provides information on the current system voltage. The information is provided by terminal 15 at the ignition starter switch.



MSSP_001_081

Oil pressure gauge

It provides information on the current engine oil pressure. The information comes from the oil pressure sensor on the engine. The engine oil pressure should be between 1 bar and 5 bar. If the oil pressure drops below 1 bar, the oil pressure warning lamp comes on and an acoustic warning signal sounds. The engine should be shut off in order to avoid engine damage.



MSSP_001_082

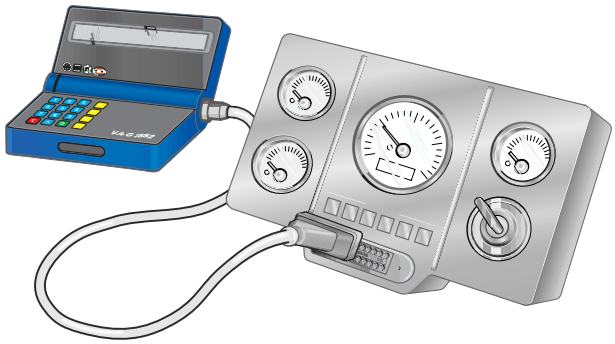
Diagnosis

The engine control unit features a system diagnosis function. Malfunctions that occur during operation are stored in the fault code memory and can then be read out with the Volkswagen diagnosis system tester V.A.G 1552.

Diagnosis with the fault readout unit V.A.G 1551 and the diagnosis system tester VAS 5051 is also possible.

It will also be possible to read out the data with the diagnosis system VAS 5052 that will be introduced at a later point in time.

The diagnosis interface is located behind the cover with the lettering "Marine" on the control panel. Another diagnosis connector is located in the central electrics unit.



MSSP_001_083

After connecting the diagnosis system tester to the diagnosis interface, "fast data transmission" ensures the system diagnosis function is used optimally.

V.A.G SELF-DIAGNOSIS	HELP
1. – Fast data transmission*	
2. – Flash code output*	

The diagnostic connection to the engine control unit is established by entering the "address word 01".

The system diagnosis contains the following functions:

- Function 01 – Check control unit version
- Function 02 – Check fault code memory
- Function 03 – Actuator diagnosis
- Function 04 – Basic setting
- Function 05 – Delete fault code memory
- Function 06 – End output
- Function 07 – Not used
- Function 08 – Read measured value block

Self-diagnosis

Function 01 – Check control unit version

The control unit identification is shown on the display.

Fast data transmission	HELP
Select function XX	

Function 02 – Check fault code memory

This function serves to check the entries in the fault code memory.

After pressing the buttons 0 and 2, the number of stored fault codes is shown on the display. The stored fault codes are displayed in succession by pressing the → button.

The faults are output in text form and with a fault ID code. You will find detailed information on the fault codes under fault identification in the Workshop Manual for the engine control.

Function 03 – Actuator diagnosis

This functions serves to check the actuators.

After pressing the buttons 0 and 3 the actuators are activated in a defined sequence.

Please refer to the current Workshop Manual for the exact description of the function check procedure of the actuators and the activation sequence.

Function 04 – Basic setting

The basic setting of the distributor-type injection pump is initiated with the function 04.

Please refer to the current Workshop manual for a detailed description of the basic setting function.

Function 05 – Delete fault code memory

The fault code memory can be deleted by pressing the buttons 0 and 5.

It is only possible to delete the fault code memory if it was checked beforehand.

Function 06 – End output

Communication with the engine control unit is ended by pressing the buttons 0 and 6.

Ending communication by disconnecting the diagnosis interface can cause temporary malfunctions in the engine control unit and is therefore not permitted.

Function 07 – Not used

Function 08 – Read measured value block

The engine operating data, e.g. current engine temperature, can be read out with the diagnosis system tester after pressing the button 0 and 8 and then entering a display group number.

The engine operating data are provided in display groups. Refer to the Workshop Manual for the list of display group numbers and the values shown on the display.

Self-diagnosis

Examples of fault code memory entries

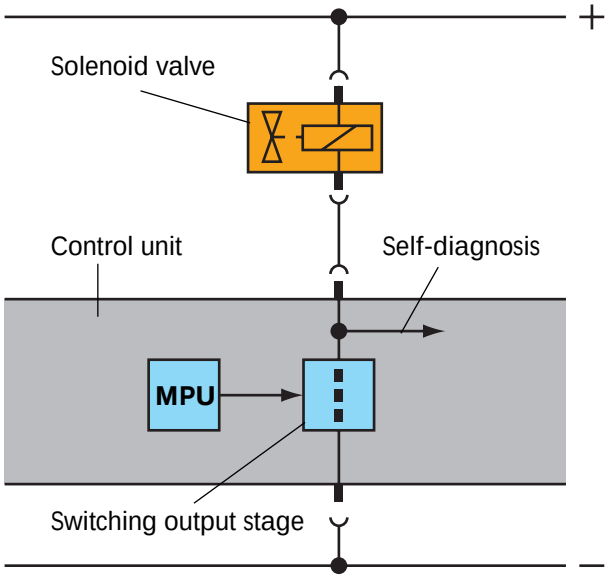
Solenoid valve controlled on negative side

Fault display in fault code memory:

No fault detected

Functional description

Depending on the activation of the solenoid valve by the computer, the self-diagnosis function alternately measures the **battery voltage** and **earth**



MSSP_001_090

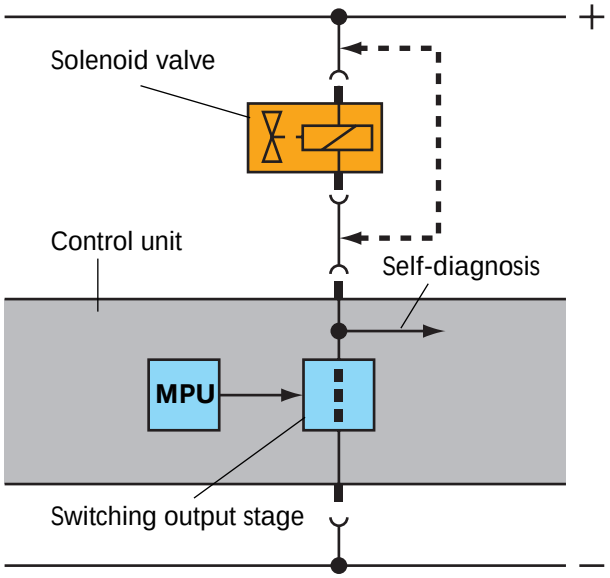
Fault display in fault code memory:

Short to positive

Functional description

There is a short to positive in the wiring harness, connector or in the component.

The self-diagnosis functions always measures **positive**.



MSSP_001_091

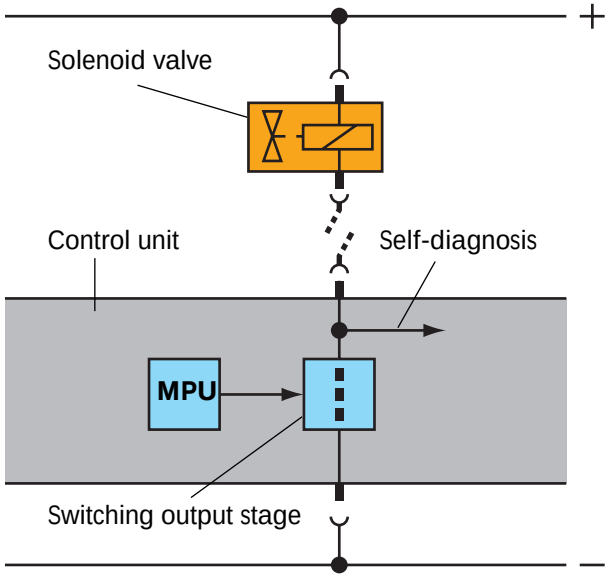
Fault display in fault code memory

Break/short to earth

Functional description

There is a wire break.

The self-diagnosis functions always measures **0 Volt**.



MSSP_001_092

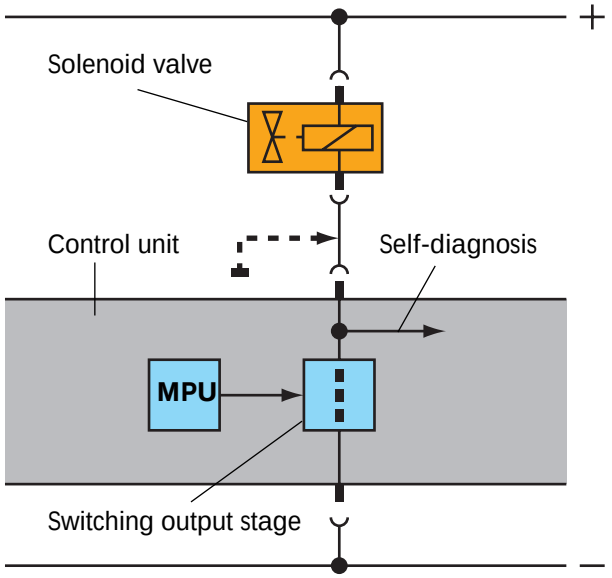
Fault display in fault code memory:

Break/short to earth

Functional description

There is a short to earth.

The self-diagnosis function always measures **0 Volt**.



MSSP_001_093

Self-diagnosis

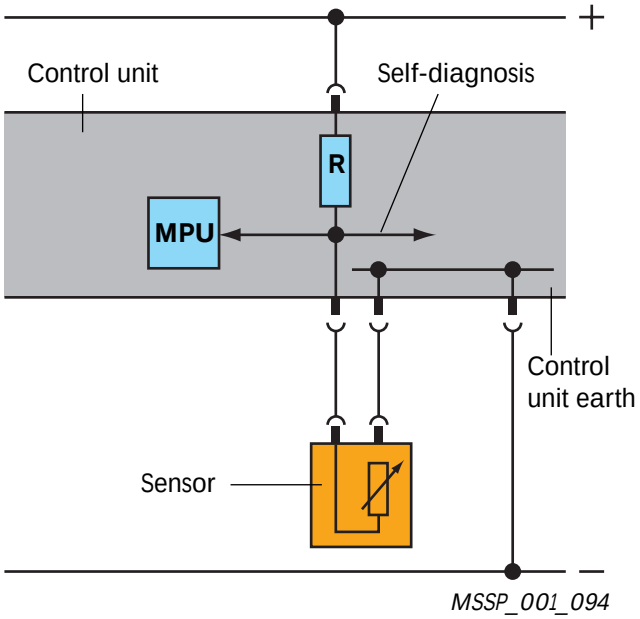
Monitored sensor, e.g. coolant temperature sender

Fault display in fault code memory:

No fault detected

Functional description

The self-diagnosis functions measures a plausible signal voltage from the temperature sender between approx. 0.5 and 4.5 Volt.



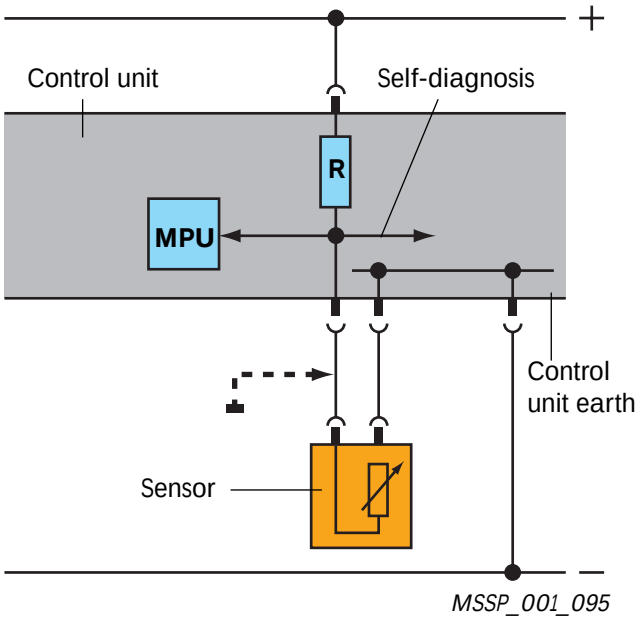
Fault display in fault code memory:

Short to earth

Functional description

There is a short to earth.

The self-diagnosis function always measures **0 Volt**.

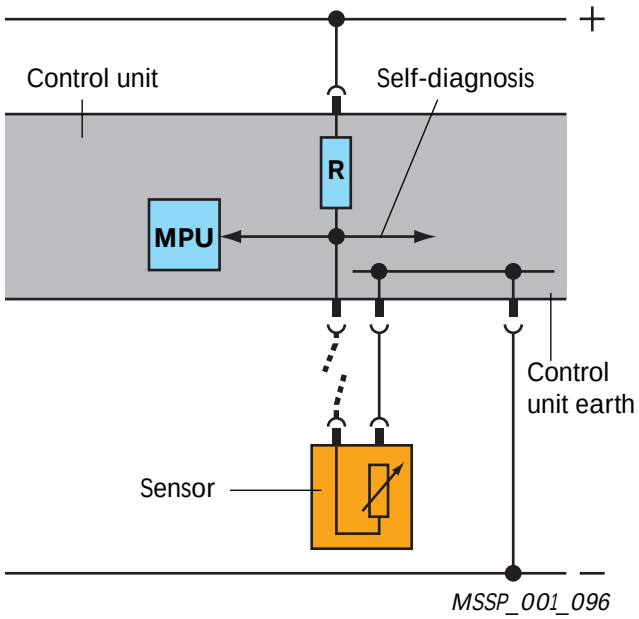


Fault display in fault code memory:

Break/short to positive

Functional description

There is a wire break.
The self-diagnosis function always measures **> 4.5 Volt.**



MSSP_001_096

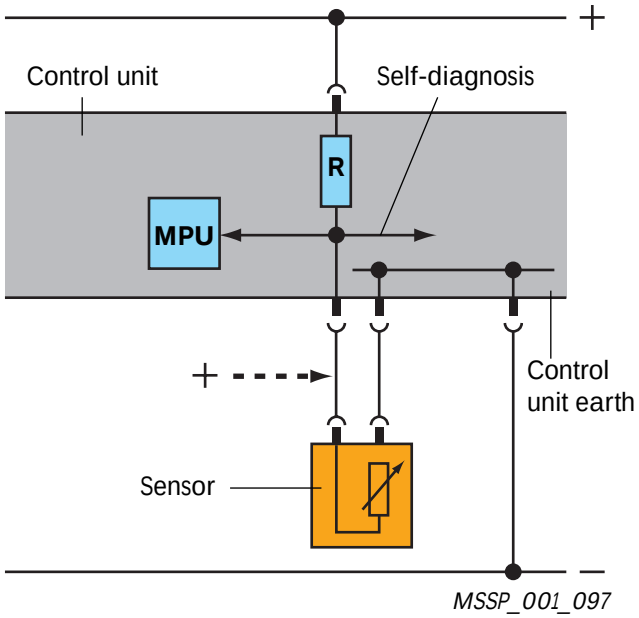
Fault display in fault code memory:

Break/short to positive

Functional description

There is a short to positive.

The self-diagnosis function always measures **> 4.5 Volt**.



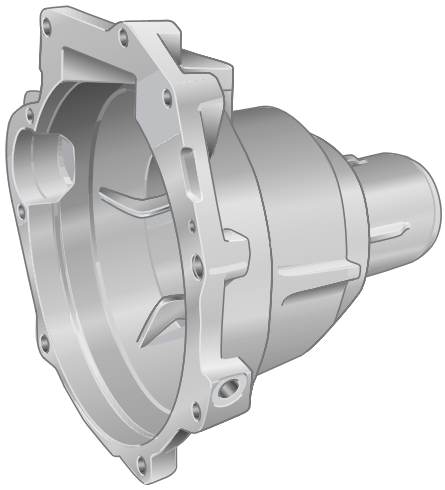
MSSP_001_097

Adaptation kits

Gearbox bell housings

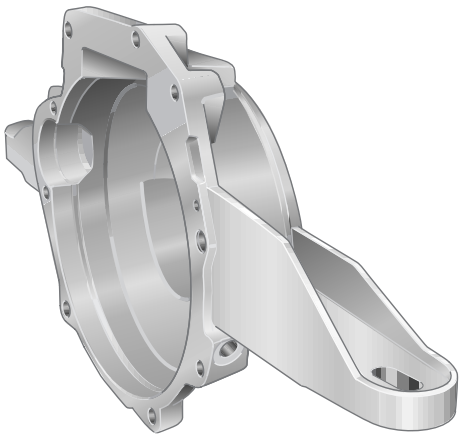
The following gearbox bell housings are available for the purpose of using different drive systems.

Gearbox bell housing for Volvo SP-E/DP-E



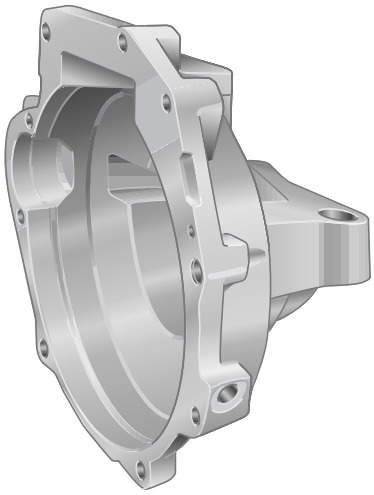
MSSP_001_086

Gearbox bell housing for reversing gearbox (SAE-7)



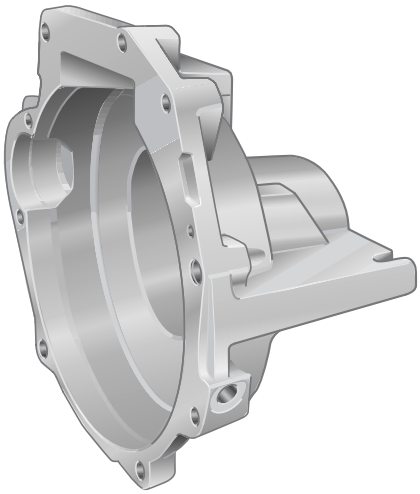
MSSP_001_087

Gearbox bell housing for Mercruiser



MSSP_001_088

Gearbox bell housing for Volvo SX/DP-S



MSSP_001_089

Please refer to the technical documentation of your Volkswagen Marine dealer for the current order numbers.

Abbreviations

List of abbreviations used

A

A - Ampere
Al - Aluminium
Au - Gold

B

BSO - **B**odensee **S**chifffahrtsver**o**rdnung
(Lake Constance Shipping Ordinance)

C

cm^3 - Cubic centimetre
Co - Carbon monoxide
Cu - Copper

F

Fe - Iron

G

g - Grams or gallons

H

H^2O - Water
h - Hours
HC - Hydrocarbon

K

KD-Literatur - Service literature
kg - Kilograms
km - Kilometre
kn - Knots
kW - Kilowatt

I

l - Litre

M

m - Miles
MDC - Marine Diesel Control
min - Minute
mm - Millimetre
mph - Miles per hour

N

nm - Nautical miles
Nm - Newton meters
NOx - Nitrogen oxide
NTC - **N**egative **T**emperature **C**oefficient

O

OT - Top dead centre

P

Pb - Lead
Pkw - Passenger vehicle
PME - Vegetable oil methyl ester
PS - Horse power

R

RME - Rape-seed oil fatty acid methyl ester

U

rpm - Revolutions per minute

V

V - Volt
VTG - **V**ariable **T**urbine **G**eometry

Notes

Self-study programme M001

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