

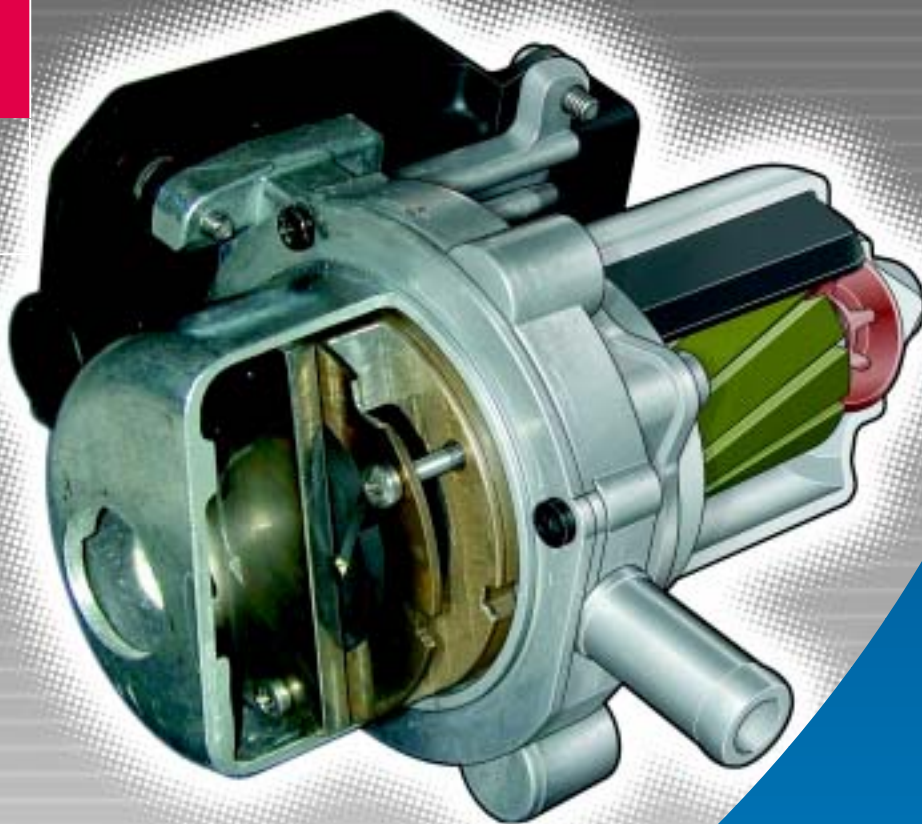
Service.



Self-Study Programme 257

Electric vacuum pump for brake servo unit

Design and Function



Cars fitted with a petrol engine in combination with an automatic gearbox which comply with the EU 4 Standard have an electric vacuum pump. This is used for assisting the brake servo unit.

In this engine-gearbox combination, the throttle valve is opened particularly wide when the engine is started from cold, as well as when it is idling with a drive position engaged and the brakes applied. This is intended to reduce the pressure drop in intake manifold.

The reasons for this greater opening of the throttle valve is the heating-up phase of the catalytic converter after a cold engine start, as required by the

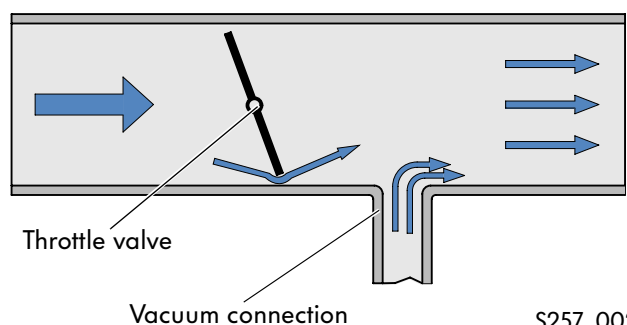
EU 4 emission standard, and compensating for the greater torque friction (resistance in torque converter) which exists under the conditions mentioned above.

Depending on the particular car model, two different versions of the electric vacuum pump are fitted:

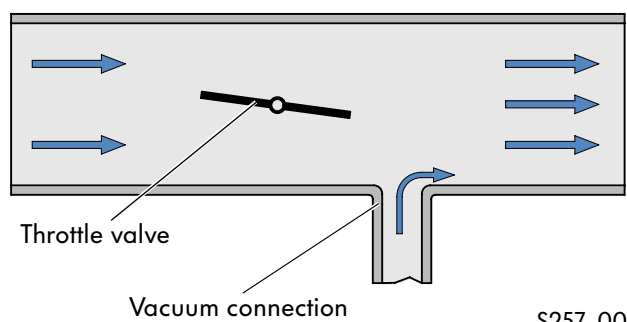
1. open-loop controlled vacuum pump
2. closed-loop controlled vacuum pump

Pressure drop when throttle valve opened

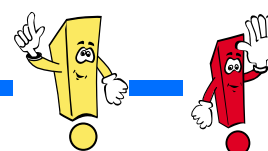
If the throttle valve is slightly opened, a high vacuum exists in the intake manifold and thus also a high vacuum at the vacuum connection for the brake servo unit.



If the throttle valve is opened wide and the engine is running at a low speed, only a very slight vacuum exists at the connection for the brake servo unit of the intake manifold.



NEW



**Important
Note**

The Self-Study Programme describes the design and function of new developments!

The contents are not updated.

Please always refer to the relevant service literature for up-to-date inspection, adjustment and repair instructions.



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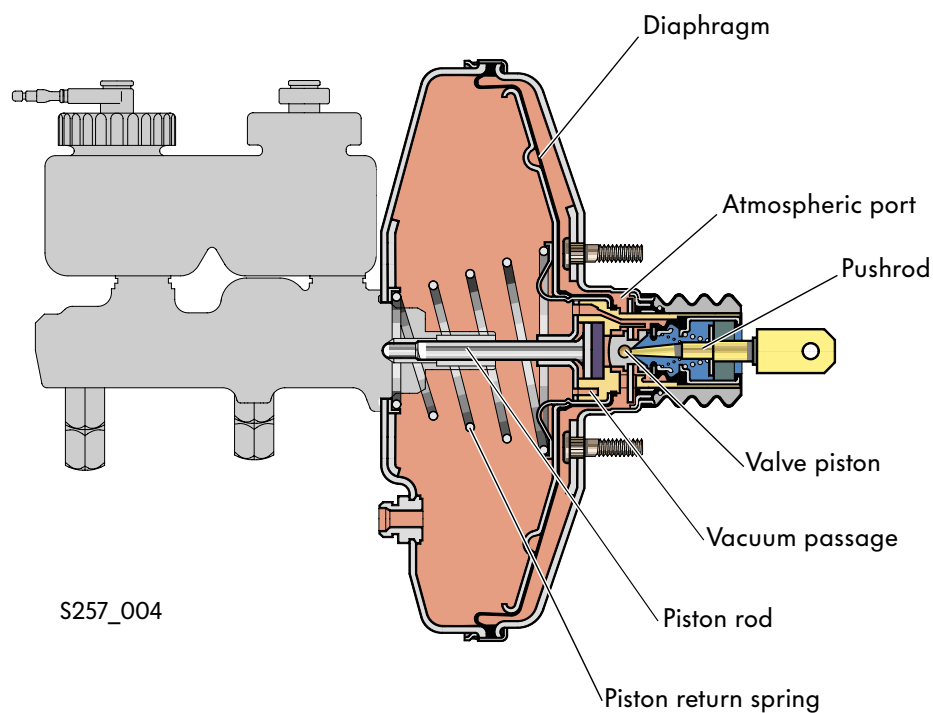


Introduction



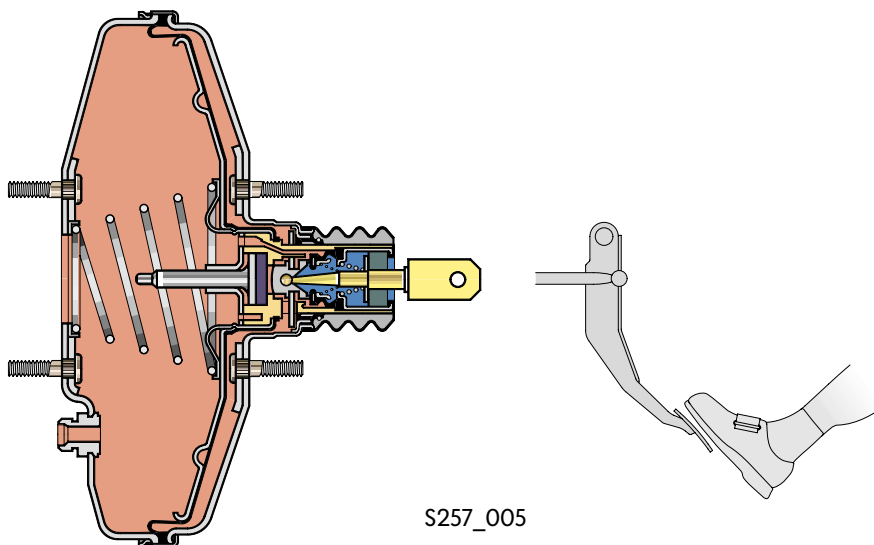
Function of the brake servo unit

In the case of the vacuum brake servo unit with a mechanical open-loop control, the vacuum part is connected to the brake master cylinder.



Released position

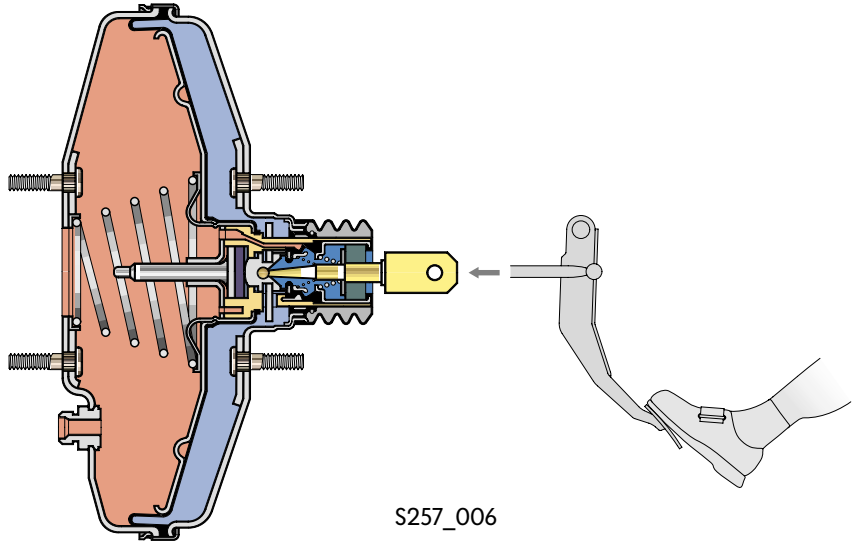
In this position, the atmospheric port is sealed off and the vacuum passage is opened. The same pressure exists upstream and downstream of the diaphragm. The diaphragm is held in the end position by the piston return spring.





Partial braking position

When the brake pedal is depressed, the piston rod is moved to the left. This seals off the vacuum passage and the atmospheric port is opened. The vacuum downstream of the diaphragm is reduced. The force produced as a result of the pressure difference moves the diaphragm, the pushrod and thus the piston in the brake master cylinder to the left by overcoming the force of the piston return spring. The atmospheric port and the vacuum

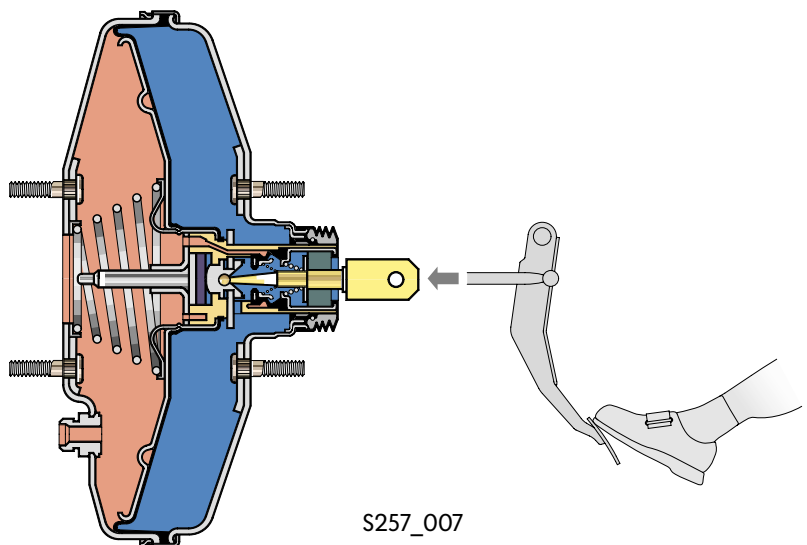


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passage are opened until the valve piston comes to a stop as a result of the hydraulic pressure produced in the brake master cylinder. The atmospheric port and the vacuum passage are closed and a ready position is thus achieved. Any change to the pressure applied to the brake pedal results in a pressure difference on both sides of the diaphragm and thus in an increase or reduction in deceleration.

Full braking position

In the full braking position, the vacuum passage is closed off and the atmospheric port is fully opened. The maximum possible pressure difference exists upstream and downstream of the diaphragm. A further increase in the force acting on the piston in the brake master cylinder can only be achieved by increasing the force acting on the brake pedal.

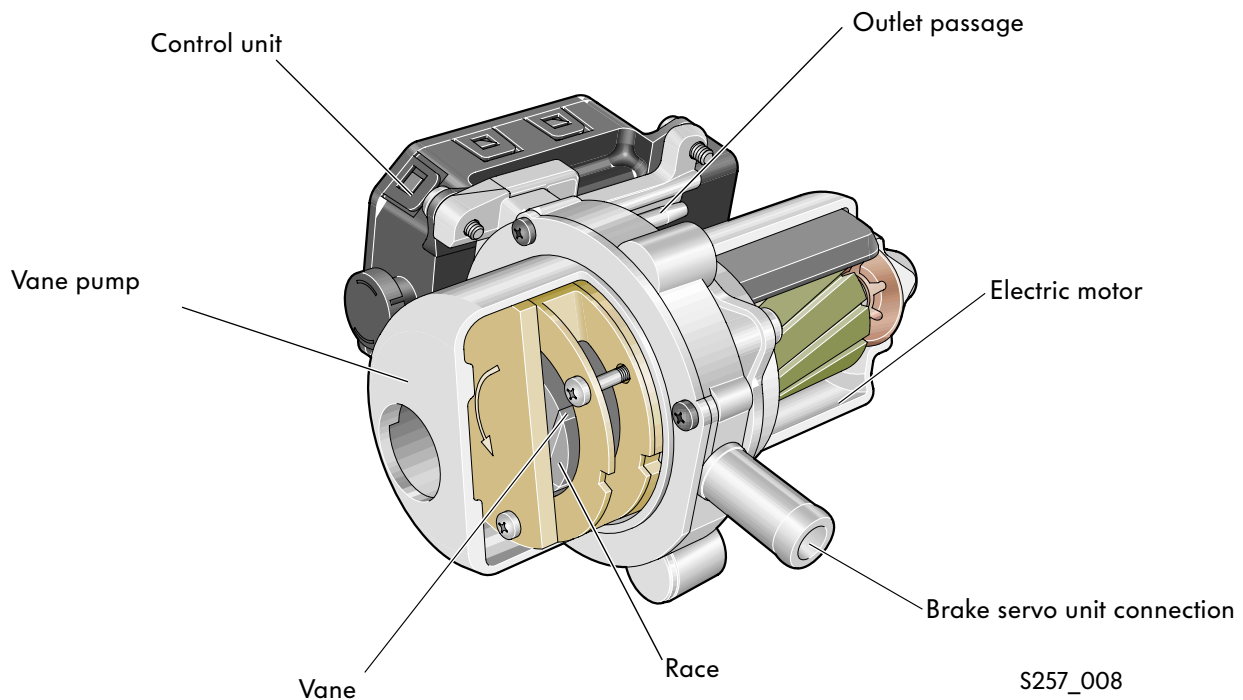


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Introduction



Design and function of the electric vacuum pump



The design and function of both versions of the electric vacuum pump are identical. In the case of the closed-loop controlled version there is no control unit at the pump housing.

Design

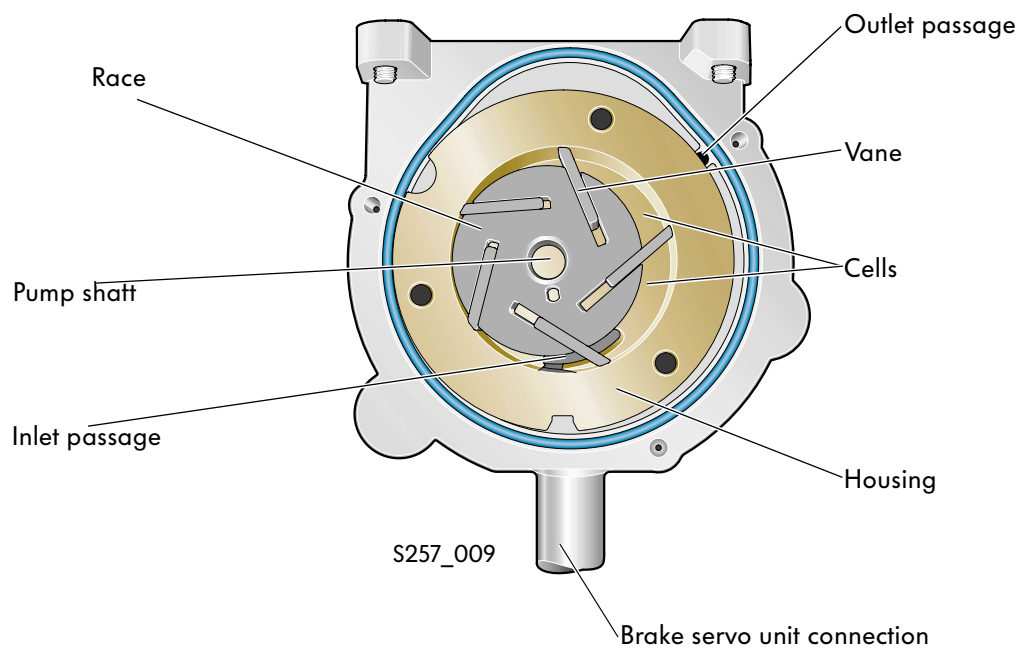
The electric vacuum pump consists of an electric motor and a vane pump.

Function

The electric motor powers the vane pump. As a result of the centrifugal force, the vanes at the circular-shaped inner wall of the race are pushed out. The off-centered mounting of the race results in an increasing volume at the inlet passage and a decreasing volume at the outlet passage. Consequently, air flows into the suction chamber and is transported by the vanes to the pump outlet. As a result, vacuum exists at the connection for the brake servo unit.

The electric vacuum pump runs for about 1 to 2 seconds each time the engine is started.

Design and function of vane pump



Design

In the vane pump, the race rotates with the movable vanes on the pump shaft within a housing. The shaft of the pump is positioned off-centered which results in cells of different size between the race and housing.

Function

The electric motor starts the pump shaft and thus also the race rotating. The movable vanes are pressed against the inner wall of the housing by the centrifugal force and seal off the cells. This causes the air within the cells, each of which is formed by two vanes and the wall of the housing, to be displaced from the suction side (at the connection of the brake servo unit) to the pressure side (at the outlet passage). The eccentric positioning of the pump shaft reduces the size of the cells and thus compresses the inducted air.

Open-loop controlled vacuum pump

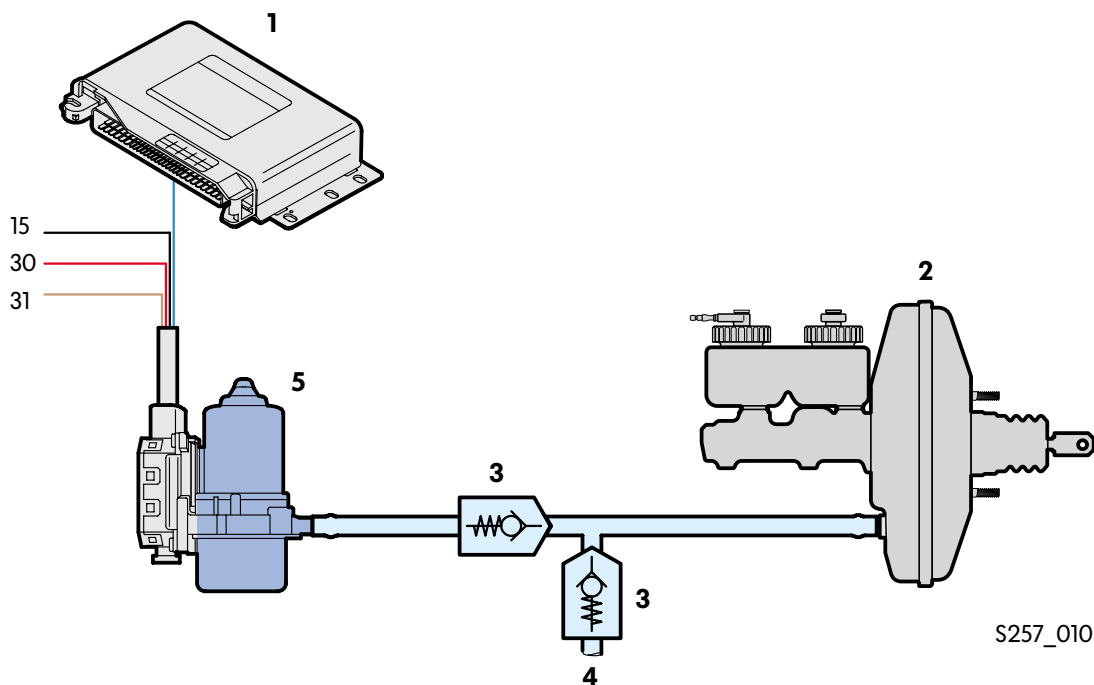
Open-loop control version

- Golf 1998 ➤
- Bora
- Audi A3

are examples of cars which are equipped with an **open-loop** controlled vacuum pump **without pressure sensor** at the brake servo unit.



System overview



- | | | | |
|---|---------------------|---|--|
| 1 | Engine control unit | 4 | To intake manifold |
| 2 | Brake servo unit | 5 | Electric vacuum pump with control unit |
| 3 | Non-return valve | | |

Features of open-loop controlled systems

Open-loop control is a process within a system in which the output variables are influenced by the input variables. The controlled elements of an open-loop control system (e.g. electr. vacuum pump) are **not** monitored by sensors. There is **no** feedback to the control device (e.g. engine control unit).

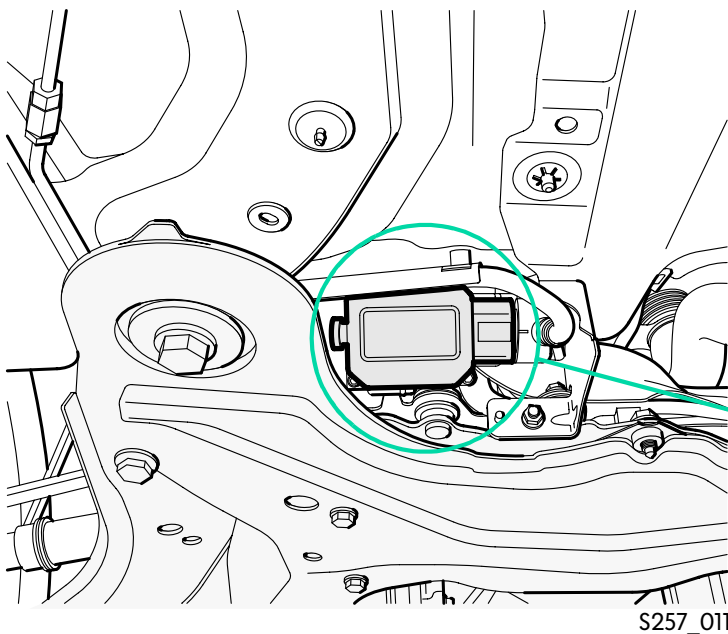
1. The open-loop controlled version operates without a pressure sensor. An intake manifold pressure model is stored in the engine control unit.
2. The control unit calculates the pressure in the brake servo unit from the following input parameters:
 - Load
 - Engine speed
 - Throttle valve position
 - Brake light switch

The engine control unit compares the computed pressure in the brake servo unit with the intake manifold pressure model in the engine control unit.

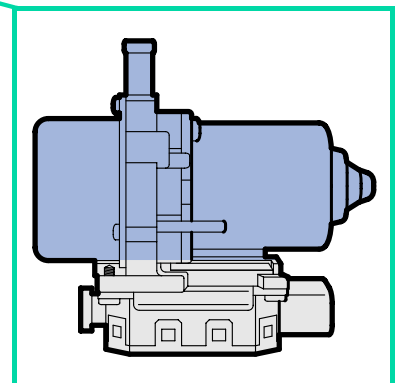


Installation position

The vacuum pump of the open-loop controlled version is located on the left of the subframe.



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S257_011a

Open-loop controlled vacuum pump

Operating conditions

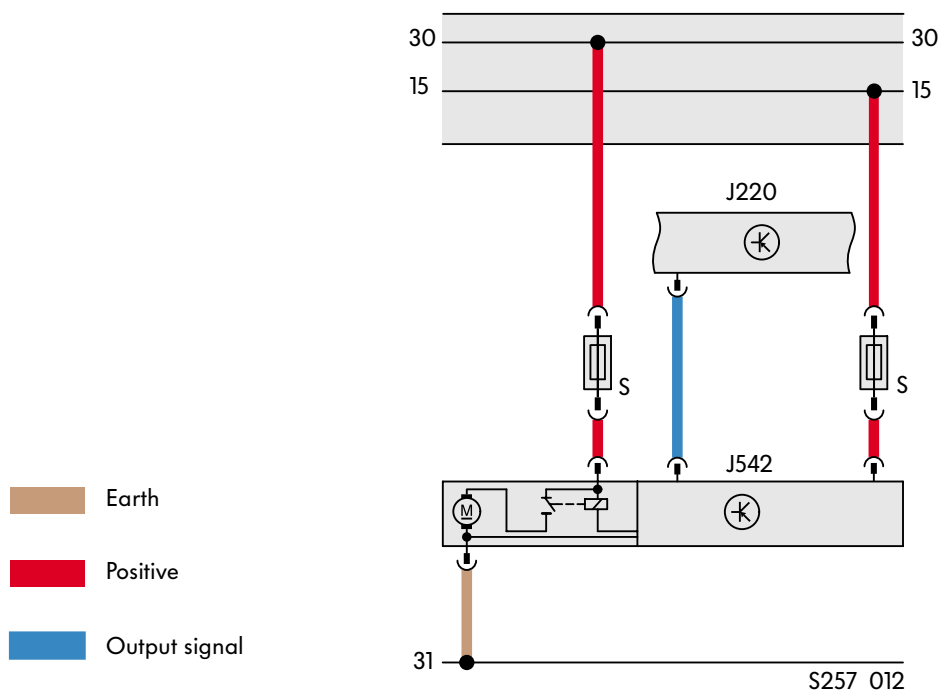
If the computed intake manifold pressure exceeds a characteristic curve stored in the intake manifold pressure model, the engine control unit transmits an earth signal to the control unit of the electric vacuum pump, which then starts running.

This characteristic curve is dependent on the ambient pressure. Depending on the engine control unit, this pressure is either computed or determined by a pressure sensor in the engine control unit.



To avoid the pump constantly switching on and off, the system operates with hysteresis. You can find further explanations of hysteresis and the hysteresis chart on page 13.

Function diagram of open-loop controlled vacuum pump



Components

- J220 Engine control unit
- J542 Brake servo unit control unit
- S Fuse

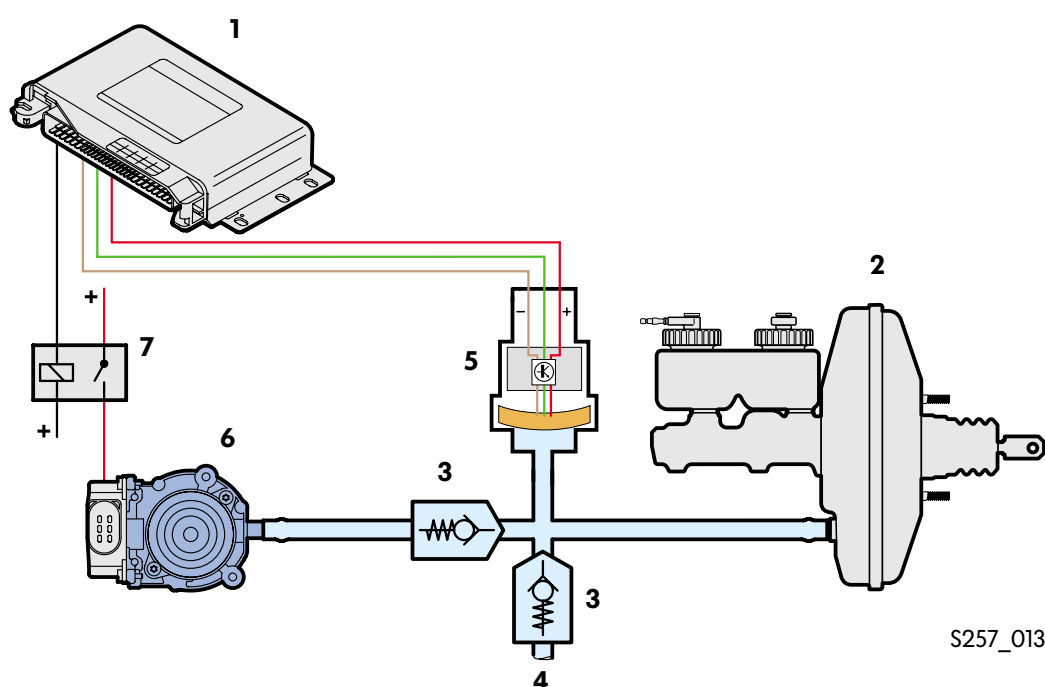
Closed-loop controlled vacuum pump

Closed-loop control version

- Passat 2001 ➤
- Audi A4
- Audi A6

are examples of cars which are equipped with a **closed-loop** controlled vacuum pump **with pressure sensor** at the brake servo unit.

System overview



- | | | | |
|---|---------------------|---|----------------------|
| 1 | Engine control unit | 5 | Pressure sensor |
| 2 | Brake servo unit | 6 | Electric vacuum pump |
| 3 | Non-return valve | 7 | Relay |

Features of closed-loop controlled systems

Closed-loop control is a process in which the quantity to be controlled (e.g. the pressure in the brake servo unit) is constantly detected by sensors (e.g. pressure sensor). The control device (e.g. engine control unit) compares the measured value supplied by the sensor with the stored set value and controls the appropriate control element (e.g. electric vacuum pump).



Closed-loop controlled vacuum pump

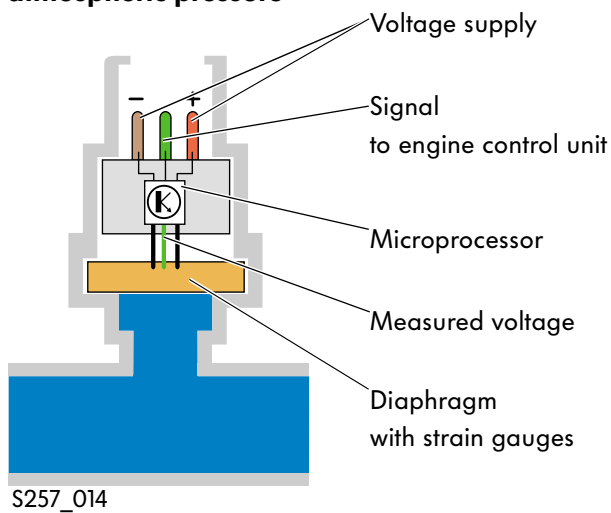
Function of the pressure sensor

In the closed-loop controlled version, a pressure sensor is installed in the line running to the brake servo unit.

After the ignition is switched on, the pressure sensor is supplied with a voltage of 5 V.

Inside the pressure sensor, there is a diaphragm with strain gauges. If the pressure within the sensor changes, the electrical resistance of the strain gauges also changes. This produces a voltage signal by means of an amplifier in the pressure sensor.

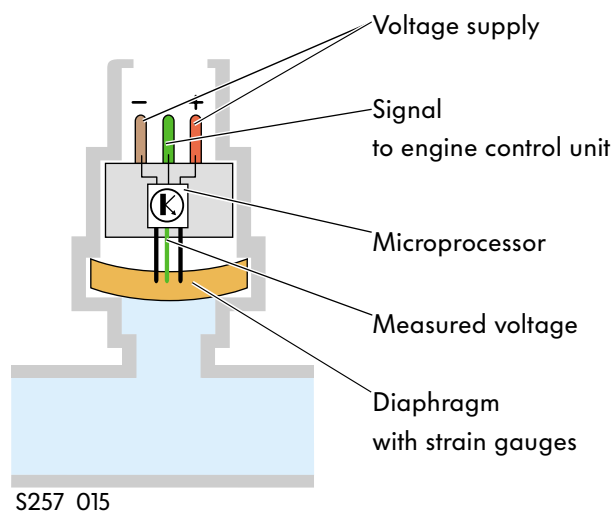
At atmospheric pressure



At atmospheric pressure, the shape of the diaphragm alters and thus that of the strain gauges as well. Consequently, the voltage applied is countered only by a slight electrical resistance.

The change in the voltage is small.

At vacuum



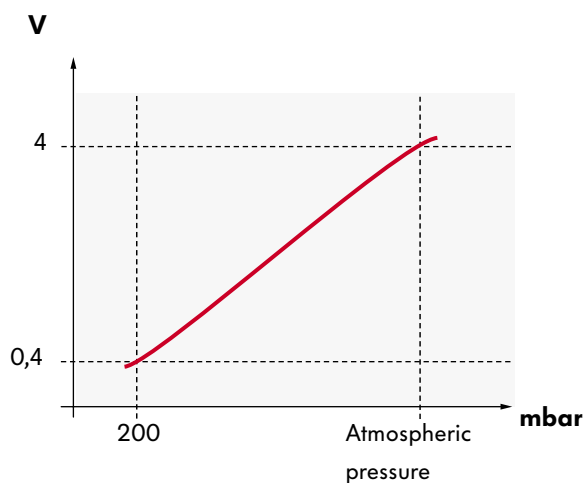
If a vacuum exists, the shape of the diaphragm alters to a greater extent, and thus that of the strain gauges as well. This results in a greater change in the resistance. The measured voltage is reduced by the same ratio.

By way of example:

The relationship between atmospheric pressure and the voltage signal from the engine control unit.



The figures in the chart opposite are approximate values!

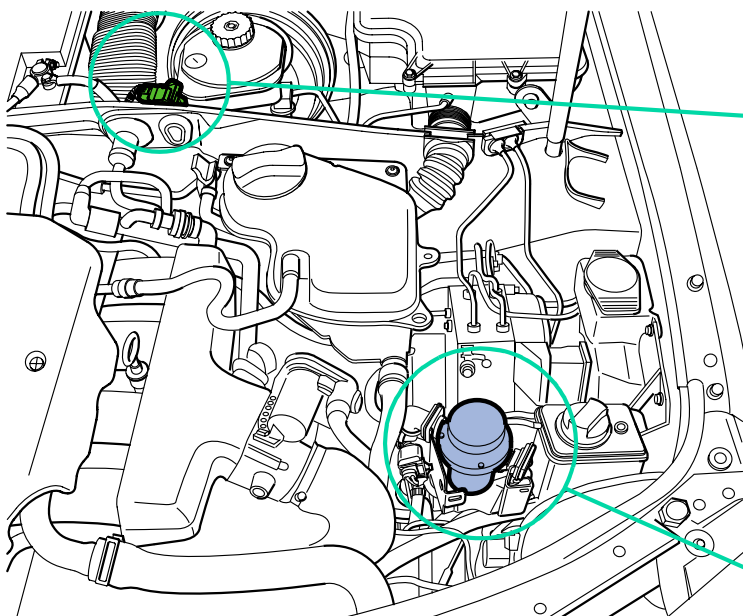


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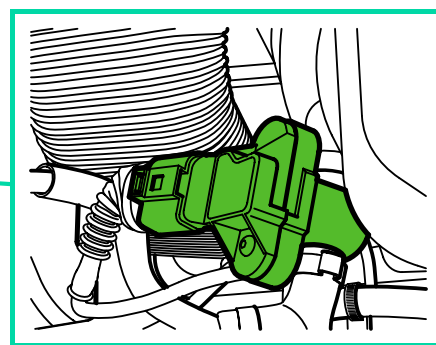
Installation position

The vacuum pump, for example on the Passat 2001 ►, is installed on the left of the engine compartment below a cover.

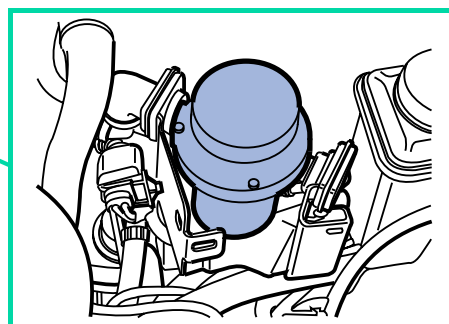
The pressure sensor for the brake servo unit is located in the plenum chamber in the line running to the brake servo unit.



S257_017



S257_017a



S257_017b

Closed-loop controlled vacuum pump

The pressure sensor is installed in the vacuum line running to the brake servo unit and supplies a voltage signal to the engine control unit.

The engine control unit actuates an load current relay (at the negative side), which switches the pump on.

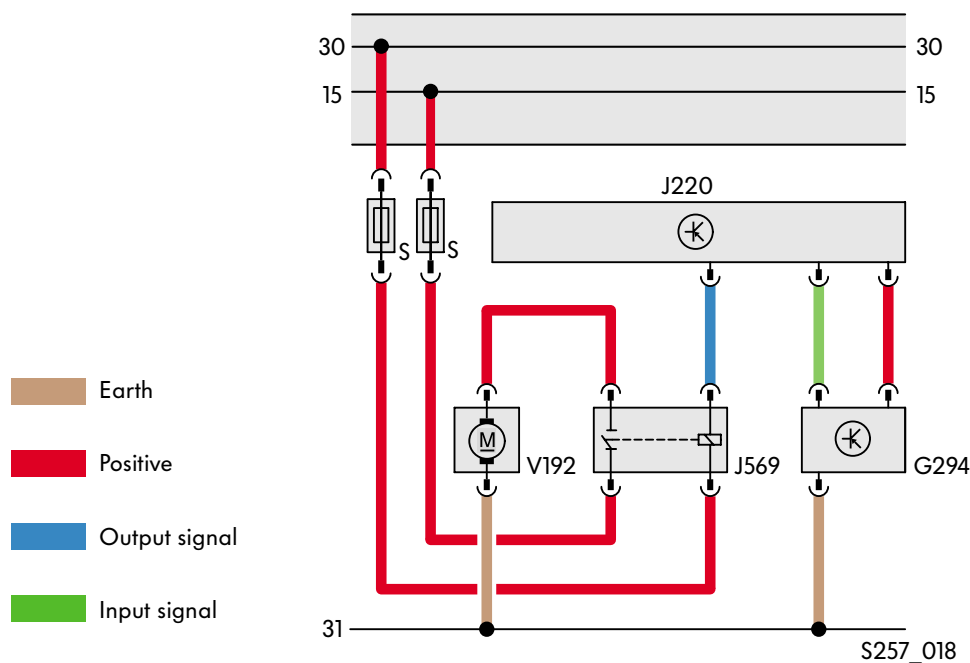
Operating conditions

A characteristic curve for controlling the electric vacuum pump is stored in the engine control unit. The switch-on point, in the same way as for the open-loop controlled version, is dependent on the pressure in the brake servo unit and on the measured ambient pressure. Depending on the engine control unit, this is either computed or determined by a pressure sensor in the engine control unit.



If the pressure sensor fails, the system switches over to the computed model of the "open-loop controlled" version.

Function diagram of closed-loop controlled vacuum pump



Components

G294 Brake servo unit pressure sensor
J220 Engine control unit
J569 Brake servo unit relay

V192 Brake servo unit vacuum pump
S Fuse

Hysteresis

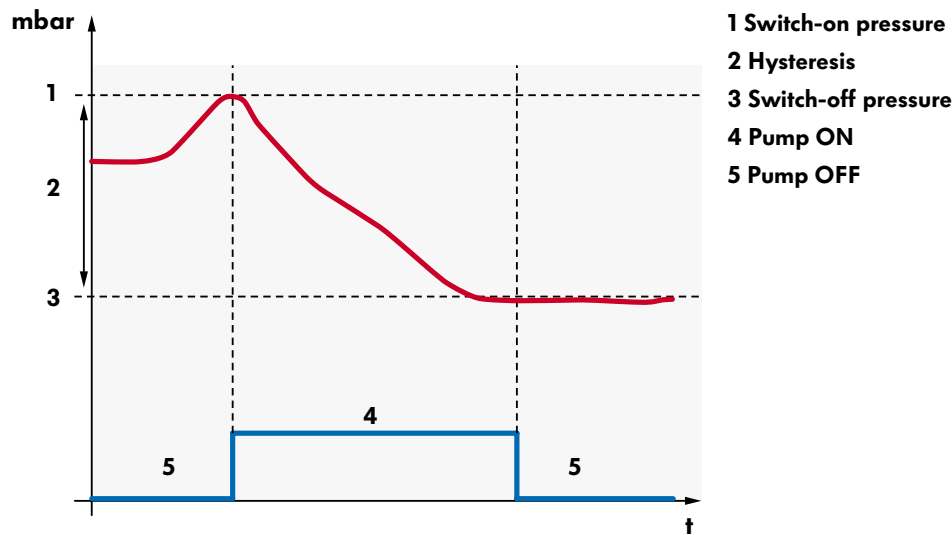
The term „hysteresis“ is of Greek origin and basically means:
continuation of an effect after the cause has ceased.

What this means, in terms of the electric vacuum pump, is that the pump switches on and off within a certain pressure range. This pressure range is the difference between the switch-on and the switch-off pressure. After the pump has switched off, the pressure is retained until it is reduced as a result of the brakes being applied.



The hysteresis differs in the case of the open-loop and the closed-loop controlled version.

Hysteresis chart



S257_019

Switch-on pressure at different altitudes

	Switch-on pressure in mbar			Hysteresis
	Mean sea level	800 m	1000 m	
Open-loop version	above about 550 mbar	above about 525 mbar		about 50 mbar
Closed-loop version	above about 600 mbar		above about 540 mbar	about 170 mbar



Self-diagnosis

Self-diagnosis can be conducted with the vehicle diagnostic, testing and information system VAS 5051 or VAS 5052.

If you select the address 01 „Engine electronics“, the following functions are available in connection with the electric vacuum pump. Certain of the following points are being phased in, in other words are not available in all vehicles.



S257_020

Open-loop controlled version

02 Interrogate fault memory

03 Final control diagnosis

05 Erase fault memory

06 End output

08 Data block

Display group **008**, display field **3**
- Absolute pressure in brake servo unit

Closed-loop controlled version

02 Interrogate fault memory

03 Final control diagnosis

04 Basic setting

System test, (see Workshop Manual)
the ventilated brake servo unit must
be evacuated again within a certain
time.

05 Erase fault memory

08 Data block

Display group **008**, display field **3**
- Absolute pressure in brake servo unit



If a fault is detected, the AC compressor is switched off if necessary.
The smaller engine load then makes it possible to close the throttle valve further.

Test your knowledge

1. Which input variables of the closed-loop controlled vacuum pump are used for calculating the pressure in the brake servo unit?

- ☐ a) Engine load
- ☐ b) Intake air temperature
- ☐ c) Engine speed
- ☐ d) Throttle valve position
- ☐ e) Signal from clutch pedal sensor
- ☐ f) Signal from brake light switch

2. What happens, in the case of the closed-loop controlled vacuum pump, if the pressure sensor fails?

- ☐ a) The system switches over to the computed model of the „open-loop controlled“ version.
- ☐ b) The electric vacuum pump is actuated and is constantly on.
- ☐ c) The brake servo unit does not operate. It is still possible to operate the brakes.

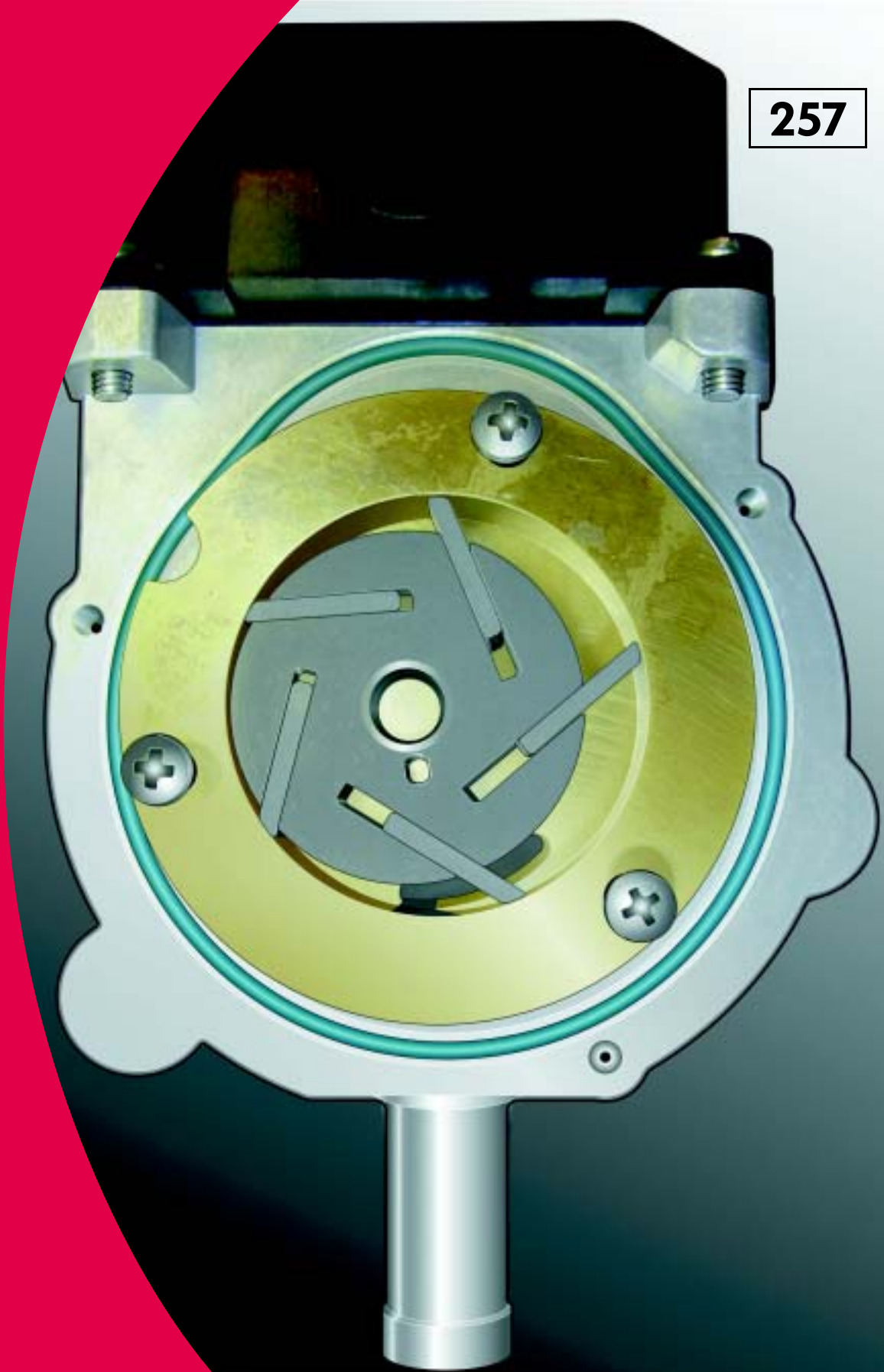
3. On which version or versions of the electric vacuum pump is it possible to carry out final control diagnosis?

- ☐ a) Only on the open-loop controlled version.
- ☐ b) Only on the closed-loop controlled version.
- ☐ c) On both versions.
- ☐ d) On neither of the two.

Answers:
1. a), c), d), f)
2. a)
3. c)



Notes



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140.2810.76.20 Corresponds to technical state 07/01

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