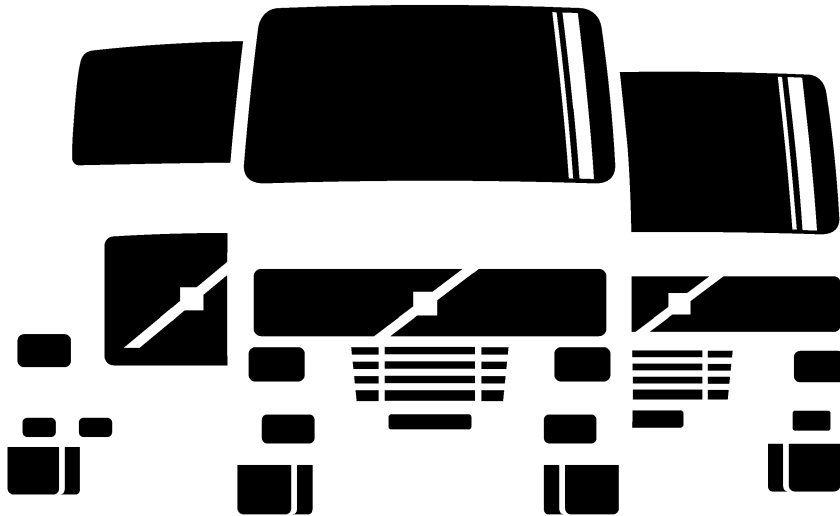


Service Manual Trucks

Group **250-610**

VOLVO Engine Brake
VE D12, D12A, D12B



Foreword

The descriptions and service procedures contained in this manual are based on designs and methods studies carried out up to February 2000.

The products are under continuous development. Vehicles and components produced after the above date may therefore have different specifications and repair methods. When this is believed to have a significant bearing on this manual, supplementary service bulletins will be issued to cover the changes.

The new edition of this manual will update the changes.

In service procedures where the title incorporates an operation number, this is a reference to an V.S.T. (Volvo Standard Times).

Service procedures which do not include an operation number in the title are for general information and no reference is made to an V.S.T.

The following levels of observations, cautions and warnings are used in this Service Documentation:

Note: Indicates a procedure, practice, or condition that must be followed in order to have the vehicle or component function in the manner intended.

Caution: Indicates an unsafe practice where damage to the product could occur.

Warning: Indicates an unsafe practice where personal injury or severe damage to the product could occur.

Danger: Indicates an unsafe practice where serious personal injury or death could occur.

Volvo Trucks North America, Inc.
Greensboro, NC USA

Order number: PV776-TSP0250610/2

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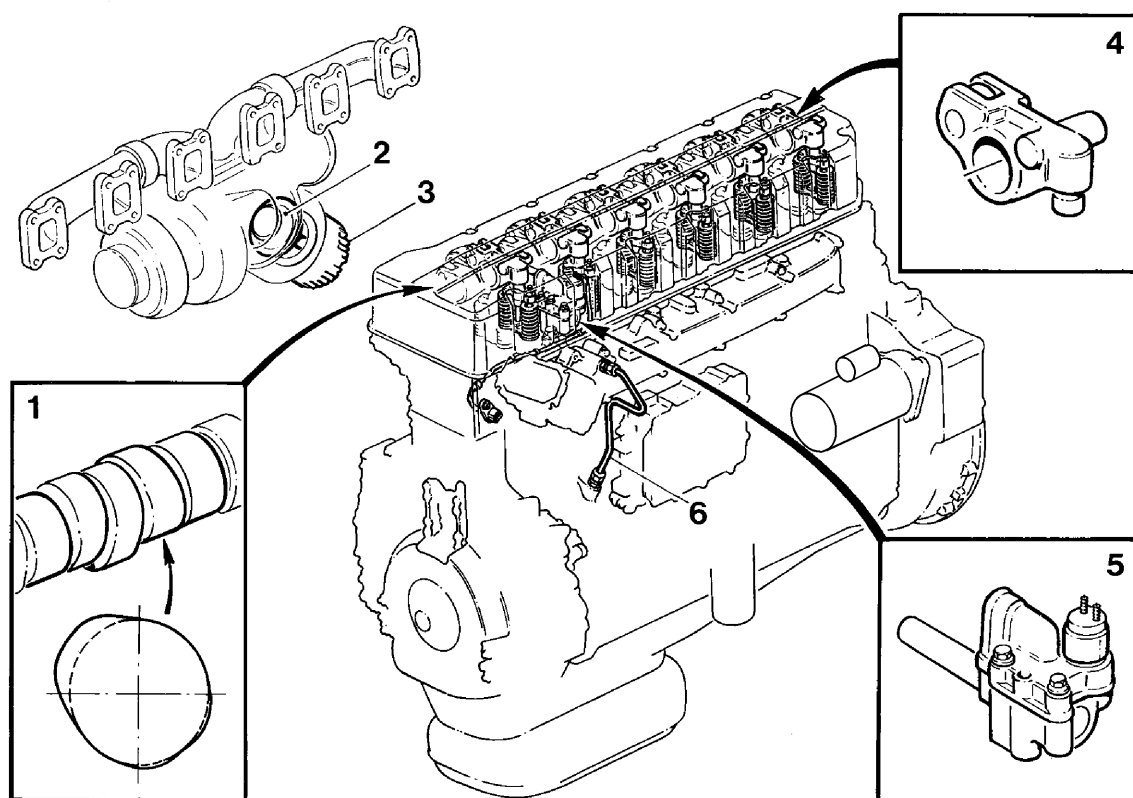
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General

VOLVO Engine Brake (VEB)

Successful troubleshooting of the VOLVO engine brake system requires information regarding system design and knowledge of how the different components function in relation to each other.



W2002155

- 1 Camshaft
- 2 Shutter
- 3 Exhaust pressure governor

- 4 Rocker arm
- 5 Control valve
- 6 Oil pipe

The description, operation and service of the Volvo Engine Brake is detailed as follows:

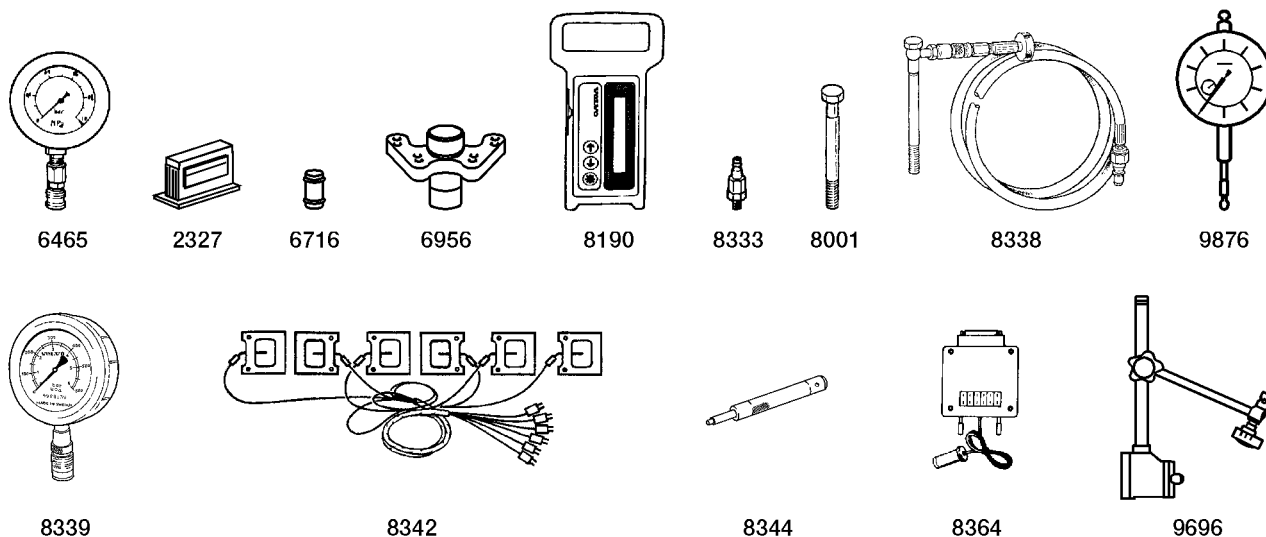
The Troubleshooting section is subdivided into **Electrical Troubleshooting** and **Mechanical Troubleshooting**.

Refer to this information along with the description and operation information when performing troubleshooting.

Tools

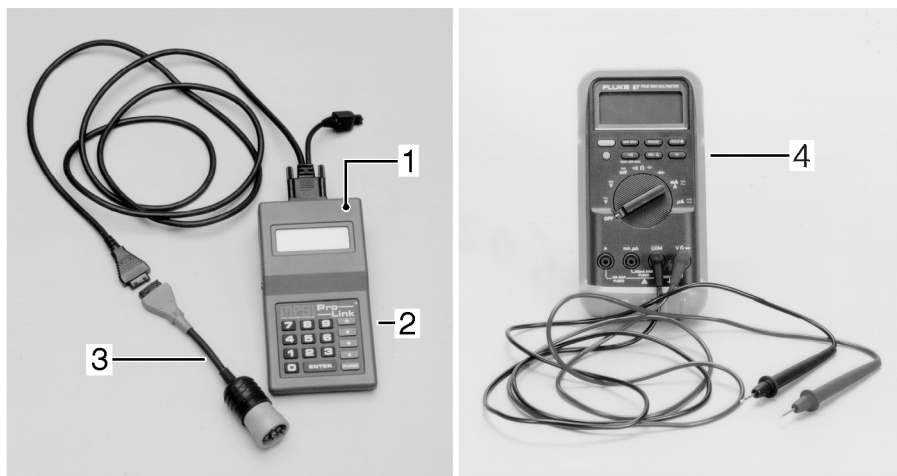
VOLVO Engine Brake, Special Tools

Servicing the Volvo Engine Brake (VEB) requires the following special tools. The tools are available from the Parts Department of Volvo Truck North America, Inc. Unless otherwise noted, all tool numbers are preceded by "999." Please specify the complete part number when ordering. Tools with part numbers beginning with "J" are available only from Kent-Moore.



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| | | | |
|----------------|--|----------------|---|
| 9996465 | Pressure gauge, 0 –10 bar (0 – 145 psi) | 9998338 | Connector for checking oil pressure in the rocker arm shaft |
| 9812327 | Memory cassette | 9989876 | Dial indicator |
| 9996716 | Drift | 9998339 | Pressure gauge, 0 – 6 bar (0 – 90 psi) |
| 9996956 | Cranking tool for flywheel | 9998342 | Temperature sensors for measuring exhaust gas temperature |
| 9998190 | Measuring instrument | 9998344 | Drift, used when changing ball seating in the rocker arm |
| 9998333 | Union, used together with pressure gauge 9996465 | 9998364 | Collation unit for temperature measuring |
| 9808001 | Bolt | 9999696 | Magnetic base |

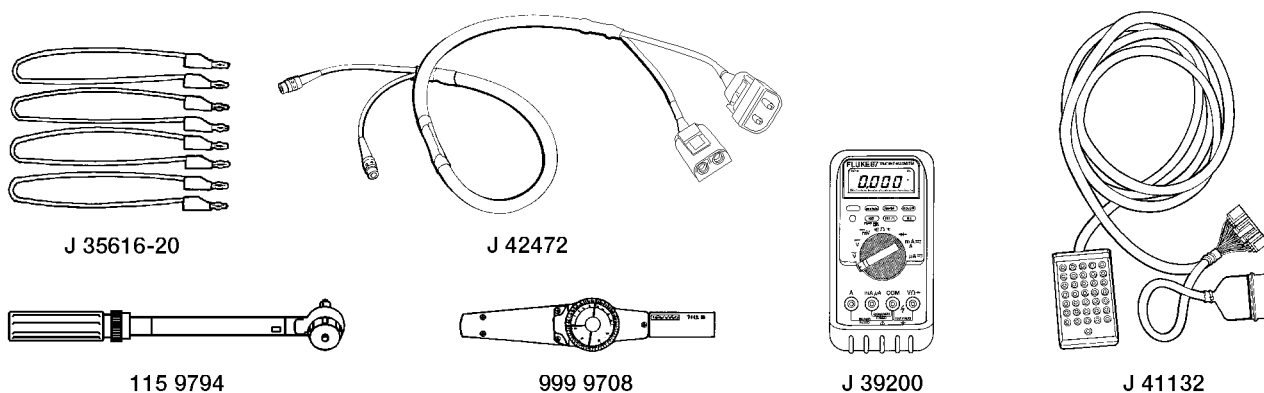


W2003381

- 1 J-38500-1 Pro-Link® 9000
- 2 J-38500-1000 Cartridge
- 3 J-38500-60A Adapter
- 4 9510060 Multimeter

Other special equipment

Tools with part numbers beginning with the letter “J” are available from your local Kent Moore dealer.

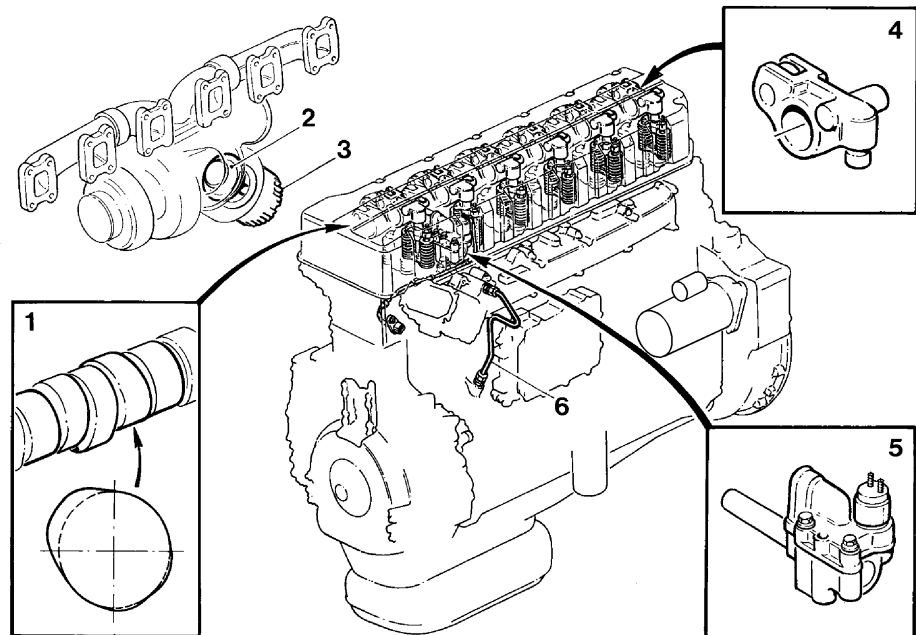


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| | | | |
|-------------------|--|-----------------|--|
| J-35616-20 | Jumper wires | 9999708 | Torque wrench 0 – 17.5 Nm (0 – 15 ft-lb) |
| J-42472 | 2-pin breakout harness | J- 39200 | Fluke 87 digital multimeter |
| 1159794 | Torque wrench 10 – 100 Nm (7.5 – 75 ft-lb) | J- 41132 | 36-pin breakout box |

Design and Function

Engine Brake



W2000702

- 1 Camshaft
- 2 Shutter

- 3 Exhaust Pressure Governor
- 4 Rocker arm

- 5 Control valve
- 6 Oil pipe

The Volvo Engine Brake consists of **two** different systems, the **exhaust brake** and the **compression brake**. In the VEB, both systems operate at the same time.

Exhaust Brake

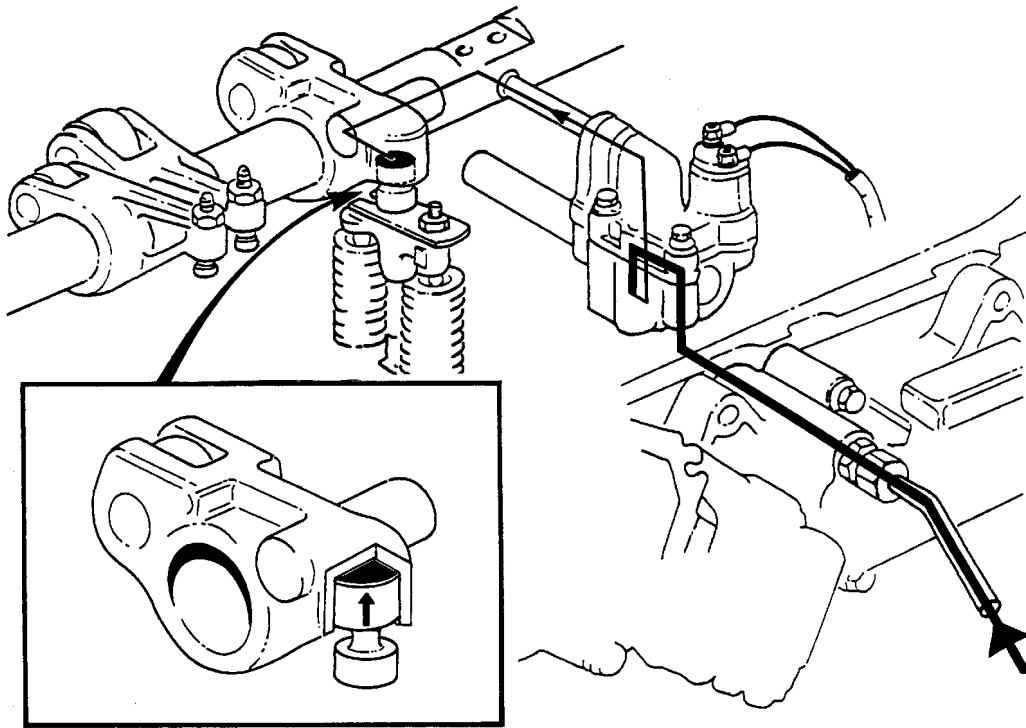
The exhaust pressure governor includes a shutter, mounted in the exhaust side of the turbocharger. This shutter, which is connected to the exhaust pressure governor plunger, restricts the exhaust gas flow when activated. Braking is achieved during the exhaust stroke by the backpressure created when the exhaust gas flow is blocked.

Compression Brake

The compression brake controls the opening of exhaust valves during the engine compression and combustion (operating) stroke. This creates backpressure in the combustion chamber which, in turn, has a braking effect.

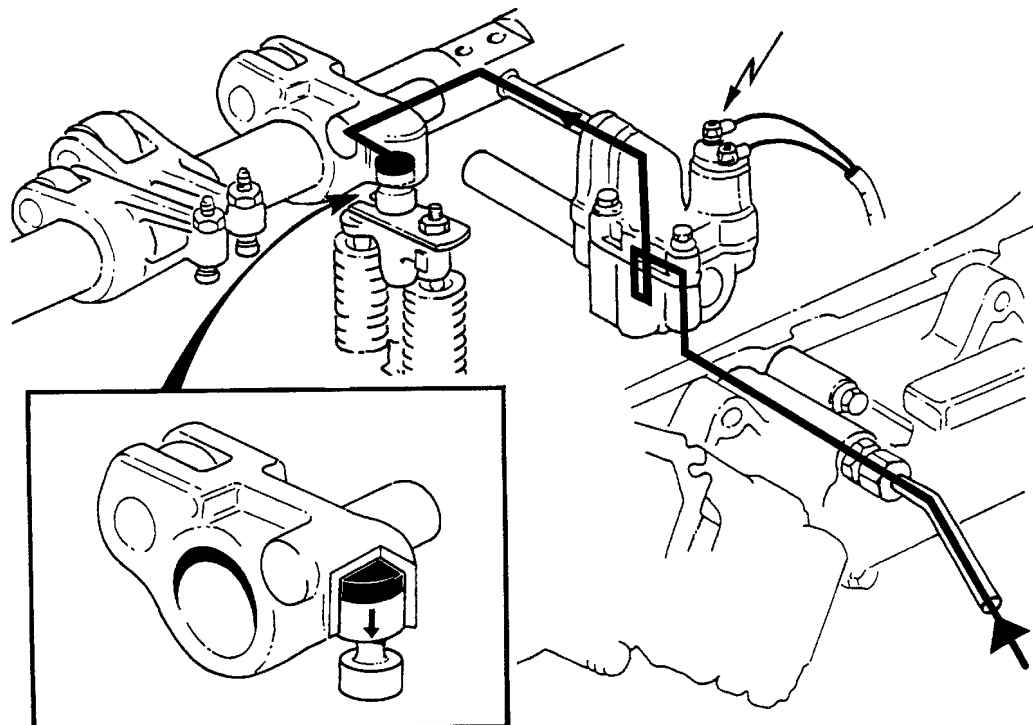
On engines with compression brakes, the camshaft has two extra lobes on each exhaust cam profile. The lift height of the extra lobes is very low compared to that of normal exhaust lobes. To enable the extra lobes to open the exhaust valves, the exhaust rocker arms are arranged in a manner which reduces valve clearance during the braking sequence.

Control Valve (VEB)



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Fig. 1: Engine in operation, the control valve solenoid valve not activated



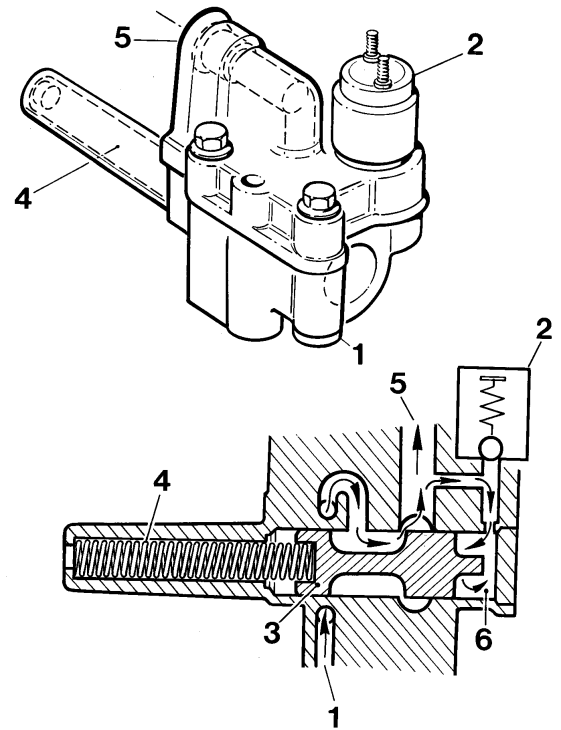
T2007788

Fig. 2: VEB engine braking, the control valve solenoid valve activated

The control valve is mounted on the cylinder head under the valve cover and is connected to the oil system ahead of the rocker arm shaft. Its purpose is to reduce oil pressure to the rocker arms while the engine is operating. There is always full system oil pressure to the control valve inlet (1). A pipe connects the inlet to the lube oil gallery in the cylinder block. Oil pressure to the rocker arm shaft can be increased by a solenoid valve (2) mounted on the control valve, from about 100 kPa (14.5 psi) while the engine is operating to over 200 kPa (29 psi) during compression braking.

During engine operation, the springs' force and oil pressure in the oil chamber hold the control valve plunger in balance. This action reduces oil pressure.

When the solenoid valve is activated, the oil chamber (6) is drained and the spring (4) presses the plunger (3) to its end position. The plunger completely opens the oil outlet (5) and the oil pressure to the rocker arm shaft is increased.



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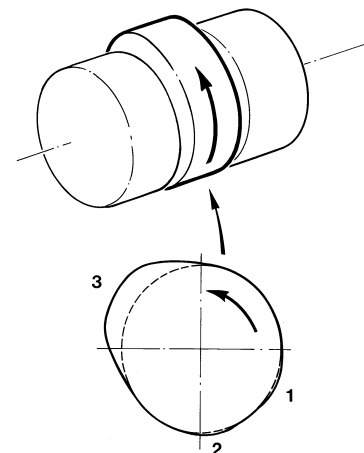
Fig. 3: Control valve

- 1 Oil inlet
- 2 Solenoid valve
- 3 Plunger
- 4 Spring
- 5 Oil outlet
- 6 Oil chamber

Camshaft (VEB)

On engines with a compression brake, the camshaft has an induction lobe (1) and decompression lobe (2) in addition to the normal exhaust lobe (3) on each cam profile for the exhaust valves. The induction and decompression lobe lift height is 0.8 mm (0.032 in.) above the basic circle, which is equivalent to about 1.1 mm (0.043 in.) at the valve bridge. The induction lobe is positioned to open the exhaust valves at the end of the intake stroke and hold them open at the beginning of the compression stroke. The decompression lobe is positioned to open the exhaust valves at the end of the compression stroke.

The valve clearance must be zero for the induction and decompression lobes to open the exhaust valves.



T2006826

Fig. 4: Camshaft section

- 1 Induction lobe
- 2 Decompression lobe
- 3 Exhaust lobe

Exhaust Rocker Arms (VEB)

The exhaust rocker arms on an engine with a compression brake are larger than those of a conventional engine.

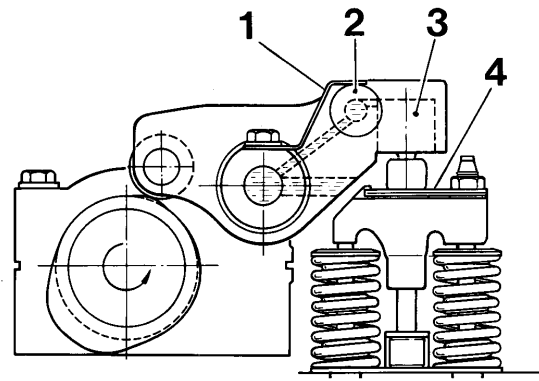
The rocker arm is equipped with a non-return valve and a plunger with a pressure-limiting valve. Its purpose is to regulate oil flow during compression braking.

Spring-tab pressure holds the rocker arm at the rest position against the valve bridge.

Valve clearance is greater on an engine without a compression brake, as the induction and decompression lobes must not open the exhaust valves while the engine is operating.

Shims are placed on the valve bridge to adjust valves.

Note: Do not use more than two shims to obtain proper valve clearance.



T2006827

Fig. 5: Exhaust rocker arm

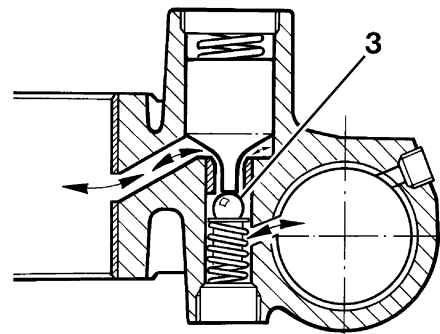
- 1 Spring tab
- 2 Non-return valve
- 3 Rocker arm plunger
- 4 Shims

Non-Return Valve (VEB)

There is a non-return valve, consisting of a plunger (1), spring (2) and ball (3) in the rocker arm. When oil from the rocker arm shaft is forced into the valve, the spring force and the oil pressure determine movement of the plunger.

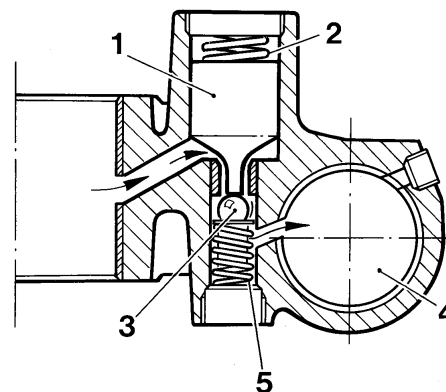
When the oil pressure is low, about 100 kPa (14.5 psi), the control valve is in its engine operating position. During this time, the plunger (1) will not move out of its rest position because the oil pressure cannot overcome the spring force. The plunger pin prevents the ball (3) from seating and the oil can flow freely through the valve in both directions.

When the control valve takes up the position for compression braking, oil pressure to the non-return valve increases. The spring force in the non-return valve is such that when the oil pressure exceeds about 200 kPa (29 psi), it overcomes the spring force and moves the plunger (1) to where it no longer controls the ball (3). The spring (5) forces the ball against its seat and the oil contained above the plunger (4) cannot flow past the ball (3). As a result, high oil pressure is formed above the plunger (4).



W2000704

Fig. 6: Non-return valve during engine operation



T2006834

Fig. 7: Non-return valve during VEB operation

- 1 Plunger
- 2 Spring
- 3 Ball
- 4 Rocker arm plunger
- 5 Spring

Rocker Arm Plunger

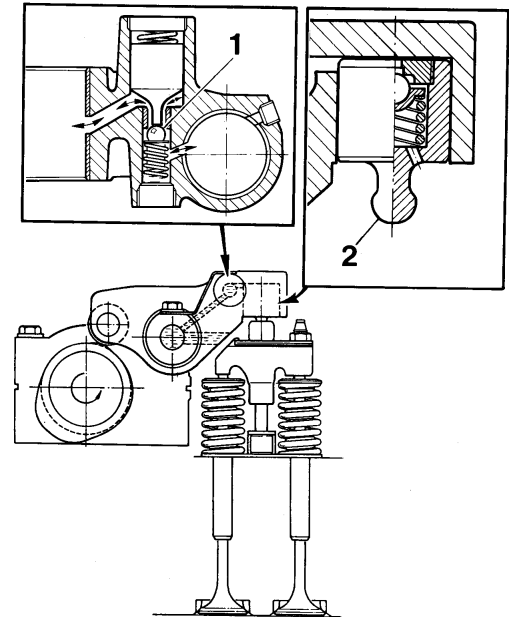
The purpose of the plunger is to zero-set the valve clearance during compression braking.

Engine Operation

When the engine is operating, there is reduced oil pressure through the control valve to the rocker arm shaft, and the rocker arm non-return valve (1) is open. Oil can flow freely through the non-return valve in both directions. Therefore, no oil pressure is built up between the rocker arm plunger (2) and the rocker arm.

The set valve clearances are great enough to prevent the cam shaft induction and decompression lobes from opening the exhaust valves.

The valve mechanism operates as it would on an engine without a compression brake. That is, only the exhaust lobe opens the exhaust valves.



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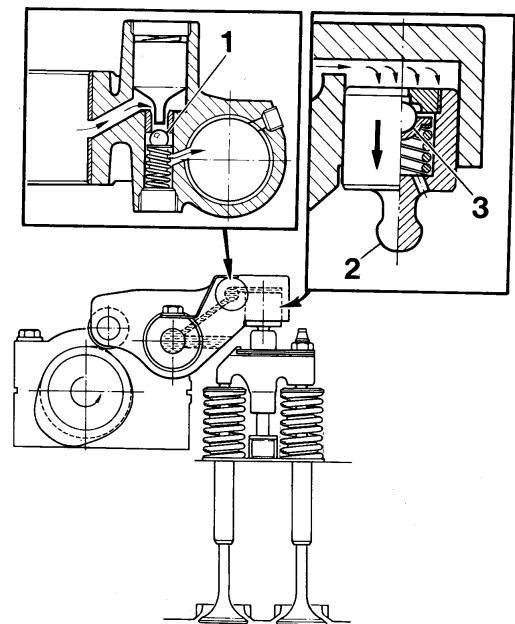
Fig. 8: Rocker arm plunger during engine operation

- 1 Non-return valve
- 2 Rocker arm plunger

Compression Braking

During compression braking, an oil pressure of at least 200 kPa (29 psi) is delivered to the rocker arm shaft as the control valve does not reduce the oil pressure.

The pressure in the rocker arm non-return valve (1) increases enough to move the plunger in the non-return valve from its rest position, and the ball now functions as a non-return valve. Pressure builds up between the rocker arm plunger (2) and the rocker arm. The plunger moves out and forces the rocker arm roller against the lobes on the camshaft. The valve clearance is eliminated and the lift height on the induction and decompression lobes is sufficient to open the exhaust valves. The rocker arm plunger is equipped with a pressure-limiting valve (3). When oil pressure between the rocker arm plunger and the rocker arm becomes too high, the pressure-limiting valve opens and oil can exit through the hole in the bottom of the plunger. The opening pressure of the pressure-limiting valve is governed by the force of the valve spring.



T2006836

Fig. 9: Rocker arm plunger during compression braking

- 1 Non-return valve
- 2 Rocker arm plunger
- 3 Pressure-limiting valve

Engine Braking

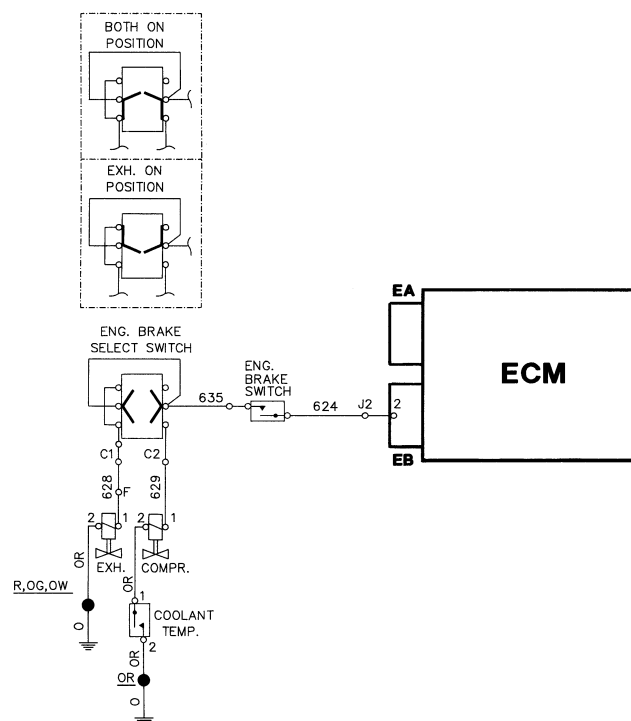
Control System, D12 and D12 A

With the complete release of the accelerator pedal, the engine brake is activated according to the selection made on the dash board, but only if certain conditions are met:

- Accelerator pedal must be fully released (fuel injection must not occur).
- Engine speed must be greater than 1100 rpm.
- Clutch pedal must not be depressed.
- Boost pressure must be lower than 150 kPa (22 psi).
- Constant engine speed mode (PTO) must not be activated.
- Engine brake disabled, input must not be activated (ABS).
- Vehicle speed must be greater than 3.2 km/h (2 mph).
- Engine temperature must be higher than the following:

| Part number of Temperature Switch | Temperature measured at outlet of cooling pump |
|-----------------------------------|--|
| p/n 8155799 | 43°C (110°F) |
| p/n 3985349 | 67°C (158°F) |

As an additional option, the engine brake may be enabled automatically if the vehicle exceeds a specified cruise control limit. If this option is selected, the engine brake may be applied at a selectable speed from 6.4 to 32 km/h (4 to 20 mph) above the cruise control set speed.

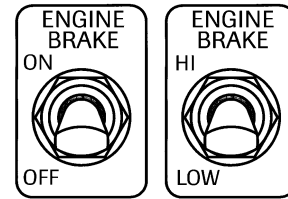


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Fig. 10: Engine brake logic schematic, D12 and D12 A.

Switches

On the dash the switches for the engine brake have different configurations. With the two dual-position switches, the brake system is activated by placing one of the switches in **ON** position. The HI/LO switch, in the HI position, selects both the exhaust brake and the compression brake (Volvo engine brake or VEB). In the LO position, only the exhaust brake is selected.



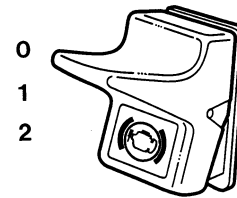
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Fig. 11: Dual-position switches for Engine brake

The engine brake switches are on some truck models replaced by a single three-position switch. As with the switches above it also regulates the engine brake for the cruise control.

The three position switch has the following selection:

- 1 No engine brake engaged
- 2 Exhaust brake, EPG
- 3 Exhaust brake and compression brake



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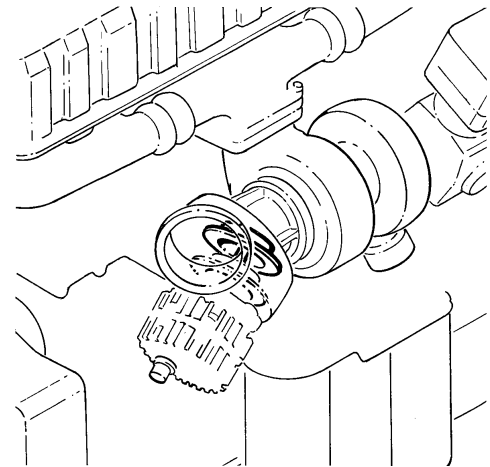
Fig. 12: Three-position switch for engine brake

Exhaust Brake

During exhaust braking, control pressure of about 752 kPa (109 psi) activates the exhaust pressure governor. The exhaust pressure governor plunger is activated and the shutter connected to the plunger restricts the flow of exhaust gases out of the cylinders.

Restricting the flow of exhaust gases creates a back pressure between the shutter and the piston crowns. This provides a braking effect on the pistons as the exhaust valves open.

The higher the engine speed during exhaust braking, the greater the braking effect.



T2006832

Fig. 13: Exhaust pressure governor

Compression Brake

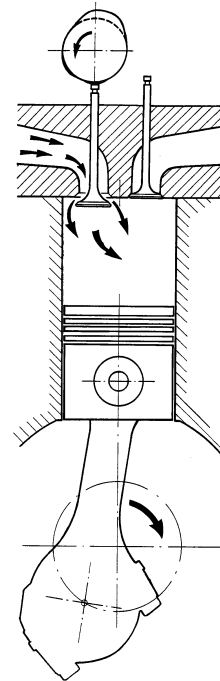
The **exhaust brake is always engaged with the compression brake**. This is because the compression brake induction phase fully utilizes the backpressure created by the exhaust brake in the exhaust manifold.

Induction Phase

The induction phase begins at the end of the intake stroke and continues slightly into the compression stroke.

The piston travels downward toward bottom dead center and the camshaft induction lobe opens the exhaust valves long enough to fill the cylinder with the backpressure created by the exhaust brake in the exhaust manifold.

When the induction lobe closes the exhaust valves, the cylinder has a backpressure at the start of the compression stroke. This backpressure increases compression considerably during the compression stroke which, in turn, creates a powerful braking effect when the piston moves upward.

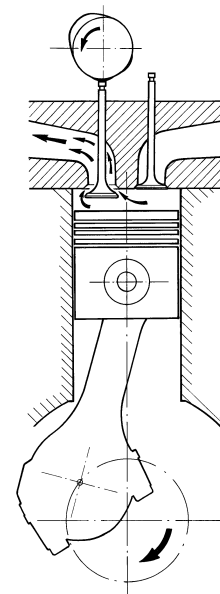


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Fig. 14: Induction phase

Decompression pPhase

At the end of the compression stroke, as the piston approaches top dead center, the camshaft decompression lobe opens the exhaust valves and releases the pressure from the cylinder. Shortly before bottom dead center, the ordinary exhaust lobe opens the exhaust valves. During the exhaust stroke, a backpressure is created in the exhaust manifold. This has a braking effect because the exhaust pressure governor shutter is closed.



T2006831

Fig. 15: Decompression phase

Troubleshooting

Engine Brake, Fault Tracing



DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.



DANGER

When operating a vehicle on streets and highways, during data collection procedure, it is mandatory to have a second person drive while a technician collects the data.



DANGER

Never disconnect an air system component unless all system pressure has been depleted. Failure to deplete system pressure before disconnecting hoses or components may result in their violent separation and can cause serious bodily injury.



WARNING

HOT ENGINE! Keep yourself and your test equipment clear of all moving or hot engine parts. A hot engine can cause serious burns or can permanently damage test equipment.



WARNING

Always wear appropriate eye protection to prevent the risk of eye injury due to contact with engine debris or fluids.



CAUTION

Always clean the engine before servicing and keep the compression brake components clean during all service and repair procedures. Lack of cleanliness during service and repair work could result in a fault or malfunction of the compression brake system.

Basic knowledge of the system description and operation is necessary to perform the troubleshooting procedures in this manual. For basic system knowledge, refer to:

Service Manuals V776–200–820SM
Specifications, VE D12
 284–610, PV776–TSP128229
Engine Control System, VE D12

VEB Diagnosis and Troubleshooting

The D12 engine is equipped with a diagnostic system to simplify troubleshooting.

The first step to take with all troubleshooting should be to check whether the diagnostic system indicates any fault codes.

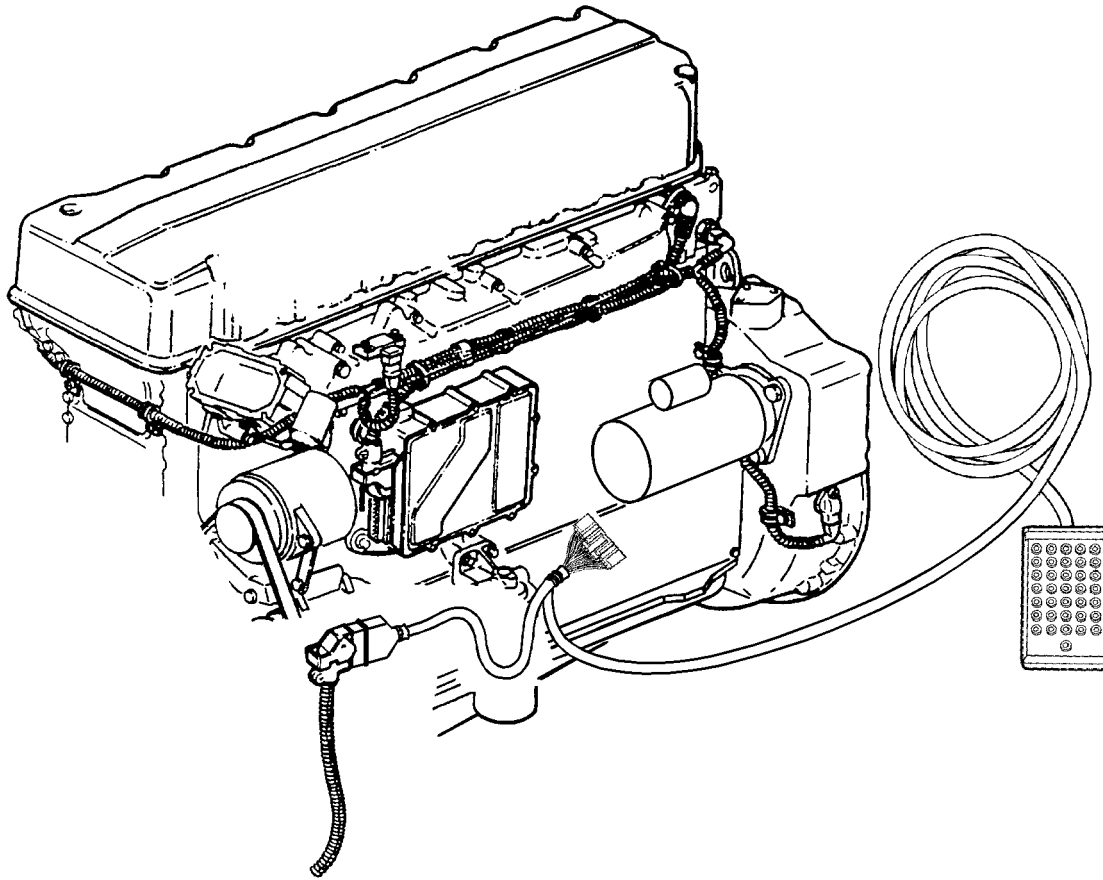
If fault codes are present, these should be corrected before proceeding further with the troubleshooting, even if the fault codes do not indicate a fault that would affect the engine brake system.

If the truck is equipped with ABS, verify that information code 61 is not displayed during the check.

For details about how the fault codes and information codes are interpreted, refer to:

Service Manual 280–600, PV776–TSP105620/1
Fault Codes, Engine Electronic Control Unit

Electrical Troubleshooting



W2002196

Special tools: J-41132

Connecting test equipment

- 1 Make sure that the ignition key is in the "OFF" position.
- 2 Clean the area around the EECU and harness connectors.
- 3 Disconnect the **EB** harness (lower harness). Inspect the harness for corrosion and damage to the connector housing, terminals, and seal. Repair as required.
- 4 Connect the 36-pin breakout box to the **EB** harness only.
Make sure the harness connectors are properly pressed together. Do not force connectors together.

Note: Do **not** connect the breakout box to the EECU.

Voltage measurement

Conditions:

- Engine running
- Engine brake switch in the **ON** position
- Selector switch in the HI position
- Throttle pedal in idle position
- Clutch pedal released
- ABS not activated
- PTO not activated
- Vehicle speed greater than 3.2 km/h (2 mph)
- Sufficient coolant temperature, see table page 12.

| Voltage Measurement | 36-Pin Box Selection | Intended Value | Probable Cause |
|---|----------------------|----------------|---|
| Engine brake supply (if all conditions are met) | 2:9 | B+ | Faulty connection Faulty engine brake switches Faulty harness |

Resistance measurement

Conditions for Resistance Measurements:

- Ignition off
- Engine not running
- Engine brake switch in the **ON** position

Note: Values in table apply to solenoid valve with part no 1610563 and 1610567.

For solenoid valves with part numbers 8143014 and 8143018, please refer to:

Service Manual PV776–280–600SM
Electronic Controls, VE D12, D12 A, D12 B

| Resistance Measurement | 36-Pin Box Selection | Intended Value | Probable Cause |
|---|----------------------|--------------------|--|
| Solenoid valve, exhaust brake (engine brake selector switch in LOW position) | 2:9 | 13 – 16 Ω | Faulty connection Faulty harness Solenoid valve (exhaust brake) Faulty exhaust brake Faulty engine brake switches |
| Solenoid valve exhaust brake and compression brake (engine brake selector in HI position) | 2:9 | 7.5 – 9.5 Ω | Faulty connection Faulty harness Solenoid valve (compression brake) Faulty engine brake switches Faulty VEB coolant temperature switch |

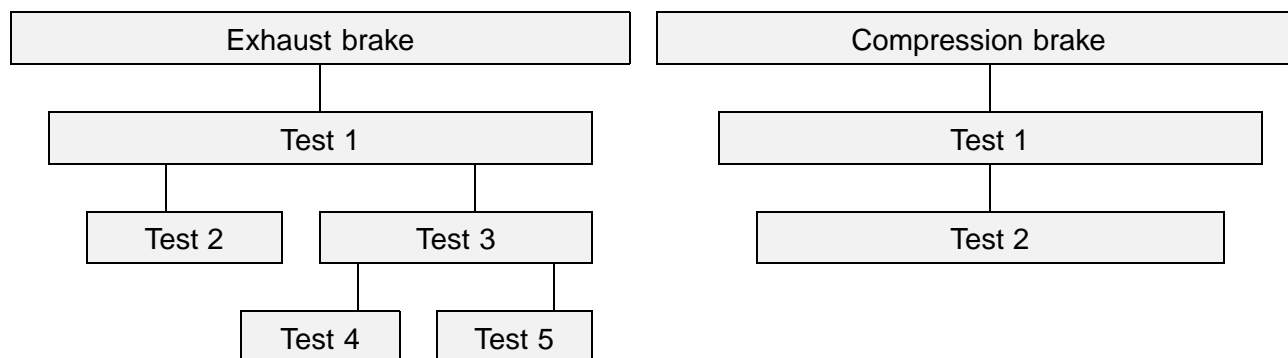
Note: If the multimeter shows 20–22 Ω when the engine brake select switch is in the HI position, the exhaust brake solenoid valve is damaged.

Mechanical Troubleshooting

Conditions

- The electrical troubleshooting has been carried out, or any possible faults in the electrical system can be completely eliminated.
- The truck has full pressure [827 kPa (120 psi)] in the air system.
- The engine has normal oil pressure.
- The engine coolant temperature is at operating temperature.

Service procedures not contained in this information are to be found in the service information for the VOLVO D12 engine under the respective group.



Carry out the tests on the exhaust brake and compression brake in numerical order according to the above diagram, when either one of the brake systems does not work.

If both brake systems work, but give poor braking effect, see “Low Engine Braking Effect (VEB)” page 21.

VEB Troubleshooting, Order to Follow

If the fault remains after correcting any indicated fault codes, and the engine and electrical system function normally, troubleshooting should be performed in the following order:

1

Begin troubleshooting by attempting to establish which of the brake systems is faulty (exhaust brake, compression brake, or both systems).

2

Verify that the following preconditions for **exhaust braking** are satisfied, with the switch(es) on the instrument panel in the ON/LOW (exhaust brake only) positions.

- Accelerator pedal position at 0% (idle position)
- Clutch pedal not depressed
- Engine speed should be greater than 1100 RPM
- PTO not activated
- Vehicle speed should be greater than 3 km/h (2 mph).
- Anti-lock Braking System (ABS) not activated.
- Boost pressure less than 150 kPa (22 psi).

Note: The exhaust brake will engage only when all of these preconditions are satisfied.

Note: When the exhaust pressure governor (EPG) is activated in conjunction with starting, running the engine warm, and keeping the engine warm, other preconditions apply.

3

Verify that the following preconditions for **VEB (exhaust braking and compression braking)** are satisfied, with the switches on the instrument panel in the ON/HI (exhaust brake and compression brake, VEB) positions.

- Accelerator pedal position at 0% (idle position)
- Clutch pedal not depressed
- Engine speed should be over 1100 RPM
- PTO not activated
- Vehicle speed should be greater than 3 km/h (2 mph).
- Anti-lock Braking System (ABS) not activated.
- The coolant temperature should be over 43 °C (110°F), otherwise only the exhaust brake will be engaged.
- Boost pressure less than 150 kPa (22 psi).

Note: An additional option is to have the VEB enable automatically if the vehicle exceeds a specified cruise control limit. If this option is selected, the VEB will automatically engage at a selectable speed approximately 6.4 to 32 km/h (4 to 20 mph) above the set cruise control speed.

4

Always begin with electrical troubleshooting, unless a fault in the electrical system can be completely ruled out.

VEB Fault Symptoms

Fault symptom 1

The engine will not start

Probable fault:

- The control valve plunger may be stuck in its rest position. If this is the case, oil is fed to the rocker arm shaft with full pressure and the plungers in the rocker arm shafts will be pressed out. This will eliminate the valve clearance and the decompression lobes will open the exhaust valves. This impairs the compression build-up and the engine cannot start.

Carry out mechanical troubleshooting.

Fault symptom 2

Neither the exhaust brake nor the compression brake functions

This indicates a fault in the electrical system. The control signal is not reaching the exhaust pressure governor and the control valve solenoid valves.

Carry out electrical troubleshooting.

Fault symptom 3

The exhaust brake functions, but not the compression brake

Probable fault:

- No control signal to the compression brake control valve
- Defective temperature sensor or diode
- Defective control valve or control valve plunger stuck
- No ground at coolant temperature switch
- Drain channel is clogged

Carry out electrical troubleshooting.

If the fault remains:

Carry out mechanical troubleshooting.

Fault symptom 4

The compression brake functions, but not the exhaust brake

Probable fault:

- No or low air pressure supplied to the EPG
- No control signal to the exhaust pressure governor solenoid valve
- Defective solenoid valve
- Defective exhaust pressure governor
- Defective quick-release valve
- Air leakage

Carry out electrical troubleshooting.

If the fault remains:

Carry out mechanical troubleshooting.

Fault symptom 5

Poor braking effect from the exhaust brake

Probable fault:

- Low control pressure supplied to the EPG
- Leaks in the exhaust manifold gaskets
- Exhaust pressure governor seizing
- Defective or leaking exhaust pressure governor

Carry out mechanical troubleshooting.

Fault symptom 6

Poor braking effect from the engine brake (exhaust brake and compression brake)

Probable fault:

- Low control pressure supplied to the EPG
- The control valve gives too low oil pressure
- Defective non-return valve in one or more of the rocker arms
- Defective pressure limiting valve in one or more of the rocker arm plungers
- The exhaust brake functions poorly or not at all
- Exhaust valve clearance is too large

See the procedures in "Low Engine Braking Effect (VEB)" page 21.

Fault symptom 7

The compression brake engages but will not disengage

If the compression brake remains engaged with full effect even though the accelerator pedal is depressed, this is due to the control valve plunger remaining in the "VEB position" and directing full system oil pressure out to the rocker arms.



DANGER

Do not depress the clutch pedal unless necessary. Engine may stop if compression brake stays engaged. This will result in loss of power steering assistance.

If the compression brake only partly disengages, it is most probable that one of the rocker arm plungers has locked in its outer position. With this fault, the engine runs unevenly due to low compression pressure in the cylinder where the rocker arm plunger has stuck.

The fault generates one of the fault codes 31–36, as the control unit compensates for the loss of power in the cylinder by increasing the amount of fuel delivered to the cylinder through the unit injector. When the maximum amount of fuel delivered by the unit injector can not compensate for the loss of power in the cylinder, the fault code is generated.

Carry out mechanical troubleshooting.

Note: Fault codes 31–36 can also be generated by an electrical fault in the fuel system.

Low Engine Braking Effect (VEB)

Note: Before carrying out the following procedure, read the troubleshooting general information in “Engine Brake, Fault Tracing” page 15.

Check Before the Test:

- That the conditions for exhaust braking and compression braking are satisfied.
- That the general condition of the engine is good.
- That the engine has normal oil pressure.
- That both the engine brake systems are functioning.

Check that both the exhaust brake and engine brake are functioning by test-driving the truck.

- Set the engine brake switch to **OFF**.
- Drive the truck downhill, fully release the accelerator pedal and set the switches to ON/LOW positions. If the engine sound does not alter and/or there is no braking effect, the exhaust brake does not function. If the engine sound changes and there is a noticeable braking effect, the exhaust brake does function. Set the switches to ON/HI positions.
- If no difference can be noted in the sound or in the braking effect, the compression brake does not function.
- If the engine sound changes and there is a noticeable braking effect, the compression brake does function.

Check that the valve clearances are within the tolerance range.

Test Equipment, Installation

1

Install the equipment for measuring the oil pressure in the rocker arm shaft according to the instructions in “Oil Pressure, Compression Brake, Checking” page 36.

2

Set the control switches to the **OFF** position (VEB disabled). Start the engine and measure the rocker arm shaft oil pressure. The pressure should be approximately 1 bar (14.5 psi).

If the pressure fluctuates or is under 0.5 bar (7.25 psi) or over 1.5 bar (21.75 psi), the control valve is faulty.

Note: Low oil pressure in the rocker arm shaft may also be due to excessive wear in the rocker arm bushings and /or the rocker arms which result in excessive oil pressure loss. See “Rocker Arm Roller, Checking” page 46.

3

Install the equipment for measuring the exhaust gas temperature, including the 36-pin breakout box. See “Exhaust Temperature, Checking” page 40.

Test-driving and Measuring

To obtain good test results, the exhaust pressure governor should be disabled when checking the function of the compression brake.

- Route the 36-pin breakout box into the cab and secure.
- Make sure the engine brake switch is **OFF**.
- Bridge terminals 2 and 11 of the 36-pin breakout box.



DANGER

When terminals 2 and 11 of the 36-pin breakout box are bridged, the compression brake will activate any time the VEB control switch is in the **ON** position, regardless of status. The compression brake will remain **ON** until the control switch is moved to the **OFF** position. While the engine brake is activated, do not depress the accelerator or clutch. If the accelerator is depressed, engine damage may result. If the clutch is depressed a loss of power steering assist may occur. Be prepared to switch off the engine brake at any time. Failure to do so may result in personal injury or death.



DANGER

When operating a vehicle on streets and highways, during data collection procedure, it is mandatory to have a second person drive while a technician collects the data.

When engine braking, the exhaust gas temperature increases on those cylinders where the compression brake functions.

On the cylinder(s) where there is little or no braking effect there is very little exhaust gas temperature increase, thus, the cylinder which gives a very low or no braking effect can be identified.

Note: The temperature difference between cylinders is not important when performing this test. Only note the difference in temperature at the beginning and end of the engine braking function **on each individual cylinder**.

For the measurement to be valid, select gears, speed and section of road where the braking procedures can be carried out continuously and without interruption.

Select a long, at least 1.2 mile (2 km), downhill section of road, where the engine braking procedures can be carried out without reducing the speed of the truck.

The truck should be loaded and the road conditions clear.

Make sure that the engine brake switch(es) on the instrument panel are in the **OFF** position, until ready to perform the test at the test location.

Voltage supply to the measuring instrument is provided by the cigarette lighter socket and the purpose of the instrument back-up mode is to prevent **stored** information being lost if the external voltage supply is temporarily broken.

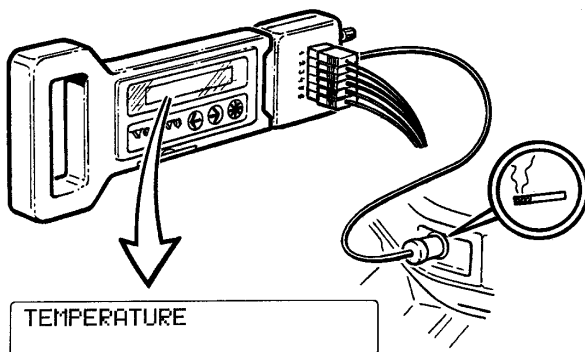
When the external voltage supply is broken, the display lighting goes out and the text begins to flash. If this occurs during measuring, the stored values are retained and the measurement procedure can continue when the instrument voltage supply is restored.

The instrument can store 10 measurement values. The first measurement value is stored as value A, the second measurement value is stored as value B, the third as value C etc. The instrument can also calculate the difference between two measurement values, for example $B - A$, $D - C$, etc.

Note: It is not possible to carry out measurements or store measurement values when the instrument is in the back-up mode.

Brake Test

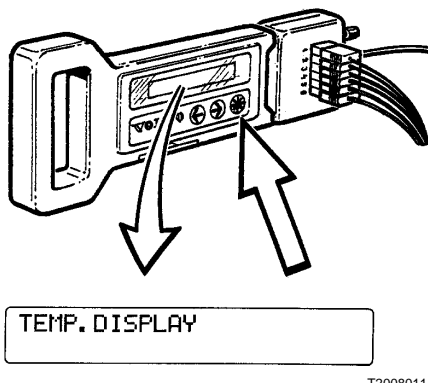
1



T2008010

Check that the measurement instrument display shows the text **Temperature**.

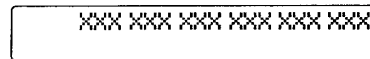
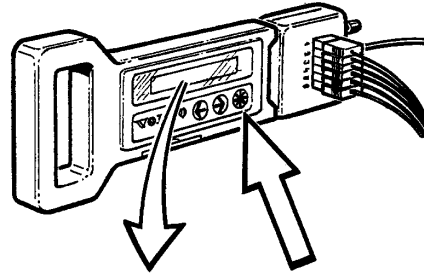
2



T2008011

Press ***** once.
The display should now show the text **Temp. Display**.

3



T2008019

Press ***** one more time.

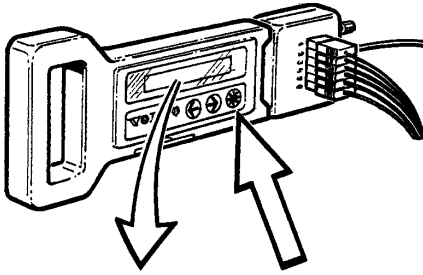
The display should now show six temperature values, one for each cylinder, with no. 1 cylinder shown on the extreme left of the display.

The instrument will now measure temperature continuously.

4

Accelerate the truck and select a gear that enables you to hold a stable engine speed of approximately 1400 RPM when the accelerator pedal is completely released (idle position).
(Use the service brakes as an aid in holding a stable engine speed, as this procedure is to be performed with the engine brake OFF.)

5



A

T2008012

- Completely release the accelerator pedal (idle position).
- While viewing the measurement instrument, wait for the exhaust gas temperature to drop and begin to stabilize.
- Press ***** once.

The measurement value designation A is shown for approximately 1 second on the display and is a confirmation that the value is registered and stored.

The measurement instrument then returns automatically to continuous measurement and shows six measurement values, one for each cylinder.

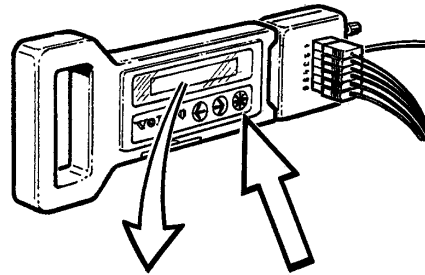
6

**DANGER**

When terminals 2 and 11 of the 36-pin breakout box are bridged, the compression brake will activate anytime the VEB control switch is in the **ON** position, regardless of status. The compression brake will remain **ON** until the control switch is moved to the **OFF** position. While the engine brake is activated, do not depress the accelerator or clutch. If the accelerator is depressed, engine damage may result. If the clutch is depressed a loss of power steering assist may occur. Be prepared to switch off the engine brake at any time. Failure to do so may result in personal injury or death.

Set the engine brake switches to ON/HI. Read the rocker arm shaft oil pressure on the pressure gauge when the pressure has stabilized. Note the value.

7



B

T2008013

- View the measurement instrument, wait for the temperature to rise and begin to stabilize.
- Press ***** once.

The measurement value designation B is shown for approximately 1 second on the display and is a confirmation that the value is registered and stored.

The measurement instrument then returns automatically to continuous measurement.

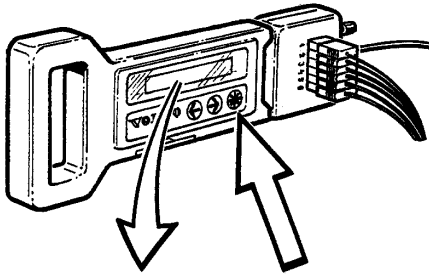
Carry out the brake test and measurements at least three times to obtain a valid result.

Note: Remember the engine brake will remain active until switched **OFF**.

Store the measurement values by pressing *****.

The instrument can store 10 measurement values (the results from 5 measurements of Low / High temperatures per cylinder).

8



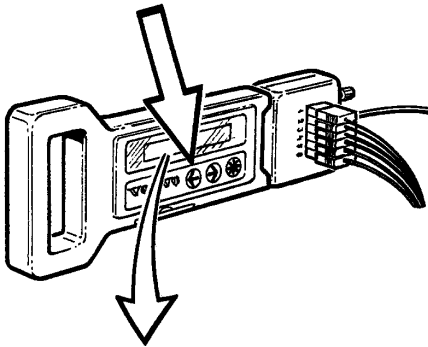
TEMP. DISPLAY

T2008011

When a sufficient number of measurements have been carried out, set the engine brake switch(es) to the **OFF** position and remove the bridge between terminals 2 and 11 at the 36-pin connector.

Hold ***** pressed in (approximately 2 seconds) until the text **Temp. Display** is shown on the display.

9

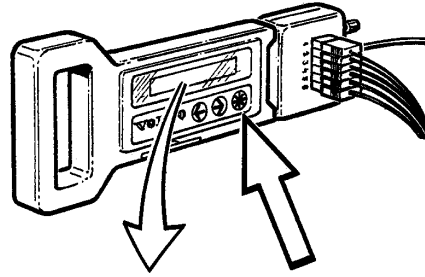


TEMP. EVALUATION

T2008014

Press **←** until the text **Temp. Evaluation** is shown on the display.

10



A XXX XXX XXX XXX XXX XXX

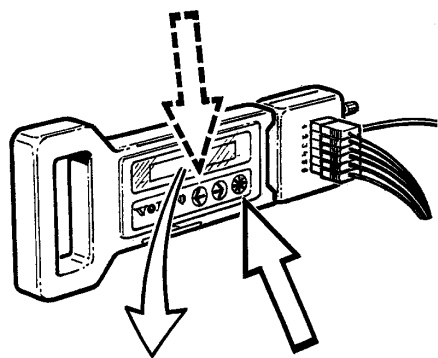
T2008021

Press ***** and the first stored measurement value is displayed. The identification letter A appears before the measurement value.

By pressing **←** or **→** it is possible to view all the values on the display.

By pressing ***** again, the measurement value stored after the letter B is displayed.

11



B-A XXX XXX XXX XXX

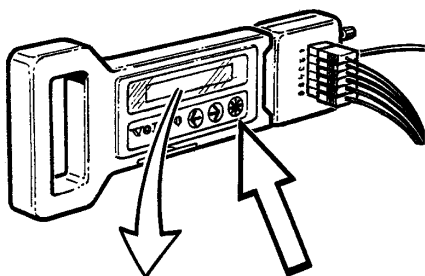
T2008022

By pressing ***** again, the difference between measurement values B and A is shown.

By pressing **←** or **→** it is possible to view all the values on the display.

Note: If the first measurement value is greater than the second, the difference between the values will be shown as a minus value on the display.

12



C XXX XXX XXX XXX XXX XXX

T2008020

Press ***** once.

The first stored value from the second measurement (value C) is shown on the display.

By pressing ***** one more time, the measurement value stored after the letter D is displayed.

By pressing ***** again, the difference between measurement values D and C is shown.

13

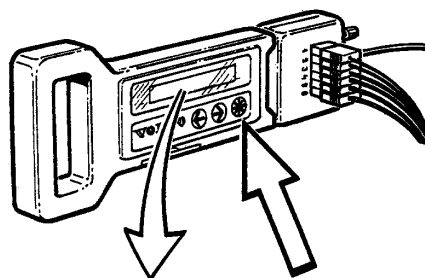
The results from the third, and if necessary, the fourth and fifth measurements are produced in the same way as with measurements one and two.

By pressing *****, it is possible to move between 10 measurement values and 5 differences.

14

Note the measurement results and remember that a fully charged back-up battery retains the stored measurement values in the instrument for **max. 20 minutes** after the external voltage supply has been broken. If possible, do not break the voltage supply to the instrument before all the measurement results have been noted.

15

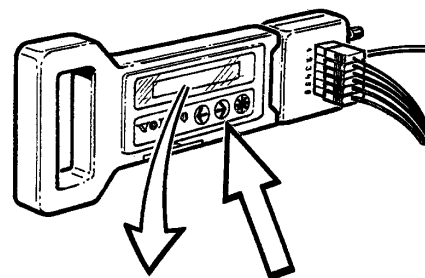


TEMP. EVALUATION

T2008015

Hold ***** pressed in (approx. 2 seconds), when all measurement results have been noted, until the text **Temp. Evaluation** is shown on the display.

16

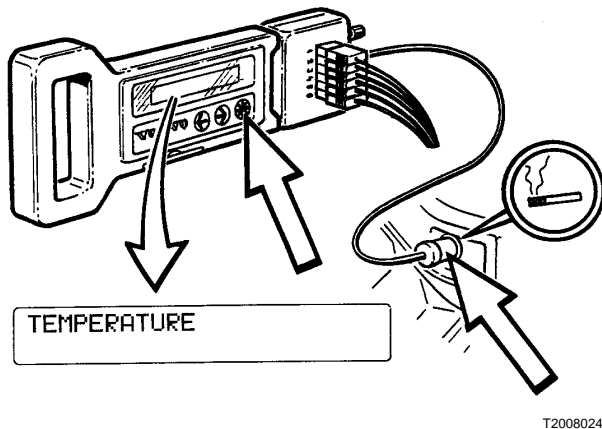


TEMP. DISPLAY

T2008023

Press **→** until the display shows the text **Temp. Display**.

17



By holding ***** pressed in for approximately 2 seconds until the display shows the text **Temperature**, the instrument leaves the back-up mode and **all the stored measurement values are cleared**.

Note: Make sure that the values are noted before the instrument is set in position **Temperature**.

18

Disconnect the electrical plug for the external voltage supply.

Note: Switch the instrument off by holding ***** pressed in for approx. 2 seconds when the display shows the text **Temp. Evaluation** or **Temp. Display**, after the external supply contact has been broken.

Do not leave the instrument in battery back-up mode. The battery will discharge very quickly if the external voltage supply is broken and the instrument has to rely on battery back-up.

19

Evaluate the test.

Evaluation of the Brake Test

When the switch(es) are moved from position **OFF** to positions **ON/HI**, the oil pressure in the rocker arm shaft should rise to min. 2 bar (29 psi).

If the oil pressure does not exceed 2 bar (29 psi), the control valve is faulty.

Note: Low oil pressure in the rocker arm shaft may also be due to excessive wear in the rocker arm bushing and/or rocker arms which result in excessive oil pressure loss. See "Rocker Arm Roller, Checking" page 46.

The temperature increase for each individual cylinder should be between 90°C and 130°C (194°F and 266°F) in order to be certain that the compression brake on each cylinder is functioning properly.

If there is no temperature increase, or if the temperature increase is less than 80°C (176°F) on any individual cylinder, the compression brake on that cylinder is not functioning properly.

If the result of a test is not clear, the test must be repeated. At least three tests should be carried out in order to obtain valid results.

The measured exhaust gas temperature varies between the cylinders, depending on the position of the cylinders.

The cylinders that are positioned nearest the turbocharger will have a higher measured value than those at either end of the cylinder block. This is due to the temperature sensors also being influenced by the passing air flow from the cylinders furthest away from the exhaust manifold outlet.

When evaluating the test, this point should also be taken into consideration.

For example, when comparing cylinders 1 and 6, the temperature increase should more or less be the same, providing that the compression brake is functioning properly on both cylinders.

The same comparison can be made between cylinders 2 and 5 and cylinders 3 and 4.

It should be pointed out that it requires repeated brake testing to be able to obtain an indication that the braking effect on a cylinder is reduced.

In instances where there is no braking effect on a cylinder, there is also no reference to compare an equivalent cylinder with.

The less the braking effect is reduced on a cylinder, the greater the difficulty in identifying the cylinder.

2531-06-02-01

Engine Brake, Checking



DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.



WARNING

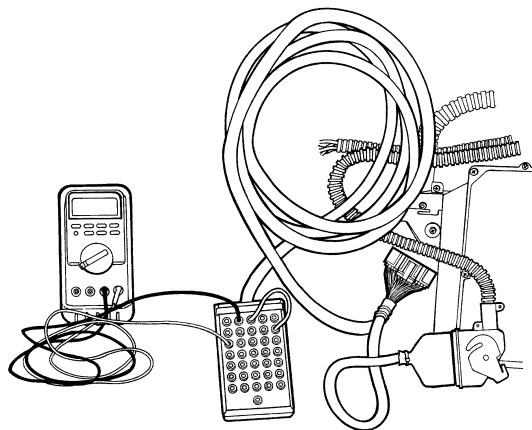
HOT ENGINE! Keep yourself and your test equipment clear of all moving or hot engine parts. A hot engine can cause serious burns or can permanently damage test equipment.

Note: Before carrying out the following procedure, read the troubleshooting general information in "Engine Brake, Fault Tracing" page 15.

Special tools: J-39200 Fluke 87 Multimeter

Measurement 1

1



W2002218

Move the switch(es) on the instrument panel to ON/HI (exhaust brake and compression brake, VEB) positions.

2

Bridge terminals 3 and 10 on the breakout box. Doing so energizes the EECU power supply relay by providing a ground to the coil side of the relay.

3

Set Multimeter to measure **Amps** and connect it to terminals 2 and 11 on the 36-pin breakout box. This supplies battery voltage and measures current draw to the brake circuit (exhaust brake only).

4

An audible "click" should be heard from the exhaust brake solenoid valve when the multimeter is connected.

5

If no "click" is heard from the exhaust brake solenoid valve, and the exhaust brake measurement 1 results were OK, replace the HI/LO switch. Otherwise, proceed to step 6.

6

Disconnect the connector on the exhaust brake solenoid valve.

7

Bridge terminals 3 and 10 on the breakout box.

8

Set Multimeter to measure **Amps** and connect it to terminals 2 and 11 on the 36-pin breakout box.

9

A faint "click" should be heard from the compression brake solenoid valve when the multimeter is connected.

Note: Coolant temperature should be above 43°C (110°F), otherwise VEB coolant switch must have a jumper wire installed.

10

The multimeter should show **0.525 Amp.**

11

If no "click" is heard from the compression brake solenoid valve, or if the multimeter does not show the value 0.525 Amp, carry out **Measurement 2**.

Measurement 2

1

Bridge terminals 2 and 11 on the 36-pin breakout box.

2

Disconnect the 2-pin connector at the exhaust brake solenoid valve and connect the J-42472 breakout harness between the solenoid valve and the wiring harness.

3

Set multimeter to measure **Voltage** and connect it to pins 1 and 2 on the compression brake connector at the upper timing gear cover.

Intended value: B+

4

If the intended value is correct, remove the valve cover and carry out **Measurement 3**.

5

If the intended value is not correct, carry out **Measurement 4**.

Measurement 3

1

Set multimeter to measure **Ohm (Ω)**.

2

Measure between 1 and 2 on the compression brake solenoid valve.

Intended value: $20 \pm 2 \Omega$

3

If the intended value is correct, check the cables between the compression brake solenoid valve and the connector at the upper timing gear cover.

4

If the intended value is not correct, replace the compression brake solenoid valve.

Measurement 4

1

Set Multimeter to measure **Voltage**.

2

Measure between alternate ground and pin 1 in the connector for the control valve solenoid valve at the upper timing gear cover.

Intended value: B+

3

If the value is not correct, check the wire to pin 1 in the connector for the control valve at the upper timing gear cover and to pin 2 at the EB connector including the engine brake switch(es). Make repairs and retest.

4

If the value is correct, measure between alternate battery supply and pin 2 in the connector for the control valve solenoid at the upper timing gear cover.

Intended value: B+

5

If the value is correct, clean and inspect both pins and sockets at the connector for the control valve solenoid. Repeat measurement 1.

6

If the value is not correct, check the wire from pin 2 in the connector for the control valve at the upper timing gear cover to its ground location, including compression brake coolant temperature switch.

2533-06-02-01 Solenoid Valve, Compression Brake, Checking



DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.



DANGER

Never disconnect an air system component unless all system pressure has been depleted. Failure to deplete system pressure before disconnecting hoses or components may result in their violent separation and can cause serious bodily injury.



WARNING

HOT ENGINE! Keep yourself and your test equipment clear of all moving or hot engine parts. A hot engine can cause serious burns or can permanently damage test equipment.



WARNING

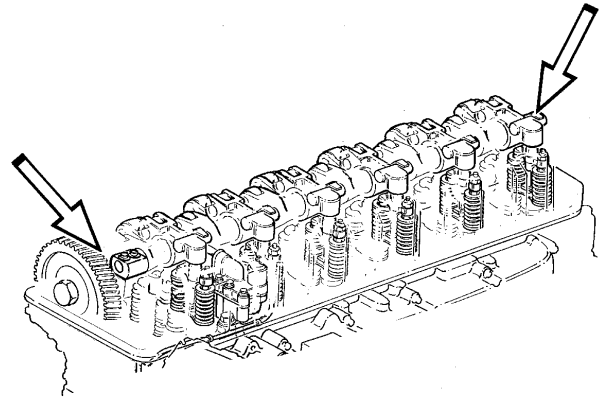
Always wear appropriate eye protection to prevent the risk of eye injury due to contact with engine debris or fluids.

Note: Before carrying out the following procedure, read the troubleshooting general information in "Engine Brake, Fault Tracing" page 15.

Special tools: 9998338, 9998339

Test 1

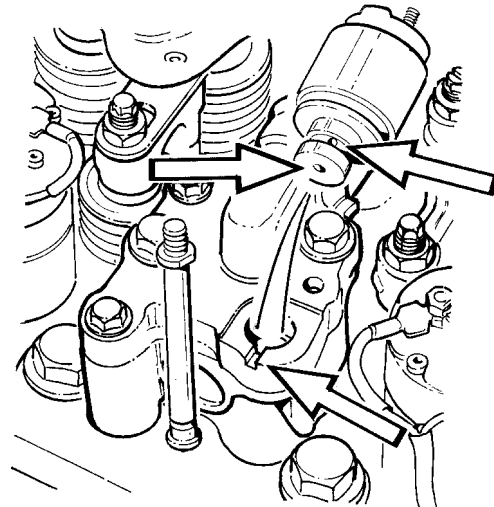
1



T2007704

Remove the valve cover and check that the plugs in the front and rear end of the rocker arm shaft are in position.

2



T2007740

Remove the control solenoid valve and check that the drain holes in the solenoid valve are not clogged.

3

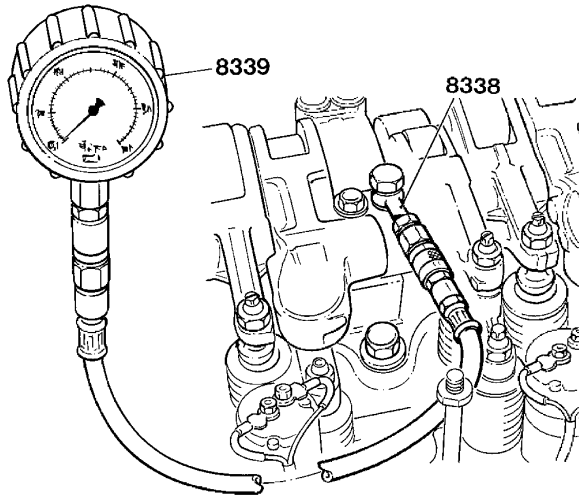
Check that the drain channel in the control valve is not clogged.

4

Check that the valve clearances are within tolerance.

Test 2

1



W2002231

Install the equipment for measuring the oil pressure in the rocker arm shaft according to the instructions in "Oil Pressure, Compression Brake, Checking" page 36.

2

Test-drive the vehicle and allow it to reach operating temperature.

3

Activate the engine brake by making sure the switch(es) on the instrument panel are in the ON/HI position and the conditions for engine braking are satisfied.

4

When the oil pressure has stabilized record the gauge reading during engine brake operation. The pressure should be **at least 2 bar (29 psi)**.

5

Repeat the test a number of times to confirm the measurement reading.

6

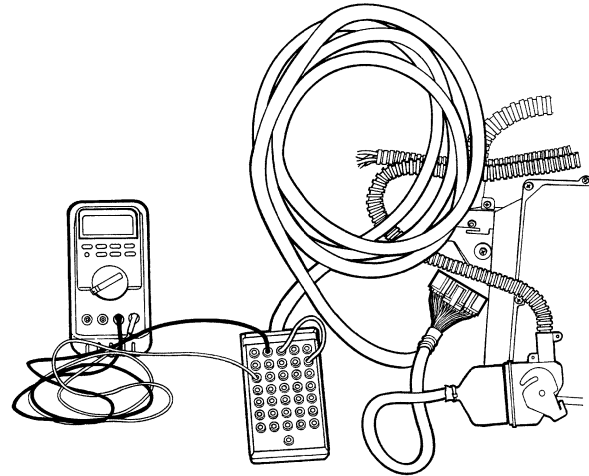
Replace the control valve if the measured pressure is below **2 bar (29 psi)** and the rocker arms, nozzles for lubricating the ball sockets, bushings and other components on the rocker arm bridge are not damaged.

2531-06-02-02

Exhaust Brake, Electronic Checking

Note: Before carrying out the following procedure, read the troubleshooting general information in "Engine Brake, Fault Tracing" page 15.

Special tools: J-3920 Fluke 87 Multimeter



W2002218

Measurement 1

1

Move the switch(es) on the instrument panel to ON/LOW (exhaust brake only) positions.

2

Bridge terminals 3 and 10 on the breakout box. Doing so energizes the EECU power supply relay by providing a ground to the coil side of the relay.

3

Set Multimeter to measure **Amps** and connect it to terminals 2 and 11 on the 36-pin breakout box. This supplies battery voltage and measures current draw to the brake circuit (exhaust brake only).

4

An audible "click" should be heard from the exhaust brake solenoid valve when the multimeter is connected.

5

The multimeter should show **0.7 ± 0.1 Amp**.

6

If no "click" is heard from the exhaust brake solenoid valve, or if the multimeter does not show the value 0.7 ± 0.1 Amp, proceed to the next measurement.

Measurement 2**1**

Bridge terminals 2 and 11 on the 36-pin breakout box in addition to the connections in measurement 1.

2

Disconnect the 2-pin connector at the exhaust brake solenoid valve and connect the J-42472 breakout harness between the solenoid valve and the wiring harness.

3

Set multimeter to measure **Voltage**. Measure between pins 1 and 2 on the breakout harness. **Intended value: B+ (battery positive voltage ~12V).**

4

If the intended value is correct, replace the exhaust brake solenoid valve.

5

If the intended value is not correct, carry out **Measurement 3**.

Measurement 3**1**

Set multimeter to measure **Voltage**.

2

Measure between alternate ground and pin 1 in the breakout harness.

Intended value: B+

3

If the intended value is correct, check the cable from pin 2 in the connector for the exhaust brake solenoid valve to ground.

4

If the intended value is not correct, check the wire between pin 1 in the connector for the exhaust brake solenoid valve and pin 2 at connector EB, including the engine brake switch(es).

Measurement 4**1**

Note: A functional diode allows current to flow in one direction only. Connect the J-42472 2-pin breakout harness to the exhaust brake solenoid only.

Note: Do not connect to the engine harness.

2

Select the diode test on the Fluke 87 or equivalent multimeter.

3

Touch the red probe to the positive side of the diode (pin 1 of the J-42472 breakout harness) and the black probe to the negative side of the diode (pin 2 of the breakout harness).

4

If the diode is good, the voltage drop should typically be 0.5 V to 0.8 V.

5

Reverse the probes and measure the voltage across the diode again. If the diode is good, the display will show OL (overload).

6

If the display shows 0.00 in both directions, the diode is shorted. If the display shows OL in both directions, the diode is open. Replace the solenoid. See "Solenoid Valve, Compression Brake, Replacement" page 51.

2531-06-02-03

Exhaust Brake, Mechanical Checking

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

WARNING

HOT ENGINE! Keep yourself and your test equipment clear of all moving or hot engine parts. A hot engine can cause serious burns or can permanently damage test equipment.

WARNING

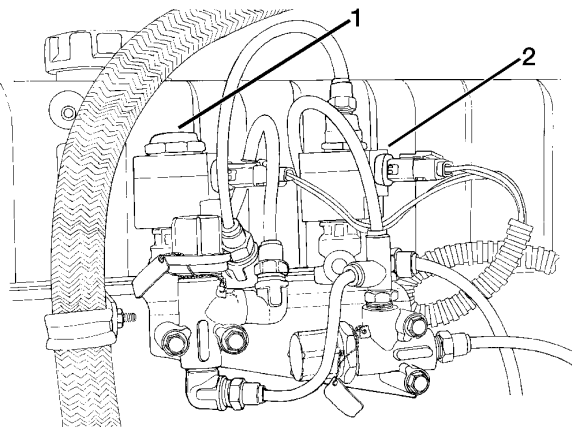
Always wear appropriate eye protection to prevent the risk of eye injury due to contact with engine debris or fluids.

Note: Before carrying out the following procedure, read the troubleshooting general information in "Engine Brake, Fault Tracing" page 15.

Special tools: 9996465, 9998333

Test 1

1



W2002234

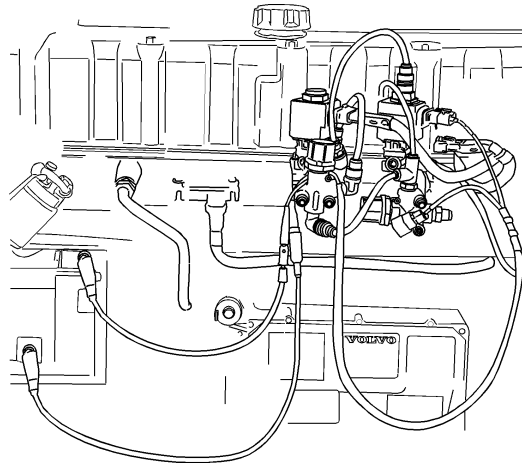
- 1 EPG solenoid (cold mode)
- 2 Exhaust brake solenoid

Verify proper wiring to solenoids. Wire 628 to the exhaust brake solenoid and wire 636k to the exhaust pressure governor (EPG) solenoid.

2

Verify correct air regulator valve is used with the proper system. The exhaust brake requires the 7.5 bar regulator, while the EPG utilizes a 2.3 bar regulator.

3



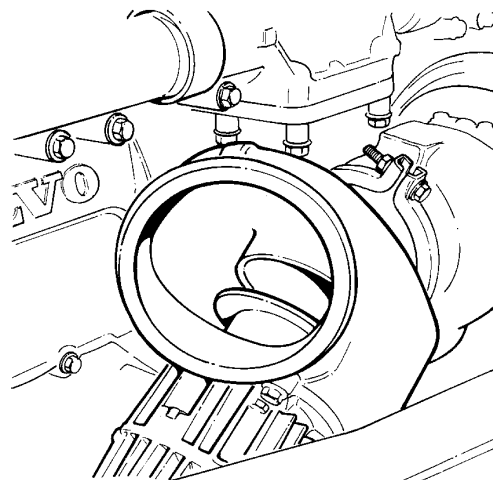
W2002198

VN solenoid location — other vehicles have solenoids located on bulkhead

Connect the J-42472 2-pin breakout harness to the exhaust brake solenoid valve, using 2 jumper wires with "alligator" type ends, supply the solenoid with an alternate ground and B+ and listen to hear if the exhaust pressure governor shutter moves.

Note: Make sure that pin 1 of the J-42472 is connected to B+ and pin 2 is connected to B-.

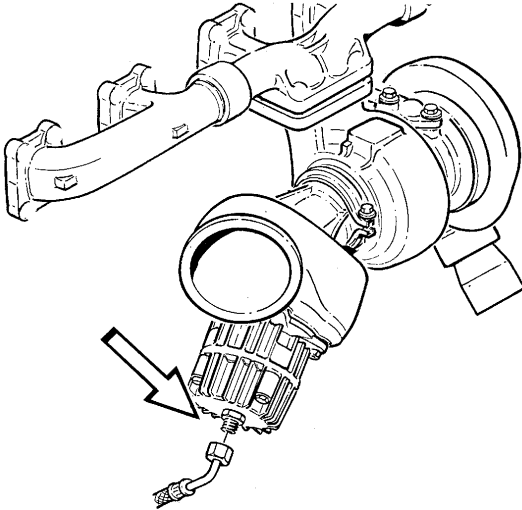
4



T2007700

If the exhaust pressure governor shutter moves, carry out test 3.

5



T2007701

If the exhaust pressure governor shutter does not move, remove the air hose from the exhaust pressure governor and activate the exhaust brake solenoid valve again.

6

If no air comes out of the hose, carry out **Test 2**.

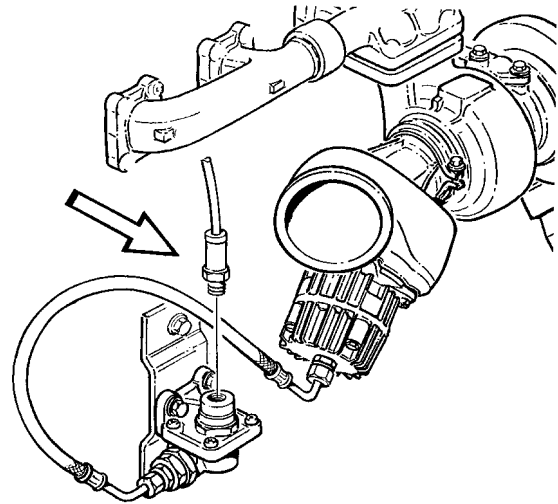
If air comes out of the hose, carry out **Test 3**.

Test 2

1

Check that the air hoses are not twisted or blocked.
Replace damaged hoses.

2



T2007953

Remove the air hose from the quick release valve and activate the exhaust brake solenoid valve.

If air comes from the hose, the quick release valve is faulty and should be replaced.

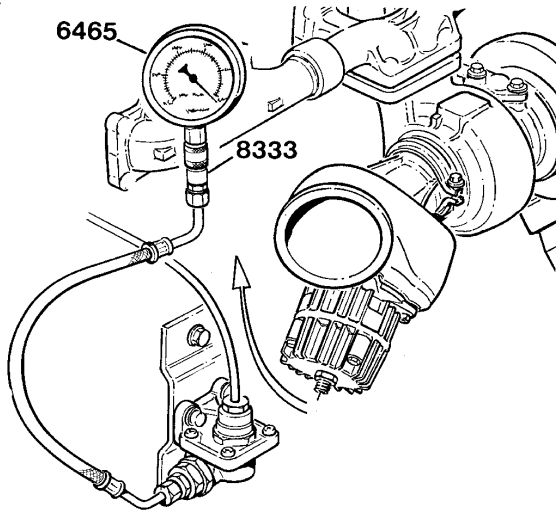
3

If no air comes out of the hose, check that air reaches the exhaust brake solenoid valve.

If air reaches the exhaust brake solenoid valve, the valve is faulty and should be replaced.

4

If no air reaches the exhaust brake solenoid valve, check that air reaches the regulator valve for the exhaust brake solenoid. If no air reaches the air regulator valve, check or replace the air supply hose. If air reaches the air regulator valve, then the air regulator valve is faulty and should be replaced.

Test 3**1**

Connect the pressure gauge to the exhaust pressure governor hose and activate the exhaust brake solenoid valve.

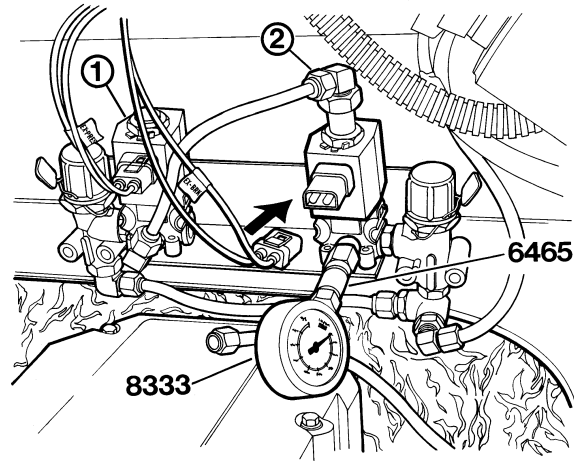
T2007707
999 6465
999 8333

2

If the pressure is too high or too low, carry out **Test 4**.
If the pressure is within the tolerances, carry out **Test 5**.

Test 4**1**

Check that the hoses are not twisted or blocked. 999 6465
Replace damaged hoses. 999 8333

2

W2002211

1 EPG solenoid (cold mode)
2 Exhaust brake solenoid
Solenoids are located on the bulkhead; VN vehicles have solenoids mounted on the engine

Remove the hose from the exhaust brake solenoid valve and measure the output pressure. The pressure should be **7.5 ± 0.3 bars (109 ± 4.4 psi)**.

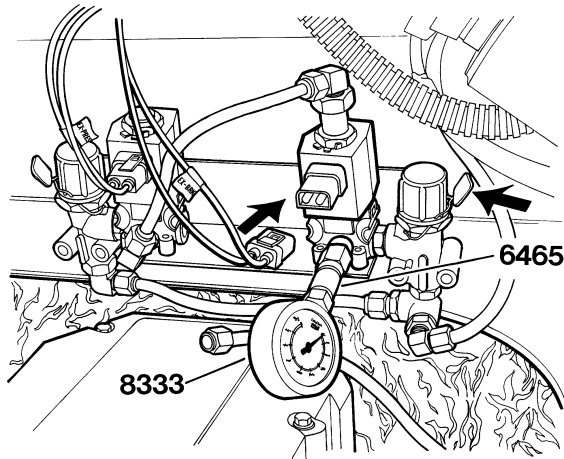
DANGER

Never disconnect an air system component unless all system pressure has been depleted. Failure to deplete system pressure before disconnecting hoses or components may result in their violent separation and can cause serious bodily injury.

3

If the pressure is within the tolerances, the quick release valve is faulty and should be replaced.

4



W2002212

If the pressure is too high, go to step 4.
If the pressure is too low, go to step 5.

Note: Trucks with a higher system pressure than 7.5 bar (109 psi) are equipped with an adjustable reduction valve to reduce the pressure to the exhaust pressure governor.

5

Adjust the valve setting to specified pressure. If pressure will not respond to adjustment, replace regulator. After adjustment, the knob on the valve should be sealed or made tamper proof.

6

Check the outlet pressure of the regulator going to the exhaust brake solenoid.

Intended value: 752 ± 30 kPa (109 ± 4.4 psi)

7

Pressure OK:

- Restriction in line from regulator valve to exhaust brake solenoid. (VN series)
- Faulty solenoid.

8

Pressure not OK:

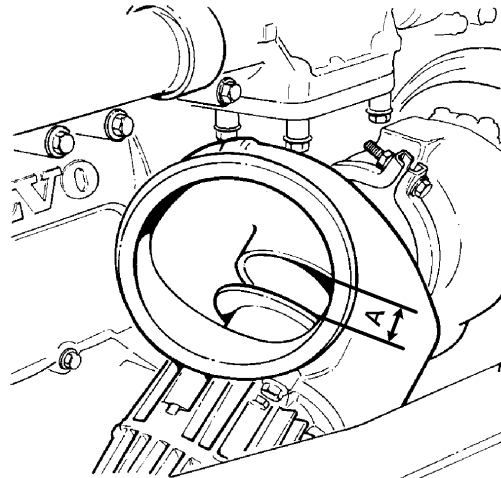
- Regulator valve out of adjustment or faulty.
- Insufficient supply pressure.

Test 5

1

Remove the exhaust pipe from the shutter housing.

2



W2002189

Measure the opening between the shutter disk and shutter housing (A), to check that the EPG shutter has not jammed in the closed or half-closed position.

The value (measurement A) should be 30 ± 2 mm (1.18 ± .08 in).

3

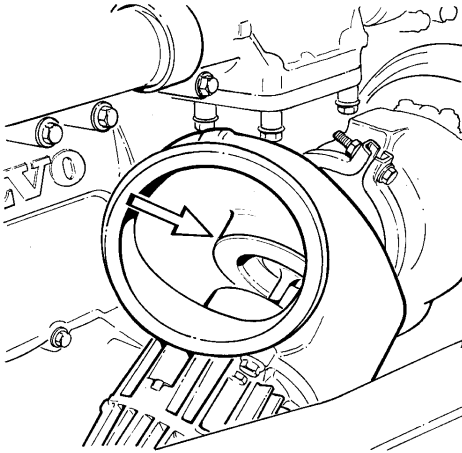
If the value is correct, replace or overhaul the EPG in accordance with the procedures found in:

| | |
|----------------|------------------------------------|
| Service | V776-250-600SM |
| Manual | Intake and Exhaust Systems, VE D12 |

4

Activate the exhaust brake solenoid valve.

5



T2007703

Check if the exhaust pressure governor shutter seals against the shutter housing.

6

If the shutter does not seal against the housing, replace or overhaul the exhaust pressure governor according to the procedures found in:

Service Manual V776-250-600SM
Intake and Exhaust
Systems, VE D12

7

If the shutter seals against the housing, remove the exhaust pressure governor and check the shutter and shutter housing.

2533-06-02-02

Oil Pressure, Compression Brake, Checking



DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.



DANGER

Never disconnect an air system component unless all system pressure has been depleted. Failure to deplete system pressure before disconnecting hoses or components may result in their violent separation and can cause serious bodily injury.



WARNING

HOT ENGINE! Keep yourself and your test equipment clear of all moving or hot engine parts. A hot engine can cause serious burns or can permanently damage test equipment.



WARNING

Always wear appropriate eye protection to prevent the risk of eye injury due to contact with engine debris or fluids.

(Measured at rocker shaft.)

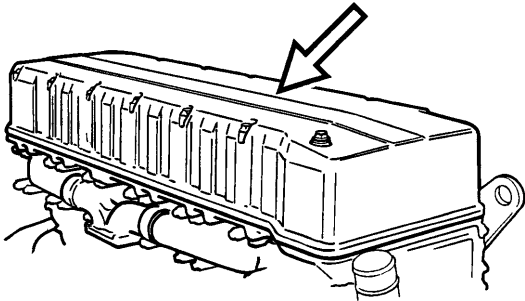
Special tools: 9998338, 9998339, J-41203
(Kent Moore)

Installation

1

Set the parking brake.

2

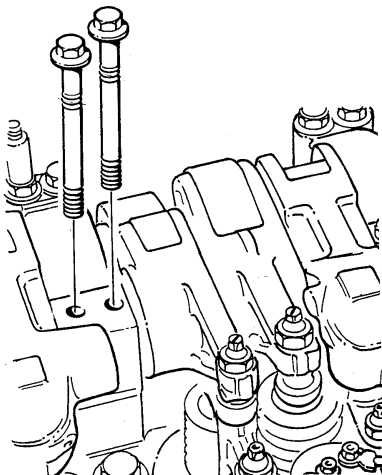


T2006731

Remove the valve cover.

Note: With older engines avoid damage to the valve cover and internal injector cable harness by making sure the mounting screws do not unscrew from the cylinder head during removal. **Do not** use impact tools to remove the nuts securing the valve cover.

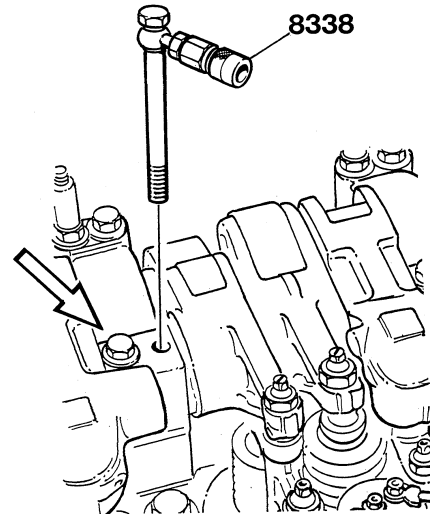
3



T2008279

Remove the bolts retaining the rocker arm bridge between cylinders 4 and 5. Remove the spring washer.

4



T2008278

Reinstall the front bolt **without** the spring washer. Install bolt 9808001 with connector 9998338 into the rear bolt hole and tighten both bolts.

9998338

Note: Bolt 9808001 must be used. It has been modified and is shorter than the previous version and does not use a sleeve.

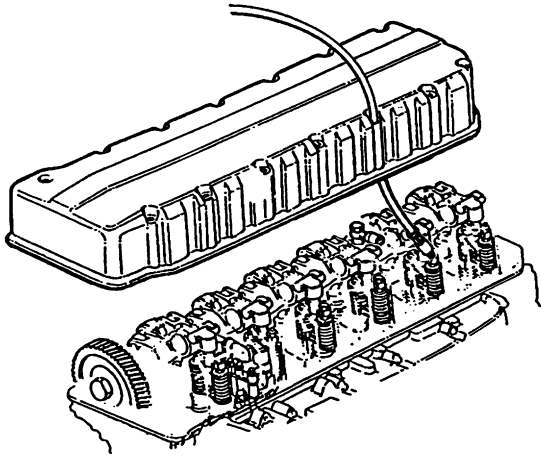
5

Remove the valve cover stud located between no. 4 and 5 injector solenoids.

J-41203

Note: Use Kent Moore tool J-41203 to remove the stud on earlier D12 engines.

6



W2002199

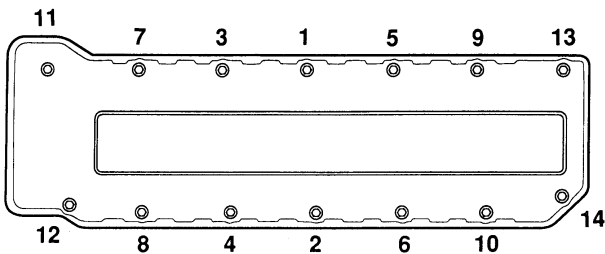
Route the oil pressure hose through the hole in the valve cover where the stud has been removed. Connect the oil pressure hose to connector 9998338.

Note: Check that connector 9998338 and the oil pressure hose do not obstruct the rocker arms. If necessary, use cable ties to prevent the oil pressure hose from being damaged by the rocker arms.

7

Install the valve cover and make sure the oil pressure hose does not interfere with any part of the valve mechanism.

8

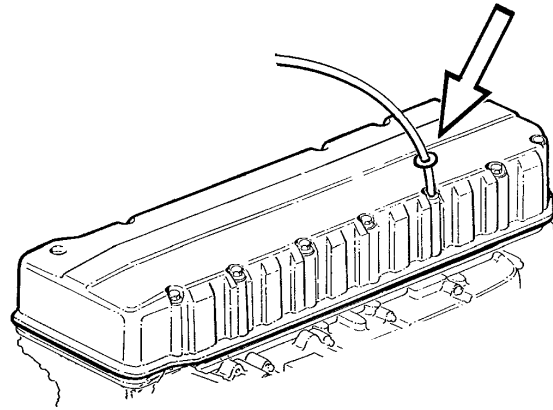


T2007003

Tighten the valve cover nuts to 30 ± 3 Nm (22 ± 2 ft-lb). Follow the tightening sequence shown.

30 ± 3 Nm
(22 ± 2 ft-lb)

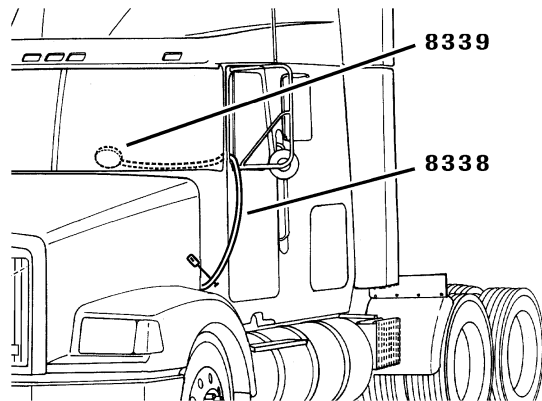
9



W2002200

Install the seal for the oil pressure hose into the hole in the valve cover. Make sure the seal fits into the stud hole in the valve cover.

10



W2002213

Route the oil pressure hose into the cab as shown. Install pressure gauge 9998339

9998339

Note: Secure the oil hose with cable ties to prevent kinks that would restrict flow.

Testing

1
Set the control switches to the **OFF** position (VEB disabled). Start the engine and measure the rocker arm shaft oil pressure. The pressure should be approximately 1 bar (14.5 psi).

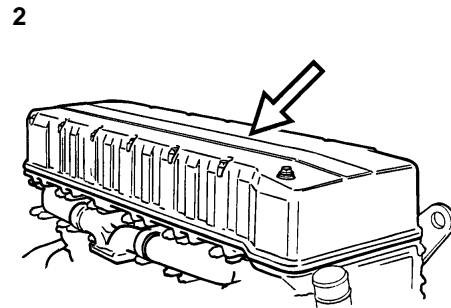
2
If the pressure fluctuates or is under 0.5 bar (7.25 psi) or over 1.5 bar (21.75 psi), the control valve is faulty.

Note: Low oil pressure in the rocker arm shaft may also be due to excessive wear in the rocker arm bushings and/or the rocker arms which result in excessive oil pressure loss. See "Rocker Arm Roller, Checking" page 46.

3
Install the equipment for measuring the exhaust gas temperature, including the 36-pin breakout box. See "Exhaust Temperature, Checking" page 40.

Removal

1
Set the parking brake. Remove the pressure gauge and oil pressure hose from the cab. Cut the oil hose free from the cable ties and disconnect the pressure gauge.



T2006731

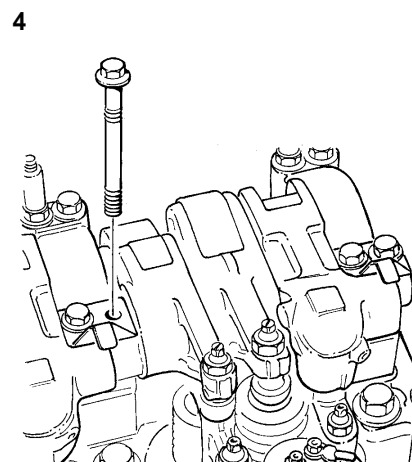
Remove the valve cover.



CAUTION

With older engines avoid damage to the valve cover and internal injector cable harness by making sure the mounting screws do not unscrew from the cylinder head during removal. **Do not** use impact tools to remove the nuts securing the valve cover.

3
Remove the oil pressure hose from connector 9998338. Pull the oil pressure hose through the valve cover and remove the oil seal.



T2007708

Remove connector 9998338 and bolt 9808001 from the rocker arm shaft. Install the spring washer and the two rocker arm bridge bolts.

5

Tighten the rocker arm bridge bolts in two steps:

- 1 Torque to 15 Nm (11 ft-lb).
- 2 Tighten both bolts an additional 90°.

15 Nm
(11 ft-lb)

6

Clean the threaded hole in the cylinder head where the valve cover stud was removed. Clean the valve cover stud bolt and apply locking fluid. Torque the stud to 48 ± 8 Nm (35 ± 6 ft-lb).

J-41203
 48 ± 8 Nm
(35 ± 6 ft-lb)

Carefully remove any excess locking fluid after the stud bolt has been tightened.

Note: Use Kent Moore tool J-41203 on early D12 engines to torque the stud.

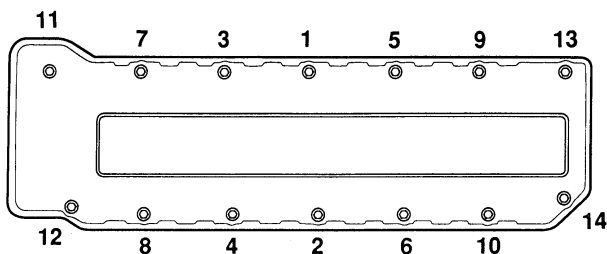
7

Press the electronic cable clamp onto the stud bolt.

Note: The electronic cable must be positioned on the outside of the valve cover studs.

8

Install the valve cover.

9

T2007003

Tighten the valve cover nuts to 30 ± 3 Nm (22 ± 2 ft-lb). Follow the tightening sequence shown.

30 ± 3 Nm
(22 ± 2 ft-lb)

10

Test run engine and check for oil leaks.

2515-06-02-01 Exhaust Temperature, Checking

**DANGER**

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

**WARNING**

HOT ENGINE! Keep yourself and your test equipment clear of all moving or hot engine parts. A hot engine can cause serious burns or can permanently damage test equipment.

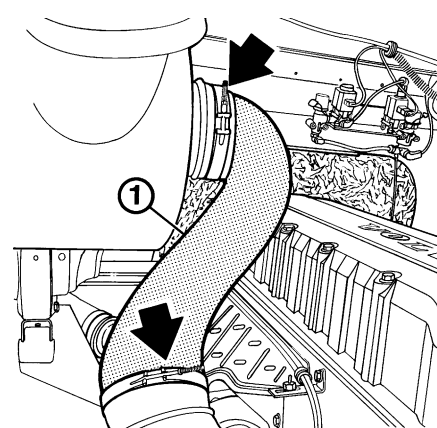
**WARNING**

Always wear appropriate eye protection to prevent the risk of eye injury due to contact with engine debris or fluids.

Special tools: 9998190, 9998342, 9998364, J-41132

Installation**1**

Set the parking brake.

2

W2002214

Disconnect the pipe from the air compressor and remove the intake pipe between the air cleaner and turbocharger.

3

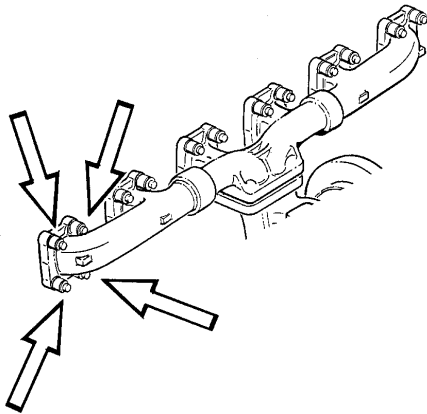
Remove bolts and spacers fastening the heat shield to the exhaust manifold.

4

Disconnect the air compressor discharge line and lay aside.

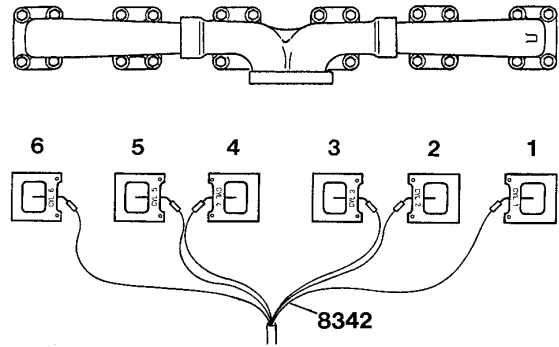
5

Unbolt the oil supply line at the turbo only.

6

T2007719

Loosen the exhaust manifold bolts just enough so that some threads remain in the cylinder head.

7

T2008047

9998342

Insert the temperature sensors between the exhaust manifold and the cylinder head.

Insert the temperature sensors far enough that the guide pins are against the edge of the exhaust manifold.

Note: The temperature sensors are numbered from one to six for the respective cylinders.

Make sure that the sensors are installed to the correct cylinders.

The sensors can be installed on either side of the gasket.

(The gaskets are replaced after the test.)

8

Tighten the exhaust manifold bolts.

9

Tighten the oil supply line at the turbo.

10

Connect the air compressor discharge line.

11

Secure the temperature sensor cables with cable ties away from the exhaust manifold and to avoid damage during testing.

Route the cables into the cab for connection to the measuring instrument.

12

Install the intake pipe between the air cleaner and the turbocharger. Connect the pipe to the air compressor.

13

Make sure that the ignition key is in the **OFF** position.

14

Clean the area around the EECU and harness connectors.

15

Disconnect the **EB** harness (lower harness) from the EECU and connect the 36-pin breakout box between the **EB** harness and the EECU.

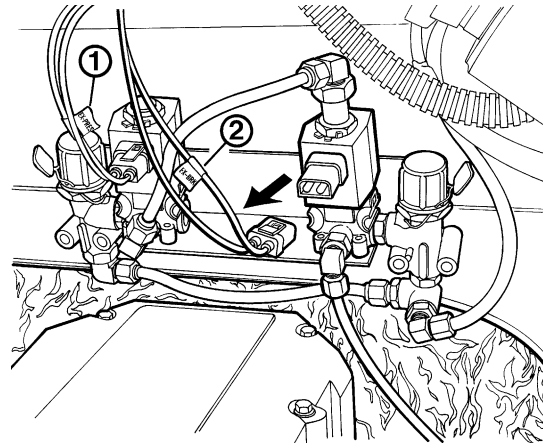
Make sure the harness connectors are properly pressed together. Do not force the connectors together.

16

Route the 36-pin breakout box into the cab and secure.

**DANGER**

When terminals 2 and 11 of the 36-pin breakout box are bridged, the compression brake will activate anytime the VEB control switch is in the **ON** position, regardless of status. The compression brake will remain **ON** until the control switch is moved to the **OFF** position. While the engine brake is activated, do not depress the accelerator or clutch. If the accelerator is depressed, engine damage may result. If the clutch is depressed a loss of power steering assist may occur. Be prepared to switch off the engine brake at any time. Failure to do so may result in personal injury or death.

17

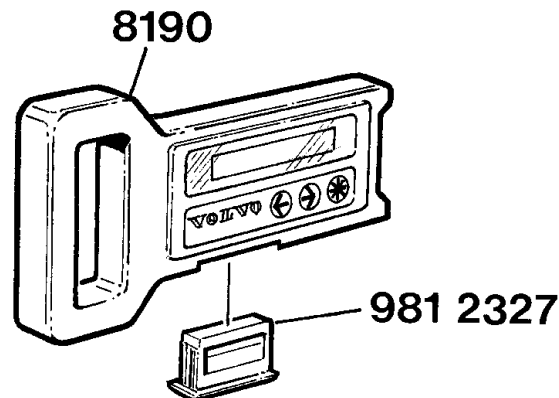
W2002215

1 EPG solenoid wiring harness

2 Exhaust brake solenoid wiring harness

Remove the connector from the exhaust brake solenoid valve.

Note: A more reliable measurement result is obtained when the exhaust brake is disabled.

*Measurement instrument 9998190***1**

T2008016

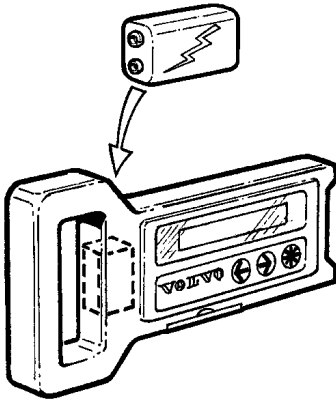
Check that the correct program unit is installed in measurement instrument 9998190.

9998190

9812327

Note: When temperature measuring, program unit **9812327** is required.

2



T2008017

Make sure that a back-up battery is installed in measurement instrument 9998190.

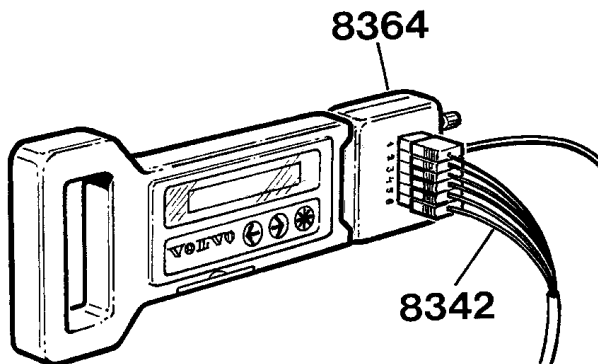
The back-up function is there to make sure that the stored information is not lost in the event of a temporary loss of supply voltage.

With a fully charged battery, the stored values in the instrument are retained for **max. 20 minutes** after the external voltage supply has been broken. Always make sure that the battery is fully charged when temperature measurement is to be carried out.

Note: Only use a 9 Volt rechargeable nickel-cadmium battery in the measurement instrument.

Collation unit 8364

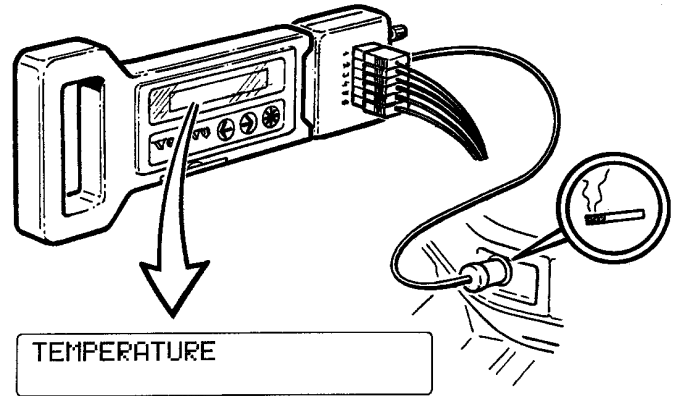
1



T2008018

Connect the collation unit to the measurement instrument and plug in the numbered electrical connectors from the temperature sensors to the numbered positions in the collation unit connection panel.

2



T2008010

Connect the collation unit electrical cable to the cigarette lighter socket and turn the ignition key to "ON" position.

Note: Check that the text **Temperature** is shown on the measurement instrument display. The measurement instrument automatically selects the temperature measurement function when the collation unit is connected.

Removal

1

Set the parking brake. Take the measurement instrument and temperature sensor electrical cables out of the cab.

2

Remove the cable ties and the electrical sensor cables.

3

Disconnect the pipe from the air compressor and remove the intake pipe between the air cleaner and turbocharger.

4

Remove the 4 mounting bolts and lift away the air filter housing.

5

Disconnect the oil supply line to the air compressor at the oil filter housing and remove the line clamp.

Note: Cover the fitting and the end of the line to keep out any debris.

6

Remove the 2 bolts attaching the lower charge air cooler pipe to the turbo and the bolt supporting the lower end of the pipe.

7

Pry the charge air cooler pipe away from the turbo and remove the end adapter for more clearance.

8

Remove the shutter housing turbo clamp. Move the shutter housing away from the turbo and let it rest on the frame.

9

Blow all debris away from the area where the turbocharger oil supply line enters the oil filter base. Remove the 2 bolts fastening the supply line to the turbocharger and remove the line.

Note: Cover the open hole in the oil filter base to prevent debris from entering.



CAUTION

In order to prevent personal injury, always wear safety glasses when working with compressed air.

10

Remove the 2 bolts fastening the oil drain back tube to the turbo.

11

Remove the 4 bolts mounting the turbo to the exhaust manifold and lift off the turbo.

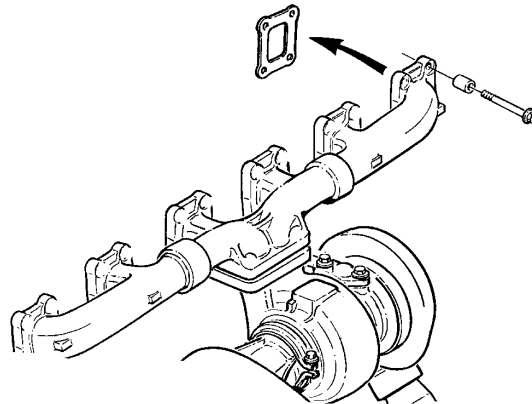
12

Remove the exhaust manifold mounting bolts and lift the manifold away from the engine.

13

Remove all of the temperature sensors.

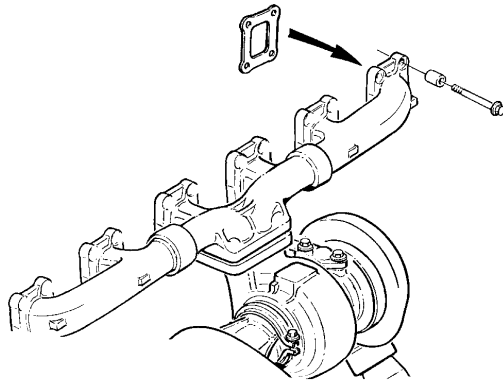
14



T2007717

Clean the cylinder head and exhaust manifold contact surfaces.
Blow clean with compressed air.

15

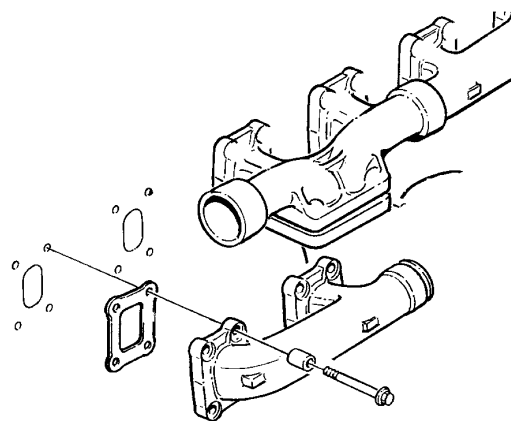


T2007718

Glue the new gaskets onto the exhaust manifold with the correct side facing the manifold.

Note: The marking "MANIFOLD SIDE" should be turned toward the exhaust manifold.

16

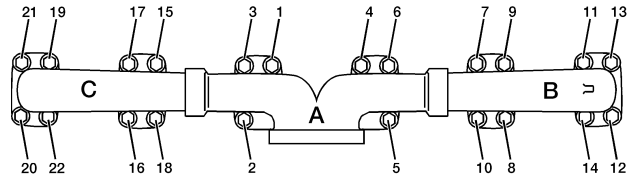


T2007724

Install 2 alignment dowels in the cylinder head to help position the manifold. Install the exhaust manifold and the corresponding bolts.

Note: Make sure that the sleeves are properly positioned in the counterbore of the manifold flange.

17



W2002224

Tighten all the exhaust manifold bolts to a torque of 48 ± 8 Nm (35 ± 6 ft-lb).

48 ± 8 Nm
(35 ± 6 ft-lb)

Use the torque tightening sequence shown.

18

Note: Make sure that all gasket surfaces on the turbocharger are free of gasket material and clean. Make sure that there is nothing inside the exhaust manifold or air piping e.g. debris from a previous failure.

Install the turbocharger with a new mounting gasket onto the exhaust manifold. Torque mounting nuts to 48 ± 8 Nm (35 ± 6 ft-lb).

48 ± 8 Nm
(35 ± 6 ft-lb)

19

Position the shutter housing and exhaust piping onto the rear of the turbocharger. Install clamp and torque to 24 ± 2 Nm (18 ± 2 ft-lb).

24 ± 2 Nm
(18 ± 2 ft-lb)

20

Connect the oil return tube (using a new gasket) to the turbocharger. Torque bolts to 24 ± 4 Nm (18 ± 3 ft-lb).

24 ± 4 Nm
(18 ± 3 ft-lb)

21

Install the oil supply tube with a new seal and gasket. Torque bolts to 24 ± 4 Nm (18 ± 3 ft-lb).

24 ± 4 Nm
(18 ± 3 ft-lb)

Note: Make sure the port in the oil filter housing for the oil supply tube and seal assembly is clean and smooth, also before installing the supply tube, pre-lubricate the turbo with clean engine oil.

22

Connect the lower charge air cooler pipe and adapter with new O-ring seals to the turbo. Install and torque the 3 charge air cooler pipe support bolts to 24 ± 4 Nm (18 ± 3 ft-lb).

24 ± 4 Nm
(18 ± 3 ft-lb)

Note: To make installation easier, apply a soapy solution to the O-rings prior to installation.

23

Connect the air compressor oil supply line and support clamp. Torque the clamp bolt to 24 ± 4 Nm (18 ± 3 ft-lb).

24 ± 4 Nm
(18 ± 3 ft-lb)

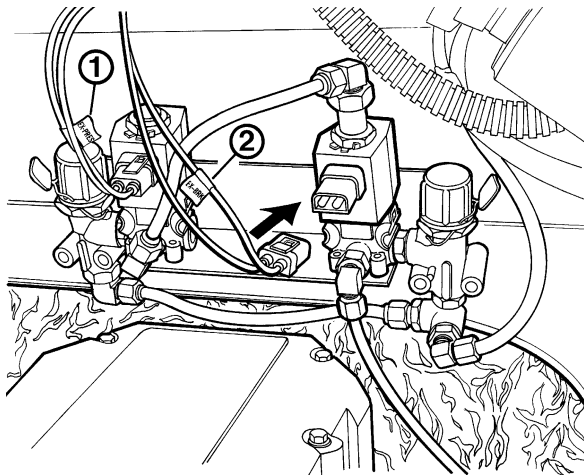
24

Install the heat shield and all of the air compressor discharge line support brackets. Connect the discharge line to the air compressor. Torque the heat shield bolts to 48 ± 8 Nm (35 ± 6 ft-lb).

48 ± 8 Nm
(35 ± 6 ft-lb)

25

Install the air filter housing and all air piping.

26

W2002216

Attach the connector to the exhaust pressure governor solenoid valve.

27

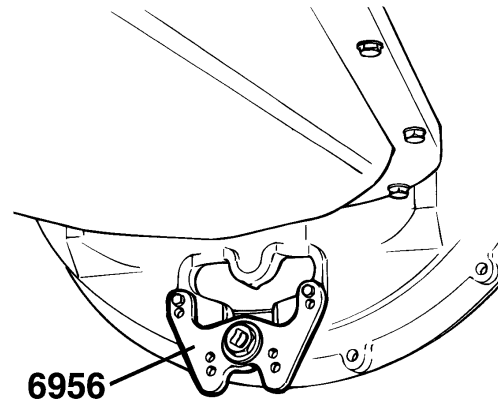
Remove the 36-pin breakout harness and reconnect the **EB** harness connector to the EECU.

2145-06-02-02**Rocker Arm Roller, Checking****DANGER**

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

Special tools: 9996956

Other special equipment: 9989876, 9999696

1

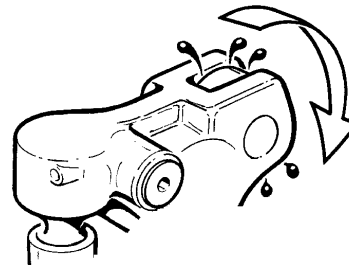
T2006672

Install the cranking tool and rotate the flywheel around until the camshaft is in a position where the rocker arm roller is not resting on any of the camshaft lobes.

9996956

2

Check that there is a gap between the rocker arm roller and the camshaft.

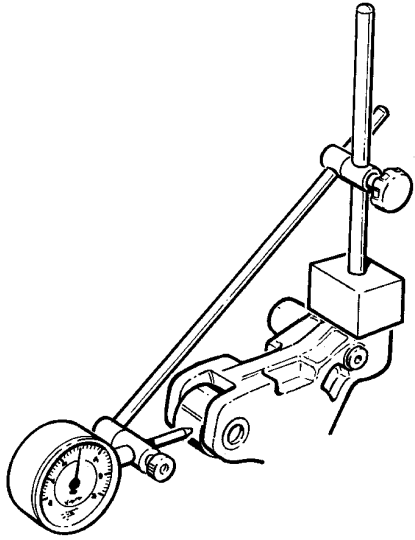
3

T2007948

Rotate the roller a number of turns to disperse the oil film between the bushing and shaft.

Note: If the roller seizes, the rocker arm must be replaced.

4



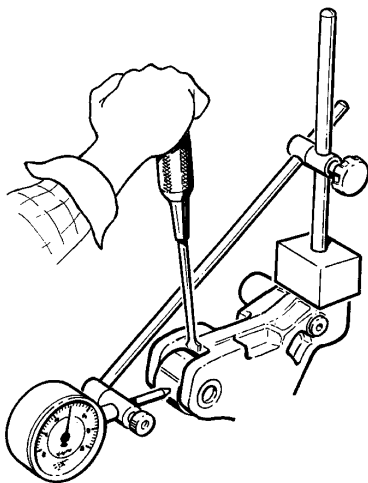
T2007949

Install a dial indicator on a magnetic base and position the magnetic base as level as possible on the rocker arm. Adjust the dial indicator probe horizontally against the center of the roller. Set the dial indicator to zero.

9999876
9999696

Note: Check that the dial indicator measuring probe is pre-loaded and permits movement in both directions.

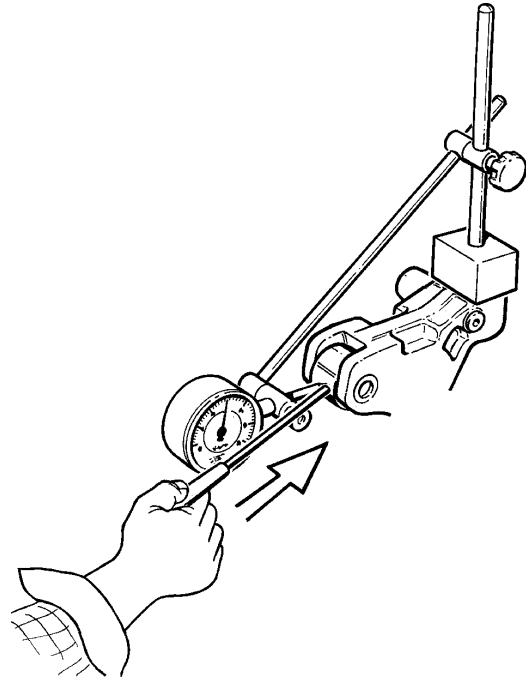
5



T2007950

Place a screwdriver between the rocker arm and roller. Press out the roller as far as possible and read the value on the dial indicator.

6



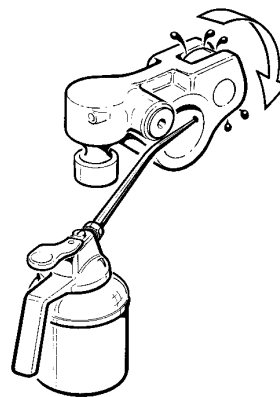
T2007951

Using a blunt object, press the roller inwards as far as possible and read the measurement value on the dial indicator.

**Max. 0.1 mm
(0.004 in)**

The max. permitted play between the bushing and the shaft is **0.1 mm (0.004 in)**. If the play is greater, the rocker arm should be replaced.

7



T2007792

If it is necessary to replace a rocker arm, lubricate the new rocker arm bushing with engine oil. Use a manual pump oil can and insert the nozzle in the oil channel hole.

Rotate the roller while pumping oil into the channel hole. Continue until oil runs out both sides of the roller.

Service Procedures

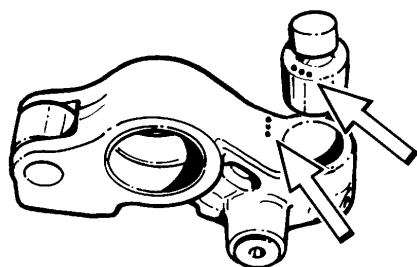
2145-04-04-02

Rocker Arm, Overhaul

Special tools: 9996716, 9998344

Repair kit: 8148353

1

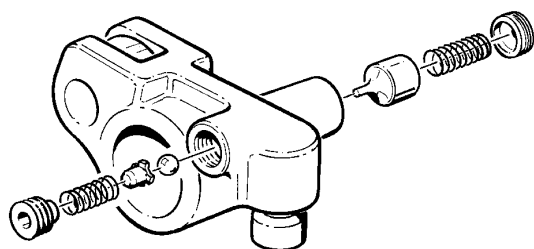


T2007725

Remove the plunger from the rocker arm.

Note: The plunger and rocker arm are a matched pair and are punch-marked for identification. They are not to be mixed when reassembled.

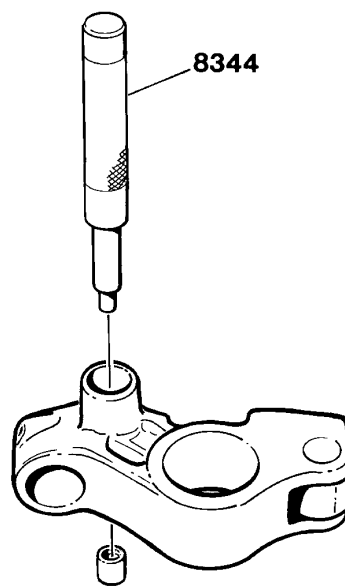
2



T2007726

Carefully heat the rocker arm plugs. Remove the plugs and take the springs, plunger, ball and spring guide out of the rocker arm.

3



T2007727

Press out the ball seat with drift 9998344.

9998344

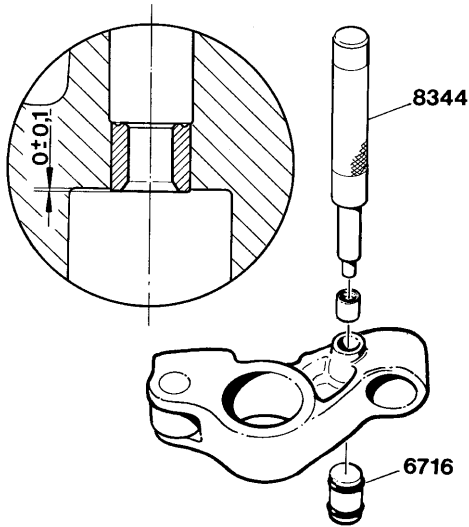
Note: Press the ball seating out in the direction as shown.

4

Clean and check the rocker arm. Make sure that all dirt is removed before assembling.

Note: If the rocker arm shaft bushing or roller is damaged, the complete rocker arm must be replaced.

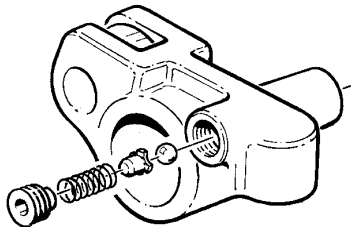
5



Use drift 9996716 as a counter-hold in the hole for the non-return valve plunger. Lubricate the new ball seat with **gear oil** and press in the seat with drift 9998344 until it bottoms against the counter-hold. Check the measurement for the ball seat position in the rocker arm.

Note: Make sure that the ball seat is positioned with the ring groove towards the ball and that no metal particles remain after pressing in the seat.

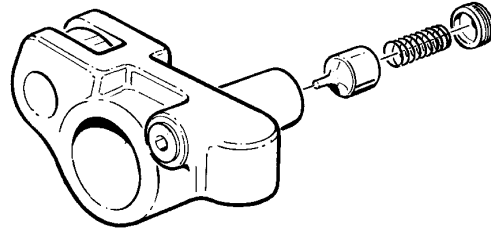
6



Lubricate the components with engine oil and install the ball, spring guide and spring. Apply **one drop** of locking fluid to the threads of the new plug and install the plug.

Note: Make sure that the plug and rocker arm threads are clean and dry before the locking fluid is applied. Carefully wipe off any excess locking fluid after the plug is installed.

7

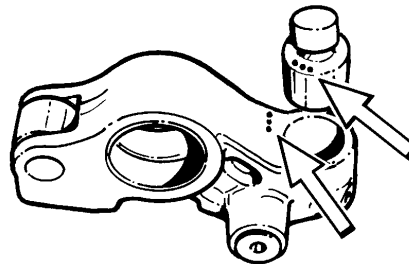


T2007730

Lubricate the non-return valve plunger with engine oil, check that the plunger moves easily in the rocker arm and install the spring. Apply **one drop** of locking fluid to the threads of the new plug and install the plug.

Note: Make sure that the plug and rocker arm threads are clean and dry before the locking fluid is applied. Carefully wipe off any excess locking fluid after the plug is installed.

8

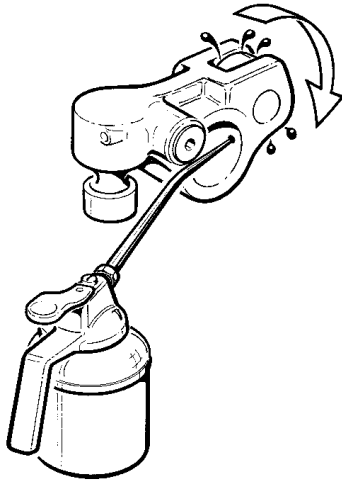


T2007725

Make sure the rocker arm and rocker arm plunger punch marks are the same. Lubricate the rocker arm plunger with engine oil and install it in the rocker arm.

Note: Place a rubber band around the rocker arm and plunger to prevent the plunger from falling out.

9



T2007792

Lubricate the journaling for the rocker arm roller with engine oil. Use a manual pump oil can and insert the nozzle in the oil channel hole. Rotate the roller while pumping oil into the channel. Continue until oil runs out both sides of the roller.

2533-03-02-05

Solenoid Valve, Compression Brake, Replacement



DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.



WARNING

HOT ENGINE! Keep yourself and your test equipment clear of all moving or hot engine parts. A hot engine can cause serious burns or can permanently damage test equipment.

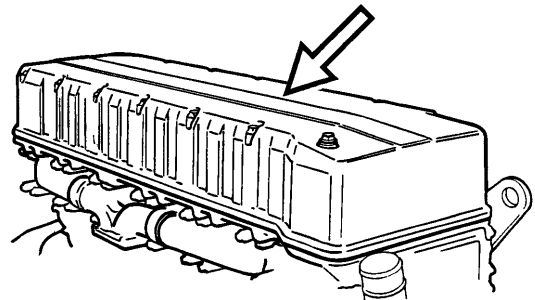


WARNING

Always wear appropriate eye protection to prevent the risk of eye injury due to contact with engine debris or fluids.

- 1 Set the parking brake.

2



T2006731

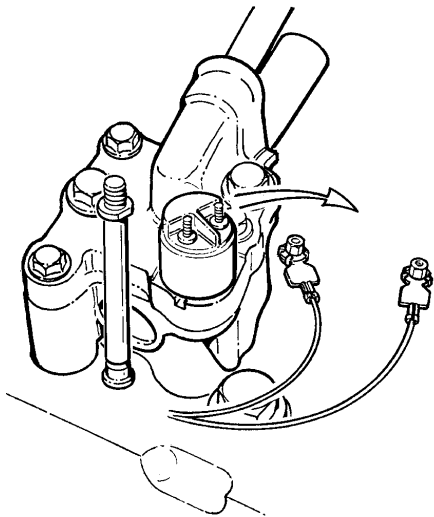
Remove the valve cover.

**CAUTION**

With older engines, avoid damage to the valve cover and injector cable harness by making sure the mounting screws do not unscrew from the cylinder head during removal. **Do not** use impact tools to remove the nuts securing the valve cover.

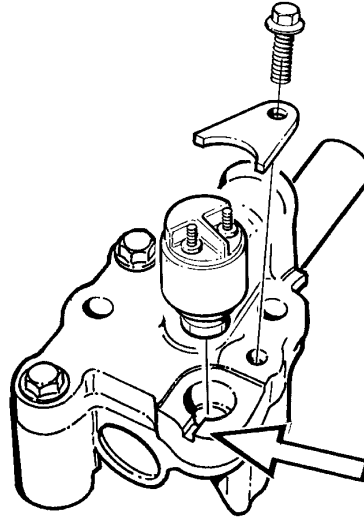
3

Clean the area round the solenoid valve.

4

T2007731

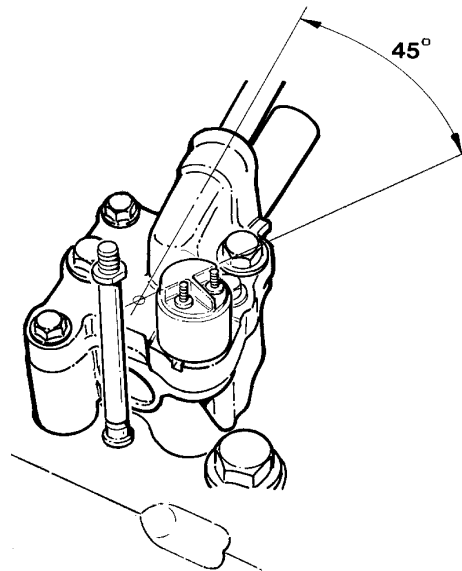
Remove the electrical connections from the solenoid valve.

5

T2007732

Remove the mounting bolt and flange. Lift off the old solenoid valve.

Note: Check that the drain channel in the VEB control valve is not clogged.

6

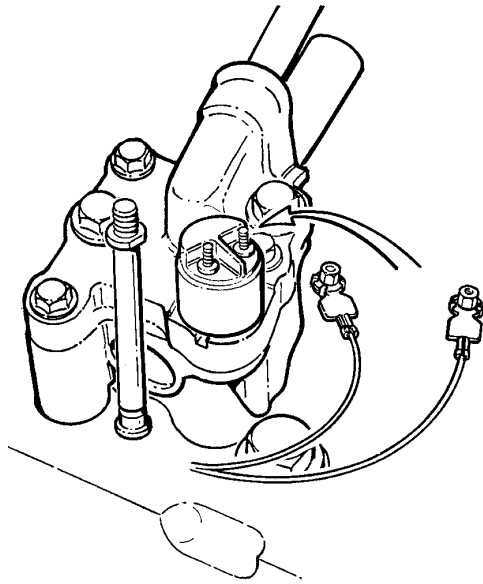
T2007736

Install the new solenoid valve, flange, and mounting bolt.

12.2 Nm
(9 ft-lb)

Note: The solenoid mounting angle is important. The terminals of the solenoid should be at a 0 to 45° angle to the VEB control valve oil pipe. Torque the solenoid mounting screw to 12.2 Nm (9 ft-lb).

7



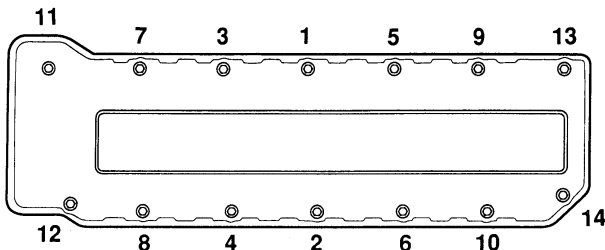
T2007733

Connect the electrical cables to the solenoid valve and tighten the nuts to a torque of 1.4 Nm (1 ft-lb).

8

Install the valve cover.

9



T2007003

Tighten the valve cover nuts to 30 ± 3 Nm (22 ± 2 ft-lb). Follow the tightening sequence shown.

10

Test run engine and check for oil leaks.

2531-03-02-02

Control Valve, Engine Brake, Replacement



DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.



WARNING

HOT ENGINE! Keep yourself and your test equipment clear of all moving or hot engine parts. A hot engine can cause serious burns or can permanently damage test equipment.



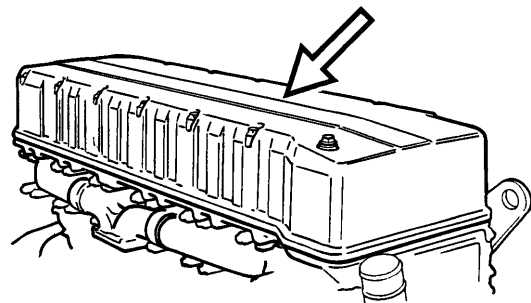
WARNING

Always wear appropriate eye protection to prevent the risk of eye injury due to contact with engine debris or fluids.

1

Set the parking brake.

2



T2006731

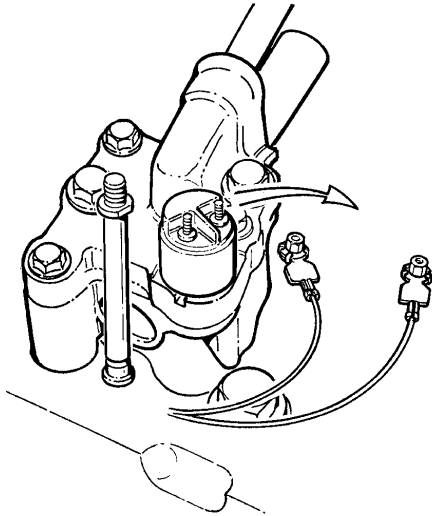
Remove the valve cover.

Note: With older engines, avoid damage to the valve cover and injector cable harness by making sure the mounting screws do not unscrew from the cylinder head during removal. **Do not** use impact tools to remove the nuts securing the valve cover.

3

Clean the area around the solenoid valve.

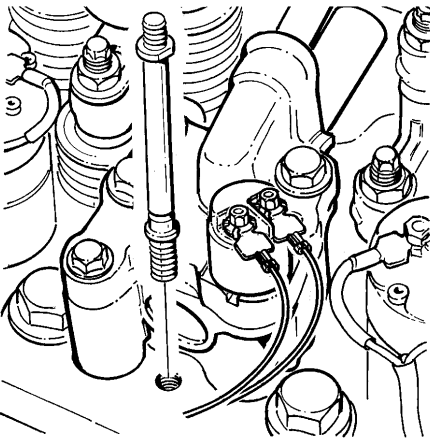
4



T2007731

Remove the electrical connections from the solenoid valve.

5



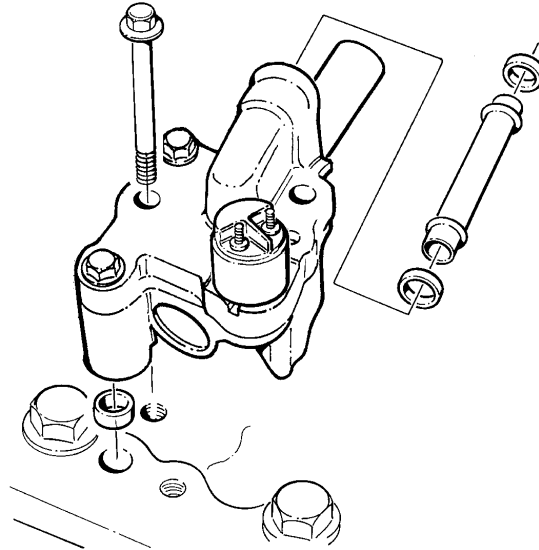
T2007722

Remove the valve cover stud located beside the VEB control valve.

J-41203

Note: Use Kent Moore tool J-41203 to torque the studs on early D12 engines.

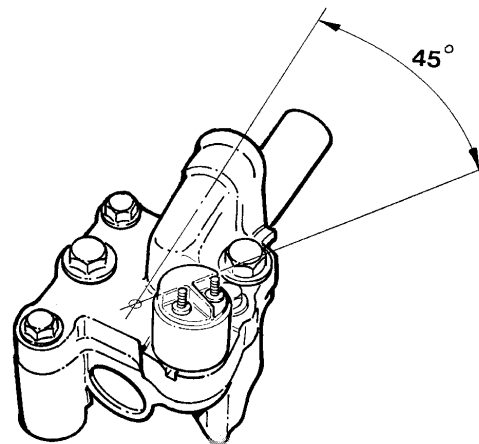
6



T2007734

Loosen the attaching bolts and remove the control valve. Also remove the oil pipe and seals between the control valve and rocker arm shaft.

7



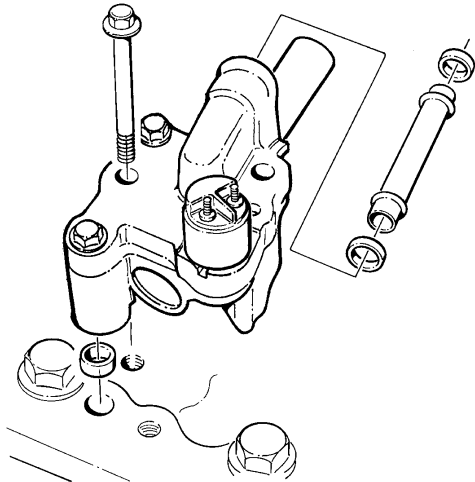
T2007794

Transfer the solenoid valve to the new control valve, if it is to be re-used. Torque the solenoid mounting screw to 12.2 Nm (9 ft-lb).

12.2 Nm
(9 ft-lb)

Note: Check that the drain holes in the VEB solenoid valve are not clogged. The solenoid mounting angle is important. The terminals of the solenoid should be at a 0 to 45° angle to the VEB control valve oil pipe.

8

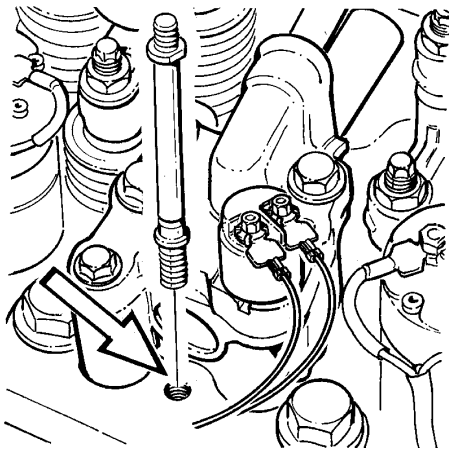


Install new seals on the pipe between the control valve and rocker arm shaft. Press the pipe (together with the seal) into the control valve. Install a new seal in the control valve oil inlet hole where it mates with the cylinder head.

Install and bolt down the control valve. Make sure that the seals against the cylinder head and rocker arm shaft are positioned correctly.

Torque the control valve mounting bolts to 20 ± 3 Nm (15 ± 2 ft-lb).

9

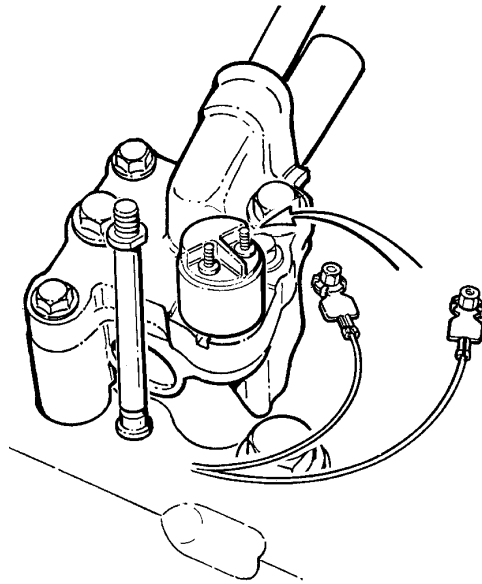


Clean the threaded hole in the cylinder head located beside the VEB control valve. Clean the valve cover stud bolt and apply locking fluid. Torque the stud to 48 ± 8 Nm (35 ± 6 ft-lb).

Note: Use Kent Moore tool J-41203 to torque the studs on early D12 engines. Carefully remove any excess locking fluid after the stud bolt has been tightened.

J-41203
 48 ± 8 Nm
(35 ± 6 ft-lb)

10



Connect the electrical cables to the solenoid valve and tighten the nuts to a torque of 1.4 Nm (1 ft-lb).

11

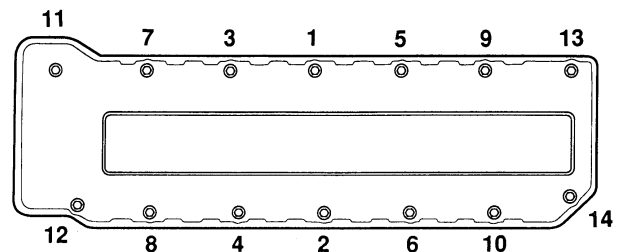
Press the electrical cable clamp onto the stud bolt.

Note: The electrical cable must be positioned on the outside of the valve cover stud.

12

Install the valve cover.

13



Tighten the valve cover nuts to 30 ± 3 Nm (22 ± 2 ft-lb). Follow the tightening sequence shown.

14

Test run engine and check for oil leaks.

Operation Numbers

| | | |
|---------------|--|----|
| 2145-04-04-02 | Rocker Arm, Overhaul | 49 |
| 2145-06-02-02 | Rocker Arm Roller, Checking | 46 |
| 2515-06-02-01 | Exhaust Temperature, Checking | 40 |
| 2531-03-02-02 | Control Valve, Engine Brake, Replacement | 53 |
| 2531-06-02-01 | Engine Brake, Checking | 27 |
| 2531-06-02-02 | Exhaust Brake, Electronic Checking | 30 |
| 2531-06-02-03 | Exhaust Brake, Mechanical Checking | 32 |
| 2533-03-02-05 | Solenoid Valve, Compression Brake, Replacement | 51 |
| 2533-06-02-01 | Solenoid Valve, Compression Brake, Checking | 29 |
| 2533-06-02-02 | Oil Pressure, Compression Brake, Checking | 36 |



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